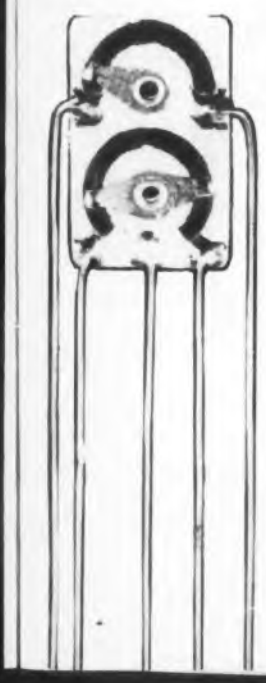
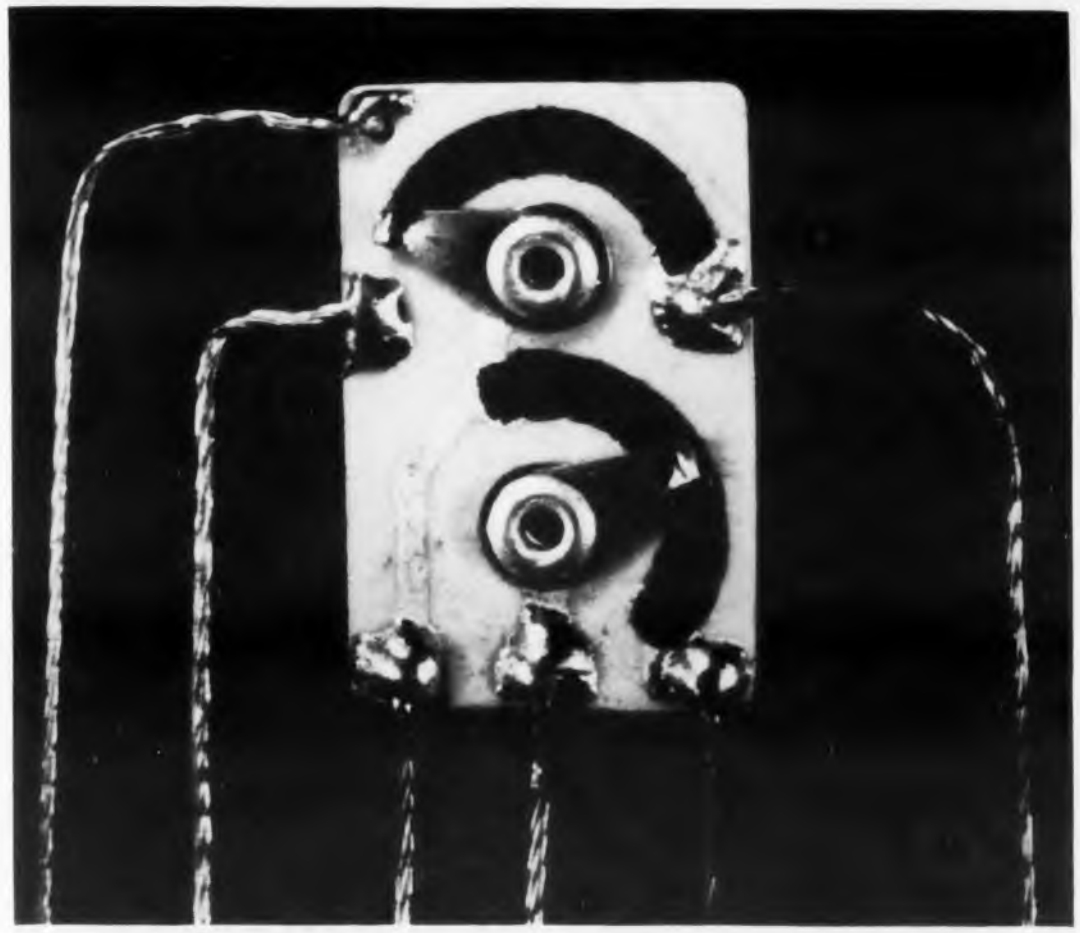
ELECTRONIC DESIGN

JULY 1955





Tiny trimmer resistors simplify transistor circuit design.

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Any job change requires requalification.

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July 1955

Contents

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MODEL 564
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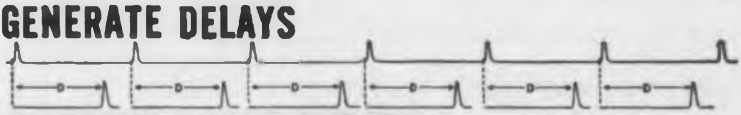
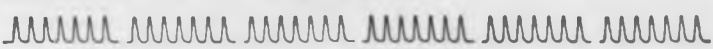


- **GENERATE PULSE BURSTS**



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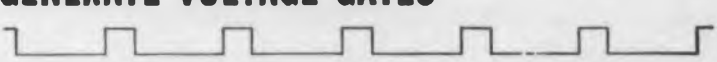

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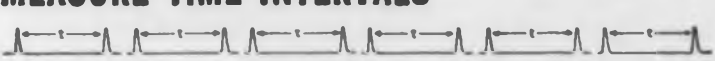

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Try this for size

For guided missiles, airborne equipment, portable and mobile ground equipment

In these and related fields, where lack of space is the problem, manufacturers have turned to miniaturization. Daven's **new ceramic switch** occupies a panel area of **less** than 1½ square inches—incorporates features that ensure long life and trouble-free operation.

Despite its small size, this switch is extremely rugged and has been designed to withstand all types of field service. Coin silver contacts, rotors and slip rings are provided for low and uniform contact resistance and excellent electrical characteristics. Ceramic parts are silicone impregnated to function under extreme humidity. Sturdy solder terminals are supplied for wiring.

Single pole style has 18 shorting type contact positions available. 2 or 3 pole types may also be obtained. Several sections may be "ganged" by adding supplementary wafers. Flash-over voltage at 60 cycles is 1000 volts peak . . . current carrying capacity is 2 amperes.

This sturdy, high-quality switch is precision produced . . . will give years of service in fine commercial and military equipment. DAVEN's expert engineering staff is at your service for help with special problems or orders to your specifications. Write today for further information.

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WORLD'S LARGEST MANUFACTURE

Editorial

Transistors

The Transistor Data Chart which appears between Pages 78 and 79 in this issue is significant to the electronic design engineer in several ways. First, of course, the body of data itself—the various types of transistors, their characteristics, and where they can be obtained—is interesting to the designer. Beyond the mere presentation of data, however, the chart has important implications.

Comparing the 1955 chart with the two previous ones published in ELECTRONIC DESIGN, we can see the rapid expansion of activity in this field. In 1953 we listed 36 transistors available from nine sources. In 1954 the number of transistors grew to 132 and suppliers totalled 17. This year's chart includes 218 transistors available from 21 sources. Transistors not generally available are not included in the chart so that the figures mentioned above are conservative.

As late as last year it was difficult to find more than a handful of commercial applications of transistors. Today a new device incorporating transistors is no longer a novelty.

This all sounds as though good progress is being made. However, real progress will never be made until there is more standardization of transistor types and ratings. Most transistorized equipment available at present incorporates special circuitry to compensate for varying characteristics between transistors of different manufacturers. This is an evil that should be quickly eliminated. Transistor circuitry is complicated enough without imposing extra burdens upon the circuit designer.

Now is the time for statesmanlike action on the part of transistor manufacturers and users to agree on some workable standardization. Right now interest in transistors is high and designers will be quick to exploit all the advantages of transistors in their equipment if given half a chance. Let's give them the chance.

Engineering Review

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

Transistor Preamplifier . . . A small two-transistor preamplifier has been developed to amplify very low level signals for application to sensitive instruments. Signals as low as 1μv can be amplified 1000 times.

The experimental device was developed by Allen B. Du Mont Labortatories, 760 Bloomfield Ave., Clifton, N. J., to aid in medical diagnosis. Its dimensions are 1" x 1" x 5" long. It is powered by four mercury cells. When connected to a low-shunt-capacity-input oscillograph, it has an input resistance of 1000 ohms and a frequency response of 20cy to 30kv. Noise referred to the input is less than 1μv, rms.

Radar Highway Warning . . . A radar-operated highway warning that tells speeding motorists to slow down has been developed. The device was shown at a recent demonstration of electronic highway safety devices by the New Hampshire Department of Public Works and Highways.

The highway warning is made by Motor Vehicle Research, Inc., South Lee, New Hampshire. Other devices demonstrated included a closed-circuit TV system in which a monitor showed traffic conditions miles away. The cameras in the system were provided by General Precision Laboratory, Pleasantville, N. Y. The microwave link between the cameras and the monitor is made by Raytheon Manufacturing Co., Waltham, Mass.

Neutron Generator for Oil Drilling . . . By means of a newly developed neutron generator that is lowered into oil wells, a chemical analysis can be made of mineral formations three miles beneath the earth's surface. The products of the neutron bombardment are detected by means of a "scintillation spectrometer". The generator produces neutrons with an energy of 14 Mev. This technique was first developed with a natural neutron source—pollonium-beryllium—of far lower energy than the generator.

Both the generator and the previously developed spectrometer are the products of McCullough Tool Co., 5820 S. Alameda St., Los Angeles 58, Calif. The technique has the advantage of operating right through the steel casing walls of the well. It can be used in the search for minerals other than oil.

Polyethylene as Waveguide . . . Experiments are now being conducted on the use of polyethylene rods as waveguides. The rod is mounted on a flat metal sheet or image surface.

The experiments are being performed by Donald D. King, Associate Director, Radiation Laboratory, Johns Hopkins Univ., 1315 St. Paul St., Baltimore 2, Md. A typical waveguide of this type for 25kMc involves a half-round polyethylene strip obtained by splitting the dielectric in a RG-59/U cable. This strip is about 1/8" and is mounted on a metal surface 8" wide.

This type of waveguide is probably most useful at higher frequencies. For example, at 100kMc the metal surface need only be one or two inches wide to produce a waveguide with losses far below that of the conventional rectangular type. Glass rods are also being considered in this experiment, but they are less efficient and more difficult to handle than polyethylene.

Radar in Railroading

Radar-actuated car retarders in the foreground are the heart of this electronically controlled Southern Pacific RR gravity switching yard at Houston, Texas. The retarders, made by General Railway Signal Co., Rochester, N. Y., prevent the cars from coupling with too great a force. The switching engines in this yard are equipped with 2-way radios. Television surveillance of part of the yard is also planned.

Russian Semiconductor Progress . . . Studies of Russian technical magazines indicate that the U.S.S.R. is making rapid progress in semiconductor development. As an indication of the interest in semiconductors behind the Iron Curtain, the following has been translated from an article entitled "Prospects of Semiconductor Technique", by Prof. A. Kugushev, a doctor of technical sciences, from the May, 1955, issue of *Radio*, the latest copy received in this country:

"It is now completely beyond doubt that in the next few years low-power vacuum-tube electronic devices will be supplanted by semiconductors. . . . The service period of semiconductor devices will in many cases exceed the service limit of the apparatus itself.

"In the very near future small-size radio-broadcast receivers will be widely installed having germanium triodes with an output signal up to 0.5v, supplied by dry batteries of 3 to 6v having a high sensitivity order of 35mkv/m, having a super-heterodyne circuit, and designed for a range of radiowaves of 200 and more meters.

"Since low-power sources with a potential of one volt or less are demanded for the feed of transistor triodes and the crystal in the electrolyte can serve as the anode of a galvanic element, it's possible to realize a semiconductor amplifier with its own source of feed. If account be taken of the possibility of using modern cheap radioactive materials in creation of electric elements, then a semiconductor electronic amplifier can be in the near future created, that is by design joined with sources of feed in the form of a solid body that guarantees uninterrupted operation over many years.

"Prospects are not as yet clear for creation of electronic semiconductor devices for generation and amplification of powerful oscillations of the whole range of radio frequency, including also ultra-short waves. On the way to creation of such devices are difficulties connected with the technology and search of the necessary materials. However, physics of the solid state will without doubt soon assist in overcoming the difficulties and rational designs will also be elaborated, and artificial semiconductor materials created.

"It must be assumed that in the near future semiconductor rectifiers will find wide application not only in radio receivers, but also in powerful radio broadcast stations where they will with success replace high-vacuum kenotrons and vacuum tubes.

"Powerful semiconductor rectifiers will be used in power stations and on electric transport. Their application can result in radical reform of such systems. In particular, it becomes possible to realize the feed of electric trains with alternating current that is transformed into direct current in the rolling stock itself with the help of compact semiconductor rectifiers that require no special service.

"It is understood that the creation of new electronic apparatus is not possible merely by means of perfecting electronic devices themselves, merely by replace-

ment of tubes by semiconductors. It is also necessary to perfect the radio parts that are applied in the systems of this apparatus. For this new materials must be developed and applied that allow for the making of more rational and small-dimension designs of transformers, capacitors, resistances, etc.

"The modern achievements of solid-state physics also make for solution of this problem. It can be hoped that in this direction practical achievements will in the near future open up the prospect for the full use of the advantages of semiconductor devices."

In the same issue of *Radio*, Prof. A. Berg, a member of the Academy of Sciences, said in an article entitled "Semiconductor Electron Devices", as follows:

" . . . . Radio receivers and television sets already exist having no vacuum tubes (apart from picture tubes), which have been replaced by miniature solid electronic amplifiers that possess great advantages of tubes: longevity, minute power consumption, mechanical ruggedness, and small size. They find the widest application in the complex systems of phone stations, in calculators, and in many automatic installations."

Improved Glass-Fiber Paper . . . Continued research on all-glass paper has resulted in a paper that is eight times stronger than the glass paper first made in 1951. In addition to its uses as an electrical insulator and dielectric, it can be used in gas masks and chemical filters.

The improved paper was developed at the National Bureau of Standards, Washington 25, D. C., as part of a project sponsored by the Naval Research Laboratory. An improved process results in the formation of a gelatinous binding material at the intersection of the filters, as shown by the accompanying photo.

Microphoto of the newly improved glass-fiber paper showing the formation of a binder at the intersections of the fibers.

Transistor in Planes . . . Successful flights with transistorized automatic navigation and landing systems have been completed. The next design goals in aircraft are transistorized flight control systems, pressure and position indicators, and liquid-level indicators. Fuel-flow indicators utilizing transistors have been available for some time.

The flights were made in the flying laboratory of the Bendix Aviation Corp., Teterboro, N. J. The equipment were engineering models. It was not indicated when the equipment would be available commercially.

Improved Computer . . . Two design improvements have been announced for the two models of the "Univac-Scientific" digital computer. A magnetic-core storage has replaced an electrostatic memory and metal magnetic tape is used instead of plastic tape as an input-output medium.

These computers are made by Remington-Rand Inc., 315 Fourth Ave., New York 10, N. Y. General storage in the Univac-Scientific has been increased from 17,408 registers to 20,480 through the replacement of 1024 electrostatic registers with 4096 registers of magnetic core storage.

Rubber Improved by Radiation . . . Materials that extend the service life of irradiated rubber at least ten times have been discovered. Known as "anti-rads", the materials are added to rubber stocks before vulcanization.

The materials were discovered at the B. F. Goodrich Research Center, Brecksville, Ohio. A cobalt-60 radiation source was recently installed at the laboratory.

Transistor Warranty Extended . . . The General Electric Company has extended the warranty period on its transistors from 90 days to one year. The new warranty applies to both fused-junction and rate-grown types. Recent test data indicates that the firm's transistors have a survival rate as high as 98% after 10,000 hr at rated capacity.

◀ CIRCLE ED-6 ON READER-SERVICE CARD

Mobile Computer . . . A mobile unit with a complete data handling system has started on a national tour. The "Data Cruiser" is a 40-foot bus equipped with data reduction machines. It resembles the DYSEAC mobile computer described in the Sept., 1954, issue of ELECTRONIC DESIGN.

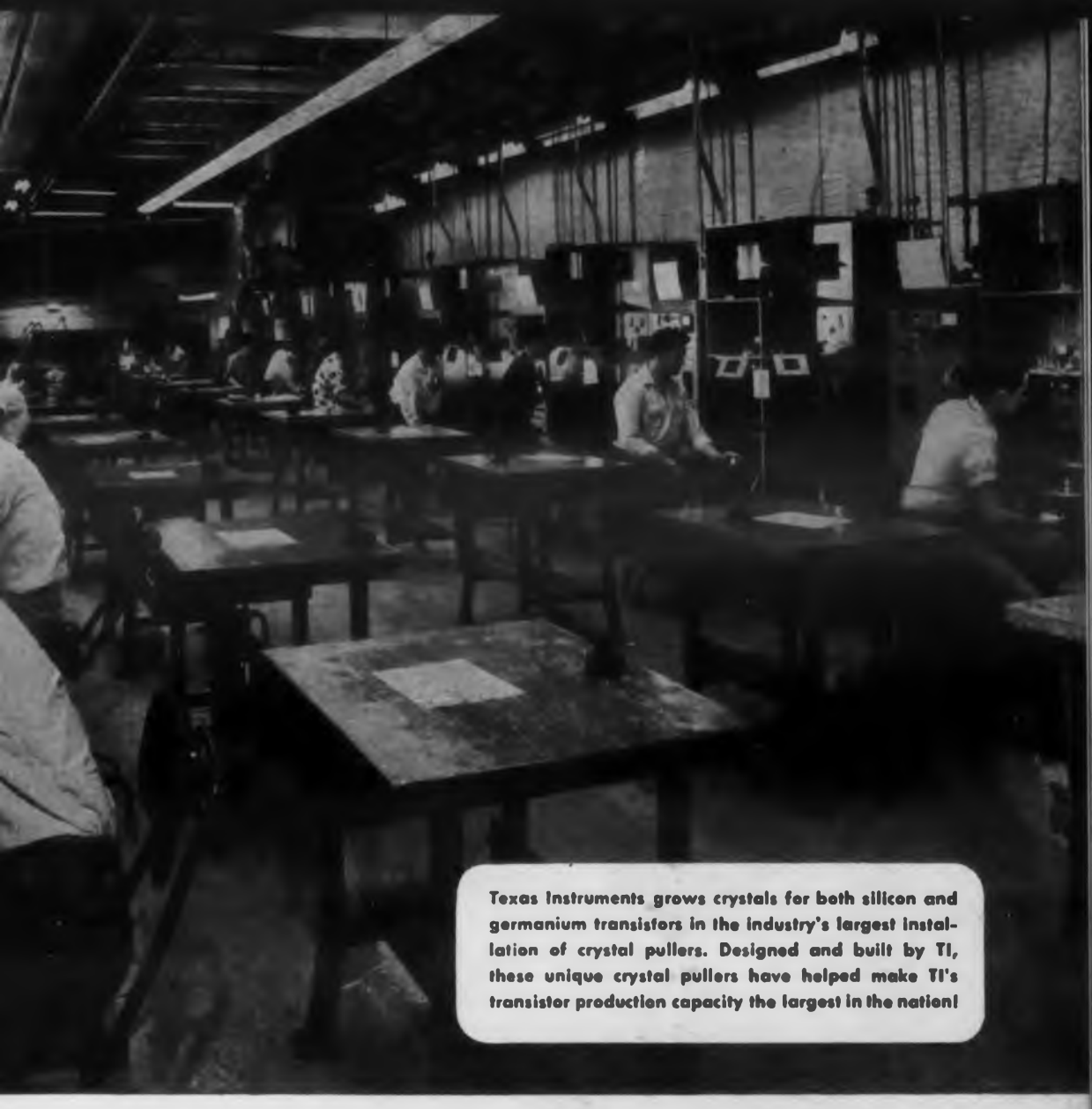
The mobile unit was developed by Benson-Lehner Corp., 2340 Sawtelle Blvd., Los Angeles 64, Calif. The purpose of the visits will be to put automatic machines directly into the hands of engineering staffs across the country to help solve problems in a number of different industries and familiarize design engineers with the capabilities of data-handling devices.

Electronic Business Failures Decline . . . Business failures of manufacturers of radio-TV-electronic equipment and components during the year ending April 1955 declined considerably in number from the total reached in the corresponding 1954 period, according to the Radio-Electronics-Television Manufacturers Association, 777 14th St., N. W., Washington 5, D.C. Twenty-six manufacturers of electronic equipment or products failed in the year ending April 30 compared with 33 for the same period a year earlier.

Transistorized Communications Gear . . . A transistorized audio control panel for aircraft has been developed by the Bendix Aviation Corp., Radio Div., Baltimore, Md.

Computers in Hydraulic Problems . . . The use of electronic analog computers in the solution of hydraulic problems will be a feature of the 11th Annual National Conference on Industrial Hydraulics, Oct. 27-28, in the La Salle Hotel, Chicago, Ill. The conference is sponsored by the Illinois Institute of Technology graduate school and Armour Research Foundation, Chicago, Ill., in cooperation with a group of engineering societies and nearly 100 industrial organizations.

CIRCLE ED-7 ON READER-SERVICE CARD ➤



Texas Instruments grows crystals for both silicon and germanium transistors in the industry's largest installation of crystal pullers. Designed and built by TI, these unique crystal pullers have helped make TI's transistor production capacity the largest in the nation!

TI mass production means transistors today . . . not "available soon"

You get immediate delivery . . . in the quantity you need . . . when you order transistors from Texas Instruments. Mass production methods mean *no waiting* for silicon or germanium transistors . . . and at low prices! Only from TI can you get high temperature silicon transistors. Only from TI can you get *product-proved* germanium radio transistors. With the industry's largest transistor production capacity, TI can meet your delivery requirements – whether you need radio-type transistors by the hundreds or hundreds of thousands!

Texas Instruments low cost germanium radio transistors are used in the *first* transistorized consumer product – a high performance pocket radio on sale across the nation. High temperature silicon transistors (stable to 150° C), produced only by TI, are already being used in important military and commercial applications.

Each TI semiconductor product is glass-to-metal hermetically sealed . . . thoroughly aged and tested . . . to assure successful performance and long range reliability. The nation's leading manufacturer of transistors, Texas Instruments is your most experienced source for semiconductor products.

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INCORPORATED
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"Thyratron" Transistor . . . A transistor that can be used to replace a thyratron in many applications has been developed. It has a point contact collector and a junction emitter. It will operate at pulse rates of one megacycle and can handle 100ma. The construction of the device is illustrated.

The transistor was developed at the International Business Machines Corporation Research Laboratory, Poughkeepsie, N. Y. It is presently being employed to operate relays in an experimental transistorized computer constructed by IBM. The transistor can be switched by both electrical and light signals. A provision is made in the cap to allow light to be focused on the n-type germanium.

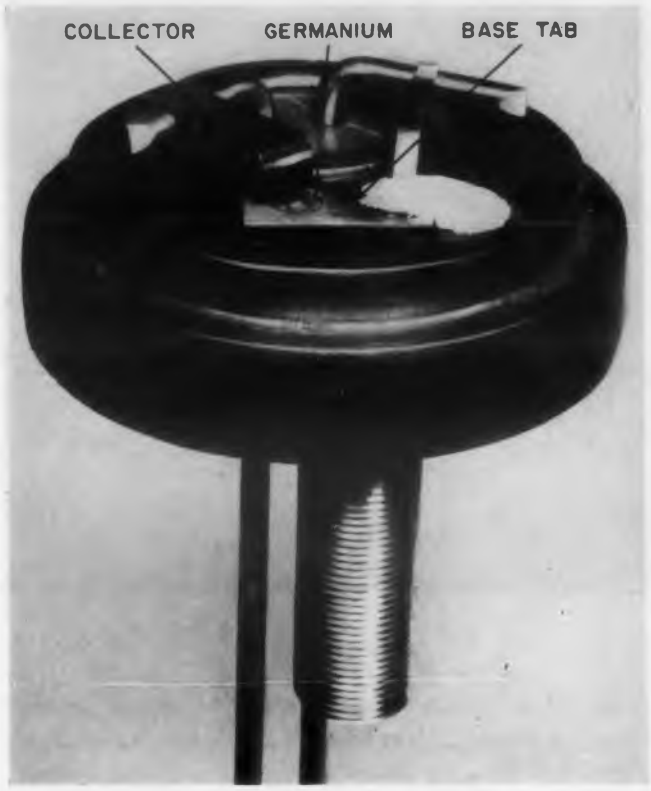
Its characteristics are similar to that of the thyratron tube. If its emitter is grounded and a load is connected between collector and emitter, a small base current will keep the collector current low. When the base current is removed, the collector-to-emitter impedance is reduced and a high load current flows. To turn the transistor off, the base current must be returned to its original value and the collector voltage reduced to a very low value.

Nuclear Heat for Sale . . . The heat to be produced by a sodium-graphite reactor now under construction has been offered for sale by the Atomic Energy Commission, Washington 25, D. C. The reactor is being built by North American Aviation, Inc., who will operate the plant. The site is about 30 miles northwest of downtown Los Angeles, Calif.

The reactor employs sodium as the coolant and graphite as the moderator. The heat will undoubtedly be used to generate electricity. The peak load of the reactor will be about 20,000kw, permitting the generation of about 7500kw of electricity.

Transistorized Mixer-Amplifier

This compact mixer-amplifier for field use by studios replaces much larger and heavier equipment. It is powered by 10 hearing aid mercury batteries. The unit was developed by Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.



The construction of the "thyratron" transistor is shown by this model. The broad "L" shaped collector makes a point contact to the circular wafer of n-type germanium. A circular p-type region is formed on the bottom of the wafer and constitutes the junction emitter. The rectangular base tab is soldered to the top of the wafer and the base connection runs from it on the right. The large supporting disc is made of copper and serves as a heat sink.

New Printed Circuit Machinery . . . New devices to improve the manufacture of printed circuits are being placed on the market in increasing numbers. The latest additions are an automatic assembly machine and a semi-automatic drill press for short runs of printed circuit boards.

The Minnesota Engineering Co., 43 Royalston St., Minneapolis 5, Minn., has developed an automatic assembly device known as the "Minn-A-Matic". Lead holes are drilled in the boards, and the component leads are inserted and clinched flat against the board in successive operations. Unlike other such machines announced to date, the boards move through the machine in a vertical position. The boards can be inserted in the device either manually or mechanically. Boards ranging in size from 1" x 1" to 12" x 17" and up to 1/4" thick can be accommodated.

Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J., has developed a new manually directed drill press for printed circuit production. Employing a template and the pantograph technique, the press turns out boards with an average of 150 holes per board at the rate of about one board every two minutes. Operators are quickly trained. A new template can be prepared in about 30 min.

V-H-F Tuner

Segmented tuning capacitors are employed in the tuner of a new 22-channel v-h-f aircraft transmitter made by Dayton Aviation Radio and Equipment Corp., Troy, Ohio. The transmitter weighs 22 oz.

Electronic Golfball . . . An electronic golfball incorporating a transistor transmitter has been developed for demonstration purposes. Whenever a golfer loses the ball in tall grass, he can find it by using a small companion receiver as a direction finder.

The golfball and a transistor radio pocket clock were demonstrated at a recent conference to illustrate the effect of transistors on electronic equipment. Daniel E. Noble, vice president, Communications & Electronics Div., Motorola, Inc., 4545 W. Augusta Blvd., Chicago 51, Ill., addressed the Association of American Railroads. He said that transistors offered the possibility of developing functional modules that would operate for ten years without servicing and without failure.

The transistor clock is tuned to the Naval Observatory in Virginia. Incorporating six transistors, it gives the time every other hour over a loudspeaker. The hermetically sealed unit will operate about five hours a day for about 25 days on two penlight batteries.

Faster Drafting . . . A reduction of more than 95% in time needed to produce engineering drawings has been achieved. New techniques in the use of photomechanical materials and processes now permit making in a matter of minutes a tracing which formerly took 6 to 18 hours. The techniques were perfected by the Medium Voltage Switchgear Dept., General Electric Co., Schenectady 5, N. Y.

In applying these new methods it is merely necessary for the engineer or draftsman to prepare a simple coded order to the Blueprint Section. This order embodies all necessary instructions for the preparation by a clerk of a composite positive film

transparency, comprising reusable positive film overlays, from which a translucent auto-positive is printed by conventional photo-mechanical methods. The auto-positive, which thus becomes the original tracing, has many advantages. It is tougher than conventional tracing paper and can stand rough handling. It has sharper contrast with dense, crisp black lines which permit high printing speeds. Erasures can be made quickly and easily by moistening the image and using a soft eraser.

A major advantage realized in use of this system is greater drafting accuracy with a saving in time of skilled engineers and draftsman.

Reprocessed Tubes . . . A Brooklyn firm and two of its officials were fined a total of $1000 for reprocessing old radio and TV receiving tubes and selling them as new tubes. According to the April 30, 1955, edition of the *New York Herald-Tribune*, the firm bought old tubes for 1 to 12 cents each, cleaned them, branded them with well-known trade names, and sold them for $2.15 to $3.20 each.

If this practice, rare today, ever became widespread, it might require legislation calling for TV servicemen to smash all defective tubes removed from sets just as bartenders are required to smash all empty whisky bottles.

Transistors Improve Plane Intercom . . . The illustrated adapter preamplifier permits economical modernization of aircraft intercommunication systems. Carbon microphones and magnetic headsets can be replaced directly with dynamic types. The 3-transistor device plugs in the plane's existing system, requires no additional wiring, and is powered by the bias voltage of the existing system.

The preamplifier was developed by Radio Corp. of America, Camden, N. J. It raises the output of the dynamic microphone to a level equal to that of the carbon type previously used. The dynamic microphone affords greater speech intelligibility. The unit provides a gain of 47db with an output of 2.5w.

Incorporating three transistors, this adapter preamplifier for plane intercoms weighs only 6 oz.

Transistor Preamplifier . . . A transistor preamplifier is used on two newly developed high fidelity consoles. A moving coil pick-up with 1-1/2 ohms impedance is connected directly to the transistor. An input transformer is not required because of the low input impedance characteristic of transistors.

The transistor replaces two tubes and an input transformer. The sound equipment is made by Radio Corp. of America, Camden, N. J., and the transistor is a *2N104*, a low-noise type made by the same firm.

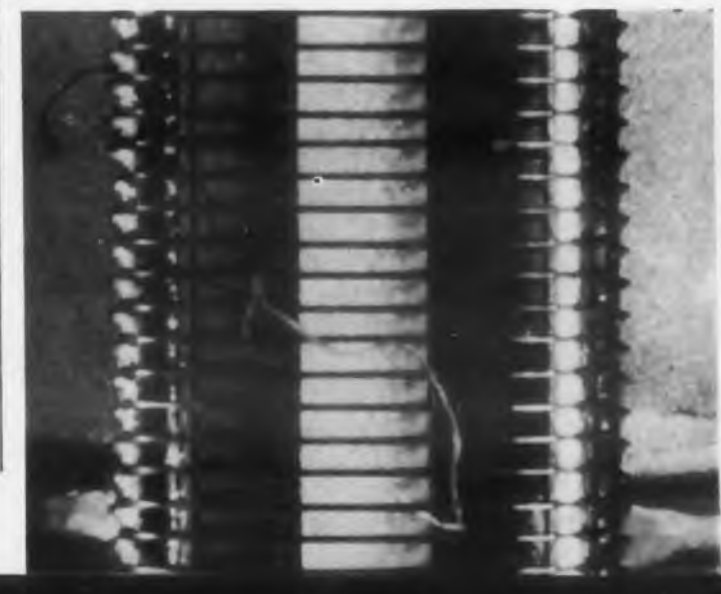
British Buy French TV . . . A recent issue of the British publication *Wireless World* reports that some Britons living along the coast are importing French TV sets to receive telecasts from across the Channel. Apparently the French programs are so good that Englishmen who can not speak French are investing in French receivers. These sets are not compatible with the British telecasting system.

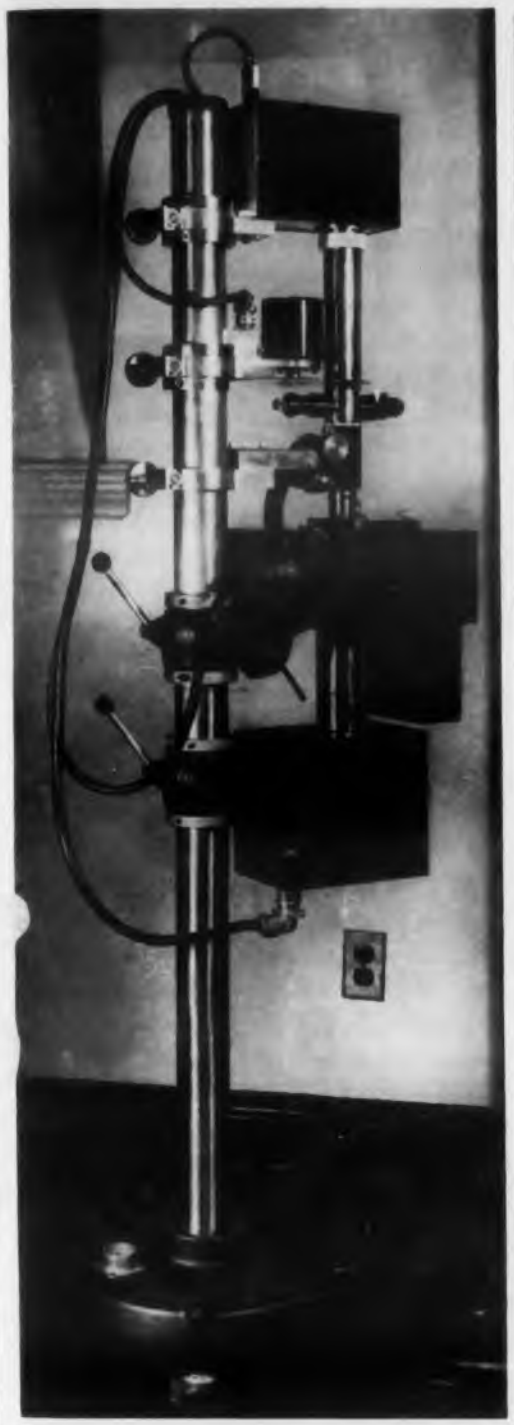
The implications of this amusing expansion of international trade are vast. The French, and any other nation on the crowded Continent, could do a lively export business in TV receivers by simply increasing the signal strength of existing stations or building new stations along their borders. In fact if transoceanic TV signal relaying (*ED, April, 1955, p. 6*) ever comes into existence, Europeans might start buying standard American sets. Eventually demands for a standard international TV system might gain great strength.

All in all this development is an interesting growth in the exchange of ideas. Television could do more to unify nations than the efforts of diplomats. Remembering our own difficulty with French in high school, we can only envy British youngsters who can learn French painlessly by watching telecasts of "Quel Est Mon Metier?" ("What's My Line?").

Lint on Grid

The lint of this tube grid could cause an intermittent short. In order to prevent lint from entering tubes as shown, the General Electric Co. operates a "lintless" tube factory at Owensboro, Ky. All employees must wear lintless nylon and dacron uniforms, and the air is filtered.





Mounting Problem

Difficulties in mounting this electronic cancer-detecting device were neatly solved by employing a standard drill press mount. Known as the "Cytoanalyzer", it was developed by Airborne Instruments Laboratory, Mineola, N. Y.

Geiger Counter in Heel . . . A reader has proposed a new type of geiger counter to be mounted in the heel of a shoe or boot. Indications from the transistorized instrument would be heard by means of a hearing-aid type speaker. This counter could be used by uranium prospectors without letting their competitors know they were making a survey.

CIRCLE ED-13 ON READER-SERVICE CARD ➤

Electronics May Rival Auto Output Value . . . "The electronics industry in America probably will double in size in the next seven or eight years to rival the automobile industry in the value of its output . . . " said J. K. Sprague, president of Sprague Electric Co., N. Adams, Mass.

Mr. Sprague recently forecast that while military equipment will continue to be the largest user of electronic equipment for many years, industrial applications will have the fastest growth of any of the markets for electronic products. Automation will be partly responsible for this growth in industrial use, he believed, and industrial TV is another field for great potential growth in the use of electronic components.

"Teflon" as Dry Lubricant . . . "Teflon", tetrafluorethylene resin, is being used as a dry lubricant and corrosion preventative coating. According to the June *Report* of the U. S. Naval Ordnance Laboratory, Silver Spring, Md., the coating can be used in temperatures ranging from −100°F to 550°F.

Teflon in a low viscosity dispersion in a water medium is used for this application. Following application, the coating must be air-dried and then fused in a furnace at temperatures up to 750°F.

Control Systems Engineering Course . . . Training in the fundamental background for the design and operation of automatic control systems for science and industry will be the basis of a new graduate program to be offered at Harvard University next fall. The program in control systems engineering will offer courses leading to both the master of science and doctor of philosophy degrees. It will stress design of integrated control systems.

Applications for admission to the first class this fall may be filed until Aug. 15 at the office of the Dean of the Graduate School of Arts and Sciences, Harvard University, 24 Quincy St., Cambridge 38, Mass.

Enamel Stands High Temperature . . . A new enamel for insulating wire has been developed. Tests show that an electric motor insulated with the new enamel can operate continuously for 10 years at a temperature of 325°F without damage to the insulation.

Known as "1267", the enamel is a modified polyester-type resin containing about 20% silicone. It was developed by F. A. Sattler and S. H. Langer of the Westinghouse Electric Corp., Pittsburgh, Pa. The enamel also has unusual resistance to flow under pressure.

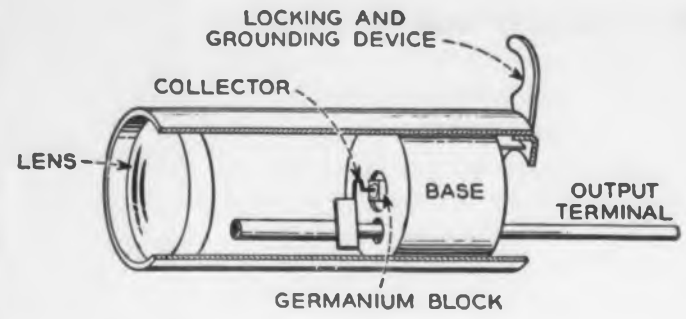
No "Late-Late" Show . . . British commercial TV may run a maximum of 35 hours during weekdays and 15 hours on the weekend, it was reported in the June issue of the *Du Mont Dispatch*, Allen B. Du Mont Laboratories, Inc., Empire State Bldg., New York, N. Y. There will be no programs before 9 am nor after 11 pm. There will be a shutdown Sunday nights during church services and a blank screen between 6 and 7 pm each evening during which children may be put to bed.

36 Million TV Receivers . . . During the 9-year period, 1946-1954, nearly 36 million TV receivers were shipped to dealers, according to a report by the Radio-Electronics-Television Manufacturers Association, 777 14th St., N.W., Washington 5, D. C. The number of sets involved ranged from 5000 sent to dealers in Alaska to 4,754,000 in New York.

If you need a special circuit, component, material, send us your request on company letterhead. We will publish it along with your name and address in the earliest issue possible. Interested readers can answer you directly.

Address brief request to Bulletin Board, ELECTRONIC DESIGN, 19 E. 62nd St., New York 21, N. Y.

CIRCLE ED-15 ON READER-SERVICE CARD ➤



Phototransistor

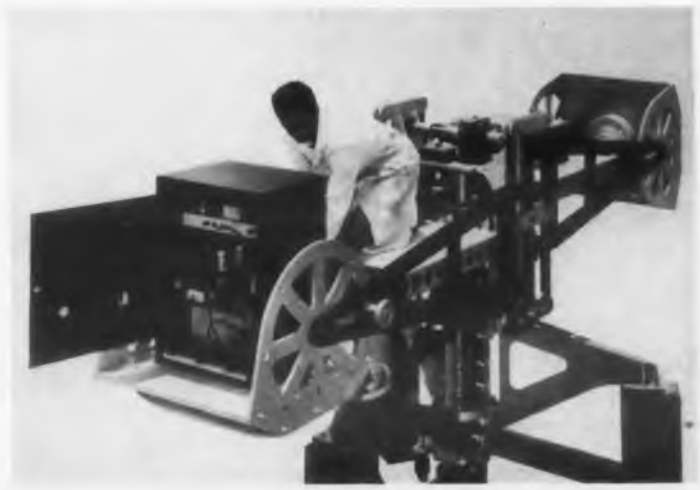
This is a cutaway view of the type of phototransistor being employed in the nationwide system of long-distance dialing. The device was developed at the Bell Telephone Laboratories, New York, N. Y. The unit senses the position of metal cards that drop in accordance with the digits dialed.

Plastics Stronger Cold . . . Unexpected strength and toughness at low temperatures has been discovered in certain plastics. These plastics have comparatively mediocre performance at room temperatures. The study of 56 rigid plastics was made by the Army Ordnance Corps.

Outstanding low-temperature performance was by the laminated thermosetting materials, of which glass fabric laminates proved the strongest. All laminates showed increase in tensile strength to —40°F, with slight reductions in strength caused by embrittlement as the temperature approached —65°F. The plastics studied include laminated, molded, and cast thermosetting materials, as well as cellulose, polystyrene, and polymethal thermoplastics. The results of the study are contained in a 143-page report entitled *Mechanical Properties of Rigid Plastics at Low Temperatures,* available from the Office of Technical Services, Dept. of Commerce, Washington 25, D. C., for $3.75.

60g Tester

This rotary centrifuge can test large equipments to 60g. Made by Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif., it features automatic dynamic balancing. This means that the center of gravity of test objects need not be computed.



Fellowships in Communication . . . A fellowship program for students doing graduate study in electrical communications has been established by Bell Telephone Laboratories, 463 West St., New York 14, N. Y. The awards, to be known as the Bell Telephone Laboratories Fellowships, are for study of one or two years leading to a doctorate. Each fellowship carries a grant of $2000 to the fellow and an additional $2000 to cover tuition, fees, and other costs to the institution at which he chooses to study.

Recipients of the fellowships will not be required to limit their study to electrical engineering, although the field of study and research must have a bearing on electrical communications. Fellows may make their own choice of an academic institution within the United States.

Ideas for Conference . . . Nearly 1100 U. S. scientists and engineers want to present papers at the United Nations international conference on peaceful uses of atomic energy at Geneva, Switzerland, in August. In response to invitations issued by the U. S. Atomic Energy Commission, that many have submitted summaries of their ideas for consideration. The first group of 189 abstracts of papers tentatively accepted have been forwarded to the United Nations.

Bulletin Board

Is the lack of a certain circuit, component, instrument, or material delaying your design project? Do you believe that some design laboratory is capable of producing a special component? Is your list of suppliers of certain components incomplete? Prepare your specifications or needs in less than 150 words, typewritten on company letterhead stationery, and send them to Bulletin Board, ELECTRONIC DESIGN, 19 East 62nd St., New York 21, N. Y. Include a name and address where our readers can communicate with you. If a sketch is necessary, please draw in black ink on white paper (no ozalids). The following requests were recently received. If you can supply any of these requests, please write to the address given.

Paper-winding: A paper-winding machine with a steady tension to be used in winding "Mylar" or "Teflon" film capacitors.

Write to: Robert Nobel, Balco Research Laboratories, Inc., 49-53 Edison Pl., Newark 2, N. J.

Counter: A three- or four-digit, 110v, 60cy counter adaptable to panel mounting and utilizing an electrical reset system. Prefer that the unit be of American manufacture.

Write to: E. J. Jackson, Test Equipment Design Section, Bell Aircraft Corp., P. O. Box 1, Buffalo 5, N. Y.

Counter: Small, compact electrically reset counter. Must be of American manufacture.

Write to: L. J. Crusco, Melpar, Inc., 3000 Arlington Blvd., Falls Church, Va.

Meetings

Aug. 15-19: *AIEE Pacific General Meeting*, Butte, Mont. For information, write to AIEE, 33 W. 39th St., New York 36, N. Y.

Aug. 22-23: *Symposium on Electronics and Automatic Production*, San Francisco, Calif. Jointly sponsored by Stanford Research Institute and the National Industrial Conference Board. For information, Write to Stanford Research Institute, Palo Alto, Calif., or the National Industrial Conference Board, 247 Park Ave., New York, N. Y.

Aug. 24-26: *Western Electronics Show and Convention*, Civic Auditorium, San Francisco, Calif. Sponsored by the West Coast Electronic Manufacturers' Association and the Seventh Region of the IRE. For information on exhibits, write Mal Mobley, Jr., 344 N. LaBrea Ave., Los Angeles, Calif.

Sept. 12-16: *Tenth Annual Instrument-Automation Conference and Exhibit,* Shrine Exposition Hall and Shrine Auditorium, Los Angeles, Calif. Sponsored by the Instrument Society of America. Analytical Instrument, Computer, and Maintenance Clinics will be held during the conference. For information, write to Dr. Arnold O. Beckman, 3443 S. Hill St., Los Angeles, Calif.

Sept. 14-16: *Annual Meeting of the Association for Computing Machinery*, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. The use of computers in scientific applications, industrial control, and automation will be discussed. For information, write to Association for Computing Machinery, 2 E. 63rd St., New York 23, N. Y.

Sept. 26-27: *Symposium on Electronics for Automation and Automation for Electronics,* Irvine Auditorium, University of Pennsylvania, Philadelphia, Pa. Sponsored by the Radio-Electronics-Television Manufacturers Association. For information, write to RETMA, 777 14th St., N. W., Washington 5, D. C.

Sept. 26-30: *Meeting on Marketing the Products of Atomic Energy and Trade Fair*, Sheraton-Park Hotel, Washington, D.C. Sponsored by the Atomic Industrial Forum. For information, write to Atomic Industrial Forum, Inc., 260 Madison Ave., New York 16, N. Y.

Oct. 3-5: *Eleventh Annual National Electronics Conference,* Hotel Sherman, Chicago, Ill. For information, write to J. Kocik, c/o Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.

Oct. 5-9: *World Plastics Fair and Trade Exposition,* National Guard Armory, Los Angeles, Calif. For information, write to Philip M. Kent, managing director, World Plastics Fair and Trade Exposition, 8762 Holloway Drive, Los Angeles 46, Calif.

Oct. 6-7: *Eleventh Annual Meeting and Design Conference of the Society of Industrial Designers,* the Woodner, Washington, D.C. The impact of automation on industrial design will be among the topics discussed. For information, write to the Society of Industrial Designers, 48 E. 49th St., New York 17, N. Y.

Oct. 12-15: *1955 Convention and Audio Fair,* Hotel New Yorker, New York, N. Y. Sponsored by the Audio Engineering Society. The convention will include panel discussions on transistors, amplifier design, and tape recording. For information, write to G. K. Dahl, 230 W. 41st St., New York 36, N. Y.

Oct. 17-19: *1955 Radio Fall Meeting,* Hotel Syracuse, Syracuse, N. Y. Sponsored by the Engineering Dept. of RETMA and the Professional Groups Committee of the IRE. For information, write to RETMA, 777 14th St., N. W., Washington 5, D.C.

Oct. 24-25: *First Annual Technical Meeting of the Professional Group on Electron Devices of the IRE,* Shoreham Hotel, Washington, D. C. For information, write to IRE, 1 E. 79th St., New York, N. Y.

Oct. 24-26: *Sixth National Conference on Standards,* Sheraton Park Hotel, Washington, D. C. Sponsored jointly by the American Standards Association and the National Bureau of Standards. For information, write to the American Standards Association, 70 E. 45th St., New York 17, N. Y.

Oct. 31-Nov. 1: *1955 East Coast Conference on Aeronautical and Navigational Electronics,* Lord Baltimore Hotel, Baltimore, Md. Sponsored by the Baltimore Section of the IRE and the IRE Professional Group on Aeronautical and Navigational Electronics. For information, write to IRE, 1 E. 79th St., New York 21, N. Y.

Nov. 1-5: *World Symposium on Applied Solar Energy,* Westward Ho Hotel, Phoenix, Ariz. Sponsored by the Association for Applied Solar Energy, Stanford Research Institute, and the University of Arizona. For information, write to W. C. Estler, Stanford Research Institute, Stanford, Calif.

Using Contour Curves In Transistor Circuit Design

Keats A. Pullen, Aberdeen Proving Ground and
Robert G. Roush, Johns Hopkins University

Editors Note: The curves in this article include both static and small-signal characteristics. This work represents a tremendous effort in improving data presentation, but it is not necessarily the final word. The authors invite readers to try the methods suggested and to send in their comments. ELECTRONIC DESIGN *editors are also interested in your reactions as we hope to publish characteristics of additional transistors as they become available.*

TRANSISTOR circuit design is a compromise between static and small signal parameters of the active element and the values of the resistors, capacitors, and voltages to be used with the active circuit. The transistor circuit design problem is similar in many ways to the tube circuit design problem. It is considerably more complex than the tube circuit design problem inasmuch as the transistor has two more non-zero small signal parameters which are roughly equivalent to grid input conductance and plate-to-grid transconductance of tubes.

Routine measurements of the small signal parameters of transistors, both junction and point contact, show that the transistors tested to date have as wide a range of variation of their small signal parameters as do tubes, Figs. 1-4. The parameters are a function of both collector voltage and current, and also of emitter (or base) current. For this reason it is apparent that some form of area-type representation of the small signal parameters is required. One of the many possible arrangements is shown in Figs. 1 through 4.

The charts on the *2N43*, *RR-14*, *HA-1*, and type *904* transistors, are the first experiments in adaptation of the conductance technique developed for data presentation on tubes to the transistor field. Because of the state of the art with respect to transistors, modificaions in the form of the curves may be required for new types of transistors as well as for present-day transistors. The curves presented here and on other types to be published in the future are being provided to help the engineer design his circuits more rapidly. The right hand portion of these curves includes collector family characteristics. The left-hand portion shows emitter family characteristics for constant values of I_e.

Since only small numbers of the included transistor types have been tested, the data included in the curves must be considered to be tentative. Some of the transistors unfortunately have not been from the most recent production lots. As a consequence, characteristics may be markedly improved in present production. The data appear to be sufficiently consistent with available experience to indicate that the forms of the contours are typical even if some of the numbers may be off by from a few percent to possibly a factor of two.

The form of amplification equation currently being used in experimental grounded base design gives the grounded base voltage amplification of a transistor. A voltage type signal source is used in the transistor emitter circuit, and the resulting output voltage is measured across the collector load resistance. In this form of circuit, the voltage amplification from emitter to collector may be written

$$K_{ec}=\mu/[1+R_{in}/r_{11}+G_L\,(R_c+r_{22}\,R_{in}/r_{11})] \qquad (1)$$

The various parameters are defined in terms of the matrix network resistance components r_{11}, r_{12}, r_{21}, and r_{22}. The matrix components are defined by the equations

$$e_1 = r_{11}\,i_1 + r_{12}\,i_2$$
$$e_2 = r_{21}\,i_1 + r_{22}\,i_2 \qquad (2)$$

The definitions are as follows:

$\mu = r_{21}/r_{11}$ $\quad R_{in}$ = voltage source impedance
$R_c = r_{22} - \mu\, r_{12} = 1/g_{22}$
$G_L = 1/R_L$ $\quad \gamma = r_{12}/r_{22}$

Each of the four small signal parameters noted in Equation 1 are measured directly in a special measuring bridge constructed to evaluate transistors.

To demonstrate the use of the amplification equation, and the related curves, assume first that the *HA-1* transistor is to be used with a supply voltage for the collector of 4v, $G_L = 0.0005$ ($R_L = 2000$ ohms) and that the static collector current is one ma ($E_c = 2$v). What is the circuit amplification? Assume $R_{in} = 1000$ ohms.

First the collector circuit load line should be drawn. This load line connects the points $E_c = 4$v, $I_c = 0$ and $E_c = 0$, $I_c = 2$ ma. The intersections of this load line with the emitter constant-current contours may be transferred to the emitter family characteristics portion (left) of the chart, giving the following corresponding points:

Collector Circuit		Emitter Circuit	
E_c(v)	I_c(ma)	E_c(v)	E_e(mv)
0.2	1.92	0.2	153
1.1	1.47	1.1	139
2.0	1.0	2.0	122
3.0	0.5	3.0	98
3.9	0.07	3.9	17

Reading the values of the various small signal parameters at the above collector and emitter circuit voltage points gives:

E_c(v)	μ	r_{22}	R_c	r_{11}
0.2	300	50k	10k	270
1.1	780	400k	60k	490
2.0	1050	800k	84k	800
3.0	1300	1.7meg	130k	1500
3.9	1400	10meg	1.5meg	10k

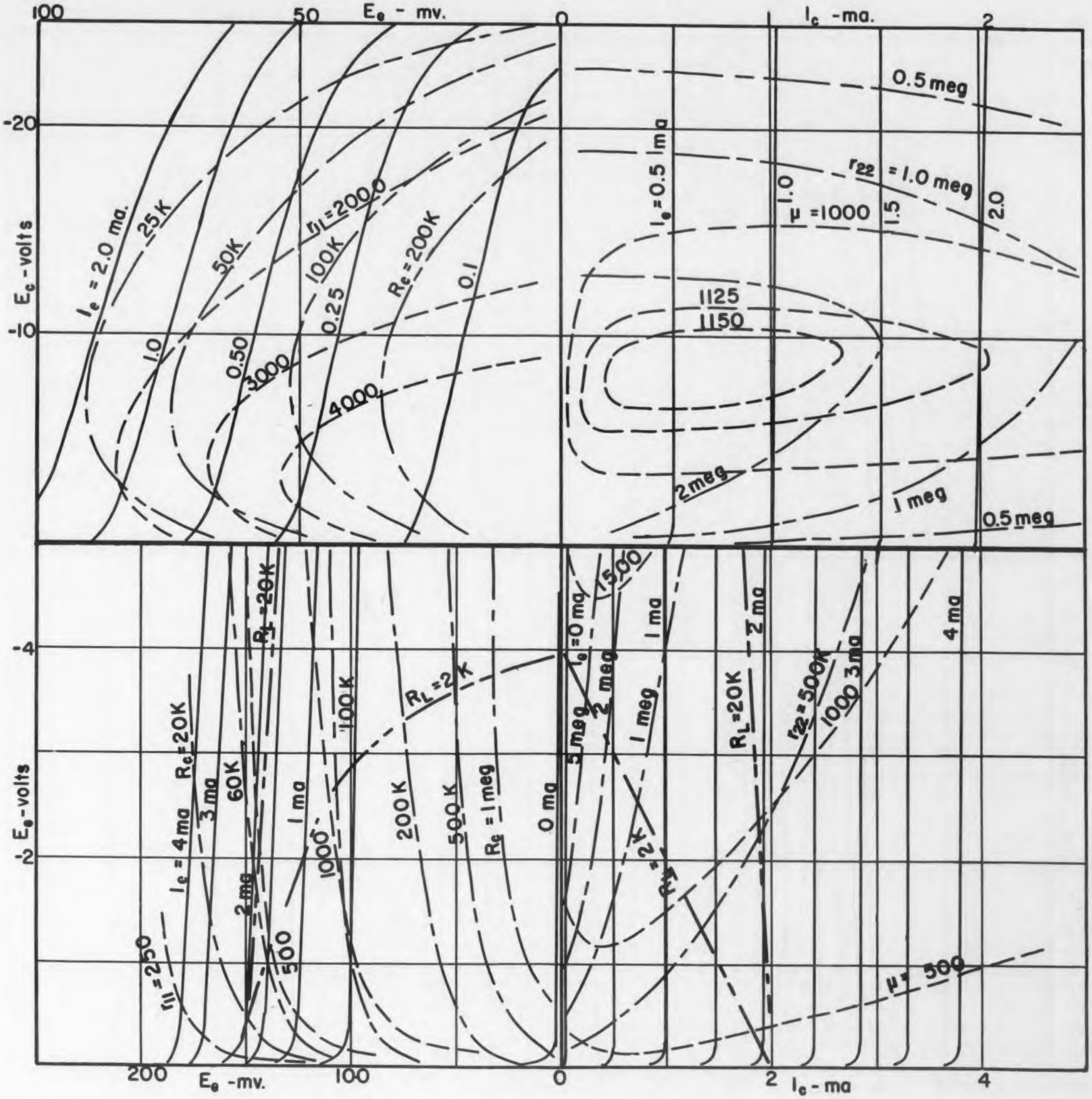


Fig. 1. (top) Contour curves for 2n34 (GE).

Fig. 2. (bottom) Contour curves for HA-1 (CBS-Hytron).

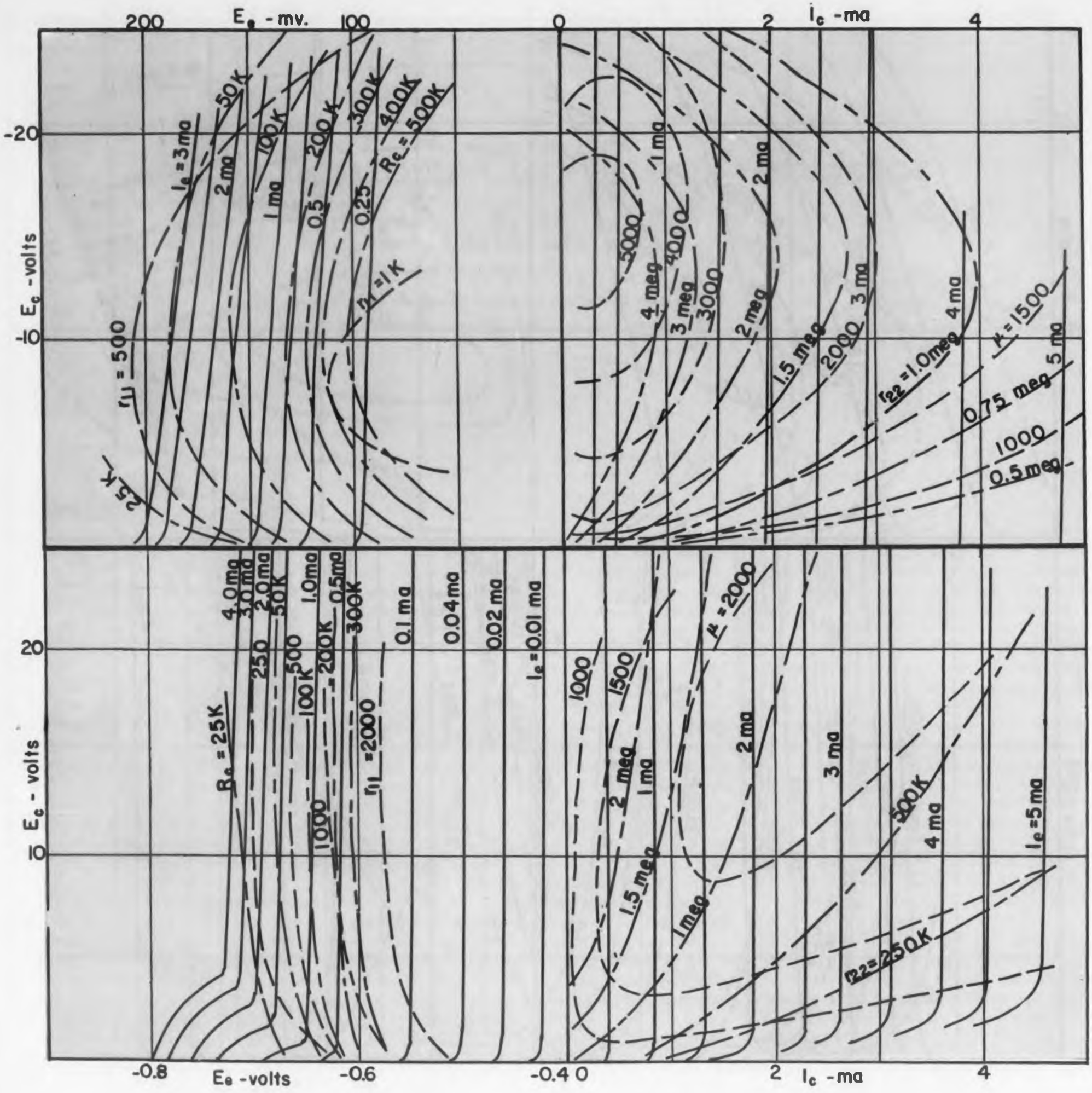


Fig. 3. (top) Contour curves for RR-14 (Radio Receptor).

Fig. 4. (bottom) Contour curves for 904 (Texas Instrument).

From these data and Equation 1, the small signal amplifications may be found. For example when $E_c = 2v$:

$$K_{ec} = 1050/[1 + 1.25 + 0.0005\ (84k + 1meg)]$$
$$= 1050/543 = 1.93$$

For the remaining collector voltages, the amplifications are:

E_c :	0.2v	1.1v	2.0v	3.0v	3.9v
K_{ec}:	2.9	1.8	1.9	2.0	1.1

As can be seen, good operation of the stage is obtained from $E_c = 1.1v$ to $E_c = 3v$. Distortion of the order of one percent results.

The low value of amplification noted in the example just considered is, of course, a result of the low value of load resistance. Effective amplification would require a supply voltage for the collector of the order of 20 to 40v, with a load resistance of the order of at least 20,000 ohms. Making a similar set of calculations for $G_L = 0.00005$ and a collector supply voltage of 40 volts gives the following amplifications:

E_c :	1.2v	3v	5v
K_{ec}:	18.3	17.1	20.8

The emitter must be biased at approximately 1.9ma current to place the collector at 3v.

The emitter characteristic curves show directly the internal voltage amplification of the transistor. The difference between the calculated input voltage required and that indicated by the emitter curves is the voltage drop across the source impedance R_{in}.

Resolving the basic four terminal network equations to take into account operation on a grounded emitter basis gives the following equation:

$$K_{bc} = (\mu - 1)/[1 + G_L(R_e + (r_{22} - \mu r_{11})R_{in}/r_{11}] \qquad (3)$$

One minor simplification has been made in the denominator of this expression. In the innermost parenthesis, the exact form of the expression is $(r_{22}[1 - \gamma] + r_{11}[1 - \mu])$. With junction transistors, μ is normally greater than 250 minimum, and γ is normally less than 0.004. Consequently, both the approximations are acceptable. (γ can be found by solving the equation $R_e = r_{22}\ [1 - \mu\gamma]$.) The numerator for the equation could be reduced to μ from the $(\mu - 1)$ given above for the same approximation.

If the calculations for the transistor with a 20,000 ohm load resistor are repeated on a grounded emitter basis at a collector voltage of 3v, the amplification from base to collector is:

$$K_{bc} = 1049 / [1 + 0.00005\ (85000 + 1.4\ (8 \times 10^5 - 7.35 \times 10^5))] = 107$$

If R_{in} were zero, however, K_{bc} would have the value:

$$K_{bc} = 1049/[1 + 0.00005 \times 85000] = 287$$

The input loading of the transistor in grounded base connection drops the small signal amplification from 107 for the equivalent grounded emitter connection to 17.1 for the grounded base.

The grounded emitter input impedance cannot be considered to be high for present-day production junction transistors. As can be seen from the above data, use of a voltage source having an internal resistance of only 1000 ohms reduces the overall amplification of the transistor from 287 to 107.

One of the particularly interesting things to be noted on the small signal contours is the general tendency of the contours to have either a saddle or plateau type of shape. There appears to be a tendency for the μ contours to take an elliptical form. The r_{11}, r_{22}, and R_c contours, on the other hand, tend to take the saddle or peninsula contour shape.

The static grounded-base collector curve families of transistors have a great similarity to each other. The information transmission problems involved in use of these curves have not been studied sufficiently to indicate which form of contour plotting on the collector family provides the most useful information. The collector family, unless supplemented with small signal contours, does give one an unjustified feeling of linearity in the transistor.

The emitter-collector voltage curve family shows the internal voltage amplification of the transistor directly. The decrease in spacing between successive contours with increasing emitter current graphically shows the increase of amplification as the emitter current is increased. At the same time, the deviation in slope of these contours from the vertical shows an increase in amplification factor with increasing collector voltages. As can be noted, the germanium junction transistors require a comparatively small number of millivolts forward bias on the emitter to produce normal collector current.

