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TRANSISTORS '57

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Editorial

Transistor Noise

Special issues generally run the risk of offering nothing of interest to a number of readers. Not so with transistors. All circuit and equipment designers are interested. The promise of unlimited life is a feature which can't be overlooked.

This is not to say transistors threaten the existence of vacuum tubes. Metal and ceramic tubes are available to operate at 500 to 800 C. The present target for top transistor operation is 500 C. By the time this is achieved, tubes will probably have exceeded 1000 C. Tubes are still well out front with regard to power, frequency response, high-temperature operation and tolerance to radiation. We expect transistors to catch up. According to Dr. Hebb of General Electric, there is every reason to expect improvements in the first three areas. Except for possible inherent limitations in radiation tolerance, Hebb finds no theoretical reason why transistors cannot match many types of tubes.

What seems to be needed is more competition. This may seem paradoxical in view of the fact that there are 430 different types in our fifth Transistor Data Chart, compared to 270 for last year. (These are types commercially available.) This impressive quantity belies the real situation. Only in a few cases do different manufacturers make the same or interchangeable types. (In only five cases are RETMA types made by more than one manufacturer.) Military designers in particular are reluctant, or may find it impossible, to specify transistors if there is only a single source available.

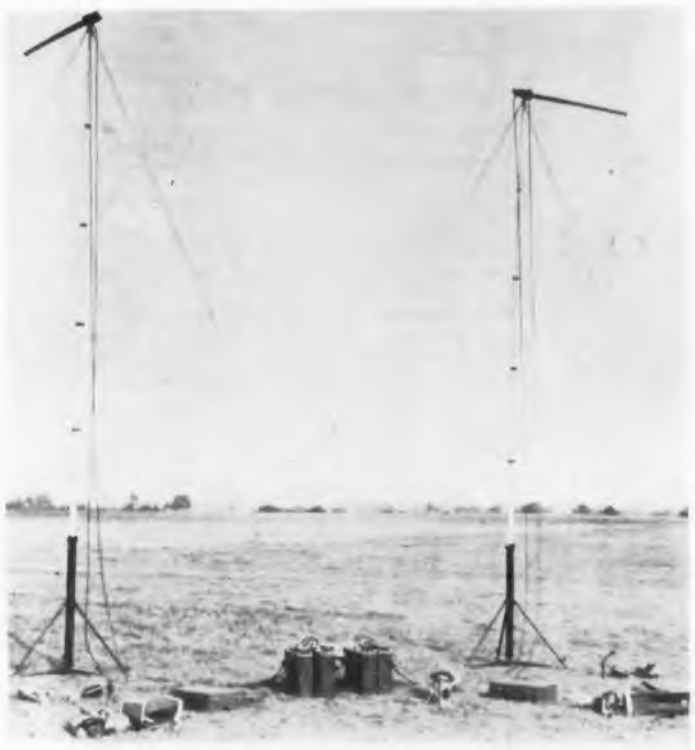
What may be needed is standardization of user demands. The perennial cry has been that manufacturers don't standardize. It will be a long time before there is or can be any standardization of manufacturing processes. Until that time, there will be few identical types. In the meantime, transistor manufacturers will put out many new types, more or less sampling the market. Those that look like they can be sold profitably will be manufactured. This means the designer's requirements and demands can influence what is made.

User criticisms about too many types but no similar types are worthless until there is an effort on the part of users to guide manufacturers intelligently. Tantalizing both users and manufacturers are valid accelerated life tests. Thwarting concentrated effort to take stock of what might be best for the future of the transistor industry is the celerity of manufacturers turning out better units and the frantic effort of users trying out all the new items. But such activity almost guarantees progress.—JAL

Next issue watch for the first of a two-part series on transistor network design.

Engineering Review

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



Two of the portable microwave stations are placed back to back to form a link. Each station can be broken down into individual units that can be carried on a man's back. The amount of time it takes to erect one of these stations is about five minutes.

Weighing less than 46 lbs per unit, a microwave communications system has been developed which should prove highly applicable to a multitude of military, emergency and industrial situations. Designed in Paris, France, by the Compagnie Generale de Telegraphie Sans Fil, the system is being marketed in this country by International Electronics Corp. of Mineola, Long Island, N.Y.

The purpose behind the design of the equipment was to furnish a system that could be carried piecemeal on men's backs and could be quickly and easily installed. As it turned out, one link of the MX-641 microwave system can be erected in approximately five minutes. The equipment is also waterproofed to allow floating it across bodies of water.

One of the components which gives this system a somewhat distinct appearance is the cigar-shaped antenna. Consisting of a disc-loaded aluminum rod, with the discs slightly varying in diameter and spacing according to frequency demands, the antenna has considerable advantages over parabolic designs in being quite light in weight and in having less wind resistance. Capable of producing a gain of about 18 db, the antenna can be easily attached to whatever offers itself, such as trees, telephone poles and the like. For the ordinary situation, a pneumatic mast permits raising of the antenna to a height of 22 ft. The length of the antenna is not critical; however, by making it longer, it becomes more directional.

A 2000 mc band was chosen in preference to a higher frequency so that rather long feeders to the antenna could be used without a crippling loss of power. Thus antennas can be set at considerable heights to achieve the required line of sight.

A terminal station, consisting of eight units, can be transported in a jeep, small trunk or by three men over terrain inaccessible to vehicles. Voltages from 105 to 240 ac v can be used for power. A switch permits selecting the proper transformer connection for the supplied voltage. A test meter for monitoring and adjusting all the important circuits in both the radio and pulse chassis is also included. Simply by juxtaposing two terminal stations, a relay station can be established. Links up to 180 miles are possible by means of such stations placed about 30 miles apart.

The microwave antenna with the new look can also be attached to trees and telephone poles. Offering less wind resistance than the parabolic type, the disc-loaded aluminum rod has a gain of about 18 db.

The Seagoing Air Force: In order to fill a missile tracking gap in the 5000 mile test range off the coast of Florida, the Air Force ARDC has taken to the water in ships obtained from no one other than the Army. Six cargo vessels were converted into telemetry ships, which will receive data from missile test flights over the Atlantic ocean and transmit this data back to Cape Canaveral, Florida.

Engineering Review

Color TV Studies Missile Takeoff

The color of flash and flame spurting from a missile during and shortly after takeoff can disclose considerable information concerning the missile's flight characteristics. Closed-circuit color TV will make the recording of such information possible, an accomplishment which was almost impossible previously without such a system. Required safety precautions and the variations in the brightness of the flame made it extremely difficult to observe its color.

The closed-circuit TV is being purchased by the Army from General Electric Co. The contract calls for delivery this month, and the system will be put to use at the Army's Missile Test Center at Cape Canaveral, Fla.

Lots of Juice

In 1963, 450 billion kw-hrs of electrical power will be required by American industry, according to Westinghouse Vice President A. C. Monteith. The figure is 12-1/2% higher than the estimate made in 1954.

Doped Gold Transistors

The development of doped gold processes, utilizing group 3 and 5 elements, for use in germanium and silicon semiconductor applications, is expected to eliminate major shortcomings of conventional materials by operating at room temperatures, and producing bright, uniformly distributed gold deposits in required thicknesses, directly from the bath. Doped with antimony or other elements, depending on the desired physical properties, the process is the result of work done by Precious Metals Division, Sel-Rex Corp., Nutley, New Jersey.

Although the electronics industry has taken advantage of gold's unique properties for years, gold processes containing small percentages of group 3 and 5 elements have not been reliable in proprietary salts or solutions, heretofore.

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Modified Matador

The Matador ground-to-ground tactical missile designed by Martin Co. and presently in operational use is being replaced by an improved version. Designated the TM-61C, the missile incorporates an improved guidance system developed by the Martin Co. Range of the TM-61C Matador will be substantially increased over the original version, and traffic capabilities—the ability to control more than one missile in the air at the same time—will be greater, thus making the firepower of a missile squadron much stronger.

One of the most important improvements in the TM-61C guidance system is stated to be the high resistance to electronic countermeasures. As in other Matador missiles, the TM-61C can be launched from rough terrain through the use of mobile launching platforms. The TM-61C is 39.6 ft long, 54 in. in diam and has a wing span of 28.7 ft. Operating at speeds of more than 650 mph, the missile is capable of altitudes over 35,000 ft.

High Altitude Altimeter

A new type altimeter, accurate in the ranges of from 75,000 ft to 225,000 ft, is being produced by Hastings-Raydist, Inc. of Hampton, Virginia. The altimeter operates on 115 v ac is unaffected by ambient temperature changes, and provides continuous direct altitude reading or recording. The instrument measures altitude by means of a transducer, which consists of a noble metal thermopile. At the higher altitudes it becomes much more sensitive than the usual bellows or capsule types of pressure indicators. Maximum sensitivity is in the range of a few mm of mercury.

These thermopile elements are compensated for ambient temperature and change of temperature. The transducer elements are designed using only metal to glass and have been operated satisfactorily through a range of temperature extending from —300 to +300 F. The elements react very rapidly to changes in pressure and altitude, having a lag of only a few hundredths of a second.

CIRCLE 4 ON READER-SERVICE CARD

Lightweight Radio Relay for Military

In line with the new Marine concept of helicopter assault operation, a new lightweight radio communications relay set that can be carried on a man's back to otherwise inaccessible battlefield locations is now available. Developed by Raytheon Manufacturing Co., Waltham, Mass., the set operates in the super high frequency range making it possible to reduce the diameter of the antenna to 2-1/2 feet.

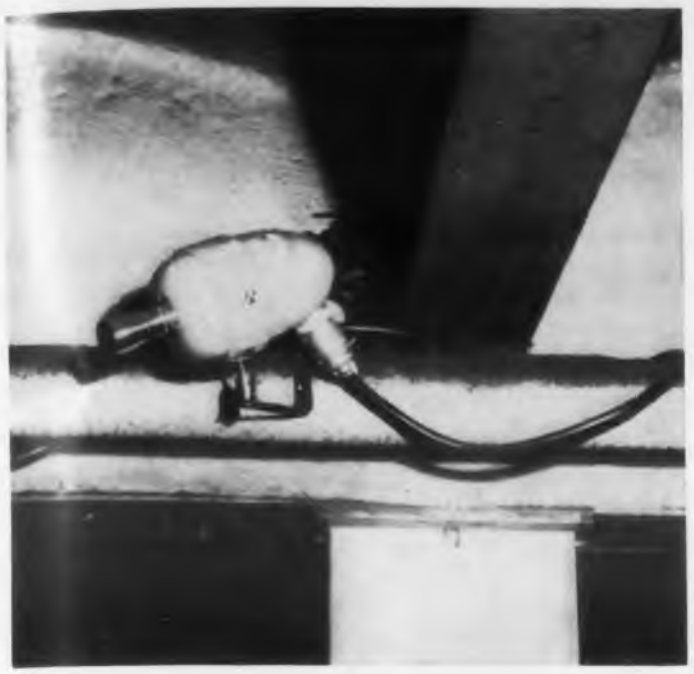
The radios have a point to point range up to 10 miles or they may be linked in chain fashion to transmit up to 40 miles. Eight messages may be sent or received simultaneously. The complete radio and all auxiliary parts can be carried by a team of five men, the heaviest unit weighing about 55 lbs. Total weight of the entire unit is about 250 lbs.

Science Faculty Fellowships

The National Science Foundation announced that applications will be accepted after June 10, 1957, for a second group of Science Faculty fellowship awards to be made in this calendar year. Closing date for receipt of applications is Sept. 3, 1957. The primary purpose of these awards is to provide an opportunity for college and university science teachers to enhance their effectiveness as teachers. Fellowships are offered for study in the mathematical, physical, medical, biological, engineering, and other sciences.

The foundation's awards will be adjusted so that the combined support–from the Foundation and other sources–will not exceed $10,000 per annum. Selection will be based on letters of recommendation, academic records, and other appropriate evidences of professional activity and competence. Application materials may be obtained from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C. Completed materials must be received not later than September 3, 1957. Selections will be announced on October 18, 1957.

CIRCLE 12 ON READER-SERVICE CARD



Policing Via TV: An experimental closed-circuit TV system is being used by the New York Transit Authority to study the possibilities of increased efficiency in subway operations. Installed by General Precision Lab., N.Y., a small camera is mounted on a ceiling beam and focused on subway exit gates to prevent riders without passes from entering. A picture of the area is transmitted by coaxial cable to a monitor screen located nearby. The use of television cameras to police entire subway platforms as a further deterrent to crime is also being considered.

More Powerful Radar: Turret-like radar antennae located behind the Terrier missiles aboard the cruiser USS Canberra will be used for long range missile guidance. Developed for the Navy by Sperry Gyroscope Company, of Great Neck, N. Y., the AN/SPQ-5 radar systems came into fleet use after several years of testing. The two systems aboard the Canberra combine several radar functions in each unit. Either system can control the missiles from a single launcher or battery, or both radars can track different target groups simultaneously.

The systems include flexible modes of scanning and provide the advantage of early warning.

Engineering Review

Bombed Again

The ARDC has just disclosed for immediate publication its Talking Bomb which, when parachuted above the heads of enemy troops, will successfully talk them into surrendering. Judging from the number of news releases received during the past year on this aerial brainwasher, it would seem that it is the century's answer to the atom bomb. Possibly, the ARDC is carrying on an intensive investigation of the effects of psychological warfare. Hearing the same thing over and over again does have its effects, and we are duly impressed by the success of these always new but identical releases from the ARDC in causing frenzied distraction among our ranks. But before we throw down our pencils and surrender, we offer this last resistance as token of our firm belief that words can still be fought with words, without recourse to swords, bombs or other devices.