The emitter family of contours is of particular interest because of the variability of transistor emitter characteristics with temperature. Emitter voltage bias appears to be very sensitive to heating effects. In spite of the high collector dissipation rating of the *2N34*, for example, it was found that with this transistor a thermal hysteresis loop could be produced by application of collector voltage with an emitter current greater than 2.5ma. From the evidence so far available, it would appear that the dissipation problem for some reason first produces difficulties in the emitter circuit. No thermal drift was noted in the collector family, either in the static contours or in the small signal contours.

The *904* silicon junction transistor is rather noteworthy with respect to the forward emitter bias voltage required for normal operation. The forward bias to provide 500μamp emitter current is over 0.6v. This bias appears to be the transistor equivalent of the Townsend diode effect. The surprising degree of constancy of the bias voltage on the various contours is a result of the relative constancy of r_{11} primarily and, to a small extent, the constancy of R_c.

A special type of transistor bridge has been developed which aids in the measurement of small signal parameters of transistors and plots constant-valued contours directly on the static curves. This bridge is the result of an engineering study of existing transistors and their measurement requirements by the Electrical Engineering Department of the Johns Hopkins University. The bridge has been designed to give the maximum possible flexibility in regulated voltages and currents for testing use. In addition, the parameter measurement arrangements have been designed to provide measurement of all the presently known and used parameters in addition to a number not previously used. Current gain, and r and h parameters are a few that can be measured.

Constant current and voltage supplies provided in the bridge can be operated with either zero or infinite (nominal) signal frequency impedance to facilitate parameter measurement. The flexibility of these power supplies makes possible the measurement of several junction transistor parameters whose measurement otherwise would be rather difficult. For example, the measurement of open circuit parameters of junction transistors is facilitated.

Static contour measurements with the bridge are made with the help of an X-Y recorder (Moseley Autograf). The measurement of voltage is accomplished by the use of repeater amplifiers to isolate the voltage measuring circuit from the transistor itself. The measurement of current is accomplished by use of chopper repeater circuits designed to eliminate interaction between the channels of the recorder and to provide minimum loading on the transistor circuit itself. A tuned impedance boosting circuit is included in the collector circuit to permit the essentially infinite impedance collector circuit to be achieved.

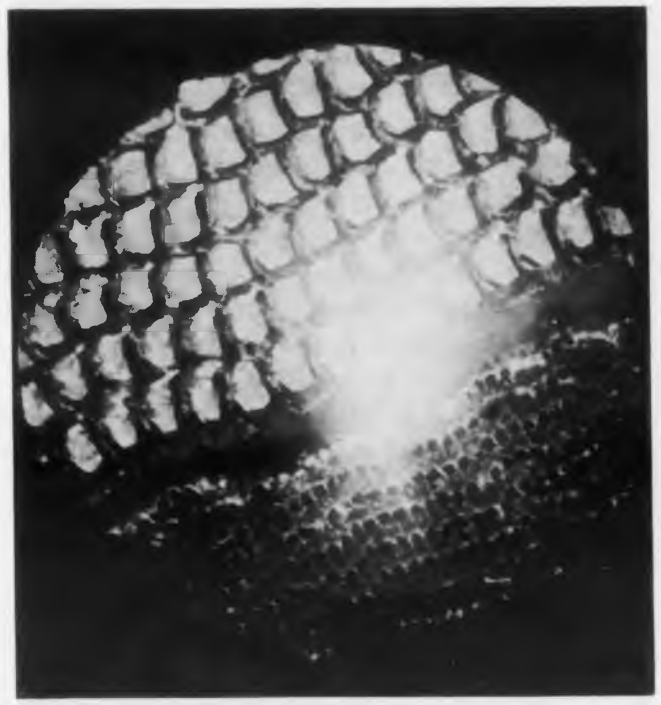
A plug and jumper board arrangement somewhat similar to that used with the General Radio vacuum tube bridge is used to provide flexibility in the small signal parameter measurements with the bridge. A tunable oscillator is built in as an integral part of the bridge.

Conclusions

The experience thus far obtained indicates that some form of coordinated data presentation system for transistors is required for efficient design. Because of the dependence of transistor operation on four different small signal parameters, the data problem is even more serious than with tubes. The method of data presentation selected should provide a complete set of small signal parameter values in addition to all of the static parameter values currently in use.

The set of parameters finally selected will include parameters making possible rapid and accurate design, parameters independent of frequency effects, thermal effects, and general manufacturing variations. Consequently, a large amount of experience and study will be required before a preferred set can be established. Considerable study has been given to static relations in transistors and considerable study has been given to the small signal characteristics. Since there appears to have been relatively little study of the coordination problems involved and their relation to transistor application, this article has been written in the hope of stirring up additional interest and to help establish a coordinated approach to the solution of the problem.

Transformers in Teflon



The upper layer in this microphoto is the secondary coil. A layer of insulation separates the secondary from the primary coil at the bottom.

With a volume of less than one inch cubed, this transformer has a weight-to-power ratio of 0.007 lb/w. Output is 12.6w.

WEIGHT and volume reductions of 50% are possible by using these Teflon-molded power transformers, audio transformers, inductances, and solenoids. Operating at up to 245°C, these units resist highly humid and corrosive environments. They are particularly valuable in aircraft or other mobile applications or where equipment is exposed to corrosive atmospheres in controlling processing plants. They replace metal-encased units.

Standard size units ranging from less than one cubic inch in volume to over 10 cubic inches are available from stock molds, but non-standard sizes can also be specified. The largest stock mold produces transformers that can dissipate 75w at 400cy. These special inductive devices are made by Ultra-Temp Transformer Co., P. O. Box 307, Groton, Conn. For more information on these devices, turn to the Reader's Service Card and circle **ED-20.**

Class B Operation of Transistors

I—Design Considerations

K. E. Loofbourrow

Tube Div., Radio Corp. of America, Harrison, N. J.

CLASS B operation of transistors in the power-output stages of battery-operated portable amplifiers offers the important advantages of high collector-circuit efficiency, low standby idling current (and battery power), and a higher ratio of power output to collector dissipation per transistor than can be realized in class A operation. Because the rated power dissipation of many commercially available junction transistors is relatively low, the inherent high efficiency of class B operation is extremely attractive for many transistor applications. The characteristics of junction transistors and other design considerations for Class B operation are discussed in this article. Actual Class B audio amplifier circuits are extensively discussed and analyzed in the second part of this article, which will appear in the next issue.

In class B operation, the transistor is biased essentially at cutoff so that the output current is nearly zero when signal voltage is absent, and when signal voltage is applied, a current flows through the load in the output circuit during one half of the cycle. In many respects, the advantages, limitations, and circuit requirements of class B operation are quite similar for both tubes and transistors. For example, low-impedance, well-regulated supply voltages are essential for optimum performance because of the high pulsating peak currents encountered in the output circuit. If bias is employed, the bias supply should also be well regulated to prevent excessive distortion in the input-circuit voltages. Reasonable matching of tube or transistor characteristics is also required for satisfactory operation.

When either tubes or transistors are used in class B, the driver stage must be capable of supplying the necessary peak input power and the power lost in the interstage transformer without excessive distortion. A major disadvantage of class B audio amplifiers is the relatively high value of odd-harmonic distortion that occurs at low power-output levels. This small-signal distortion, however, can be kept within allowable limits provided the transistor is designed for its optimum transfer characteristic and proper circuit-configuration and operation conditions are chosen.

Class B Circuit Advantages

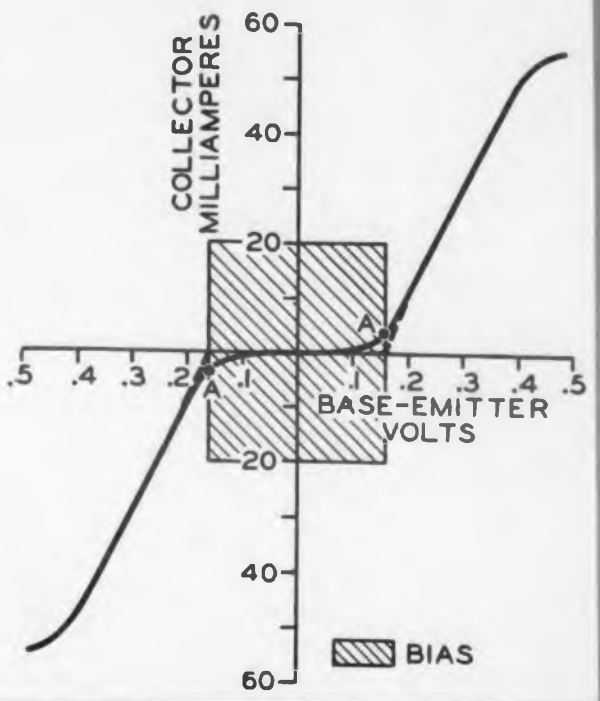
In some respects, transistors differ from tubes when used in class B operation and display several advantages that make them somewhat easier and more desirable to use. For example, the lower impedance levels involved permit the use of smaller and less expensive interstage and output transformers. In addition, the variation in input impedance with signal level is not nearly so great with transistors as with tubes when driven into the positive-grid-current region. As a result, design of the driver stage and driver transformer is simplified, and instability due to parasitics is eliminated.

Because the output characteristics of junction transistors have extremely low-voltage, sharp "knees" in comparison with many vacuum tubes designed for class B operation, circuit designs having higher circuit efficiencies can be used which in some cases closely approach the maximum theoretical value of 78%. When transistors have controlled large-signal characteristics, i.e., high-current amplification factors at values of high collector peak currents, it is possible to design power amplifiers that utilize very low supply voltages and yet maintain relatively high power sensitivity.

Large-signal α will be defined as the ratio of collector current to base current at a collector current of 50ma and a collector-to-emitter voltage of 1v. This measurement may be made for d-c or peak values with good correlation. Because the power gain or sensitivity of the transistor in large-signal amplifiers is proportional to this characteristic, high values of large-signal α are extremely desirable. The peak-collector-current rating, which is determined for a given device by collector-saturation effects and life considerations, is conservatively selected for this transistor at 50ma. As shown in Fig. 2, the magnitude of α at a collector current of 50ma is approximately one-half that at low collector current.[3] The nonlinearity of the α characteristic, which is instrumental in determining the total harmonic distortion, can be altered by changes in the design or processing of transistors. This nonlinearity is partially compensated for by the decrease in input impedance that occurs as the signal increases, causing more base current to flow for a given base voltage at high excitation levels. A more ideal characteristic from the standpoint of α fall-off and reduced harmonic distortion is shown in the dashed curve of Fig. 2.

Transfer and Collector Characteristics

Composite transfer characteristics for two *2N109* transistors in class B operation are shown in Fig. 1. Maximum collector-circuit efficiency is obtained when the base of each transistor is biased to cutoff so that the static operating collector current and the power dissipation are reduced to zero. It is impractical to use zero bias in many circuits, however, because the nonlinearity in the small-signal region causes a high



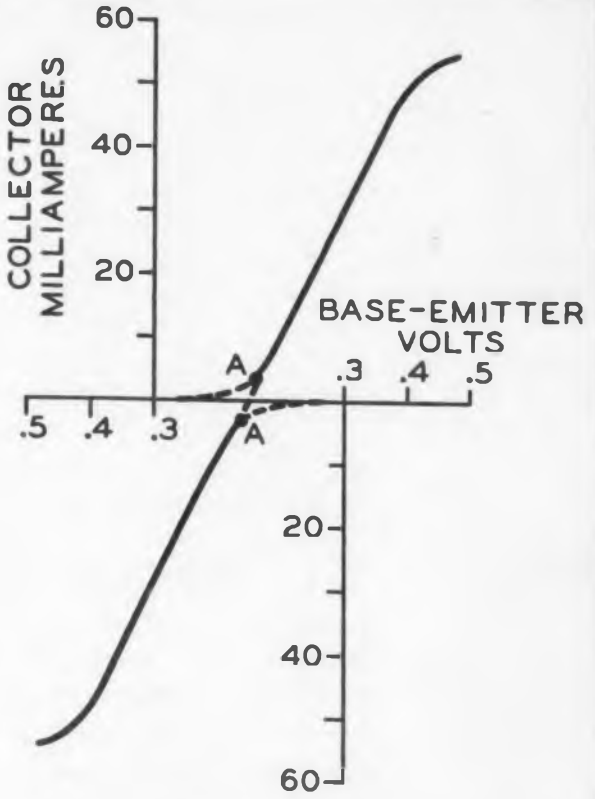
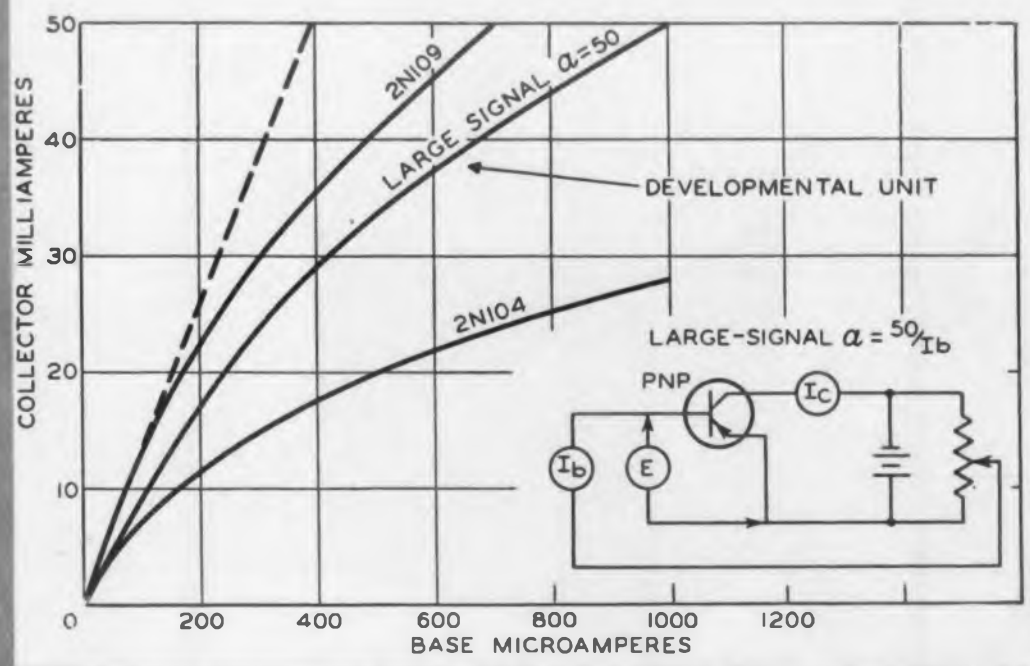


Fig. 1. The composite transfer characteristics for two *2N109* junction transistors in Class B operation with a common emitter are shown at the top, left. The characteristics are modified at the bottom, left, to show use of projected-cutoff bias.

Fig. 2. Typical large-signal current-amplification-factor characteristics for three junction transistors.



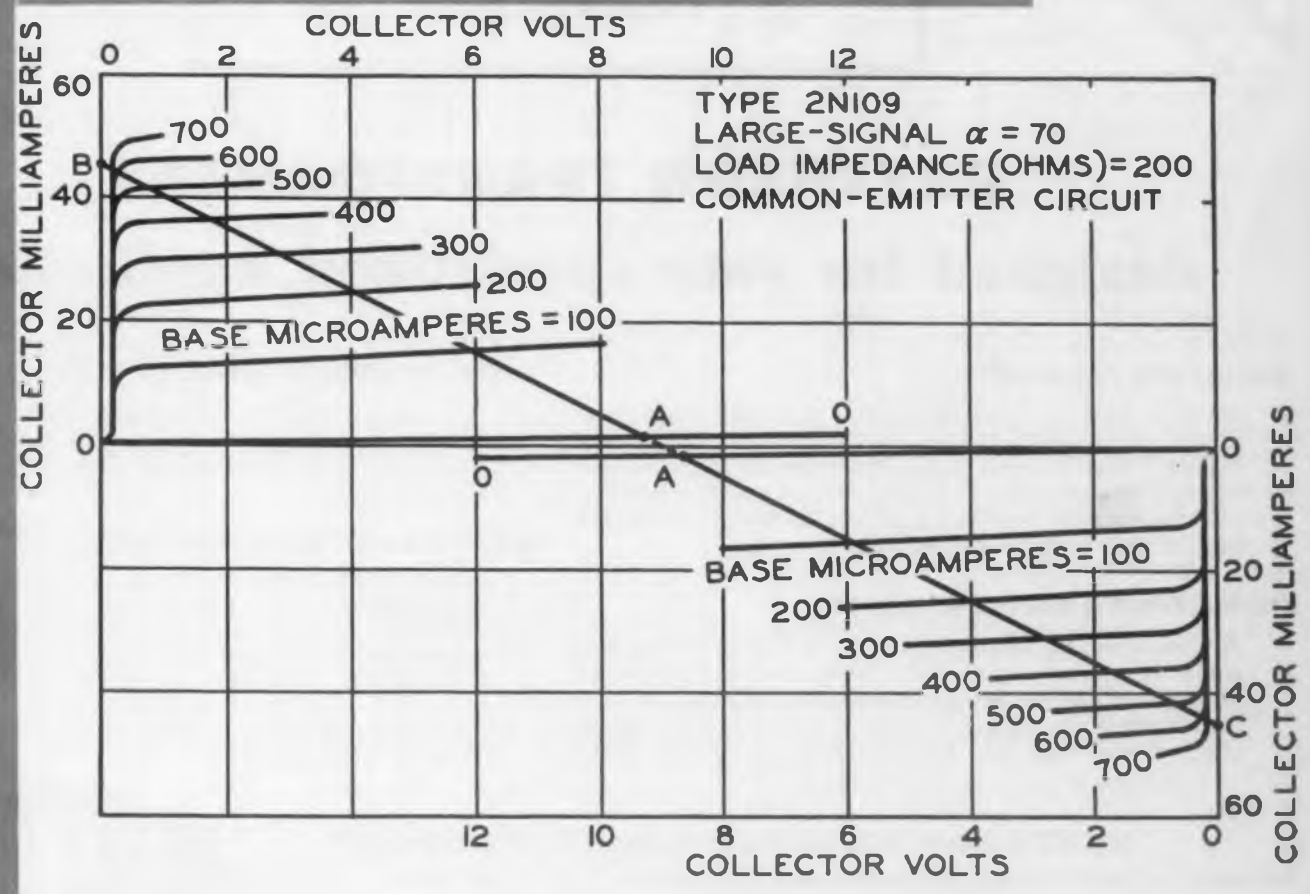


Fig. 3. Composite collector characteristics for two *2N109* junction transistors.

percentage of nonlinear distortion, especially at low levels. At high values of output, the non-linearity in the curve causes progressively less distortion.

Cross-over distortion can be effectively reduced by the use of a small forward base bias, shown by point *A* in Fig. 1, top, which allows a small quiescent collector current to flow during standby. For any given transistor type, there is a particular value of base bias that results in a good balance between cross-over distortion and collector-circuit efficiency. 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, as shown in Fig. 1. The resulting composite curve is also shown in Fig. 1, bottom. Use of projected-cutoff bias appreciably reduces cross-over distortion to a point at which any remaining distortion can be reduced by the use of negative feedback. The change in the slope of the transfer characteristics at high values of base voltage is caused by the fall off in α or collector-current saturation.

The composite collector characteristics for two *2N109* transistors operating from a 9v supply are shown in Fig. 3. Operation at point *A* on the load line *BAC* allows some quiescent collector current to flow at zero excitation voltage. The reduction in the current amplification factor of the transistors at the higher values of collector current is illustrated by the compression of the collector characteristics in this region. When transistors are operated from high supply voltages, the maximum power output is limited by the maximum peak inverse collector voltage and the collector dissipation. When transformer coupling is used, the peak inverse voltage applied to each transistor is approximately twice the collector supply voltage. At lower supply voltages, the maximum power output is limited by the maximum permissible peak collector current and the collector dissipation.

Finding Operating Conditions

If it is assumed that the input voltage is sinusoidal and that the transistors are biased at cutoff, and a one-volt "safe knee" is estimated, the following approximate formulas define the operating conditions:

The peak collector current, I_c', is given by

$$I_c' = (E_{cc} - 1)/R_L$$

where E_{cc} is the collector supply voltage, and R_L, the load impedance in each collector, is equal to one quarter of the total primary impedance of the output transformer.

Average power output, P_o, of the transistors is

$$P_o - (Peak\ Power)/2 = [(E_{cc} - 1)I_c']/2$$

or, in terms of load impedance,

$$P_o - 2\,(E_{cc} - 1)^2/(R_{cc}) = (E_{cc} - 1)^2/2\,R_L$$

where R_{cc} is the collector-to-collector load impedance.

The average current, I_{avg}, for each transistor is

$$I_{avg} = I_c'/\pi = 0.318\ I_c'$$

The battery power, P_B, is given by

$$P_B = 2\ (I_{avg}\ E_{cc})$$

The collector-circuit efficiency, E_{ff}, in per cent is

$$E_{ff} = 100\ P_O/P_B$$

The collector dissipation for each transistor in equal to 1/2 $(P_B - P_O)$.

Transformer Requirements

The frequency response of junction-transistor class B amplifiers is determined primarily by the characteristics of the transformers and transistors used, although the exact relationships are somewhat complicated because of the intermittent collector currents present in the output circuit. The low-frequency response is dependent upon the primary inductance of the transformers; the frequency at which the power output is 3db down from the output at mid-frequency is reached approximately when the primary reactance of the transformer is equal to the collector load impedance plus the total winding resistance of the transformers referred to the primary. The high-frequency response is dependent upon the leakage reactance and winding capacitance of the transformers and the cutoff-frequency characteristic of the transistors. It is desirable that well balanced transformers be designed and that the leakage inductance between the two halves of the primary be minimized. Balanced transformers minimize the d-c-polarizing currents, aid in the cancellation of even-order harmonics in the output, and reduce the possibility of distortion due to unbalance in the input signal.

Because high values of collector peak currents and low supply voltages are involved, the d-c resistance of the primary of the output transformer should be made as low as possible to retain high efficiencies. The secondary winding of the driver transformer should also have low d-c resistance to minimize the effects of collector back currents upon the operating point. It should be emphasized that the transformer requirements mentioned are not particularly difficult to achieve because of the extremely low impedance levels involved. Although there are circuit variations that make it possible to eliminate the output transformer, these circuits generally require the use of a power supply or a load impedance that is center-tapped. The driver transformer may also be eliminated in some circuits, although it is difficult in practice to obtain the relatively low d-c impedance required without the use of a transformer.

Editor's Note: An actual example of Class B operation is shown on pp. 48-49, "Tube-Transistor Radio".

Multi-Step Standard Resistance

ACCURACIES in the vicinity of 0.0015% in digital-to-analog conversion and in resistance value synthesis may be achieved with the BMR-105 Binary Multi-Resistor. The hermetically sealed unit consists of 16 high-precision resistors whose values are in a binary sequence. By connecting the resistors together through relays, resistance values between zero and 131,070 ohms can be realized in two-ohm increments.

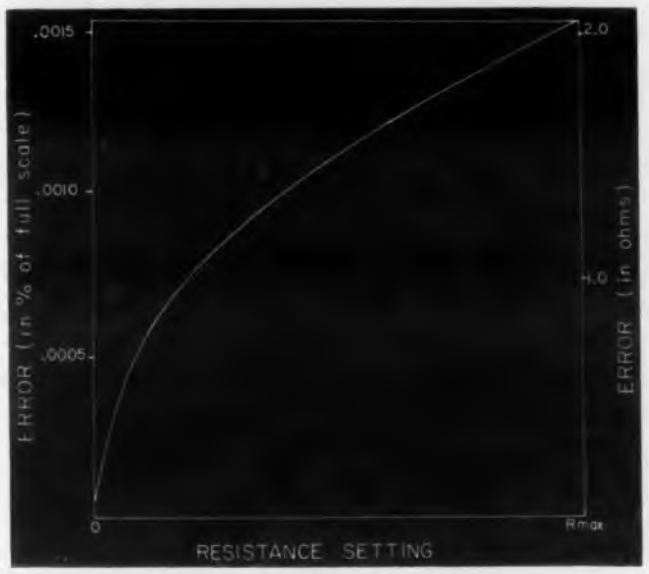
The individual resistors are made to an accuracy of 0.0015% with comparable stability. Overall temperature coefficient of resistance is held to within five parts per million per degree centigrade at 20°C. Each resistor consists of several separate resistances arranged to provide compensation for such effects as temperature change, differential expansion, and winding strains.

The error as percent of full scale, shown in one of the graphs, is also a measure of the analog accuracy achievable in digital-to-analog conversion. This conversion may be accomplished by driving the unit from a suitable constant-current source and taking the voltage across the resistance as the output. The output voltage is directly proportional to resistance and, therefore, to the number represented by the state of the resistance network.

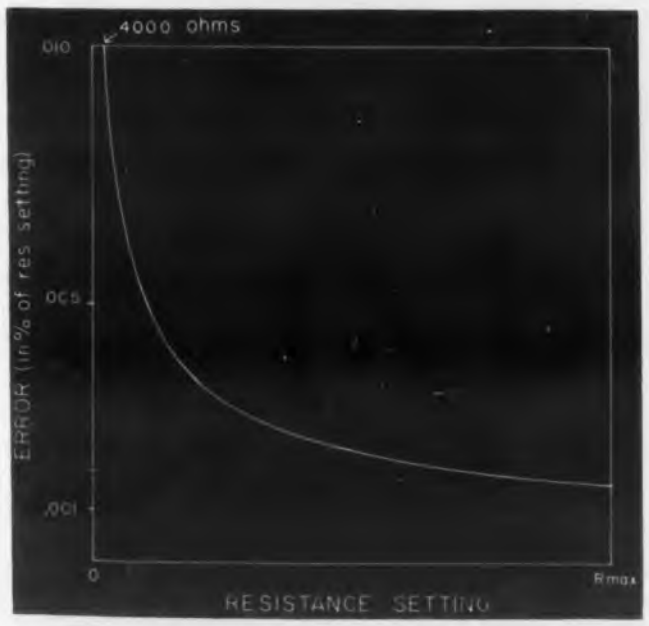
Examination of the graph of error expressed as a percentage of resistance setting shows that it is possible to synthesize resistance values between 3000 and 131,070 ohms in two-ohm steps with an accuracy ranging from 0.01% to 0.0015% of the resistance reading. Thus, the unit takes the place of a large number of resistance standards. The unit is made by Julie Research Laboratories, 341 East 149th St., New York 51, N. Y.

The enclosure of the unit provides electrostatic shielding. It can be mounted by its four threaded mounting studs. It is filled with oil. For more information on these standard resistances, turn to the Reader's Service Card and circle **ED-25.**

The hermetically sealed unit is 4" x 5" x 1-3/4" in dimension.



Peak error as a percentage of full scale.



Error as a percentage of resistance setting.

Silicon Or Germanium?

Norman B. Saunders

Circuit Engineering Consultant, Weston, Mass.

TRANSISTORS are made of silicon or germanium; the latter being most prevalent. Each semiconducting material has its place as comparison will show. One or the other is usually definitely indicated by the particular requirement of the application. The silicon transistors that are readily available are grown junction units in the deciwatt dissipation class. They will be compared with similar type germanium transistors. These basic types have practical and superficial differences as well as inherent ones. The fundamental difference is in their energy gap; this, and the workability of material, largely determine the difference in properties. These properties in turn determine relative suitability for each application. The final choice also depends on the availability of transistors having these various semiconductor differences.

The preferred transistor on the basis of several characteristics is given in Table 1. This table is based upon a limited experience with, and knowledge of, transistor characteristics and application and will undoubtedly be modified as the work of others becomes known. Usually, in any particular circuit, one characteristic is of greater importance than the others and leads to the selection of the optimum transistor. This procedure of selection goes beyond the choice between silicon or germanium.

Transistors are available with varying current gains, maximum voltage levels, noise figures, power gains, etc., within each of the several types. Of the approximately one hundred combinations that can be formed from the columns of Table 2, more than thirty are represented by germanium types commercially available. Practically all types have been made at one time or another. In contrast, the silicon transistor is available in only two types. The alloy silicon junction triode is under development but as of today there are many difficulties to surmount[1]. The apparent difficulty of fabricating silicon units seems to be born out by the fact that the comparable germanium unit costs but one fifth as much as the silicon unit.

Table 2. Transistor type discriminants

Characteristic	Type
Carrier	n-p-n, p-n-p
Contact	Point, junction, other
Power level	centiwatt, deciwatt, watt
Process	grown, alloy
Connections	diode, triode, tetrode
Material	germanium, silicon

The most striking difference between silicon and germanium transistors is in the collector cut-off current, Table 3. For a typical silicon unit, I_{co} is typically one one-hundredth as much as that for germanium[2]. The variation of collector cut-off current for silicon transistors, from unit to unit, is ten times as great as that for germanium.

The other difference is in the bias voltage required to produce a given bias current in the emitter. This arises directly from the difference in energy gap and is discussed later. The problem of the larger bias requirement for silicon is aggravated by the fact that the reverse breakdown potential of the emitter is only 2 or 3v as compared to 10 to 30v for the grown junction germanium transistors. That is, the ratio of permissible reverse to forward voltage swing is only about five for silicon compared to fifty for germanium. This may be of concern in the design of circuits such as flip-flops. A factor compensating for this smaller input ratio is that silicon transistors are

OPERATION		GROWN S	GROWN G	ALLOY S	ALLOY G
Temperature	greater than 75°C	√		Not Yet Available	
	25 to 75°C	√	√		√
	less than 25°C		√		√
Bias Currents	greater than 10ma				√
	1ma to 10ma	√	√		√
	less than 1ma		√		
Bias Voltages	greater than 40v	√			
	5v to 40v	√	√		√
	less than 5v		√		√
Current gain	High		√		
	Stable with temperature				√
	Stable with time		√		
High frequency	alpha cut-off	√			lower power units only
	power gain		√		
	detection		√		
Collector cut-off Current	very low stability of	√	√		
Low cost			√		√

Table 1. Suggested transistor choice according to operating requirement

Table 3. Typical junction transistor coefficients

		Symbol	SILICON Grown	GERMANIUM Grown	GERMANIUM Alloy
Collector	Voltage (Maximum) (v)	$V_{c\ max}$	40	40	25
	Dissipation (Maximum) (mw)	—	150	50	50
	Cut-off current (μa)	I_{co}	0.02	2	10
	Capacitance ($\mu\mu$fds)	C_c	7	14	40
	Conductance—parallel (μmhos)	g_c	0.3	0.2	1.0
	Resistance—series (ohms)	r_c	500	200	20
Emitter	Current (Minimum useable) (ma)	I_e	1	0.01	0.1
	Reverse Voltage (Maximum) (v)	$V_{e\ max}$	2	10	5
	Bias Voltage (mv)	V_e	500	160	160
	Resistance (ohms)	r_e	100	25	25
Base	Resistance (ohms)	r'_b	500	150	300
Gain	Power (db)	G_o	35	47	40
	Current	B	26	35	40
	Frequency cut-off (Mc)	f_α	6	2.5	1

obtainable with a collector voltage rating three times that of germanium units. The output to input current ratio, or current gain, tends to be somewhat less in the silicon units. They also require about a milliampere to achieve the rated alpha or beta whereas the grown junction germanium unit retains a high value of current gain with biases in the order of microamperes.

The frequency of alpha cut-off for the silicon units is somewhat higher than that for the germanium. This is of little practical importance, however, since the higher impedances of the silicon units make their power gain at high frequencies considerably less, equation (1).

$$G_o\,(BW)^2 \approx f_\alpha / 4(2\pi C_c)\,(r'_b + r'_c) \qquad (1)$$

G_o = Power gain
BW = Bandwidth
f_α = Frequency of alpha cut-off
C_c = Collector capacitance
r'_b = Extrinsic base resistance
r'_c = Extrinsic collector resistance
$1/(2\pi C_c)\,(r'_b + r'_c)$ = Upper collector critical frequency

This occurs, in spite of the lower collector capacitance of the silicon, because of its higher extrinsic base and collector resistances. The higher base resistance of the silicon transistor makes the input voltage and hence the driving power higher when connected as a grounded emitter. The extrinsic collector resistance of the silicon units limits the power output directly by reducing the voltage drop available to the load and indirectly because additional dissipation causes thermal limits to be reached sooner[3].

Effect of Temperature

The collector cut-off current is the coefficient most susceptible to the effects of temperature. The rate of increase with temperature is much the same for both materials. The cut-off current of germanium transistors shows no change as a function of time except for an increase when the time is measured in years. Silicon units on the other hand have taken a day or two to recover their normal room temperature current after being soaked at high temperatures. However, the final value of current reached may be less than that which existed before the heating. The bias required to produce a given current in the germanium units is less dependent upon the temperature than that required for the silicon because the energy gap of the latter varies by half a volt between minus 55 and plus 125° C, Table 5.

The current gain of both types falls off as the temperature departs from room temperature, that of the silicon unit becoming very low at low temperatures, Table 5. Some designers specify heaters within the chassis to avoid the deleterious effects of low temperature upon the operation of the silicon. The even higher impedances of silicon at low temperatures also make its use at these low temperatures difficult, Table 5. The fractional change of resistance with temperature is much the same for both materials.

Semiconductor Properties

Shockley and others have adequately described how and why the energy gap effects the junction performance in a semiconductor. The random nature of the charge-carrier energies and their smallness relative to the energy gap causes the exponential increase of current with applied potential. Taking the ratio of the exponentials, it can be shown that for units identical in applied voltage bias and physically identical except for the semiconducting material, the current ratio is more than a million to one. The bias voltage required to produce a given junction current in these two materials is tabulated in Table 4 and is helpful in determining the required bias. A simple rule is that silicon at room temperature requires 380mv more bias for the same current. Since energy gaps are functions of temperature[5], Table 5, so is the difference in potentials.

The densities of electrons, n, and holes, p, are greatly influenced by temperature. The density at room temperature of the carriers in the intrinsic material is about one three-hundredths as great in silicon. The velocity of the carriers in silicon is only about one-third as great as in germanium. The conductivity is given by a combination of these factors so that the resistivity of the silicon is more than a thousand times greater than that of the germanium. The transistor maker then has a choice of making the silicon unit with far higher extrinsic resistances, or greater impurity content which results in shorter lifetimes. This in turn, requires a narrower base region. Practically, the carrier lifetimes of silicon are less than those of germanium, perhaps because of the far greater difficulty of obtaining pure (or purifying) silicon, and certainly because of the difficulty of stabilizing its surface to have large surface lifetime.

The thermal constants of the two materials are much alike. A one millimeter cube will pass about 70mw from face to opposite face for a one celsius degree temperature difference. The thermal time constant is found from the heat storage and transfer constants. Because the heat transfer in a solid is a diffusion process, the time increases as the square of the distance. A one millimeter thick cube or slab of either material takes about 25 milliseconds to reach two-thirds of the equilibrium change following application of a pulse which heats one face.

Table 4. Typical junction diode voltages for forward current

Current (μa)	Voltage* (mv)	
	Silicon	Germanium
2	360	0
4	378	18
10	402	42
20	420	60
40	438	78
100	462	102
200	480	120
400	498	138
1 ma	522	162
10 ma	582	222
100 ma	642	282
1 amp	702	342

* When the diode has no leakage conductance and no series resistance.

References

1. Gudmundsen et al., "Recent Developments in Silicon Fusion Transistors," IRE Trans. PGED 2, No. 1, Jan. 55, pp. 74-81.
2. Texas Instrument Co. data sheets and distribution curves.
3. N. DeWolf, "Rating Transistors to Prevent 'Runaway'" Electronic Design, Vol. 3, No. 2, Feb. 1955, pp. 28-29.
4. M. Ratner, Germanium Products Corporation, Private communication.
5. E. M. Conwell, "Properties of Silicon and Germanium" Proc. IRE 40, No. 11, Nov. 1952, pp. 1327-37.
6. N. B. Saunders, "Designing Reliable Transistor Circuits" Electronic Design, Vol 3, No. 3, March 1955, pp. 24-27 and No. 4, April 1955, pp. 36-39.

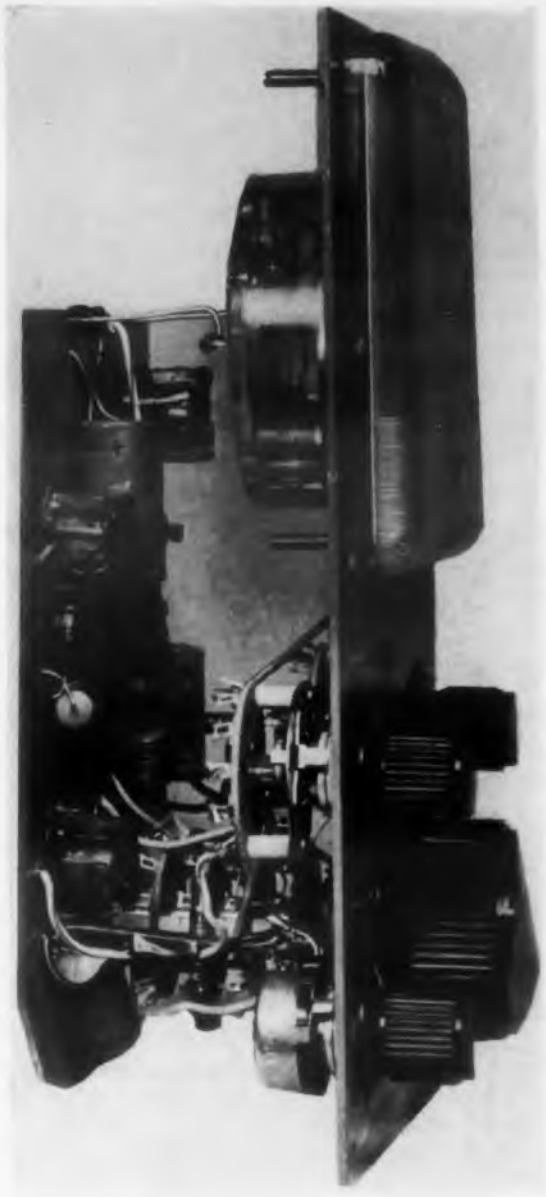
	−55°C		+25°C		+125°C	
	Silicon	Germanium	Silicon	Germanium	Silicon	Germanium
Energy Gap (v)	1.35	0.76	1.12	0.75	0.8	0.74
I_{co} (μa	<1	<1	<1	2	5	1000
α	0.8	0.90	0.97	0.97	0.93	—
r_c (megohms)	10	10	2	3	0.5	0.1
r_b (ohms)	5000	1000	500	300	500	—
r_e (ohms)	50	20	100	25	200	50

Table 5. Coefficient variation with temperature

Transistorized Transistor Analyzer

COMPLETELY portable, this compact, three-pound junction transistor analyzer uses transistorized circuitry. It is powered by three flashlight batteries. The analyzer measures h_{21} (β), the short circuit current gain, and I_{co}, collector cut-off current. True small signal parameter, h_{21}, is measurable for various values of emitter bias. Unlike transistors can be compared for identical operating biases.

A self-calibration feature of the Model JHI, manufactured by Quantum Electronics, Inc., 1921 Virginia St., N. E., Albuquerque, N. M., gives the unit good stability. It is essentially free from ambient temperature effects and changes in component values within the instrument. Its simplicity makes it easy to use and reliable for field operation. A description of short-circuit current gain measurement gives an idea of the unit's capabilities. An audio oscillator is required as the a-c voltage



One of the G. E. 2N44 transistors can be seen in the center of the printed circuit board. Large meter gives direct reading of I_{e1}, I_{co1}, and h_{21}. Range of h_{21} is 0-50 or 0-100.

source. An input current of approximately 5μa, peak-to-peak, is injected into the base-emitter terminals of the transistor being tested. The resulting peak-to-peak current swing in the collector circuit is measured by monitoring the voltage appearing across a very low resistance load, which is in the order of 50 ohms. The ratio of the output signal current to the input signal current is the short circuit current gain and is indicated directly on the meter.

Self-calibration, and current ratio measurement is accomplished by a substitution method utilizing precision resistors. Small signal gain is measured with an accuracy of 5% or better over a wide ambient temperature range. Emitter current is adjustable and metered from 0-100ma d-c. The unit accommodates p-n-p and n-p-n silicon and germanium transistors. For more information, turn to the Reader's Service Card and circle **ED-28.**

Field Effect Transistor Circuit Design

I—Characteristics

Chaang Huang, Melvin Marshall, and B. H. White

Sylvania Electric Products, Inc., Electronics Div., Ipswich, Mass.

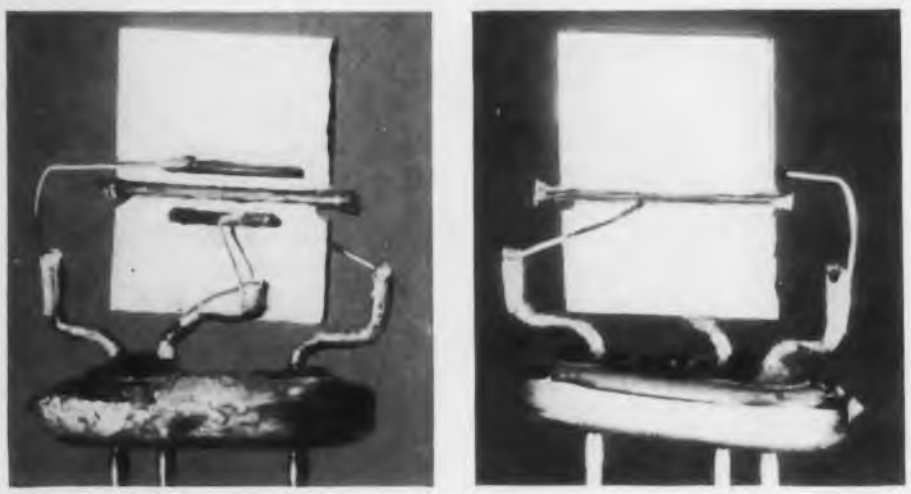


Fig. 1. Both sides of an uncased Sylvania field effect transistor now in pilot-plant production.

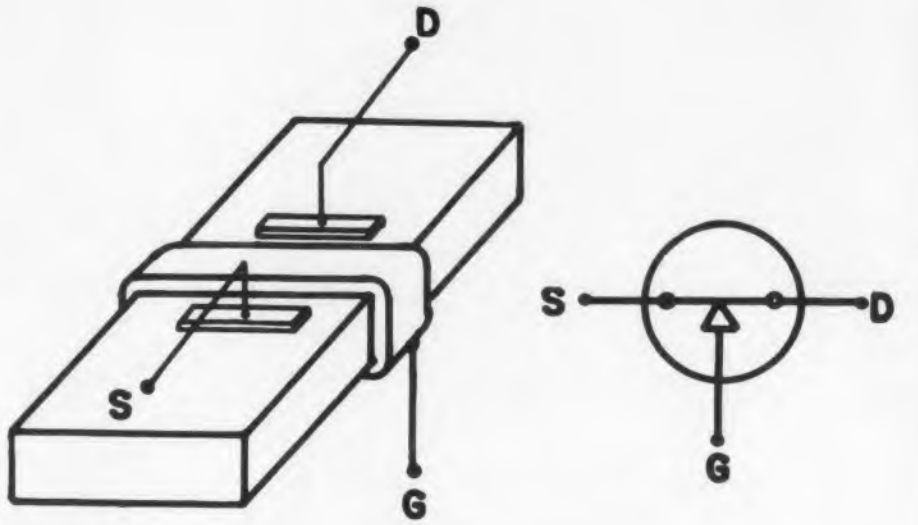


Fig. 2. The nomenclature of the field effect transistor symbol at the right, "source", "drain", and "gate", is related to the physical appearance of the semiconductor device by the drawing.

FIELD effect transistors[1], a unipolar device, are distinguishable from junction transistors in the following two ways: (1) the current flow is carried predominantly by one type of carrier alone, and (2) the electric field intensity is relatively high, thus the current flow is caused by field drift instead of by diffusion. They consist of a piece of n-type germanium slab with a p-type junction formed around the center of the slab. Two ohmic contacts are placed in the vicinity of the junction. Three electrodes are connected to the transistor. The electrode that is connected to the junction is called the "gate". The electrodes that are connected to the ohmic contacts are called the "source" and the "drain".

The characteristics and equivalent circuits for the field effect transistor are given in this part of the article, while the circuits and techniques for utilizing these transistors in Colpitts and relaxation oscillators, bistable, monostable, and multivibrator circuits are to be presented in the concluding portion in the next issue. The Colpitts oscillator circuit and characteristics will be extensively analyzed. In addition to the above circuits, the field effect transistor can also be used in flip-flops and sinewave oscillators and other widely applicable circuits.

The dependence[1, 2] of the drain current on the drain and gate voltages is shown in Fig. 6. When a positive voltage is applied to the drain, with the source grounded, an electric field is set up in the germanium. Hence, the carriers, which are electrons for n-type material, will flow from the source to the drain. If a negative voltage is applied to the gate, the drain current will decrease due to conductivity modulation. When the magnitude of the gate voltage is increased to the pinch-off value, W_o, the electron current will cease to flow, and the drain current is essentially the leakage current of the pn junction. On the other hand, if the gate voltage is kept constant, the drain current will increase with the drain voltage until a certain drain voltage is reached. After that the current is relatively constant, indicating a high output impedance. It is to be noted that the gate voltage should always be kept negative. Otherwise, excessive currents will flow, causing damage to the transistor. This is similar to the positive grid current of a vacuum tube.

Equivalent Circuit

Since the fundamental transistor action is a modulation of the drain current responding to a change in the gate voltage, the active part of the transistor can be best described by a transadmittance. This description suggests an equivalent circuit as shown in Fig. 7. It consists of the parallel combination of a passive, reciprocal network with elements y_{11}, y_{12}, y_{22} and an active current generator $(y_{21} - y_{12})\ V_G$. The relationship between drain and gate voltages and currents is described by

$$i_G = y_{11}\ V_G + y_{12}\ V_D$$

$$i_D = y_{12}\ V_G + y_{22}\ V_D + (y_{21} - y_{12})\ V_G$$

The y parameters are complex, and change with frequency. They are measured by using a Tektronix

535 dual beam scope, with the d-c bias kept at drain voltage of 60v and drain current of 5ma*. The results of the measurement of the conductance matrix elements are shown in Fig. 8. We can see that g_{21} decreases with frequency. Since g_{21} is essentially the transconductance, it shows the frequency response of the transistor. g_{12} is negative and is smaller in magnitude than g_{11} and g_{22}. This insures that the network consisting of y_{11}, y_{12}, y_{22} is a passive network. The measured results of the susceptance matrix elements are shown in Fig. 9. The fact that b_{12} is negative, and that the magnitude of b_{12} is less than b_{11} and b_{22} indicates that the susceptances are capacitive. When these matrix elements are combined, we find that the passive network formed by y_{11}, y_{12}, and y_{22} can be reduced to a r-c network as shown in Fig. 3. The interelectrode capacitances C_{gs}, C_{gd}, C_{ds} remain practically constant over the entire frequency range. For the field effect transistor studied, C_{gs}, C_{gd}, and C_{sd} are about 23, 3, and 33$\mu\mu$fd, respectively, as illustrated. The resistances, however, do decrease with frequency. These decreases are probably due to the distributed nature of the device. The variation of the transadmittance, y_m, is plotted in Fig. 4. We can see that the 3db point at which g_m equals b_m occurs around 4.5Mc.. This value does not represent the highest frequency characteristics obtainable for a field effect transistor. On the other hand, it represents the characteristic of a typical pilot production transistor, which has a reasonable cost and yield. If the physical dimensions of the transistor are reduced, the frequency response of the transistor can be improved at the expense of reduction in power rating and increase in cost. The maximum frequency of oscillation for a typical transistor is around 10 to 12Mc. The input resistance remains relatively high up to 500kc. Beyond that frequency, the resistances decrease rapidly from several hundred thousand ohms to several thousand ohms. On the other hand, the results indicate that within a certain bandwidth we can approximate the elements by a constant r-c network, with the resistance taking a value at the center of the frequency band. This approximation results in great simplicity in the amplifier, oscillator, or other designs.

* Due to high impedance levels the y parameters cannot be measured accurately by a radio frequency bridge.

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(2) G. C. Dacey and I. M. Ross, "Unipolar 'Field Effect' Transistor", *Proc.I.R.E.*, Vol. 41, Aug. 1953, pp. 970-979.

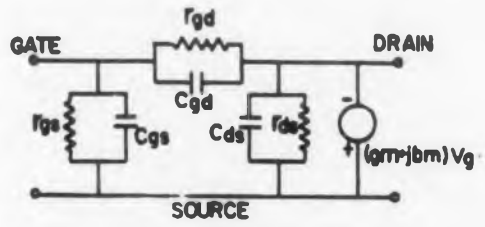


Fig. 3. The equivalent circuit of the field effect transistor reduced to an r-c network.

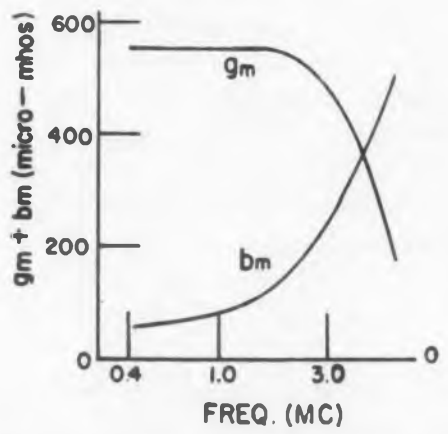


Fig. 4. Variation of transadmittance with frequency of unit shown in photographs.

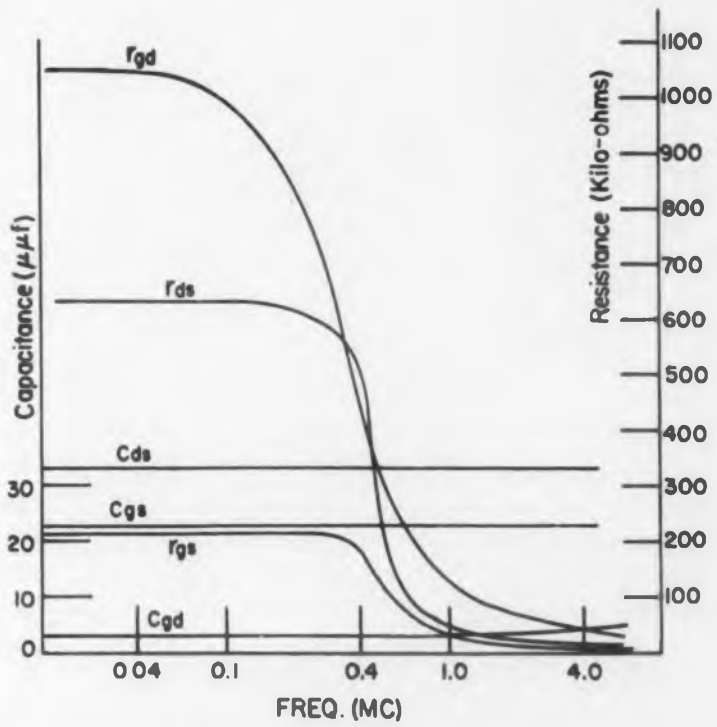


Fig. 5. Variation of equivalent circuit parameters with frequency.

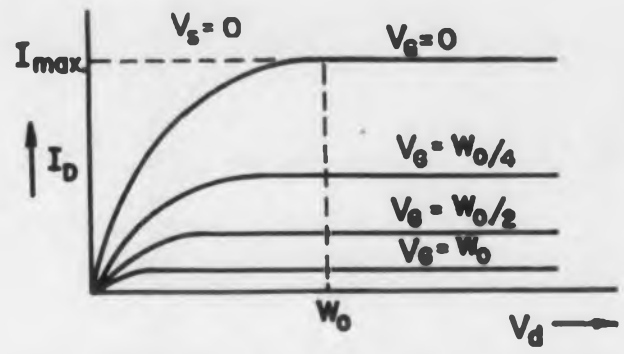


Fig. 6. Field effect transistor static characteristics. W_o is the "pinch-off" value.

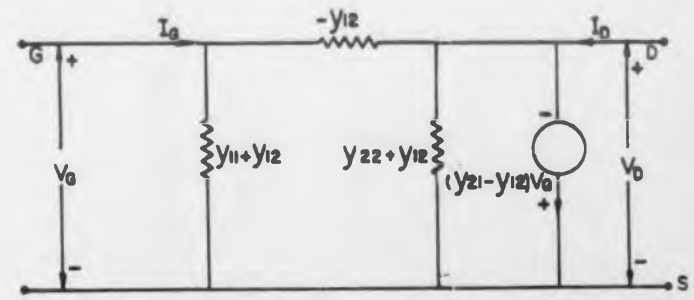


Fig. 7. Equivalent circuit of the field effect transistor. It is reduced down to the circuit of Fig. 3.

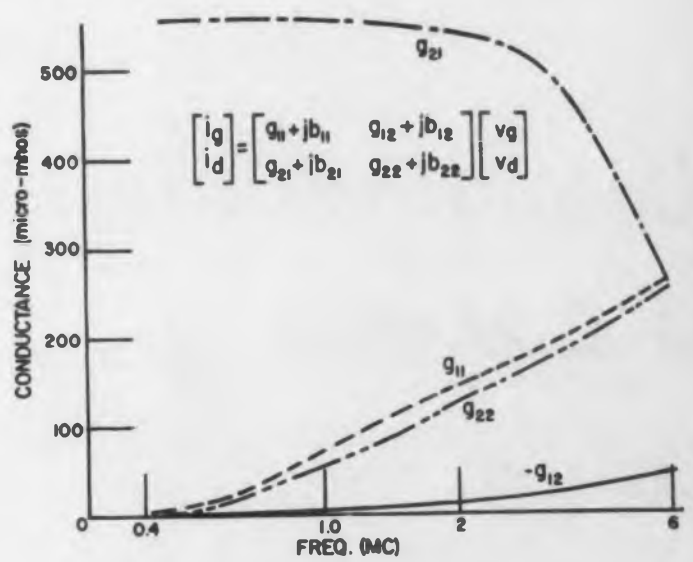


Fig. 8. Conductance matrix elements vs. frequency.

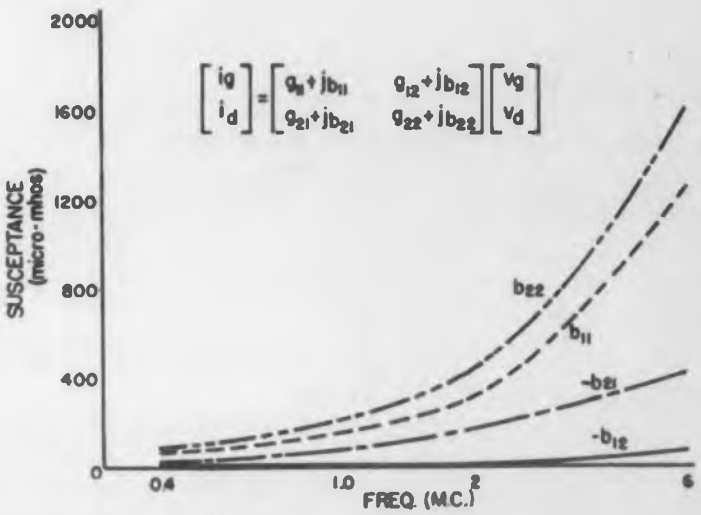
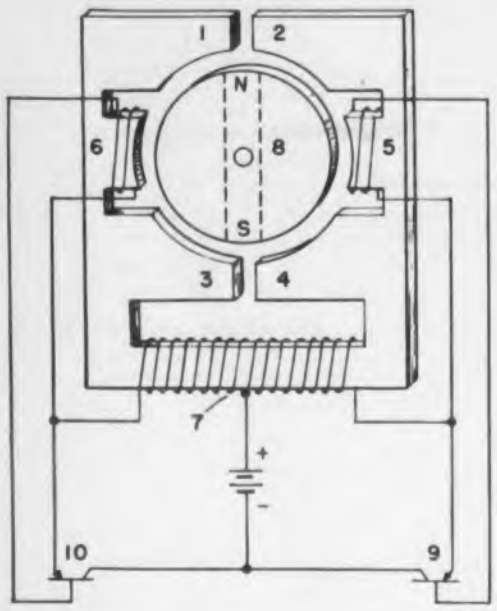
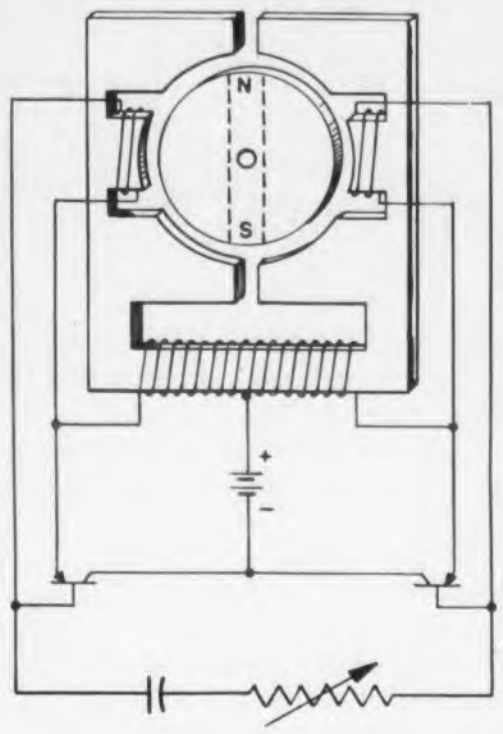


Fig. 9. Susceptance matrix elements vs. frequency.





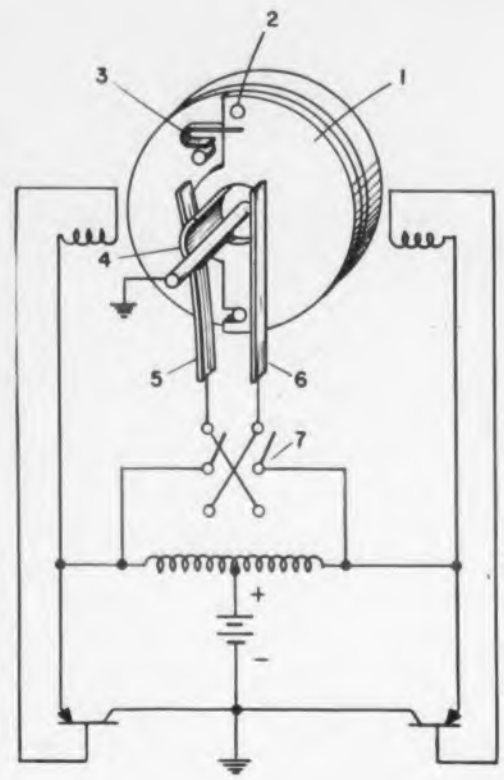


Fig. 1 (left). The basic commutatorless motor.

Fig. 2 (middle). By adding an r-c network to the basic circuit, constant speed over a limited range is achieved.

Fig. 3 (right). This motor has a higher starting torque and is reversible.

Commutatorless D-C Motor Using Transistors

Harrison D. Brailsford

Brailsford & Co., Inc., Rye, New York

TRANSISTORS provide a simple means of achieving commutation in d-c motors without any moving current-carrying parts in the structure. Elimination of the make-and-break or sliding contacts of conventional commutators not only increases the service life, but removes radio-frequency interference; frequently a serious problem. Motors of this design, particularly in the miniature range, can be of great value in telemetering and remote, unattended instruments using self-contained batteries.

The field structure of the transistor-commutator motor consists of a pair of running poles (*1-3, 2-4*), a connecting yoke, and a center-tapped running winding (*7*). The pole faces are notched out, as shown, to form a pair of sub-poles (*5-6*) each of which is fitted with a pickup coil. The rotor (*8*) consists of a bar or disc of Alnico, magnetized across its diameter. The magnetic structure and air gap are proportioned so that with no field from the running coil, the rotor will seek the position shown with its magnetic axis parallel to the pole faces. With the rotor at rest, no current can flow since there is no bias on the base of either transistor (*9-10*). If now we rotate the rotor clockwise, currents will be induced in the two pickup coils (*5-6*). The current induced in coil *5* will be of proper polarity to put negative bias on transistor *9* rendering it conducting and permitting current to flow through the right half of running winding *7*. An electro-magnetic field is thus set up in the field yoke making poles *2-4* North, and poles *1-3* South. The action of the South pole of the rotor on pickup coil *6* has no effect because the induced current from that coil, in that position, simply makes the base of transistor *10* positive, maintaining it in a non-conductive condition. As the rotor pole reaches magnetic alignment with poles *5-6*, the induced currents decay and as the rotor poles pass this point reverse their polarities so that transistor *9* becomes non-conducting, and transistor *10* becomes conducting. Thus, the left half of running winding *7* is energized, reversing the polarity of the running poles providing a second impulse to the rotor. In the two-pole structure shown, there are thus two power pulses per revolution.

The speed characteristic is similar to that of a conventional shunt or permanent magnet field d-c motor; that is, it is a function of applied voltage and/or load. Constant speed may be provided over a limited range of driving voltage by means of a resistance capacitance net work shunted across the bases of the two transistors, as shown in Fig. 2. As will be apparent from the diagram, the r-c shunt functions to by-pass a portion of the biasing voltage from the active to the inactive transistor. Since the two transistors are oppositely phased, if at the instant transistor *9* is conducting to the right half of the winding to cause the motor to run, then conduction through transistor *10* and its associated portion of the running winding will tend to oppose rotation. The proportion of the bias voltage on transistor *9* that reaches transistor *10* will then be a function of the frequency, which is a function of the speed of the rotor, and the values of the r-c circuit. The greater the capacitance, the greater the bucking voltage for any given frequency, and, conversely, the greater the frequency, the greater the bucking voltage for a given capacitance.

Self-Starting

The structure described is not inherently self-starting and will run equally well in either direction, being similar in this respect to a single-phase a-c

Fig. 4. An experimental model of the transistor motor.

motor. Self-starting has been accomplished experimentally by applying a transient pulse and by designing a feed-back type of structure so that the transistors oscillate electrically. The centrifugal device illustrated in Fig. 3, however, offers the advantage of both controlling the direction of rotation and affording a higher starting torque than has been achieved by other means. The device consists essentially of an eccentrically weighted member (*1*) pivoted at (*2*). A contacting segment (*4*) makes electrical contact with either brush (*5* or *6*) when the rotor is at rest, mechanically shorting the transistors. When current is applied, the running winding functions through the mechanical contact to revolve the rotor. As soon as the rotor has attained running speed, centrifugal force on off-center weight *1* overcomes tension of the spring (*3*) withdrawing commutating segment (*4*) from contact with the brushes. The motor then continues to run by transistor-commutation as previously described. The double-pole double-throw switch shown is used for reversing.

The power range of the transistor motor is limited only by the size or power handling capacity of the transistors. For most instrument work we have found commercially available transistors of the *RR21* and similar type to provide adequate power handling capacity. The motor described, operates at an input of from 30 to 90mw and can handle loads of 10 oz-in, and over, at 1rpm on a continuous duty cycle. Larger transistors, such as the *2N57* can naturally accommodate a larger and more powerful structure.

The overall efficiency of the experimental models indicates that the transistor motor will compare favorably with conventional units of similar size. Efficiencies up to 15% have been measured on the experimental models of this motor.