Resilient Mounts: a "Crutch"

When approaching the problems of vibration and isolation of airborne equipment, resilient mounts should be used if all other solutions have been investigated and appear impractical. According to a paper delivered at the AIEE Air Transportation Conference, isolation should always be regarded as a crutch, and all possible means should be used to obtain compatibility of equipment with environment without using resilient mounts.

The engineer was advised to proceed directly to the solution of resilient mounts only when the level of shock transmitted by the structure to the equipment supports is sufficiently greater than the fragility level, removing all doubt that no other means is practical. In short, this implies that a vibration specialist should be employed to translate environment level into terms comparable to fragility level. The engineer would then be able to consider the fragility factor in realistic terms, and therefore maintain better design control.

OINT IS COMPLETED WITHOUT TRIPPING WIRE with Analac wire dipped in 50-50 tin-lead solder at 360°C (680°F). The insulation is noved at the temperature of molten solder.

1. STRONG JOINTS—as strong as the same joints made in bare copper wire—are produced. Here in laboratory test, joint holds under high stress.

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Automatic Ferrite Memory Core Tester

An Automatic Ferrite Memory Core Tester, with the ability to test, select and reject cores according to the customer's specifications three times as fast as was formerly possible with most semi-automatic devices has been developed. Currently in operation at the RCA Components Division, Camden, N. J., the core tester couples a mechanical handling device with an electronic pulse program generator and electronic measuring and evaluating circuits. The device hopper-feeds 0.050 I.D. x 0.080 O.D. x 0.025 thick ferrite memory cores through the Tester. Each core is tested for its one output on a Go-No-Go basis. The Tester also examines each core for Disturbed Zero output, then classifies the test run into five groups according to value. In addition to its high-speed fully-automatic operation, it features the ability to segregate cores.

Retreat of Transistor Heat Barrier

Experimental use of new compound semi-conductors in place of germanium or silicon has led to laboratory types of transistors and diodes that can operate efficiently over a broad range of frequencies at temperatures as high as 850 deg F.

Describing recent work at RCA labs, Princeton, N. J., Dr. Dietrich Jenny noted that efforts to combine in a single material the best features of both germanium and silicon have now resulted in new experimental devices employing various compound materials, notably gallium arsenide. Germanium is most useful for its high frequency properties, silicon greater efficiency at higher temperatures.

Correction

In "Resistor Performance Levels," *ED*, June 15, 1957, the symbols for Composition Resistors and the New Pyrolytic General Purpose Resistors in the bar graph of Performance Characteristics (Fig. 6) were accidentally reversed. This leaves the erroneous impression that the performance of the new pyrolytic resistors was worst in the comparison, whereas—it was indeed the best.

◀ CIRCLE 7 ON READER-SERVICE CARD

Engineering Review

Large-scale military sponsorship of research during and since World War II has, besides accelerating the pace of industrial research, equalized the competitive position formerly held by companies. According to a recent address by Dr. E. W. Engstrom of RCA, the rapid growth of research and the increasing number of participants, together with shortening of the time cycle from research to product, is having a leveling effect on all of industry. Dr. Engstrom found the sharing of know-how in actual procedures and techniques on so wide a front and across competitive barriers to be a deeply significant change in the industrial research environment.

Referring to the past half century as the pioneering period for industrial research, the RCA executive said that the recent impetus of large-scale military sponsorship has brought about stability and maturity. Although the value of any one research result to the organization doing the work continues in intrinsic value, this value is diluted by the larger sum total of the research effort; and it is particularly diluted by the large amount of research sponsored by the government in the military area.

World's Largest Radio-Telescope

Now being readied to go into full use at Nancay, 93 miles from Paris, is the world's largest radio-telescope. The French Academy of Sciences expects it to reveal many new facts about the sun. For example, the sun sometimes shoots torrents of electrified particles into the atmosphere, seriously disturbing radio communications in the world. The radio-telescope, over 0.9 of a mile long, already has enabled a group of French scientists to discover that these radio-electric storms emanate not from the sun's surface, but from within the solar corona—perhaps 62,000 miles from the surface.

Helicopters Fly Blind

The combination of an automatic navigator, a sonic altimeter, and a glide path indicator enables helicopter pilots to take off, fly to any spot inside a 100-mile area, make an instrument approach to within 10 ft of the ground and then land without looking outside the helicopter cabin.

The navigator system, developed originally by Decca Navigation Co. Ltd. of England, but being built for use in this country by Bendix-Pacific Corp., uses transmission of radio signals from three ground stations to receiving equipment in the aircraft. The airborne unit, which weighs 40 lb, can pinpoint the helicopter's location with 25-ft accuracy. The triangular arrangement of stations creates a pattern of precisely known and stable geographical positions.

Position information is computed and displayed by decometers or by plotting boards. Pilots can follow the navigation-position lines displayed on the board, deviating from one line or direction to another as necessary, similar to the way one follows a road map from one city to another. The sonic altimeter weighs 16 lb and measures absolute altitude from 0 to 150 ft, with an accuracy of less than 6 in.

3-D TV?

A television screen, developed by the Naval Research Lab., may lead to three-dimensional television. In its present state it offers a simplified approach to color TV. The basis for the new screen is a process for depositing phosphor on the face of the TV tube in the form of thin, transparent films, instead of the opaque white powders now in use. Films that create different colors may be deposited on top of each other and may be lighted separately or mixed by controlling the speed or the direction of the electrons in the tube. By using one film of each of the three primary colors, the complete color spectrum can be obtained by proper mixing. The process has been successfully demonstrated in a full range of colors.

CIRCLE 9 ON READER-SERVICE CARD ➤

Engineering Review

Sperry is Superclean and Ultraprecise

Ultraprecision machining to 25 millionths of an inch has been achieved on a production basis by Sperry Gyroscope Co. for "floating" integrating gyros used as "stable tables." Cleanliness is a major problem in manufacturing inertial navigation equipment, as specks of dust or bacterial organisms might cause errors of miles at the end of 5000-mile flights.

What is tolerable in the way of foreign particles and what constitutes a cleanliness hazard is not fully known. To be on the safe side, Sperry considers the assembly room the key to the problem. Sperry assemblers, that put floating integrating gyros and accelerometers together, work in what has been judged the cleanest place on earth. This pure environment is 5000 sq ft in size. Ceilings, walls and floors are vinyl covered. The skilled workers are carefully screened for desirable skin conditions, and are clad from head to toe in special nylon gowns, caps and boots (of different colors for psychological reasons). The uniforms prevent microscopic dust or lint from clothing from reaching the ultrasensitive elements put together under 45-power microscopes. No paper is allowed in these rooms—"blueprints" are plastic sheets.

Sperry's all-out effort to design and analyze inertial components of extreme accuracy has resulted in the development of new supersensitive test devices. Reaction torques less than 0.05 dyne-cm and output torques accurate to 1/10 dyne-cm can be measured. Heavy seismic blocks for testing are completely isolated from the building floor.

Fabrication of the high-precision gyros on a production basis with needed accuracy and ruggedness is considered a manufacturing breakthrough. In addition to machining and cutting gears to 25 millionths of an inch, special deburring processes are used. Relatively new electropolishing techniques and dental polishing tools are used. A leak detector can note 2/10,000 micron per cu ft per hr.

◀ CIRCLE 10 ON READER-SERVICE CARD

CIRCLE 11 ON READER-SERVICE CARD ▶

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NEW from Beckman®/ *Berkeley*

Variable Time Base Universal EPUT® Meters For Direct Digital Readout Without Conversion!

NEW MODELS 7351
(shown on preceding page) and 7361

With their variable preset "count down" time bases, Models 7351 (100 kc) and 7361 (1 mc) Preset Universal EPUT* Meters are unique multipurpose instruments. Regardless of transducer conversion factors, results may be read in direct digital form by merely selecting the proper time base. These instruments will measure time intervals of any number of periods from 1 to 10,000 over the frequency range 0 to 10 kc, totalize a selectable sequence of events, divide frequency, function as single preset counters, generate pulses of varying frequency.

Applications include precise measurement of velocity, pressure, flow, viscosity, low and high frequency, frequency ratio and period, and tachometry.

NEW MODEL 5230 PORTABLE UNIVERSAL EPUT* METER

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

MODELS 7350 and 7360 UNIVERSAL EPUT* METERS

DESCRIPTION—These truly universal instruments combine high-speed electronic counting with a precision time base in multi-purpose circuitry. They function as counters, timers, time-interval meters, EPUT* meters, frequency, frequency ratio or period meters, or as secondary frequency standards.

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

FEATURES

1 *0.1 v rms sensitivity*
2 *Step attenuators; trigger-adjusted noise discriminators*
3 *More stable frequency dividers*
4 *Electronic (not relay) reset*
5 *External frequency standard input connection*
6 *AC or DC coupling of all input circuits; 10 megohm input impedance*
7 *Multivoltage accessory socket to power photocells, etc.*
8 *Binary-coded output with direct connection to digital printers, data converters, inline readouts, etc.*
9 *Crystal-controlled time marker output*
10 *Unitized modular design*
11 *Larger, brighter readout numbers*
12 *Modern-styled all-aluminum cabinets*

CCESSORIES

MODEL 1452 DIGITAL PRINTER

Automatically and permanently records information from any Berkeley 5571 or 7000 Series instrument, prints data in digital form on standard adding machine tape from printer and scanner in one compact unit. May be modified to print "Time" or "Code" information simultaneously with data. Rack or bench mounted: available in up to 8 digits. One printout every 0.85 seconds. Price (6-digit), $950.00.

MODEL 5916 IN-LINE READOUT

Large, illuminated in-line IN-PLANE figures reduce fatigue and error. Ideal for remote observation of data. Connects directly to any Berkeley 5571 or 7000 Series instrument. Presentation rate up to 15 per second; accepts binary voltages. Price (six digit unit), $775.00.

TRANSDUCERS

A large number of transducers especially designed for use with Berkeley counting, timing, and frequency measuring equipment are available. These include tachometer pick-ups, photocells, and light sources. Specifications and technical description on request.

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A new department with complete specialized engineering, model shop and manufacturing facilities is ready to give prompt service on special modifications to standard Beckman/Berkeley instruments, or supply special equipment to your specifications.

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

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

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

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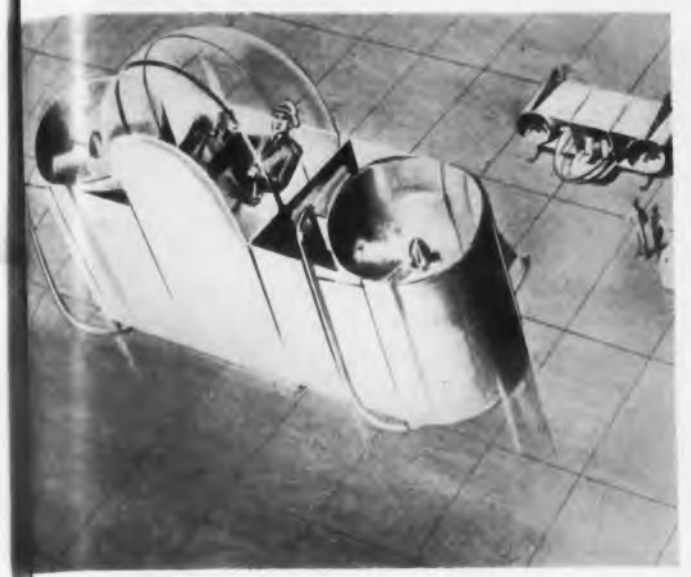


Rock 'N' Fly: This all-purpose utility plane, that rocks on take-off and landing, combines the aero-dynamic principles or ring wings, ducted propulsion and elevons. It rests on the ground horizontally and is rocked back into vertical take-off position with partial power. The plane lands the same way, backing down to the ground, then forward to rest. Designed by M. A. Novosel, the plane is one of the eighteen designs selected for awards in Mars Drafting Pencils Design Series. Another contest is planned for next season.

ramic-vs-Glass Tubes

Electron tubes made of ceramics will prove of reat value in atomic-powered and other high eed aircraft according to Electronic Products, c. In a paper delivered before the Boston Chap- of an IRE Group on Electron Devices, it was ted that ceramic materials can endure intense clear bombardment far better than the glass mponents of conventional tubes, making it pos- le to remove considerable shielding weight from electronic systems of nuclear-powered planes.

The construction of a stacked tube which uses mic parts extensively even for the envelope s described. The tube parts are stacked one on the other in a radical departure from ordi- ry assembly methods. While possessing electri- l characteristics comparable to conventional bes, the ceramic stacked tubes are smaller than unterparts. The unusually stable life perform- ce of stacked tubes under conditions of shock, bration, and high ambient temperatures was inted out. This performance was attributed to e resiliency of the ceramic material, the stacked nstruction, and the high-temperature outgassing at can be employed in the manufacturing proc- s of the tubes.

CIRCLE 11 ON READER-SERVICE CARD

Washington Report

Herbert H. Rosen

Wilson Directives to Curtail Defense Spending

Now that we are into the Government's new fiscal year, some of the pressure on cost-saving in defense projects may be somewhat relieved. However, the effects of three recent Wilson directives on spending are expected to have far-reaching effects on the future of electronics. One directive concerns overtime work. It is merely a reaffirmation of existing ASPR regulations governing the authorization of overtime on defense contracts. The final decision on whether a project is of sufficient importance to warrant overtime engineering and labor will rest chiefly with the Government's project engineer. He has been given instructions that will help guide him to his decision.

Another order was designed to lop off some $500 million from the Fiscal '57 spending budget just passed. But the order seems to have come a little too late to be wholly effective, as was hoped. The inertia of Government projects just does not allow a cut of this magnitude in so short a time.

The third order restricts the services from letting a contract for a project or program until all of the money required for their completion is in the "bank." This means the services cannot order 100 widgets, pay for 20, and hold up delivery on the remaining 80 for some later date when and if the money is made available.

In terms of the future, these directives mean that the defense effort, especially in electronics, is stretched out for an undetermined length of time. Sec'y of the Air Force Douglas estimates that the directives mean an ultimate cut of over $3.5 billion from the AF's purchasing ability. Some programs that have been marginal for lack of conclusive data may now very well be discontinued until more money becomes available—if it ever will.

But of particular importance, the element of time is severely sacrificed. No one has been able to figure out just how bad a sacrifice this will eventually be. Another factor obviously overlooked is that much of the huge spending in '57 and '58—estimated at about $42 billion—is the result of two or three year old programs coming into fruition. In all, some severe economies will have to be instituted by the electronic industries. From here on the cry will be for the same or better gear as before at a lower price. It will be up to the design engineer to give his company that equipment.

Is Automation Passe?

A meeting in Washington of the IRE Professional Group on Production Techniques seemed to prove one thing: There's reasonably little that's new in

the field of automatic production. Further, that while the electronic industries are and will be to a greater extent responsible for automation in other industries, the "art" is a long way off for itself. True, mechanization may become more highly refined. But the day of automatic feedback loops and computer directed mechanization that will control the assembly of a piece of electronic gear is far off.

The meeting did demonstrate one important concept to the design engineer. The concept of standardization. From here on in there will be greater and greater emphasis on cost coupled with reliability. And it seems that the only way to achieve these two factors simultaneously is by standardization.

One step in this direction is RETMA standard RS-188. This lays down the recommendation that "dimensions which must be controlled for automatic purposes be multiples of 0.025 inch. . . ." The standard also represents an early attempt to bring about an era of mechanical standardization. It also means that if an end assembler hopes to mechanize any of his production capability, his design engineers may have to design the end equipment around these suggested standards.

Another document disclosed at this meeting concerns itself with design requirements for printed wiring used in electronic equipment produced for the Signal Corps. It lays down suggested ground rules for circuit design, packaging, printed wiring boards, component mounting, modular dimensions.

Anticollision Study

Bendix Aviation has been awarded a small Air Force contract to help defray their costs for developing a device to give proximity warning and avoid collision of airplanes. The company has been working on the problem for about 2 years and have reached the point of proving their mathematical hypotheses. The Air Force has asked Bendix to study the problem, first, from the standpoint of defining the proximity and collision problems. Once this has been done, possible technical approaches to the solution of the defined problems are to be suggested. Finally, Bendix is to build a research model of the instrument that is supposed to do the job. Deadline for the project is March 1958.

Behind all of this activity is a minimum market worth $10 million. This is the value set by the airlines industry on what they—as a combined group—would pay to equip their airliners.

And still in the realm of air safety and navigation, the Department of Defense has finally declassified four types of Doppler radar. Generally, these units are self-contained navigation aids and fit in ideally with the space and power limitations of a commercial airliner. By type numbers, the equipments released are AN/APN's 66, 78, 105, 79, and 67. A commercial version of the APN-66, called the RADAM, is supposed to be turned over to ATA by General Precision Laboratories via the Air Force.

Printed Circuit Board Problems

Gentlemen:

I found your editorial appearing in the January 15th issue of ELECTRONIC DESIGN to be very timely. As of this date, we are experiencing considerable difficulty with one of our suppliers who builds a piece of airborne electronic equipment for us, due to printed circuit board problems. Certainly, your indication that evidence is accumulating showing that plated through holes on printed circuit boards are oft times troublesome is disturbing to us, since we plan a change to "plate-through" holes as a solution to some of our problems. Specific information that you may have concerning types and frequency of failures would be of immediate interest.

Noting that an association of manufacturers is now being set up to establish standards for printed circuits, I would appreciate being advised as to the membership of this group with the thought in mind of contributing our experience as well as requirements to assist in their undertaking.

W. E. Shannon
Electrical Design Group
Allison Division
General Motors Corp.

▶ The technical problem seems to be with soldering plated-through holes. See article on p 40, April 1 ELECTRONIC DESIGN for an hourglass hole configuration which may be a solution. We have received many such letters from people expressing concern about the problem.

Our latest word is that the manufacturers association is not yet officially formed. According to RETMA, Committee 40C on Printed Circuits has recently been reorganized into subcommittees to more efficiently consider printed circuit problems. Subcommittees are: 40C2, Industrial Standards Survey; 40C3, Conductivity and Temperature Rise; 40C6, Arc and Flame Resistance; 40C7, Insulation Resistance; 40C8, Adhesion and Solderability; 40C9, Definition and Register; 40C10, Contamination; 40C13, Mechanical Consideration; and 40C14, Hardware.

Letters to the Editor

Russia Not First

Dear Sir:

The Russian translation starting on page 180 of your March 1st issue describes "A new photoconductive pickup tube of the Vidicon type. . .recently developed in Russia. . . .," employing SB_2S_3.

It may be of interest to recall here that an SB_2S_3 Vidicon of very high sensitivity was rather extensively described back in September, 1951 in this country in the RCA REVIEW article "Properties of Some Photoconductors, Principally Antimony Trisulfide" by S. V. Forgue, R. R. Goodrich and A. D. Cope.

One of our modifications of SB_2S_3 having good speed of response has been commercially available for several years in the RCA 6198 Vidicon.

Stanley V. Forgue
RCA Laboratories
Princeton, N.J.

▶ It's comforting to know the U.S.S.R. is five years behind, in this instance at least.

Correction

In the article, "Cooling Packaged Electronic Equipment," Part I, May 15, equation (2) should read:

$$h_p = \frac{h_1}{[1 - e^{-(h_1/T)}]}. \qquad (2)$$

The expansion of the exponential should read:

$$e^{-(h_1/T)} = 1 - \frac{t_1}{T} + \frac{t_1^2}{2\,!\,T^2} - \frac{t_1^3}{3\,!\,T^3} + \cdots$$

Correction Please!

Martin Berger of Minitran Corp., 5 Oliver St., Newark, N.J., was the unidentified author of "Transformer Design Nomograph-III" appearing on page 36 of the June 1st issue. Minitran Corp. manufactures miniaturized transformers. We regret that the by-line was omitted.

Meetings

Aug. 7-9: Sixth Annual Conference on Industrial Applications of X-Ray Analysis

Albany Hotel, Denver, Colo. Sponsored by the Denver Research Institute Metallurgy Div. Twenty-three papers will be presented. For further details write to the Metallurgy Div., Denver Research Institute, Univ. of Denver, Denver 10, Colo.

Aug. 20-21: Third Biennial Electron Beam Symposium

General Electric Co. X-Ray Dept., Milwaukee, Wis. There will be reports on radiation equipment, applications of radiations, and economic evaluation of processes and methods. Chemical, plastic and petroleum applications are to be stressed. A conducted tour of GE facilities for fabricating electron beam generators and linear accelerators will be offered. More information may be obtained from J. J. Ludwig, General Electric Co., X-Ray Dept., 4855 Electric Ave., Milwaukee 1, Wis.

Aug. 20-23: Wescon (Western Electronic Show and Convention)

Cow Palace, San Francisco, Calif. Sponsored by the San Francisco and Los Angeles Sections representing the Seventh Region IRE and West Coast Electronic Manufacturers Association. For more information write to Don Larson, Business Manager, 342 N. LaBrea Ave., Los Angeles 36, Calif.

Aug. 29-30: Fourth Annual Symposium on Computers and Data Processing

Albany Hotel, Denver, Colo. Sponsored by the Denver Research Institute. Technical papers on components, devices, systems organization, analysis techniques, and design techniques will be presented. For further information write to J. Marshall Cavenah, Electronics Div., Denver Research Institute, University of Denver 10, Colo.

Sept. 4-6: Special Technical Conference on Magnetic Amplifiers

Penn Sheraton Hotel, Pittsburgh, Pa. Sponsored by the AIEE and the IRE. The program's four sessions will deal with New Circuits and Techniques, Analysis and Design, and Applications. For more information, write to D. Feldman, Bell Telephone Labs.

Sept. 8-13: Second Annual Course on Investment Castings

MIT Cambridge, Mass. Sponsored by the Investment Casting Institute. Lectures, laboratory exercises and demonstrations will be offered on investment materials; melting; gating, risering, solidification and heat transfer; metal and alloy systems; defects in castings; and consideration of new investment and allied processes. For further information, write Harry P. Dolan, Investment Casting Institute, 27 E. Monroe St., Chicago 3, Ill.

Sept. 9-13: Twelfth Annual Instrument-Automation Conference and Exhibit

Cleveland Auditorium, Cleveland, Ohio. Sponsored by the ISA. Organized under the unifying theme, "Instrumentation for Systems Control," the conference will open with formal sessions devoted to data handling and instrument terminology. Following these there will be individual workshop sessions in limited discussion groups covering such topics as aircraft and missiles (excluding propulsion), wind tunnels, flight propulsion systems, process industries, power generation and distribution, meteorological, nuclear, medical, geophysical exploration and general industrial laboratories. Some 100 papers will be presented at the technical sessions. There will be about 500 exhibits. For details of the technical program write to Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh, Pa.

Sept. 17-18: RETMA Symposium on Numerical Control Systems for Machine Tools

Ambassador Hotel, Los Angeles, Calif. For details write to RETMA, Room 650, 11 W. 42nd St., New York 36, N.Y.

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

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

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

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

CIRCLE 18 ON READER-SERVICE CARD FOR MORE INFORMATIC

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

Shoreham Hotel, Washington, D.C. Those interested in submitting papers should check the paper deadlines at the end of this section. For more information, write W. M. Webster, RCA Semiconductor Div., Somerville, N.J.

Nov. 6-8: Tenth Annual Conference on Electronic Techniques in Medicine and Biology

Boston, Mass. Sponsored by ISA and AIEE. Further details and advance programs may be obtained from H. S. Kindler, Director of Technical Programs, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

Nov. 6-8: Third Aero-Com Symposium

Hotel Utica, Utica, N.Y. Sponsored by the IRE Professional Group on Communications Systems. The conference will deal with systems, equipment design, techniques, antennas, spectrum conservation, air traffic control, management and other topics. For the presentation of confidential material, there will be a classified session on Nov. 8. For more information, write to R. C. Benoit, 138 Riverview Pkwy., Rome, N.Y.

Nov. 11-13: Third Annual Instrumentation Conference

Biltmore Hotel, Atlanta, Ga. The theme of this conference will be "Instrumentation for Data Handling" with special symposiums on electronic instrumentation as applied to medicine and the sales and purchasing aspects of electronic instrumentation. Papers should be submitted to Lamar Whittle, Federal Telecommunications Lab., 1389 Peachtree St., N.E., Atlanta, Ga. For more information write B. J. Dasher, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

Nov. 13-14: Mid-America Electronics Convention

Municipal Auditorium and Hotel Muehlebach, Kansas City, Mo. Sponsored by the Kansas City Section of the IRE. There will be exhibits and twelve technical sessions. Approximately thirty papers will deal with medical electronics, airborne electronics, instrumentation, engineering management, electronics in nucleonics and a diversity of other subjects. Persons who want to submit papers should contact the Technical Papers Chairman, MAECON, 5109 Cherry St., Kansas City 10, Mo. The deadline for submissions is Aug. 15. For more information write Richard L. Clarke, 425 Volker Blvd., Kansas City 10, Mo.

Nov. 13-15: Eighth National Conference on Standards

St. Francis Hotel, San Francisco, Calif. Sponsored by the American Standards Association. Emphasis will be on standards as a key to progress and profits. Sessions will cover radiation exposure, electronics, industrial preparedness, motion pictures and television, purchasing, company standards, technical communications, government standards and safety. For more information, write to D. E. Denton, ASA, 70 E. 45th St., New York 17, N.Y.

Dec. 9-12: Seventh Eastern Joint Computer Conference and Exhibit

Sheraton-Park Hotel, Washington, D.C. Sponsored by the IRE, Association for Computing Machinery and AIEE. "Computers with Deadlines to Meet" will be the central theme. Papers will be presented on record keeping, materials handling, traffic, deadline data reduction, communication, flight simulation, and other computer deadline areas. For more details, write to Malcolm B. Catlin, Council for Economic and Industry Research, Inc., Arlington 2, Va.

Jan. 6-8: Fourth National Symposium on Reliability and Quality Control

Hotel Statler, Washington, D.C. Sponsored by the IRE, ASQC and AIEE. Covering fields of reliability in the electronic industries, the symposium will encompass the following topics: reliability organization and management; theory and mathematical techniques; application of these techniques; design information; and education and training for reliability. For detailed information, contact Richard M. Jacobs, RCA Bldg. 108-2, Moorestown, N.J.

Paper Deadlines

Nov. 1: Deadline for papers to be presented at the 1958 **IRE National Convention.** The convention will be held March 24-27 at the Waldorf-Astoria and the New York Coliseum, New York, N.Y. Prospective authors should submit a 100-word abstract and a 500-word summary. Both must be in triplicate with the title of the paper and the name and address of the author. The technical field in which the paper falls must also be indicated. Only papers not published or presented prior to the convention will be considered. Military or company clearance must be obtained before submittal. Address all material to Dr. George L. Haller, Chairman, 1958 Technical Program Committee, IRE, 1 E. 79th St., New York 21, N.Y.