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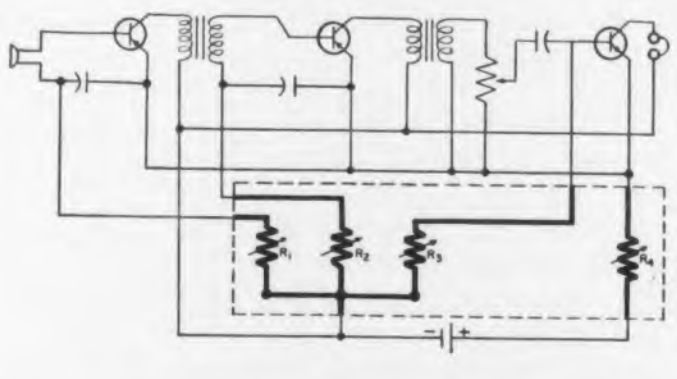
Trimmer Resistors for Transistors

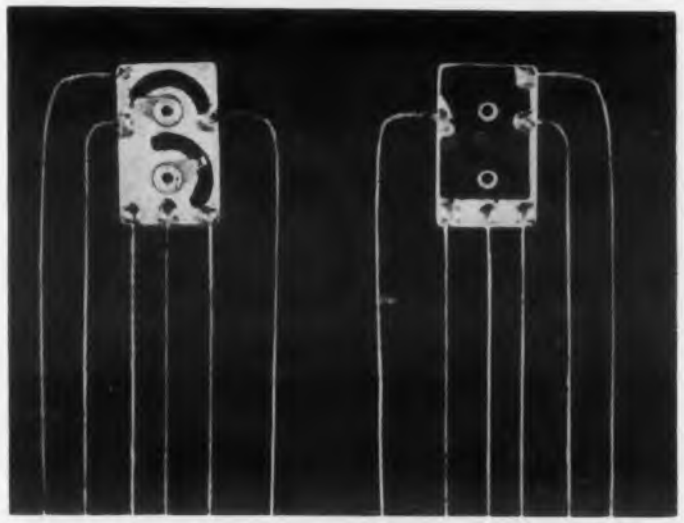
PRODUCTION and maintenance of transistorized devices is simplified by incorporating these compact trimmer resistors in transistor designs. Each transistor in a device can be individually biassed for optimum performance. Therefore, extensive matching of transistors and bias resistors is not necessary prior to installation. These resistors are already extensively used in hearing aids, but should find wide application in mass-produced transistor devices. These trimmer resistors are also illustrated on this month's cover.

There are three types of trimmer resistors. Models I and II allow individual adjustment of base resistance. Model III allows adjustment of widely varying battery voltages to give proper voltage ratio and for individual setting of the output stage for proper current conditions. These units are made by Centralab, div. of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.

The maximum resistances for Model I, illustrated in the circuit diagram are: R_1 and R_2 both equal 625,000 ohms; R_3 equals 94,000 ohms; and R_4 equals 75,000 ohms, all 20% tolerance. The corresponding values for Model III are 12,000, 250,000, 800, and 800 ohms, respectively. Model II has three resistors of 625,000, 625,000, and 200,000 ohms, respectively. The resistances are printed and fired onto ceramic bases. They are 1" x 0.680" x 0.431" in dimension. For more information, turn to the Reader's Service Card and circle **ED-31.**



One of the trimmer resistor assemblies is shown in the box in this hearing-aid application.



Front and back views of the Model III trimmer resistor. A Model I is shown at the top of the page.

Operating Transistors at Higher Voltages

G. H. Didinger
Manager, Battery Engineering Dept.,
National Carbon Co., New York, N. Y.

TRANSISTORS are operated more efficiently at higher voltages in most designs[1]. The following valuable characteristics of transistors can be gained when they are operated at higher voltages:

1. *More power is available from transistors of a given size.* As with all devices, maximum power rating is determined by the ability of the transistor to dissipate the heat generated by its losses without exceeding the permissible temperature rise. The principal loss is the I^2R loss of the collector. A maximum permissible collector current is thus established. The more voltage this current can generate across the output load, the more power will be obtained. Naturally, the collector breakdown voltage must not be exceeded; but this is subject to control in manufacture, by proper adjustment of base layer thickness and impurity densities. Fortunately, power stages of electronic equipment often operate at audio frequencies, where thicker base layers are not objectionable.

2. *Greater power sensitivity can be achieved.* For a given power output, the load impedance will be higher, producing greater gain.

3. *Distortion can be reduced.* Since lower currents are required for a given power, there is less likelihood of encountering the reduction of alpha that is associated with high current densities. This cause of altered waveform is thus minimized or eliminated.

4. *The efficiency of the output stage will be increased* Since the ratio of load impedance to collector resistance will be larger, a larger portion of the total power of the collector circuit will be delivered.

5. *The relative standby power of the output stage can be reduced.* Even with class B operation, the quiescent current will not be zero, if minimum crossover distortion is to be achieved. The minimum bias voltage thus required will be a smaller percentage of the maximum output voltage, if a higher supply potential is used.

6. *Greater gain may be achieved without sacrifice of efficiency.* If emitter current drops too low, emitter resistance rises, and available gain drops. The necessary emitter current and voltage, which may be in series with the collector supply, is a smaller percentage of a higher collector voltage.

7. *Temperature stabilization is more easily achieved, without sacrificing other design objectives.* Reference to standard transistor characteristics will show that constant voltage bias permits an increase in quiescent collector current with an increase in temperature. This type of operation may result in sufficient increase in dissipation to further raise the temperature and quiescent current, leading to a runaway condition. This condition may be avoided by a closer approach to constant current bias. Since such biasing requires a higher value of emitter bias resistance, more emitter bias voltage will be required for a given operating point. Higher collector voltage will thus be desirable to retain high efficiency and low distortion.

8. *Adequate automatic volume control is easier to achieve.* The maximum a-v-c voltage is limited by the collector voltage. Higher collector voltages, therefore, permit more control voltage to be developed and greater control sensitivity to be attained.

9. *Complementary symmetry can be used.* Since only half of the supply voltage may be applied to each transistor of a complementary stage, higher available voltage is especially important in this case. Complementary symmetry eliminates the need for an input transformer and may be used to avoid an output transformer as well. Since the n-p-n collector current can be made to balance the complementary current of the p-n-p, no quiescent current need flow in the output load. This stage may thus be coupled directly to a speaker voice coil. In fact, the optimum load resistance of the stage is low enough to make a reasonably good match possible. It is thus possible to rid the stage of both the cost and performance limitations imposed by a transformer.

10. *A saving in transistor cost is possible.* Since more power can be derived from transistors of a given type, the use of expensive power transistors may not be necessary. One type of low cost, standard audio transistor is known to produce 100mw easily in a 9v

Table 1. Comparison of the new flat dry cells with cylindrical cells.

Cells	Volume (inch³)	Approximate Dimensions (inches)	Weight (oz)	Cost (percent)	Service (hours)	Service Per Unit Volume (hr per inch)	Service Per Unit Weight (hr per oz)	Service Per Unit Cost (percent)
Cylindrical	29.2	2-3/4 x 2-1/2 x 4-1/4	20	122	420	14.4	21.0	797
Flat	31.8	2-9/16 x 2-1/32 x 6-1/8	28	182	1000	31.4	35.7	1275
Cylindrical	15.0	2-1/8 x 2-1/8 x 3-5/16	9	119	140	9.3	15.5	273
Flat	18.7	2-9/16 x 2-1/32 x 3-19/32	15	112	500	26.7	33.3	1032
Cylindrical	5.45	2-3/16 x 1-3/16 x 2-1/8	6	139	60	11.0	10.0	100
Flat	4.97	1-3/8 x 1-3/8 x 2-5/8	6	100	165	33.2	27.5	384

class B push-pull stage. In fact, while the manufacturer does not so rate this transistor, measurements have shown that it is possible to obtain one watt from such a stage at 22.5v without exceeding 80°C.

11. *Higher cut-off frequencies are possible.* Collector capacitance shunts the output at high frequencies, reducing the gain of the stage. Since raising the voltage decreases this capacitance, it raises the frequency at which its effect becomes important. Such operation also leads to a higher gain-bandwidth product for an i-f stage using such a transistor.

12. *Grown junction transistors can be used,* since their relatively smaller junction areas need not be troublesome at higher voltage. Advantage can thus be taken of their planar junctions to extend the alpha cut-off frequency. Since minority carriers in a field-free base layer move by diffusion, they travel in different directions toward the collector. With planar junctions, the differences in transit distance, and hence in transit time, are smaller. A shorter half period is thus required for cancellation to take place as the result of carriers, emitted at the peak of a signal, arriving at the collector simultaneously with other carriers that were emitted at the trough of the signal. A shorter half period, of course, corresponds to a higher frequency of cut-off. As with reduced collector capacitance, this gain can lead to a higher gain band-width product.

13. *P-N-I-P transistors may be used.* J. M. Early[2] has described the advantages of these transistors for high frequencies and higher powers and the need for higher voltage to reach through the intrinsic layer. (See Electronic Design, October, 1954, p. 5 for a discussion of p-n-i-p transistors.)

14. *Field effect transistors can be used* since higher voltage makes possible adequate gating of the signal. In the opinion of some designers their higher impedance permits a reduction in the cost of i-f coils.

15. *Point contact transistors can be used.* Advantage can thus be taken of their inherent negative resistance characteristic for simplified switching or oscillation. Point-contact transistors also permit operation at generally higher frequencies. (A comparison of the operating voltage requirements of point-contact and junction transistors can be made by referring to the "Transistor Data Chart" insert.)

Lower-Voltage Advantages

There are some advantages to operating transistors at lower voltages. It should be recognized, of course, that these advantages are available to any equipment having a higher voltage supply. They are:

1. Since transistor noise increases with voltage, it may be minimized by lowering voltage. This effect is usually of importance only to the input stage.

2. Certain radio-frequency junction transistors and surface barrier transistors have extremely thin base layers. Lower voltage is, therefore, required to avoid "punch-through".

3. At least one manufacturer claims his transistors have longer life at reduced voltage. For many applications, however, these transistors have adequate life at voltages that are more favorable to other design objectives such as compact battery supplies.

4. Very low power equipment such as hearing aids may be operated from a single cell. In some cases, this arrangement permits more economical operation.

In view of the predominant advantages of higher voltage operation of transistors, it would be natural to wonder why so much stress has been placed upon lower potentials for portable transistorized equipment. Apart from the interest that is always aroused by novelty, this stress has been caused by a widespread belief that battery energy is cheaper when obtained at lower voltage and higher current. While this belief may once have been true, it would be most unfortunate to allow the notion to persist in view of the present state of the battery art.

The technique of producing flat cells has been constantly improved until today it is possible, through their use, to couple the advantages of higher voltage with a saving in the cost of manufacturing transistor equipment as well as a saving in operation cost.

In addition, certain new batteries permit full use of the advantages of higher voltage, without sacrificing any of those of lower potential because:

1. They provide an inexpensive high voltage source.
2. The high voltage stack may now be tapped to obtain low voltages directly without the use of bleeders.
3. The lower voltage sections of a polypotential supply may now be arranged for more or less current capacity than the higher voltage sections. This arrangement permits use of identical cells throughout, giving the energizer a uniform cross section.

These energizers make possible lower manufacturing cost for transistor equipment. Since the power supply is reduced to a single unit, expensive cell holders and spring contacts may be eliminated. In addition, the removal of spring loading minimizes the likelihood of deforming plastic panels at elevated temperatures. The absence of mountings for holders and spring contacts simplifies both the force and cavity of injection molds, thereby reducing the cost of tooling plastic cabinets.

Table 1 compares transistor power packs made with several of the more popular sizes of cylindrical cells with flat cell packs, which are suggested as more suitable substitutes. These comparisons are made for a modern transistor radio receiver having a Class B push-pull output stage. A typical starting drain of 15ma is assumed with a nine volt supply. Service is given at a schedule of two hours per day, which is considered average for radio receivers.

It is obvious from Table 1 that modern flat cells are superior to the cylindrical cells, which they are replacing in service per unit volume, service per unit weight, and service per unit cost. It should also be noted that this comparison is true at a moderate potential of nine volts. The economy of flat cells becomes even more outstanding as the voltage rises.

It may also be observed from Table 1 that flat cells offer more options to the designer. In the space required by the older style cells, they can provide much more service. If the extra service is not needed, they offer a considerable saving in volume. It is, of course, possible to compare other sizes with similar results.

Several transistor power supplies that have already gained considerable acceptance at the design level are given in Table 2. Many other combinations are, of course, possible and in view of the newness of the field it is suggested that specific problems be addressed to the battery manufacturer.

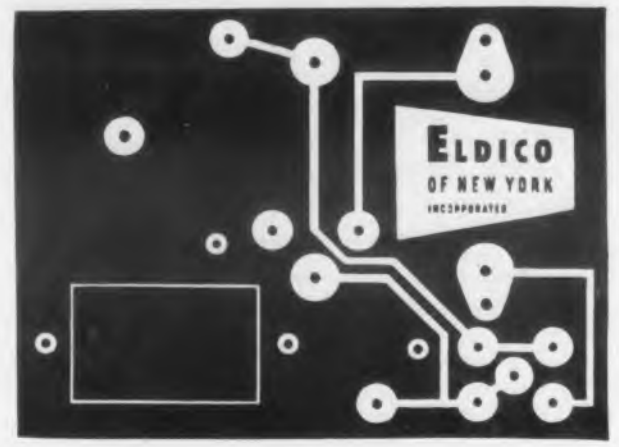
Table 2. Typical transistor power supplies utilizing flat cells.

Voltage	Approximate Dimensions (inches)			Approx. Weight (ounces)	Terminals
	L	W	H		
6	1-13/16	1-51/64	3-5/16	9.5	2-hole socket
9	1	1	1-7/8	2	snap fastens at each end
9	1-3/8	1-3/8	2-5/8	6	2-hole socket
9	2-9/16	2-1/32	3-19/32	15	2-hole socket
9, 13.5	1-15/16	1	2-11/16	3	3-hole socket
22.5	1-1/32	5/8	2	1.2	raised contact at each end
22.5	1-11/32	1-5/16	3-7/16	6.75	raised contact at each end

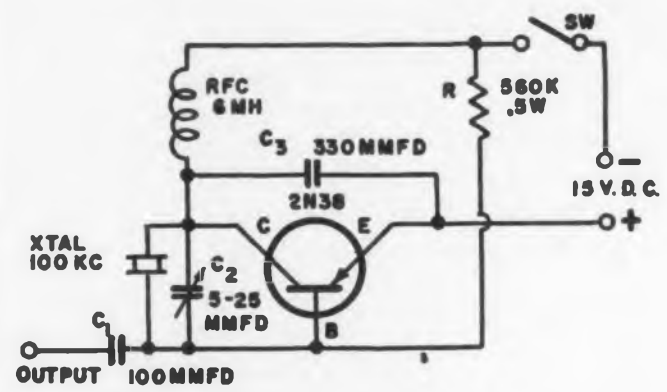
References

1. *Proceedings of the IRE,* Nov. 1952, Proceedings of the Transistor Short Course, Penn State, June, 1953
2. *The Bell System Technical Journal,* May, 1954, p. 517

CIRCLE ED-34 ON READER-SERVICE CARD FOR MORE INFORMATION



This is the actual size of the printed circuit board for the FS-100 Frequency Standard. Rectangular outline is part of switch.



Transistor oscillator circuit requires extremely small tuning capacitance.

Self-contained unit is crystal controlled. No external connections are required.

Single Transistor Frequency Standard

SMALLER than a king-sized package of cigarettes, this tiny transistorized frequency standard is complete and requires no external connections. It is crystal-controlled and supplies accurate frequency markers every 100kc on the receiver dial up to 30Mc.

Because of the low current drain of the *2N38* transistor, trouble-free operation of the FS-100, manufactured by Eldico of New York, Inc., 72 E. Second St., Mineola, N. Y., may be expected for the shelf-life of the battery. Operation is simple; set the switch to "on" and couple the output to the antenna. The variable trimmer capacitor C_2 permits the oscillator to be zeroed against WWV. The output of the FS-100 is beat against the WWV signal and C_2 adjusted for zero beat.

To prevent loading the transistor with too much capacitance, the trimmer is small (5-25mmfd). To maintain control of tuning, the crystal frequency is held to within ±2cy of 100kc. The crystal was developed for this transistor application by E. B. Lewis Co., 11 Bragg St., East Hartford, Conn. CBS-Hytron's *2N38* transistor was used because of uniformity of production lots.

The signal from the FS-100 can be frequency-modulated for identification purposes by depressing the case slightly. For more information on this transistorized precision 100kc frequency standard, turn to the Reader's Service Card and circle **ED-35.**

Design Forum

Tube-Transistor Radio

BEFORE DESIGNING all-transistor devices, many manufacturers of electronic equipment may take the intermediate step of combining tubes and transistors. The hybrid portable radio discussed on these pages is a clever combination in which an all-tube device was converted with a minimum of redesign, reconstruction, and retooling. By substituting two matched transistors operating Class B push-pull for one tube, output power and "B" battery life have been more than doubled.

This radio is a Model 838, made by Emerson Radio and Phonograph Corp., Jersey City, N. J. The earlier portable from which it was adapted is the Model 747. As the photos show, there were few changes made in the chassis. The cabinet is the same size, but the front panel was changed. The two controls are the same.

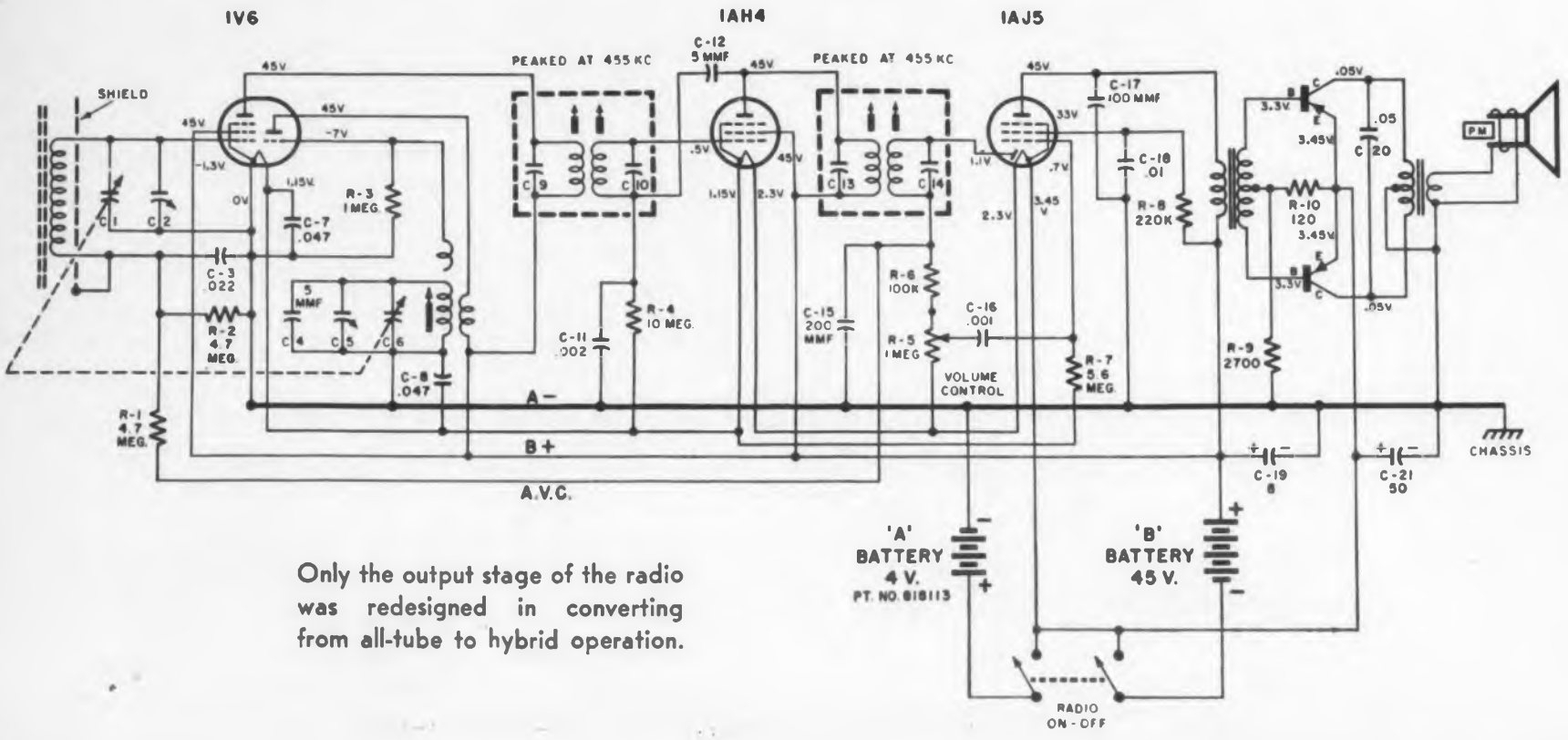
The major reason that this firm did not redesign their small portable into an all-transistor version was cost. It would cost more to the consumer than a hybrid radio. Other factors were the added delay involved in a complete redesign, and the limited availability and performance of transistors at radio frequencies. In order to produce an all-transistor portable with performance equal to the Model 838, four or five transistors would be necessary to replace the three tubes remaining in the hybrid version.

Only the output stage was redesigned in the new radio. The conversion called for some other changes, however. In the Model 747, the filaments of the four tubes were in parallel across a 1.5v battery. In the hybrid version, the filaments of the three remaining tubes are in series across a 4v battery. This battery, which consists of three mercury cells in series, also supplies the transistors.

The change in the heater arrangement necessitated some modifications in the a-v-c and grid networks for proper biasing. The screen resistor and bias voltage of the first audio tube were changed for optimum operation in driving transistors instead of one tube. It is interesting to note that the input transformer to the output stage is physically larger than the output transformer. The size of this input transformer was determined by the need for sufficient inductance to preserve low-frequency response, since a high impedance is then being coupled to a low impedance.

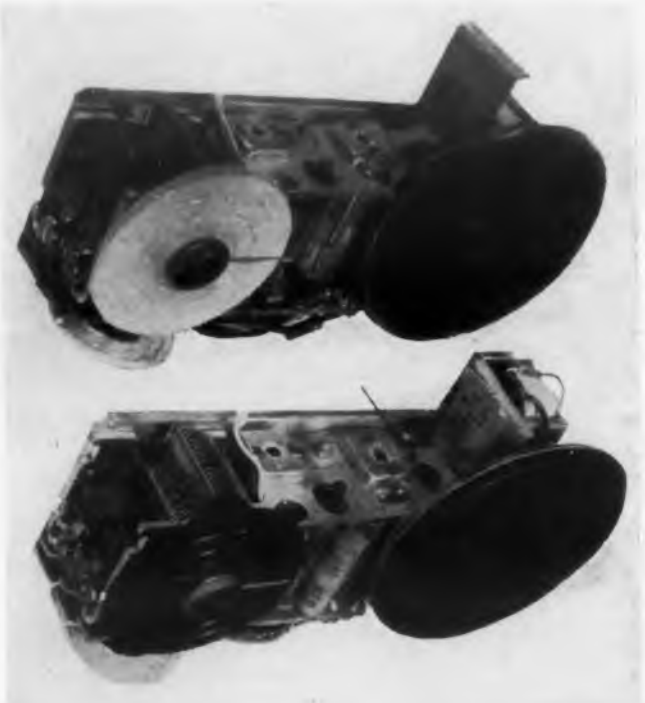
Since the 45v "B" battery does not have to supply the plate requirements of the power stage in the tube-transistor radio, its life has been greatly extended as compared with the Model 747. The normal battery drain is about 2.5ma, compared to 4.5 to 5ma for the earlier model. The undistorted output of the 838 at 10% distortion is 35mw, compared with 15mw for the 747. Maximum power output is more than double these values. The transistors used in this radio are supplied in matched pairs to Emerson specifications.

All-transistor devices including portables have already been placed on the market. Eventually all radios, portable, non-portable, and automobile, will use transistors. In the meanwhile, the combination of tubes and transistors is a practical advance, effecting a great improvement in performance at minimum cost. At the same time, the men servicing this firm's products can gain experience in using transistors in an easy dose. For the highly competitive consumer market, the development of this radio represents sound engineering practice.

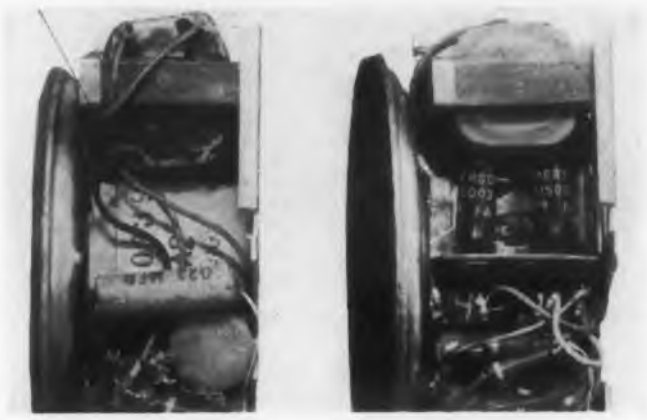


Only the output stage of the radio was redesigned in converting from all-tube to hybrid operation.

The tube-transistor radio showing how the batteries are replaced without removing the chassis. The hole near the dial is for a final trimmer adjustment after assembly.



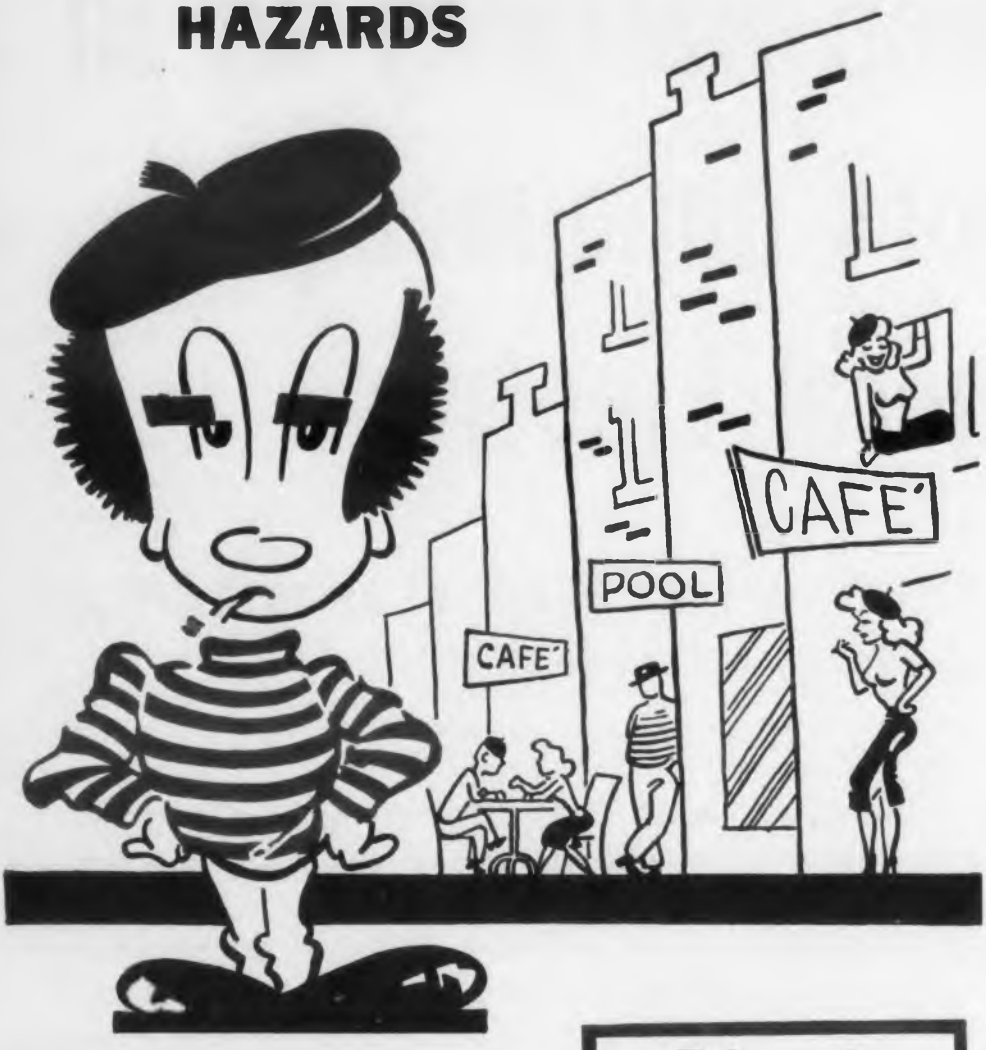
The hybrid version compared with the earlier all-tube radio (top). A capacitor occupies the space (arrow) where the output tube was mounted, and a capacitor and input transformer have been added.



The transistors are mounted in a previously empty space behind the speaker.

Environmental

HAZARDS



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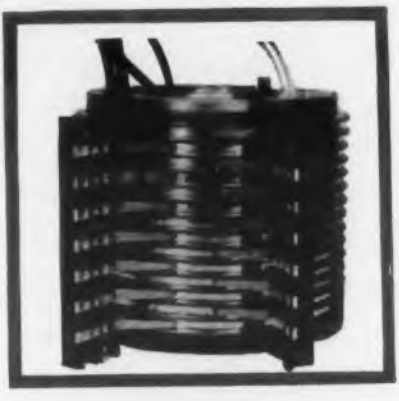

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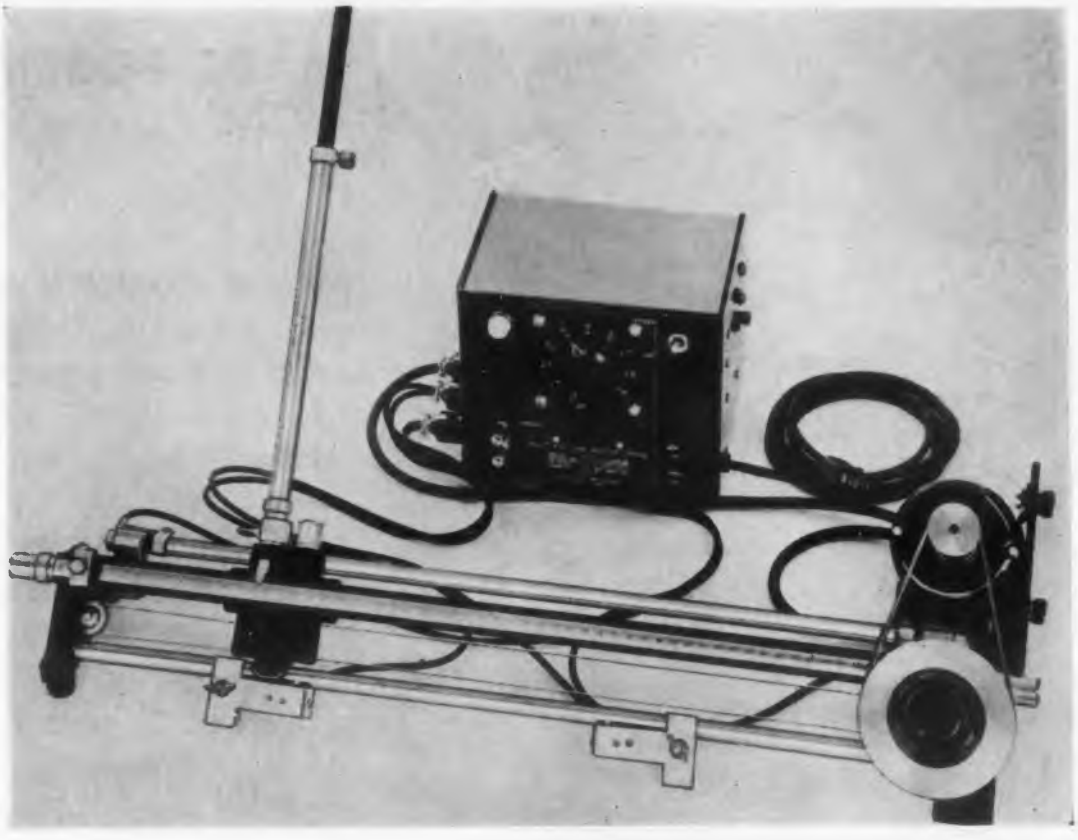
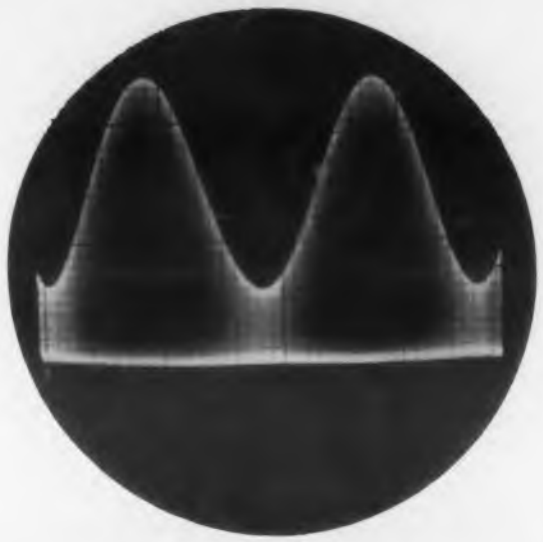


The length of the sweep on this motor-driven slotted line is set by means of the two microswitches on the lower bar. Short sweeps can be made in 1/5 sec.



Standing-wave pattern produced by illustrated apparatus.

MICROWAVE design and development engineers plagued by a lack of time or competent technical assistance should welcome the apparatus described on these pages. VSWR, voltage minimum and angle of reflection coefficient can be rapidly read on an oscilloscope by means of the motor drive attached to this standard slotted line.

The 1/50hp motor drive has two speeds. With the high-speed pulley, maximum speeds range from one sweep per second for the entire line to five sweeps per second for short sweeps. One sweep in 20sec can be made of the entire line by means of the low-speed pulley. The motor is controlled by a "Variac". The equipment is known as the Type 874-MD Slotted-Line Motor Drive, made by General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. The drive can only be used with this firm's slotted line, Type 874-LBA.

In order to produce the illustrated standing-wave pattern, a sine-wave modulated generator is employed. Two crystal diodes in a clamped circuit suppress the lower half of the typical sine-wave pattern and establish the baseline. An unmodulated generator or a square-wave modulated generator can also be employed in other arrangements. The length of the sweep is adjustable from 1 to 47cm by moving two stops that actuate microswitches. The equipment weighs 16-3/4 lb. For more data, turn to the Reader's Service Card and circle **ED-39.**

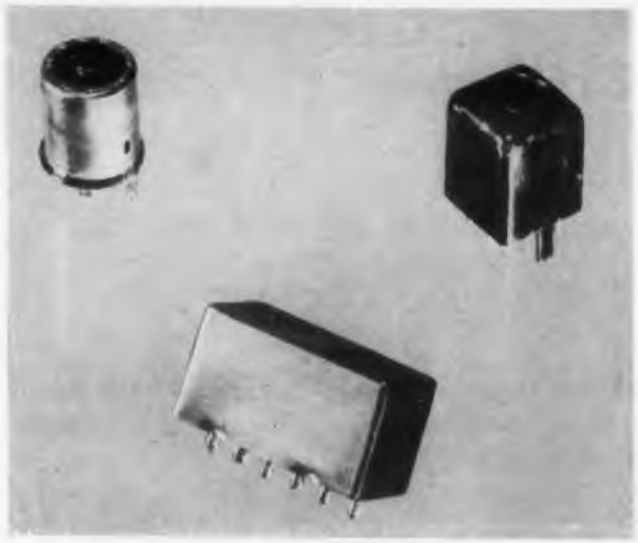
Tandem-Tuned Transformer

SUBMINIATURE in size, this tiny 1/2" x 1/2" by 1" double-tuned i-f transformer is particularly suited for transistor radios. Also illustrated is a 455kc single-tuned i-f transformer housed in a 1/2" cubical can. These components are outgrowths from the cylindrical i-f transformers originally used in the all-transistor Regency radio.

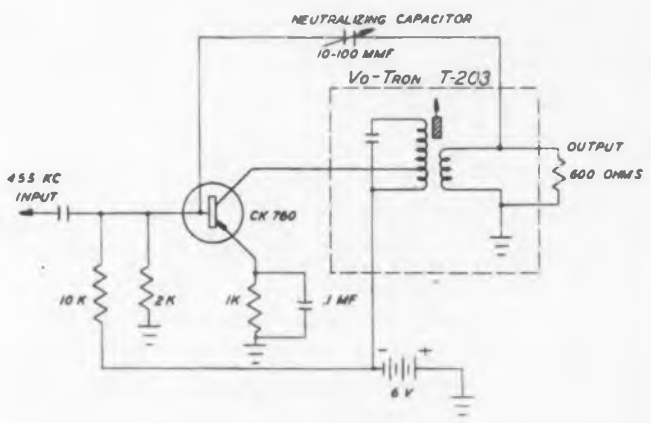
Units having wide ranges of turns ratios and impedances are available from the manufacturer, Vokar Corporation, Dexter, Michigan. Bandpass is about 7kc at the 6db point. Impedances match transistors; both the primary and secondary windings are tapped. Both the primary and secondary windings of the tandem-tuned units are inductance-tuned. Capacitance is 440mmfd. Tuning can be made from above or below the chassis. Q-values up to 160 may be obtained.

Units are vacuum-impregnated and have good time and temperature stability. The tandem-tuned component, Model TT600, is a plug-in type with six pins. Single-tuned units are available with 4, 5, and 6 hooked or plain-type pins on 0.100" centers. A ground lug is included. The capacitors are enclosed in the aluminum cans. The single-tuned unit is available for i-fs of 262kc. For more data on these subminiature i-f transformers, turn to the Reader's Service Card and circle **ED-42.**

Tandem-tuned unit, left, and square and cylinder units for i-fs of 455kc.



All transformers are tunable from above or below chassis; 262kc single-tuned units are available.



Typical i-f stage using 455kc transformer.

British Transistor Applications

D. D. Jones

**Research Laboratories, General Electric Co., Ltd.,
Magnet House, Kingsway, London, England**

DEVELOPMENT and production of semi-conductor devices got off to a slower start in Britian than in the United States. But because of the tremendous importance of these devices, the position is now changing very rapidly. A number of companies in Britain are marketing germanium point contact and junction transistors, and photocells. The prices of these, though generally lower than in the United States are still too high for many applications. Point-contact germanium diodes can be obtained for the equivalent of about 20¢, and are used extensively in TV receivers. So far no silicon junction devices have been marketed, but it is known that some are now in an advanced state of development.

Binaural Hearing Aid

Transistors are now used extensively in Britain in commercial hearing aid amplifiers, although the British National Health Service aids still use vacuum tubes. The circuit in Fig. 2 shows one "half" of a binaural hearing aid amplifier developed by the General Electric Co. The bias conditions are stabilized against temperature changes. A feature of this aid is the absence of interstage transformers; it is usually found that the small transformers available saturate at currents of a few hundred microamperes and the transformer primary inductance often resonates with the collector capacitance in the audio frequency range. Recent junction transistors have a significantly lower noise factor than earlier junction types; measured at 1kc and with respect to a 500 ohm source resistance noise factors of less than 10db are quite common.

This hearing-aid circuit has a maximum output of 4mw. Variable resistance R is adjusted for a collector current of 3ma in the final stage. All four transistors are type *EW53*.

Transistor Tester

A simple application of transistors to measuring instruments is shown in Fig. 1. This particular application is a simple bridge for measuring the collector capacitance of junction transistors. In this apparatus, transistor V_1 operates as a 100kc oscillator and its output is loosely coupled to a parallel tuned circuit via transformer T_2. The secondary of T_2 forms the inductance of this tuned circuit. The capacitance of the tuned circuit includes a calibrated variable capacitor. An output appears across a tertiary winding of T_1 when the tuned circuit is adjusted for resonance at the oscillator frequency (100kc). This output is amplified by two *GET1* point-contact transistors and detected by means of a germanium diode bridge arrangement.

The amplification of the amplifier detector circuit is such that a voltage of 70mv rms across the tuned circuit produces a reading of 30μa in the output meter. The method of measurement is as follows: 1. The variable capacitor is adjusted so that the tuned circuit is in resonance at the oscillator frequency. 2. The collector and base terminals of the junction transistor (suitably biased) are now connected across the tuned circuit and the variable capacitor readjusted for resonance. The change in capacitance is a measure of the effective capacitance across the junction transistor output terminals. (*Editor's Note: A transistor tester that also incorporates transistors is described on pp. 36 to 37.*)

Telephonic Applications

Great interest in transistors is taken by the British telephone industry. In addition to their possibilities in electronic telephone exchanges and line amplifiers, their low voltage requirements make it possible to include electronic circuits in the subscriber's handset, the power supply being obtained from the exchange battery. One well known suggestion is the replacement of a carbon microphone by a moving coil or moving iron microphone to obtain higher quality transmission, the resulting loss in sensitivity being made up by a transistor amplifier. Two other possibilities are illustrated in Figs. 3 and 4. In the first a 10kc oscillator is built into the receiver; the output from this oscillator is sent out along the line and is detected at the exchange. If no signal reaches the exchange (due to an open or short circuit in the line) an alarm is automatically given at the exchange. The

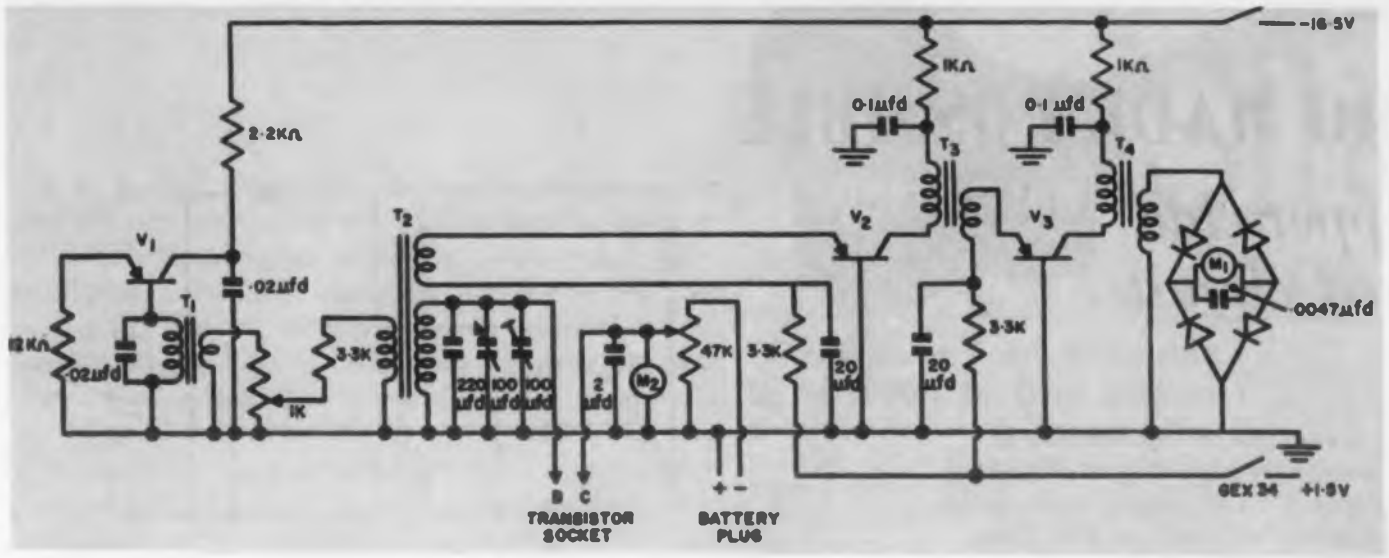


Fig. 1. This transistor tester measures collector capacitance.

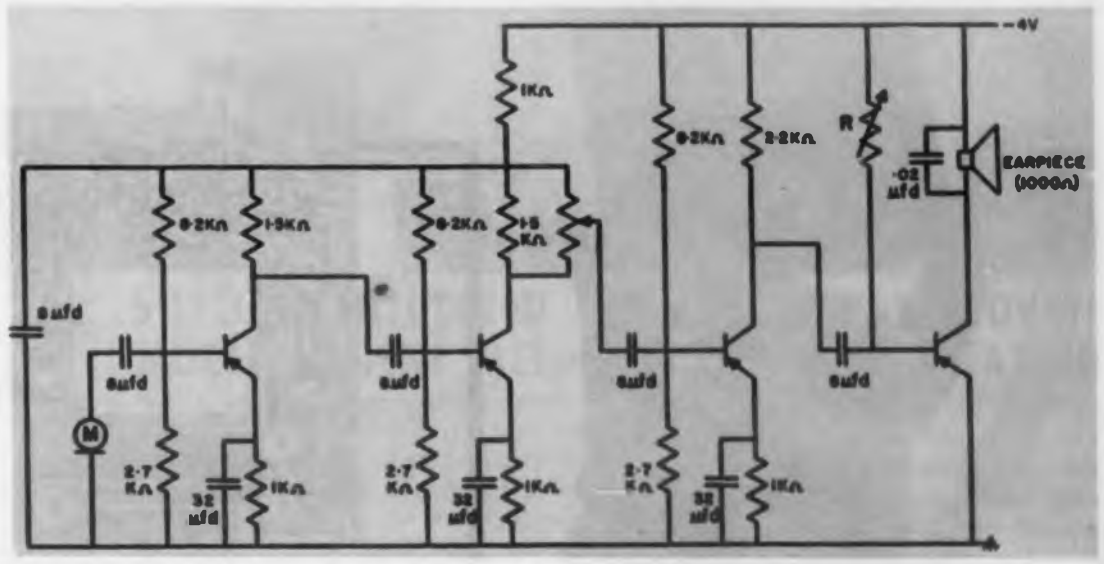


Fig. 2. One half of a binaural hearing aid.

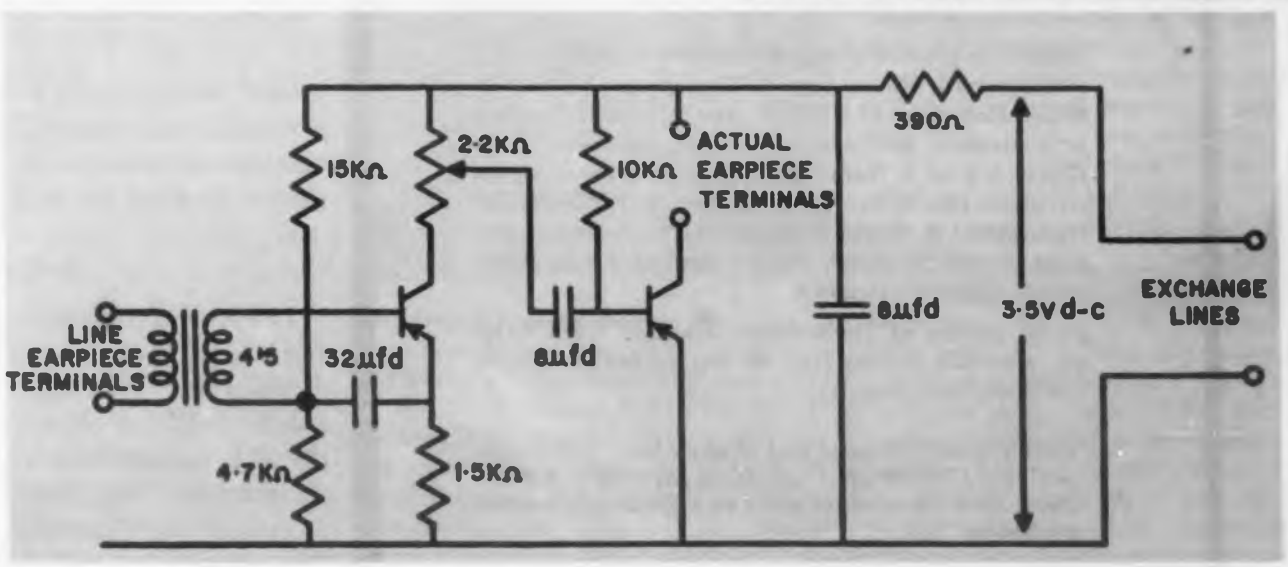


Fig. 3. A hearing aid built into a telephone handset.

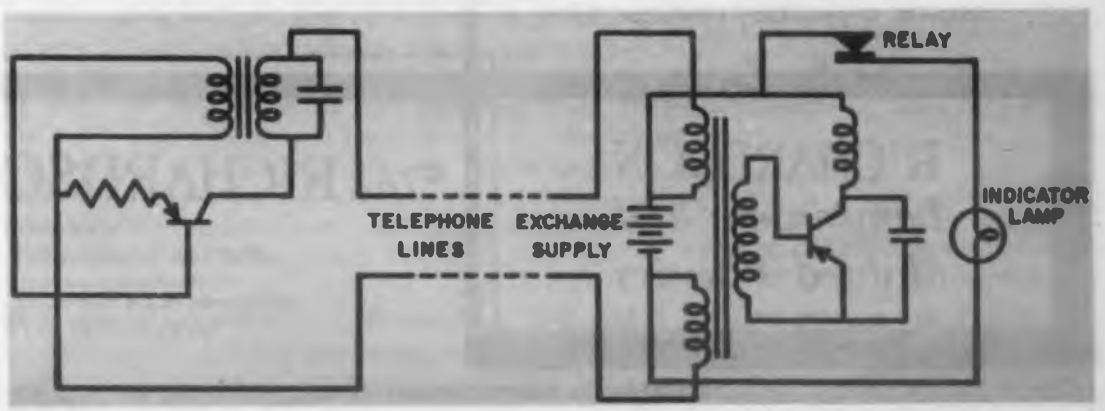


Fig. 4. An automatic telephone line interruption alarm. The oscillator circuit at the left is in the handset and the detector is in the exchange at the right.

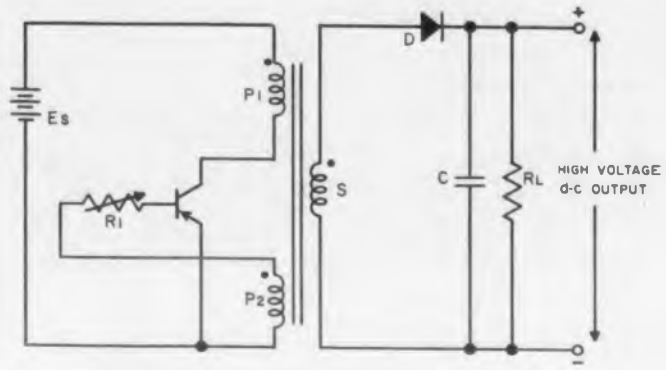


Fig. 5. A d-c converter system.

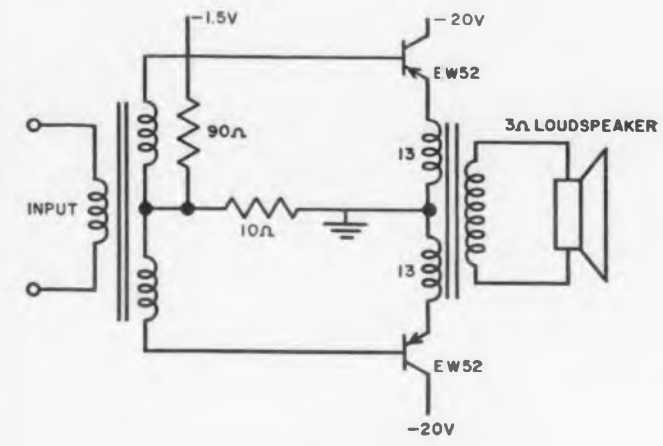


Fig. 6. Push-pull output stage for a portable radio receiver.

second circuit shows a built-in hearing aid amplifier, a variable gain control being fitted to the front of the receiver. In this circuit two resistance capacity coupled amplifiers are used.

D-C Converter

The use of transistors in direct-current converter systems is attracting much attention. Thus D. L. Johnson in "Wireless World" recently described a simple oscillator circuit for providing the plate supply of a vacuum-tube amplifier used in the first stage of composite transistor-tube hearing aid amplifiers. A typical d-c converter system is shown in Fig. 5. This circuit uses a relaxation oscillator. Suppose that, initially, the base is at a negative potential and that R_1 is adjusted so that sufficient base current flows to "bottom" the transistor. In this case a voltage approximately equal to the supply voltage appears across the primary winding P_1 of the transformer and the collector current will increase linearly with time at a rate dependent on the inductance of P_1.

When the collector current reaches the maximum value allowed by the base current and transistor gain, the voltage across P_1 will commence to fall; this action causes the negative voltage across the base wind-

ing P_2 to fall, eventually reaching a positive value and cutting the transistor off. This rapid change of collector voltage causes a positive going square wave to appear across the secondary winding S_1; if this is greater than the voltage across the storage capacitor C and the diode D conducts, the resulting current transfers the energy stored in the transformer to the capacitor. When this current ceases, the base is returned to negative potential and the whole action is repeated. By using a step-up transformer it is possible to produce an output d-c voltage many times higher than the supply voltage. Efficiencies of upwards of 75% are obtainable.

The repetition frequency is usually kept low to avoid losses due to "hole storage" effects in the transistor. When high output powers are required, it is sometimes preferred to use an alternative system; in this the output of a sine-wave oscillator is applied to a class B push-pull amplifier, the peak input signal being sufficient to cause the push-pull amplifier to "bottom." The output voltage from the amplifier is approximately a 50-50 square wave and it is then stepped up to a high voltage level by means of a transformer and rectified. Efficiencies well in excess of 75% are again possible. This system is an attractive alternative to the vibrator power pack for providing power supplies for a vacuum-tube automobile radio receiver from the main car battery.

Portable Radio

An important potential field of application is to be found in personal portable radio receivers. Although it is possible to obtain transistors having high values of alpha cut-off frequency, it is found that the product of the base spreading resistance and collector capacitance of most readily available transistors is such that the design of 465kc i-f amplifiers is difficult. The design of transistors suitable for use in good quality output stages working at high efficiency does, however, present less difficulties. The common collector push-pull amplifier circuit combines reasonable stage gain and low harmonic distortion.

The circuit shown in Fig. 6 uses low power junction transistors type *EW52* made by the General Electric Co., Ltd. The maximum collector dissipation for this type is 100mw; an output of 0.5w has been obtained from this amplifier. The power gain was 14db and the harmonic distortion was less than 5%. Because the emitter resistance is high at low level of input signal and decreases inversely with emitter current, it is found that the amplifier can suffer from "cross over" distortion; this can be overcome by applying a small amount of forward bias to the transistor input circuits as shown.

Design Procedures for Power Transistors—Part I

Howard T. Mooers, Transistor Engineering
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

CIRCUITS using power transistors present two design problems. One problem is the standard electrical circuit design with which this article is concerned, the other is the thermal design of the equipment to make available the most favorable electrical circuit parameters, "Power Transistor Temperature Rating", ED, June 1955.

The electrical design problem is straight-forward and similar, in many ways, to the methods used for power vacuum tubes, especially zero bias types such as the *6N7* vacuum tube. The useful region of the output characteristic of this vacuum tube, when the two grids are tied together, requires both an input voltage and input current. The limits of a power transistor are different, but the general behavior is identical.

In order to lay the foundation to properly discuss circuit design, the limits and characteristics of transistors will be discussed in detail first, and then these principles will be applied to the general problem of circuitry. Because of its length, this article will be presented in three parts. The first sections will deal exclusively with circuit analysis and transistor behavior, and the last will use these principles to develop proper transistor circuits for safe optimum power operation.

Limits

The transistor has several electrical limits which will determine the extremes of operation of the unit. The present discussion will be concerned with power transistors in general, and the *2N57* transistor in particular.

One important limit is the maximum voltage, above which the unit may be damaged or fail completely. For a *2N57*, the voltage limit is 60v.

Another limit is the total power dissipation of the device. The allowable dissipation is dependent upon the temperature of the mounting base. At 70° F the transistor can dissipate 20w. The power dissipation limit is linear with temperature and decreases to zero at 200° F.

A third limit is the maximum recommended current. No circuit should be designed which requires or permits operation beyond the value of current specified by the manufacturer. The current limit for the *2N57* is 1.0amp.

These three limits act as boundaries of the static characteristics. Any quiescent operating point and any dynamic operation is permissible within these limits.

The above limits are maximums. Certain minimums also govern circuitry and operation. For instance, a vacuum tube can be cut off to any extent necessary by increasing the negative grid bias. A transistor on the other hand cannot be cut off completely. The current can be reduced to and often slightly below the fundamental collector junction leakage current, usually designated as I_{co}. This leakage current is a function of both voltage and temperature. Except at high temperatures the magnitude of this leakage current is only a very small fraction of the current rating of the device. Thus for practical purposes in evaluating a dynamic swing along a load line, the leakage current can be considered to be zero, and operation of the device continued up to the axis. Several important second order effects of this leakage current will be analyzed later.

Another boundary of operation is the voltage necessary across the output terminals of the transistor to cause output current to flow. A vacuum tube may require 50v across the tube to conduct the rated current. The voltage required across a transistor is much less. In the common-base configuration, the full rated current can be passed even with a restraining potential applied to the transistor In this case the collector dissipation is negative—the collector is delivering power to the load. This power is derived from the emitter circuit and would otherwise be emitter dissipation if the collector circuit were short circuited or had the normal negative bias.

Characteristics

Common base—The common-base output characteristic for a typical *2N57* transistor is shown as Fig. 1. The useful portion of this characteristic is bounded by the voltage limit (60v), the power dissipation limit (20w), the current limit (1.0amp), the saturation collector voltage determined by the emitter drive, and the leakage current which is usually indistinguishable from the vertical axis.

It is seen that double input characteristics are used. It is not enough to specify only the current input to derive the output characteristics. It is generally impractical to drive a power transistor from a source of high enough impedance to assure constant current drive. In order to maintain a reasonable stage gain, some attempt at impedance matching will be necessary, but for any practical operation between the limits defined by the constant current and constant voltage characteristics, the input impedance varies with input drive, and both voltage and current vary simultaneously but not in a fixed proportion. How then can impedance matching be attempted on the basis of constant-current curves alone? For this reason the constant voltage input characteristics are also shown. From the two sets of curves, the d-c input resistance and dynamic input resistance may be calculated for any position along any load line. By successive approximations the output characteristics for any given source impedance and drive may be drawn.

The common-base configuration is characterized by its large current drive requirements, lowest input impedance (about 7 ohms), highest output impedance (7,000 ohms), greatest linearity of current gain, low power gain and lowest leakage current with open input circuit.

Common Emitter—The common-emitter configura-

tion yields an output characteristic which is bounded by the same limits as the common-base circuit, except that a definite minimum voltage must be applied across the output of the transistor in order to pass any given output current. This voltage-current relationship is in the nature of a resistance whose value is the lowest resistance that the transistor can present to the external circuit. This value is about 1 ohm for the *2N57* transistor. Along the voltage axis the characteristics are bounded by the same basic collector junction leakage current as for the common-base configuration. However, the collector current with zero voltage input or zero current input is higher than the fundamental collector junction leakage current, and to approach this fundamental leakage current limit the input must be biased in the reverse direction.

The common emitter output characteristics are plotted with both voltage and current inputs. The slopes of these output characteristics are less than those shown in Fig. 1, indicating a lower dynamic output impedance. The output impedances for voltage drive are equal for both common-base and common-emitter connections, and under constant voltage drive, the output characteristics are identical except for the shift in reference point in drawing the plots. The constant-current curves for the common-emitter configuration show a large current gain and a lower output impedance than any of the previous curves.

The common-emitter configuration is characterized by its small current drive requirements, medium input impedance (35 ohms), lower output impedance (700 ohms), considerable nonlinearity of current gain, the same transconductance as the common-base configuration, good linearity for voltage drive, highest power gain, and higher leakage current with an open input circuit. The leakage current, however, can be reduced to the same value as for the common-base circuit by using a slight restraining bias on the base input.

Common Collector—The common-collector configuration is very useful, but the control characteristic has seldom been published. This is probably because it can be easily derived from the common-emitter characteristic. With respect to constant current drive operation, the output characteristics are identical to the common-emitter characteristics except that the output current is the emitter current which is greater than the collector current.

These characteristics are bounded by the same limits as the common-emitter characteristic except for the maximum current limit. This limit is the emitter current necessary to give full rated collector current. For the *2N57* transistor it is 1.2amps.

The common-collector characteristics are plotted with both constant voltage and constant current inputs. The constant current input curves have about the same output impedance as the constant current curves of the common-emitter configuration. In fact, with current drive the circuits are identical except for a change in reference point in drawing the chart. The constant voltage characteristics have a dynamic output impedance equal to the input resistance of the common base configuration (about 7 ohms). As the input source impedance increases, the output resistance will increase until it approaches the value for constant current drive. In the same manner as indicated for the other charts, the output characteristics for any given source impedance may be drawn on the characteristic curves.

The common-collector configuration is characterized by high input impedance (dependent to a major extent on the load impedance), its small current drive, large voltage swings for the input, the lowest output impedance (dependent on the source resistance), good transconductance linearity, current gain linearity somewhat better than the common emitter circuit, highest output power, low power gain, and leakage current characteristic for open input identical to that of the common emitter configuration.

Theoretical Amplifier

The preceding characteristics define the operation of a transistor in several circuit configurations. Let us now analyze the characteristics of an ideal amplifying device. This analysis will indicate the theoretical limits of perfect amplifiers and provide a basis for judging transistors against other types of amplifiers, as well as point out places where improvements in transistor characteristics are desirable. Since the transistor is very close to a theoretical amplifier, the following analyses apply to transistors to a much greater extent than to vacuum tubes.

A perfect amplifier is one whose output characteristics are linear with equal increments of input. The most general case would require that the output characteristics (for equal increments of input) are parallel and equidistant. These characteristics are indicated in Fig. 4, Case I. With such an amplifier there would be no distortion irrespective of choice of quiescent operating point, load line, or power output (as long as the instantaneous excursion of the operating point stays within the boundaries of the characteristic). The out-

Fig. 1. Common base characteristics for *2N57* with mounting base 70° F.

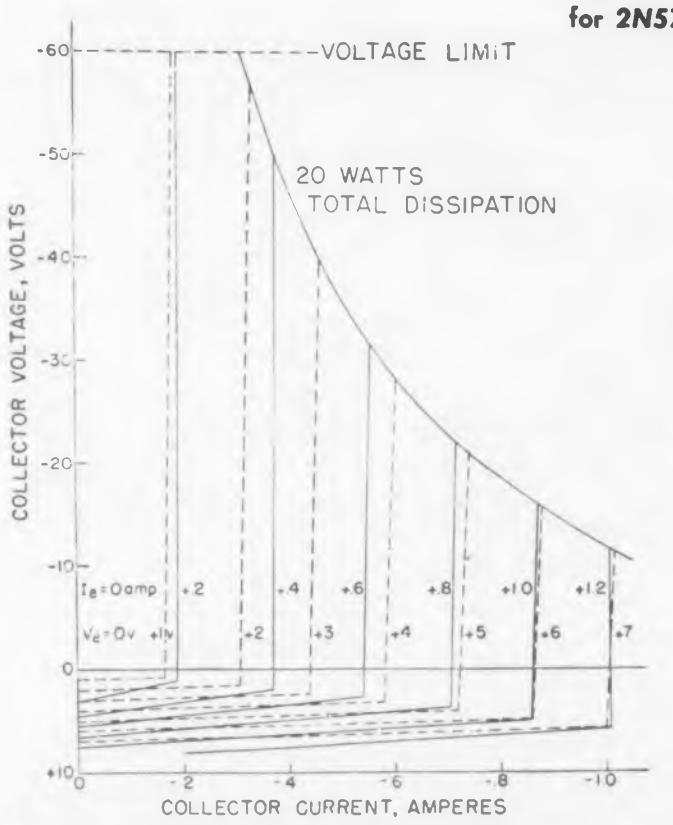


Fig. 2. Common emitter characteristics for *2N57* with mounting base at 70° F.

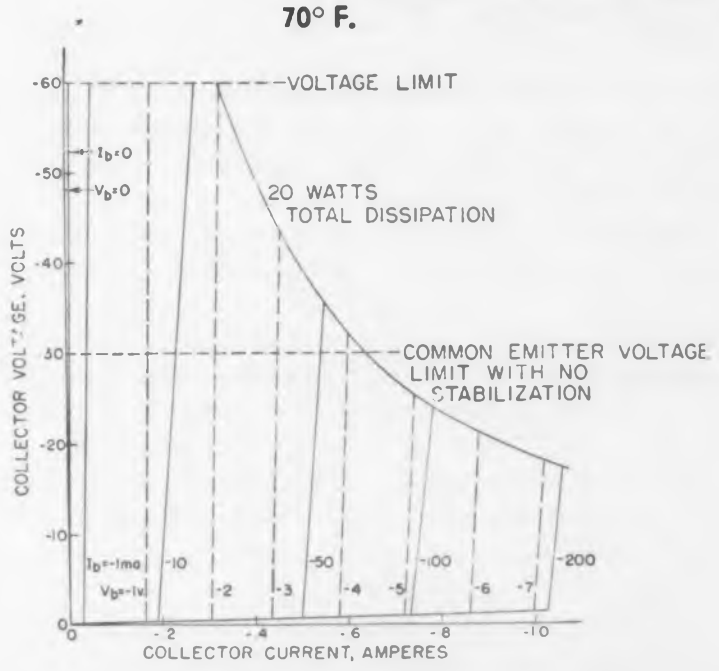
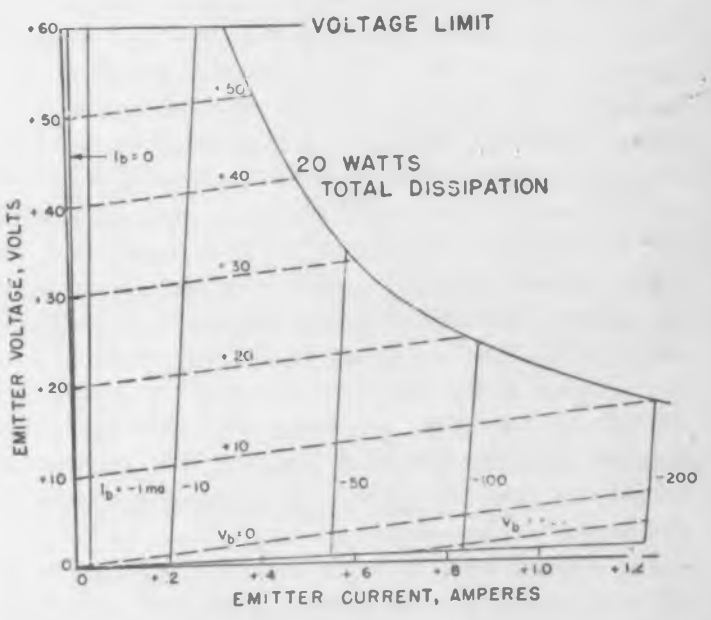


Fig. 3. Common collector characteristics for *2N57* with mounting base at 70° F.



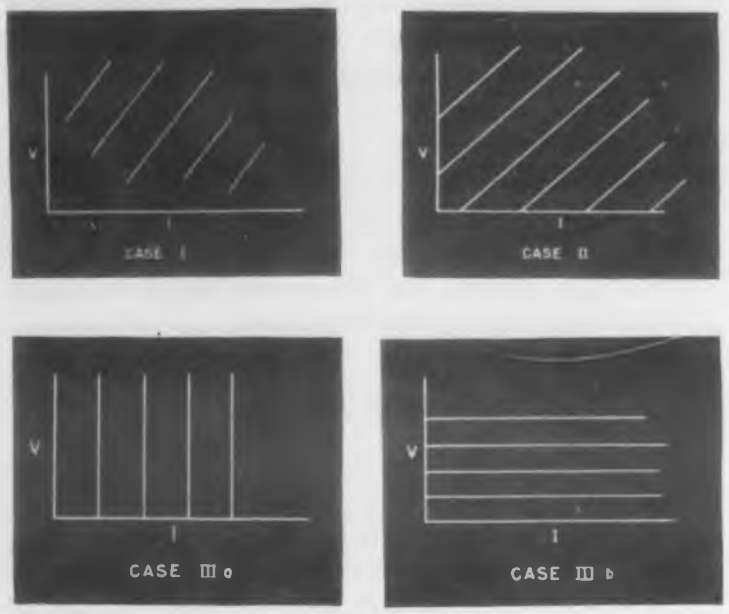


Fig. 4. Characteristics of theoretical amplifier showing general characteristics (*I*) plus their linear extension to cut-off (*II*), and cases of infinite (*IIIa*) or zero (*IIIb*) output impedance.

put impedance would be constant, in fact the small signal parameters would not change with instantaneous operating point, and consequently would be valid for all signals, large or small, within this region.

Case II requires that this linearity continue to the voltage and current axes. This means that the amplifier current can be cut off completely, and the gain is linear right up to cutoff. It also provides that current may flow through the device with no voltage drop across it, in other words, zero d-c resistance. This characteristic allows operation along the load line from full voltage and no current to full current and no voltage.

A further requirement may be imposed. Case III shows the characteristics of a theoretical amplifier whose characteristics are continued to the axes and as a further restriction, the characteristic curves are parallel to either the voltage or current axis.

It can be shown that with an amplifier of the types indicated in Case II and Case III, the Class A operating efficiency is 50%. The quiescent operating point is selected at the midpoint of the load line and full signal input will drive the output along the load line alternately to cut-off and to zero resistance. The average d-c power input to the system is constant whether for zero signal, part signal, or full signal. The amplifier is used to divert a portion of the d-c supply to a-c output. The remainder is consumed in the device and exhibits itself as power dissipation. Consequently the internal dissipation is least when the amplifier is driven to capacity, and the internal dissipation doubles when the signal is removed. The greatest internal dissipation for Class A operation occurs when the device has no signal.

For Class B operation, the amplifier is biased at cut off and conducts only during alternate half cycles. Usually two units are used in push-pull to give full wave operation. The quiescent dissipation is zero and the full load efficiency is 78%. The d-c power input is not constant. It increases as the signal increases. For the same power output, there is less average power dissipation in the amplifier for Class B operation.

In switching circuits the amplifier operates at either extreme of the load line. The region between the two extremities is transversed quickly enough so that there is little internal dissipation due to the transition from one extremity to the other. There remains only the evaluation of the dissipation at the end points. For the theoretical amplifier defined as Case II and III, the dissipation is zero at each end point. For an amplifier which falls short of the requirements set forth for Case II and III, there will be a definite dissipation at each terminus of operation on the load line. The average dissipation of such an amplifier used in repetitive switching will be dependent upon the duty cycle or fraction of time spent in each conduction state. For a 50% duty cycle, the dissipation will be the arithmetic mean of the dissipations at each extremity.

Load Line Characteristics

Electronic designers are familiar with the process of drawing a resistive load line on a set of characteristics to determine the locus of instantaneous operating points. Likewise they are familiar with the process of matching the load to the source impedance to secure the best power transfer. Both of these philosophies must be critically analyzed for their proper application to power transistor circuits. This is necessary because the thermal time constant of transistors is so small. The devices operate at a high current density and generate a considerable power in a very tiny volume. Because of this, the temperature of the junction varies so fast that only extremely short overloads can be tolerated. A fuse in the circuit will not protect a transistor. As a comparison, power vacuum tubes are often rated for power surges at a 15 second time-average power dissipation. In addition, vacuum tubes are limited in operation to a design maximum plate dissipation. Normally there is no current limit, and only a very unusual load would press the voltage limit. Thus considerable liberties have been taken in the design of vacuum tube circuits.

In comparison, transistors have voltage and power limits which should not be exceeded even for very short times.

Let us examine the conditions imposed upon a load line by the limits of the *2N57* transistor. The voltage limit is 60v, the power limit is 20w, and the current limit is 1 amp. These give the static characteristic boundaries within which the dynamic operating point must be contained. Fig. 5 shows these limits and several possible load lines using a resistance for the load.

Load line *a* passes through 60v at no current and 1 amp at zero voltage. Its resistance is 60 ohms and can deliver a theoretical Class A power of 7-1/2w output and has a maximum dissipation of 15w at its quiescent operating point. This load line does not exceed any limits during its normal operation and will not exceed them in case of overdrive or change of input bias.

Load line *b* is also a 60 ohm load line with its quiescent dissipation adjusted to 20w. Full drive along this load line will exceed both the voltage and current limits and possibly damage the transistor. In order to keep from exceeding these limits, the maximum power output must be limited to less than 7w. Thus in this case the power output is governed by the voltage and current limits rather than the dissipation limit.

A load line such as *c* operates to the voltage limit but not to the current limit and consequently the output power is less than the full capabilities of the device. A load line such as *d* will deliver the same power as *c* but if overdriven will exceed the voltage limit. A load line such as *e* operates to the current limit but not the voltage limit, consequently the output power is less than the capabilities of the unit. The load line *f* delivers the same power as *e* but the power limit and current limit may be exceeded in cases of overdrive.

From the above, it is obvious that the power dissipation limit is not the only controlling limit for the power output. The maximum Class A power output is achieved by having the load line pass through the voltage axis at the voltage limit and the current axis at the current limit provided the load line does not cross the power dissipation limit for the temperatures involved.

So far no mention has been made of the output impedance of the device or the slope of the control characteristics. The maximum power output is *not* a function of matching the load to the transistor impedance, it is only a function of the limits of the device.

For transformer coupled loads, the supply voltage approximately equals the quiescent operating voltage, and the resistance reflected to the primary establishes the slope of the load line. Under these conditions a shift in the Class A bias point will move the load line to the right or left and thus expose the transistors to conditions which may exceed their ratings where the same load line using a resistance for a load is invarient with respect to the bias level. Changes in bias in this case will only move the quiescent operating point up and down the established load line.

Class B push-pull circuits may be analyzed using a composite characteristic. Using transformer coupling for the push-pull pair places double the supply voltage on each transistor when the other is conducting at its peak level.

The composite characteristic such as shown in Fig. 6 is made by placing two characteristics back to back in such a way that the voltage axes are superimposed, and the supply voltage points on both charts coincide. The load line must be drawn through this point.

Supply voltages higher than 30v cannot be used or the voltages on the transistors may exceed 60v with full drive. To trace the dynamic excursion of the instantaneous operating point, start at the point where the

input signal just crosses its axis. As the signal increases the operating point moves down the load line as far as the input signal drives it. As the peak of the wave passes, the operating point moves back along the same line until it is at the axis when the input signal is zero. The signal now increases in the opposite direction. The first transistor is cut off while the other conducts. During cut off, the voltage on this transistor rises above the supply voltage as far as the voltage on the conducting unit drops below the supply voltage. Under full drive each transistor has double the supply voltage impressed across it while it is cut off. For this reason the maximum power is extracted from a push-pull circuit when each transistor operates into half the load resistance that is optimum for Class A operation.

If the turns ratio of the output transformer is as indicated in Fig. 7, each transistor will see 30ohms resistance while it is conducting, and the load line on the characteristic will have a slope equal to 30ohms and intercepts at 30v and 1 amp. The collector to collector impedance of the transformer will be 120ohms. This value is the one usually specified, but it is four times the value that each transistor drives, and four times the proper load line slope. It has no meaning except to calculate transformer turns ratio.

Non-Ohmic Load Lines

Often the loads for electronic circuits are not pure resistances. These loads may be a loudspeaker, a filter network, a resonant circuit, the amplifier phase of a servo positioning motor, a relay, or any other device which has reactance.

If the dynamic load line is observed on an oscilloscope, it will appear as an ellipse. If the load is a pure reactance, the axes of the ellipse will be parallel to the voltage and current axes. As the load is made more and more resistive, the axes will align themselves with the resistive component of the load. When the reactive component is reduced to zero, the ellipse collapses to the resistive load line.

This behavior of the load line was relatively unimportant until transistors began to be used extensively to drive such loads. One of the most dangerous conditions is removing the load from the secondary of an output transformer. The impedance presented by the primary changes abruptly from nearly a resistive characteristic to a high inductance. Fig. 8 shows the behavior of such a system for small input signals.

With the secondary of the transformer loaded, and a small signal impressed, the instantaneous operating point would move along the load line *CD* and trace a peak to peak amplitude of *AB* about the quiescent operating point *P*. So far the nature of the output characteristics have not been specified, the input is such that for this resistive load the instantaneous operating point will move between points *A* and *B*. Suppose that the output characteristics were vertical, representing an infinite or very high output impedance. This is the usual case with transistor circuits. The operation along the load line is well behaved until the load is removed and the transistor forces the same a-c current through the high inductance of the primary. The load characteristic will immediately change to an ellipse whose slope is determined by the primary impedance of the transformer when the secondary is open. for well-designed, efficient transformers this impedance is quite high. The voltage peaks developed may easily exceed the transistor voltage rating even with a small signal applied. Consider what would happen if the load were removed when the transistor is driving to its limits. At 60 or 400cy it would take only one cycle to destroy the transistor!

Suppose the same output transformer were driven by a device whose output characteristics were horizontal instead of vertical. This would be similar to the case of driving the output transformer from a low impedance source such as a Variac or Powerstat. In transistor circuitry, this low output impedance is obtainable from the common collector circuit. This configuration will also drive the instantaneous operating point from *A* to *B* along the load line *CD*. As long as the load is connected to the secondary, the results are identical. The mechanism of drive is different. In this case we are placing a sinusoidal voltage across the primary of the transformer, whereas in the previous case we were driving a sinusoidal current through it. Suppose now that the load were removed from the secondary of the transformer. The load characteristic will immediately change to an ellipse with the same slope, but instead of having the ellipse become tangent to the vertical output characteristics, it now is limited by the horizontal characteristics which determined the motion from point *A* to point *B* when the circuit was properly loaded. There is no overvoltage and the circuit is safe and stable irrespective of whether the load is connected or not. For conditions of full drive, the load may be removed and the circuit is still reasonably safe unless the ellipse passes into the region where the power dissipation is too great.

For inductive loads or transformer coupled loads, where the load my become disconnected, the common collector circuit with a low impedance drive is recommended. For any load that is questionable, it is recommended that the load characteristic be displayed upon an oscilloscope screen to ascertain that the transistor limits are not exceeded during any portion of the signal cycle.

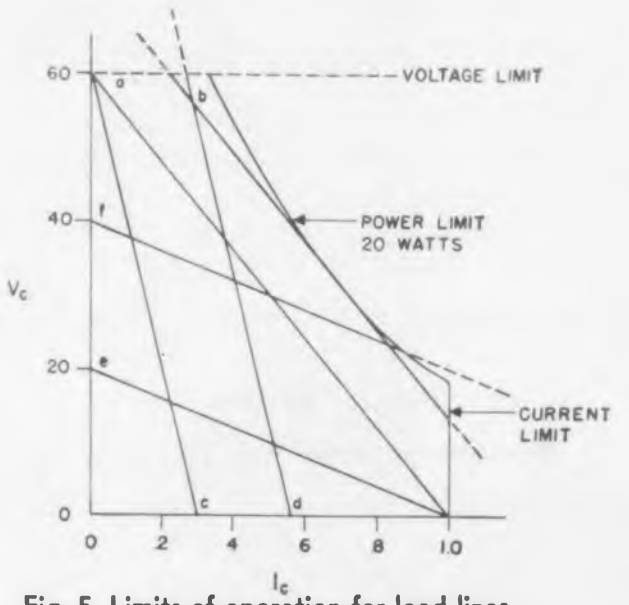


Fig. 5. Limits of operation for load lines.

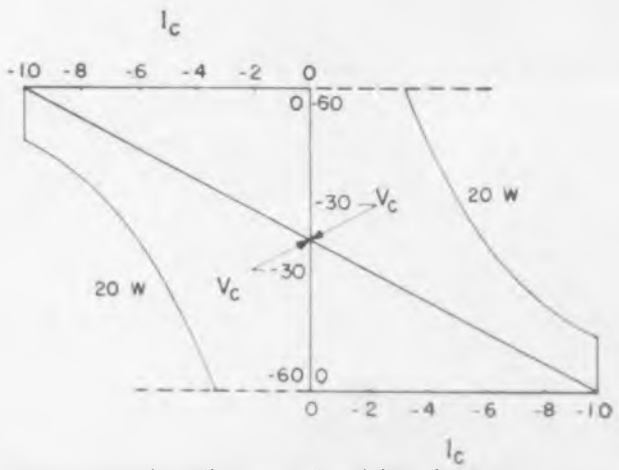


Fig. 6. Push-pull circuit load line limits.

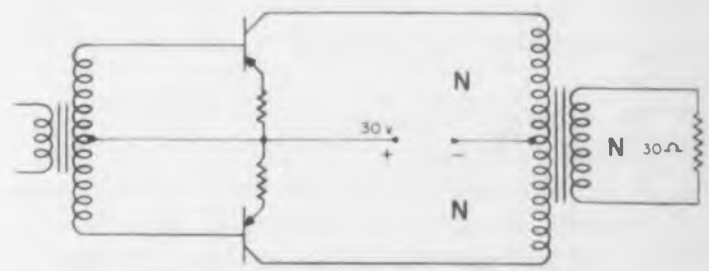


Fig. 7. Typical transistor push-pull circuit.

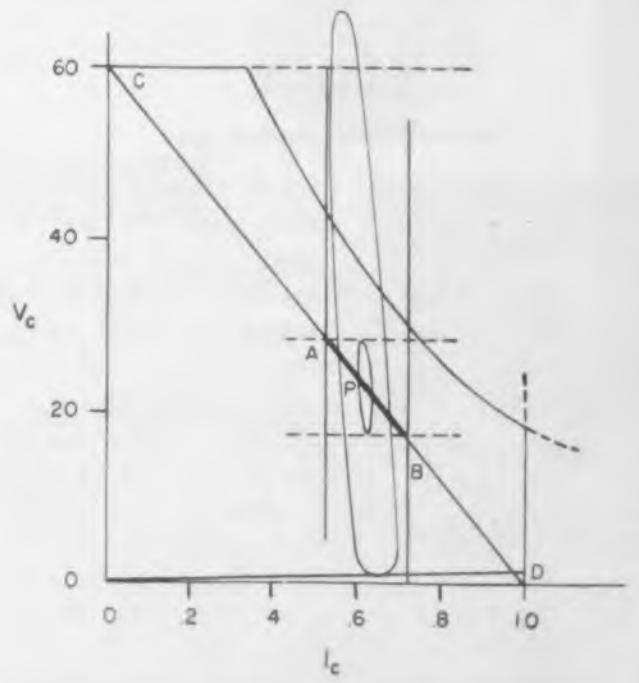
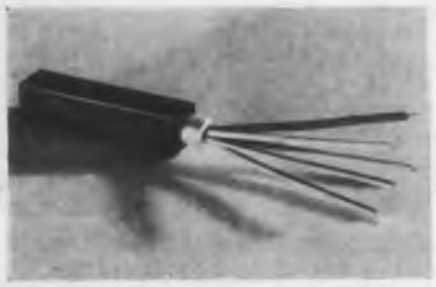


Fig. 8. Open inductive load characteristics.

New Products...

Subminiature Relay

For Missiles



Smaller than a cigarette, this new sub-miniature sensitive relay is especially designed for guided missile and other applications requiring an extremely small, compact and sensitive relay. Known as the Husky 503, it is provided with one set of single pole double throw contacts rated at 0.5amps, 120v d-c, non-inductive.

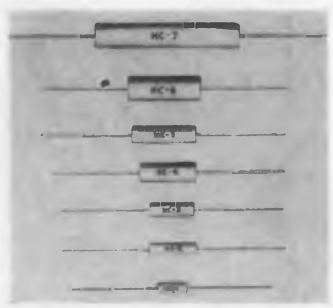
The relay armature is a center pivoted, dynamically-balanced member extending through the center of the coil, attracted to a pole piece at each end of the coil. The magnetic return path is through the body or frame surrounding the coil. The contacts are spring-closed and are opened by the cam action of a sliding insulation leaf attached to one end of the armature.

When adjusted to a sensitivity of 0.50w, the 503 will resist 30g vibration up to 2,000cy. It will withstand operating shock of 50g and 0.011 second duration, mechanical shock of 2,000 foot pounds and 1,000g rotary acceleration. It is less than 2 inches in length and only 13/32 of an inch square. Price Electric Corp., Dept. ED, Frederick, Md.

CIRCLE ED-52 ON READER-SERVICE CARD FOR MORE INFORMATION

Resistors

Hermetically Sealed Line

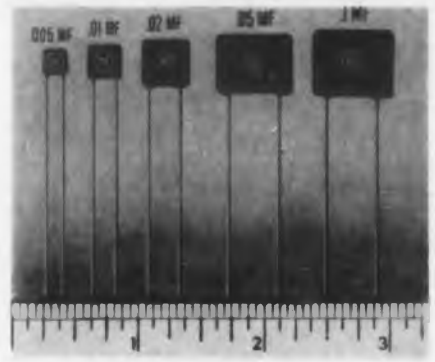


With the addition of two new sizes (1/4w and 1/2w), this firm's line of hermetically-sealed, deposited carbon resistors now consists of seven units, ranging in size from 1/4 to 3w. These resistors are for close-tolerance applications where extreme temperature or humidity conditions are a factor, or where extra mechanical or chemical protection is required. Electra Manufacturing Co., Electronics Div., Dept. ED, 2537 Madison, Kansas City, Mo.

CIRCLE ED-47 ON READER-SERVICE CARD FOR MORE INFORMATION

Subminiature Capacitors

For Transistor Circuits



These high-capacitance subminiature ceramic capacitors are small in size making them ideal components for transistor circuits. Rated at 25v d-c, these units are available in 5 stock capacitance values ranging from 0.005mf to 0.1mf. Smallest size is 13/64"; largest is 17/32" x 21/32". Thickness ranges from 0..090" max. to 0.110" max.

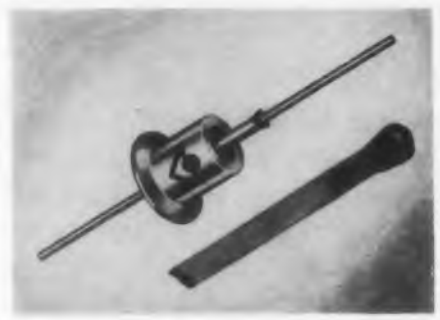
Made of Super-K ceramic material, these capacitors have radial No. 26 leads, and are normally used from 5 to 40°C.

Small in size for their capacitance, these units are being applied as by-pass, coupling and tone control circuits in personal transistor radios, auto receivers and other subminiature equipment. Mucon Corp., Dept. ED, 9 St. Francis St., Newark 5, N. J.

CIRCLE ED-48 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Diodes

Give Low Leakage, High Efficiency



These germanium diffused junction power diodes are designed to provide exceptionally low leakage and high rectification efficiency. Reliability is a result of complete hermetic sealing of the housing, consisting of glass-to-metal and welded metal-to-metal seals throughout. Freedom from contamination and long operating life are assured because no solders or fluxes are used.

Standard types such as 1N91, 1N92, and 1N93 diodes are now available from production. Special units can be produced. Semiconductor Div., International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE ED-49 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Transistor

For Audio Amplifiers

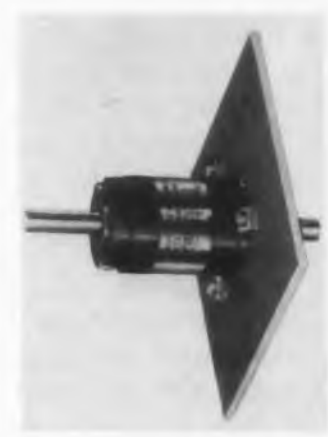
The type *2N115* is a germanium junction transistor of the p-n-p alloy type in a hermetically-sealed metal can. It is particularly recommended for audio frequency applications at a collector dissipation up to 2w. As a general-purpose power amplifier, the *2N115* can be used at frequencies up to 0.3Mc in common base. Further applications are switching and oscillator circuits where large signals are involved.

The hermetically-sealed metal can construction insures absolute moisture resistance and long life. The transistor is shock-proof and insensitive to ambient illumination. It is provided with a screw for easy mounting on a chassis which acts as a heat dissipator. Connections to the transistor are made by soldering. For common emitter, typical collector current is -1amp for $V_{ce} = -6$v and base current of 35ma. Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, N. Y.

CIRCLE ED-50 ON READER-SERVICE CARD FOR MORE INFORMATION

Speed Reducers

With Servo-Mount Ends



Series 106 Miniature Speed Reducers with servo-mount ends are available for quick delivery. These prefabricated reducers come in 448 different ratios, from 1:1 to 531,441:1. Many special ratios, not among the 448, may be had upon request.

These speed reducers may be mounted by using the groove and a clamp assembly similar to the one shown, or end mounted, using four tapped mounting holes. They have a nominal 1/40hp rating, and utilize hobbed spur gears hardened to give smooth operation and long life. Metron Instrument Co., Dept. ED, 432 Lincoln St., Denver 3, Colo.

CIRCLE ED-51 ON READER-SERVICE CARD FOR MORE INFORMATION

Servo-Gear Motor
1-1/8" in Diameter

A tiny servo-gear motor, only 1-1/8" in diam. and 2-17/64" long, has been designed for applications where size and weight are important features.

Weighing barely 4-1/2 oz, it is well adapted for missiles, auto pilots, instrumentation and control devices. Various rpm and torque combinations are transmitted through precision-cut gears mounted in miniature precision ball bearings. Modifications include hysteresis-synchronous and capacitor induction motors at various voltages and frequencies.

The miniature gear motor operates from an input voltage of 115v, 2 phase; frequency 400cy; no-load speed 180 rpm; full load 135 rpm; gear reduction 28.4; duty continuous. Eastern Air Devices, Inc., Dept. ED, 391 Central Ave., Dover, N. H.

CIRCLE ED-56 ON READER-SERVICE CARD

Compass Pencil
Folds up to Pencil Size

Made in Switzerland, the "Compass Pencil" is a sturdy, lightweight, aluminum product for designers, engineers, and draftsmen. It can be folded up to normal pencil size and carried in the pocket. Radix Co. of America, Dept. ED, Box 584, Great Neck, N. Y.

CIRCLE ED-53 ON READER-SERVICE CARD

Matched Transistors
For Class B Operation

The *2N108* is a matched pair of p-n-p junction transistors. These matched transistors are designed and selected for use in low power, Class B push-pull audio stages where low battery drain is important.

In the appropriate circuit, they are capable of producing 35mw of low distortion output at an efficiency of over 50% from a 3.5v battery source.

In addition, the devices are contained in hermetically-sealed metal cans to prevent deterioration from moisture. CBS-Hytron, Dept. ED, Danvers, Mass.

CIRCLE ED-54 ON READER-SERVICE CARD

CIRCLE ED-55 ON READER-SERVICE CARD ➤

Silicon Solar Cell

Produces 10 milliwatts

The Type S-1 Silicon Solar Cell comprises a hermetically - sealed large area silicon p-n junction, designed as a unit for the electrical conversion of solar energy and photo-voltaic applications. It is superior in temperature characteristics to germanium and similar types of photo-voltaic devices. The Type S-1 Cell enclosure is designed for easy mounting in either a series or parallel bank with minimum space requirement and simplified electrical wiring.

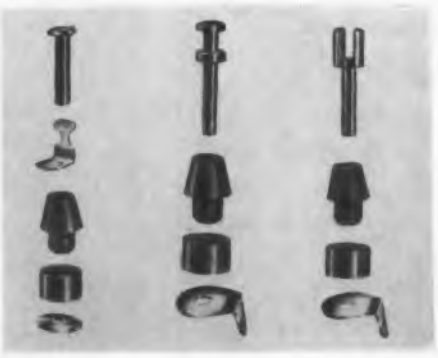
Internal impedance will vary with light flux incident upon the sensitive surface of the cell. For direct noon sunlight, the output is from 0.3 to 0.5v open circuit. Across a resistive load of 10 ohms, the voltage is 0.25v. A typical S-1 Cell will convert solar energy to electrical power, under optimum conditions of sunlight and exposure, at a rate up to 10 milliwatts.

The spectral response curve of power versus wavelength for the silicon p-n junction employed in the Type S-1 Cell shows a broad flat maximum extending from 0.7 microns to 0.85 microns (7000 to 8500 angstroms). The half maximum values are 0.55 microns (5500 to 9500 angstroms). The theoretical maximum solar power conversion efficiency has been computed by Bell Telephone Labs, Inc. to be 22% over the entire solar spectrum. National Fabricated Products, Dept. ED, 2650 W. Belden Ave., Chicago 47, Ill.

CIRCLE ED-60 ON READER-SERVICE CARD FOR MORE INFORMATION

Hermetic Terminal

Easy to Assemble



These hermetic terminals can be assembled with any simple rivet-staking equipment. They have a solid silicone rubber body and are of the double-gland, double-seal type.

Terminals are made in three sizes, the largest having a flashover point of 15,000v rms. All sizes are available with a wide variety of studs and lugs.

The terminals are assembled through ordinary punched holes, using only a simple anvil or cup to hold the head of the stud, and a rivet-setting tool to stake the hollow end. Strat-O-Seal Mfg. Co., Dept. ED, 3039 W. Fullerton Ave., Chicago 47, Ill.

CIRCLE ED-61 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Noise Meter

A Rapid, Easily-Used Instrument

This meter furnishes accurate information on the noise figure of a transistor in a single reading simply by inserting the transistor into a socket. Valuable as a laboratory tool, it also is useful for large scale users of transistors. Its high speed of operation makes 100% inspection possible.

The equipment measures 21-1/2" x 10-7/8" x 16-1/4". It contains a rapid-insertion transistor socket and provision so that the test set may be used in conjunction with other transistor test equipment with a single insertion of the transistor. Radio Receptor Co., Inc., Dept. ED, 240 Wythe Ave., Brooklyn, N. Y.

CIRCLE ED-58 ON READER-SERVICE CARD FOR MORE INFORMATION

VSWR Computer

For Automatic Testing

Model 621B VSWR Computer is designed to provide expanded utility and operator convenience in automatic development and production tests of microwave components and systems. Four linear scales, each covering a 10:1 range, are provided for voltage reflection coefficient percentages from 0.5 to 100. In addition, the 6.5" display meter carries two vswr ranges: from 1.01 to 1.1, and from 1.1 to 3.

The Model 621B is insensitive to r-f power changes over a 20:1 change, and is equipped with matching transformers for operation with both bolometer and crystal detectors. Used with suitable reflectometers, it is ideally suited for swept or single frequency exploration of transmission characteristics by non-technical personnel. A linear d-c output is available for simultaneous oscillograph recording or oscilloscope display of voltage reflection coefficient. Cubic Corp., Dept. ED, 2841 Canon St., San Diego, Calif.

CIRCLE ED-59 ON READER-SERVICE CARD FOR MORE INFORMATION

Matched Pair Transistors

Glass Encased

The *2-OC72* matched pair of p-n-p, germanium transistors are designed for Class B output stages where their ability to deliver undistorted power at low supply voltage is particularly advantageous. These transistors have an allowable dissipation of 50mw each at an ambient temperature of 45°C, so that in a Class B output stage, a total of 200mw can be obtained. The two transistors are so selected that at a base current of 2 milliamperes, the relative collector currents differ less than 30%. The transistors are in an all-glass hermetically-sealed envelope. Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, N. Y.

CIRCLE ED-63 ON READER-SERVICE CARD

Tubing and Sleeving

Various Fiberglass Types

The Alphlex line includes extruded plastic tubing, impregnated tubing and sleeving (fiberglass or organic base), high temperature fiberglass sleeving, plastic coated fiberglass tubing and sleeving, silicone impregnated fiberglass sleeving, and silicone rubber coated fiberglass tubing. The line conforms to MIL specs and UL standards. Alpha Wire Corp., Dept. ED, 430 Broadway, New York 13, N. Y.

CIRCLE ED-64 ON READER-SERVICE CARD

P-n-p Junction Transistors

For Hearing Aid Applications

HA-8, *HA-9*, and *HA-10*, junction germanium transistors are smaller versions of the *HA-1*, *2*, and *3* series. The first two are low-level, high gain units especially tested to meet low noise requirements of hearing aids. The *HA-10* (and *HA-3*) is suited for the power output stage. Also available is the *2N38A* transistor which supersedes the former *2N38*. This transistor is similar to the HA series except the gains are rated slightly less. CBS-Hytron, Dept. ED, Danvers, Mass.

CIRCLE ED-65 ON READER-SERVICE CARD

◀ CIRCLE ED-66 ON READER-SERVICE CARD

Adjustable Inductor

Cuts Production Costs

Without increasing space or cost requirements materially, the "Adjustoroid" permits designers to provide adjustable resonant frequency, phase, or impedance in circuits for audio or low radio frequencies. Circuits can be matched or production variations can be compensated for with negligible loss of time. In most cases, production costs can be reduced by eliminating the need for expensive precision fixed components.

The "Adjustoroid" allows inductance to be varied by a simple screwdriver adjustment. Amount of inductance variation normally is 10% of the nominal value for 180° rotation, although in some models it is as high as 20%. Once set, the inductance value is extremely stable, affected very little by changes in temperature and other conditions. Units are hermetic-sealed and normally are made of brass. The adjusting screw is binder-head, slotted type.

"Adjustoroids" are available in inductance values as from 0.00032 up to 10.0h in standard-size cases, and up to 3.2h in miniature cases. Five different core types are available from stock. Burnell & Co., Dept. ED, 45 Warburton Ave., Yonkers 2, N. Y.

CIRCLE ED-68 ON READER-SERVICE CARD FOR MORE INFORMATION

Circuit Breaker

For Power Cords

An extra margin of safety for household electrical appliances is available in the form of the "Mini-Breaker" MP-452. The unit affords complete circuit protection for home appliances. It fits easily on the power cord, and guards against damage due to overloads and short circuits.

The breaker is designed to protect 3amp to 10amp circuits. In case of an interruption, service can normally be restored within 10sec by pressing the reset button. Yet the unit is absolutely trip-free; it will not maintain a circuit that has not been cleared. This same reset button warns the user (when tripping is persistent) that a service check-up is necessary. Mechanical Products, Inc., Dept. ED, 1840 River St., Jackson, Mich.

CIRCLE ED-69 ON READER-SERVICE CARD FOR MORE INFORMATION

NEW *Electra* Hermetically Sealed DEPOSITED CARBON RESISTOR'S

HC-7

SEVEN SIZES

HC-1

THEY'RE ARMORED!

SUPER PROTECTION AGAINST:

High Temperature—Humidity
Radical Temperature Change—Abrasion
Chemical Compounds—Electrical Shock

SIZE CHART

Part No.	Wattage	Maximum Rated Voltage	Resistance Range	Length (A)	Dia. (B)
HC 1	¼	250	4 Ohms 250K	15/32"	5/32"
HC 2	⅓	300	5 Ohms 1 Meg	¾"	3/16"
HC 3	½	350	3 Ohms 2.2 Megs	11/16"	¼"
HC 4	1	500	3 Ohms 5 Megs	⅞"	5/16"
HC 5	1	500	6 Ohms 5 Megs	1"	9/32"
HC 6	2	500	3 Ohms 10 Megs	1⅛"	⅜"
HC 7	3	1000	10 Ohms 50 Megs	2¼"	⅜"

*All lead lengths are 1⅜". Resistors supplied in tolerances of 1%, 2%, 5% or 10%.

Electra Hermetically-Sealed resistors are designed for those tough applications calling for a deposited carbon resistor that will really take it. They're rugged and thoroughly insulated, ALSO give you all of the close tolerance characteristics that have made Electra's line of standard deposited carbon resistors the first choice on thousands of blueprints from coast to coast. Choose Electra and know you've got the best.

FILL OUT AND MAIL THIS COUPON TODAY FOR FULL DETAILS

Electra carbon coat PRECISION RESISTORS

Please send Bulletin #60 on Hermetically-Sealed Resistors ☐
and/or Bulletin #50 on Standard Deposited Carbon Resistors ☐

ELECTRA
M F G. C O.
Electronics Div.
2537 Madison
Kansas City, Mo.

Name _____
Title _____
Company _____
Street _____
City _____ State _____

CIRCLE ED-70 ON READER-SERVICE CARD FOR MORE INFORMATION

Vinyl Impregnated Fiberglas
Flexible at Low Temperatures

Resinite vinyl glass is a new vinyl impregnated Fiberglas electrical insulation sleeving. It is designed primarily for applications where extreme temperature conditions or severe usage are encountered and where extreme flexibility and high dielectric strength are essential.

The sleeving is available in a wide range of sizes from No. 24 to 5/8" I.D. and in 11 colors. It is made in three grades: B-A-1, B-B-1, and B-C-1. Resin Industries, Inc., Dept. ED, Santa Barbara, Calif.

CIRCLE ED-71 ON READER-SERVICE CARD

Passive Cathode Alloy
Available in Various Sleeves

A new passive grade of cathode alloy is available in the form of Weldrawn (welded and drawn) and Lockseam cathode sleeves.

Designated as Cathaloy P-50, the new material is characterized by exceptional uniformity of cathode activation and electron emission level. It exhibits the low rate of barium evolution, minimum sublimation, and freedom from interface impedance required of passive cathodes. Superior Tube Co., 52 Germantown Ave., Norristown, Pa.

CIRCLE ED-72 ON READER-SERVICE CARD

Self-Sticking Label Tape
Writing Is Protected

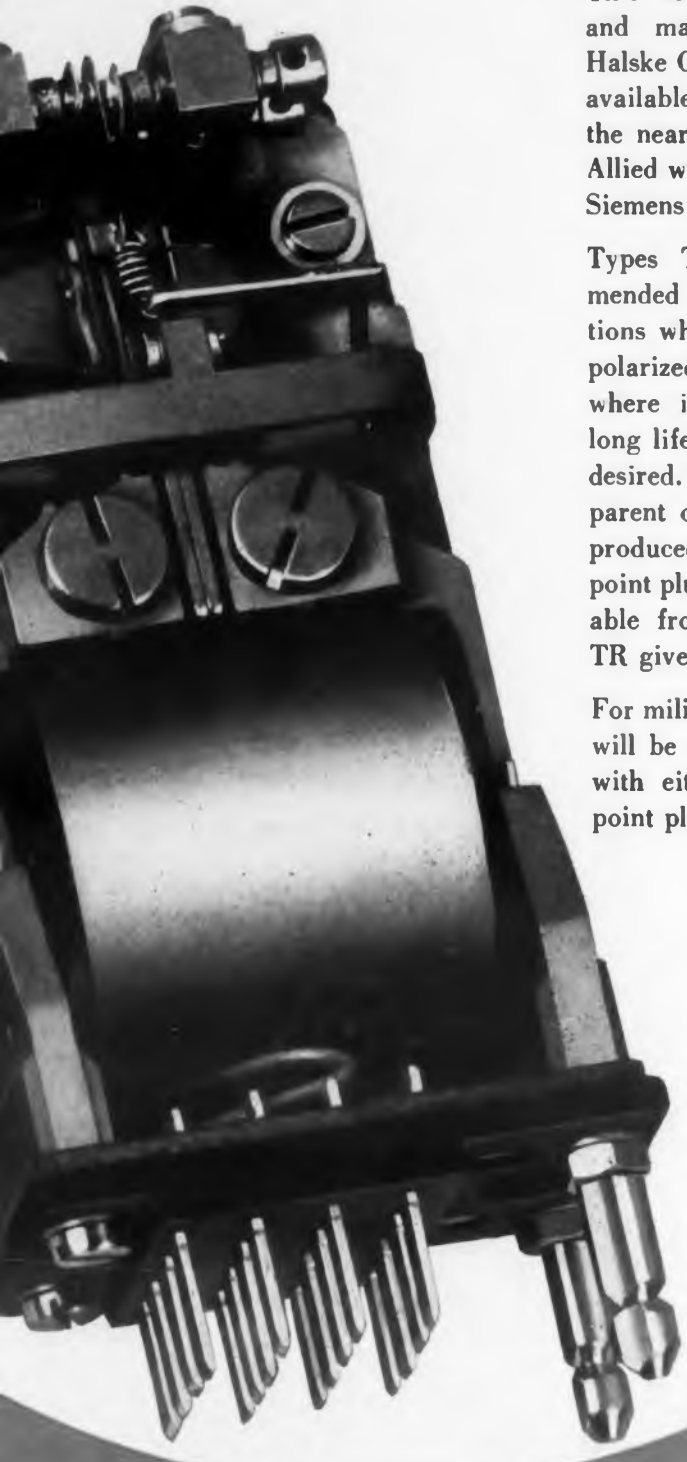
A new combination printed and "write on it" pressure-sensitive tape protects both printing and writing by a transparent plastic layer.

Printing and writing are actually beneath the transparent layer and are protected by it against smudging as well as against dirt, dust, oil, water, and most chemicals. Only pressure by the writing instrument is required to make the writing appear—no ink, pencil lead, or crayon is required. Any dry, blunt point such as a pencil or stylus may be used for writing. Labelon Tape Co., Inc., Dept. ED, 450 Atlantic Ave., Rochester 9, N. Y.

CIRCLE ED-73 ON READER-SERVICE CARD

CIRCLE ED-74 ON READER-SERVICE CARD ➤

...'s NEW



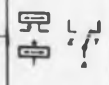
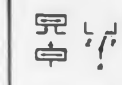
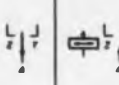
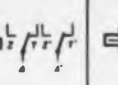
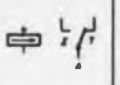
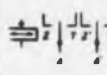
This new polarized relay, designed and manufactured by Siemens & Halske Company of Germany, is now available from Allied Control, and in the near future will be produced by Allied with the technical assistance of Siemens & Halske.

Types Trls 63 to 69 are recommended for use in industrial applications where the special features of a polarized relay are required, or where its inherent high sensitivity, long life and precision operation are desired. They are available with transparent or metal dust covers and are produced with solder terminals or 16 point plug-in bases (sockets are available from Allied Control). Bulletin TR gives complete details.

For military applications, these relays will be available hermetically sealed with either solder terminals or 16 point plug-in base.

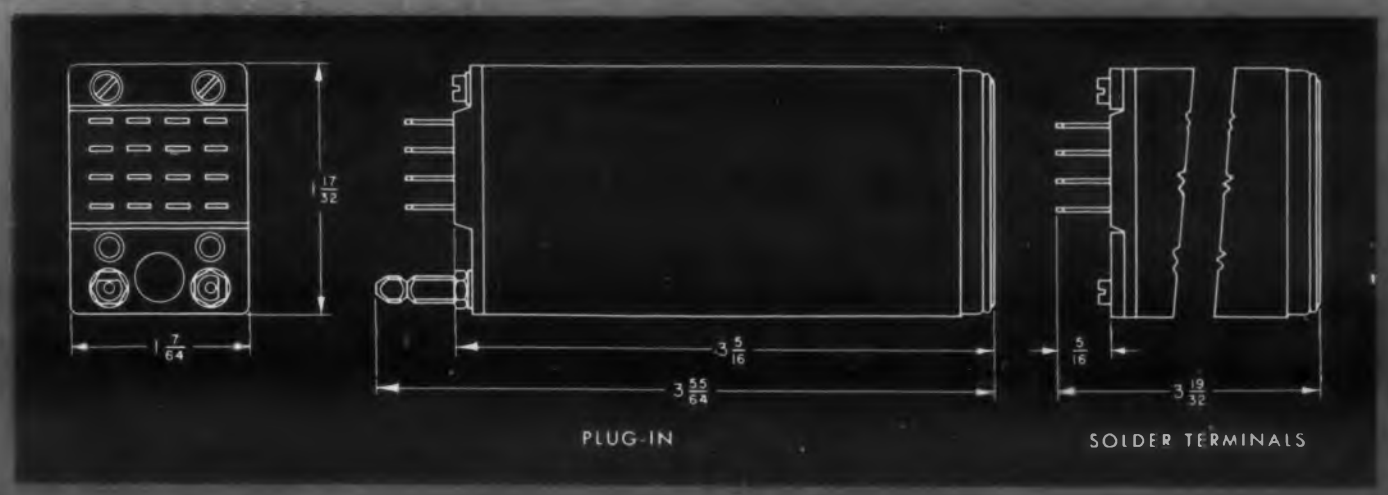
POLARIZED RELAY

Specifications For Allied's Types Trls 63-69

Type Number		Trls 63	Trls 64	Trls 65	Trls 66	Trls 67	Trls 68	Trls 69
Description	Positions	2		3	2	2	3	2
	Operation	Magnetic Latch						
		High Contact Pressure	High Sensitivity	Null-Center	Magnetic Latch	Spring Biased	Null-Center	Spring Biased
Contact Arrangement		SPDT		SPDT	DPDT	SPDT	DPDT	DPDT
Circuit Symbols	for telegraphy							
	other purposes							
"Operate" Excitation	Amp. Turns	7	2	2.2	5.5	5	4	15
"Operate" Power	μ Watts	500	40	50	300	250	160	2250
Working Excitation	Amp. Turns	15	4	6	10	10	10	25
Working Power	μ Watts	2250	160	360	1000	1000	1000	6250
"Release" Excitation	Amp. Turns			2.2		2.4	4	5
Max. Rate of Operation	Oper./Sec.	200	200	200	200	100	200	100

Contacts:	Silver, General Purpose		
	2 amp., 28v d-c resistive load		
	Platinum Alloy A. Low-Level		
	Applications up to 1 amp.		
	Platinum Alloy B. Heavy Duty		
	Applications above 1 amp.		
	Max. Continuous Current 5 amps.		
Dielectric Test Voltage	Coil to Frame	500v rms.	
	Contact to Contact	350v rms.	
	Contact to Frame	500v rms.	
	Coil to Coil	150-500v rms.	
Standard Coils	Resistances from 1.1 to 18,000 ohms		
	Max. number of windings	8	
	Max. Continuous Loading	1 watt	
Temperature	Max. Ambient	85°C	

DIMENSIONS



ALLIED CONTROL

ALLIED CONTROL COMPANY, INC., 2 EAST END AVENUE, NEW YORK 21, N. Y.

Panel Instruments

Curved Face Types to 0.25%

This firm offers a complete line of precision Reference Standard Panel Instruments available in both edgewise and vertically mounted panel types.

Edgewise types (curved face) are available in a-c and d-c current meters, voltmeters, wattmeters, thermocouple instruments, fluxmeters, differential galvanometers, and many specialized types. Accuracies are 0.5% and 0.25%, depending on sensitivities desired. Normal sensitivities are 4-μamp, and 2mv full scale (d-c); and 2ma and 200mv full scale (a-c). Scale length is 5" and 4" in two case types.

Vertical types (flat faced) are all current and voltage instruments. Sensitivities, and accuracies are somewhat less. Permanent magnet, dynamometer, moving iron, and electrostatic types are available. Sensitive Research Instrument Corp., Dept. ED, Mount Vernon, N. Y.

CIRCLE ED-75 ON READER-SERVICE CARD

Strippable Coating

Aluminum Pigmented

An aluminum-pigmented strippable coating provides a fast, economical method of protecting metal surfaces during interim periods.

Designated as PV-845, the coating may be applied by either brush or spray. It requires no surface preparation and can be stripped off easily when desired without leaving a greasy residue. The aluminum pigment inherent in the coating helps to provide maximum surface toughness and assists in forestalling moisture transmission.

A film 3 mils thick, sufficient to provide adequate strength for stripping, will dry to handle in 5 to 10 minutes under average temperature and humidity conditions. Specialty Coatings, Inc., Div. of Thompson and Co., Dept. ED, 1085 Allegheny Ave., Oakmont, Pa.

CIRCLE ED-76 ON READER-SERVICE CARD

CIRCLE ED-74 ON READER-SERVICE CARD

Analog Computer

Features Pre-Problem Check

"Problem Check", developed for the REAC 400 computer, gives an adequate method of verification of the problem before it is run. The checking is done directly from the problem equations and hence verifies the operation of every component used in running of the problem, the patching of the problem from the diagram, and the diagramming of the problem from the equations. An error in any of these will immediately be apparent from the check results.

The new REAC also features a "building block" design and greatly improved electrical performance characteristics. Servo multipliers and resolver servos in particular have vastly improved dynamic response, amplifiers are wider in bandwidth with greater power output and improved efficiency, and auxiliary equipment such as multipliers, function generators have been all redesigned for improved stability and general performance.

For maximum ease of maintenance and adjustment of the new REAC all major elements are plug-in from the front, so individual units can be removed for servicing and spares plugged into their place. Reeves Instrument Corp., Dept. ED, 215 E. 91st St., New York 28, N. Y.

CIRCLE ED-78 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Tetrode

Both Air and Water Cooled

The "Eimac" *4W300B* radial-beam power tetrode may be used as an amplifier, oscillator, or frequency multiplier into u-h-f. It is a water and air-cooled version of the "Eimac" *4X150A*. Rated at 300w plate dissipation, this powerful little tube delivers 140w of useful power output at 500Mc in a coaxial-cavity amplifier circuit. The tube is especially suitable for applications requiring higher plate dissipation capabilities than the air-cooled *4X150A*. The 4X150A/4001 air-system socket is recommended for use with this tetrode. Eitel-McCullough, Inc., Dept. ED, San Bruno, Calif.

CIRCLE ED-79 ON READER-SERVICE CARD FOR MORE INFORMATION

Silicon Transistors

Three New Types

Types *951, 952, 953* are medium power n-p-n grown junction silicon transistors. They can produce a power gain of 30db, supply up to 1w of Class B power, and be operated up to 150°C. Designed for audio or servo amplifier applications, they are furnished with a heat sink connection. Texas Instruments, Dept. ED, 6000 Lemmon Ave., Dallas 9, Texas.

CIRCLE ED-80 ON READER-SERVICE CARD

Button-Stem Tube Versions

Same Characteristics

Straight-sided button-stem versions of two popular receiving type tubes have been added to this firm's line.

The *5R4-GY.A* retains the same electrical characteristics as the *5R4-GY*. However, in the T-12 size bulb, the new tube is half an inch smaller in diameter than the ST-16 glass type bulb. The new 6L6-GB is about 1/4" shorter and 1/4" smaller in diameter than the 6L6-GA and is considerably smaller than the *6L6-G*. Tube Dept., Dept. ED, General Electric Co., Schenectady 5, N. Y.

CIRCLE ED-81 ON READER-SERVICE CARD

Etched Circuit Kits

Feature Simple Processing

Two etched circuit kits facilitate the rapid development of experimental and prototype etched copper circuits. All essential chemical and materials for processing are supplied. The "Professional" kit features presensitized, copper-clad phenolic sheets and materials for preparing negatives. The "Standard" kit requires a manual application of the desired circuit on the copper-clad sheet. Presensitized, copper-clad sheets of various sizes and processing materials are available separately. Keil Engineering Products, Dept. ED, 4356 Duncan Ave., St. Louis 10, Mo.

CIRCLE ED-82 ON READER-SERVICE CARD

CIRCLE ED-385 ON READER-SERVICE CARD ➤

Servo Amplifier

A Transistor-Magnetic Combination

The PRD R40G7W6 is a combination silicon transistor-magnetic servo amplifier. It will deliver full power to the parallel connected control windings of the 400cy BuOrd Mk7 or Mk14 servo motors.

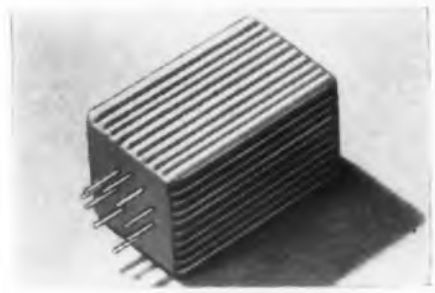
Overall voltage gain when driving the Mk7 motor is greater than 2000. This very high gain, coupled with the wide bandwidth of 0 to 70cy, makes the unit a useful component in instrument servo systems. The use of silicon type transistors for the preamplifier allows operation at ambient temperatures up to 85°C. Internal stabilization is available by utilizing the d-c component present in the amplifier output.

Containing no vacuum tubes, the unit is a low-cost, lightweight product designed to add ruggedness, reliability, and simplicity to any closed-loop control system where high performance is of prime importance. Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

CIRCLE ED-84 ON READER-SERVICE CARD FOR MORE INFORMATION

Clamped Flip-Flop

Transistorized Plug-in Unit



Designed to meet a need for a subminiature plug-in binary element for computer applications, the new encapsulated Type 200C5 flip-flop combines proven transistor circuitry and manufacturing techniques. It uses a unique printed circuit design permitting almost 20 circuit elements to be packaged in a 1" by 1-5/8" space.

Power and space requirements of the 200C5 have been reduced by a factor of 3 compared to conventionally-wired tube flip-flop circuits. The 200C5 is a bistable circuit, including two junction transistors, two input diodes, and four clamping diodes.

The trigger pulse requirements are +15v at 40kc. Rise time is 2μsec; fall time 12μsec. Load current of 2ma may be drawn. The entire unit, encapsulated in a plastic jacket for humidity resistance, has a standard 7-pin miniature tube-type plug-in base. Sprague Electric Co., Dept. ED, North Adams, Mass.

CIRCLE ED-85 ON READER-SERVICE CARD FOR MORE INFORMATION

Panel Meters

Give Longer Scale in Small Size

These panel instruments are designed to give up to 50% more scale length in the same space as conventional round or square faced meters. Known as "Medalist" Meters, they are available in 2-1/2" and 3-1/2" sizes, and meet standard ASA/JAN dimensional requirements. The long dial arc, large numerals, and longer pointer allow a small meter to replace a larger standard unit. The meters are available in various colors. Marion Electrical Instruments Co., Dept. ED, 402 Canal St., Manchester, N. H.

CIRCLE ED-86 ON READER-SERVICE CARD FOR MORE INFORMATION

Variable Delay Networks

With Delay to 0.75μsec

A series of Variable Delay Networks is offered for laboratory use to facilitate design and development of advanced computer and radar systems. Compactly constructed for front panel mounting, they offer a variation of delay from 0 to 0.75μsec in 10 turns of a vernier control shaft. E. S. C. Corp., Dept. ED, 534 Bergen Blvd., Palisades Park, N. J.

CIRCLE ED-87 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetrons

Weigh Only 26 Oz

Two packaged, pulsed, low-power oscillators, Types 6229, and 6230, have been added to this firm's line of Magnetrons. They are for operation in the 3cm band and tunable between 8900 and 9400Mc/sec.

These units are extremely small in size, as well as light in weight (26oz), making them particularly suitable for airborne applications. Forced-air or liquid cooling is not required. Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, L. I., N. Y.

CIRCLE ED-88 ON READER-SERVICE CARD FOR MORE INFORMATION

Portable Oscilloscope

D-C to 4Mc Unit

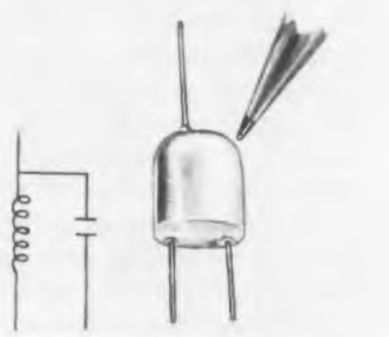
The Type 310 Oscilloscope is a d-c to 4Mc portable precision instrument, designed for both field and laboratory applications. With its small size (10″ x 6-3/4″ x 17″) and light weight (23-1/2 lb) it is easily handled and fits into tight spots, yet is fully capable of handling many laboratory applications.

Features include: wide-range sweep circuit (0.5μsec/div to 0.6sec/div continuously variable with 18 calibrated steps from 0.5μsec/div to 0.2sec/div); accuracy within 3%; 5x magnifier, accurate on all ranges; trigger amplitude selection or automatic triggering and d-c-coupled unblanking. Vertical amplifier rise time is 0.09μsec. The unit has accurately calibrated sensitivity from 0.1 v/div to 50v/div in nine steps at d-c to 4Mc, with three additional steps from 0.01v/div to 0.05v/div at 2cy to 3.5Mc. Sensitivity is continuously variable from 0.01v/div to 150v/div. It has a square-wave voltage calibrator; 1.85kv accelerating potential on 3″ crt; regulated power supply; and a hinged chassis for easy accessibility. It operates on 105 to 125v, 60 to 800cy. Tektronix, Inc., Dept. ED, P. O. Box 831, Portland 7, Ore.

CIRCLE ED-91 ON READER-SERVICE CARD FOR MORE INFORMATION

Coil and Condenser

Plastic-Molded in One Unit

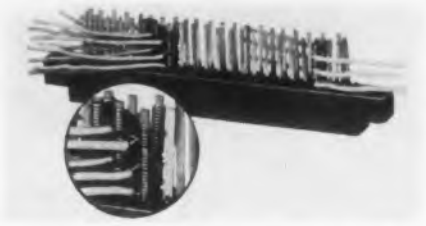


Especially suited for printed circuits and miniaturization, this molded coil and condenser unit measures 3/8″ thick x 15/32″ wide x 9/16″ long. It was designed to minimize components by molding two parts that are connected in the same circuit in one compact package. Where desirable, resistors may be molded with the coils in place of the condenser or along with the other two to form a small, sealed unit. The items meet military specifications. National Coil Co., Dept. ED, 3001 N. Main, Sheridan, Wyo.

CIRCLE ED-92 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Connector

Takes 132 Connections



The PCW-22, a printed-circuit "Continental" connector, was developed originally for computer applications. It can handle 132 solderless connections with 24 gage wire. The illustration shows three wires wrapped around each of 44 contacts (two rows of 22 contacts each).

This receptacle accommodates 0.093" printed-circuit board. Gold-plated spring-temper phosphor-bronze contacts assure sustained reliability. A polarizing stud can be placed at any contact point on the connector. Molding compounds include a choice of mineral-filled melamine, Plaskon-reinforced (glass) Alkyd 440A, or Orlon-filled diallyl phthalate. DeJur Amsco Corp., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N. Y.

CIRCLE ED-95 ON READER-SERVICE CARD FOR MORE INFORMATION

Capacitor

For −70° to +200°C Range

The HT-4 Capacitor has been run continuously for 17,000hr at 200°C and 140% of rated voltage without deterioration. Average change in capacitance is less than 2% after repeated cycling from room temperature down to −70°C, up to +200°C, and back to room temperature.

Insulation resistances as high as 10^{14} ohms are available, enabling these capacitors to hold a charge for an extreme length of time. Special processing of the dielectric results in low relaxation time and minimum dielectric absorption. Full hermetic seal plus extremely rugged construction prevent damage despite severe shock and vibration.

Power factor is less than 0.05% from 0 to v-h-f band (Q of 2000). In the u-h-f band the Q is as good as mica. Standard ratings are 0.0001 to 4.0mfd. Conservatively rated at standard working voltages of 200, 400, 600, and 1000v d-c or a-c peak voltage, units will withstand overload of twice rated voltage for a period of 1 minute.

Standard tolerance is ±10%. Units are available with tolerances of ±5%, ±3%, ±1%, and ±0.25%. Sizes range from (capacity 0.001mfd) 0.190" diam x 3/4" long to (0.500mfd) 1.25" diam x 1-7/8" long. Balco Research Laboratories, Dept. ED, 49 Edison Pl., Newark 2, N. J.

CIRCLE ED-96 ON READER-SERVICE CARD FOR MORE INFORMATION

CIRCLE ED-94 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistorized Preamplifier

With Noise Less Than 0.5μv Rms

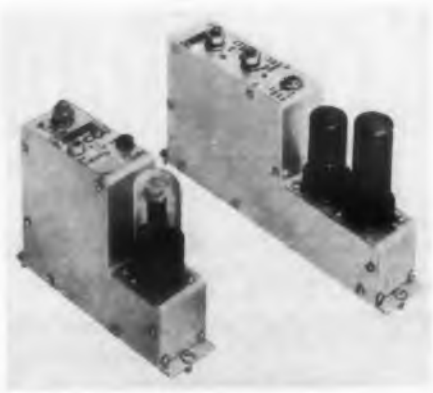
The Type VS-61 "ultra-low-noise scope preamplifier" has less than 0.5μv rms noise over its entire frequency range of 2cy to 60kc. Its design is based on the discovery that transistor noise can be reduced substantially below the noise level of vacuum tubes if suitable low-noise operating parameters are selected.

The amplifier is recommended for hot-wire anemometer measurements, strain gage measurements, and other applications where noise-reduction is of vital importance. It offers an input impedance of 1000 ohms, gain of 1000, and a choice of differential or adding input. It contains four transistors and six vacuum tubes and is entirely battery-operated. Volkers & Schaffer Manufacturing Corp., Dept. ED, P. O. Box 996, Schenectady, N. Y.

CIRCLE ED-105 ON READER-SERVICE CARD FOR MORE INFORMATION

Tone Oscillators, Detectors

In Plug-In Assemblies



Audio frequency tone oscillators and detectors offered by this firm are designed for maximum stability under wide variations of voltage and temperature. Standard plug-in assemblies, they are used in applications such as remote control, telemetering, and selective calling where telephone lines, radio, and microwave links are used.

One tone oscillator and its companion tone detector comprise a complete tone signalling channel. The tone oscillator employs a modified Wein-bridge circuit. The tone detector consists of an isolated, temperature-compensated L-C filter followed by a two-stage vacuum-tube amplifier.

Any number of tone oscillators and detectors having any combination of different frequencies may be combined in a system. Both units are designed for continuous unattended operation. Available channel frequencies range from 500cy to 600cy. Pacific Div., Bendix Aviation Corp., Dept. ED, 11600 Sherman Way, North Hollywood, Calif.

CIRCLE ED-106 ON READER-SERVICE CARD FOR MORE INFORMATION

Modular Power Supply

Permits Variety of Sources

The Model 130 Modular Power Supply, featuring excellent stability and regulation, serves as an inexpensive power source in four ways: when limited power is required, it can be used singly; if higher output voltages are necessary, several identical units can be connected in series; greater output currents can be obtained by connecting units in parallel; for both higher voltages and greater currents, units can be connected in series-parallel. Interconnections are quickly and easily made by means of connectors incorporated into the rear of the units.

Output voltage varies less than 0.1% with variation of power line voltage between 105v and 125v, and less than 0.2v between no-load and full-load conditions. Ripple is less than 2mv rms. Output is 145-310v at 0-80ma. Power consumption runs approximately 100w under full-load conditions from a 105-125v, single-phase a-c power line. Furst Electronics, Dept. ED, 3322 W. Lawrence Ave., Chicago 25, Ill.

CIRCLE ED-109 ON READER-SERVICE CARD FOR MORE INFORMATION

Variable Delay Line

60-position Rotary Switch

This delay line consists of 60 sections of LC m-derived networks and one 60-position rotary switch. The networks are especially designed for fast rise time and negligible overshoot. The switch is used to change the amount of time delay between the input and output by connecting the output terminal to any one of the 60 sections of LC networks. The accuracy of time delay can be as high as ±0.5% of the time delay at any point.

There are five different types available. Type 605a, as an example, has a maximum time delay of 0.6μsec in steps of 0.01μsec, 75 ohms impedance, 32Mc bandwidth, and 0.01μsec rise time. The units range from 1.5μsec to 12μsec total delay. Advance Electronic Co., Inc., Dept. ED, 451 Highland Ave., Passaic, N. J.