What is the Status of Transistors?

Bernard Reich

U. S. Army Signal Corps Eng. Labs.
Ft. Monmouth, N. J.

THIS report covers the current status of transistor development. Specific areas of transistor development are discussed; power, high frequency, and switching.

Over the last three years, the state of the transistor art has progressed quite rapidly. During this period new advances were made to allow operation at higher temperatures in germanium devices, and to remove existing frequency barriers; however, the designer interested in developing equipment utilizing transistors has the primary problem of securing devices which are available and reliable. Because of the nature of the industry, the availability and reliability of devices has not been defined. [The Transistor Data Chart section lists the types reported by manufacturers as being available.] This lack of definition regarding the current status of transistor development requires amplification. It is the purpose of this paper to clarify, as much as possible, the status of transistor developments and the extent of availability. The statements set forth are based on the experience of the writer in his contacts with the transistor industry.

Power Transistors

Two to three years ago the upper limit for germanium power transistors was 10 to 15 w. These ratings were attainable under the most optimum conditions and very limited numbers were available. Maximum operating junction temperatures of 80 C were quoted; however, the reliability of most devices at this temperature was not defined, or may not have been known. By the spring last year most power transistors were rated at 85 C operating junction temperature. Many manufacturers sold units meeting this specification; but often poor hermetic seals caused device failure during operation. Although the effects of moisture on junctions was well known at the time, apparently no short-term test was available to remove leaky devices. Experiments performed at these Laboratories indicated a definite correlation between operating failures and non-moisture resistant transistors.

During the last year, the power transistor demand has increased many-fold by the inclusion of the devices in the audio output stages of automobile receivers. With this requirement on the transistor industry has come the fabrication of devices capable of operating at junction temperatures to 100 C. In some instances, devices manufactured to these specifications are guaranteed a minimum of 1000 hours of reliable operation. The transistors utilized in radio applications have collector-to-base or collector-to-emitter voltage ratings of the order of 40 v, and thermal resistances of 1 to 4 deg C per watt. There are approximately eight suppliers of this type of device, and most of the suppliers use the same type of package indicating semi-standardization in power transistors.

In limited instances, the above devices are suitable for military applications; however, provisions must be made for higher voltage operation. Units have been manufactured with the required voltage ratings by approximately six suppliers. Of the higher voltage units, one is presently covered by a Signal Corps specification.

Other units are available with thermal resistances of 1 deg C per watt or less; however, the number of manufacturers is limited to two or three.

The impetus of the automobile radio business, and the requirements for power transistors in power supplies have caused the number of power transistor suppliers to increase. Because of the competition involved, the yields in manufacture have increased, making available power transistors for other uses.

The discussion on power transistors thus far has been limited to germanium devices. Some applications require silicon because of the temperature limitations on germanium. Some power transistors (approximately one-watt devices) have been fabricated in silicon by grown-junction techniques. Grown junction silicon transistors and some early development alloy silicon power transistors have been fabricated. One of the major problems is the alpha vs. I_r response of these devices leading to high output harmonic distortion in audio circuits. It appears that the upper operating junction temperature of silicon devices presently available is in the neighborhood of 150 C.

Future developments in silicon power devices will include fabrication by diffusion techniques. At this time, it is difficult to see whether any startling operational differences will be noted. This can be explained by the lack of information on the nature of the silicon material and associated surface conditions. In addition, high temperature materials associated with the fabrication of silicon devices must be developed. Eventually, silicon power devices will be available with operating junction temperatures of 200-300 C. Much research and development work is still necessary before the full benefits of silicon transistors will be realized.

Switching Transistors

The potentiality of transistors will be fully exploited in the switching applications area. Computers utilize many transistors and other semiconductor devices. Long life under mild operating conditions are requirements.

For low-speed switching applications such as dc to dc converters, many germanium audio devices in various power ranges exist. With the additional specification of the key-parameters requisite of a switching transistor, devices normally used as audio amplifiers can be employed. As with all audio devices fabricated by alloying techniques, p-n-p transistors are more available than the n-p-n variety. Some n-p-n germanium transistors fabricated by grown-junction techniques do exist; however, these devices bear the characteristics resulting from fabrication by this method. It appears, at present, that there are many different types of p-n-p devices for

w-speed switching applications. Some of these devices are covered by military specifications, while many others are commercially available. A few of the n-p-n units are comparable to the p-n-p counterparts.

In the low-power medium-speed switching range, many alloy germanium p-n-p devices exist. In general, the availability of this type of device is considered fair. There are some n-p-n switching devices in this area manufactured by three suppliers. The overall availability of these units is considered poor to fair, mainly because of fabrication problems.

Core switches developed for computer use also fall into this same general frequency area. Some limited operation core switches are available commercially. The Signal Corps, at present, is developing both germanium and silicon core drivers. A very limited number of feasibility samples have been evaluated. In coming months, state-of-the-art samples will become available. Approximately one year hence, pilot-line production quantities are expected. Summarizing the core switch situation, some commercial units are presently available; however, more units should appear in about one year.

New developments are occurring in the high-speed switching area where rise times in the order of a few millimicrosec are required. Already an extremely limited quantity of devices have been evaluated with rise, storage and fall times in the neighborhood of 10 millimicrosec. These devices are being fabricated by diffusion techniques. It is believed that in the next 18 months, many more units should be available for circuit evaluation, and limited numbers for equipment models.

High-Frequency Transistors

The development of high-frequency transistors will open new areas of application in communications equipment. A year ago, alloy or surface barrier homogeneous base transistors were being used. In addition to these triode devices, some tetrodes were and are still used in high-frequency applications. At that time, some devices were available for operation as radio-frequency and intermediate frequency amplifiers up to about 10 mc.

With the advent of the p-n-i-p and drift transistors, the limiting frequency barrier was lifted. The possibility of operating transistors to 3000-5000 mc is now feasible. It is known that many interested device manufacturers are utilizing the advantages of the p-n-i-p and drift structures.

At present, the supply of diffused-base high-frequency transistors is quite limited; however, it is expected that within the next 12 to 18 months more units will be available for advanced circuit design and development. At that time, 200 mc amplifiers and oscillators should be available.

Silicon Transistors

At present, for operating junction temperatures of over 100 C, it is necessary to use silicon transistors. Most silicon transistors available are of the grown type and are supplied mainly by two manufacturers. For high-power, high-current operation, silicon transistors are practically non-existent. [For a new type see *ED*, June 15, p 42.] Most silicon devices suffer from high saturation resistance and low current gains at higher current levels.

The operating temperature potential of silicon should be in the range of 200-300 C. At present, available devices are rated to about 150 C. The technology of preparing silicon is not understood as well as is necessary for the fabrication of better devices. Injection efficiencies of the emitter diode must be improved to improve current gain. Silicon surfaces require study in order to be understood. It is also difficult to predict when silicon transistors will become as available as comparable performing germanium devices.

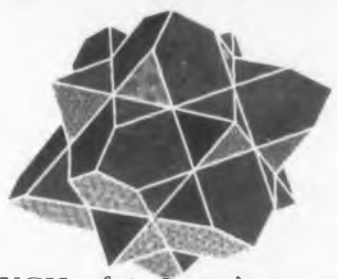
In summarizing, it can be stated that germanium audio devices of various power levels are available. One of the major problems in this area, which should be overcome within the next year, is standard packaging.

Low and medium-frequency p-n-p switching transistors are in fairly good supply. The n-p-n varieties, especially the alloy type, are not as available. High-speed switching devices are in extremely limited supply.

High-frequency p-n-i-p or drift types are, at present, in extremely limited supply. It is expected that this type will blossom within the next 12 to 18 months.

The advances to be made in silicon transistor fabrication are difficult to estimate because of the status of very basic material problems.

New Frontiers in Solid-State Physics



Dr. Malcolm H. Hebb
Manager, General Physics Research
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MUCH of industry's interest in solid-state science is related to the importance of solid-state devices to automation. Those who have made the most careful studies of tomorrow's population trends and production requirements describe automation not as a problem of the future but rather as the only solution to a problem of the future. A key function of electronics in automation is control, and the key requirement for control elements is reliability. Solid-state devices give every promise of providing the ultimate in long life, low maintenance, and reliability that will be required if automation is to be a dependable servant instead of a sick relative requiring constant nursing and medication.

Included in control—whether control of a chemical process, control of a manufacturing operation, control of inventory or of distribution—are three functions: 1) sensing the actual state of affairs, 2) processing the information so obtained with such aids as computers and instructions stored in memory devices, and 3) finally the execution of the control. For all of these control tasks, and particularly for the first two, solid-state devices are being developed at an ever-increasing pace. For sensing elements there are tiny devices that see (photo detectors), hear (piezoelectric materials), feel (magnetic materials), and smell (leak detectors). A solid that tastes is not known to the author, but it might be made if there were sufficient demand for it. There are many forms of solid-state substitutes for brain cells, although none thus far that could reproduce the complexity of the human brain in anything smaller than a warehouse packed with approximately ten billion transistors, ten billion transformers, ten billion solid-state memory cells, and more wire than anyone—even a machine—would want to think about. Solid-state devices can *talk* and they can *do*. And best of all, by performing these functions in solids, we can foresee the day when all of these devices can be built to last a lifetime, using very little power to operate them, and requiring no maintenance at all.

An example of how the transistor may turn up in some unexpected places in tomorrow's world is the report that automobile designers are working on a transistorized fuel-injection system. This appears to be an application never considered for the vacuum tube, however, most ideas for the use of transistors involve putting them in places now occupied by vacuum devices.

One can look forward to developments in another direction. Of particular interest are devices comprising more than one or two rectifying junctions. An example is a rectifier—somewhat like a hook

transistor—that might "fire" over a controlled part of the electrical cycle in the manner of a thyratron.

Photoconductors

The previous mention of solid-state devices that "see" was a reference to a whole family of photo detectors—photoconductors, photo diodes, photo transistors. Because they are relatively inexpensive and have high output, the photoconductors are coming in for a large share of scientific attention. Recently RCA announced it is making a photo conductive cell for use in a headlight dimmer for automobiles. General Electric's X-ray Department uses photoconductor detectors in an x-ray system that "looks" through beer cans to ensure that they are completely full before they leave the brewery. This way is faster than detecting a light can by its weight. Improved photoconductors would also extend the usefulness of the vidicon, that is now limited mostly to industrial TV applications because of low sensitivity and speed of response.

Tiny germanium-junction photoelectric cells recently announced by Standard Telephones and Cables Limited in Great Britain are less than a tenth of an inch in diameter and are designed specifically for scanning operations in punched-card and perforated-tape machines. They speed operations by eliminating certain machined and other intermediate steps involved in storing information from punched-card systems.

Electroluminescence

Solid-state devices can be light-producing as well as light-sensitive. Electroluminescence—the well-publicized "wall of light" phenomenon to which important contributions have been announced recently by Sylvania and Westinghouse—is essentially the direct conversion of electrical energy into light energy in a solid phosphor film. There is no question but that—with improvements in efficiency—electroluminescence will have an important place in the lighting techniques of the future. We should not forget, however, that even if it can become an economically efficient producer of light, the "wall of light" has certain limitations. One of the author's associates, tongue in cheek, has suggested that if Edison had invented electroluminescence instead of the light bulb, every research laboratory would be knocking itself out trying to produce a different kind of electric light source, one that wouldn't take up the whole wall and could be put in some compact form—maybe even in a little glass sphere.

Junction Light Sources

Solid-state research *may* have an answer to the need for more efficient light sources that also are compact. Some semiconductor junctions emit light when a current is passing through them. Although this phenomenon has been useful in clarifying certain theories of "breakdown" in transistors, it has not yet been evaluated as a useful source of light because of the extremely poor efficiency. Some of the solid-state theoreticians at G.E.'s Research Laboratory, however, have ventured that the junction light source just might be the key to getting closer to the theoretical 200 lumens from every watt of electricity instead of the approximately 20 lumens per watt produced by a good incandescent bulb and the 60 lumens per watt of fluorescent lamps.

"Light-carrier" Amplifier

An interesting combination of the two solid-state phenomena just discussed—light sensitivity and light production—is involved in a method of controlling electric currents in a manner that cannot be accomplished by ordinary relays or amplifiers. In this system, electrical energy is converted into light by a form of electroluminescence; the light therefrom falls on a light-sensitive photoconductor, producing an electrical current. This sounds like a complicated method of starting out and ending up with the same thing—electrical energy—but it offers certain opportunities for control that might not be possible by more straightforward methods.

New Light Amplifier

The converse of the above system would be to use light to control an electric current through a photoconductor and then convert the electric energy back into light by electroluminescence. A number of systems of this type have been developed under the general description of "light amplifiers." G.E. has developed another method of light amplification that is unique because the amplification and conversion (in this case the conversion of one kind of light energy directly into another kind of light energy) all takes place in a single solid-state layer of phosphor. The most appealing application at the present time appears to be in x-ray fluoroscopy, where amplification and conversion in a simple, thin device would combine a brilliant image for the doctor and minimum exposure for the patient.

The Cryotron

The Cryotron appears to be the first practical application of the phenomenon superconductivity. Superconductive materials actually have no electrical resistance at all at extremely low temperatures—within a few degrees of absolute zero. The Cryotron is an amplifying device that makes use of the superconducting properties of tantalum when cooled in liquid helium. Because it is compact, simple, and inexpensive in construction—and consumes very little power apart from the modest power needed to create the very low temperatures—the Cryotron may play an important role in computers.

Masers

"Maser" stands for Microwave Amplifier by Stimulated Emission of Radiation. Not all of the Masers developed to date are solid-state devices, although the solid-state Masers appear—obviously—to have conspicuous advantages. Applications of the Maser are expected to be principally in the amplification of radar signals and in scatter communication.

Purity—Needed Breakthrough

Thus far devices, applications—even gadgets have been discussed. Now let us turn to one fundamental that is important to the future of solid-state physics—purity. Purity has one meaning to a preacher, another to a water commissioner, but to the solid-state scientist purity has a meaning that is difficult to visualize. Semiconductors demand the extreme in freedom from chemical impurity and freedom from structural imperfections such as misplaced atoms. Germanium and silicon are routinely prepared with no more than one part per billion of electrically-active impurities. They have been prepared with no more than one part per trillion. Some concept of this last number is given by noting that it is less than one counterfeit dollar in the national debt.

This critical need for purer materials seems somewhat paradoxical since almost all semiconductor devices require eventually that certain impurities be intentionally introduced. However, other impurities must still be vigorously excluded, and to improve practical devices we must have the understanding that comes from studying extremely pure materials.

Eventually these efforts may produce the materials or the knowledge that can lead not only to important devices for industry and defense but even to cheaper and better lighting, or to baby-sitting TV sets, or to electronic computers that do most of the household chores automatically. Everyday use of solid-state electronic helpers "at home" will demand low-cost devices, and learning how to make power materials is closely tied to making electronics less expensive.

To accomplish some of the new things mentioned it will be necessary to extend the technology now available for silicon and germanium to other materials. It will require the talent and cooperation of several scientific disciplines: physics, metallurgy, chemistry, and others.

Keep an eye on the fundamental efforts to produce purer, cleaner materials for solid-state research. This is the "breakthrough" that is needed to produce many of the fantastic electronic devices that have been promised for the future.

Adapted from a talk at the 1957 IRE National Convention for use by ELECTRONIC DESIGN.

Analysis of Nuclear Radiation Effects on Transistors

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CURRENTLY available silicon transistors seem to stand up under radiation better than audio frequency germanium devices but not as well as high-frequency germanium devices.

For most polycrystalline materials, thermal neutron capture or transmutation is more important as a cause of damage than fast neutrons. However, in transistors, where regular single crystal structure is essential for the proper operation of the device, fast neutrons are the chief cause of damage.

Gamma rays must also be considered. Low energy gamma rays generally cause photoelectric effect to which most semiconductors are relatively sensitive. However, except under prolonged or intense low energy gamma radiation, generated photo emf's are of secondary importance and not a cause of permanent damage.

Another important consideration is Compton effect or Compton scatter—a process in which a gamma ray is captured with a subsequent release of a high energy electron. Thus, although electrons themselves are not capable of penetrating the case used for a transistor, they may be generated inside of the transistor package itself.

These particles are capable of causing crystal damage in the same manner as fast neutrons. All gamma ray with a certain minimum energy are capable of breaking chemical bonds in such a manner as to change the nature of the bombarded material. Silicone grease or oil may in this manner be vulcanized to rubber. Long chain type organic molecules decompose into smaller more stable compounds possibly with the evolution of Hydrogen gas. In transistors, this is very important, since at the surface of the crystal, various types of chemical bonds exist and various susceptible materials are used as fillers and capsulents.

The radiation effects on transistors can be recognized as primarily two discrete types, surface effects generally induced by gamma rays and damage to the crystal lattice primarily due to fast neutrons. Compton scatter electrons and thermal neutron capture may be regarded as second order sources of damage. The surface effects may be recognized by charges in surface recombination velocity, while bulk damage relates directly to decreases in minority carrier lifetime. The most sensitive design parameters relating these fundamental characteristics are:

beta(common emitter current gain)
I_{co} (leakage and saturation current)

Typical gain curves are shown in Fig. 1 for transistors subjected to nuclear radiation. There are three modes of change. Curve A which indicates little change in gain hence, the most desirable characteristic occurred only on some of the highest frequency devices. This is due primarily to their much narrower base width as compared to lower frequency devices. Curve A on a somewhat different time base would take on the character of Curve C if the test had been continued for sufficient dura-

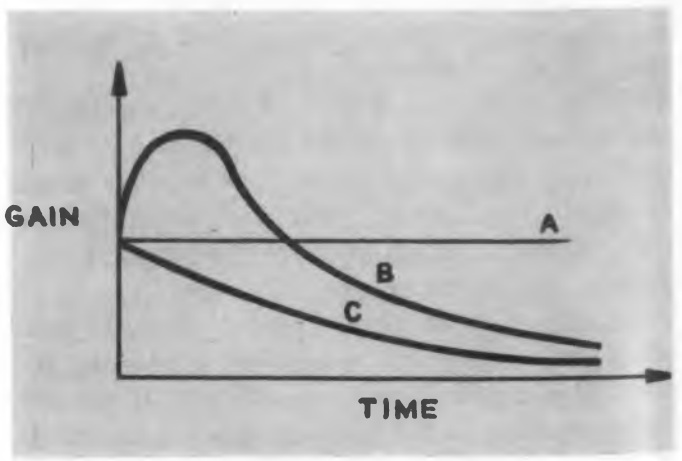


Fig. 1. Gain curves for transistors subjected to nuclear radiation. Curve *A* is that exhibited by most high-frequency transistors. Curve C is the usual curve for most transistors with a few following curve *B* as explained in the text.

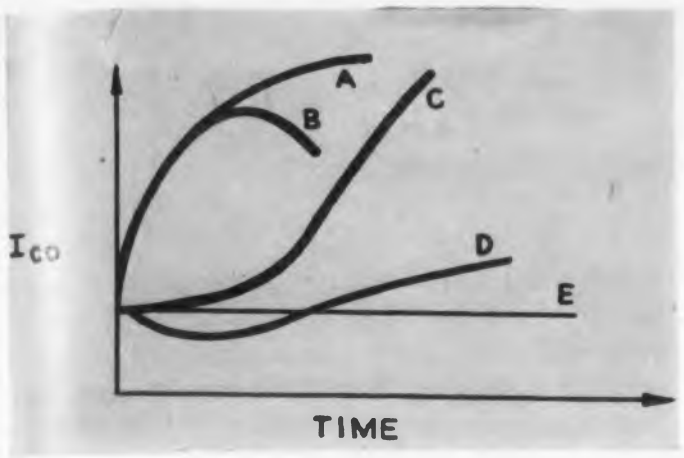


Fig. 2. Typical I_{co} vs Time curves for various transistors tested in presence of nuclear radiation. Most transistors followed curves A or C.

tion. While most transistors exhibit the predicted hyperbolic deterioration in gain as a function of time as depicted in Curve C, a fair number of them had the type of characteristic shown in Curve B. Most of these are p-n-p alloyed junction types in which the initial increases in gain are attributable to surface changes which tended to improve them by decreasing surface recombination velocity. The majority of units, however, show an initial deterioration of gain that might be expected due to bulk effects alone. Devices that initially have relatively low beta exhibit the same type of gain deterioration except that the percentage change is much less since they start so much lower down on the hyperbolic curves.

A composite of the variation I_{co} is shown in Fig. 2. Analysis is not as simple or straight forward as that for changes in gain. The initial I_{co} variations are primarily gamma induced surface changes while the long term increases are bulk induced, the former due to leakage current, the latter due to saturation current. Most transistors follow Curve A or C. Some of the units which exhibit the E characteristics had relatively high I_{co} initially. Units of a single type from one manufacturer produced in the same lot exhibited different types and amounts of I_{co} changes as a function of irradiation and time. This suggests an immediate expedient for obtaining reasonable radiation resistant devices for use in current equipment until more highly radiation resistant types are made by design. A simple screening process whereby all units required for an equipment design which would be exposed to a medium intensity gamma source for a relatively short period of time while the I_{co} changes are being monitored. All units exhibiting large I_{co} deterioration or instability would be eliminated and the balance could then be expected to be deteriorated as predicted by the bulk damage due to neutron flux only.

Most transistors recover or anneal to some extent after removal from radiation flux. Two distinct types

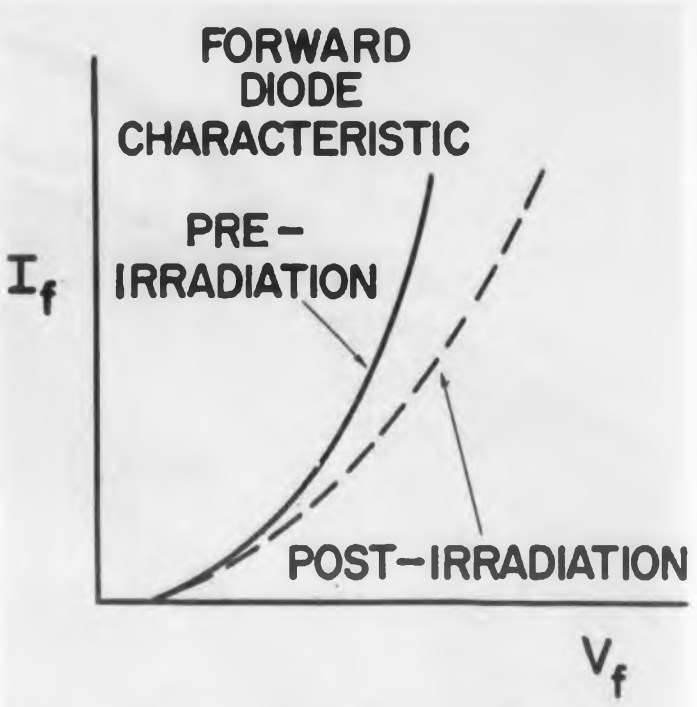


Fig. 3. Diode characteristic—before and after being subjected to nuclear radiation.

of annealing are important, bulk and surface. Both of these processes are temperature and time dependent. While bulk annealing of germanium at 25 C is negligible, it becomes appreciable and increases rapidly above 100 C. Hence, devices might be rejuvenated by a high temperature baking process. Complete recovery could not be achieved at temperatures which would not destroy currently available germanium transistors due to the temperature limitations of other materials employed in fabrication. Although currently available silicon transistors have an upper limit of 200 C, it is now conceivable that they could be made in a manner that would permit baking at temperatures in excess of 500 C.

Surface recovery is not as clearly understood as bulk annealing. We believe it is so however, to predict that an exact repetition of the manufacturer's surface preparation technique could remove all traces of radiation effects from the surface. Radiation induced surface changes may cause either improvement or deterioration of device characteristics. Annealing reverses this process such that in some instances slight deterioration was noticed after removal of the units from the radiation environment, and in one exceptional instance the characteristics after annealing were markedly better than before the radiation test by a ratio of about six to one. This was however a very poor device initially and was rejectable on the basis of manufacturers specifications. Generally, most commercially available devices can be expected to deteriorate due to surface changes during irradiation and recovered partially as a function of time and temperature after removal.

Effects Noted

In Fig. 3 is shown a diode characteristic before and after irradiation. The input impedance and saturation resistance of diodes, which have a linear relationship with common base and common emitter transistor circuits, should increase as a function of bulk deterioration. These changes will generally be relatively slight.

The output characteristics of a transistor are shown in Fig. 4 with the collector voltage plotted against the collector current and with the base current as the independent variable. The solid lines are pre-irradiation, and the dotted lines are pre-irradiation. The changes predicted on the basis of the forward diode characteristic are clearly apparent. In addition, from this it can be seen that the output impedance will generally decrease. The change being attributable to surface effects. In rare cases the converse might be true.

Maximum breakdown voltage should generally be decreased due to surface effects. Breakdown voltage which is generally a function of restivity will not be noticed before the device is virtually destroyed due to the deterioration of minority carrier lifetime except possibly for extremely narrow base width units.

Noise figure will increase as a function of surface deterioration. Discrete noise pulses due to incident particles and rays are insignificant except possibly in the presence of an intense cosmic shower. The probability of which is insignificantly small up to altitude in excess of 250 miles.

Improved silicon devices will show a greater sensitivity to nuclear radiation damage than equivalent germanium devices by a factor of two to five.

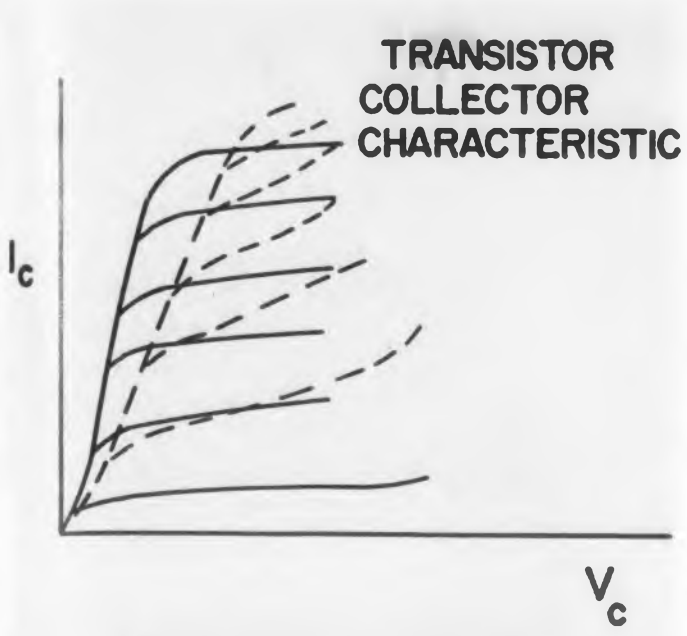


Fig. 4. Transistor output characteristics curves—before (solid) and after (dotted) subjection to radiation fields.