CIRCLE ED-110 ON READER-SERVICE CARD FOR MORE INFORMATION

D-C Scopes

In Chopper-Stabilized Series

The VS-900B series of sensitive d-c oscilloscopes features exceptionally small d-c drifts due to chopper - stabilization of vertical amplifiers. Guaranteed drifts are less than 1mv after 2 minutes warm-up. D-c sensitivity is 700-μv/cm.

These scopes are available in three different models: VS-930B has symmetrical push-pull input only on its most sensitive range (700μv/cm). VS-940B has symmetrical push-pull input on all ranges, to facilitate elimination of common interference signals, such as hum, at high as well as low signal levels. VS-960B has a built-in "hushed transistor preamplifier" with less than 1μv rms noise over a 60kc pass-band, to increase its a-c sensitivity which is 1μv rms/cm, with less than 0.5μv noise. Volkers & Schaffer Mfg. Corp., Dept. ED, Box 996, Schenectady, N. Y.

CIRCLE ED-98 ON READER-SERVICE CARD FOR MORE INFORMATION

Vibration Pickup

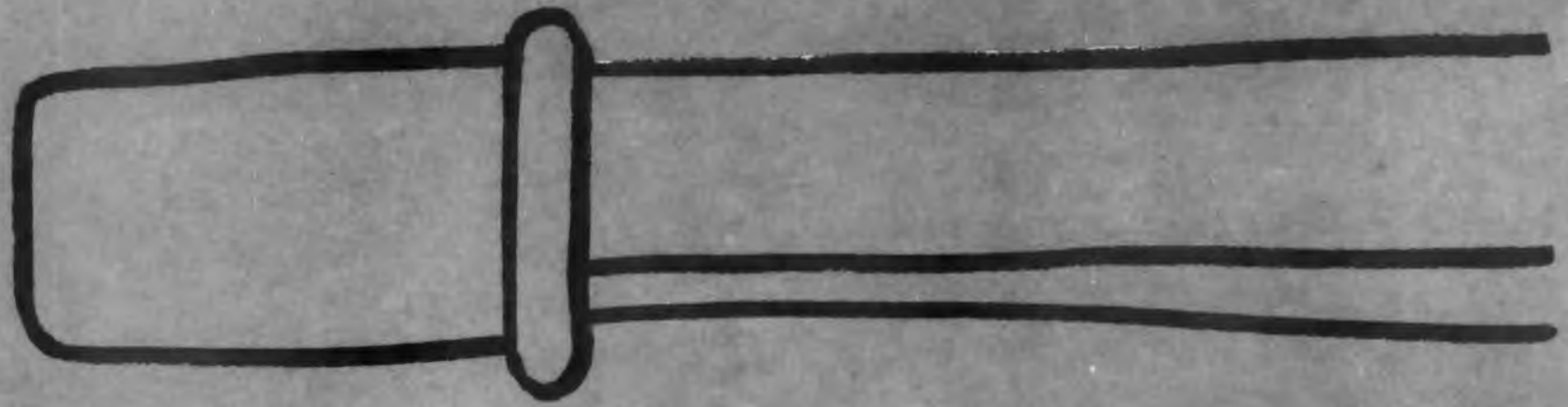
Can be Held in Hand

A hand-held instrument, the Type 115 Pickup can be used to explore surfaces, bearings, lightweight objects, etc., and will detect vibration with great accuracy for analysis and measurement. A sensitive probe is attached to a pivoted coil moving between Alnico V permanent magnets. It transmits motion from a vibrating surface to the coil, to cause motion and a generated voltage corresponding to the motion. The signal is generally run through leads to vibration meter, recorder, spectrum analyzer, and other instruments.

The light probe hand-held against a surface adds negligible loading or weight to the vibrating surface and therefore yields precise data on the natural frequencies involved. In the study of noise through airplane windows, as an example, the probe needs only to be held against the window to produce valid data. In ground vibration testing of airplanes, the hand-held pickup can be moved over large areas of thin skin to search outlines of maximum and minimum vibratory amplitude. The MB Manufacturing Co., Inc., Dept. ED, New Haven 11, Conn.

CIRCLE ED-99 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Data Chart



Transistor Data Chart

COMMERCIALLY available transistors are listed on the chart shown on these pages. This is the third such annual compilation (ELECTRONIC DESIGN, *July, 1953, p. 11; July, 1954, pp. 20-21*). Transistors being produced for military consumption only or those made for special users are not included. The data were obtained from information furnished by the manufacturer, or, in the case of the imported units, from the importer. The companies listed at the right are sources of transistors.

Most of the junction transistors are of the p-n-p variety. Those transistors with an n-p-n configuration are indicated by an asterisk next to their type number.

For certain transistors intended for switching circuits, rise times (T_r) and cut-off times (T_c) are listed instead of or in addition to other characteristics.

In addition to the transistors listed, photo transistors are produced by Radio Receptor (Type *RR66*), Texas Instruments (Type *800*), and Transistor Products (Type *X-25*).

The column headings at the top of the chart stand for the following parameters:

V_c .....Collector voltage
I_c .....Collector current
W_c .....Collector dissipation (Where available, the temperature at which W_c was measured is given in parentheses.)
α .....“alpha” or current amplification factor (listed value less than unity).
β .....base current amplification factor (listed value more than unity)
PG .....Power gain
PO .....Power output
Z_s .....Source impedance at which *PG* and *PO* measured
R_L .....Load resistance at which *PG* and *PO* measured
NF .....Noise factor
F_{co} .....Cutoff frequency
C .....Type of circuit for which the characteristics are listed. “GE” being grounded emitter; “GB” being grounded base; “GC” being grounded collector; “CE” being common emitter connection.

Most of these transistors are hermetically sealed in either metal or glass. A smaller number are plastic encapsulated, and a few of the latter are both plastic encapsulated and hermetically sealed. For a reprint of this data chart, turn to the Reader's Service Card and circle **ED-100.**

Made By	Type No.	Maximum Ratings V_c (volts)	I_c (ma)	W_c (mw)
Junction Transistors—Triodes				
A	OC70	−5	−10	25
	OC71	−5	−10	25
	2-OC72 (a)	−6.5	−45	45 (45°C)
CBS	2N38A	−20	−8	50(50°C)
	2N80	−25	−2	20(75°C)
	2N82	−20	−15	35(71°C)
	2N108(a)	−20	−15	50(25°C)
	2N116	−20	− 8	50(25°C)
	HA1-HA8(d)	−20	− 8	50(50°C)
	HA2-HA9(d)	−20	− 8	50(50°C)
	HA3-HA10(d)	−20	−12	50(50°C)
	HC1	−20	− 8	50(50°C)
	HD-197	−40		500(25°C)
F	2N34	−25	+ 8	50(30°C)
	2N35*	25	− 8	50(30°C)
	2N36	−25	+ 8	50(30°C)
	2N37	−25	+ 8	50(30°C)
	2N38	−25	+ 8	50(30°C)
GE	2N43	−45	−50	150(25°C)
	2N43A	−45	−50	150(25°C)
	2N44	−45	−50	150(25°C)
	2N45	−45	−50	150(25°C)
	2N76	−20	−10	
	2N78*	15	20	50
	2N123	−20	−20	75
G	2N34	−25		70(50°C)
	2N36	−25		70(50°C)
	2N37	−25		70(50°C)
	2N38	−25		70(50°C)
	2N39	−30		50(50°C)
	2N40	−30		50(50°C)
	2N42	−30		50(50°C)
	2N43	−45	−50	150(25°C)
	2N44	−45	−50	150(25°C)
	2N45	−45	−50	150(25°C)
	2N63	−22	−10	33(30°C)
	2N64	−22	−10	33(30°C)
	2N65	−22	−10	33(30°C)
	GT-14	−25	(g)	70(50°C)
	GT-20	−25	(g)	70(50°C)
	GT-24	−6	(g)	40(50°C)
	GT-34	−25	(g)	70(50°C)
	GT-38	−6	(g)	40(50°C)
	GT-81	−25	(g)	70(50°C)
	GT-81h	−6	(g)	40(50°C)
	GT-83	−25	(g)	70(50°C)
	GT-87	−25	(g)	70(50°C)
	GT-88	−25	(g)	70(50°C)
	GT-760	115		40(50°C)
GP	2N97*	30	−10	50(25°C)
	2N98*	40	−10	50(25°C)
	2N99*	40	−10	50(25°C)
	2N100*	25	− 5	25(25°C)
	2N103*	35	−10	50(25°C)

Typical Operation												
I_e (ma)	V_c (volts)	I_c (ma)	α or β	PG (db)	PO (mw)	Z_S (kilohm)	R_L (kilohm)	NF (db)	F_{co} (Mc)	C	Application	Made By	Typ
	−2	0.5	30					10	0.4	GE	Audio	H	CQ-1
	−2	3	47					10	0.4	GE	Audio		HA-1
	−6	60		27	200				0.01	GE	Audio out.		HF-1
													J-1
													J-2
	−3	−0.5	18	34				27(b)			Hearing aid		J-3
	−6	−1	80							GE	High temp.		JP-1(a
	−6	−1	60								High temp.		
	−3.5	27		13	58(c)	2	100	27(b)		GB(c)	Audio out.	I	2X 30
	−3	−0.5	18	34		0.5	3.1	27(b)			Low noise		3X 30
	−3	−0.5	40	40		1	30	12(e)		GE	Hearing aid		3X 30
	−3	−0.5	30	37		1	30	27(e)		GE	Hearing aid		
	−3	−2.5	35		3	1	1.2			GE	Hearing aid	NU	T34D
1	−6		45	40		1	30		0.7	GE	Computer		T34E
	−10	−50	10	30		0.1	5		0.15	GE	Power		T34F
												P	2N47
	−6	−1	0.98	40		0.5	30	50		GE			2N49
	+6	+1	0.98	40		0.5	30	50		GE			SB-10
	−6	−1	45	40		1	30	50		GE			
	−6	−1	30	36		1	30	50		GE		RCA	2N77
	−6	−1	15	32		1	30	50		GE			2N10
													2N10
1	−5	−1	0.98	39		1	30	22	1	GE	Hi-gain amp.		2N10
1	−5	−1	0.977	39		1	30	10	1	GE	Med. power	RR	2N34
1	−5	−1	0.95	38		0.7	30	22	1	GE	Med. power		2N36
1	−5	−1	0.92	36		0.45	30	22	1	GE	Med. power		2N37
1	−5	−1	0.95	38		1	30	18	1	GE	Gen. purpose		2N38
−1	5	1	0.95	22(f)		1.5	10	14	4	GE	r-f, i-f amp.		2N39
1	−5	−1		25(f)				11	6.5	GE	r-f/i-f amp.		2N40
													2N42
1	−6		40	40		0.5	30			GE			2N93
1	−6		45	40		1	30			GE			RR14
1	−6		30	36		1	30			GE			RR20
1	−6		15	32		1	30			GE			RR34
1	−4.5	1		39		0.5	30	24		GE			RR38
1	−4.5	1		38		0.5	30	24		GE			RR83
1	−4.5	1		36		0.5	30	24		GE			RR87
1	−5			39		0.6	4	22	1	GE			RR10
5	−20			33		0.22	4.5	22	1	GE			RR11
5	−20			30		0.125	4.5	22	1	GE			RR11
1	−6		22	39		0.8	20	25	0.8	GE	Audio		RR12
1	−6		45	41		1.5	20	22	0.8	GE	Audio		RR16
1	−6		90	42		2.7	20	20	0.8	GE	Audio		RR16
1	−4.5		28	36		1	30	16		GE	Audio		RR16
1	−4.5		45	40		1	30	16		GE	Audio		
1	−1.5		45	40		1	30	16		GE	Hearing aid	RAY	CK-7
1	−4.5		15	32		1	30	16		GE	Audio		CK-7
1	−1.5			28	1	0.5	0.35			GE	Hearing aid		CK72
1	−4.5		65	42		1	30	16		GE	Audio		CK72
1	−1.5		90	42		1	30	12		GE	Hearing aid		2N63
1	−4.5		45	40		1	30	16	0.7	GE	Computer		2N64
1	−4.5		28	36		1	30	16	0.5	GE	Computer		2N65
1	−4.5		65	42		1	30	16	1	GE	Computer		2N10
1	−6		40	30(f)					5	GE	Comp. & i-f		2N11
													2N11
													2N11
−1	4.5	1	0.93	38		0.4	100	20	1	GE	Med. gai		
−1	4.5	1	0.975	47		0.85	100	20	2.5	GE	Hi-gain amp.	S	2N34
−1	4.5	1	0.975	47		0.85	100	15	3.5	GE	Computer		2N35
−1	4.5	1	0.993	53		3.5	100	20	5	GE	Computer		2N94
−1	4.5	1	0.80	33		0.225	100	22	0.75	GE	Computer		2N94

Made By	Type No.	Maximum Ratings V_c (volts)	I_c (ma)	W_c (mw)	Typical Operation I_e (ma)	V_c (volts)	I_c (ma)	α or β	PG (db)	PO (mw)	Z_S (kilohm)	R_L (kilohm)	NF (db)	F_{co} (Mc)	C	Application
H	CQ-1	−40	−10	150(50°C)	1	−6		0.90	30					0.5	CE	Medium gain
	HA-1	−20	−10	100(50°C)				0.975					20			Hearing aid
	HF-1	−12	− 3	30(55°C)	0.5	−4.5			22					5	GE	Medium gain
	J-1	−40	−10	150(50°C)	1	−6		0.97					11	1	GB	Low power
	J-2	−40	−10	150(50°C)	1	−6		0.94					22	0.5	GB	Low power
	J-3	−40	−10	150(50°C)	1	−6		0.90					33	0.5	GB	Low power
	JP-1(a)	−45	−50	350(50°C)	15	−22.5			15	225		1	15		CB	Power
I	3X/300N			200(20°C)					27		2	20	25	0.5		lo-power audio
	3X/301N			200(20°C)					27		2	20	25	0.5		lo-power audio
	3X/302N			200(20°C)					27		2	20	25	0.5		lo-power audio
NU	T34D	−30	12	50(25°C)	1	−4.5	1	.97	39		0.5	30	10-30	0.25	GE	Audio
	T34E	−30	12	50(25°C)	1	−4.5	1	.94-.97	38		0.5	30	10-30	0.25	GE	Audio
	T34F	−30	12	50(25°C)	1	−4.5	1	.90-.94	36		0.5	30	10-30	0.25	GE	Audio
P	2N47	−35	−20	50(25°C)	1	−5	−1	0.975	40		1	20	15	0.8	GE	Hearing aid
	2N49	−35	−20	50(25°C)	1	−5	−1	0.975	40		1	20	15	0.8	GE	Lo-noise audio
	SB-100	−4.5	−5	10(40°C)	1	−3	−1	0.95	33(f)		1	20	12	45(h)	GE	Computer, r-f
RCA	2N77	−25	−15	35		−4	−0.7	55	41		1.98	95	6.5	0.7	CE	Lo-power audio
	2N104	−30	−50	150		−6	−1	44	41		1.05	68	12	0.7	CE	Lo-power audio
	2N105	−25	−15	35		−4	−0.7	55	42		1.75	100	4.5	0.75	CE	Lo-power audio
	2N109	−20	−50	50		−4.5	−13	70	30(c)	75(i)	.375(j)	0.1(k)			CE	Large signal
RR	2N34	−25	(g)	50(50°C)	1	−6	1	40	40		0.5	30	24		GE	Audio
	2N36	−25	(g)	50(50°C)	1	−6	1	45	40		1	30	24		GE	Gen. purpose
	2N37	−25	(g)	50(50°C)	1	−6	1	30	36		1	30	24		GE	Switching
	2N38	−25	(g)	50(50°C)	1	−6	1	15	32		1	30	24		GE	Gen. purpose
	2N39	−30	(g)	50(50°C)	1	−4.5	1	32	39		0.5	30	24		GE	Gen. purpose
	2N40	−30	(g)	50(50°C)	1	−4.5	1	15-32	38		0.5	30	24		GE	Gen. purpose
	2N42	−30	(g)	50(50°C)	1	−4.5	1	9-15	36		0.5	30	24		GE	Gen. purpose
	2N93	−25	(g)	36(71°C)	1	−4.5	1	20-60	39		1	20	24		GE	Hi-temp. appl.
	RR14	−25	(g)	50(50°C)	1	−4.5	1	20-34	39		1.5	30	24		GE	Gen. purpose
	RR20	−25	(g)	50(50°C)	1	−4.5	1	45	41		1.5	30	24		GE	Gen. purpose
	RR34	−25	(g)	50(50°C)	1	−4.5	1	10-19	36		1.5	30	24		GE	Gen. purpose
	RR38		(g)												GE	Hearing aid
	RR83	−25	(g)	50(50°C)		−5		40-90					24	0.7	GE	Computer
	RR87	−25	(g)	50(50°C)	8	−4.5	8	35					24	0.5	GE	Computer
	RR106(a)	−25	(g)	50(50°C)		−12	0.8		21	200	2	1.2			GE(c)	Cl. B push-pull
	RR115	−25	(g)	50(50°C)	1	−4.5	1	15	36		1.5	30	30		GE	Gen. purpose
	RR117	−25	(g)	50(50°C)				40-90					24	1	GE	Computer
	RR122	−12	(g)	50(50°C)	1	−4.5	1	35					24	2	GE	Switching
	RR160	−12	(g)	50(25°C)	1	−4.5	1	30	31		0.5(i)	20(i)		5	GE	r-f, i-f
	RR161	−12	(g)	50(25°C)	1	−4.5	1	60	33		0.5(i)	20(i)		10	GE	r-f, i-f
	RR162	−6	(g)	50(25°C)	1	−4.5	1	150	34		0.5(i)	20(i)		20	GE	r-f, i-f
RAY	CK-721	−15	−10	180(25°C)	1	−6		45	41				22	0.8	GE	Gen. purpose
	CK-722	−22	−10	180(25°C)	1	−6		22	39				25	0.7	GE	Gen. purpose
	CK725	−12	−10	180(25°C)	1	−6		90	42				20	0.9	GE	Hi-gain
	CK727	−6	−10	180(25°C)	0.5	−1.5		25	36				10	0.8	GE	Low noise
	2N63	−22	−10	100(25°C)	1	−6		22	39				25	0.7	GE	Gen. purpose
	2N64	−15	−10	100(25°C)	1	−6		45	41				22	0.8	GE	Gen. purpose
	2N65	−12	−10	100(25°C)	1	−6		90	42				20	0.9	GE	High gain
	2N106	−6	−10	100(25°C)	0.5	−1.5		25	36				10	0.8	GE	Low noise
	2N112	−6	−5	100(25°C)	1	−6		40	32(f)					5	GE	Hi-frequency
	2N113	−6	−5	100(25°C)	1	−6		45	33(f)					10	GE	Hi-frequency
	2N114	−6	−5	100(25°C)	1	−6		65						20	GE	Hi-frequency
S	2N34	−25	−8	50(25°C)	1	−6		40	40		0.5	30	18	0.6	GE	Amp.
	2N35*	25	8	50(25°C)	−1	6		40	40		0.5	30	16	0.8	GE	Amp.
	2N94*	20	10	50(25°C)	−0.5	6			32		0.5	25	15	3	GE	Switching
	2N94A*	20	10	50(25°C)	−0.5	6			35		0.5	25	15	6	GE	Switching

Made By	Type No.
TI	200*
	201*
	202*
	210*
	220*
	221*
	222*
	223*
	300
	301
	350(a)
	X-2*
	X-59*
TP	X-22*
	X-23*
	X-27*
	X-102
TR	2N34
	2N36
	2N37
	2N38
	2N43
	2N43A
	2N44
	2N45
	2N63
	2N64
	2N65
	2N76
	2N85
	2N86
	2N87
	2N88
	2N89
	2N90
	2N91
	2N92
TS	DR-126
	DR-128
	DR-129
	DR-130
	DR-131
	DR-154
	DR-155
W	2N54
	2N55
	2N56
	2N73
	2N74
	2N75

Tetrode Transistors

GP	3N23
	3N23A
	3N23B
	3N23C
TI	700*

Maximum Ratings			Typical Operation												
V_c (volts)	I_c (ma)	W_c (mw)	I_c (ma)	V_c (volts)	I_c (ma)	α or β	PG (db)	PO (mw)	Z_S (kilohm)	R_L (kilohm)	NF (db)	F_{co} (Mc)	C	Application
30	5	50(25°C)	−1	5		9	37	2.15(l)	0.5	20	26	0.9	GE	Hi-gain audio
30	5	50(25°C)	−1	5		19	40	2.30(l)	0.5	20	23	1.1	GE	Hi-gain audio
30	5	50(25°C)	−1	5		49	43	2.38(l)	1.25	20	20	1.3	GE	Hi-gain audio
30	5	50(25°C)		22.5	2		39	12	0.5	10			GE	Audio
30	5	50(25°C)		22.5	0.7		31						GE	i-f amp.
30	5	50(25°C)		22.5	0.7		33						GE	i-f amp.
30	5	50(25°C)		22.5	0.7		35						GE	i-f amp.
30	5	50(25°C)		22.5	0.7								GE	Osc.-mixer
−30	−10	50(25°C)	1	−5		9					25		GE	Audio
−30	−10	50(25°C)	1	−5		19					20		GE	Audio
				12			20	500		0.5			CE	Aud. output
35	75	350(50°C)(m)		22.5	40		9.5	500		1			GB(c)	Med. power
10	8	50(75°C)				12-200		T_r = 1 μsec; T_c = 2 μsec				5	GE	Switching
40	5	50	1	4.5		0.9							GB	Amp.
40	5	50	1	4.5		0.95							GB	Amp.
40	5	50	1	4.5		0.8							GB	Amp.
−45	−50	500	75	−35	−25		10	300				0.01	GC	Power
−25	−20	125	1	−6	−1	55	41		1	30	20	0.8	GE	Hi-gain amp.
−25	−20	125	1	−6	−1	60	41		1	30	20	0.8	GE	Hi-gain amp.
−25	−20	125	1	−6	−1	38	37		1	30	22	0.6	GE	Medium gain
−25	−20	125	1	−6	−1	22	35		1	30	24	0.5	GE	Gen. purpose
−45	−50	375 (m)	1	−6	−1	50	40		1	30	20	0.7	GE	Hi-gain amp.
−45	−50	150(25°C)	1	−6	−1	45	40		1	30	10	1	GE	Hi-gain amp.
−45	−50	375	1	−6	−1	22	37		1	30	22	0.5	GE	Medium gain
−45	−50	375	1	−6	−1	19	33		1	30	22	0.4	GE	Gen. purpose
−45	−20	125	1	−6	−1	22	38		1	30	18	0.5	GE	Gen. purpose
−25	−20	125	1	−6	−1	45	39		1	30	16	0.7	GE	Medium gain
−25	−20	125	1	−6	−1	90	42		1	30	15	1	GE	High gain
−20	−10	125(25°C)	1	−6	−1	20	36				18	0.5	GE	Gen. purpose
−45	−100	750(25°C)(m)	10	−12	−10	45	33	1000(c)	2	0.8	20	0.8	GE	Med. power
−60	−100	750(25°C)(m)	10	−12	−10	25	30	1400(c)	2	1.2	20	0.8	GE	Med. power
−30	−100	750(25°C)(m)	10	−12	−10	25	30	500(c)	2	0.8	20	0.8	GE	Med. power
−12	−10	25(25°C)	0.5	−1.3	−0.5	35	39		.025	1.5	10	0.5	GE	Subminiature
−12	−10	25(25°C)	0.5	−1.3	−0.5	35	39		.025	1.5	20	0.5	GE	Subminiature
−12	−10	25(25°C)	0.5	−1.3	−0.5	50	30	1.5	1	0.6	20	0.5	GE	Subminiature
−15	500	500(25°C)(m)	1	−6	−1	40							GE	Switching
−25	200	500(25°C)(m)	1	−6	−1	50							GE	Switching
−10	8	50(25°C)		−1.5	0.01	0.96	33		1	30	14		GE	Hearing aid
−10	8	50(25°C)		−1.5	5	0.975	26	2.5	0.2	0.2	18		GE	Hearing aid
−25	8	50(25°C)		−1.5	0.01	0.97	35		1	30	18	0.9	GE	Gen. purpose
−25	8	50(25°C)		−1.5	0.01	0.93	27		1	30	21	0.5	GE	Gen. purpose
−25	8	50(25°C)		−1.5	0.01	0.87	24		1	30	24	0.4	GE	Gen.pur pose
−25	8	50(25°C)		−1.5	0.01	0.99	35		1	30	28	0.7	GE	High gain
−25	8	50(25°C)		−1.5	0.01	0.97	35		1	30	28	1.4	GE	R-F
−45	−100	200(25°C)		−20	−7.5	0.97	40		0.3	10		0.5	GE	Lo-power amp.
−45	−100	200(25°C)		−20	−7.5	0.95	36		0.3	10		0.5	GE	Lo-power amp.
−45	−100	200(25°C)		−20	−7.5	0.92	32		0.3	10		0.5	GE	Lo-power amp.
−20	−150	200(25°C)	Low frequency switching										GE	Switching
−50	−150	200(25°C)	Low frequency switching										GE	Switching
−20	−150	200(25°C)	Low frequency switching										GE	Switching
30	− 5	50(25°C)	2	22.5	1.3		12(r)		.025	9		15(s)	GB	H-F osc., amp.
30	− 5	50(25°C)	2	22.5	1.3		14(r)		.025	9		30(s)	GB	H-F osc., amp.
30	− 5	50(25°C)	2	22.5	1.3		15(r)		.025	9		40(s)	GB	H-F osc., amp.
30	− 5	50(25°C)	2	22.5	1.3		17(r)		.025	9		60(s)	GB	H-F osc., amp.
30		50(25°C)	−1	5		0.95							GE	A-G-C circuit

Made By	Type No.	Maximum Ratings V_c (volts)	I_c (ma)	W_c (mw)	Typical Operation I_c (ma)	V_c (volts)	I_c (ma)	α or β	PG (db)	PO (mw)	Z_S (kilohm)
Power Transistors (units with an output of one watt or higher. W_c and PO given in watts, R_L and Z_S in ohms. All rated with a heat sink.)											
A	2N115	−16	2000	3(60°)		−12	636	25	27	6	Class B,
MH	2N57	−60	1000	20(70°F)	550	28	500	0.86	16	6.25	23
	H1	−60	800	20(70°F)	460	28	400	0.8	15	5	20
	H2	−60	1400	20(70°F)	635	28	600	0.92	20	7.5	26
	H3	−60	350	5(70°F)	170	28	150	0.82	16	1.9	50
	H4	−60	500	5(70°F)	160	28	150	0.90	21	1.9	60
	P-11	−60	5000	60(70°F)	2130	28	2000	0.82	20	24	3.4
S	2N68	−25	1500	4(25°C)		−12	−550		15	5	50
	2N95*	25	1500	4(25°C)		12	550		15	5	50
	2N101	−25	1500	4(25°C)		−12	−550		15	5	50
	2N102*	25	1500	4(25°C)		12	550		15	5	50
TI	951*	50	60	1(25°C)		28			20	0.45	1
	952*	80	50	1(25°C)		45			21	0.6	1
	953*	120	40	1(25°C)		67.5			23	1	1
TP	X-78B	45	50	1	150	35	40		10	0.6	
	X-78C	45	50	1	150	35	40		10	0.6	
	X-78E	45	50	1	150	35	40		10	0.6	
	X-107	60	1000	2.25(25°C)	75	30		0.95	23	1	1.5
	X-120	60	1000	15(25°C)	500	30			23	5.3	0.8
	X-122	60	1000	7.5(25°C)	250	30			23	2.8	0.9
TR	2N83	−45	−1000	10(25°C)	100	−20	−100	20	30(n)	2.5(c)	100
	2N84	−30	−1000	10(25°C)	100	−20	−100	20	32(n)	2.0(c)	100
Point Contact Transistors—Triodes											
F	2N32	−40	− 8	50(30°C)		−25		2.2	21		0.3
	2N33	−85	− 7	30(30°C)		− 8	−3.3		22	1	0.5
H	A-0	−20	8	50(50°C)	0.3	− 8		2			
	A-1	−20	8	50(50°C)	0.3	− 8		2			
	A-2	−20	8	50(50°C)	0.3	− 8		2			
	A-3	−20	8	50(50°C)	0.3	− 8		2			
	S-0	−40	8	50(50°C)	T_r = 0.2 μsec; T_c = 1 μsec						
	S-1	−40	8	50(50°C)	T_r = 0.5 μsec; T_c = 2 μsec						
	S-2	−30	8	50(50°C)	T_r = 1 μsec; T_c = 6 μsec						
I	3X 100N	−50	30	150(40°C)	3	−3	−5				
	3X 101N	−50	30	150(40°C)	3	−3	−5				
SH	TS13	−30	−25	120	1.5	−5		>1.5	20		
	TS33	−100	−15	120	3	− 3	−5				
TP	2A	−50	− 8	120	1	−30		1.5	22		0.5
	2C	−50	− 8	100	2	−15		2			
	2D	−50	− 8	100	1	−30		1.5	22		0.5
	2E	−50	− 8	100	1	−30		1.5	22		0.5
	2G	−50	− 8	120	2	−15		2			
	2H	−50	− 8	100	1	−30		2	22		0.5
	2L	−50	− 8	50	1	−15		2.2	22		
	2N32	−40	− 8	50	0.5	−25		2.2	21		0.5
	2N33	−8.5	− 7	30	0.3	−8.5		2.3	22		0.5
	2N50	−15	− 1	50	2	−15		2	22		0.5
	2N51	−50	− 8	100	8	− 7		2.2			
	2N52	−50	− 8	120	1	−30		1.5	22		0.5
	2N53	−50	− 8	120	2	−15		2			
Silicon Transistors—Triodes (Silicon power types are listed under power transistors.)											
TI	903*	30	10	75(150°C)	−1	5		.90-.95			
	904*	30	10	75(150°C)	−1	5		.95-.975			
	905*	30	10	75(150°C)	−1	5		≥.975			
	904A*	30	10	75(150°C)	−1	5		≥.95			

Typical Operation						
PO (mw)	Z_g (kilohm)	R_L (kilohm)	NF (db)	F_c (Mc)	C	Application
6	Class B, push-pull			0.3	GE	
6.25	23	56		0.2	CE	
5	20	70		0.15	CE	
7.5	26	47		0.385	CE	
1.9	50	187			CE	
1.9	60	87			CE	
24	3.4	11		0.1	CE	
5	50	12(k)			GE(c)	
5	50	12(k)			GE(c)	
5	50	12(k)			GE(c)	
5	50	12(k)			GE(c)	
0.45	1	1.5			CE	(Silicon)
0.6	1	4			CE	(Silicon)
1	1	8			CE	(Silicon)
0.6				0.01	GB	
0.6				0.01	GB	
0.6				0.01	GE	
1	1.5	375			GB	
5.3	0.8	700			GB	
2.8	0.9	150			GB	
n) 2.5(c)	100	600		0.2	GE	
n) 2.0(c)	100	400		0.2	GE	
	0.3	31	40		GE	
1	0.5		40		GE	
				3	GB	Amp.
				2	GB	Amp.
				1	GB	Amp.
				0.3	GB	Amp.
μsec; T_c = 1 μsec					GB	Switching
μsec; T_c = 2 μsec					GB	Switching
μsec; T_c = 6 μsec					GB	Switching
				2		Switching
			50	0.4		Amp.
						Switching
	0.5	15			GB	Amp., osc.
					GB	Switch
	0.5	15		2(o)	GB	Amp., osc.
	0.5	15			GB	Amp.
				10(p)	GB	Switch
	0.5	15			GB	Amp.
				5	GB	Switch
	0.5	20		2.7	GB	Switch
	0.5	20		3(o)	GB	Switch
	0.5	15		3(o)	GB	Switch
				(P)	GB	Switch, osc.
	0.5	15		1	GB	Amp., osc.
				5(q)	GB	Switch
			23	3	GB	Hi-gain, lo-level
			23	3	GB	Hi-gain, lo-level
			23	3	GB	Hi-gain, lo-level
			23	>8	GB	Hi-gain, lo-leve

A.....Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N. Y.

CBS....CBS-Hytron, Division of Columbia Broadcasting System, Danvers, Mass.

F.....Freteo, Inc., 406 N. Craig St., Pittsburgh 13, Pa.

GE.....General Electric Co., Electronics Park, Syracuse, N. Y.

G.....General Transistor Corp., 95-18 Sutphin Blvd., Jamaica 35, N. Y.

GP.....Germanium Products Corp., 26 Cornelison Ave., Jersey City 4, N. J.

H.....Hydro-Aire, Inc., 3000 Winona Ave., Burbank, Calif.

I.....International Standard Trading Corp., 22 Thames St., New York 6, N. Y. (Imported)

MH....Minneapolis-Honeywell Regulator Corp., 2747 Fourth Ave. S., Minneapolis, Minn.

NU.....National Union Electric Corp., 350 Scotland Rd., Orange, N. J.

P.....Philco Corp., Government & Industrial Div., 4700 Wissahickon Ave., Philadelphia 44, Pa.

RCA....Radio Corporation of America, Tube Dept., Harrison, N. J.

RR.....Radio Receptor Co., 251 W. 19th St., New York 11, N. Y.

RAY....Raytheon Manufacturing Co., 55 Chapel St., Newton, Mass.

S.....Sylvania Electric Products Co., 1740 Broadway, New York 19, N. Y.

SH.....Siemens & Halske, Germany. Available from Metropolitan Overseas Supply Corp., 1133 Broadway, N. Y. 10, N. Y.

TI.....Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Texas

TP.....Transistor Products, Inc., 241-253 Crescent Street, Waltham 54, Mass.

TR.....Transitron Electronic Corp., 403 Main St., Melrose 76, Mass.

TS.....Tung-Sol Electric Inc., 95 Eighth Ave., Newark 4, N. J.

W.....Westinghouse Electric Corp., Electronic Tube Div., P. O. Box 284, Elmira, N. Y.

Footnotes

* n-p-n

(a) Available in matched pairs. Power output (PO) indicated is for a pair.

(b) Measured with Z_g = 1000 ohms; R_L = 20,000 ohms; f = 1000cy.

(c) Push-pull, Class B.

(d) These types have the same electrical characteristics, but the higher number units are in a smaller case.

(e) Measured with Z_g = 1000 ohms; R_L = 20,000 ohms, and f = 1500cy.

(f) Measured at 455kc.

(g) As limited by dissipation.

(h) Frequency maximum.

(i) Per transistor.

(j) Per base connection.

(k) Per collector.

(l) Measured with R_L = 5000 ohms and a high Z_g.

(m) With heat sink.

(n) Measured with R_g = 25 and R_L = 1500 ohms.

(o) T_r = 0.2μsec.

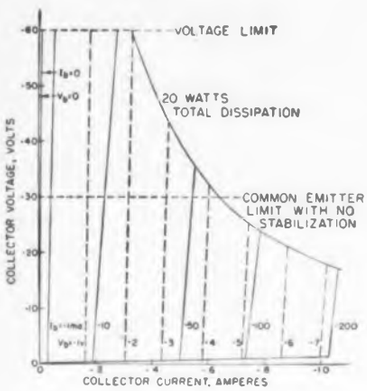
(p) T_r = 0.1μsec.

(q) T_r = 0.15μsec.

(r) Measured at 5Mc.

(s) Oscillation frequency.

High current values— a Honeywell feature

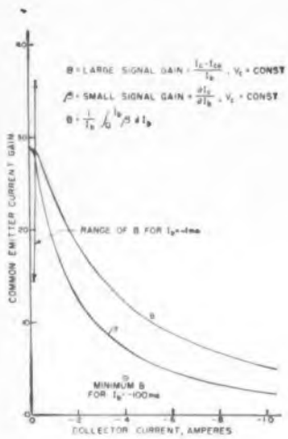


Common emitter characteristics, 2N57

(Mounting base temperature 70°F, 60 cycle oscilloscope pattern.)

Not in the development stage, but stocked in quantity

Power Transistors available now



Common emitter current gain, 2N57

(Mounting base temperature 70°F, Vc=2v)

Typical operating conditions, 2N57

(Common emitter, transformer output, 28 volt supply, mounting base temperature 70°F.)

Peak Collector Current (amperes)	Class A Single Unit		Class B Push pull—2 units	
	Output (watts)	Gain (db)	Output (watts)	Gain (db)
—.2	1.25	29	2.5	26
—.4	2.5	23	5.0	20
—1.0	6.25	16	12.5	13

Honeywell Line of Power Transistors

Other transistors are available with the same voltage ratings as the 2N57. All the transistors below can withstand 60-volt peaks and therefore can operate in voltage-doubling transformer circuits with 28-volt supplies. Ratings are at 70°F. base temperature.

TYPE	H-1	2N57	H-2	H-3	H-4
OUTPUT IN WATTS AT MAX. COLLECTOR CURRENT	5.0	6.25	8.5	2.0	2.0
GAIN	15db	16db	18db	16db	21db

Quality power transistors you can order and get in any quantity—that's one big advantage Honeywell transistors offer. You can design circuits around them and *count on delivery.*

No other manufacturer has such a line available with such large current values.

Typical of the line is the 2N57 you see above—Germanium, P-N-P, alloyed junction, hermetically sealed. Maximum junction temperature is 200°. Thermal resistance is 6.5°F/watt from junction to the mounting base.

Another in the line—the H-2—gives a greater output per dollar than any other transistor.

To date Honeywell has shipped transistors to nearly 400 companies, most of them leaders of the electronics industry.

For further information on the Honeywell transistor line, prices and ordering procedures, write or wire Honeywell, Dept. ED-7-121, Minneapolis 8, Minn.

Technical papers ("Germanium Power Transistors" and "Power Transistor Temperature Rating") are available for the asking.

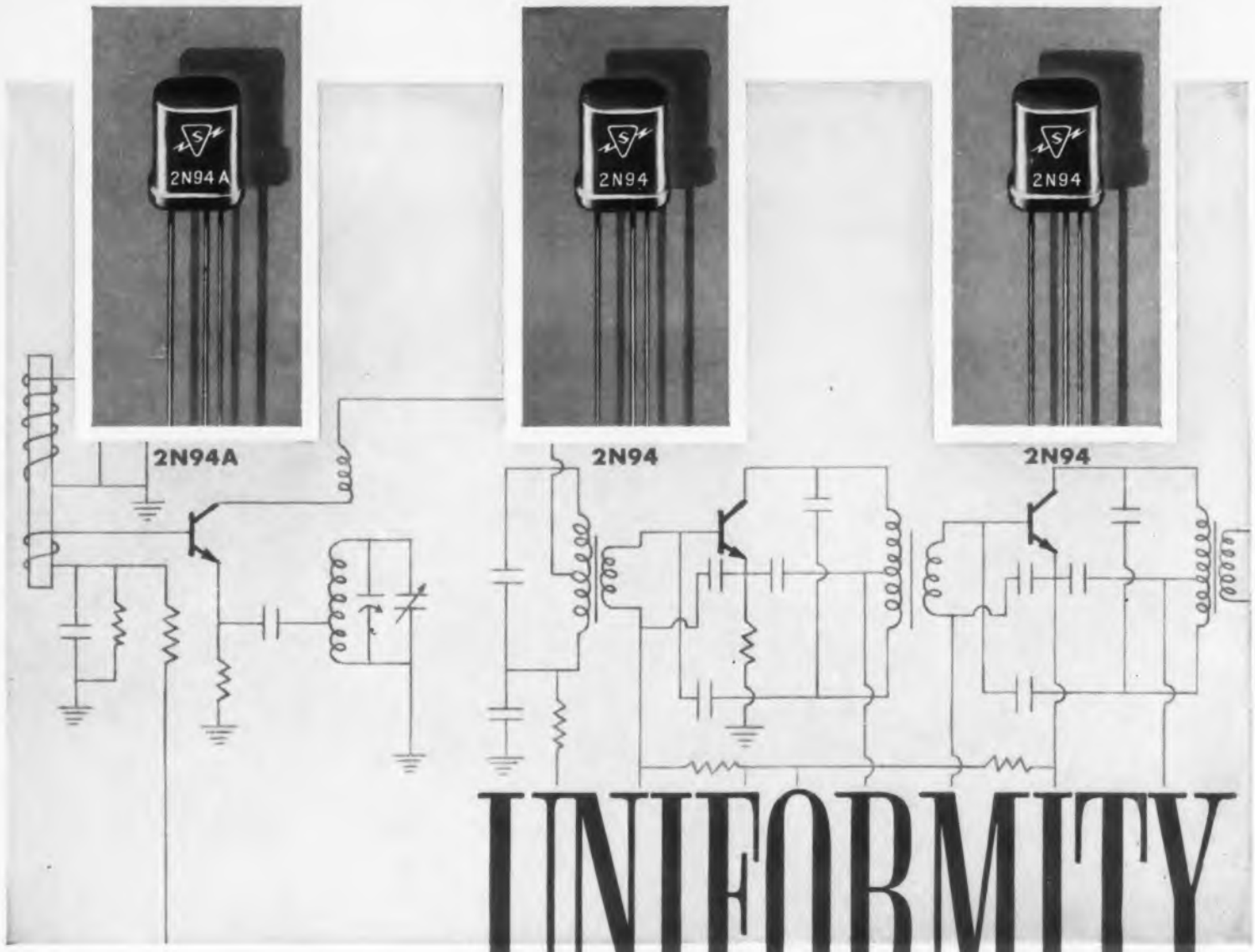
MINNEAPOLIS **Honeywell**

H HONEYWELL

Transistor Division

Minneapolis • Chicago • Union, N. J. • Los Angeles

CIRCLE ED-101 ON READER-SERVICE CARD FOR MORE INFORMATION



UNIFORMITY

...for more gain from stage to stage without preselecting

For your broadcast applications, Sylvania high frequency transistors Type 2N94 and 2N94A offer higher gain without preselection by stage. Production is simplified; performance is more stable; servicing problems are minimized.

Low collector capacitance and ease of neutralization account for this important advantage. In a typical broadcast application, the addition of a single 10 μμf capacitor in the collector circuit of IF and RF stages provides adequate neutralization.

Uniformity is obtained through unique construction techniques permitting close production control.

In computer applications Sylvania Transistors offer quick recovery time for high speed switching and provide higher gains at higher operating currents.

High Frequency Transistors
Type 2N94 (3 mc alpha cutoff)
Type 2N94A (6 mc alpha cutoff)
featuring
- high gain
- high uniformity
- low collector capacity
- ease of neutralization

Low Frequency—High Gain
Type 2N34 (PNP)
Type 2N35 (NPN)
—for low to medium power use. Gains up to 40 db in grounded emitter circuit

High Power—Low Frequency
Type 2N68 (PNP)
Type 2N95 (NPN)
—increased power ratings—to 2.5 watts. Use for high current, low voltage applications (6—24 volt power supplies)
Type 2N101 (PNP)
Type 2N102 (NPN).
Similar to types 2N68 and 2N95 without cooling fins. Power dissipation 1 watt.

For complete information on Sylvania Transistors write to Department G22R.

"Another reason why it pays to specify Sylvania"

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC., 1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd., University Tower Building, Montreal

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

CIRCLE ED-102 ON READER-SERVICE CARD FOR MORE INFORMATION

Components an Test Equipment for Transistors

Components Designed for Transistor Circ

Component	Use/Characteristic
Batteries	
zinc carbon	transistor power supplies
mercury	transistor power supplies
Capacitors	
ceramic	submin. coupling type; 25wvdc
electrolytics—tantalum or aluminum, miniature and subminiature	by-pass, filtering; high capacity—low voltage
variable	broadcast tuning
Coils*	
antenna	loop—broadcast band
i-f transformer	tapped for impedance matching, adjustable, 262 & 455kc
oscillator	for broadcast superhets
toroids	to 2h, ⅜"OD x ¼" deep
Crystals	
quartz	oscillator, 100kc ±2cy
Loudspeakers	
pm; low impedance	16 ohms, 1⅛" deep by 2¾" dia.
pm; high impedance	800 ohms, center-tapped coil
Microphone	
magnetic	hearing-aid type; 1000-2000 ohm
Resistors**	
deposited carbon	stable type, 1/10w, 50 ohm to 1 megohm
molded composition	general purpose, 1/10w, 0.140" lg, 0.015" dia.
trimmer, printed ceramic	volume control, units to 625k
Sockets	
5 contact, RETMA	general purpose & special mtg.
Transformers*	
chokes	general purpose
driver	push-pull type
input	high-impedance primary
interstage	20,000 ohm—primary winding
output	500-1000 ohms primary
power	for junction transistor oscillator

* Code numbers indicate manufacturers stocking this item. to customers specifications.

** Consult also manufacturers of MIL-R-10509A, DC-⅛ typ of miniature ⅛w resistors.

ts and ment tors

POWER, current, and voltage ratings of components for transistor circuits can often be reduced. This results in smaller component sizes comparable to transistors themselves. Because transistors have more parameters affecting circuit design than electron tubes, and because they operate at lower voltages special test equipment and power supplies are necessary to facilitate performance analysis.

Tabulated, here, are a variety of circuit components, test equipment and power supplies designed especially for transistors. The list is not complete as new products for transistor work are being announced each week. Tiny potentiometers, resistors, ceramic capacitors, switches, and connectors produced for miniaturization in general and printed circuits in particular are eminently suited for transistor circuits, but our tabulation includes only those miniaturized items that have either low voltage ratings not generally suited for tube circuits or impedance ratings that match transistors only. Not included are products which transistor manufacturers use such as cases, cat-whiskers, germanium pellets, etc. Also not included is a growing list of light-weight transistorized power supplies intended for transistorized equipment.

The listing of test equipment and laboratory power supplies is quite complete so far as we know. Space limitations prevented including all the pertinent information and engineers are urged to contact manufacturers for more details. Space limitations also forced us to identify the numerous manufacturers by a code. Complete names and mailing addresses are given in the manufacturer's index to the right.

or Transistor Circuits

aracteristic	Manufacturer
upplies	*BB, GDB, NC*
upplies	*GDB, NC, MAL*
ype; 25wvdc	*MU*
high capacity—low	*AS, CD, FM, GE, IC, MAL, SPR*
	GI, RC
band	*MI*
dance matching,	*MI, SI, V*
& 455kc	
erhets	*MI, SI, V*
¼" deep	*FOR*
±2cy	*L*
deep by 2¾" dia.	*J*
tapped coil	*U*
1000-2000 ohm	*KN*
10w, 50 ohm to 1	*GL*
1/10w, 0.140" lg,	*AB*
its to 625k	*CEN*
¾ special mtg.	*CJ, H*
	MT, TI
	CP, FL, FTC, MT, U
primary	*CTC, CP, FTC, NET, MT, TI*
mary winding	*CTC, CP, FTC, KES, NET, MT, TE, TI, TT*
primary	*CTC, CP, FL, FTC, GH, NET, MT, TI, U*
stor oscillator	*FL*

stocking this item. Most other types made

10509A, DC-⅛ types for additional sources

Transistor Test Equipment

Name	Description	Manufacturer
Small Signal Analyzers		
Test Set, Model GP	Measures directly all *h* and equiv. *t* resistances. Measures α, β, C_c, $f\alpha_c$, I_{co}, voltage feedback ratio and channel effect voltage	Baird Assoc.
Test Set, Type 210	Measures *h* parameters including r_{11}, , y_{22}, α, I_{co}	Owen Labs
Test Set, Model T-62	Measures h_{11}, h_{12}, h_{22}, α, 1-α, and static values	Scientific Specialties
Analyzer, Model JHI	Measures h_{21}, I_{co} for various biases	Quantum
	See Transistor Analyzers Models TA-1 and TA-4 below	
Curve Tracers		
Dynamic Analyzer	Provides swept current gain, collector, transfer, and emitter characteristic measurements	Fairchild Engine
Curve Plotter	Plots input, transfer, and output on X-Y pen recorder	Kay Electric
Curve Tracer	Plots family of collector or feedback transfer curves	Magnetic Amplifier
Analyzer, Model TA-1A	Measures α, β. Plots α vs. I_e and β vs. I_b	Polyphase Instr.
Analyzer Model TA-2	Traces neg. resistance of point contact types. Traces collector, transfer, emitter characteristics	Polyphase Instr.
Analyzer Model TA-3	Displays r_{12}, r_{22}, h_{12}	Polyphase Instr.
Analyzer Model TA-4	Presents α and β vs. frequency	Polyphase Instr.
Testers		
Semi-Conductor Tester, Model JR1	Determines conductivity (n or p) of sample	Baird Assoc.
Transistor Tester	Tests current gain. Includes 270cy osc.	Devenco
Comparison Tester, Model TT-11A	Compares r_e, r_b, r_c, gain and stability with standard transistor	Electronic Research
Alpha Tester, Model AT-10	Direct reading of α and β and α cut-off vs. bias	Electronic Research
Noise Figure Meters		
N F Meter, Model NFC-1A	Automatically measures noise figure, 5 to 65 db	Electronic Research
Noise Figure Test Set	Shows noise figure directly on 5-25 or 25-45 db range. Agc.	Radio Receptor
Miscellaneous		
Semi-Conductor Minority Carrier Lifetime Test Set, Model JJ1	Measures exponential increase as carriers recombine when pulse of light is removed	Baird Assoc.
Semi-Conductor Resistivity Test Set, Model JN1	Measures resistivity of semi-conductor in range of 0.1-100 ohms/cm.	Baird Assoc.

Power Supplies for Transistors

Name	Description	Manufacturer
Power Unit, Model 212-A	0-100v d-c output at 100 ma. Regulated output can be regulated	Electronic Measurements
Power Supply, Model 210	Adjustable constant voltage and constant current	Electronic Research
High Current P. S., Model 30	1.5 amp max., 30va capacity. Tubeless supply	Electronic Research
Dual Supply, Model 110	Dual d-c output for any combination of emitter or collector bias	Electronic Research
Voltage Regulated P. S., Model 4500	Two identical regulated d-c outputs. Regulated	Kepco Laboratories
Power Supply, Model UHR-220	Ultra-high regulation at low voltages. Low internal impedance	Krohn-Hite Instr.
Power Supply, Model DV60-1	0-60v d-c. Stable at low voltages	Model Rectifier
Twin Power Supply, Model TR-200AT	Dual output precision regulated	Universal

Components and Test Equipment for Transistors

POWER, current, and voltage ratings of components for transistor circuits can often be reduced. This results in smaller component sizes comparable to transistors themselves. Because transistors have more parameters affecting circuit design than electron tubes, and because they operate at lower voltages special test equipment and power supplies are necessary to facilitate performance analysis.

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zinc carbon	transistor power supplies	*BB, GDB, NC*
mercury	transistor power supplies	*GDB, NC, MAL*
Capacitors		
ceramic	submin. coupling type; 25wvdc	*MU*
electrolytics—tantalum or aluminum, miniature and subminiature	by-pass, filtering; high capacity—low voltage	*AS, CD, FM, GE, IC, MAL, SPR*
variable	broadcast tuning	*GI, RC*
Coils*		
antenna	loop—broadcast band	*MI*
i-f transformer	tapped for impedance matching, adjustable, 262 & 455kc	*MI, SI, V*
oscillator	for broadcast superhets	*MI, SI, V*
toroids	to 2h, ⅝"OD x ¼" deep	*FOR*
Crystals		
quartz	oscillator, 100kc ±2cy	*L*
Loudspeakers		
pm; low impedance	16 ohms, 1⅛" deep by 2¾" dia.	*J*
pm; high impedance	800 ohms, center-tapped coil	*U*
Microphone		
magnetic	hearing-aid type; 1000-2000 ohm	*KN*
Resistors**		
deposited carbon	stable type, 1/10w, 50 ohm to 1 megohm	*GL*
molded composition	general purpose, 1/10w, 0.140" lg, 0.015" dia.	*AB*
trimmer, printed ceramic	volume control, units to 625k	*CEN*
Sockets		
5 contact, RETMA	general purpose & special mtg.	*CJ, H*
Transformers*		
chokes	general purpose	*MT, TI*
driver	push-pull type	*CP, FL, FTC, MT, U*
input	high-impedance primary	*CTC, CP, FTC, NET, MT, TI*
interstage	20,000 ohm—primary winding	*CTC, CP, FTC, KES, NET, MT, TE, TI, TT*
output	500-1000 ohms primary	*CTC, CP, FL, FTC, GH, NET, MT, TI, U*
power	for junction transistor oscillator	*FL*

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Twin Power Supply, Model TR-200AT	Dual output precision regulated	Universal

items that have either
suited for tube circuits
transistors only. Not
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Assoc.

Manufacturer

nic Measurements
nic Research
nic Research
nic Research
Laboratories
-Hite Instr.
Rectifier
sal

AB.....Allen-Bradley Co.,
136 W. Greenfield Ave.,
Milwaukee 4, Wis.

AS.....Astron Corp.,
255 Grant Ave.,
East Newark, N. J.

BA.....Baird Associates, Inc.,
33 University Rd.,
Cambridge 38, Mass.

BI.....Barco, Inc.,
Milwaukee 1, Wis. (Imported)

BB.....Burgess Battery Co.,
Freeport, Illinois

CEN...Centralab,
Div. of Globe Union, Inc.,
914Y E. Keefe Ave.,
Milwaukee 1, Wis.

CTC...Chicago Standard
Transformer Corp.,
3580 Elston Ave.,
Chicago 18, Ill.

C-J....Cinch Mfg. Corp.,
10265 Homan Ave.,
Chicago 24, Ill.

CP.....Columbia Process Co., Inc.,
Columbus, Indiana

C-D....Cornell Dubilier Elec. Corp.,
South Plainfield, N. J.

D.....Devenco, Inc.,
150 Broadway,
New York 38, N. Y.

EMC...Electronic Measurements
Co., Inc.,
Lewis St. & Maple Ave.,
Eatontown, N. J.

ERA....Electronic Research
Associates, Inc.,
Box 29, Caldwell, N. J.

FEA....Fairchild Engine & Airplane
Corp., Guided Missile Div.,
Wyandanch, N. Y.

FM.....Fansteel Metallurgical Corp.,
2200 Sheridan Rd.,
North Chicago, Ill.

FOR...Forrest Mfg. Co.,
Culver City, Calif.

FL.....Fortiphone, Ltd.,
247 Regent St., W 1,
London, England (Imported)

FTC...Freed Transformer Co., Inc.,
1736 Weirfield St.,
Brooklyn 27, N. Y.

GDB....General Dry Batteries, Inc.,
Cleveland, Ohio

GE.....General Electric Co.,
Electronics Park,
Syracuse, N. Y.

GI.....General Instrument Corp.,
829 Newark Ave.,
Elizabeth 3, N. J.

GL.....Glenco Corp.,
Metuchen, N. J.

GH.....Gramer Halldorson
Transformer Corp.,
2734 N. Pulaski Rd ,
Chicago 39, Ill.

H.....Hydro-Aire, Inc.,
3000 Winona Ave.,
Burbank, Calif.

IC.....Illinois Condenser Co.,
1616 N. Throop St.,
Chicago 22, Ill.

J.....Jensen Mfg. Co.,
6601 S. Laramie Ave.,
Chicago 38, Ill.

KAY...Kay Electric Company,
14 Maple Ave.,
Pine Brook, N. J.

K.....Kepco Labs.,
131-38 Sanford Ave.,
Flushing 55, N. Y.

KES....Kessler Co., Frank,
41-45 47th St.,
Long Island City 4, N. Y.

KN.....Knowles Electronics, Inc.,
9400 Belmont Ave.,
Franklin Park, Ill.

K-H.....Krohn-Hite Instrument Co.,
580 Massachusetts Ave.,
Cambridge 39, Mass.

L.....Lewis Co., E. B.,
11 Bragg St.,
East Hartford, Conn.

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

MAL....Mallory & Co., Inc., P. R.,
3029 E. Washington St.,
Indianapolis 6, Ind.

MT.....Microtran Co.,
84-13 Rockaway Beach Blvd.,
Rockaway Beach 93, N. Y.

MI.....Miller Co., J. W.,
5917 S. Main St.,
Los Angeles 3, Calif.

MR.....Model Rectifier Corp.,
557 Rogers Ave.,
Brooklyn 25, N. Y.

MU.....Mucon Corp.,
9 St. Francis St.,
Newark 5, N. J.

NC.....National Carbon Co.,
30 E. 42nd St.,
New York 17, N. Y.

NET....New England
Transformer Co.,
Somerville, Mass.

O.....Owen Laboratories,
412 Woodward Blvd.,
Pasadena 10, Calif.

PI.....Polyphase Instrument Co.,
705 Haverford Rd.,
Bryn Mawr, Pa.

Q.....Quantum Electronics, Inc.,
1921 Virginia St.,
Albuquerque, N. M.

RC.....Radio Condenser Co.,
Camden, N. J.

RR.....Radio Receptor Co., Inc.,
251 W. 19th St.,
New York 11, N. Y.

SS.....Scientific Specialties Corp.,
Snow & Union Sts.,
Boston 35, Mass.

SI.....Sickles, F. W., Div.,
165 Front St.,
Chicopee, Mass.

SPR....Sprague Electric Co.,
North Adams, Mass.

TE.....Telex, Inc.,
Telex Park, St. Paul, Minn.

TI.....Texas Instruments, Inc.,
6000 Lemmon Ave.,
Dallas 9, Texas

TT.....Triad Transformer Corp.,
4055 Redwood Ave.,
Venice, Calif.

UE.....Universal Electronics,
2012 So. Sepulveda Blvd.,
Los Angeles, Calif.

U.....Utah Radio Products Co., Inc.,
1123 E. Franklin St.,
Huntington, Indiana

V.....Vokar Corp.,
7300 Huron River Drive,
Dexter, Mich.

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CIRCLE ED-103 ON READER-SERVICE CARD ➤

Wheatstone Bridge

A Portable "Fault Locator"

This Wheatstone and "Fault Locating Bridge" is engineered for rough use in the field, yet offers excellent readability with high accuracy and reliability. It is supplied in a strong, lightweight, weatherproofed case. Direct straight line readings are made on a "Dekadial".

As a Wheatstone Bridge, resistance within a 0 to 1.2 megohm range can be measured directly. For fault locating measurements, Varley Loop ratios offered by the instrument are 1/1, 1/4, and 1/9; Murray Loop ratios include 10, 100, and 1000. Extra features include a loop selecting switch arrangement built directly into the "Dekadial", and a battery reversing switch to check error from external line voltage sources. Battery power is used only when the galvanometer pushbuttons are depressed; these buttons can be locked. Provisions are made for the use of an external galvanometer and batteries when necessary. Electro-Measurements, Inc., Dept. ED, 4312 S. E. Stark St., Portland 15, Ore.

CIRCLE ED-112 ON READER-SERVICE CARD FOR MORE INFORMATION

Metallized-Paper Capacitor

With Molded Plastic Shell

This metallized-paper, molded-plastic, miniature tubular capacitor, "The Comet", combines the operating characteristics of a metallized - paper capacitor with the protection of a molded plastic shell and bonded seal. It possesses properties that provide extra protection against overloads and momentary surges.

Metallized-paper construction results in small size and light weight with low r-f impedance. A new, solid thermosetting impregnant provides high dielectric strength and improved insulation resistance. The capacitor operates dependably up to 125°C, and the shell and seal are immersion-proof and impervious to extremes of heat, cold and moisture. Leads cannot pull out or melt out. Every unit is individually tested and guaranteed. Astron Corp., Dept. ED, 255 Grant Ave., E. Newark, N. J.

CIRCLE ED-113 ON READER-SERVICE CARD FOR MORE INFORMATION

Encapsulating Compounds
Three Types Available

New encapsulating compounds are available in three distinct types and formulae—transparent, flexible, and foam. The transparent compound is quick setting in 15 minutes at a temperature of 180°F, is inexpensive, and is easily released from the molds.

The flexible compound is an epoxy formulation that features variable flexibility, and is considerably less expensive than other epoxy formulations. Telectro Industries Corp., Dept. ED, 35-18 37th St., Long Island City 1, N. Y.

CIRCLE ED-115 ON READER-SERVICE CARD

Electrostatic Sealing Strip
For Sealing and Shielding

A new dual-purpose electrostatic sealing strip for access doors and panels of electronic apparatus is available in various widths and thicknesses. It consists of a strip of pliable Neoprene, to one or both edges of which is bonded a margin of finely woven, crushed, silver-plated wire which served as an effective electrostatic continuity medium. Industrial Rubber Products Div., Oliver Tire & Rubber Co., Dept. ED, 4341 San Pablo Ave., Oakland 8, Calif.

CIRCLE ED-116 ON READER-SERVICE CARD

Insulation Tape
Has Improved Adhesiveness

Designated "Scotch" brand electrical tape No. 39, the improved thermosetting paper tape features a pressure-sensitive adhesive that sticks tight on contact with 50% more "grab" than its predecessor.

The improved tape is thinner in construction being only 5 mils thick. The dielectric strength is 1500v; tensile strength is 45 lb per inch of tape width; insulation resistance is 10 megohms at 96% relative humidity, and the electrolytic corrosion factor is 0.95. Minnesota Mining and Manufacturing Co., Dept. ED, Dept. E5-33, St. Paul, Minn.

CIRCLE ED-117 ON READER-SERVICE CARD

Frequency Counter

Has Direct Digital Readout

The DS-6100-T Frequency Counter is designed for direct measurement of any electrical, mechanical, or optical phenomena which can be converted to varying voltage. Engineered to read out in direct digital form, it requires no interpolation or reference to curves or tables. Simplicity of operation makes it ideal for use by unskilled as well as skilled personnel.

With the high accuracy of $\pm 10\mu$sec over the frequency range of 1-10,000 events/sec, the unit will also measure frequencies from 10,000-100,000 with an accuracy of ± 1 count ± 1 part in 100,000 (one part in 1,000,000 with crystal oven).

Features include: a 10-cycle gate for increasing accuracy of period measurement; batch counting; and multi-sampling (manually scanning the unknown frequency for any multiple of the time base for greater accuracy). The DS-6100-T operates on 117v $\pm 10\%$, 50-60cy (50-400cy optional) power. Size is only 14-1/4" x 7-1/2" x 13-1/2", and weight is approximately 28 lb. The Computer-Measurements Div., Detectron Corp., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

CIRCLE ED-118 ON READER-SERVICE CARD FOR MORE INFORMATION

Pads and Terminations

Uses Type C and N Connectors

This complete line of Coaxial Attenuator Pads and Line Terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles; either male or female connectors can be mounted on the same pad so that it may serve as an adapter as well as an attenuator.

Characteristic impedance is 50 ohms, with attenuation available in any value from 0.1 to 60db. The vswr is less than 1.2 from d-c to 3000Mc for all values of attenuation from 10 to 60db. As the value decreases below 10db, the vswr increases to not over 1.5. Resistive T-section circuits are utilized in all pads except in the range of 0.1 to 1.0db. These units use series resistive elements. Pads and terminations are conservatively rated to handle 1w average power dissipation. Stoddart Aircraft Radio Co., Inc., Dept. ED, 6644 Santa Monica Blvd., Hollywood 38, Calif.

CIRCLE ED-119 ON READER-SERVICE CARD FOR MORE INFORMATION

CIRCLE ED-120 ON READER-SERVICE CARD FOR MORE INFORMATION

Junction Transistor
For Audio Applications

The *2N104* is a germanium alloy-junction transistor of the p-n-p type for low-power audio applications. It has been carefully designed and manufactured for extreme stability, very low leakage currents, and excellent uniformity of characteristics throughout its life.