Information is currently available for the initiation of development of devices specifically intended for use in radiation environments. Much work has yet to be done in this area, surface preparation and capsulating materials which can readily be analyzed and tested might be a fruitful area for work. More radiation resistant surfaces could be manufactured by design, but in the interim (by the screening technique suggested previously) highly resistant devices can be selected to be satisfactory for most requirements.

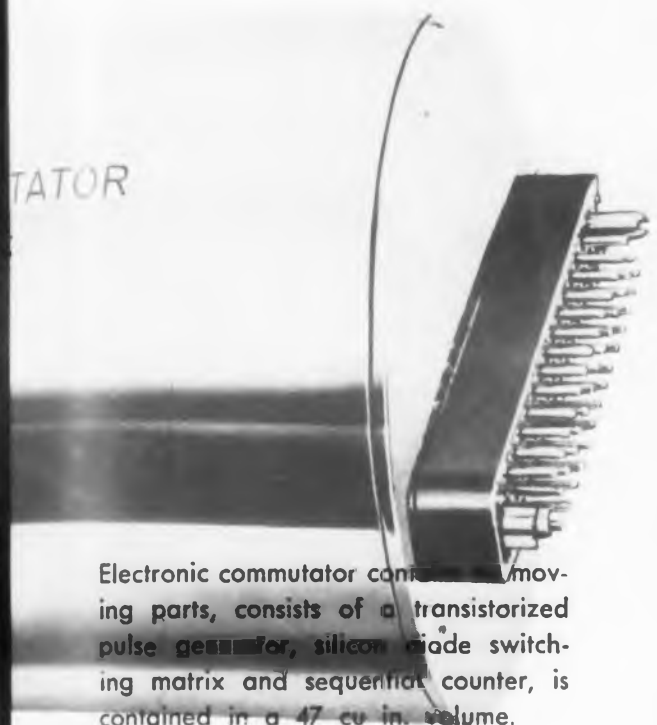
All the tests that have been conducted so far have been with very intense radiations such as are found in the heart of a reactor or under extremely intense gamma sources. The transistors tested were capable of lasting specific lengths of time. Some gave indications of little or no deterioration under very intense gamma flux; others under the most severe atomic pile conditions gave appearances of useful life in the order of hundreds of hours. Under these conditions, human beings could not be expected to survive after a fraction of one percent of this time. Due to their single crystalline structure, transistors are somewhat more sensitive to radiation damage than other conventional components, with a few exceptions.

This article is based on a talk given by Mr. Kret at the Electronics Components Symposium in Chicago, May 1-3, 1957.

Airborne Telemetering

USED FOR telemetering information in aircraft and missiles, this electronic commutator can be expected to have a life of 5000 hours. Twenty-eight data channels are switched without recourse to moving parts. The unit, consisting of a transistorized pulse generator, a silicon diode switching matrix and a sequential counter, is contained in a package 3 in. diam x 5 in. long and weighs 2 lb.

The commutator, manufactured by Arnoux Corp., 11924 W. Washington Blvd., Los Angeles 66, Calif., is designed to operate at fixed speeds from 2-1/2 to 30 cps and to handle input signals over the range 0 to 5 v with a 25 K source impedance. One of the 28 input channels is used for frame synchronizing purposes. With an input signal between 0 and 5 v applied to this channel, the device produces a frame synchronizing pulse in the output equal in width to three *on* periods and two *off* periods. Output amplitudes are from 5 to 7 v with a 5 v input, constant to ±5 per cent.



Electronic commutator contains no moving parts, consists of a transistorized pulse generator, silicon diode switching matrix and sequential counter, is contained in a 47 cu in. volume.

Electronic Commutator

The variation in output pulse level corresponding to inputs between 0 to 5 v is less than 10 per cent of the pulse width, while the peak-to-peak noise level on the output pulse train is less than half a per cent of the full scale range. Cross-talk between channels is less than 0.25 per cent of the full scale range. With equal inputs to all channels—0 to 5 v—the variation in pulse levels between channels is again plus or minus half a per cent of the full scale range.

Designed to operate from +150 ±5 v dc, the unit requires 2 w. It will operate between −65 and 185 F, sea level and 80 kilofeet.

The electronic commutator was developed to fulfill a need left by mechanical switches that wear relatively quickly when a common wiper makes contact with the data channel contacts at speeds from 150 to 1800 rpm.

For more information on this electronic commutator, turn to the Reader's Service Card and circle 33.

Frequency Division with Semiconductor Devices

A William Carlson
Transistor Applications, Inc.
Boston, Mass.

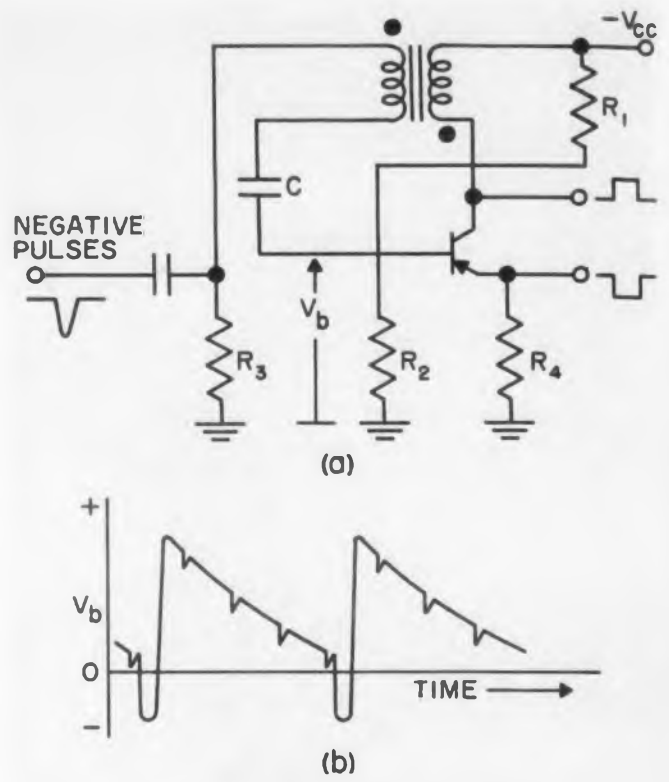


Fig. 1. a) A typical blocking oscillator b) Base voltage waveforms

FREQUENCY division may be accomplished in a number of ways with semiconductor devices. It is a process of deriving from a source frequency f a frequency of exactly f/n, where n is an integer. Frequency division is used in radar systems, radio navigation systems, computers, television transmitters, some fm transmitters, electronic clocks and in a host of other applications where it is necessary to obtain a frequency that is an exact integral submultiple of another frequency. It finds important application in frequency measurement equipment where a low frequency signal is obtained from a precision high frequency source.

Frequency division may be accomplished with semiconductor devices by use of:

- Blocking oscillators
- Multivibrators
- Devices showing negative resistance (double base diodes, point contact transistors, negative resistance diodes, avalanche transistors, combinations of junction transistors)
- Counter circuits (binary counters and ring counters)
- Regenerative frequency dividers
- Circuits in which increments of charge are added to a capacitor which is then discharged at a given count (an integrating type of counter)

A junction transistor blocking oscillator is shown in Fig. 1a. This circuit is similar to one often used with vacuum tubes. The operation of the circuit may be explained by assuming that a negative pulse has just driven the base negative, causing the collector to conduct and the voltage at the collector to swing positive. The transformer secondary in the base circuit inverts the voltage across the primary in the collector circuit and drives the base more negative causing the transistor to conduct more heavily. This action is regenerative and rapidly drives the transistor to full conduction. The duration of the pulse is a function of the size of the coupling capacitor in the base circuit and the mutual inductance of the transformer, among other things.

When the voltage across the capacitor begins to change, and when the voltage across the transformer starts to drop, the voltage at the base begins to decrease, causing a decrease in collector current. This initiates regenerative action in the other direction and the transistor is rapidly turned off. Because of the charge placed on capacitor C during the conduction interval the base is now biased positively and the transistor will remain in the cut-off condition until the capacitor discharges to zero or a pulse drives the base negative.

The base wave form is shown in Fig. 1b. The capacitor discharges with a time constant determined mainly by C and R_3 in series with the parallel combination of R_1 and R_2. When the transistor is turned off, the impedance looking into the base is very high. If the transistor did not conduct when the base voltage became negative the capacitor would discharge to $-V_{cc}\, R_2/(R_1 + R_2)$.

Fig. 1b illustrates division by four. The negative pulses are too small to drive the base negative until base voltage has dropped to the point where the fourth pulse triggers the circuit. The free-running period of the circuit is longer than the triggered period. By placing R_4 in the emitter circuit a negative pulse is available to drive another similar dividing circuit. A positive pulse is available at the collector.

Blocking oscillator circuits take different forms. In Fig. 2a the RC circuit controlling the frequency is placed in the emitter circuit. A negative output is available from a transformer winding and a positive pulse is obtained at the collector. In Fig. 2b the transformer secondary and the RC circuit are in the emitter circuit, with a positive pulse available at the collector.

Multivibrators

A junction transistor multivibrator and the associated waveforms are shown in Fig. 3. The parameters R_{b1}, R_{b2}, and C_2 may be adjusted for the desired conduction periods. The circuit may be modified by returning R_{b1} and R_{b2} to voltages other than $-V_{cc}$. Every third pulse applied to the base of transistor 1 causes triggering in the example shown.

Negative Resistance Devices

Semiconductor devices capable of producing negative resistance characteristics include point contact transistors, double-base diodes, avalanche transistors and combinations of junctions transistors. A typical negative resistance curve is shown in Fig. 4a. If a load resistance R_L is used with a

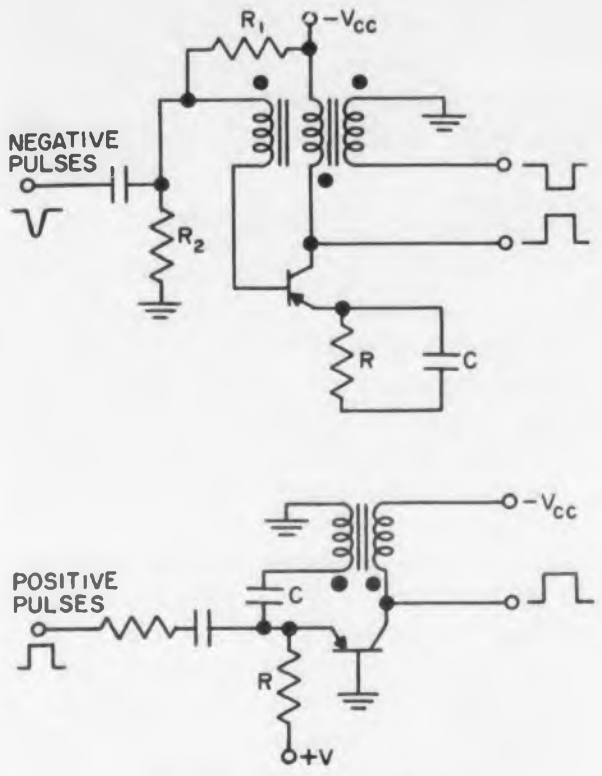


Fig. 2. Blocking oscillators using junction transistors

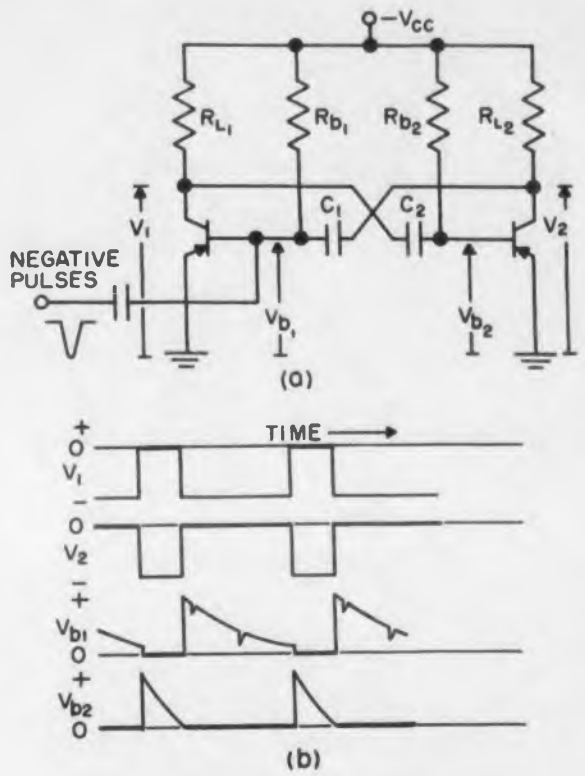


Fig. 3. A junction transistor multivibrator and the associated waveforms

voltage V_s to bias the device in the negative resistance region and a capacitor is placed across the input as shown in Fig. 4b, relaxation oscillations will result. The voltage appearing across the capacitor is shown in Fig. 4c where division by three is shown. The path of the operating point is shown by arrows in Fig. 4a. Operation of the circuit may be explained by assuming that the device is initially in the cut-off region. The capacitor charges towards V_s through R_L until the peak point V_p of the negative resistance curve is reached.

Upon reaching the peak point voltage, the operating point switches rapidly to the conduction region where the capacitor is quickly discharged to the valley point voltage V_v at which point the device is turned off and the cycle repeats. By superposing small timing pulses as indicated in Fig. 4b and 4c frequency division may be accomplished.