The *2N104* features a low base-lead resistance which improves frequency response, among other things. In a common-emitter circuit, the 2N104 has a collector-to-base current amplification ratio of 44; a matched-impedance, low-frequency power gain of 40db; and a collector-to-base alpha frequency cutoff of 13.9kc. It has a low noise factor of only 12db.

The collector dissipation rating of the *2N104* is given in terms of associated circuitry, electrical operating conditions, and ambient temperature. It is in the order of 35mw.

The unit is hermetically sealed, utilizes an insulated metal envelope, and has a linotetrar 3-pin base. It is 1/4" in diameter and 11/16" in overall length. Radio Corp. of America, Dept. ED, Harrison, N. J.

CIRCLE ED-122 ON READER-SERVICE CARD FOR MORE INFORMATION

Sensitive Amplifier
With Gain of 10,000

The Model BL-550 is a high-sensitivity d-c recording amplifier with a gain of 10,000. It is a sturdy, direct-coupled amplifier employing a chopper stabilized feedback circuit that eliminates the need for matched tubes. This circuit permits extended frequency response. When used with Brush direct-writing oscillographs, the frequency response is d-c to 100cy. In its application to photographic equipment, the frequency range can be extended to 5000cy.

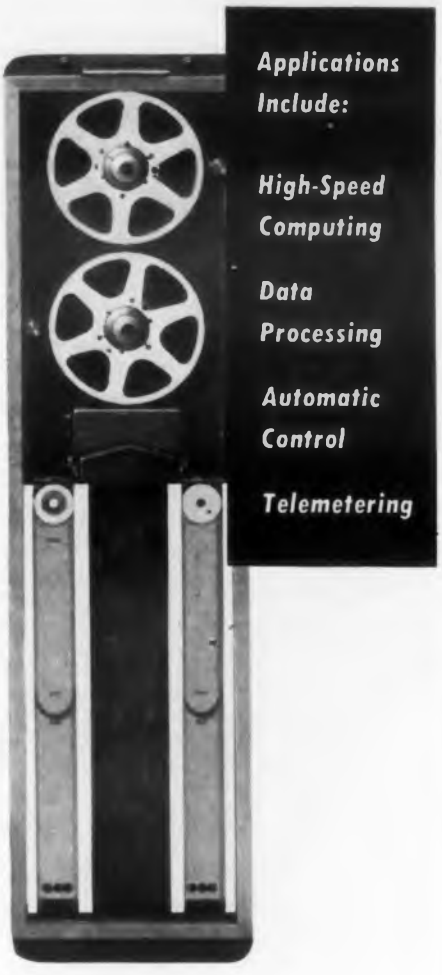
Measurement range covers a spread from 100μv to 500v, and maximum sensitivity in use with an oscillograph is 100μv per chart millimeter. High stability in use is demonstrated by its less than one-quarter of a chart millimeter drift per hour. Brush Electronics Co., Dept. ED, 3405 Perkins Ave., Cleveland 14, Ohio.

CIRCLE ED-123 ON READER-SERVICE CARD FOR MORE INFORMATION

DataReader

Model 546

A transport unit for high speed searching, reading and recording of data on magnetic tape.



PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.

END-OF-TAPE SENSING—stops automatically at either end of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

FOR FURTHER INFORMATION WRITE
ElectroData Corporation
Component Sales Division
717 No. Lake St., Pasadena 6, Calif.

ElectroData

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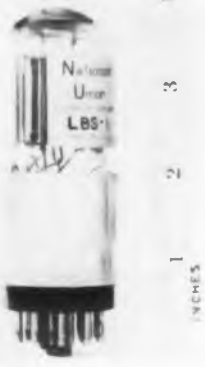
ElectroData Corporation maintains a nation-wide sales and service organization.

CIRCLE ED-125 ON READER-SERVICE CARD

Line Beam Switch Tube

For Analog to Digital Translation



The LBS-1 Line Beam Switch Tube is intended for high-speed commutation of a single electron beam source to a multi-anode target. The beam switching is proportional to the electrostatic deflection and thus permits analog-to-digital translation. The output secured from each target anode is of positive polarity and in many applications is of sufficient amplitude to permit gating without preamplification and phase inversion.

Ten separate output anodes are provided, and outputs of 35v peak from each anode are obtainable across 100K load resistors. Less than 10 anodes may be employed in the operation of this tube by placing the unused anodes at B plus.

The tube is in a T-11 bulb and has a maximum overall length of only 4.25". Under normal 300v operation with 6ma of cathode current, the 10 output anodes can be swept with a deflection voltage of 60v. National Union Electric Corp., Dept. ED, 405 Lexington Ave., New York, N. Y.

CIRCLE ED-126 ON READER-SERVICE CARD FOR MORE INFORMATION

Frequency Meter

For 100-10,000Mc Range

The Type 504 Heterodyne Frequency Meter is engineered for precise measurement of frequencies of 100 to above 10,000Mc. It features a direct-reading dial, visual and aural zero-beat check, crystal calibration, and sensitivity of better than —30dbm at 500Mc and above. An easy-to-operate instrument, it consists of a 500 to 900Mc heterodyne oscillator, high-gain 1Mc video amplifier, 5 and 50Mc crystal calibrators, harmonic generators and a cathode-ray tube. Zero beat between heterodyne oscillator and signal fundamental or harmonic is rapidly located with a CRO or headphones.

Accuracy is 0.004% at the 5Mc check points. The 5Mc crystal oscillator is temperature controlled. Interpolation accuracy is better than 0.02%, and resetability of oscillator is 0.02%. A trimmer adjustment is provided for zero-beating with WWV. Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

CIRCLE ED-127 ON READER-SERVICE CARD FOR MORE INFORMATION

(See you at the Wescon Show, Booth 1417-18)

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GYROS • SYNCHROS • SERVO MOTORS

From the time drafting pencil first touches paper until the inspector okays the finished product, every step we take with E-P precision components is geared directly to conform with Military Specifications.

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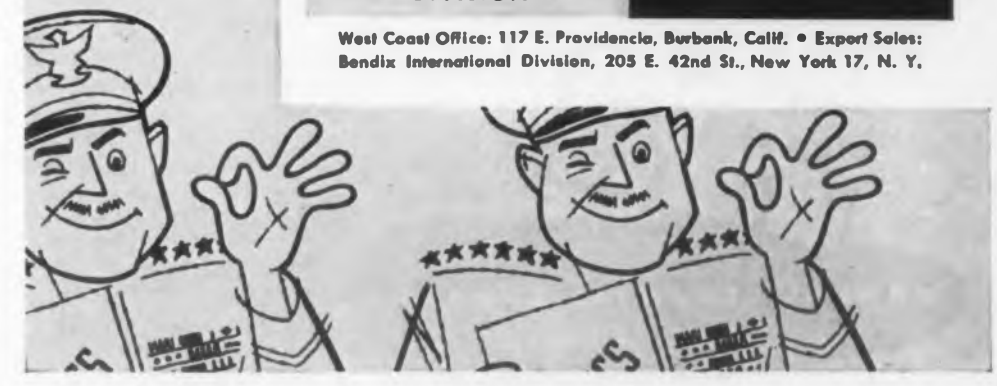
West Coast Office: 117 E. Providencia, Burbank, Calif. • Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.



CIRCLE ED-128 ON READER-SERVICE CARD FOR MORE INFORMATION

Angle Counter

In Three Digits

The Model 1502 Angle Counter features a reduced number of moving parts. It indicates angular changes from 0 to 359° and back to 0, in 1° divisions. One revolution of the input shaft is equal to one revolution of the unit drum.

Input shaft may be operated clockwise, counterclockwise, or reversible. Input speed is rated at 500rpm. Housing material is black anodized aluminum for light weight (within 2.5 oz), and all internal parts are treated for high corrosion resistance. The counter generally conforms to Navy BuOrd specifications for Counter MK 3 Mod O.

Typical applications are in high-speed automatic machinery, fire-control devices, radar indicators, and positioning of servomechanisms. Bowmar Instrument Corp., Dept. ED, 2428 Pennsylvania St., Fort Wayne, Ind.

CIRCLE ED-130 ON READER-SERVICE CARD FOR MORE INFORMATION

2-Channel Scope

Offered at Low Cost

The Model K-26 Dual-Channel Oscilloscope is for viewing or photographing virtually any two simultaneous phenomena. It is designed for low cost plus wide applicability. The scope employs two completely separate and independent channels with channels with both signals displayed on the 5″ screen of a single Type 5AFP dual-beam cathode-ray tube. Individual or common sweeps from 2sec to 50,000cy may be selected from the front panel.

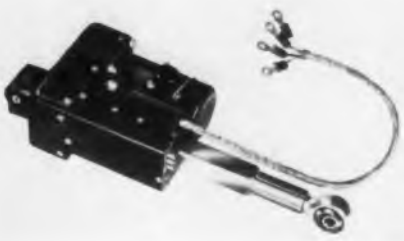
Frequency response of both vertical and horizontal amplifiers is flat to d-c, down not more than 10% at 100kc. Deflection factor of vertical amplifiers is 0.025v peak-to-peak per inch; horizontal amplifier, 0.3v peak-to-peak per inch.

The instrument employs compartmentalized construction throughout for easier servicing, better heat dissipation, and unusually stable operation. It is housed in black wrinkle-finished cabinet, 17-1/2″ x 16-3/4″ x 22-3/4″ deep. Front panel markings are white on a soft pastel green background for readability. Electronic Tube Corp., Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE ED-131 ON READER-SERVICE CARD FOR MORE INFORMATION

Linear Actuator

Weighs Only 1.40 lb



This linear actuator, Type ACT-3090, weighs only 1.40 lb, an important consideration in aircraft application. All major dimensions are reduced by 25%, accomplished by blending gear train and motor into a single unique homogeneous unit. The rate may be changed in convenient steps at any time merely by substituting two gears.

Maximum end play is less than 0.0018" in the screw and nut. A positive mechanical jaw-type stop is used at each end of the actuator. An overload clutch dissipates the extremely high forces encountered in "impact" stopping; this clutch is adjusted to slip at many times the maximum load expected to be moved by the actuator.

Either internally or externally adjusted limit switches are available, as well as any type of rod end peculiar to any aircraft application. The actuator is capable of operating in an extremely high ambient temperature. Applications are primarily for the aircraft industry and for automatic control devices. John Oster Manufacturing Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE ED-134 ON READER-SERVICE CARD FOR MORE INFORMATION

Work Solenoids

Standard Units Withstand 600°F

A series of d-c high-temperature work solenoids is offered in either single or double coil types that meet aircraft and missile standards. The solenoids provide positive, efficient, trouble-free operation under conditions of high ambient temperature up to 600°F, and in some instances up to 750°F, depending upon the application.

The solenoids are available in a variety of sizes in both pull and push types for valve operations or other applications.

The illustrated Model 1212, a single-coil push type for aircraft valve applications, is rated at 24v d-c for continuous duty. Minimum pull available at the beginning of the stroke is 2 lb at 3amp, 550°F and 18v d-c. Stroke is 0.1". Weighing 11.2 oz, the unit is 2-7/8" in overall length and has 2-1/8" diam at the mounting flange. Carruthers & Fernandez, Inc., Dept. ED, 1501 Colorado Ave., Santa Monica, Calif.

CIRCLE ED-135 ON READER-SERVICE CARD FOR MORE INFORMATION

TRANSISTOR TEST SET
Type 210

ACCURATE •
CONVENIENT •
SELF-CONTAINED •

DESIGNED for those using transistors, this test set is particularly adapted to the needs of the circuit development laboratory and the incoming inspection department. Operation is simple and straightforward, and no auxiliary equipment is required. The Type 210 is completely a-c powered, and contains no batteries or other short-life components.

The "h" parameters, as standardized upon by transistor manufacturers, are quickly measured over a wide range of d-c conditions. Base-input current amplification and collector saturation current are also directly indicated.

A transistor socket adaptor and a test adaptor for making a variety of other measurements using accessory instruments are furnished with the test set. Write for complete data, or call the nearest representative listed below for a demonstration.

CONDENSED SPECIFICATIONS

Transistor types: • PNP or NPN junction or point contact.

D-C operating conditions: • constant emitter current, zero to 7.5 ma; constant collector voltage, zero to 75 volts.

A-C operating conditions: • measurements made at 1.5 kc. Parameter meter (a-c voltmeter) sensitivity is one millivolt rms full-scale.

Parameters measured: •
h_{11}, input impedance.
h_{12}, voltage feedback ratio.
h_{22}, output impedance.
h_{21}, current gain with emitter input (α).
β, current gain with base input.
I_{c0}, collector saturation current.

and with external variable-frequency oscillator and voltmeter:
Alpha cut-off frequency.
Beta cut-off frequency.
Collector capacitance.

Size: • 15 x 13 x 4 inches. Weight approximately 18 lbs.

Price: • $475, f.o.b. Pasadena.

Chicago: • JKM Inc., Whitehall 4-6345
Cleveland: • S. Sterling Co., Evergreen 2-4114
Detroit: • S. Sterling Co., Broadway 3-2900
Los Angeles: • Luscombe Engineering Co., Madison 6-0211
New York-Newark: • Gawler-Knoop Co., Digby 4-8417, Caldwell 6-4545
Philadelphia: • Gawler-Knoop Co., Livingston 8-5480, Ogontz 8805
Pittsburgh: • H. E. Ransford Co., Grant 1-1880
Washington: • Gawler-Knoop Co., Juniper 5-7550

Øwen LABORATORIES

412 Woodward Boulevard
Pasadena 10, California
SYcamore 6-5167

CIRCLE ED-136 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Receiver

With 20-3,000cy Band Width

Wide bandwidth and ultra-thin size are features of this magnetic transistor receiver developed for use in portable amplifiers, hearing aids, earphones, and other electro-acoustical devices. The receiver is available in three impedances: 128 ohms, 500 ohms, and 1000 ohms. Average sensitivity is 120db above 0.0002 dynes/sq cm/mw power input, and band width extends from 20cy to 3000cy.

Thickness is only 1/3"; diameter is less than 7/8"; and weight (minus cord) is 1/4 oz. The unit also features polarized contacts and a flash-colored plastic cover, and may be used with a variety of cords. Telex, Inc., Dept. ED, Telex Park, St. Paul 1, Minn.

CIRCLE ED-138 ON READER-SERVICE CARD FOR MORE INFORMATION

Turns Ratio Bridge

Compact, Easy to Use

The Model MC-127 Turns Ratio Bridge is fed by an RC type audio generator and an amplifier. It has two unknown transformer windings in two legs. The ratio division resistors are in the third leg, and the balancing decade resistor is in the fourth leg.

Output of the bridge is fed to a selective amplifier and to the vtvm which operates the meter. A phasing switch reverses connections to transformer under test, which speeds testing operations. Read-out is direct from decades in turns ratio. A "Hi-Lo" ratio switch changes the decimal point on the panel. A high-sensitivity switch provides accurate adjustment.

Bridge ratio arms are accurate to ±0.1%. Normal operation indicates a single turn in a thousand. Binding posts provide for an external vernier which could be marked for plus or minus percent limits. Power requirements are 115v a-c at 0.5amp, 50-60cy. Size is 8-3/4" x 19" x 9-3/4". Weight is 22 lb. Specific Products, Dept. ED, 14515 Dickens St., Sherman Oaks, Calif.

CIRCLE ED-139 ON READER-SERVICE CARD FOR MORE INFORMATION

Baseball umpires need CONTROL...and so do electrical systems. For complete information, write:

ELECTRIC REGULATOR CORPORATION
140 Pearl Street, Norwalk, Conn.

REGOHM

CIRCLE ED-141 ON READER-SERVICE CARD FOR MORE INFORMATION

specify standard

FLEXLOC SELF-LOCKING NUTS

FLEXLOC DESIGN FEATURES

- One-piece, all-metal construction
- Resilient locking segments
- Controlled locking torques
- Lock and stop nut in one
- Every thread carries its full share of load

DO YOU KNOW? FLEXLOCS do not have to be seated to lock. They lock anywhere on a bolt as soon as the locking threads are fully engaged. And FLEXLOCS are stocked by authorized industrial distributors in a full range of sizes from #4 to 2". Write for Bulletin 866. STANDARD PRESSED STEEL CO., Jenkintown 12, Pa.

FLEXLOC LOCKNUT DIVISION SPS JENKINTOWN PENNSYLVANIA

CIRCLE ED-142 ON READER-SERVICE CARD FOR MORE INFORMATION

Fusible Resistors

Withstand Surge Current

A diversified line of fusible resistors, known as "Fusistors", has been developed for use in protecting more expensive components in TV and radio circuits. Serving both as fuse and resistor, they are constructed of material that will withstand a guaranteed load surge current yet will fuse when the current exceeds a given amperage.

One typical "Fusistor" is a 5 ohm unit which will operate continuously at 1amp and after 1 hour withstand 1.4amp for 1 min. It will fuse in less than 2 minutes at 3amp. Another 4.7 ohm unit will carry 1.25amp continuously; after 1 hour it will carry 1.75amp for 1 minute; it will fuse in less than 3 minutes when passing 2.5amp. Bradford Components, Inc., Dept. ED, 33-35 Bishop St., Bradford, Pa.

CIRCLE ED-143 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Supply

Offers 0.001% Regulation

The Model UHR-240 Regulated Power Supply provides up to 1/2-amp of d-c at 0-500v with 0.001% regulation and less than 100μv of ripple. The stabilization for $\pm$10% change in line voltage is better than 0.003%.

The d-c and low frequency impedance is less than 0.05 ohm. The a-c impedance is less than 0.05 ohm in series with 0.1μh (4" of wire). Transient response is 0.001 millisec. Typical 10 hour drift is 300ppm + 20mv. The ultra-high regulation applies over the entire operating range. For line voltages between 105v and 125v, the full maximum current can be drawn continuously at any output voltage.

There is an additional 0-150v, 0-5ma negative supply with 0.05% line stabilization and less than 2mv of ripple. A 5-13v, 0-2.5amp d-c heater supply with less than 20mv of ripple is included in addition to two independent 6.3v a-c, 10amp heater supplies.

The two 3-1/2" front panel meters are ruggedized and hermetically sealed. Dimensions are 17-1/2" x 9" x 15-1/2" deep. The unit is also available for rack mounting. Krohn-Hite Instrument Co., Dept. ED, 580 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE ED-144 ON READER-SERVICE CARD FOR MORE INFORMATION

A SURE Source of Supply for ALLOY FINE WIRE

IN STAINLESS STEELS • NICKEL • MONEL INCONEL • RESISTANCE ALLOYS SPECIAL ALLOYS

FOR WEAVING • FORMING • COLD HEADING • WELDING • KNITTING AND BRAIDING • ELECTRONIC APPLICATIONS

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COMPANY _____
ADDRESS _____

CIRCLE ED-145 ON READER-SERVICE CARD FOR MORE INFORMATION

Isolator-Duplexer

Uses Ferrites

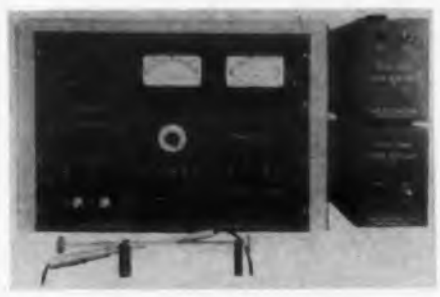
The high-power ferrite circulator is a broad-band, high-performance, lightweight, non-reciprocal ferrite component capable of handling full magnetron power without external cooling. The circulator has dual application as a load isolator or a combination isolator-duplexer package. It is used to stabilize high-power magnetrons that are susceptible to load vswr and long lines. As an isolator-duplexer, it saves a great deal of space by performing both operations. In this connection, the circulator eliminates dual TR tubes and possible unbalanced operation and replaces them with conventional single TR tubes.

Because the unit has extremely broad band width and low insertion loss, it also finds a wide application in the laboratory. Here it eliminates lossy pads and provides excellent frequency stability with variable impedance loads. Canoga Corp., Dept. ED, 5955 Sepulveda Blvd., Van Nuys, Calif.

CIRCLE ED-153 ON READER-SERVICE CARD FOR MORE INFORMATION

Measuring Instrument

Reads Radar Noise Figure



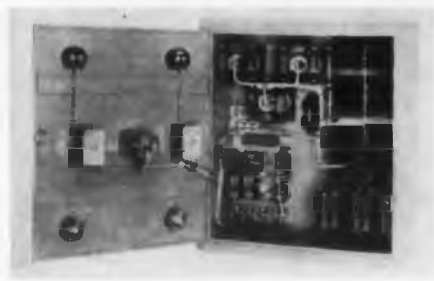
A complete radar noise figure measuring set, the "Rada-Node" is designed to cover the entire range from 5Mc to 26,500Mc. The set combines all auxiliary equipment required for production and laboratory measurement of noise figure and receiver gain for i-f and r-f. It includes 30Mc and 60Mc amplifiers, calibrated attenuators, i-f detector probe and indicating meter, and all necessary power supplies. Higher frequency noise sources are optional and available separately. Accuracy is within 0.1db.

The set may be used as an i-f noise source in the 5Mc to 400Mc range, and the 10Mc to 3000Mc range, with the supplied noise diode and an optional diode that is also available, respectively. Or it may be used as an r-f noise source with a range of 1200Mc to 26,500Mc (inert gas tubes) covered in eight bands. The i-f input is fed through switchable attenuators, with a total range of 21db, and a single fixed 3db attenuator to the i-f amplifiers. Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N. J.

CIRCLE ED-154 ON READER-SERVICE CARD FOR MORE INFORMATION

Voltage Regulators

Mag-Amp Types



This line of magnetic amplifier type voltage regulators is for both single and variable frequency alternators. No tubes or moving parts are used, and no warm-up time is required.

The regulators work into the field of the exciter or the field of the generator, thereby eliminating exciter maintenance; or they can be used in series or shunt with the generator ouptput. The power for the regulator can be derived from an external power source of any frequency from 50cy to 1000cy, or in case of an a-c generator, from the generator output itself.

These regulators cover alternator ranges from 100w to 100kw, 50, 60, 400, and 800cy, and variable frequency of 50-70cy, 350-450cy and 300-1000cy. Voltage regulation of 0.5% from no-load to full-load is available with a response time of 0.1sec, 0.2sec, or 0.3sec. Units are constructed to withstand rough operating conditions, and their life is rated in terms of years of maintenance-free operation. Mag-Electric Products, Inc., Dept. ED, 12822 S. Yukon Ave., Hawthorne, Calif.

CIRCLE ED-157 ON READER-SERVICE CARD FOR MORE INFORMATION

Amplifier

For Variety of Uses

The Type 138B Universal Amplifier has been designed to fill the need for a small medium amplifier for microphone use, or use as a cueing amplifier in broadcast, f-m, TV, and wired music services. It is completely self-contained, including power supply. All connections are of the plug-in type.

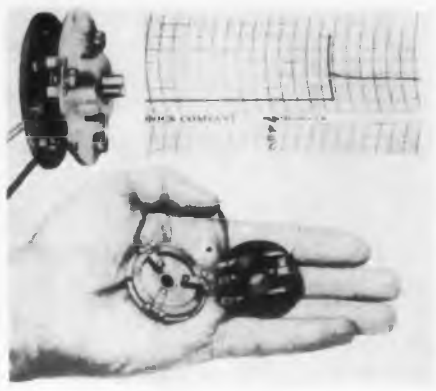
The small size of the amplifier permits mounting in consoles and cabinets or directly in the monitor speaker housing. Where several of the amplifiers are required, as in a rack installation, as many as four may be mounted on a standard Langevin 10B Mounting Frame.

Power output is +39dbm; frequency response (±1db) is 30-15,000cy; gain is 90db max; input impedances are 30, 150, and 600 ohms; output impedances are 3.2, 6.4, 16, and 600 ohms; and noise is −110dbm max. Langevin Manufacturing Corp., Dept. ED, 37 W. 65th St., New York 33, N. Y.

CIRCLE ED-158 ON READER-SERVICE CARD FOR MORE INFORMATION

Centrifugal Switches

Completely Non-Fluttering



The high-speed "Synchro-Snap" rotary switches are designed to provide complete and instantaneous cut-in or cut-out. Construction results in a non-fluttering, snap-acting device. The illustration shows a section of a test chart which traces the characteristics of a unit calibrated to cut-out at 7400rpm; snap-type switching action is completed within 3rpm of the shaft to which the switch is attached.

The switches operate on a virtually frictionless principle. They employ a principle which requires a decreasing amount of force for actuation as the critical speed is approached. At the same time, centrifugal force increases by the square of the speed of the shaft. They are presently furnished for any speed to 13,000rpm. Torq Engineered Products, Inc., Dept. ED, Interstate St., Bedford, Ohio.

CIRCLE ED-161 ON READER-SERVICE CARD FOR MORE INFORMATION

High-Power Rectifiers

For 125° Operation

These high-power silicon rectifiers are capable of continuous operation at full rated power at an ambient temperature of 125° C. They provide reliable operation under wide variation in ambient temperature.

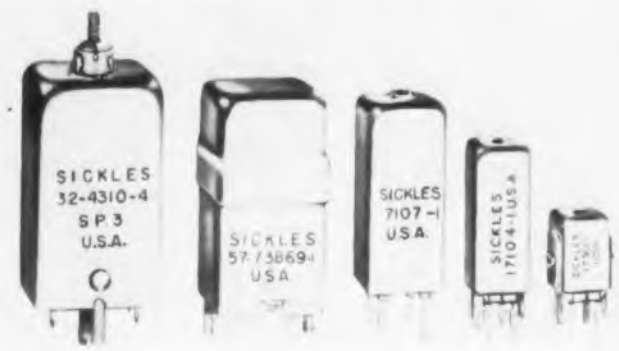
High forward conductance and low leakage current allow operation at extremely high efficiencies. In most applications, efficiencies of 90% to 99% are easily achieved. The silicon rectifiers do not exhibit aging effects common to other rectifiers and therefore offer much longer life under severe operating conditions. Their hermetically sealed construction provides permanent protection against environment.

Types range in power handling ability from 10amp at 50v PIV to 5amp at 200v PIV, all rated at 125°C. Designed for conduction cooling, the rectifiers provide savings in both size and weight. Transitron Electronic Corp., Dept. ED, Melrose 76, Mass.

CIRCLE ED-162 ON READER-SERVICE CARD FOR MORE INFORMATION

Transformer

1/2" Unit Added to Line



The Type S 506 is a 1/2" intermediate frequency transformer for use in pocket-size portable radios, other communications applications, and in conjunction with transistors where space saving is an important design requirement. It is mounted by two rugged lugs which may be either soldered or twist-locked to the chassis. The tuning cores are accessible from top or bottom of the assembly and units can be made with different coupling to accommodate various end requirements.

Shown at the right in the illustration the unit occupies only about 1/5 the cubic space of the 3/4" i-f transformer (center) and only 1/15 the space of the 1-1/4" model (left). F. W. Sickles Div., General Instrument Corp., Dept. ED, P. O. Box 330, Chicopee, Mass.

CIRCLE ED-165 ON READER-SERVICE CARD FOR MORE INFORMATION

Rotary Actuator

Has Hermetic Switch

This unit combines rotary actuation plus a hermetically sealed basic switch. The sturdy roller actuator arm has optional settings throughout 360° with operating travel of 90°. The long overtravel of 81° protects the basic hermetic switch and also permits flexibility of application.

The basic switch uses a sealing principle proven environment-free by larger models used for aircraft applications. It is not affected by temperature cycling, moisture, extreme heat or cold, dust, dirt, or other foreign elements. The heavy actuating force of 20 lb assures positive operation and "break-thru" of any ice formations on the switch.

With an extreme life span of 200,000 cycles, the switch is rated for 10amp, 125/250v a-c, and 28v d-c inductive or resistive. Ambient temperature range is −100° to +250°F. Weight is 0.06 lb. Electro-Snap Switch & Mfg. Co., Dept. ED, 4218 W. Lake St., Chicago 24, Ill.

CIRCLE ED-166 ON READER-SERVICE CARD FOR MORE INFORMATION

Xenon Thyratron

Uses Tough Glass Wafer Stem

The *6044* is an inert-gas grid-controlled rectifier featuring the use of a high-shock multiform glass wafer stem. It is designed especially for motor control circuits where short deionization time is required. The tube will also serve on applications requiring high peak-current-carrying capacity, such as timing control.

Utilizing a design where electrical contacts and mechanical supports are provided by the same set of connections, the *6044* can be fastened to the mounting panel by captive screws on the tube terminals. This construction provides extreme rigidity and eliminates tube sockets for simplified mounting.

The tube features a 6.4amp average anode current and a low average arc drop of 12v. Ambient temperature limits are −65° to +85°C. Filament voltage is 2.5v a-c or d-c, and filament current is 17amp. Peak current is 77amp, and peaked forward or inverse voltage is 500v. Maximum physical dimensions are 5.5″ high x 2.2″ diam. Taylor Tubes, Inc., Dept. ED, 2312 W. Wabansia Ave., Chicago 47, Ill.

CIRCLE ED-171 ON READER-SERVICE CARD FOR MORE INFORMATION

Transducer Component

Converts Capacitance to Voltage

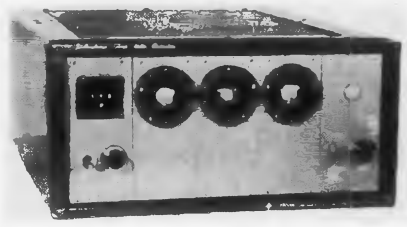
The "Delta Unit", converts changes in capacitance to changes in voltage. It may be applied to the measurement of any physical phenomena which can be resolved into changes of capacitance, including micrometric and macrometric displacement, angular motion, vibration, temperature, pressure, liquid level, humidity, dielectrica, continuous weighing, and many others—with a sensitivity as high as 5v/mmfdΔC.

The output is a phase-sensitive d-c signal as high as 60v, providing a basis for display, recording, and control of variables with simplicity and low cost. It utilizes the "T-42 Ionization Transducer" making it readily adaptable to many measurement problems. The unit, containing the T-42 and the necessary excitation source, requires only a capacitor configuration and power supply to provide an analogous output signal. It measures 7″ x 3″ x 3″, and weighs 1-1/2 lb. Decker Aviation Corp., Dept. ED, 1361 Frankford Ave., Philadelphia 25, Pa.

CIRCLE ED-172 ON READER-SERVICE CARD FOR MORE INFORMATION

Totalizer

Can Make 4000 Counts/Sec



The Model 8003 "Fast Industrial Counter" is readily applied to the rapid counting of high-speed, high-volume outputs. It is designed to tally count of continuous, discontinuous, random, or cyclic succession of events or passage of linear or liquid flow.

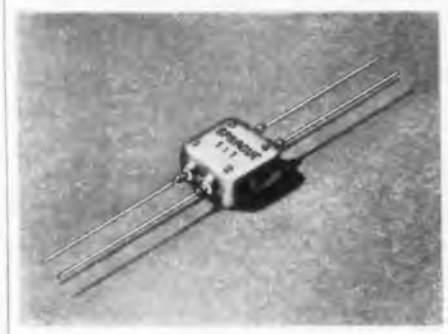
The maximum counting rate of 4000 counts/sec is achieved through a combination of low-heat, cold-cathode glow transfer counting tubes and an electromechanical register. Pulse pair resolution is 250μsec, and total count capacity is seven digits (9,999,999). Counters are built from "unitized functional plug-in strips."

The counter is actuated from pick-ups which can produce a single 10v pulse of either positive or negative polarity for each event to be counted. These may be of the magnetic, piezoelectric, photocell, acoustic, pressure or strain sensitive, or contact closure types. The unit measures 13" x 5-1/4" x 12-1/2" and is available as a bench instrument or with wing brackets for 19" rack mounting. Atomic Instrument Co., Dept. ED, 84 Massachusetts Ave., Cambridge, Mass.

CIRCLE ED-175 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Rectangular Transformers

Volume only 0.19 cu in



The 152 series pulse transformers, for use in high-speed circuits, are designed especially for use as memory array current-driving transformers, blocking oscillator transformers, impedance matching circuits, and magnetic tape recording transformers. Hermetically sealed with glass-to-metal solder seals in drawn-shell rectangular containers, standard units will meet military specifications and operate at ambients up to 85°C. They have a physical volume of 0.19 cu in, pulse width range of 0.4μsec to 10μsec and maximum rise time of 0.1μsec. Typical maximum primary inductance is 25mh.

Special designs for high acceleration and for high ambient temperature operation are available to meet individual requirements, and the electrical counterparts of each transformer can be obtained in lower cost housings for typical commercial environmental requirements. Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE ED-176 ON READER-SERVICE CARD FOR MORE INFORMATION

D-C Power Supplies

In 10 Standard Units

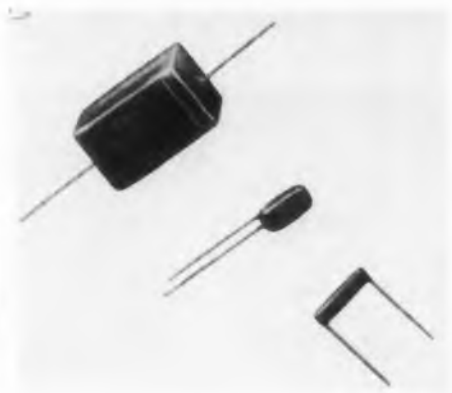
This series of 10 standard low-voltage high-current "Powerunit" d-c power supplies is available in a space-saving portable cabinet design, adaptable to rack panel mounting. Units are available in the 0-15v, 0-50amp range; 0-30v, 0-27amp range, and 0-90v, 0-9amp range. Convection-cooled selenium and germanium rectifiers are used for power conversion.

"Powerunits delivering full-wave rectified d-c or filtered d-c in varying degrees to 0.03% ripple are available. Outputs are continuously variable within listed ranges. Circuit-breaker protection is used. There are no moving parts or vacuum tubes. Model Rectifier Corp., Dept. ED, 557 Rogers Ave., Brooklyn 25, N. Y.

CIRCLE ED-177 ON READER-SERVICE CARD FOR MORE INFORMATION

Metallized-Paper Capacitors

With Choice of Lead Locations



These subminiature metallized-paper capacitors are offered with a choice of lead locations. Axial leads, radial leads, and single end parallel leads lend themselves strongly to the field of automation.

These leads are available in all capacitor sizes as well as on special units to meet specific requirements. The capacitors are fungi inert plastic encased and rectangular in shape for maximum conservation of space. Hopkins Engineering Co., Dept. ED, 2082 Lincoln Ave., Altadena, Calif.

CIRCLE ED-178 ON READER-SERVICE CARD FOR MORE INFORMATION

If you need a special circuit, component, material, send us your request on company letterhead. We will publish it along with your name and address in the earliest issue possible. Interested readers can answer you directly.

Address brief requests to Bulletin Board, ELECTRONIC DESIGN, 19 E. 62nd St., New York 21, N. Y.

R-F Wattmeter Bridge

With Many Uses

The Type 28 is a compact, r-f wattmeter bridge measuring only 2" x 4" x 8". It performs three r-f measurements. As a wattmeter, impedance bridge, or probe, it has a wide application in determining the r-f characteristics of transmission lines, wave traps, resonant impedances, antennas, etc., and also functions as a field strength indicator, and AM detector.

For power measurements, the instrument has three ranges of 1, 10, and 100w, and it presents a resistive load of 50 ohms (±1 ohm) for frequencies up to 180Mc. Constant service rating is 30w, and intermittent is in excess of 60w. The resistive bridge portion is direct-reading over a calibrated range of 4 to 250 ohms for frequencies from 500kc to 200Mc. Appropriate coupling cables are supplied for checking r-f impedances of filters, radiation systems, resonant line sections, etc. When the bridge is used as a probe, a full-scale sensitivity of 100mv is available.

The r-f probe shunt capacitance is only 6-10mmfd when used with its multiplier. Substituting an antenna for the probe permits field strength measurements at high sensitivities, and headphone output terminals permit aural observation and meter readings of AM modulated r-f signals. Budelman Radio Corp., Dept. ED, 375 Fairfield Ave., Stamford, Conn.

CIRCLE ED-181 ON READER-SERVICE CARD FOR MORE INFORMATION

C-R Tube Indicator

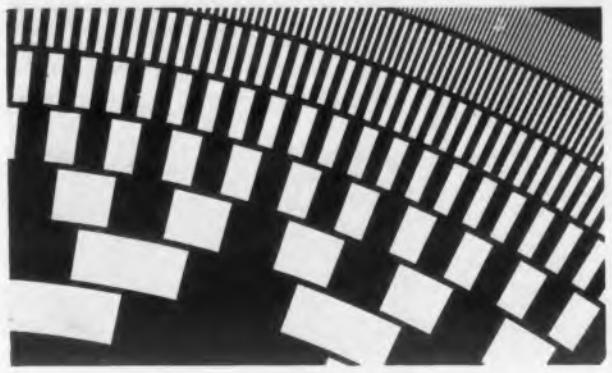
For Daylight Viewing

The Type NU-DVI-3 is a high-brightness, daylight-viewing 5" oscillograph presentation unit that uses both electrostatic focusing and magnetic deflection. It presents a small brilliant spot and is capable of providing a sharply focused TV raster at high brightness levels.

The unit is designed to withstand MIL shock and vibration tests, and to facilitate mounting on aircraft instrument panels and similar applications. The unit weighs only 4 lb 8 oz, and has a diameter of 5-1/4" with length of 10". National Union Electric Corp., Dept. ED, 405 Lexington Ave., New York, N. Y.

CIRCLE ED-182 ON READER-SERVICE CARD FOR MORE INFORMATION

Gurley Standard Binary Code Discs Now Available in Four Versions



Gurley, manufacturer of the *standard* binary code disc for the electronics industries, is now able to supply four versions for use in either photo-electric, magnetic or contact types of pickups.

Containing concentric zones of information in the gray (reflected) code, the Gurley discs contain alternate clear and opaque sectors. Thin annular rings separating adjacent zones are opaque. Varying patterns record up to 8192 bits of information (65,536 on special designs!).

Four coatings are available: "Type T"—photoengraver's glue with colloidal (black) silver, essentially grainless; "Type R" with etched metal coating, for reflectivity and transmission contrast; "Type M" with chemically deposited ferrous alloy possessing both *magnetic* and optical transmission contrast; and "Type C"—metal bonded on glass for electrical *contact* use as well as in contrast of optical transmission. WRITE FOR BULLETIN 7000.

W. & L. E. GURLEY • 525 Fulton Street, Troy, N. Y.

GURLEY *since 1845*

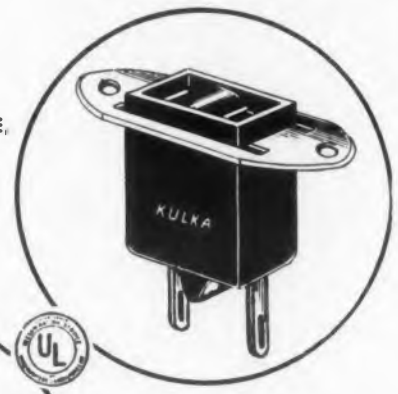
CIRCLE ED-185 ON READER-SERVICE CARD FOR MORE INFORMATION

New Miniature POWER OUTLETS

For Small Electrical and Electronic Units

SHOWN FULL SIZE

- SMALLEST MADE
- TAKE STANDARD PLUG
- MOUNT FROM TOP OR BOTTOM OF FLAT BRACKET
- CHOICE PRE-WIRED STYLE, OR WITH SOLDERING TERMINALS
- PHENOLIC BLOCK HAS BARRIER TO PREVENT SHORTS
- AC and DC



No. 221 (above) with soldering terminals and steel bracket with #6 clearance mounting holes. Also No. 222 with 6-32 tapped mounting holes. No. 223 (left) with 8" #14 or #16 plastic wire leads and steel bracket with #5 clearance mounting holes. Also No. 224 with 6-32 tapped mounting holes.

KULKA ELECTRIC MFG. CO., Inc.

Manufacturers of Electrical Wiring Devices

MOUNT VERNON, N. Y.

CIRCLE ED-186 ON READER-SERVICE CARD FOR MORE INFORMATION

Multimeter

V-O-M Has 70 Ranges

The Model 630-NA "Volt-Ohm-Mil-Ammeter" features meter protection against overloads; 70 ranges, nearly double those of conventional testers; and frequency compensation up to 20kc, providing for accurate readings over the entire audio range. In addition, it has high accuracy on the same scale for a-c and d-c: 1-1/2% d-c to 1200v, and 3% a-c to 1200v.

The meter has temperature compensation, giving full accuracy within a wide range of ambient temperatures. Triplett Electrical Instrument Co., Dept. ED, Bluffton, Ohio.

CIRCLE ED-187 ON READER-SERVICE CARD FOR MORE INFORMATION

Digital Delay Generator

For Precise Time Measurement

This time discrimination instrument, the "Precision Digital Delay Generator", opens up possibilities for precise measurements in the fields of electronic navigation, digital computers, geophysics, and nucleonics. It can provide pulses, precisely delayed in time, with respect to an internally generated reference pulse at any repetition rate. Digital circuitry and thermostatic crystal controlled stability permit accuracies of better than 0.001μsec in 1000μsec.

Digital circuitry is used only as control elements to gate out the initiating reference pulse, the first delayed pulse, and the second delayed pulse. The accuracy of both repetition rate and pulse delay are determined by the accuracy of the crystal oscillator. The instrument can also be used as an elapsed time indicator, and therefore, can check itself. By setting the control dials for a given delay or a given repetition rate, and feeding the delayed pulse back into the elapsed time "stop" jack, the lights can be read and must agree with the previously set delay.

The unit can be operated in either the steady-state or one-shot mode. Housed in a standard rack cabinet 20" high, the instrument weighs approximately 90 lb with a power consumption of 700w. Kaiser Metal Products, Inc., Dept. ED, Bristol, Pa.

CIRCLE ED-188 ON READER-SERVICE CARD FOR MORE INFORMATION

THERMOSTATIC

DELAY RELAYS

STANDARD

Provide delays ranging from 2 to 150 seconds.

MOST COMPACT
MOST ECONOMICAL
HERMETICALLY SEALED

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes. • Circuits: *SPST only*—normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from —55° to +70°C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *very inexpensive!*

TYPES: Standard Radio Octal, and 9-Pin Miniature.

PROBLEM? Send for Bulletin No. TR-81

MINIATURE

Also — a new line of Amperite Differential Relays — *may be used for automatic overload, over-voltage, under-voltage or under-current protection.*

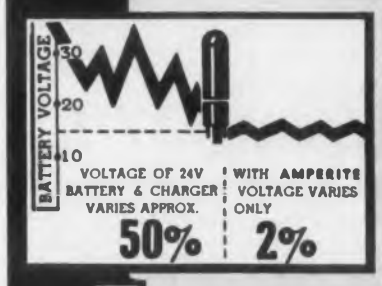
AMPERITE

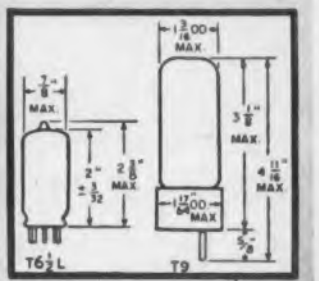
BALLAST REGULATORS

T9 BULB

- Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.).
- For currents of 60 ma. to 5 amps. *Operates on A.C., D.C., or Pulsating Current.*
- Hermetically sealed, light, compact; most inexpensive.

Amperite Regulators are the simplest, most effective method for obtaining ***automatic regulation*** of current or voltage. ***Hermetically sealed;*** not affected by changes in altitude, ambient temperature (—55° to +90°C), or humidity. Rugged; no moving parts; changed as easily as a radio tube.





Write for 4-page Technical Bulletin No. AB-51

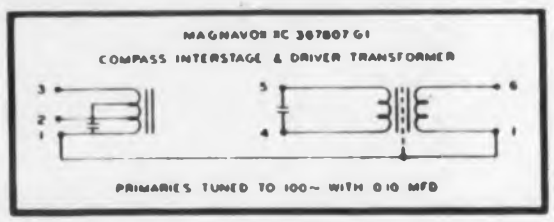
AMPERITE CO., Inc.

561 Broadway, New York 12, N. Y.

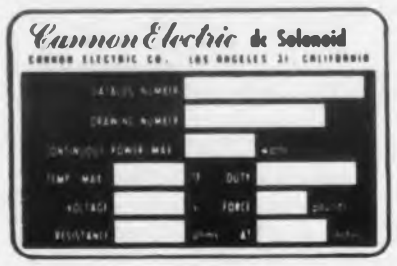
In Canada: Atlas Radio Corp., Ltd., 560 King St., W., Toronto 2B

CIRCLE ED-189 ON READER-SERVICE CARD FOR MORE INFORMATION

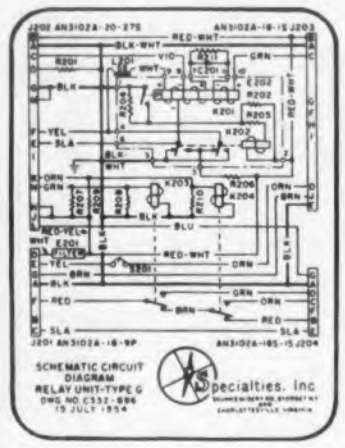
SYSTEM TRACERS



SPECIFICATION DATA



WIRING DIAGRAM

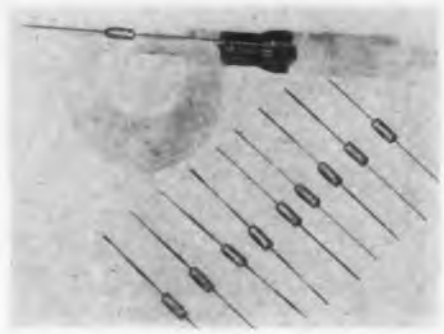


SERIAL NUMBERS

PRODUCT IDENTIFICATION

Electrolytic Capacitor

Tantalum Unit For Transistors



The Series NT tantalum electrolytic capacitor measures only 1/8" diam to 5/16" in length. This miniature unit retains all the excellent characteristics of large prototypes and is especially well suited for applications in transistor, printed circuit, and other applications where space is at a premium.

The capacitor has extremely low leakage, long shelf and service life, stability, and power-factor characteristics, within a temperature range of —20 to + 55°C. All units are of polarized construction. Capacity range is from 1.0mfd at 16v d-c to 8.0mfd at 4v d-c. Cornell-Dubilier Electric Corp., Dept. ED, S. Plainfield, N.J.

CIRCLE ED-191 ON READER-SERVICE CARD FOR MORE INFORMATION

Tiny Relay

Weighs 10 Grams

This hermetically sealed microminiature relay is less than 1" in height and weighs only 10gr. For use in aircraft systems, the relay has a contact rating of 2amp resistive load at 30v d-c or 115v a-c. Simplicity of adjustment and extra assurance of reliability are achieved by a balanced armature construction which also gives high resistance to shock and vibration.

Rated for operation at 1.5millisec, the relay has contact springs of beryllium copper. Shock rating is over 50g, and vibration resistance is 10-55cy at 0.12" max excursion and 55-500cy at 20g acceleration.

Two models are available. The standard relay, 0.81" from base of header to top, designated CR2791G200, has a standard coil resistance of approximately 600 ohms for operation from 28v d-c; coil resistance up to 4800 ohms is available. The current sensitive model, 1.12" long, designated CR2791G210, has a maximum coil resistance of 9600 ohms and a pick-up current of approximately 3.2ma. Specialty Control, Dept. ED, General Electric Co., Schenectady 5, N. Y.

CIRCLE ED-192 ON READER-SERVICE CARD FOR MORE INFORMATION

Variable Resistor Kit
With Dual-Concentric Control

Experimental work or pilot model building will be aided by using dual-concentric variable resistors included in this "Fastatch" dual-concentric control kit. A sturdy metal stocking cabinet is furnished with the most popular front and rear units in the control system. A total of 22 controls can be built from a possible 363 combinations of resistance, taper, and switch or plain types. Centralab, Div. of Globe-Union, Inc., 900 E. Keefe Ave., Dept. ED, Milwaukee 1, Wis.

CIRCLE ED-194 ON READER-SERVICE CARD

Self-Sticking Felt
For Sound Dampening

These pressure sensitive self-adhesive felts may be applied instantaneously and will adhere securely to rough or smooth surfaces of wood metal, plastic, glass, ceramics, etc. Standard sizes in tape form are available in 1/16" and 1/8" thickness and 1/8" to 6" in width. Standard discs have diameters of 1/4", 3/8", 7/16", and 1/2".

Such felt shapes may be used for surface protection, as separators, silencers, vibration, sound and electrical insulation, rattle control, for sealing openings and seams against dirt penetration, as instrument parts. J. B. Dawn Products, Inc., Dept. ED, 3905 W. 64th St., Chicago 29, Ill.

CIRCLE ED-195 ON READER-SERVICE CARD

Aluminum Bonding Metals
Speed Manufacturing

A bonding metal known as Percoloy absorbs the aluminum surface oxides before bonding or a affining with the aluminum surface.

Percoloy is manufactured in three types, identifiable by their melt temperature. Solbond (375° to 475°F) is capable of bonding all aluminum alloys, including 24S-T and the latest H.Z.M. 100. Brabond has a melt temperature range from 500°F to 825°F. Welbond is the high melt-temp and high strength Percoloy. Precision Electronic Research Co., Dept. ED, Glendora, Calif.

CIRCLE ED-196 ON READER-SERVICE CARD

CIRCLE ED-197 ON READER-SERVICE CARD ➤

Pressure Transducer

A Variable Inductance Unit

The Model S-6 Pressure Transducer is a single-coil, diaphragm-type, variable inductance unit. It is designed for use either as the variable inductor of inductance controlled fm/fm sub-carrier oscillators or for voltage controlled oscillators and bridge circuits. For voltage output applications, the gage is supplied with a matched dummy so that gage and dummy become two arms of an electrical bridge circuit. Depending on the application, the gage is constructed so that curves of pressure vs frequency, pressure vs inductance, or pressure vs voltage will be linear functions. The gage can also be made non-linear to match a predetermined curve.

The unit is 7/8" diam x 7/8" long. The acceleration sensitivity is 0.01%/ag or less and the rise time to a step pressure pulse is of the order of 50μsec. It can withstand pressure overloads in excess of 1000% of full range pressure. Frequency deviations of $\pm$7-1/2% to $\pm$15% and voltage sensitivities of 100mv/v are standard.

To allow use from 400cy to 80kc, coil inductances from 10 to 300mh are available. For some applications, the gage can be plated to resist extremely corrosive fluids. It weighs 2 oz. Standard pressure ranges from 1 to 500psi, gage, differential, or absolute, are available. Ultradyne Engineering Labs., Inc., Dept. ED, P. O. Box 8007, Albuquerque, N.M.

CIRCLE ED-198 ON READER-SERVICE CARD FOR MORE INFORMATION

Twin Triode Tube

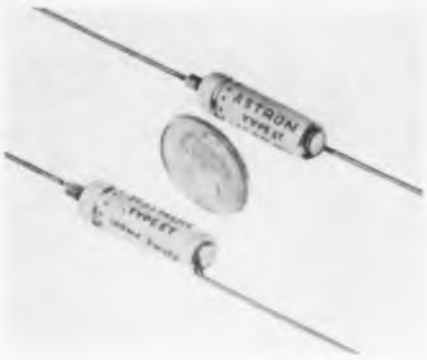
With Minimum Cross Modulation

The *4BC8* is a miniature medium mu, semi-remote cutoff, twin triode designed to provide more satisfactory performance in AGC systems. It is intended for application as a v-h-f cascode amplifier in series string TV receivers, and it features a 600ma, 4.2v heater, with controlled heater warm-up time. Objectionable cross modulation effects are minimized under strong and weak signal conditions. Sylvania Electric Products, Inc., Dept. ED, Emporium, Pa.

CIRCLE ED-199 ON READER-SERVICE CARD FOR MORE INFORMATION

Subminiature Electrolytics

For Printed Circuitry



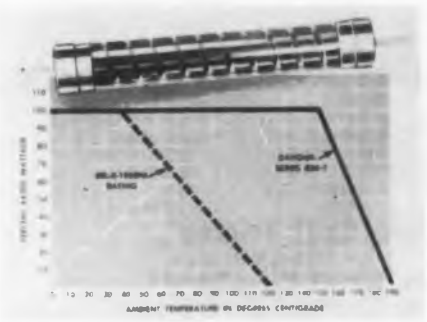
Type ET Subminiature Electrolytic Capacitors are for applications where space is severely limited, such as portable TV sets, miniature radios, hearing aids, miniature tape recorders, and other assemblies using miniaturized tubes and/or transistors.

Features include: wide range of values, stable high-gain etch process, exceptionally low leakage current, and low-resistance terminal tab connection. The units are hermetically sealed in aluminum cases. The electrolyte formulas employed contribute top self-restoration properties and the ability to withstand high surge voltages, ripple current, and high temperature applications. Stable operation over a wide temeprature range and consistent 85°C operation are assured by individual product testing. Astron Corp., Dept. ED, 255 Grant Ave., E. Newark, N. J.

CIRCLE ED-202 ON READER-SERVICE CARD FOR MORE INFORMATION

Film Type Resistor

For Hi-Temp Applications



The "Davohm" Series 850-T Film Type Resistors can be used at 150°C at full rated power. They derate linearly to zero power at 190°C. The temperature coefficient is below +400ppm/°C, is always positive in value, and is independent of resistance value. Any ohmic value of these resistors will track within approximately +200-ppm/°C of the normal temperature coefficient value over the temperature range. This allows matching resistance network values through wide temperature ranges with high accuracy.

These hermetically sealed units offer excellent moisture resistance and load life stability. On a typical MIL cycle 1000hr load test of twelve 2w type 852-T 200,000 ohm resistors, one had a maximum deviation of 0.2% and the rest had maximum deviations of 0.1%. The voltage coefficient is below 0.0005%/v.

The resistors are available in 1/2, 1, and 2w ratings. Dimensions range from 5/16" long x 3/16" diam to 2-1/32" long x 5/16" diam. The Daven Co., Dept. RK, 191 Central Ave., Newark 4, N. J.

CIRCLE ED-203 ON READER-SERVICE CARD FOR MORE INFORMATION

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CIRCLE ED-204 ON READER-SERVICE CARD FOR MORE INFORMATION

Function Programmer

For Aircraft, Missiles, Industry

Designed for minimum functional accuracy of 0.1 sec under extreme environmental conditions, the Function Programmer can provide 0.01 sec accuracy under lab conditions. Time of travel is 50 sec nominal. The time may be varied above and below nominal by changing the gear ratio, motor rmp, or leadscrew pitch. The unit uses no clutch, cams, or snap-action switches.

The programmer incorporates four resistance and two switch functions nominal, and it is possible to incorporate any combination of switches and resistances up to six. The resistance functions are capable of having a linear increase to at least 100,000 ohms total. Non-linear elements are available. Switch functions may be obtained with a single on/off impulse, or a variety of impulses spaced evenly or irregularly over the timing cycle.

The various resistance and/or switch functions desired are calculated, fabricated, and inserted into the programmer before final assembly. Provision is made to "zero set" each of the functional elements separately for accuracy. Hubbard Scientific Laboratories, Inc., Dept. ED, 1292 E. 3rd St., Pomona, Calif.

CIRCLE ED-206 ON READER-SERVICE CARD FOR MORE INFORMATION

Portable Coil Tester

Detects Short Circuits

The "Coil Tester" instantaneously indicates the presence of short-circuited turns or defective insulation coils. The unit operates from 115v 60cy, is portable, easy to use, safe, and inexpensive. Under normal conditions, the tester can identify down to a single short-circuited turn of No. 42 AWG copper wire (0.0025" diam).

A great variety of coil sizes can be tested by simply placing the coil to be tested over one of several cores which are available and noting the deflection of the meter. Size is 10" x 10" x 11", and weight is 10 lb. Sunshine Scientific Instrument, Dept. ED, 1810 Grant Ave., Philadelphia 15, Pa.

CIRCLE ED-207 ON READER-SERVICE CARD FOR MORE INFORMATION

Junction Germanium Diodes
Glass, Hermetically-Sealed

Types HD-292, HD-293, HD-294, HD-295, HD-296, and HD-297 are gold-bonded, junction germanium diodes. Electrically, they have a forward current much greater than that of point-contact germanium diodes. This characteristic, plus their low forward voltage drop and low reverse current, make these units especially desirable in applications such as computers, control systems, and small power supplies.

Gold-bonding provides maximum protection against the effects of shock and vibration. The glass case of these units insures a true hermetic seal that provides maximum protection against the detrimental effects of moisture and surface contamination. CBS-Hytron, Div. of Columbia Broadcasting System, Inc., Dept. ED, Danvers, Mass.

CIRCLE ED-209 ON READER-SERVICE CARD

Copper-Clad Silicone Rubber
Laminate May Be Curved

This copper-clad silicone rubber laminate is composed of copper foil up to 0.003 thick bonded securely to one or both sides of silicone rubber from 0.010 to 0.100 in thickness. Present sheet size is 12" by 48". The chemical and heat resistance of silicone rubber allows acid or ferric chloride etching with subsequent dip soldering. Flexibility makes it possible to stencil and etch on a plane and later to form the circuit carrying surface around a mandrel for most efficient use of available space.

Silicone rubber retains its properties over a 600°F temperature range from —100°F to 500°F. Its dielectric strength is of the order of 500v per mil, its dielectric constant is approximately 4 at 1Mc. Loss factor and moisture absorption are both low. Industrial Rubber Products Div., Oliver Tire & Rubber Co., Dept. ED, 4341 San Pablo Ave., Oakland 8, Calif.

CIRCLE ED-210 ON READER-SERVICE CARD

CIRCLE ED-211 ON READER-SERVICE CARD ➤

Pushbutton Oscillator

2000 Frequencies at 1/20%

Any of 2000 different frequencies are available on the Model 440-B Precision Pushbutton Oscillator, which covers the frequency range from 0.5cy to 1000cy in 1/2cy steps. Calibration accuracy is ±0.05% and the drift per hour is less than 0.005%.

Distortion and hum are less than 0.1% at any output level. Amplitude varies less than ±0.25db over the entire frequency range. The output amplitude is adjustable continuously by a logarithmical output level control with a scale calibrated in rms volts from 0.01 to 10v maximum. Power output is 100mw into 1000 ohms. Krohn-Hite Instrument Co., Dept. ED, 580 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE ED-213 ON READER-SERVICE CARD FOR MORE INFORMATION

Preamplifier

For Test Equipment

The Type 230 Miniature Preamplifier is a compact, inexpensive accessory designed to increase the sensitivity of laboratory oscilloscopes, a-c vacuum-tube voltmeters, frequency counters and similar test equipment. Only 3-1/2" x 4" x 1-1/4", it plugs directly into input terminals having standard spacing; adaptors can be furnished for other types of connectors.

Gain is 10 or 25, over a frequency range dependent upon gain setting and input capacitance of the instrument with which it is used. With a typical oscilloscope, and gain of 25, response will extend from 5cy to 10kc, or from 20cy to 50kc with a typical voltmeter and at a gain of 10. Battery life is 50 hours of continuous operation. With a DuMont 304 oscilloscope, the unit gives a deflection factor of 1mv peak-to-peak per inch.

Upper limit of frequency response is 80kc. Maximum output is 10v peak-to-peak. Input impedance is 5 megohms, 25mmfd. Owen Laboratories, Dept. ED, 412 Woodward Blvd., Pasadena 10, Calif.

CIRCLE ED-214 ON READER-SERVICE CARD FOR MORE INFORMATION

Dynamic Visual Monitor

Displays 24 Signals

The Model 20 Dynamic Visual Monitor combines 24 moving-spot, light-beam galvanometers in one package, 8-1/2″ x 8-1/2″ x 6″, weighing less than 13.5 lb, to permit simultaneous display of 24 separate electrical signals on a single 3″ x 4″ ground glass screen. It permits viewing the outputs of a series of thermocouples, pressure, transducers, strain gages, or other similar signal sources.

Use of low-period galvanometers and a long-path optical system permits presentation of electrical signals up to 120cy with only 0.24ma required for full-scale deflection. Spot intensity is sufficient to permit photography in photo panel displays or for viewing under conditions of high incident light.

The unit is completely self-contained and may be shock-mounted for use where extreme conditions of shock and vibration may be found. It is made for operation from 22-28v a-c/d-c at 1.5amp. Century Geophysical Corp., Dept. ED, 1333 N. Utica, Tulsa, Okla.

CIRCLE ED-219 ON READER-SERVICE CARD FOR MORE INFORMATION

Adjustable Inductors

In 16 Standard Values

Style B Type 1 Variable Inductors are carbonyl-iron cup-core units completely embedded in epoxy resin. They are provided in 16 standard values from 56μh to 18mh. Their construction makes them resistant to the effects of large amplitude vibration and shock, as well as moisture and chemical attack.

Tunable over an inductance range of 2:1, the inductors have voltage ratings of 400v and power-dissipation ratings of 5w at 20°C temperature rise. On special order, these units can be provided in values up to approximately 200mh, and in the form of complete sealed tuned circuits with shunt capacitors included to specification.

The formula of the core material gives constant inductance characteristics free from non-linear effects. The units are operable over a temperature range from −50° to +100°C, with a temperature coefficient of inductance less than 50ppm/°C. Levinthal Electronic Products Inc., Dept. ED, 2758 Fair Oaks Ave., Redwood City, Calif.

CIRCLE ED-220 ON READER-SERVICE CARD FOR MORE INFORMATION

Light Beam Galvanometers

Withstand up to 25g Shock

A series of highly compact, shock-resistant, light-beam galvanometers, with sensitivities up to 0.105-μamp per millimeter division, has been developed by this firm. They are available as completely housed assemblies, with lamp and projection system included, ready for installation and use.

Originally developed to withstand the shock and vibration encountered in field servicing and testing of jet aircraft, the galvanometer is particularly suited to field work as well as for laboratory and production testing. Separately, the movement may be installed as an integral part of other industrial instrumentation.

High compactness is achieved, along with high sensitivity, through an ingeniously folded light beam. The effective length of the beam is 80mm. The unit resists up to 25g shock or vibration. Overall size is 2.6″ x 3.62″ x 3.615″. Coil resistances are 20, 100, 500, and 1000 ohms. The units are designed for flush or surface mounting. Howell Instrument Co., Dept. ED, 1106 Norwood, Fort Worth, Tex.

CIRCLE ED-225 ON READER-SERVICE CARD FOR MORE INFORMATION

Mercury Relay

With up to Four Switching Tubes

This relay includes as many as four mercury switching tubes (a three-tube unit is illustrated). The tilting tube has no internal moving part except mercury and cannot stick.

Mercury tubes are available in many ratings, up to 65amp non-inductive load at 110v or 52amp at 220v. The tubes can be all "normally open" or "normally closed", or some of each, depending upon switching requirements. "Break-before-make" and "make-before-break" combinations are available. Tubes of different ratings can be mounted in the same unit.

The magnetic circuit and the actuating mechanism of this relay are of new design. The relay coil takes very little power and runs cool. A-c and d-c models are available. The units are designed for low cost, as compared to analogous plunger types. Corona Engineering Service, Dept. ED, 94-52 Corona Ave., Elmhurst, N. Y.

CIRCLE ED-226 ON READER-SERVICE CARD FOR MORE INFORMATION

Induction Heating Unit

Easy-to-Use 3kw Unit

Induction Heating Unit Model IH-3 has a conservatively rated output of 3kw (per NEMA standards). It features simplicity of design and rugged construction. Selective dial setting and recycling by an automatic timer facilitate high production rate. Power output is selectively variable. The output transformer makes possible extremely low voltage in the output coil.

This firm's heating units feature a single-turn coil that accommodates complex shapes. Multiple-turn coils also are available. They are valuable for heat treating, soldering, and brazing. Industron Corp., Dept. ED, 50 Brook Rd., Needham Heights, Mass.

CIRCLE ED-223 ON READER-SERVICE CARD FOR MORE INFORMATION

Vertical Speed Transducer

Gives Climb Rate in Aircraft

The Vertical Speed Transducer is designed to provide an electrical signal proportional to the rate of ascent and descent of an aircraft. The instrument is fast enough so that it may be used for the purpose of stabilizing altitude servos and for manual level flight control, as well as for a rate-of-climb indicator.

The instrument employs on "Equibar" to measure the differential pressure between the pressure in the aircraft's static line and a cavity that is connected to this static line by a small capillary. The difference pressure is proportional to vertical speeds. At 50,000′ the unit has a time constant of 2sec. The time constant decreases to less than 0.2sec, at sea level. The high speed of response of this vertical speed indicator makes it an effective instrument for obtaining an "anti-porpoising" signal.

Output voltage varies between 0 and 5v peak-to-peak and may be telemetered on standard FM/FM telemetering systems. Normally powered from a 400cy, 115v supply, the unit may be powered by any frequency from 350cy to 10kc. The output signal shifts in phase by 180° between climbing and descending. Trans-Sonics, Inc., Dept. ED, Bedford Airport, Bedford, Mass.

CIRCLE ED-224 ON READER-SERVICE CARD FOR MORE INFORMATION

R-F Distortion Meter

Measures 1-100Mc

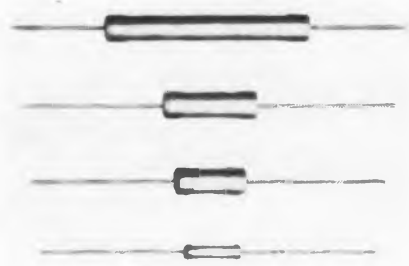
This R-F Distortion Meter is designed to measure the total harmonic distortion present in r-f sources from 1 to 100Mc. In principle, the meter completely suppresses the fundamental frequency, leaving the residual harmonic voltages which are detected by a full wave square law detector and amplified by a high gain d-c amplifier.

The sensitivity is such that harmonics can be detected down to 70db below the 3v maximum input level. Input impedance is approximately 50 ohms. Boonton Electronics Corp., Dept. ED, Boonton, N. J.

CIRCLE ED-229 ON READER-SERVICE CARD FOR MORE INFORMATION

Carbon Film Resistors

In Tolerances of 1%, 2%, 5%

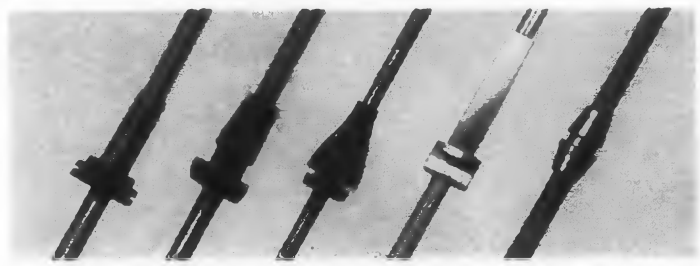


These Carbon Film Resistors are offered in a line of 1/4, 1/2, 1 and 2w ratings. Resistance range is 10 ohms through 20 megohms, and tolerances of 1%, 2%, and 5% are available at moderate cost. They are designed to meet the requirements of Mil-R-10509A. Continental Carbon, Inc., Dept. ED, 13900 Lorain Ave., Cleveland 11, Ohio.

CIRCLE ED-230 ON READER-SERVICE CARD FOR MORE INFORMATION

Strain Reliefs

Improve Cord Life



Illustrated are several of this firm's custom strain reliefs which give cords higher flexibility and longer life. The units are designed to reduce strain on electrical appliance power cords. They are custom-styled to meet many construction requirements. Phalo Plasties Corp., Dept. ED, 25 Foster St., Worcester, Mass.

CIRCLE ED-231 ON READER-SERVICE CARD FOR MORE INFORMATION

Mechanical Integrator

With 0.1% Accuracy

The "Belock" Ball and Disk Integrator features high accuracy and rugged construction. This 2" ball and disk integrator is designed especially for use in computers and gunfire control systems in the solution of differential equations. It is well adapted for use in high-performance closed-loop servo systems and is an accurate variable-speed drive.

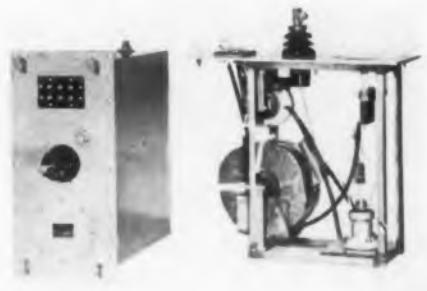
Total ball-carriage travel is 2". Disk diameter is just over 2", and it is hardened to Rockwell 65 and lapped to a superfinish. The ball carriage is positioned by an angular shaft displacement. Ball bearings are used for friction-free operation.

Integrator error in percent of total local value is less than 0.1% over most of the ball carriage range under typical disk speed and output torque conditions. Maximum dimensions are 1-1/4" x 1-1/4" x 3-3/4" (over shaft ends). Instrument Components, Inc., Dept. ED, 14-34 112th St., College Point, N. Y.

CIRCLE ED-236 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Supply

Provides 31kv D-c Peak



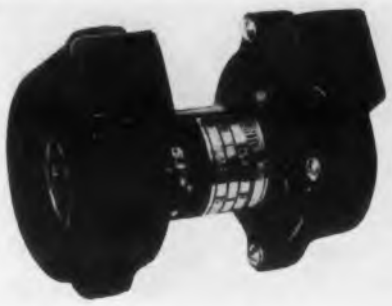
The Model S6-105 Power Supply consists of separate plate and filament transformers and a high voltage rectifier tube enclosed in a steel tank filled with an inhibited mineral oil. The tube may be replaced, when necessary, without draining the assembly. Separate inputs are provided for the plate and filament transformers so the output voltage may be varied. Two low-voltage terminals are provided so plate current can be metered readily.

This model is designed for 115v, 50/60cy input and 31kv d-c peak at 10ma output with negative ground. It is used widely in cable fault-finding apparatus and other applications requiring high potential d-c. Other ratings can be furnished where needed. Central Transformer Co., Dept. ED, 910 W. Jackson Blvd., Chicago 7, Ill.

CIRCLE ED-237 ON READER-SERVICE CARD FOR MORE INFORMATION

Double-Ended Blower

Only 3 3/4" Long



The miniature double-ended squirrel-cage centrifugal blower, Type No. 5012-203, is supplied in an all-metal housing. It is designed to operate at elevated temperatures without distortion.

This 3-3/4" x 2-5/8" blower weighs 12oz and will deliver approximately 50cfm of air. The unit shown is operated by a 1-1/4" standard Burton PM motor, is designed for 27-1/2v d-c operation, and will draw approximately 3/4amp in normal use.

The blower is designed for continuous duty in aircraft and other applications. Its design is such that its mounting can be made in a normal cradle-type mount with complete accessibility to the brushes. It is adaptable to specific cooling problems of electronic equipment, and is available for operation on voltages ranging from 6v to 110v d-c. Filters can be supplied for specific MIL requirements. Burton Manufacturing Co., 11201 W. Pico Blvd., Los Angeles 64, Calif.

CIRCLE ED-245 ON READER-SERVICE CARD FOR MORE INFORMATION

Sweep Generators

In Line of Wide-Band Units

A line of wide-band sweep generators, announced by this firm, is for use in work with TV antenna and cable systems, or similar applications. Frequency ranges of the three models are 52-92Mc; 10-92Mc; and 160-220Mc, respectively. Output is 0.3v into 72 ohms with response ±1db over the frequency range.

Sweep rate is approximately 58cy when power line source is 60cy. Hum in equipment under test thus shows up as 2cy modulation of the response curve and not as a fixed error in the curve.

The equipment utilizes a unique magnetic pick-off arrangement for sweep generation and blanking so that no slip rings or relays are required. The sweep signal is on for one-fourth of the sweep cycle and is blanking during the remainder. Community Engineering Corp., Dept. ED, State College, Pa.

CIRCLE ED-246 ON READER-SERVICE CARD FOR MORE INFORMATION

Transmit-Recieve Switch

Uses no Relays

This compact automatic electronic transmit-receive switch is suitable for amateur and commercial radio transmitters with up to 1kw inputs between 1.7 and 32Mc. It is designed to eliminate difficulties met in heavy-duty antenna change-over relays for switching of transmitters and receivers from a common antenna. It requires no tuning and contains no coils or variable capacitors.

The switch can be installed simply and conveniently at the rear or side of a transmitter cabinet. The plug for the transmitter output terminal is connected by a short coaxial cable. The antenna transmission line is connected to a coaxial receptacle. Receiver connections are made by screw-type terminals.

Within its rated range, receiver insertion loss will not exceed one S-unit, and power absorbed during transmission will be negligible with respect to transmitter output. The switch is rated for handling 50 to 1000w, and an impedance of 50-75 ohms. It measures only 2″ x 2″ x 3-1/2″. Transitron, Inc., Dept. ED, 154 Spring St., New York 12, N. Y.

CIRCLE ED-252 ON READER-SERVICE CARD FOR MORE INFORMATION

Sliding Scale Recorder

Measures Electro-Acoustics

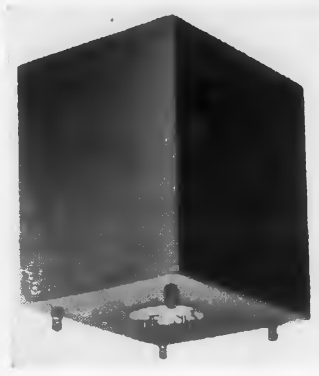
For electro-acoustical measurements, this recorder is based on the electro - dynamic principle and utilizes a "sliding coil" for the operation of the writing mechanism. It offers such features as: variable, electronically controlled, writing speeds; extreme stability and accuracy produced by a patented feedback principle; rugged construction for field and laboratory use, with true portability; and easy serviceability.

Known as the "Sliding-Coil Recorder", Model SL-2, it records on a 2″ wide chart and is a self-contained, compact instrument particularly suited for measurements of reverberation, sound intensity, vibration, sound decay, and any impulse or phenomena which can be converted into an electrical signal. The recording scale function depends only on the taper of the input potentiometer, and this permits a multiplicity of scale functions that may be recorded. Sound Apparatus Co., Dept. ED, Stirling, N. J.

CIRCLE ED-253 ON READER-SERVICE CARD FOR MORE INFORMATION

60cy Servo Amplifier

Magnetic Type



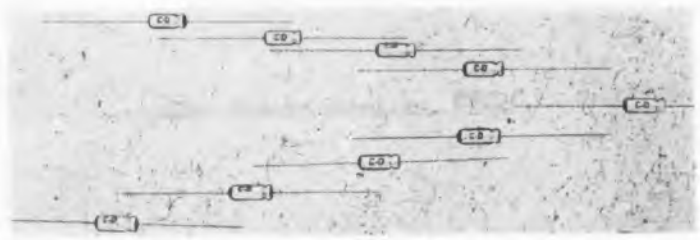
The PRD T6C16W1 Saturable Transformer will drive 115v 60cy servo motors requiring up to 16w to the control phase. Performing without the use of rectifiers, this inexpensive unit provides low drift and exceptionally long, trouble-free life over a range of temperatures from —55° to +85°C. Containing only static magnetic components, it is highly resistant to shock and vibration.

The band width of the unit is 0 to 3cy, and a power gain of 20 is realized. Hermetically sealed in a MIL type can, the unit is 3-7/8" long x 3-5/16" wide x 5-1/4" high. It weighs 6-1/2 lb. It is designed to operate with a simple vacuum-tube voltage preamplifier, such as a 12AU7. Neither the T6C16W1 nor its preamplifier requires a d-c power supply. This saturable transformer adds ruggedness, reliability, and simplicity to servo systems where low cost is of prime importance. Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N. Y.

CIRCLE ED-257 ON READER-SERVICE CARD FOR MORE INFORMATION

Electrolytic Capacitors

With Tantalum Anodes



The Type TX is a miniature sintered-anode tantalum capacitor with low leakage characteristics, low power factor, exceptionally long shelf life, and moisture-impervious hermetic sealing. The anode consists of a porous, sintered tantalum body with a short length of tantalum wire which terminates in a nickel wire serving as the anode lead. The sealed, fine-silver tubular case serves as the cathode to which the cathode lead is attached. Positive sealing is achieved by using a "Double Seal" construction which prevents movement of either lead or slug.

These capacitors have dimensions of 7/32" diam x 31/64" long. Temperature range is —55 to +85°C. At —55°C, capacity is at least 70% of normal, and power factor is not over 40%. Cornell-Dubilier Electric Corp., Dept. ED, S. Plainfield, N. J.

CIRCLE ED-258 ON READER-SERVICE CARD FOR MORE INFORMATION

Non-Destructive Tester

For Ferrous Items

The "Magnetic Comparator" provides a non-destructive, quick, simple method of testing ferrous parts for quality. Rods, bolts, springs, shafts, shell cases, and other parts can be compared with a preselected standard to detect a difference in composition, heat-treatment, or other characteristics which alter the resistivity or magnetic properties. In many cases, the instrument will distinguish between steels with a difference in hardness as little as two points of Rockwell, or composition of 0.1% carbon.

A testing rate up to 1200 pieces an hour is possible. Parts are tested by insertion in electric coils, available in various sizes, or through the use of gage heads placed on larger pieces. A meter indicates deviation from the preselected sample. Sunshine Scientific Instrument, Dept. ED, 1810 Grant Ave., Philadelphia 15, Pa.

CIRCLE ED-263 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulse Transformers

In Plug-In Series

The Type 40Z series of pulse transformers is designed especially for use as impedance matching circuits and blocking oscillator transformers. Hermetically sealed in drawn-shell cylindrical containers with 7- and 9-plug-in bases, standard units will meet military specifications and operate at ambient temperatures up to 85°C. They take up only 1.10 cu in of space.

Pulse width range is from 1.0μsec to 50μsec. Rise time is a maximum of 0.5μsec. Typical maximum primary inductance is 250mh, and the number of windings is limited to four. Special designs for high acceleration and for high ambient temperature operation are available to meet individual requirements. In addition, electrical counterparts of the Type 40Z series can be obtained in a lower-cost housing for typical commerical environment requirements. Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE ED-264 ON READER-SERVICE CARD FOR MORE INFORMATION

Superior makes quantity molded mechanical parts . . . of iron, brass, nickel, silver and tungsten alloys . . . *with individual precision*

● Why machine or cast small, intricate parts? Superior can produce quantities of accurate parts at a very low cost per piece by powder metallurgy. Every piece of a run will be uniform in size, strength and density. Superior can make alloyed metal parts to fit your application, recommending the right material for the job you have in mind. Consult Superior first.

Send us your blueprint and specifications.

SUPERIOR CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

SCP SUPERIOR CARBON BRUSHES "Since 1919"

CIRCLE ED-266 ON READER-SERVICE CARD FOR MORE INFORMATION

S-Band Wavemeter

A Rugged, Accurate Unit

The "C&D" S-band wavemeter is an inexpensive unit for the frequency range from 1800 to 3800Mc. It features highly sensitive indication of resonance, with a control for setting the sensitivity of the instrument. Its micrometer extends outside the instrument, providing easy reading.

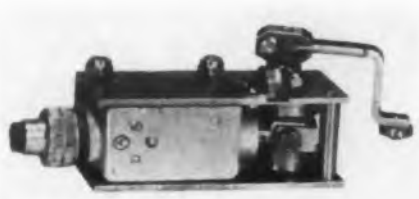
The unit has a precision cavity assembly for accurate repeatable readings, with an anti-backlash device which gives further accuracy. All silver-plated parts are rhodium flashed to minimize corrosion.

Specifications include: accuracy of ±1/2Mc at 3260Mc, and a loaded Q of approximately 1000. A ruggedized 50μa indicating instrument is provided. The r-f detector is a selected type IN21-B silicon diode. Input connections are two type N Jacks. Overall size is 8" x 7-3/4" x 2-1/4". Net weight is 2-1/2 lb. Amerac, Inc., Dept. ED, 116 Topsfield Rd., Wenham, Mass.

CIRCLE ED-267 ON READER-SERVICE CARD FOR MORE INFORMATION

Aircraft Switch

Operates in Ice



This hermetically sealed switch has the ability to reset even when coated with ice. The high operating and reset force enables it to be used on applications that were previously considered impossible.

The hermetic seal protects against temperature cycling, extreme range of heat or cold, and all foreign elements. Earlier switching developments, using this same sealing principle, have been used for landing gear, flaps, etc.

The small size of this unit eliminates excessive weight and permits ease of installations in compact areas. With the wiring conduit opposite the actuating mechanism, greater flexibility is possible to meet specific application requirements. A variety of actuators is available, including roller, leaf, cam, and many others. The switch complies to government specifications and is rated at 10amp for 125/250v a-c, 28v d-c inductive, and 28v d-c resistive. Electrical and mechanical life is 200,000cy. Electro-Snap Switch & Mfg. Co., Dept. ED, 4218 W. Lake St., Chicago 24, Ill.

CIRCLE ED-268 ON READER-SERVICE CARD FOR MORE INFORMATION

HEYCO NYLON STRAIN RELIEF BUSHINGS CUT PRODUCTION COSTS AND IMPROVE PRODUCT QUALITY

Approved

With Heycos it's no longer necessary to tie wire knots or use insulating grommets. Product life is increased and product appearance is greatly enhanced.

HEYMAN MANUFACTURING COMPANY
Kenilworth 16 New Jersey

HEYCO

Send wire sizes for free samples and specifications.

CIRCLE ED-269 ON READER-SERVICE CARD FOR MORE INFORMATION

Better Performance . . .

WITH THIS *NEW* HERMETICALLY SEALED RELAY

Developed to meet exacting specifications for a current aircraft equipment application, this hermetically sealed, solenoid-type relay combines high contact rating and large contact area in a lightweight, compact envelope.

No. A-53-110

CHARACTERISTICS

DESCRIPTION: SPST, NO., bracket mounted.
COIL DATA: Nominal voltage 24-28 VDC; maximum operating voltage 29 VDC; maximum pick-up voltage 18 VDC; drop-out voltage 7 VDC, plus 0, minus 5.5 VDC; standard coil 160 ohms, maximum coil current .180 amps.
CONTACT RATING: 25 amp. resistive; 20 amp. inductive; 15 amp. motor.
RATED DUTY: Continuous.
WEIGHT: 6.25 ounces.
MAXIMUM DIMENSIONS: Width $1\frac{15}{32}$", length $1\frac{15}{16}$", height $2\frac{3}{4}$".

Brochure and specifications available upon request.

RELAY DIVISION
Electrical Products CORP
1100 North Main Street, Los Angeles 12, California

CIRCLE ED-270 ON READER-SERVICE CARD FOR MORE INFORMATION

TENSION GAUGE is PRE-SETTABLE

For GO/NO-GO Tests of Springs and Contact Pressres

Speedy, one-hand operation and precise calibration over a range of 4 to 2500 grams, with adjustable zero setting, are the important features of G. E. C. tension gauges. Designed for GO/NO-GO checking of spring tensions or other resistive forces, these gauges permit inspection or production testing by unskilled personnel.

To use this gauge: just preset the tension by turning the micrometer knob until the pointer shows he desired tension on the scale and apply the tip of the gauge-operating strip where force is to be checked. If the force being checked matches the gauge setting, the operating strip and the resisting element will move at the same time. Attention is focused on one point only—movement at the point of contact; there are no dials or scales to be read.

Six models are available, covering ranges of 4-24, 10-80, 50-250, 100-500, 200-1600, and 500-2500 grams. For detailed descriptive bulletin and prices, write: General Electric Company, Limited, c/o Imtra Corporation (U. S. Agents), 58 Charles Street, Cambridge, Massachusetts, U. S. A.

CIRCLE ED-272 ON READER-SERVICE CARD FOR MORE INFORMATION

Humidity Cabinet

Uses Pyrex Chamber for Low Cost

The "Vapor-Temp" automatically controls relative humidity from 20% to near saturated, at any point, depending upon dry bulb temperature. Accuracy of the wet bulb is within ±2%; dry bulb accuracy is ±1°F from ambient to 158°F.

This cabinet uses an inverted Pyrex jar (16″ diam x 12″ high) as the work chamber, thereby cutting costs. The jar is placed on a welded 18-8 stainless-steel cabinet which houses wet and dry bulb controls, heavy-duty motor, corrosion-resistant blower, cooling coil, and solenoid valve. A 1/2″ aperture for thermocouple lead-ins or for recording humidity, etc., is provided. Wet and dry bulb thermometers, stainless-steel water box and wick, and alloy adjustable shelf are standard equipment. Rating is 1200w, 115v 60cy.

Another feature is high humidity without condensation on test specimen. Distilled water can be used if required. Blue M Electric Co., Dept. ED, 138th & Chatham St., Blue Island, Ill.

CIRCLE ED-273 ON READER-SERVICE CARD FOR MORE INFORMATION

Bandpass Filter

Incorporates Precision Toroids

This filter is designed specifically for single sideband. Its construction includes use of eight stabilized toroidal inductances and precision silver mica capacitors in an LC type filter designed to pass the frequencies 17.0kc to 20kc. The filter amplitude characteristic is relatively flat for its 3.0kc, passband with sharp skirt selectivity on *both* sides.

A receiving type, Model 360, with an impedance value of 20,000 ohms for both input and output, permitting operational use as an interstage coupling device, is available as standard. Model 361, for use in transmitting and receiving applications with balanced coupling windings of 500 ohms and/or 10,000 ohms, is available on special order.

Both models are precision adjusted and housed in hermetically sealed tinned-steel cases measuring 2-5/8″ x 2-1/4″ x 3-3/4″, exclusive of mounting studs and terminals. Barker & Williamson, Inc., Dept. ED, 237 Fairfield Ave., Upper Darby, Pa.

CIRCLE ED-274 ON READER-SERVICE CARD FOR MORE INFORMATION

Commutating Switch

Employs Jet of Mercury

This high-speed commutating and sampling switch is for monitoring 120 circuits 60 times per sec. It employs a mercury jet stream continuously emanating from a central pool (the pole of the switch) contained in the rotor. This jet stream is caused to sequentially contact pins located circumferentially around the stator, thereby electrically connecting each pin in succession to the pole.

In addition to its high sampling speed, the switch is characterized by a lack of contact bounce phenomena, by a low noise level in general, and by the potential of hundreds or thousands of hours of continuous trouble-free operation. This switch was originally developed in conjunction with a telemetering system for the University of California Radiation Laboratory. Detroit Controls Corp., Research Div., Dept. ED, Redwood City, Calif.

CIRCLE ED-278 ON READER-SERVICE CARD FOR MORE INFORMATION

Shaded-Pole Motor

With Unit Bearing Construction

Extended life, almost inaudible noise, and wide speed ranges are principal features of the SP-25 4-pole, shaded-pole motor. It is rated at 1/60-1/30hp, depending on customer specifications. It can be supplied to operate at speeds between 900 and 1550 rpm at rated input of 115v a-c. At reduced voltages, very stable speeds as low as 400rpm can be attained.

The SP-25 can be operated in vertical or horizontal positions without sacrifice of performance or life expectancy. Three standard frames with double or single-shaft extensions make it highly versatile from the application standpoint.

Unit bearing construction, which integrates motor housing and a single bearing in one iron casting, is employed, making misalignment of rotating and stationary elements impossible. Electric Motors and Specialties, Inc., Dept. ED, King and Hamsher Sts., Garrett, Ind.

CIRCLE ED-279 ON READER-SERVICE CARD FOR MORE INFORMATION

Hybrid T

For 8500-9600Mc Range

"Hughes" H-Plane Folded Hybrid T's are made of aluminum or beryllium copper precision castings, terminated in flat flanges. They are available in two classes of performance, standard or special, in the frequency range 8500-9600Mc for RG 52/U waveguide.

Characteristics of the standard Hybrid T are: vswr (all arms) less than or equal to 1.12; isolation (perpendicular arms) greater than or equal to 40db; isolation (parallel arms) greater than or equal to 28db; power balance equal ±0.1db; peak power 250kw. Characteristics of the Special Hybrid T are: vswr (all arms) less than or equal to 1.1; isolation (perpendicular arms) greater than or equal to 45db; isolation (parallel arms) greater than or equal to 30db; power balance equal to ±0.1db; peak power, 250kw. Microwave Development Laboratories, Dept. ED, 92 Broad St., Babson Park, Mass.

CIRCLE ED-284 ON READER-SERVICE CARD FOR MORE INFORMATION

Millivolt Indicator

Portable, Seven-Range Unit

Seven ranges, covering values from 0.25 to 25mv are provided in this portable indicating instrument. Laboratory precision is combined with ruggedness, permitting field use. Specific uses include measuring thermal radiometers, heat-flow transducers, surface-temperature explorations, and the checking of recording potentiometers.

Balance in this unit is indicated by a light-beam spot-type galvanometer protected by automatic short-circuiting when the instrument is off, and a shunt resistor when ranges are changed.

Accuracy is 0.5% of each range. The instrument, weighing 13 lb with full complement of batteries, measures 13" x 7-1/4" x 8". Beckman & Whitley, Inc., Dept. ED, 1085 E. San Carlos Ave., San Carlos, Calif.

CIRCLE ED-285 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature . . .

Electronic Components 289

Catalog No. D-55 includes additions to this firm's standard line of electronic components plus two new lines. Teflon electronic components include stand-off and feed-thru insulators, sockets, and spaghetti. Also shown are the electronic components of Corning Glass Works, including various types of capacitors and resistors. The catalog includes listings, illustrations, descriptions, and procedures for ordering. Erie Resistor Corp., Dept. S, Erie, Pa.

Teflon Products 290

Three bulletins cover this company's lines of "Teflon" packings, gaskets, special parts and stocks. Bulletin No. CP552 gives descriptions of Teflon ring packing, seal cages, etc. Gaskets and joints are discussed in Bulletin No. CP553 and special molded and machined parts and extruded stock are covered in Bulletin No. CP554. Chemical & Power Products, Inc., 11 Broadway, New York 4, N. Y.

Code Converter 291

An all-electronic computer that translates International Morse code signals from the air or other sources and converts them automatically to printed page copy on a standard teletypewriter printer is described in a new bulletin. A block diagram illustrates operating principles. CGS Laboratories, 391 Ludlow St., Stamford, Conn.

Molded Printed Circuits 292

A technical data sheet (Bulletin No. M-1) describes this firm's molded printed electronic circuits. Comprehensive data is given on types, construction, applications, dimensions, design service, leads and terminals, and charts. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Beam Switching Tube 293

Technical literature on the magnetron beam switching type includes a technical article on the tube, instruction sheets on the test chassis, data sheets, and price list. Circuit diagrams, dimensional drawings, typical characteristics, and operating requirements are provided. Applications Engineering Dept., Haydu Brothers of New Jersey, c/o Burroughs Research Center, Paoli, Pa.

Magnetic Amplifiers 294

Bulletin No. MA describes manufacturer's standard type magnetic amplifiers of toroidal construction. Information is given regarding special designs to suit individual requirements. Hycor Co., Inc., 11423 Vanowen St., N. Hollywood, Calif.

Transformers 295

A new general catalog, No. TR-55, lists 685 transformers, 79 of which are new to the line. Included in the new items are a series of subminiature audio transformers, available in either hermetically sealed or open-frame type; several additions to the series of high fidelity output transformers, power components, geoformers, replacement power, audio transformers, and dry disc rectifier transformers, TV replacement items. Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.

Resistors 296

A new axial-lead wire-wound resistor line is described in Bulletin No. M-714. The new resistors satisfy MIL specification performance requirements with a 35% to 50% reduction in size. The resistors are available in 172 types, rated at 3, 5, and 10w, with ohmic values from 1 to 50,000 ohms. Sprague Products Co., 347 Marshall St., N. Adams, Mass.

Multiplier Phototubes 297

A comprehensive catalog of operational theory, data on applications, and specifications for standard and special multiplier phototubes has been published. The 64-page, illustrated catalog has been divided into three sections. The first section contains a simplified technical discussion of photo and secondary emissions and their effect on design and operation of multiplier phototubes. The second section describes uses and applications and the third section gives full specifications and information on accessories. Technical Sales Dept., Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

Motivation Research 298

This pamphlet, "The Power of Motivation Research", states the facts about a scientific practical way to find out why people accept or reject a particular product, service, or idea. The pamphlet gives some of the questions that should be considered by a designer in introducing new products and in getting their acceptance. Dunlap and Associates, Inc., 429 Atlantic St., Stamford, Conn.

Tracing and Drawing Paper 299

A drawing and tracing paper with "disappearing" grid lines is described and illustrated in a new catalog. This paper is printed with light-blue cross section rulings which completely disappear on direct print reproductions and blue prints. It is available in both rolls and sheets. Cross-section, mathematical, logarithmic, and time-period forms are shown. Clearprint Paper Co., 1482 67th St., Emeryville, Calif.

Relays 300

Bulletin No. 108 lists sensitive relays and plug-in assemblies for automatic control circuits. Circuit diagrams and dimensional drawings are included. Assembly Products, Inc., Chesterland, Ohio.

Potentiometers 301

Series AN precision potentiometers offering linearity within ±0.025% are the subject of data sheet No. 54-11. The sheet contains details of construction, specifications, characteristics. Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif.

GENERAL ELECTRIC ANNOUNCES . . .

NEW, faster, smaller micro-miniature relay

LIGHT WEIGHT, SMALL SIZE: Weighs only .35 ounces and measures .34" x .781" x .81". This tiny relay utilizes balanced armature and simple design, giving you quality and more reliable operation at a consistently high level.
HIGH CONTACT RATING: For low contact resistance and long life, fine silver is used . . . contact rating is 2 amps resistive load at 30 V d-c or 115 V a-c.
FAST OPERATION: With rated voltage on coil, operating time is 1.5 milliseconds. By adding series resistance in coil circuit or by applying high voltage pulse to coil . . . pickup time will be less than 1 millisecond!
LOW OPERATING POWER: 250 milliwatts for standard model . . . 100 milliwatts for current sensitive model.
HIGH SHOCK: VIBRATION RESISTANT: G.E.'s balanced armature and high tip forces withstand shock of over 50 g's and vibration of 10-55 cp's at .12" maximum excursion and 55–500 cp's at 20 g's acceleration.
HIGH TEMP OPERATION: This new micro-miniature relay gives you continuous and efficient operation at ambient temperatures of 125° C.

G.E.'s line of aircraft-type relays will help solve your space-weight problems. Contact your G-E Apparatus Sales office for more application information. General Electric Company, Schenectady 5, New York.

MAIL THIS COUPON FOR G-E RELAY DATA . . .


A


B


C


D

- ☐ **A: Micro-miniature Relay—Bulletin GEA-6346**
- ☐ **B: High Speed Relay—Bulletin GEA-6212**
- ☐ **C: Miniature Relay—Bulletin GEA-6213**
- ☐ **D: Subminiature Relay—Bulletin GEA-6211**
- ☐ **E: Have Sales Engineer contact me.**

Section C792-2, General Electric Company, Schenectady 5, New York

NAME..... **TITLE**.....

COMPANY.....

ADDRESS.....

CITY..... **STATE**.....

GENERAL ELECTRIC

Chemical Catalog 305

A new catalog lists information on chemical products made by this company. The Table of Contents lists acids and anhydrides, alcohols, aldehydes, plasticizers, solvents, amines, phenols, phenol ethers, petroleum additives and other miscellaneous chemicals, concluding with information on cellulose products and inorganic chemicals. Eastman Chemical Products, Inc., Kingsport, Tenn.

Automatic Control Systems 306

A new brochure describes this firm's facilities for the engineering design, development, and manufacture of electronic and electro-mechanical controls and devices. Autron Engineering, Inc., 1254 W. Sixth St., Los Angeles 17, Calif.

Forging Glossary 307

A glossary of terms commonly used in connection with brass forgings is given in a 4-page brochure. More than 150 terms are defined. Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y.

Photoelectric Controls 308

A 20-page illustrated bulletin, "Proved Answers to Successful Automation", contains specifications, descriptive data, and operational charts of photoelectric controls for industrial uses. Among the applications described are high-speed counting, inspection and sorting, smoke control, high-temperature measurement and control, machinery safeguards, and conveyor control. Wiring diagrams, block diagrams, and dimensional drawings are included. Photoswitch Div., Electronics Corp. of America, 77 Broadway, Cambridge 42, Mass.

Spectrographic Source Unit 309

Bulletin No. 35A contains information on the three circuits available in this company's spectrographic source unit. A selector switch permits quick and easy change from the three basic circuits—high voltage condensed spark, a-c arc, and d-c arc—without physically changing the leads. Specifications and features of the circuits are presented, with schematic diagrams of each. Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.

Simplified Drafting 311

A 36-page booklet on "Simplified Drafting" presents 11 common-sense rules for simplifying drafting practices. Through the medium of sample drawings of engineered parts and assemblies, the 11 rules are illustrated and a comparison made between old and simplified methods. General Engineering Laboratory, American Machine & Foundry Co., 11 Bruce Pl., Greenwich, Conn.

All-Nylon Fastenings 312

All-nylon fastenings are described in a 4-page pamphlet. Mechanical, thermal, and electrical properties are listed, and various types of fasteners are illustrated. Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N. Y.

Tantalum Capacitors 313

The Type TH tantalum electrolytic capacitor is illustrated and described in a technical data sheet. Typical ratings, life test and temperature characteristics and dimensional drawings are given. Cornell-Dubilier Electric Corp., S. Plainfield, N. J.

Precision Tooling 314

A 38-page brochure covers the precision tooling requirements of industry. The brochure discusses such subjects as custom, standard, and special purpose lamination dies; various phases of tungsten carbide fabrication; compacting dies for metal and ceramic operations; jigs and fixtures; precision gages; custom jig grinding and boring; precision testing equipment; special purpose equipment, plus the engineering and service available. Cleveland Tool & Die Co., 1643 Eddy Rd., Cleveland 12, Ohio.

Airless Blast Cleaning 315

A new bulletin (No. 834) discusses cleaning operations connected with the manufacture of electrical parts. Dealing with the airless abrasive blast cleaning method, the bulletin gives case histories on the following subjects: cleaning metal castings for electrical machinery, deflashing compression molded plastic components, and surfacing electrical line and cable fittings prior to such operations as galvanizing. American Wheelabrator & Equipment Corp., 1750 S. Byrkit St., Mishawaka, Ind.

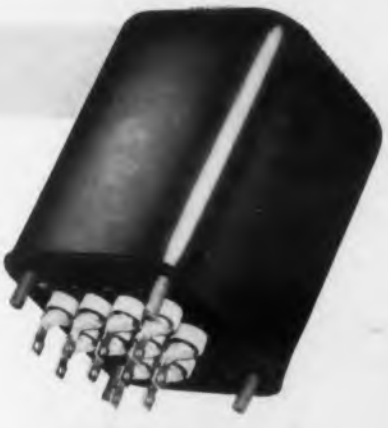
for absolute reliability in

RAYDIST
ultra-sensitive electronic tracking systems

This power supply, shown with the Raydist mobile electronic tracking system, is typical of the use of CHICAGO transformers in Raydist equipment.

THE LOGICAL CHOICE WAS

CHICAGO *the World's Toughest* TRANSFORMERS



CHICAGO MIL-T-27
Sealed-in-Steel Transformer

Raydist, designed and built by the Hastings Instrument Company, Inc., of Hampton, Virginia, is a remarkably precise and sensitive electronic radio location system. Raydist systems are used for air and marine navigation tracking, marine geophysical surveying, chartmaking, meteorological studies and a host of applications requiring infinitely accurate tracking and plotting.

Because Raydist precision performance is dependent upon the quality of the components used, Hastings specifies and uses CHICAGO MIL-T-27 hermetically sealed transformers.

Wherever absolute reliability and optimum precision are essential, you'll find CHICAGO, truly the world's toughest transformers.

FREE: CHICAGO Catalog CT-554, listing over 500 Sealed-in-Steel transformers. Available from your parts distributor.

CHICAGO STANDARD TRANSFORMER CORPORATION
Addison and Elston • Chicago 18, Illinois

EXPORT SALES:
Roburn Agencies, Inc.
431 Greenwich St.
New York 13, N.Y.

CIRCLE ED-317 ON READER-SERVICE CARD FOR MORE INFORMATION

Catalog Supplement 319

A new catalog supplement, "Labaratus", has been issued by this company. The 64-page booklet lists 350 of the company's manufactured and specialty instruments, including a current price list. Photographs and descriptions of new and improved products are presented throughout the book. Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.

Frequency Meters 320

A new line of 3-1/2" flush panel mounting vibrating reed frequency meters is described and illustrated in a 4-page brochure. Specifications and ranges are given. Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.

Miniature Terminals 321

Miniature tubular terminals and contacts for printed circuit applications are illustrated and described in a 4-page brochure. Typical applications are illustrated and dimensional drawings are included. Malco Tool and Manufacturing Co., 4025 W. Lake St., Chicago 24, Ill.

Relay Rack Panels 322

A new catalog describes new additions to this firm's line of products for the electronics industry. The new items consist of standard relay rack panels, meter panels, enclosed meter panels, metal door rack panels, sloping front cabinets, chassis supporting angles, chassis mounting brackets, rack shelves, and deluxe cabinet racks with front door and adjustable mounting angles. Wyco Metal Products, 6918 Beck Ave., N. Hollywood, Calif.

Hermetic Terminals 323

Three basic lines of hermetic terminals are illustrated and described in a new catalog. Dimensional drawings, chemical resistance, electrical, water resistance, oil resistance, and mechanical properties are provided. Silicone Seals, Inc., 3125 Milwaukee Ave., Chicago 18, Ill.

Parts Catalog 324

Catalog No. 55-A lists nearly 1000 components. Data is provided on coils, chokes, filters, transformers, trimmers, windings, etc. A price list is included. J. W. Miller Co., 5917 S. Main St., Los Angeles 3, Calif.

Connectors and Cables 326

Catalog No. B4 provides a complete listing of this company's products. Included are AN and r-f connectors, coaxial cables, Blue Ribbon and miniature connectors, radio sockets and plugs, TV antennas and accessories, and microphone connectors. American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Miniature Transformers 327

This company's line of miniature transformers are described and illustrated in a 4-page brochure. Included are miniature, sub-miniature, and micro-miniature audio and transistor transformers and veriminiature transformers for use with transistor circuitry. A price list is included. Microtran Co., 84-11 Boulevard, Rockaway Beach, N. Y.

Split Bearings 328

This 24-page catalog illustrates and describes this company's line of split ballbearings. Charts give tolerances and design advantages. Split Ballbearing Corporation, Lebanon, N. H.

Powder Metallurgy 329

A 52-page treatise on powder metallurgy is illustrated with photos, tables, charts, and graphs. Separate sections in the manual are devoted to bearings, components parts, and filters. Subjects include design, loads and speeds, installation, flow rates, etc. Hypothetical problems are outlined and solved step-by-step. Amplex Div., Chrysler Corp., P. O. Box 2718, Detroit 31, Mich.

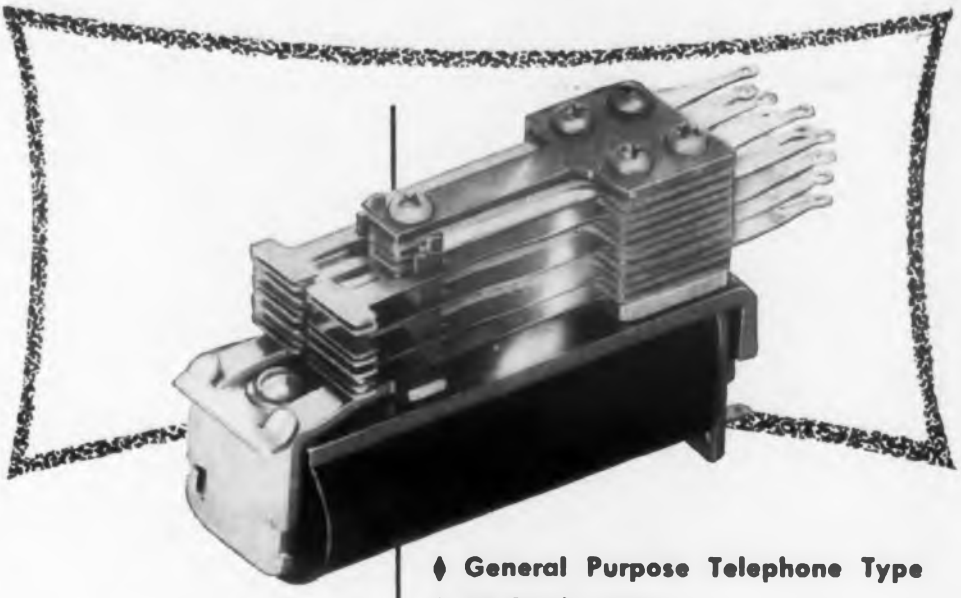
Oscillogram Processor 330

The type 23-109 oscillogram processor is described and illustrated in a 4-page brochure. Complete specifications and a cutaway drawing are provided. Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Capacitors 331

The "Super Micadon" capacitor is described in engineering bulletin No. 160. The features of this new concept in miniature mica capacitor design are presented and graphs and charts show performance characteristics. Cornell-Dubilier Electric Corp., S. Plainfield, N. J.

Kellogg provides custom assembled relays for industry



- **General Purpose Telephone Type**
- **At Stock Prices**
- **Life Expectancy— Over 100 Million Operations**
- **1710 Contact Spring Combinations**
- **100 Stock Coils Available**
- **Precious Metal Contacts— Palladium or Gold Alloy**
- **Delivery 20 to 45 Days**

Variations of Relays available at Kellogg:

TIME DELAY RELAYS
TWIN RELAY—2 relays in space of one
SNAP ACTION RELAY
MULTI-CONTACT RELAY
PLUG-IN RELAY

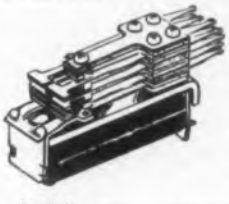
SPECIFICATIONS

COIL—Single or double wound.
ARMATURE—Frictionless armature travel. Both knife edge and hinged pivots.
OPERATING VOLTAGE—Up to 115 volts, D.C.
OPERATING TIME—From 2 to 30 milliseconds.
RELEASE TIME—From 5 to 50 milliseconds.
RESIDUAL—Fixed (clip) or adjustable (lock screw).
CONTACTS—Twin bar-dome type palladium contacts.
CONTACT ASSEMBLY—Forms A to D. Maximum of 16 A's, 14 B's, 10 C's, 10 D's or any equivalent combination of these contacts.
MOUNTING—Two No. 8-32 tapped holes in heelpiece allow versatile mounting.

KELLOGG — Division of I T&T

A famous name in communications now solving problems in the control industry

INDUSTRIAL SALES DEPARTMENT
KELLOGG SWITCHBOARD AND SUPPLY CO.
A Division of International Telephone and Telegraph Corporation
Sales Offices: 79 West Monroe Street
CHICAGO 3, ILLINOIS



KELLOGG SWITCHBOARD AND SUPPLY COMPANY
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☐ **Please have representative call.**
☐ **Please send detailed Relay information.**

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

CIRCLE ED-333 ON READER-SERVICE CARD FOR MORE INFORMATION

Measuring Equipment 335

A new 12-page catalog illustrates this company's complete line of electronic precision measuring equipment. This catalog contains complete specifications and characteristics of transconductance analyzers and circuit simulators, a-m signal generators, u-h-f TV sweep frequency generators, frequeuncy standards, and many others. New London Instrument Co., Inc., 82 Union St., New London, Conn.

Frequency Counter 336

A catalog sheet provides features, description, applications, specifications, and block diagram of the Model DS-6100-T frequency counter. Detectron Corp., Computer-Measurements Div., 5528 Vineland Ave., N. Hollywood, Calif.

Rotary Electrical Equipment 337

Bulletin No. 254A contains specifications and descriptions of more than 50 miniature motors, fans, and blowers. Dimensional drawings and complete technical specifications are given. Electro Products Div., Western Gear, 132 W. Colorado St., Pasadena, Calif.

Time Delay Relay 338

The Model SF "Agastat" time delay relay is described in a 2-page, 2-color bulletin. The relay is a hermetically sealed aircraft type. Circuit diagrams and dimensional drawings illustrate characteristics and specifications. Aga Div., Elastic Stop Nut Corp. of America, 1029 Newark Ave., Elizabeth, N. J.

Shaft Seal 339

A mechanical seal specifically designed for use on rotary shafts at pressures up to 150psi is described in Bulletin No. AD-150. Cut-away and dimensional drawings illustrate various applications. Garlock Packing Co., Palmyra, N. Y.

Current-Limiting Fuses 340

Current-limiting fuses rated at 250 and 600v in sizes from 6 to 200amp are described in Bulletin No. GEA-6319. The 8-page publication includes specifications, curves of current-limiting characteristics, tables of maximum rating for conductors, melting times, and minimum back-up as well as table of dimensions. General Electric Co., Schenectady 5, N. Y.

Mounting Bases 342

A complete line of mounting bases, vibration and shock controls is described in a new catalog. The catalog includes detailed descriptions of standard and special mounting bases, and a wide selection of vibration and shock controls—all of which meet JAN and MIL specifications. T. R. Finn & Co., Inc., Electronics Div., 200 Central Ave., Hawthorne, N. J.

Facilities and Services 343

A 16-page illustrated brochure entitled "Facilities and Services" explains this company's experience and its capability to perform electronic design and construction, research and development engineering. Standard Electronic Corp., 285 Emmet St., Newark 55, N. J.

Photocopying 344

A new method of office photocopying, "Auto-Stat", is discussed in a 6-page booklet. Applications and requirements for use are described. American Photocopy Equipment Co., 1920 W. Peterson Ave., Chicago 26, Ill.

Tone Signaling Units 345

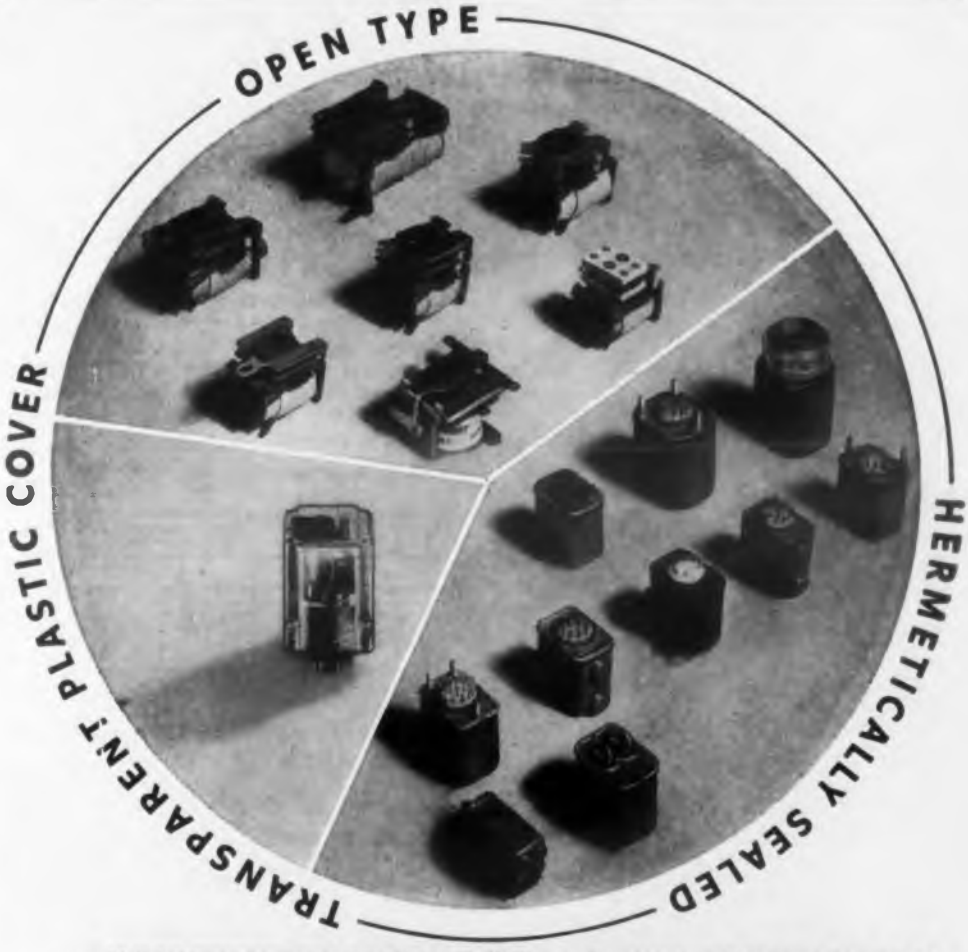
A 6-page brochure describes the operating features and performance of this firm's new supervisory tone equipment of modular design. The brochure tells how these units transmit and receive signalling, dialing, telemetering, supervisory controls and other information, over wire lines, telephone or power-line carrier, and radio microwave communication circuit. Hammarlund Manufacturing Co., Inc., 460 W. 34th St., New York 1, N. Y.

Greek Alphabet 346

A ready reference guide for Greek symbols that are used in engineering work is available. Printed on "Transeal" stock to simulate a title block, the complete alphabet image measures 4-1/8" x 2-3/8". Johnson Research Corp., Bethpage, L. I., N. Y.

Potentiometers 347

A 4-page illustrated color bulletin gives features and specifications on 2" ball-bearing potentiometers designed for applications requiring great precision. Electronic Sales Div., DeJur-Amsco Corp., 40-01 Northern Blvd., Long Island City 1, N. Y.



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CIRCLE ED-349 ON READER-SERVICE CARD FOR MORE INFORMATION

Numerical Data Printers 351

Two new folders describes specifications and applications of two numerical data printers for business, industry, and laboratory. The folders list six models of parallel entry and four models of serial entry numerical data printers. Electronic Div., Clary Corp., San Gabriel, Calif.

Hairsprings 352

Hairsprings for instruments, clocks and fine mechanisms are described in an 8-page booklet. Manufacturing processes and materials used are detailed and calculations for curvature, resilience, stress, and stress concentrations are given. F. N. Manross & Sons, Div. of Associated Spring Corp., Bristol, Conn.

Subminiature Potentiometer 353

A 2-page, illustrated bulletin, No. CO78-455, describes and illustrates a new series of precision potentiometers with only 7/8" diam and weighing only 1/2 oz. Single hole and servo mountings are shown. Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Charts 354

Bulletin No. Y1904 describes the engineering charts made by this company. The paper, plate, and printing used in the manufacture of the charts, as well as the inks and pens used in recording information on the charts are discussed. Bristol Co., Waterbury 20, Conn.

Temperature Sensitive Paint 355

A leaflet describes a temperature-sensitive paint that changes color at 400°F from the original mustard yellow to maroon in 5 min. The leaflet also gives directions for application prices. Tempil Corp., 132 W. 22nd St., New York 11, N. Y.

Meters 356

Five types of meters are illustrated and described in this pamphlet. The types are Universal Meter UM, High-Resistance Universal Voltmeter UM, Universal Millivoltmeter UM, Universal Volt- and Outputmeter UM, and D-C Multi-range Meter UM. Allgemeine. Elektricitats-Gesellschaft. U. S. Importer, Donald C. Seibert, Box 281, Wilmington, Del.

Screw Machine Products 358

A 4-page brochure deals with industrial fasteners produced to rigid specifications, hardware specialties, screw machine products, and special screws. Six examples are presented in detail through engineering drawings and text. Abbott Products, Inc., 150-50 12th Ave., Whitestone 57, N. Y.

Teflon Terminals 359

"Press-fit" teflon terminals are the subject of an 8-page brochure. Electrical, mechanical, and chemical properties and terminal applications are listed. Dimensional diagrams and installation procedure are included. Sealectro Corp., 186 Union Ave., New Rochelle, N. Y.

Ball Bearings 360

A technical data sheet gives information on a new line of radial bearings from 5/8" diam to 1-1/2" diam. Stud and bore types are available. Dimensional drawings are provided. Grant Pulley and Hardware Corp., 31-85 Whitestone Pkwy., Flushing 54, N. Y.

Magnetic Amplifiers 361

A 10-page catalog describes a newly developed line of high performance magnetic amplifiers and frequency multipliers. Performance characteristics, specifications, and applications are given. American Research & Manufacturing Corp., 4914 Del Ray Ave., Bethesda 14, Md.

Toggle Switches 362

New lightweight, subminiature toggle switches for commercial and military applications are described in a technical data sheet. Rated performance and design data are given for the 10amp, 50v d-c switches. Electronics Div., Torsion Balance Co., Clifton, N.J.

Broadcasting Equipment 363

Catalog No. 123 gives basic information on TV, broadcasting, public address, recording, communications, and special purpose microphones and accessories. It illustrates and describes high-fidelity speakers, speaker systems, components and enclosures. Electro-Voice, Inc., Buchanan, Mich.

Silicon Powder 367

Technical data sheets Nos. PMS-76 and 77 list chemical and physical properties of two grades of silicon powder which are sold under the trade name "Plast-Silicon". Physical property tests are by Metal Powder Association Standard Methods. Plastic Metals Div., National-U. S. Radiator Co., Johnstown, Pa.

Digital Printers 368

A 4-page bulletin describes this firm's line of high speed digital printers. Three basic models, the lister, the accumulator, and the multiplier, are discussed. Specifications and applications are given. Electronics Div., Victor Adding Machine Co., 3900 N. Rockwell Ave., Chicago 18, Ill.

All-Metal Locknuts 369

A 4-page illustrated folder describes Flexloc self-locking nuts. Drawings illustrate the locking action of the one-piece all-metal nut which can be used either as a locknut or a stop nut. Applications of the nut are illustrated in small drawings. Standard Pressed Steel Co., Box 202, Jenkintown, Pa.

Wire Manufacturing 386

A new booklet describes the facilities of this company for the manufacture of fine wire and ribbon, wire and ribbon parts, and small parts plating. The 12-page illustrated booklet contains chemical composition charts which indicate percentages of base material used in fine wire and ribbon. Testing procedures are outlined. Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y.

Coils and Coil Forms 387

A new brochure contains 8 pages of various types of coils and coil forms which may be of interest to design engineers for prototype and research work. Charts show electrical specifications and mechanical specifications are given in dimensional drawings. Coil Winders, Inc., New York Ave., Westbury, N. Y.

Waxes 388

A 16-page technical bulletin describes paraffin and microcrystalline waxes. In both tabular and graph form, the principal characteristics of each of the nine standard grades are given. These waxes may be used in waxing capacitors and other components. Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.

Socket Screws 370

A new series of data sheets lists the physical properties of this company's line of socket screw products. The first two sheets list the ultimate tensile strength, yield point, elongation, reduction in area, and Rockwell hardness of the material from which the screws are made, as well as the actual minimum breaking strength of all standard size socket screws. Socket Screw Div., The Bristol Co., Waterbury 20, Conn.

Aerial Photography 371

"Advancing Horizons" describes aspects of this company's research and production in electronically controlled aerial photographic equipment. Such systems as camera control, image motion compensation and viewfinder are discussed. Chicago Aerial Industries, Inc., 1980 N. Hawthorne Ave., Melrose Park, Ill.

Diffusion and Booster Pumps 389

Greatly increased pumping speeds in the pressure ranges from 0.1 to 10 microns and from 1 to 100 microns are provided by the "Ring-Jet" diffusion and booster pumps described in this set of bulletins. Pumping speed curves, throughput curves, and forepressure tolerance curves for each of the several sizes of pumps are given. F. J. Stokes Machine Co., 5500 Tabor Rd., Philadelphia 20, Pa.

Automatic Tuning Lock 390

A special bulletin describes the Trak automatic tuning lock, an auxiliary device for frequency-shift communications receivers. The tuning lock automatically maintains a frequency-shift signal in tune despite drift from any cause, receiver temperature changes, or other and has greater efficiency in reception. CGS Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

Wire and Cable 391

Applications, physical characteristics, and qualities of this firm's line of wire and cable are given in a new catalog. Tables are used to describe the various types of cables, wires, cord and cord sets, flexible tubing, and wiring harness. An appendix includes definitions, common conversion tables, temperature tables, comparison of sizes, decimal equivalents, and other pertinent data. Phalo Plastics Corp., 25 Foster St., Worcester, Mass.

Heat Detector Cells 374

A 4-page illustrated brochure covers a group of remote detectors of far infrared energy. The units are designed for use in heat detection, measurement, or control systems where direct contact with the source is inadvisable or impossible. Typical construction, features, and specifications are given. Servo Corp. of America, 2020 Jericho Turnpike, New Hyde Park, N. Y.

Stand-Offs 375

A 4-page brochure provides complete technical data and drawings on this company's line of single terminal feed-thru's and standoffs. These are offered as standard with flanged bodies for easy positioning and soldering. Hermetic Seal Products Co., 29-37 S. Sixth St., Newark 4, N. J.

Potentiometers 376

A 4-page brochure gives specifications and characteristics of potentiometers available from this company. Dimensional drawings and charts are included. Vari-ohm Corp., P. O. Box 19, Amityville, N. Y.

Transparent Plastics 377

Seven new and improved transparent plastics are described in an illustrated 6-page brochure. Properties are outlined and applications suggested. The plastics may be used for television faces, instrument dial covers, and plotting boards. Homalite Corp., 11-13 Brookside Drive, Wilmington 166, Del.

Delay Lines 378

A new catalog describes delay lines, variable delay lines, and pulse forming equipment. E. S. C. Corp., 534 Bergen Blvd., Palisades Park, N. J.

Constant-Force Spring 379

More than 25 actual design applications of this firm's constant-force spring are described and illustrated in a 2-color, 16-page technical bulletin. The operation of this constant-force, long-extension spring and its six major forms are also pictured and discussed in terms of their utility in mechanical design. Hunter Spring Co., 21 Spring Ave., Lansdale, Pa.

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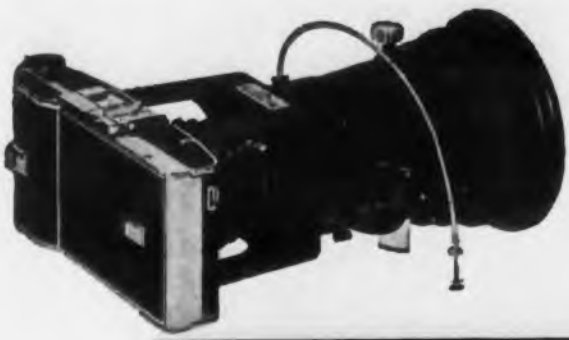

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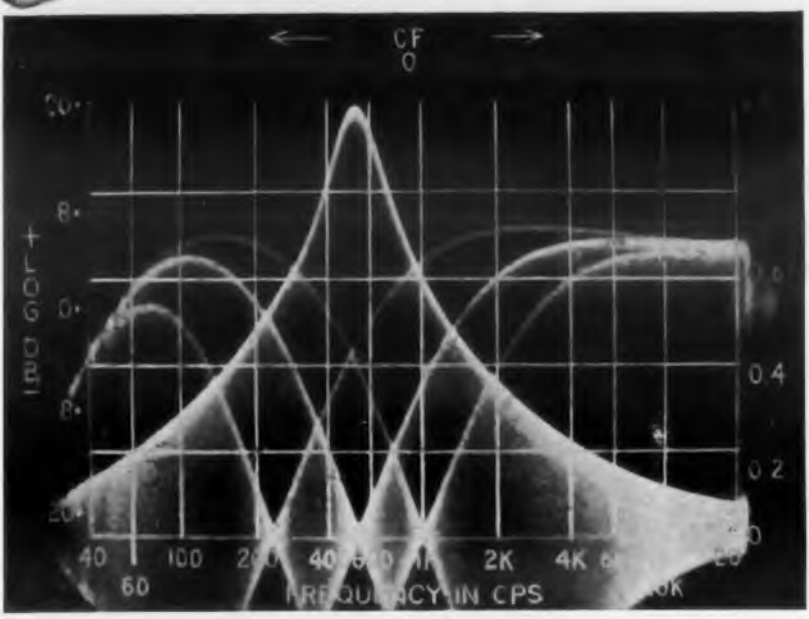

Performance evaluation of a Fischer electronic (low frequency—high frequency) filter; wave forms signify the following: Variable null marker to check points on response curve at 1 Kc, 2.2 Kc and 5.5 Kc. This is a log amplitude presentation where the frequency is multiplied by a factor of 10. Instrument used is SGI Sweep Generator; courtesy Panoramic Radio Products Corporation.

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This special Fairchild adaptation of the Polaroid-Land principle delivers a permanent, photographically accurate, full-size record of single transients or identical repetitive phenomena in 60 seconds after they appear on the C-R Tube. It is the only practical method to obtain a quick, permanent record of scope patterns like the one above. Because this photographic method is so fast, laboratory work can proceed continuously without interruptions or delays so usual where conventional film is used. The life size 3¼ x 4¼ in. image makes evaluation easy and accurate. Camera is automatically in focus when attached to the oscilloscope. Also provides for critical focusing adjustment where thick grids or filters are interposed between the tube face and camera hood.

For accurate records of continuously varying phenomena or single transients and stationary patterns on 35 mm. film, the Fairchild Oscillo-Record Camera is available. For more information, write Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Expressway, Jamaica, New York, Department 120-23NI.

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Patents . . .

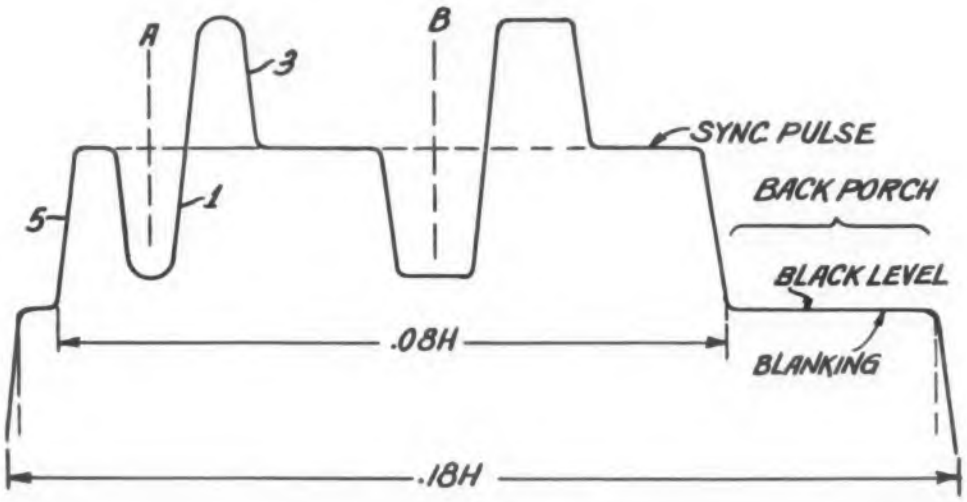
By John Montstream

Conveyance of Auxiliary Information in a Television System . . . *Patent No. 2,686,202. George C. Sziklai and Francis J. Darke, Jr. (Assigned to Radio Corp. of America, New York, N. Y.)*

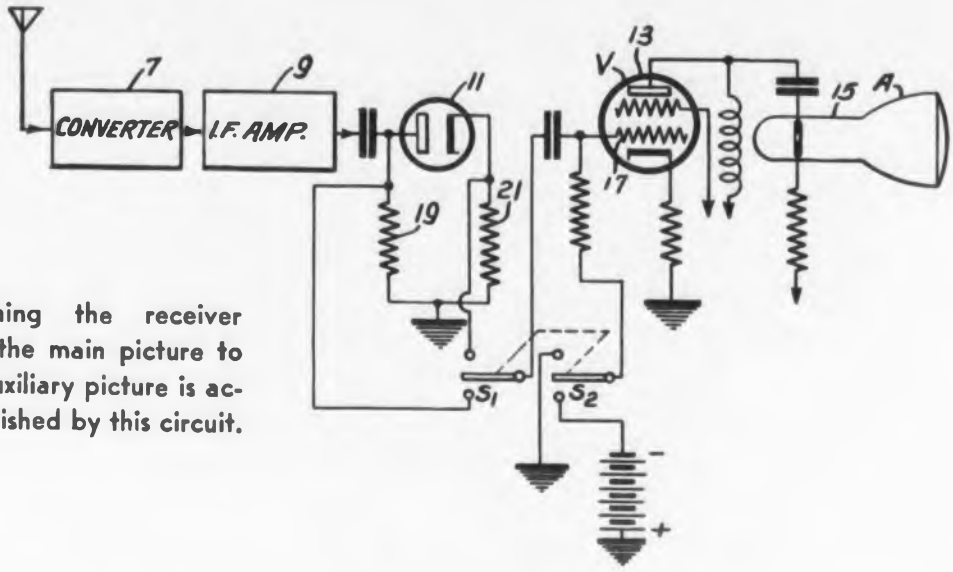
The use of the line blanking pulse in a television signal for the transmission of the sound accompaniment was proposed many years ago. Others have developed various systems or circuits that use the blanking signal for the transmission of sound. The patentees, now, have devised a system for using the blanking signal for the transmission of a visual image that conveys some information. Such information may be the time, weather reports, station identification, scores of games, advertising, and other information of a wide general character. This visual information is sent without an increase in the channel width.