The negative resistance curve of Fig. 4a is typical of the V-I characteristics obtainable with the devices mentioned above except that the location of the curve in the V-I plane may differ. All the devices mentioned are three terminal devices with the exception of the negative resistance diode. The diode is not available on the market but a great deal of research is being carried on, as indicated at a recent conference on semiconductor devices where one-third of the papers presented were on the subject of negative resistance diodes.

The negative resistance diode is capable of very high frequency operation. Relaxation oscillators at

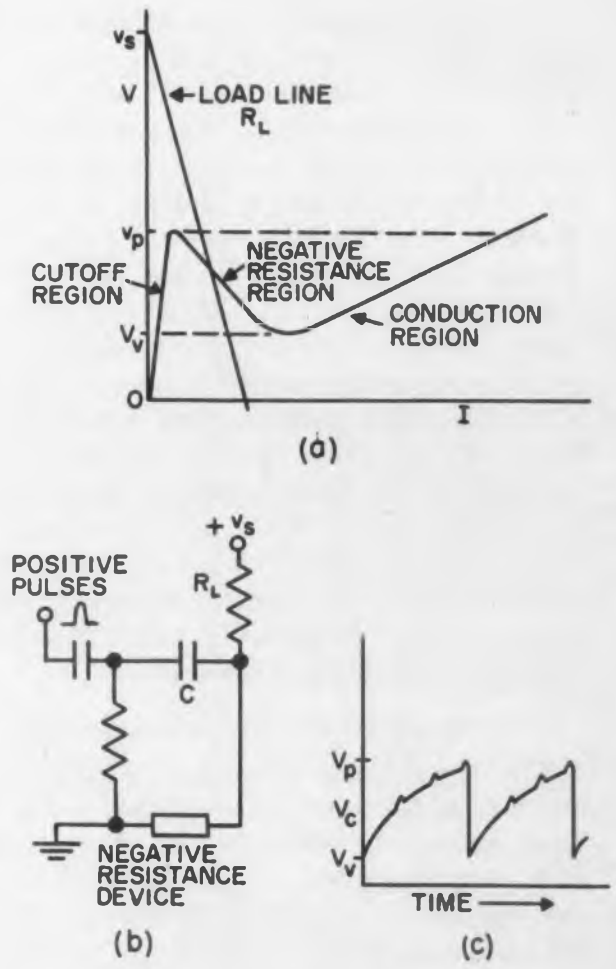


Fig. 4. a) A typical negative resistance curve b) A negative resistance frequency divider c) Voltage across the capacitor of Fig. 4b for division by three

30 mc have been obtained. Fig. 4b gives a fair indication of the simplicity of a relaxation oscillator using a two-terminal negative resistance diode. For a three-terminal device, the block in Fig. 4b represents the two terminals across which negative resistance characteristics appear. In three-terminal devices, the third terminal may be used for a signal output.

Fig. 5 illustrates some other circuits having a negative resistance characteristic. The combination of a PNP and an NPN transistor as shown in Fig. 5d is equivalent to a point contact transistor except that the current gain is higher. The avalanche transistor is not shown but consists essentially of an ordinary junction transistor operated at higher than normal collector voltages where heavy conduction occurs due to avalanche multiplication at the collector. This "breakdown" current may be controlled by base current and the transistor may be used in circuits similar to those used with point contact transistors. The remarkable feature of the avalanche transistor is that a switching time of a fraction of a microsecond may be obtained with low frequency audio transistors.

Counters

Binary counters and ring counters may be used for frequency division. They differ from the frequency divider circuits previously mentioned in that they are not free-running and are not as sensitive to trigger pulse, supply voltage, or circuit parameter variations. They are, however, more

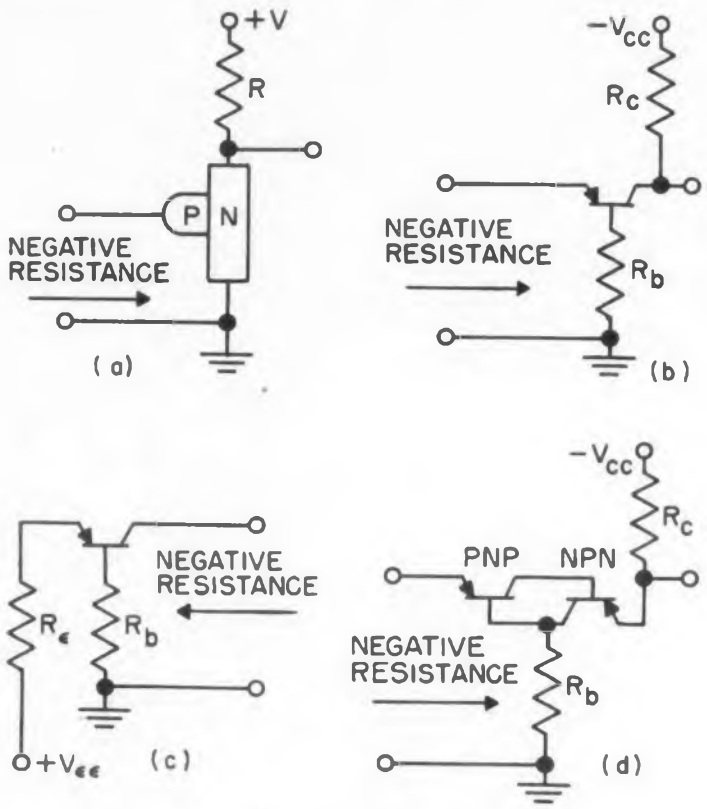


Fig. 5. Circuits having negative resistance characteristics a) Double base diode b) Point contact transistor c) Point contact transistor d) Combination of junction transistors

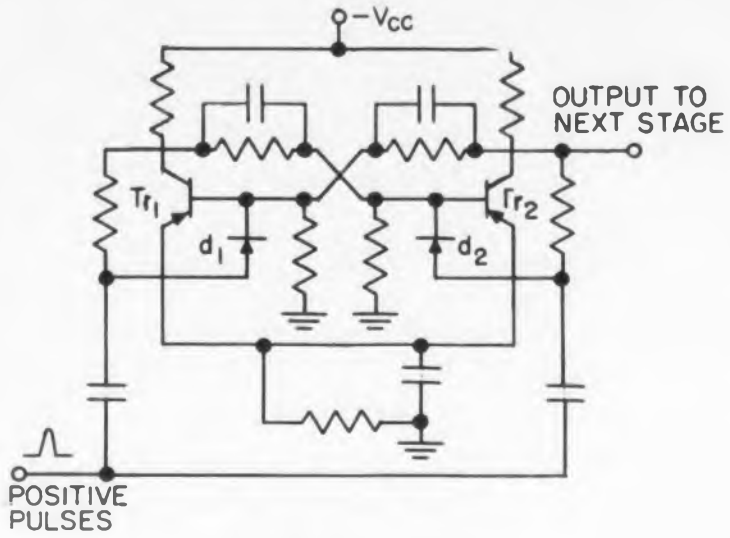


Fig. 6. A binary counter frequency divider

complicated than the free-running circuits. If the counter accepts n pulses before returning to its original state, it will produce an output pulse once for each n input pulses. The counter may be constructed with transistors of either the point contact or junction type and may be either a ring counter or a binary type made up of a number of binary flip-flops. Fig. 6 shows a typical binary counter stage using junction transistors.

Ring counters may be constructed to divide by any integer. Binary counters normally count in powers of two but may be used with feedback circuits to reset at the desired count and thus may also be used to divide by any integer. The binary counter of Fig. 6 operates as follows. If Tr_2 is 'on' a positive pulse applied to the flip-flop will pass through d_2 to the base of Tr_2 and turn it 'off' and at the same time turn Tr_1 'on', (diode d_1 is reverse-biased by the negative collector voltage of Tr_1).

The next positive pulse will turn Tr_1 'off' and Tr_2 'on' producing a positive going voltage at the collector of Tr_2 which may be applied to another binary stage for further division. Thus every other input pulse applied to the flip-flop returns it to the same state. In a ring counter an 'on' condition is transferred from one stage to the next at each input pulse with the frequency division determined by the number of stages in the counters.

Regenerative Frequency Dividers

The regenerative frequency divider shown in Fig. 7 is similar to the counter types in that it is not free-running, but differs in that it is essentially a sine wave circuit. Fig. 7a shows a block diagram of the regenerative frequency divider. To understand the operation of the circuit, assume the system is in operation with an input frequency f and an output frequency f/n. A signal of frequency f/n. is applied to a harmonic generator tuned to the $(n\text{-}1)$th harmonic of the f/n signal and thus has an output frequency of $(n\text{-}1)f/n$ which is applied to the mixer. The mixer output circuit is tuned to the difference frequency of the two signals coming into the mixer, f and $(n\text{-}1)f/n$, this difference frequency being the desired output frequency, f/n. Fig. 7b illustrates how the circuit might be realized with junction transistors.

Integrators

Fig. 8a shows a counter in which an increment of charge is added to a capacitor each time a pulse is applied to the circuit. After a desired number of pulses the negative resistance circuit discharges the capacitor. In explaining the operation of the circuit, it will be assumed that the negative resistance device has a V-I characteristic similar to that in Fig. 4a. The transistor is normally 'off' and a negative pulse is assumed to drive the transistor fully 'on' so that the collector goes nearly to ground potential during the pulse. C_1 is much smaller than C_2. Assume that the negative resistance device has just discharged C_2 at time t_o. C_1 is charged to a voltage of nearly $-V_{cc}$ (the voltage at the collector when cut off). When a short negative pulse arrives it drives the transistor to full conduction, the collector approaches ground potential, and C_1 transfers most of its charge to C_2 through diode D_2 causing a positive step of voltage to appear across C_2 as shown in Fig. 8b. After the trigger pulse disappears, C_1 charges again to $-V_{cc}$ through R_L and diode D_1. The next trigger pulse to arrive results in another transfer of charge from C_1 to C_2 and another jump in voltage across C_2. The process continues until the

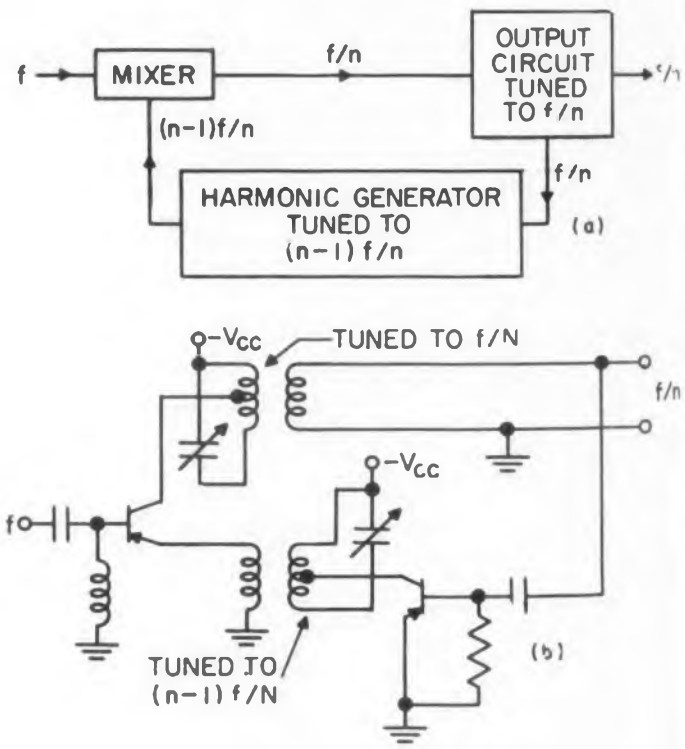


Fig. 7. a) Block diagram of a regenerative frequency divider b) Circuit of a regenerative frequency divider

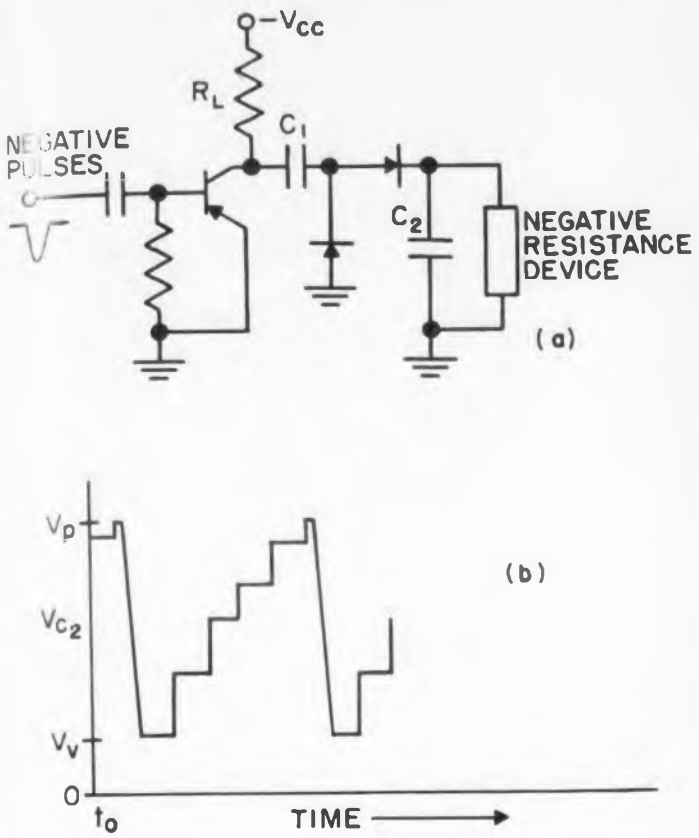


Fig. 8. a) An integrating type of frequency divider b) Associated waveform

voltage across C_2 reaches the peak point of the negative resistance device causing it to fire, at which time the cycle of events repeats. It is assumed that the back resistance of the diodes and the cut-off resistance of the negative resistance device is high enough so that C_2 does not discharge appreciably between trigger pulses. The negative going waveform appearing when C_2 is discharged could be used to operate another similar counter circuit. Fig. 8b shows frequency division by five.