An enlarged view of a synchronizing pulse that is modulated to carry a signal (*A* and *B*) for the auxiliary image is illustrated. The signal is carried between the front edge (*5*) and the back edge so that there will be no interference with the timing of the scanning. The signal curve (*1*) is followed by an equal curve so that the energy of the pulse will not be altered. Since the retrace time of the beam is fast, the visual information in a horizontal direction carried by the pulse cannot be nearly as detailed as the usual television picture, however, considerable information can be conveyed nevertheless.

The television receiver circuit needs but a minor addition in order to switch the set to the auxiliary visual signal. A circuit modification is shown for switching the receiver from the main picture to the auxiliary picture. This switching is accomplished with a pair of switches (S_1 and S_2) which are ganged together. For the main picture, the switches are in the up position so that the signal passes from the cathode of the diode detector (*11*) to the control grid (*17*) of the amplifier (*13*). The control grid is grounded through a resistor and switch S_2. In the down position of the switches, the anode of the diode is connected with the control grid of the ampli-



The blanking pulse modulated to carry the auxiliary signal.



Switching the receiver from the main picture to the auxiliary picture is accomplished by this circuit.

fier and a bias voltage is applied to the control grid through switch S_1. The switching inverts the auxiliary signal and gives it a proper reference level.

In the form of switching circuit shown there is a signal inversion so far as the auxiliary signal is concerned. A downward modulation *1* in the usual signal is in the direction of white and an upward signal is in the direction of black. With the signal inversion, downward modulation *1* is in fact the direction of black and the upward modulation (*3*) is in the white direction. Since a signal at the level of the synchronization pulse is completely in the black region, the auxiliary signal level must be changed to produce a visual response on the screen. The biasing of the control grid of amplifier *13* gives the auxiliary signal its proper reference level. The patent describes also various modifications in the basic concept of the invention.

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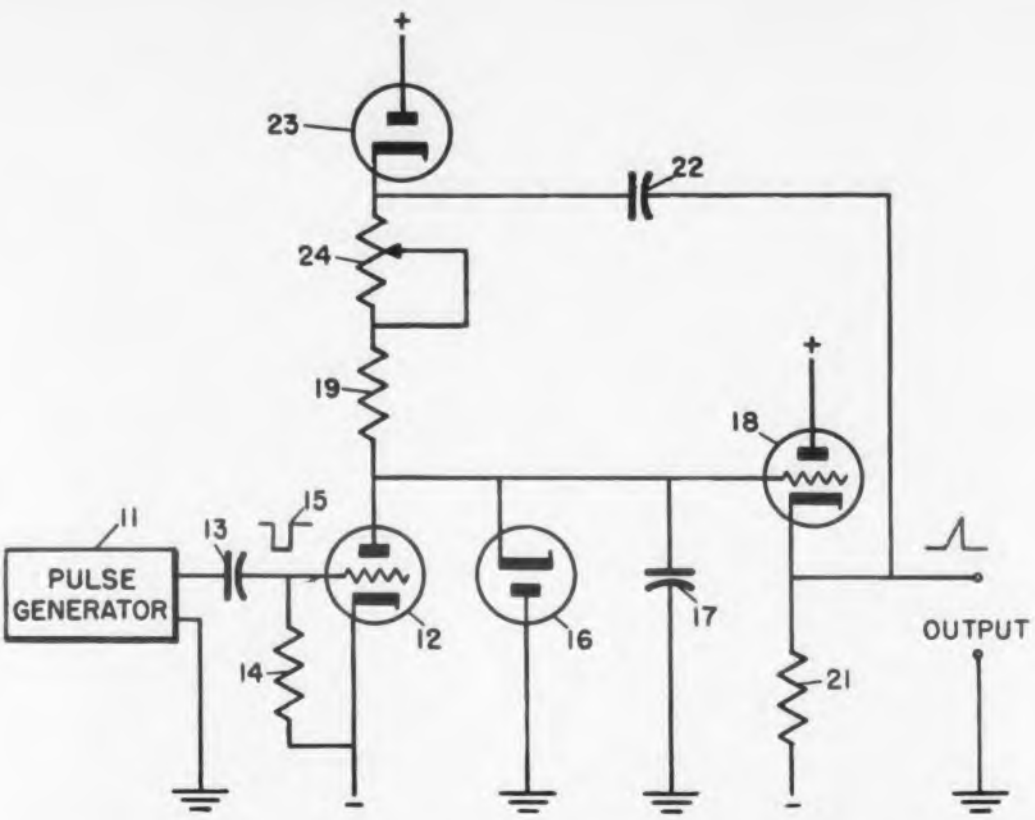
Sawtooth Wave Generator . . . *Patent No. 2,688,075. R. C. Palmer. (Assigned to Allen B. Du Mont Laboratories, Inc., Clifton, N. J.)*

Driven sawtooth voltage or sweep generators as heretofore known resulted in an undesired change in the starting potential across the sweep capacitor when a change of resistance was made to vary the speed of the sweep. The illustrated circuit reduces this variation of the starting voltage whenever the speed of the sweep is changed and also secures a more stable driven sweep generator.

The sawtooth wave generator uses a pulse generator (*11*) that applies a negative pulse (*15*) to the control grid of a trigger tube (*12*) to bias it to cut off. Normally the tube is conducting. The cathode of this tube has a negative potential applied to it so that the plate is negative with respect to ground during conduction. Tube *12* with the anode connected resistors (*19* and *24*) and the diode (*23*) constitute in effect, a voltage divider. A sweep capacitor (*17*) is provided between the anode of tube *12* and ground. This capacitor is paralleled by a clamping diode (16). This diode maintains the potential across capacitor *17* at a relatively low value when tube *12* is conducting. The diode, therefore, clamps the potential across the sweep capacitor at a low value relatively to the ground. Also this potential remains the same irrespective of any adjustment of resistor *24* by means of which the period of the sweep is controlled.

When the negative pulse (*15*) is applied to the control grid of trigger tube *12*, it is cut off. Sweep capacitor *17* then begins to charge through diode *23* and resistors *24* and *19* towards the potential applied to the anode of diode *23*. As capacitor *17* charges, it increases the potential on the control grid of tube *18*. This voltage is amplified across its cathode resistor (*21*) to produce an amplified sawtooth wave form across the output terminals.

As the sweep capacitor charges, it approaches the potential applied to the anode of diode *23* and cuts it off. A feedback capacitor *22* is provided between the cathode of tube *18* and the cathode of diode *23*. This feedback capacitor, therefore, continues to charge capacitor *17* after the potential across diode *23* reaches a point where it ceases to conduct. Draining of the



charge on feedback capacitor *22* would, if continued, restore the cathode of diode *23* to a point where it again becomes conducting. While capacitor *17* is still charging, therefore, the end of negative pulse *15* restores the grid of tube *12* to a positive potential with respect to the cathode so that this tube again begins to conduct. This action establishes the initial conditions and potential across sweep capacitor *17*.

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Decades	2	3	4	5	6
Count Capacity	100	1000	10,000	100,000	1,000,000
Counts Per Second	0-100,000				
Input Sensitivity	0-10 counts per second: 1 volt RMS 10-20 counts per second: 0.5 volt RMS 20-100,000 counts per second: 0.1 volt RMS				
Input Impedance	1 megohm., 0.05 mf.				
Output Signal	50 volt positive pulse				
Recycling Rate	35,000 per second				
Relay Hold Time	Automatic: 0.01 to 0.1 seconds 0.1 to 1.0 seconds 1.0 to 10 seconds			Manual: Until reset	
Power Requirements	117 volts ± 10%, 50-60 cycles				

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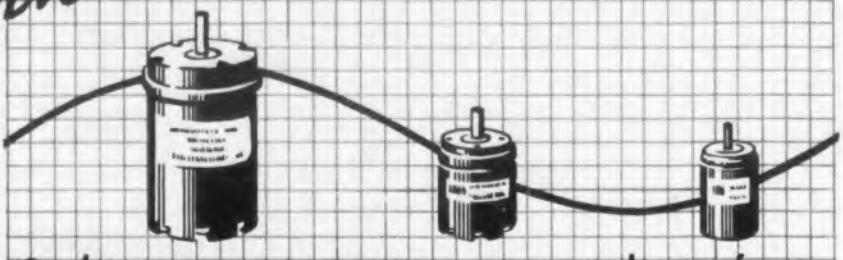

- *Synchros, permanent-magnet generators, resolvers, reference generators and inverters; 23, 15 & 11 size*

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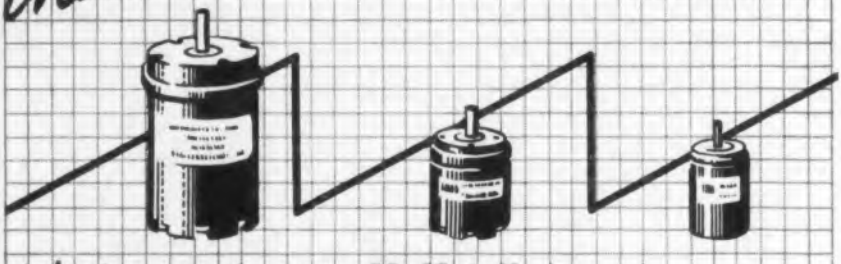
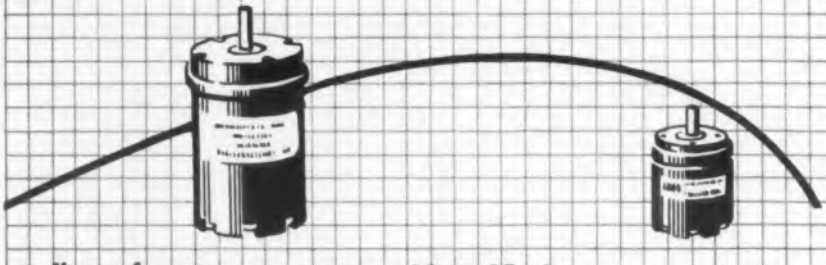


- *Induction potentiometers; 23, 15 & 11 size*

Ballistic



- *Ballistic function generators; 23 & 15 size*

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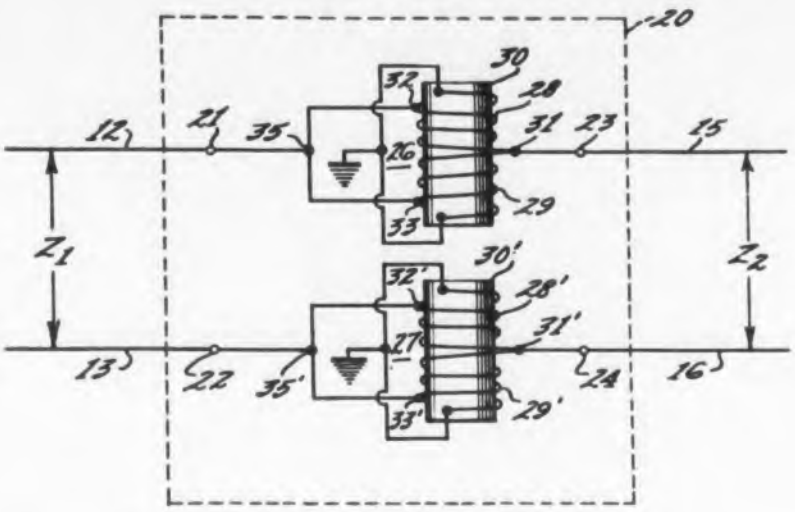
Impedance Transformation Network . . . *Patent No. 2,687,513. N. E. Lindenblad. (Assigned to Radio Corp. of America, New York, N. Y.)*

A transformer network used for impedance matching in circuits operating at high power and high frequencies are generally single-layer windings and of the auto-transformer type. The purpose is to secure non-resonant transformation with a minimum of magnetic coupling leakage. The leakage is, however, objectionably high. This leakage appears as a series inductance effect which affects seriously the transformation efficiency of the network and, hence, such transformers are not used extensively where a wide frequency range is desired.

The transformation network of the patent is applicable particularly for radio transmitter station use for impedance matching between the output circuit of the transmitter and the distribution line to the antenna where high power is transmitted at radio frequency. Air-core transformers are effective and economical means for accomplishing this impedance transformation and are particularly desirable when patch cords (*12* and *13*) are used, the impedance of which must be matched with the antenna distribution lines (*15* and *16*). Patch cords for high power have not been used extensively because of the difficulty of designing transformers having low leakage. The auto-transformer matching network of the patent uses a pair of symmetrical twin-winding coils (*26* and *27*). Each coil is a pair of windings (*28* and *29*) wound in opposite directions on a coil form (*30*). Antenna distribution lines *15* and *16* are connected to the mid-point *31* of its respective coil. Each input line *12* and *13* is connected at spaced points (*32* and *33*, and *32'* and *33'*, respectively) on its coil and the outer ends of the two coils are grounded. The coils are of the single-layer winding type.

In an auto-transformer there is a portion of the winding that is not coextensive with both the primary and secondary windings of the transformer coil. It is threaded, however, by the magnetic field. When the turns-ratio of the coils is unity, the part of the magnetic field that threads this portion of the winding appears in the circuit as a shunt-inductance. The shunt-inductance is easily minimized if it is made sufficiently large. If, however, the turns ratio

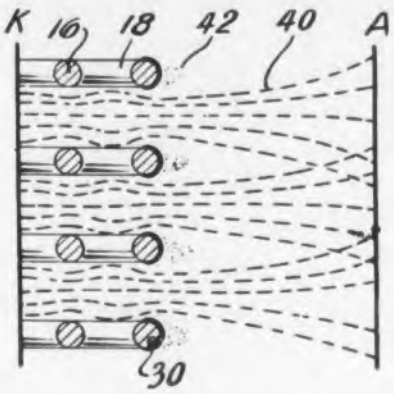


is not unity, coupling leakage occurs and appears as a series inductance. This series inductance is not easily minimized so that the efficiency of the transformer is affected. With the auto-transformers of the patent, the opposed halves of each coil between tap points *32* and *33* are in parallel so that any undesired induced voltages in the windings are equal and opposite. With the portions of the coils between taps *32*, *33* symmetrically located centrally of the coils practically the entire magnetic field passes through these coil portions and the series inductance effects are avoided.

With the auto-transformer impedance matching network shown, the frequency range was found to be wide, in fact it compares favorably with tapered lines. In addition, the network occupies little space, which is important in crowded transmitter stations having many transmitters. Also with the network, distribution line *16* may be grounded without affecting the balance of the input circuit with the respect to ground. The networks may also be used reversed, that is, with the input terminals being *23* and *24* and the output terminals being *21* and *22*.

Insulated Coated Grid for Electron Discharge Devices . . . *Patent No. 2,686,885. R. C. Bailin. (Assigned to Sylvania Electric Products, Inc., Ipswich, Mass.)*

This patent illustrates how a simple change in the construction of a tube can on occasion result in materially improved performance. By coating the surfaces of the screen grid facing toward the anode of a tetrode power tube, the screen grid current has been reduced to 2.00% as compared to 3.14% for a beam power tube. In addition the tube has low distortion, low radiated noise, a reduction in the mounting difficulties and a reduction in the shrinkage encountered in the manufacture of a tube.



The heavy lines (30) indicate where the insulated coating is added to the screen grid.

The improved tube is like the tetrodes heretofore made except that the surfaces of the screen grid wires (*18*) as well as of the uprights, which face towards the anode are coated with an insulating material (*30*). Powdered alundum or silica mixed with a dry binder and water provides a coating which can be sprayed on the grid surfaces, after which the coating is dried. The spraying is done with a shield around the control grid (*16*) so that no insulating material is sprayed on it. Any parts of the screen grid that are to be welding points are also shielded against being coated.

A tube with its screen grid coated as described, accumulates electrons (*42*), when operated, on the insulated surface which creates a static electron charge. This

charge converges the stream of electrons from the cathode K so that secondary electrons emitted from the anode have a steeper potential gradient to overcome in reaching the screen grid. This action substantially reduces the screen grid current so that the dynatron portion usually found in the characteristic curve is practically eliminated. The tube has many of the characteristics of a beamed power tube so that it may be used to replace such tubes. Since this screen grid coated tetrode does not use a suppressor nor beam plates, it is simpler to manufacture. Also the coated surface is light in color, which aids the assemblers materially in securing alignment of the grids and reduces greatly manufacturing shrinkage.

If it should be desired to confine the stream of electrons to a greater degree, this result can be secured by coating the inside surfaces of the side rods that support the grid wires. In fact a portion of the grid lateral wires may also be coated. The inner coating may be obtained by coating the entire grid, which may be done by dipping and then wiping off the coating on those areas that are not to be coated.

Color Television Camera . . . *Patent No. 2,689,271. P. K. Weimer (Assigned to Radio Corp. of America, New York, N. Y.)*

In color television, the light from the object to be viewed passes through color filters of the primary colors before striking the target of the camera. The electron beam of the camera scans the target and passes through areas of the target receiving light of the different primary colors. Unless the beam is sharply restricted, it may well infringe on or spread over more than one color area so that the signal generated is responsive to more than one color and true color reproduction is not produced.

The camera of the patent is designed to permit the beam to be of greater cross-sectional area than the individual color area being scanned or overlap adjacent areas. The signal generated, however, does not contain color values other than that of the desired color area.

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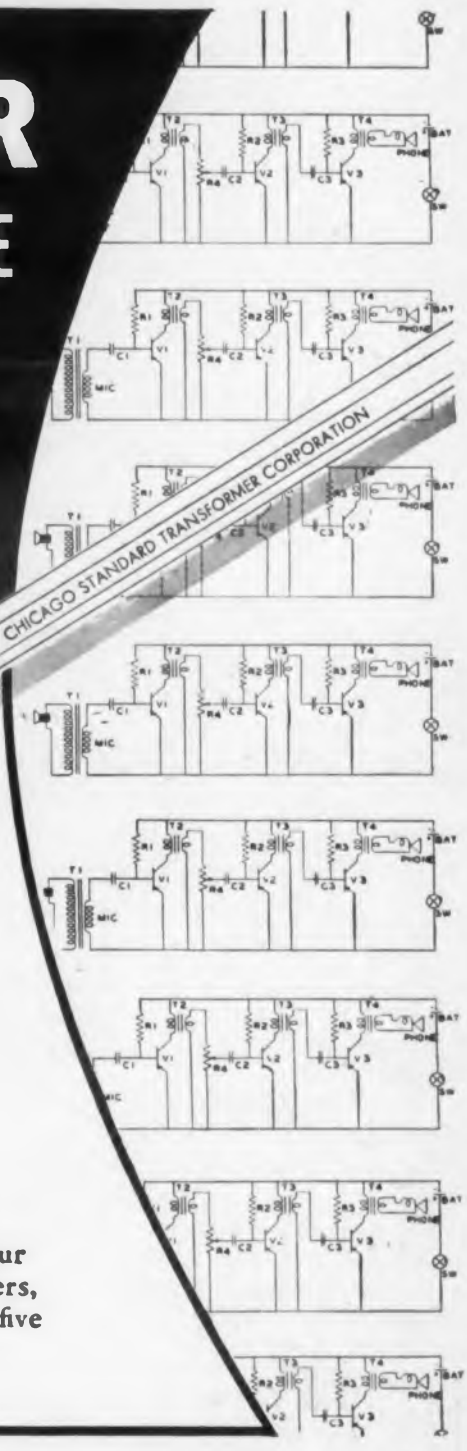

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UM-110	Interstage	20,000	1,000	1675	285
UM-111	Output or matching	1,000	50/60	120	9.0
UM-112	High imp. mic. input	200,000	1,000	4000	195
UM-113	Interstage	20,000	1,000	1350	205
UM-114	Output or matching	500	50/60	70	9.0

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Books . . .

Editors's Note: The following titles are books on transistors that have been reviewed in past issues of ELECTRONIC DESIGN.

Fundamentals of Transistors . . . *By Leonard Krugman, 160 pages, paper bound. John F. Rider Publisher, Inc., 480 Canal St., New York 13, N. Y. $2.70.*

Principles of Transistor Circuits . . . *By Richard F. Shea. 535 pages. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $11.00*

Transistors and Their Applications in Television-Radio-Electronics . . . *By Louis E. Garner, Jr. Paper bound, approximately 100 pages. Published by Coyne Electrical School, distributed by Howard W. Sams & Co., 2201 E. 46th St., Indianapolis 5, Ind.*

Transistor Audio Amplifiers . . . *By Richard F. Shea. 219 pages. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $6.00.*

Transistors: Theory and Applications . . . *By Abraham Coblenz and Harry L. Owens. 313 pages. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. $6.00.*

Transistors—Theory and Practice . . . *By Rufus P. Turner. 144 pages, paper bound. Gernsback Publications, Inc., 25 W. Broadway, New York 7, N. Y. $2.00*

Symposium on Electro-Magnetic Relays . . . *64 pages. Published by Potter & Brumfield, Princeton, Ind., available without charge.*

This booklet contains a selection of 19 papers presented at a Symposium on Electro-Magnetic Relays, given at Oklahoma Institute of Technology, Stillwater, Okla. Of particular interest to electronic design engineers are "Design for Performance vs. Design for Specifications", "Relay Design Modifications", "Relay Time Delay Techniques", "New Development in Vacuum Relays", "Efficient Application of Relays".

The Transistor: Selected Reference Material on Characteristics and Applications . . . *Prepared by Bell Telephone Laboratories, Inc. paper-bound, 792 pages. Available from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Publication PB 111054. $20.00.*

This volume was first published in the fall of 1951 for distribution to the military services. It has now been made available to industry. Despite the speed with which transistor technology is advancing, much of the material in this large volume remains pertinent.

Following discussions of semicondutor physics by leading figures in the development of the transistor such as Shockly, Morton, and Pearson, circuit applications of the device are extensively treated. Among the circuits considered are: switching; amplifiers; oscillators; modulators; binary counters; shift registers; and logical functions. The next to the last chapter discusses the use of transistors in high-speed digital computers. This chapter was written by J. H. Felker, who headed the group that constructed TRADIC, the first transistor computer (ELECTRONIC DESIGN, *April, 1955, pp. 10-11*).

1955 National Telemetering Conference . . . *paper-bound, 212 pages. Available from AIEE, IAS, IRE, or ISA. $3.50.*

The complete papers presented at this year's National Telemetering Conference are reproduced in this volume. In general, each aspect of telemetering is discussed from two aspects: components, and systems. Photographs, charts, and tables are included to illustrate the articles.

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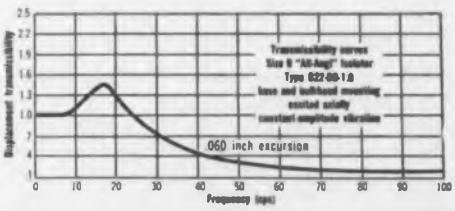

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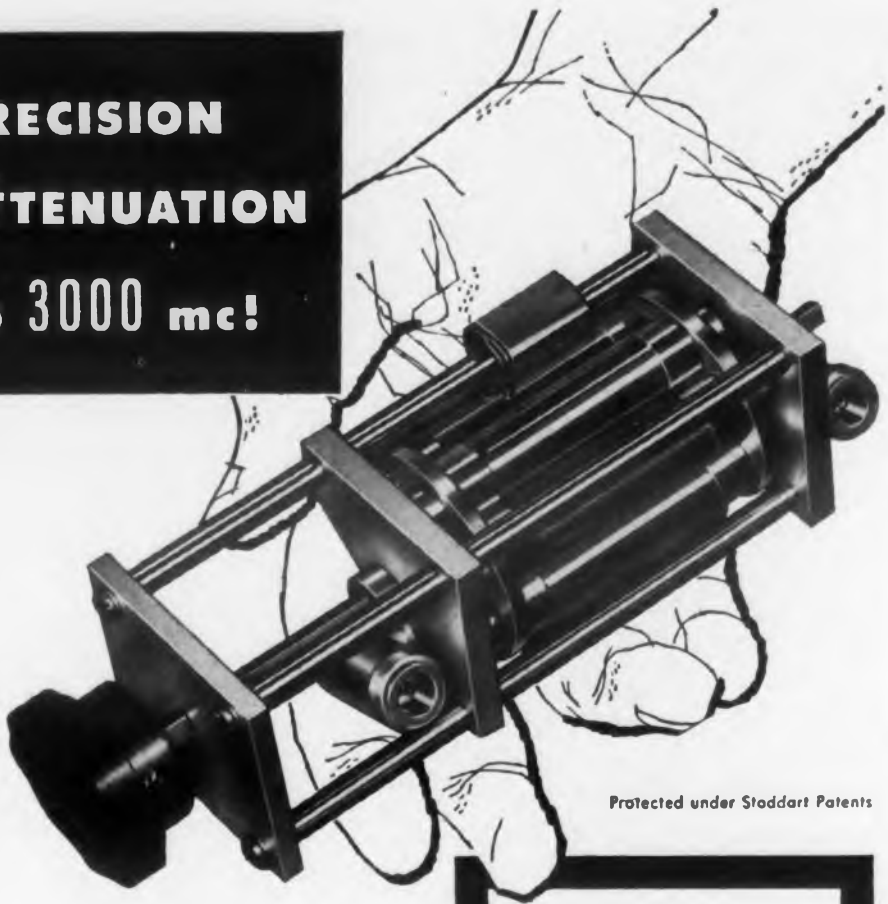

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Abstracts

Pertinent condensations from foreign journals, house organs, reports, and periodicals of related technologies that frequently miss the attention of electronic designers.

Switching Systems

Vacuum Relays

Ferrites

Plastic Testing

Switching Systems

IMPROVEMENTS in electro-mechanical relays appear to be marginal in nature. There are few, if any, commercially available relays that meet the Signal Corps requirements for guided missile relays which are capable of withstanding 30g from 55 to 2000cy and centrifugal accelerations of 5000g. To pass tests, the relay must operate 20 times at rated load while the acceleration increases from zero to 5000g in 2 minutes and is held at this maximum for 10 minutes.

Extreme vibration and acceleration requirements suggest that solid state devices may, in the future, replace electromechanical switches. Some of the following classes of devices should be of interest to relay engineers because they may perform some switching functions better than relays: magnetic switches, transistor switches, electron-tube switches.

A high-frequency carrier switch is an example of the magnetic type. The carrier-type switch is a saturable core magnetic amplifier with a large amount of positive feedback. It is similar to a flip-flop circuit. A high frequency carrier provides the energy to lock one of the two cores into a saturation state. When the core is saturated by d-c, small changes in r-f current do not change flux. The carrier switches that have been developed employ a carrier frequency of 1.4Mc and operate at a maximum pulse rate of 400kc. These switches, to date, are primarily used in binary counters, and pulse amplifiers for digital computers.

The ferro-resonant switch is another magnetic type whose operation is based on the non-linearity of the magnetic core. The Computer Research Corp., Hawthorne, Calif., has developed a switch circuit with two distinct states, Fig. 1. A-c saturation will cause E_{LC} to correspond to point *M* or *N*. If a second winding were applied to the core of inductor *L*, it is possible to

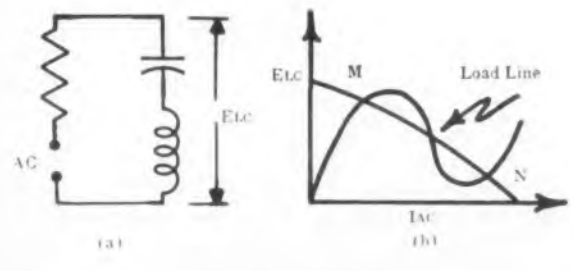

Fig. 1. Ferroresonant circuit produces two stable states if d-c winding is added.

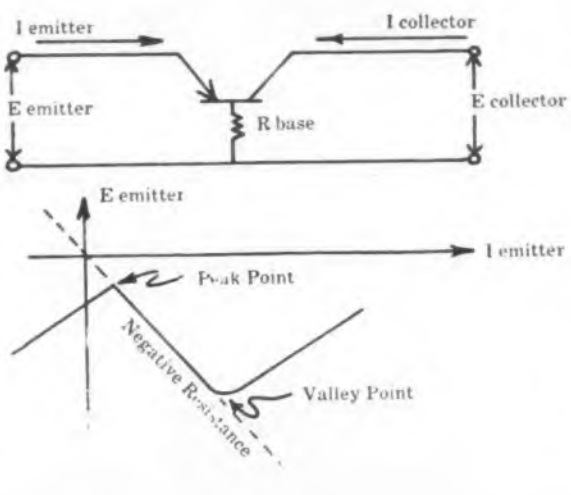

Fig. 2. Negative resistance property of point contact transistor with base resistor.

raise the current in the circuit from point M to point N by the application or a d-c trigger pulse which temporarily reduces the inductance of L and allows the current to jump to point N, where the current holds since the device is self latching.

Applications for this fundamental ferroresonant circuit include gates, counters, oscillators, subharmonic generators, and pulse generators. Typical limits for reliable triggering are from 1μsec to 4μsec.

Transistor switching techniques use either point contact or junction types. If an external resistor is connected in series with the base electrode of a point contact transistor, emitter current causes the base to become more negative thereby increasing the emitter current. This regenerative process gives rise to the negative resistance portion of the characteristic, Fig. 2. The process is limited by collector current saturation.

Commerically available junction transistors appear more uniform in characteristics than point contact types. Junction types, however, do not have negative resistance characteristics but can be used in a positive feedback circuit such as an Eccles Jordan multivibrator. The repsonse is limited to around 140kc where with the point contact, it is around 500kc.

Westinghouse Electric Corp. has a transistor chopper capable of operating at frequencies up to hundreds of kilocycles. The advantages of transistors choppers include millivolt operation; 50 to 90°C temperature range; small size, weight and power consumption; and long life. A chopper using fused junction transistors has a resistance in the closed position of 1 to 2 ohms, and up to megohms as an open circuit.

One application of an electron tube switch that has proven superior to the electromechanical relay is in discontinuous speed switching circuits.

A two speed positional servo must have a switching device that connects the output or either the coarse speed synchro or the fine speed synchro to the servo amplifier. At low values of error signal, the neon tube will not conduct, and the system operates at the fine speed. When the error becomes excessive, the coarse error signal, modified by A_1, cause the neon tube to ignite. Voltage divider action of R_1 and the transformer secondary highly attenuates the fine error signal. This method was used in V-2 rockets—*James L. Wimpey, McDonnell Aircraft Corp. Note source page 144.*

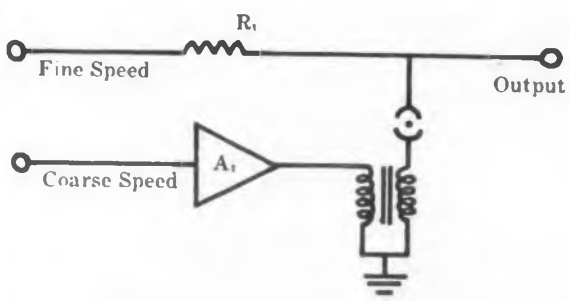

Fig. 3. Two-speed servo switching circuit uses amplifier and neon tube.

Vacuum Relays

BREAKDOWN up to 5000v per mil (0.001") in vacuum compared to 300v per mil air breakdown for the same contact shape and spacing is commonly attained for close spacing of less than 0.005". This difference of air breakdown and vacuum breakdown approximates ratios up to 30 to 1 for modern vacuum techniques. Remarkable vacuum relay benefits besides high dielectric strength include better contact life, less contact resistance, and faster current interruption. Much less contact opening is required for either high or low voltage current interruption. Arc interruption is much more rapid for slower contact opening speeds. Especially important is the fact that at proper opening speeds deionization occurs at the first current zero of an alternating current with no restrikes. This is especially valuable in switching capacitor loads.

Development work at Jennings Radio Manufacturing Corp., San Jose, Calif., has centered around 3 mechanical types. The first type is the metallic bellows vacuum seal. It is the most useful unit for the large mechanical movements and higher contact pressures required in high power applications. The second and third types have a magnetic circuit built inside the vacuum, utilizing conductors as part of the vacuum seal. This arrangement allows a comparatively small, low wattage coil to be used which is easily removable. For simple contact arrangements the clapper type of armature is used. For more complicated contact arrangements a modified solenoid type is necessary to provide wider contact opening and greater contact pressures. Many vacuum relays of this type have mechanical lives of a million operations or more.

With new permanent vacuum processing, tungsten and "moly" contact surfaces stay so free from surface contaminants that two closed contacts create practically a solid

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Current ..... Up to 200 milliamperes
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Output Impedance .. Will not exceed 2 ohms from 1 cps to 200,000 cps
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Voltage	150 V DC	150 V DC	150 V DC
Current	150 ma	250 ma	300 ma
Ripple	5 MV rms	5 MV rms	5 MV rms
Impedance	2 ohms	2 ohms	2 ohms
Regulation	0.5%	0.5%	0.5%
Unregulated output			
Voltage	250 V DC	250 V DC	250 V DC
Current	100 ma	100 ma	200 ma
Power requirement			
Input voltage	27 V DC ±10%	27 V DC ±10%	27 V DC ±10%
Input current	6 amps	10 amps	14 amps

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Specifications

Input ..... 115 V, 400 cycle, single phase
Regulated Output ..... 150 V, dc at 200 ma
Regulation ..... Within 0.05% for Load Variations of ±25% and input variations of ±20%
Ripple ..... .5MV rms
Output Impedance ..... Will not exceed 2 ohms from 1 cps to 200,000 cps
Size ..... 8-3/4" x 2-5/16" x 3-1/8"
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conductor electrically. These seem to be two of the best metals for good contacts.

The removal of surface contaminating films alter the cohesiveness of such metals as copper. When two copper surfaces are gently pressed together after undergoing this vacuum process, molecular cohesion is so strong without the usual intervening oxide layer that they may require forces many times more than the initial pressure to pull them apart again.

Contact welding on closure due to the high charging currents of capacitors, transformers, and inductors, and tungsten lamps is a source of difficulty for contacts in many types of atmospheres. In vacuum, welding rarely occurs even with extremely high make currents. Relays cycling a load transformer supplying 50amp to low voltage carbon resistance elements once every 18sec have operated over a two year period without need for maintenance on the 1/4" diameter contacts and are still being used daily.

Contact resistances of 0.001 to 0.00001 are common. The noise factor is low for low voltage relaying. Low contact pressure and extremely close contact spacings permit sensitive relays to be made which can handle sizeable amounts of current. Completely sealed arcs prevent explosions. The materials as well as the vacuum medium itself are ideal for r-f, 60cy, and d-c operation.

Small vacuum switches are valuable for transferring high voltage power used in guided missiles from the ground power supply to the self-contained supplies at takeoff.

The most popular materials for permanent vacuums are copper, stainless steel, nickel, monel, Kovar steel alloy, tantalum, pyrex glass, and fused alumina ceramic.—*Hugh C. Ross, Jennings Radio Mfg. Corp.*

The preceding two abstracts are from reprints of papers read at the Third Annual Relay Symposium, Oklahoma A & M College, March 9-11, 1955. The complete papers, along with 17 others, are available in book form from Potter and Brumfield, Subsidiary of American Machine and Foundry, Princeton, Ind.

Ferrites For Microwaves

FERRITES show promise of replacing such microwave components as TR's ATR's modulators, switches, attenuators, phase shifters, matching sections, and polarization changers.

Basic studies of the characteristics of ferrites at microwave frequencies have been enthusiastically pursued after the successful operation of C. H. Luhr's microwave switch (1951). Results of these studies have proved the practicality of an antenna whose beam can be electronically scanned; one-way transmission lines to isolate the generator from the load; modulators for amplitude regulation and c-w modulation; and a magnetometer for detecting magnetic field changes of a small fraction of an oerstad.

Electrical rotation of a plane-polarized wave, the Faraday effect, in the microwave band with ferrites opens up entirely new control techniques, Fig. 1. The microwave switch of Luhr's is based on a ferrite rotator which accomplishes the century-old Faraday effect of rotating the plane of polarization. Any material whose dielectric constant or permeability can be changed by an external electric field could be used to shift phase, but other materials are often too lossy for microwave signals. Ferrite, being controlled magnetically, is conveniently located inside a circular waveguide. The input and output sections are rectangular waveguides. The output waveguide is rotated 90° about its longitudinal axis with respect to the input waveguide. When the coil is energized, the ferrite rotates the plane of polarization 90° and the input and output guides are coupled. When the ferrite is unmagnetized, the isolation is about 50db.

The NRL scientists of the Microwave Antennas and Components Branch measured the ferrite properties with respect to phase shift, attenuation, power-handling capacity, and losses of various sizes and shapes in both circular and rectangular

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RESISTANCE: from 10 ohms/inch to 13,000 ohms/inch
RESOLUTION: from .001" to .005" or 0.10° to 0.25° depending on resistance
STROKE: (on linear potentiometers) from ¼" to 27½"
LIFE: at least 1,000,000 cycles
SHOCK: to 100 g in any direction
VIBRATION: 15 g from 10 to 1500 cps
TEMPERATURE: from —65° to 400° F.

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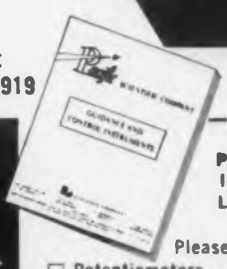

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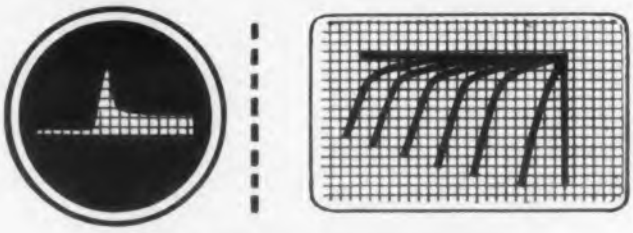
LABORATORY PROVEN

FAIRCHILD

Transistor Analyzer

Developed in the Electronic Laboratories of the Fairchild Guided Missiles Division, the Fairchild Transistor Dynamic Analyzer incorporates in a single instrument all features necessary for testing transistor characteristics. During the past two years, this instrument has served as an essential tool in the Fairchild Laboratories for designing transistor circuits for use in missile guidance systems.

The Analyzer provides accurate and complete plots of static and dynamic characteristics of Transistors — point contact and junction. Its principles are basic, to meet future Transistor needs. Complete with all calibrating circuits built in — only external equipment, a standard DC oscilloscope.



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Presents on the Scope: Alpha vs Emitter Current • Collector, Emitter and Transfer Characteristics • Collector Characteristics in Grounded Emitter Connection • Sweeping Technique Shows Up Anomalies • Complete families of curves obtainable in 10 incremental steps for each 5 ranges.

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WRITE FOR DETAILED TECHNICAL BULLETIN

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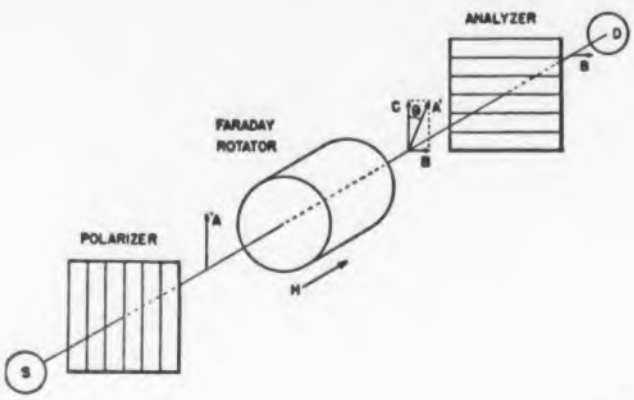


Fig. 1. Ferrite rotator produces Faraday effect by shifting wave through an angle of θ.

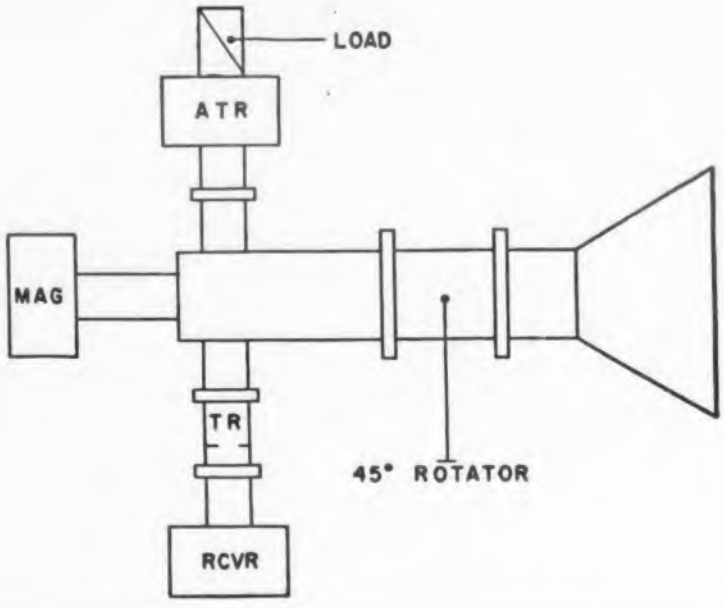


Fig. 2. Ferrite rotator isolates magnetron from load by rotating field by 90°.

waveguides for longitudinal and transverse magnetic fields. Ordinary waveguide formulas do not hold. Phase shift increases as a function of length and diameter. Phase shift can be obtained in rectangular as well as circular waveguides. A laboratory model of an electronically-scanned antenna consists of a series of shunt slots cut along the edge of a rectangular waveguide. Pieces of ferrite located behind and between the slots are energized by electromagnets in such a way as to change the phase at each slot progressively, thus causing the radiated beam to scan.

Isolation of the generator from the load is possible with ferrites by achieveing one-way transmission characteristics. Such isolation permits new antenna schemes to be developed as their impedance is not important. One-way transmission lines may take one of two forms. One type transmits in one direction but absorbs energy in the reverse direction. A typical X-band component presents 16db of attenuation one way and 0.2db in the other over a 400Mc band. A second method avoids heat dissipation problems by reflecting power in the reverse direction. Such a component for the X-band has been built having a 0.5db loss going from generator to antenna and 0.2db loss from antenna to receiver.

The Tracking Branch of the Radar Div. of NRL has developed a microwave sweep oscillator which sweeps the range of 8500 to 9500Mc in about 1.5sec so that the amplitude characteristic can be displayed on a cathode-ray tube. A ferrite modulator provides amplitude modulation of the swept c-w source and regulates amplitude to within ±0.1db over the frequency range.

Other studies on ferrites being conducted in the Ferromagnetics Branch at NRL include relaxation frequencies, saturation, magnetization and g-factor as related to shape and position in a r-f system.—*Adapted from "Ferrites", an Article by Charles De Vore, Naval Research Laboratory, published in* SIGNAL, *Mar.-Apr., 1955, Journal of the Armed Forces Communications and Electronics Association.*

NEW
CHEMELEC CONNECTORS

Aluminum Base Type CNA

Compression Mounted,
TEFLON-Insulated Terminals

2 to 34 Pins

Lower Cost . . . High Performance

These Chemelec Connectors are designed for low loss, high frequency service in interconnection of radio, radar and other electronic equipment—where connectors must be unaffected by a wide range in ambient temperatures, pressure altitudes, humidity and mechanical shock and vibration.

Current rating is 3 amp. for .040 pins and 5 amp. for .063 pins. Voltage rating is 3,300 V. RMS (short time test at sea level).

The TEFLON insulation is serviceable at temperatures from minus 110°F to plus 500°F, for operation in pressure altitudes from 0 ft. to 60,000 ft. Water absorption is zero by ASTM Test.

TEFLON will not carbonize under arcing, and will not support combustion. Its dielectric strength is greater than 500 Volts/Mil.

Lower prices are accomplished by individual compression-mounted, TEFLON-Insulated Terminals in low-cost aluminum bases.

These same terminals are also available for compression-mounting, directly into drilled or punched holes in the chassis itself, without need of additional hardware. (see below).

Write for Catalog EC-455.

Fluorocarbon Products, Inc. Division of
UNITED STATES GASKET CO., CAMDEN 1, NEW JERSEY

FABRICATORS OF FLUOROCARBONS AND OTHER PLASTICS

Representatives in principal cities throughout the world

CIRCLE ED-483 ON READER-SERVICE CARD FOR MORE INFORMATION

Dynamic Plastic Testing

HIGH polymers may be used as rubbers, films, and for structural purposes. Many of the usual mechanical tests tell very little about the fundamental nature of the material and offer no correlation between test results and actual molecular structure. Recent work shows that loading rates, time scale, and viscoelastic behavior are very significant in strength tests. This article discusses these factors. Dynamic tests are discussed. Determination of long-term behavior by a series of short simple tests are covered. Visco-mechanical concepts are used.

Plastics when loaded, behave in a manner intermediate between that of a viscous fluid and an elastic solid, as shown in the model representation, Fig. 1. Very low rates favor viscous flow in addition to elastic deformation. At a higher t, the result is different and extremes of the time scale must be used to provide useful information. When elastic response is delayed by the viscous resistance to deformation, another "model" (parallel type) is required.

Dynamic testing is a measurement of response of a sample to vibration or periodical forces. Creep and relaxation data have made it possible to estimate the degree of molecular cross-linking and branching thereby influencing future design.

The effect of molecular structure on strength properties can also be represented by mechanical behavior or electrical analogies. From these equivalents the strain versus time curve is obtained. Fig. 3. The secondary creep is the property obtained when the usual ASTM test is performed.

Additional tests described show the rapid tensile strength (including crazing) increase with increase in molecular weight.

Where the behavior of rubber over a wide range of frequencies (vibration) is required, simple temperature variation suffices, Fig. 2.—"*Visco Mechanical Concept of Plastic Testing*", *L. A. Darling*, Sperry Engineering Review, *pp. 13-18, Mar.-Apr. 1955, Sperry Gyroscope Co., Great Neck, N. Y.*

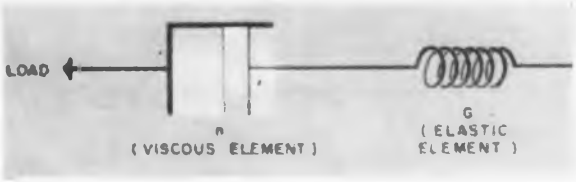
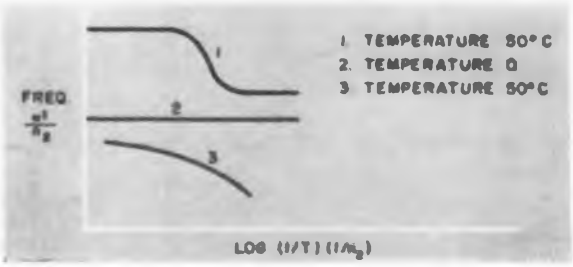


Fig. 1. Visco elastic plastic is represented by spring and dashpot.

Fig. 2. Relation of temperature and frequency on rubber changing from glassy to rubbery state.



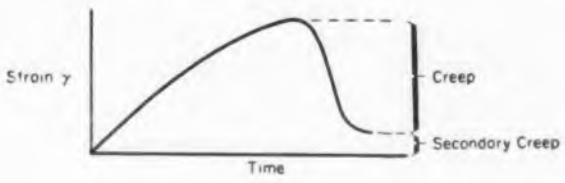


Fig. 3. Plot of creep as strain is measured against time.

TUNG-SOL "Magic Mirror" ALUMINIZED PICTURE TUBE

BRIGHTER-SHARPER
MORE DETAIL
MORE CONTRAST

The "Magic Mirror" Aluminized Picture Tube creates the brightest, most realistic TV picture ever seen in the American home. The "Magic Mirror" Tube effectively utilizes *all* the light generated by the phosphor screen.

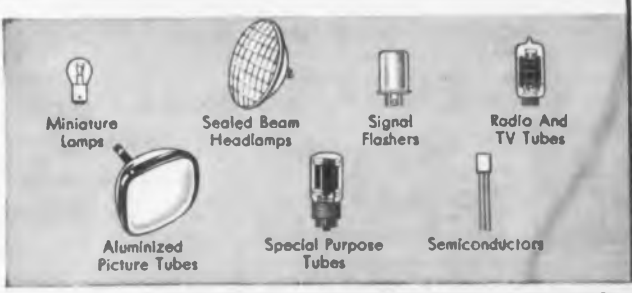
Tung-Sol has developed a unique method of backing the phosphor screen with a mirror-like aluminum reflector: Light is prevented from radiating uselessly back into the Tube. All of the intense detail of which the receiver is capable is brought out by the full light.

Tung-Sol's exacting standards of quality control, manufacture and testing further guarantee the high uniformity and maximum performance of the "Magic-Mirror" TV Picture Tube.

Let the superior qualities of "Magic-Mirror" Picture Tubes add selling advantages to your set.

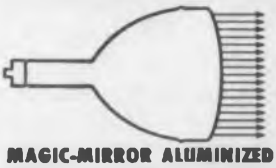
TUNG-SOL ELECTRIC INC., Newark 4, N. J.

Sales Offices: Atlanta, Chicago, Columbus, Culver City (Los Angeles), Dallas, Denver, Detroit, Montreal (Canada), Newark, Seattle.



ORDINARY TUBE—Only *half* the light produced by the phosphor screen is utilized in the picture. Other half radiates wastefully back into tube.

RESULT—A light background within the tube which reduces picture contrast.



MAGIC-MIRROR ALUMINIZED TUBE—Aluminized reflector allows electron beam through. Blocks wasted light from backing up into tube. Reflects *all* the light into picture.

RESULT—Pronounced increase in contrast to make a bright, clear, more realistic picture.

CIRCLE ED-486 ON READER-SERVICE CARD FOR MORE INFORMATION

Standards and Specs

By Sherman H. Hubelbank

This department surveys new issues, revisions, and amendments, covering military and industry standards and specifications. Our sources of information include the Armed Services Electro-Standards Agency (ASESA), the cumulative indexes to Military Specifications, Vols. II, IV, American Standards Association (ASA) and other standards societies.

Standards

The American Standard Association has recently issued a price list and index of all standards approved and issued by them. This booklet describes how to purchase American Standards. It also contains a complete alphabetical and numerical listing of 1500 American Standards. There are 272 electrical and 158 safety standards. Included in the Circuit Breaker section was the announcement of the standard entitled *Preferred Ratings for Power Circuit Breakers* C37.6-1955 as having been recently issued.

ASA has announced the approval of ASA Standard C16.25-1955, entitled *Measurement of Interference Output of Television Receivers in the Range of 300 to 10,000kc.*

Transformers

MIL-T-27A, TRANSFORMERS AND REACTORS (AUDIO, POWER, AND PULSE), 14 MARCH 1955 . . . This revision supersedes MIL-T-27 and MIL-T-8300 (USAF). Six grades of transformers and reactors replace the previous two grades. There are now three ruggedized and three non-ruggedized grades. In addition, three types of units are now provided for. These are metal encased, encapsulated, and open types. The range of weight coverage is now limited to three hundred pounds. Extension of qualification approval for mechanical design features will no longer be issued by ASESA. Electrical preproduction tests are required for all transformers. The methods of packing and packaging have been simplified to three groups: immediate use, short time storage, and overseas shipment.

Crystals

CROSS INDEX OF CRYSTAL UNIT TYPE NUMBERS VS APPLICABLE DOCUMENTS, ASESA INFORMATION BULLETIN 42, 18 APRIL 1955 . . . This cross index contains a complete list of crystal unit type numbers versus specifications, standards, and/or exhibits. A remarks column is also included giving pertinent crystal unit interchangeability features and background information on the specification history of some of the crystals. Crystal units CR-1A/AR through CR-56/U are covered by this cross index.

Packaging

MIL-E-1755B (SHIPS), PRESERVATION, PACKAGING, PACKING, AND MARKING OF ELECTRONIC EQUIPMENT AND ASSOCIATED MAINTENANCE PARTS, AMENDMENT No. 2, 12 APRIL, 1955 . . . The requirement that gasket material conform to class II, grade 60 of spec MIL-R-6855 was changed to require conformance to spec MIL-G-10352. A requirement that the equipment box that contains the technical publications be conspicuously marked "Technical Manual Inside" has been added. The method of packaging the technical publications has been changed.

Electrical Metering

ASESA 51-4, APPLICATION DESIGN NOTES (ADN-6), PANEL TYPE ELECTRICAL INDICATING METERS, 31 JANUARY 1955 . . . This revision to the Application Design Notes brings these reference notes up to date regarding pertinent design data for the classification of electrical meters covered by MIL-M-6A. An important contribution of this revision was the alphabetical listing of the definitions.

ASA C16.5-1954, RECOMMENDED PRACTICE FOR VOLUME MEASUREMENTS OF ELECTRICAL SPEECH AND PROGRAM WAVES . . . This standard applies to the method of measuring the strength of audio frequency electrical waves such as speech and program waves. The VU reference level is defined and the specifications of a volume indicator are given. Copies may be purchased from ASA for $0.50.

Insulators

MIL-I-3676, INSULATORS, PIN (LIME-GLASS), AMENDMENT No. 3, 13 APRIL 1955 . . . This amendment changes the qualification test failures from 4 out of 48 to 3 out of 24. Qualification test procedures and acceptance test procedures now require that separate specimens be tested for gaging and thermal shock. The method of marking is now in accordance with MIL-STD-130. The alternate method of 100% inspection for Group A acceptance tests has been deleted.

Electron Tubes

USAF BULLETIN No. 114, USE OF IMPROVED ELECTRON TUBES, 22 DECEMBER 1954 . . . This bulletin establishes a list of improved electron tube types for use in the design of new equipment and a list for use in determining the supply and maintenance replacements or the replacements in production and recorded equipment. The improved electron tubes listed in the table of tubes for new equipment designs will be used in lieu of those listed in MIL-STD-200.

Electrical Insulating Materials

The American Society for Testing Materials recently published a compilation of standards on electrical insulating materials. This 652 page publication includes standard specifications and testing procedures for electrical insulating materials. The approximately 95 standards cover such material as: insulating varnishes, molded materials, solid filling and treating compounds, electrical tests, mica, rubber, textiles, etc. Special reports are included to cover tests. Copies of this publication are available from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. for $5.50 ($4.25 to ASTM members). Order Publication No. D-9, *Insulating Materials, Electrical*, Compilation of Standards (February 1955).

Military Qualified Products Lists

ASESA has announced that inquiries pertaining to arrangements for qualification tests are invited. Manufacturers whose products pass the qualification tests are listed on the qualified products list. This list informs equipment manufacturers as to which suppliers have demonstrated the ability to design and manufacture certain components which conform to the qualification testing requirements of the applicable Armed Forces specs.

Preferred Parts List

Component	PPL No. & Date
Capacitors, Ceramic, Variable	81-CV 1 Mar 55
Capacitors, Fixed, Electrolytic	3871-CJ 28 Jan 55
Capacitors, Fixed Paper	91-CN 1 Mar 55
Crystal Units, Quartz	3098-CR 1 Mar 55
Indicator Light Assemblies	3661-LH 1 Mar 55
Insulators, Glass	9-NA 11 Feb 55
Insulators, Porcelain	21-NP 11 Feb 55
Insulators, Steatite	8-NS 28 Jan 55
Resistors, Variable, Composition	19-RV 11 Feb 55
Resistors, Variable, Wirewound-2 watts	19-RA 28 Jan 55
Resistors, Variable, Wirewound-25 watts	22-RP 1 Mar 55

The above issues bring the ASESA 49-1 publication up to date. An index to the Preferred Parts List has been issued by ASESA. This index has been revised to March 1, 1955.

Specifications listed on these pages are for information only and government contractors should be guided by their contracts. Copies of military specs should be obtained from sources recommended by procuring officers. ASESA bulletins may be obtained from Fort Monmouth, N. J. ASA standards may be obtained from American Standards Agency, 70 E. 15th St., New York 17, N. Y., unless otherwise noted.

Advertisers' Index

July, 1955

Speaking of resistor quality

. . . it is worthy of note that Stackpole Fixed Resistors are one of the most widely used brands in meeting today's exacting specifications.

Speaking of resistor supplier co-operation

. . . the Stackpole record of personal attention to detail in matching resistor requirements and of following through with "on time" deliveries of dependable, fully quality-controlled units, speaks for itself.

Electronic Components Division
STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

STACKPOLE

FIXED COMPOSITION

R E S I S T O R S

Backed by the keen personal interest and full co-operation of the specialists who produce them

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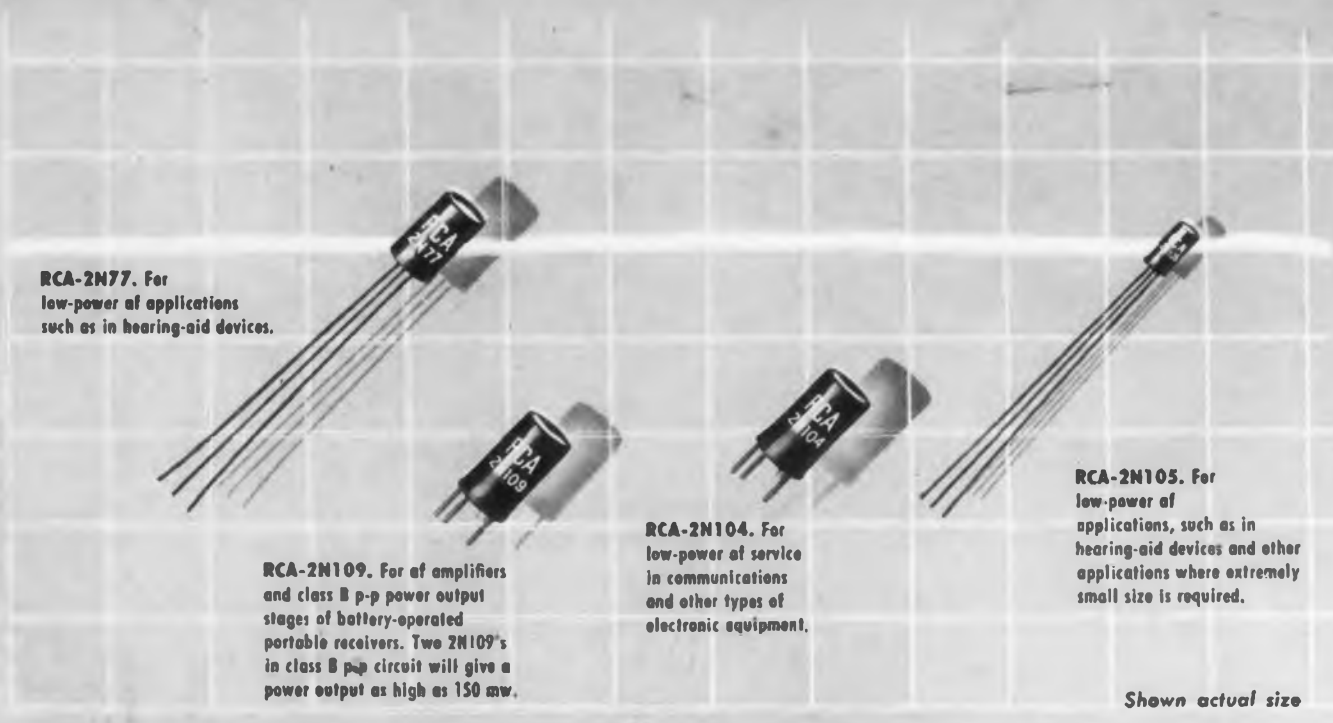
ELECTRONIC DESIGN is the fastest growing of all business publications.

Advertising increased 422 pages during first half of 1955 over the same period of 1954.



RCA-2N77. For low-power af applications such as in hearing-aid devices.

RCA-2N109. For af amplifiers and class B p-p power output stages of battery-operated portable receivers. Two 2N109's in class B p-p circuit will give a power output as high as 150 mw.

RCA-2N104. For low-power af service in communications and other types of electronic equipment.

RCA-2N105. For low-power af applications, such as in hearing-aid devices and other applications where extremely small size is required.

Shown actual size

Exceptional Uniformity
Extreme Stability
—*throughout life!*

RCA HIGH-QUALITY TRANSISTORS

For applications where extreme stability is paramount . . . for circuits where very low collector cutoff current is essential . . . for services that require exceptional uniformity of characteristics . . . RCA-developed transistors provide consistent high-quality and dependable performance. *Closely-controlled processing and manufacturing techniques assure high-level performance initially and THROUGHOUT LIFE!*

Here again is specific technical evidence of RCA's continuous effort to provide advanced-quality products. For a quick rundown on the ratings and characteristics of the four transistors pictured here, see the chart. For complete technical data, call your RCA Field Representative—or write RCA, Commercial Engineering, Harrison, New Jersey.

At WESCON Show, visit RCA . . . Booth 801-802

The RCA-2N77, -2N104, -2N105, and -2N109 are hermetically sealed, germanium p-n-p alloy-junction types—and each carries the RCA one-year warranty!

	RCA-2N77	RCA-2N104	RCA-2N105	RCA-2N109
MAX. RATINGS (Absolute Values):				
Collector Volts	−25	−30	−25	−20
Collector Ma.	−15	−50	−15	−50
Collector Dissip. (mw)	35	up to 150*	35	50
Operating Temperature (°C)	50	70	50	50
TYPICAL OPERATION:†				
Collector Volts	−1	−6	−1	−4.5
Collector Ma.	−0.7	−1	−0.7	−13
Alpha (Collector-to-base connection)	55	44	55	70††
Power Gain (db)	41	41	42	30**
Power Output (mw) approx.	—	—	—	75**
Source Imped. (ohms)	2450	1400	2300	375 per base connection
Load Imped. (ohms)	20,000	20,000	20,000	100 per collector
Noise Factor (db)	6.5 av.	12 max.	4.5 av.	—
Cutoff Freq. (kc)	700	700	750	—
Figure of Merit for High Frequency Performance (Mc)	1.7	1.6	2.6	—

* Depends on temperature and circuit parameters
† In common-emitter circuit at 25° C, ambient temp.
†† Large-Signal
** For 2 transistors in class B af circuit, and maximum distortion at 10 percent

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