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Fig. 1. Stable 400 cycle multivibrator

OCCUPYING less than one fifth of a cubic inch, these minute transistorized circuit assemblies provide remarkable performance for their size. They operate within specifications from −25 to +50 deg C, and may be stored safely from −40 to +70 C. The units are particularly suitable for use in missiles, portable equipment, telemetering, balloons, and other ap-

Fig. 2. Schematic of tiny 400 cycle multivibrator

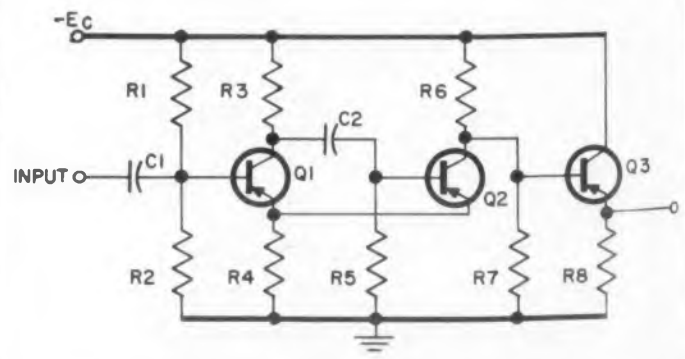

Fig. 3. Schematic of one-shot multivibrator which occupies less than one-fifth of a cubic inch

Tiny Transistor Assemblies

plications where reliability is of prime importance.

Circuit configurations currently available are a two-stage audio amplifier, three db down at 40 cps and 60 kc with a minimum voltage gain of 30 db; a 400 cycle multivibrator; a one-shot multi; a flip-flop which can be triggered at rates up to 20 kc; and a bootstrap sawtooth generator.

These minuscule assemblies are designed and manufactured with emphasis on reliability. The manufacturer, M F Electronics Co., 122 E. 25th St., New York 10, N.Y., includes testing as one of a major series of operations in their fabrication. The units are subjected to exhaustive tests, first at the mock-up stage, again prior to potting, then once again after the units have been potted and set for several days. In addition temperature runs are made on representative units to insure that the specified temperature requirements are met.

The 400-cycle multi, which may be used, typically, to drive a gate, act as a pulse source, or drive a counter, is shown in Fig. 1, and its schematic in Fig. 2. Critical components *R1*, *R4*, *C1*, and *C2* are chosen to be the most stable components available. 5 v peak to peak are available, using a 6 vdc supply providing 3 ma. Even more impressive from the viewpoint of space economy is the three-transistor one-shot multi whose schematic is shown in Fig. 3.

These Lilliputian circuits are encapsulated with epoxy resin in drawn nickel silver cases, offering complete protection from humidity—even operation under water. The container measures 0.75 in. h. x 0.717 in. w. x 0.312 in. t., and the complete assembly weighs less than one-third of an ounce. For more information about these tiny circuits, turn to the Reader's Service Card and circle 28.

Editors Note: Use of conductance curves[1] for designing electronic circuits has been the subject of many articles by Mr. Pullen. In this article he points out some interesting conduction ratios which can be used in the design of oscillators. Part I, which appeared in the July 1 issue, discussed the design of vacuum tube oscillators using conductance values. Part II extends these techniques to a variety of transistor oscillators.

Design of Oscillators—II

Transistor

K. A. Pullen, Jr.
Ballistic Research Laboratories
Aberdeen Proving Ground, Md.

TRANSISTORS are excellent active elements for low-power oscillators. High stability and almost unbelievable economy can be attained when transistors are used in design of oscillators. In Part I of this article, the principals involved in design of vacuum tube oscillators were analyzed in terms of practical problems of design. Conductance values were used in the analysis to coordinate the tube (active element) with other components in the circuit. Design techniques were considered from a small signal point of view with emphasis on sinusoidal oscillators. The techniques developed in Part I will now be extended to include practical design problems of transistor oscillators.

The factors which are important in design of transistor oscillators are: (1) the active element functions best when used in a voltage control, or conductance mode. (2) Impedance of passive circuits coupled to the input terminals of the active element should satisfy the relation $gZ<1$ at the appropriate port or terminal pair. (g is conductance of the active device, and Z source impedance of the passive circuit). (3) Loading of the feedback network should have a negligible effect on the output voltage of the active device. (4) Loop amplification should exceed unity for proper starting. (5) When good frequency stability is necessary, circuit feedback must be sufficiently small to prevent amplitude limiting as a result of clamping.

Each of these requirements are elaborated upon in the discussion which follows.

Operating Conditions

The first step in the practical design of transistor oscillators is establishment of operating conditions which will provide amplitude limiting. The high degree of current gain constancy in transistors prohibits the use of constant current conditions—starting is too hard to obtain in sinusoidal oscillator circuits. Amplitude control is readily obtained when the transistor is used in a conductance mode of operation (constant input voltage). Thermal stability requires that either base or emitter current be held approximately constant. Base current is held constant when a common emitter connection is used. Emitter current is held constant with a grounded base connection. It is for this reason that starting base current is call I_{bo} and the starting emitter current I_{eo} in this article.

Equations for voltage amplifications* in terms of small-signal parameters measured at the common emitter connection for grounded emitter and grounded base transistor amplifiers are:

$$K_{ve} = \frac{-g_{fe} R_L}{1+g_{ie}(R_i+r_b')+g_{oe}R_L+g_{ie}g_{ce}(R_i+r_b')R_L} \quad (1)$$

$$K_{vb} = \frac{g_{fe} R_L}{1+(g_{ie}+g_{fe})(R_i+r_b)+g_{oe}R_L} \quad (2)$$

Two conclusions can be drawn from these equations: the first is that if R_i (or r_b') is sufficiently large, variations of K_v are difficult to obtain since R_L and R_i are constants; the second is that available values of amplification are relatively small.

Input admittance of a transistor is rather large compared to that for a tube. The reason is evident when the significance of g_{ie} is considered. The design technique used to compensate for capacitive charging current in the input circuit of a tube is to arrange the input circuit to provide the required

*Notations used in the equations are described in the transistor data chart.

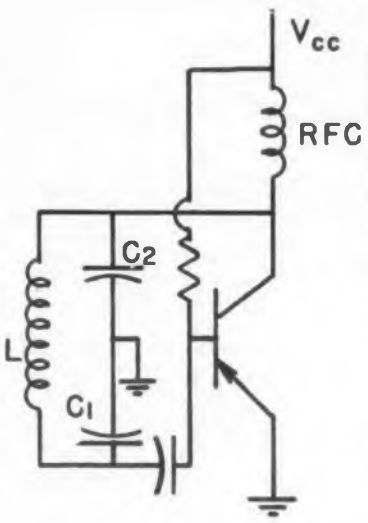

Fig. 1. Colpitts oscillator. An SB-100 transistor is used in 5 MC oscillator.

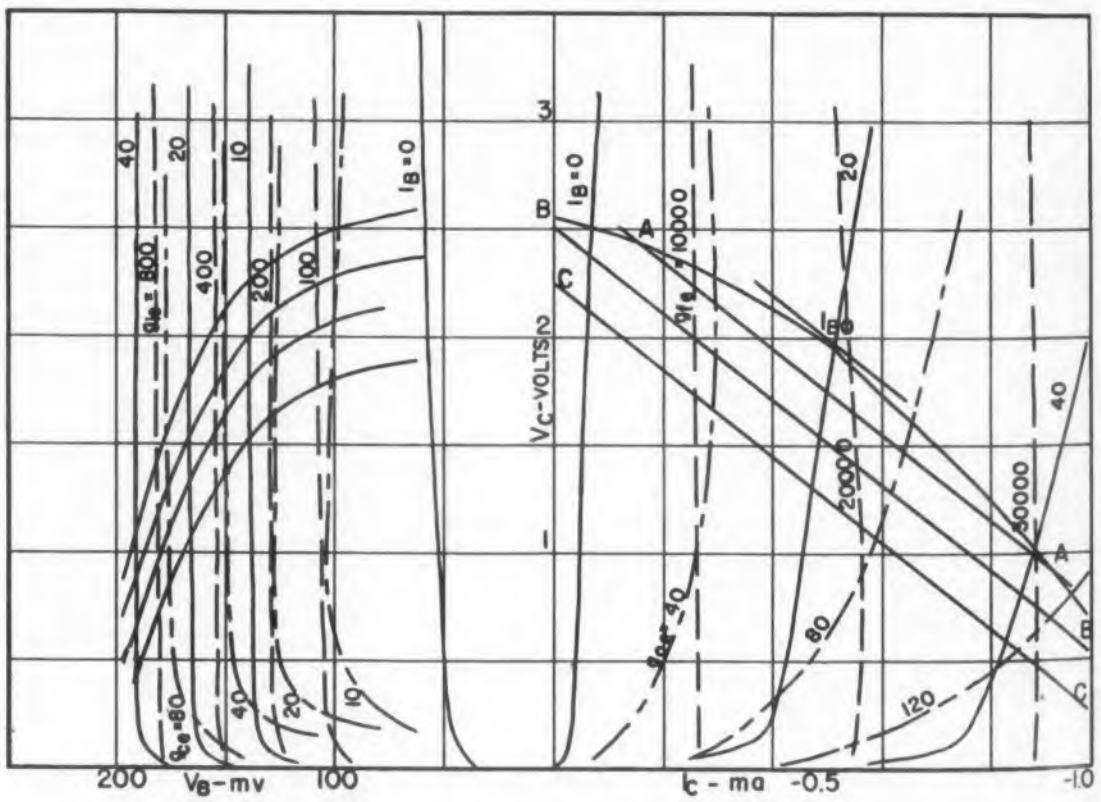

Fig. 2. Characteristic curves for SB-100 transistor with limit contours.

charging current without upsetting impedance relations. The same technique may be used with transistors.

Input conductance of a grounded emitter transistor is approximately equal to g_{ie}, and for a grounded base transistor it is approximately $(g_{ie} + g_{fe})$. Complete equations for input admittances of common emitter and degenerative emitter amplifiers are:

$$g_{in} = \frac{g_{ie}\,(1+g_{ce}\,R_L)}{1+g_{ie}(R_i+r_b')+g_{oe}R_L+g_{ie}\,g_{ce}\,(R_i+r_b')\,R_L} \quad (3)$$

$$g_{id} = \frac{g_{ie}\,[1+g_{ce}\,(R_e+R_L)]}{1+g_{ie}\,(R_i+r_b+R_e)+(g_{fe}+g_{oe})\,R_e+g_{oe}\,R_L+g_{ie}\,g_{ce}\,[(R_i+r_b)+(R_e+R_L)+R_e\,R_L]} \quad (4)$$

Equation 4 is of particular importance in the design of phase-shift oscillators. Without emitter degeneration input admittance can not be made sufficiently small to function with the phase-shift network.

Colpitts Oscillator

Design procedures discussed in the first part of this article** will now be applied to a transistorized Colpitt's oscillator (Fig. 1). The following relations apply in a well-designed oscillator. For the output circuit:

$$g_{oe}\,Z_L < 1 \quad (5)$$

and the input circuit:

$$g_{ie}\,R_i = g_{ie}(C_2/C_1)^2 Z_L < 1 \quad (6)$$

**Design of Oscillators-I, Electronic Design pp. 52 to 55 July 1, 1957

Feedback gain is:

$$K_f = C_2/C_1 \quad (7)$$

and the loop gain is approximately:

$$K_L = K\,K_f = g_{fe}\,Z_L\,(C_2/C_1 \geq 1 \quad (8)$$

For oscillation to start, the terms in (8) should be selected so that the product is equal to at least 1.5.

A 5 mc transistor Colpitts oscillator will be designed to illustrate equations 5 through 8. The transistor selected is an SB-100 (Fig. 2). A trial collector supply voltage of −2v with a collector current of 0.5 ma is used as starting point for design. Since g_{ie} has a value of 550 micromhos, $(C_2/C_1)^2 Z_L$ must have a value of about 1,000 to satisfy eq. 11. Taking $C_2/C_1 = 0.1$, gives value of Z_L in the neighborhood of 2500 ohms. Since the value of g_{fe} at the starting point is 0.018 mhos, a value of 0.05 for C_2/C_1 and 2000 ohms for Z_L gives a $K\,K_f$ of 1.8. The approximate impedance of the circuit which supplies the base is $(0.05)^2 \times 2000$, or five ohms. A typical value for g_{oe} is 60 micromhos. Substituting in eq. 5 gives $g_{oe}\,Z_L = 0.12$, indicating that the effect of collector loading can also be neglected.

Assuming a Q of 100 for the overall tuned circuit, the reactance of the collector circuit is 20 ohms, giving a capacitance C_2 of 1600 μμfd, and $C_1 =$ 3200 μμfd. The required inductance L is 0.67 microhenries.

The next step is to plot limit contours on the transistor characteristic curves, Fig. 2, and locate the amplification limit conditions. Operating limits along any load line are determined by finding the set of points which will simultaneously give the same average base current as that chosen at the starting point, and a positive excursion of the base voltage equal to the negative excursion, Fig. 3.

Two points are taken along the load contour drawn on the base family. The points represent equal changes of base voltage, one positive, ΔV_{bp}, and the other negative ΔV_{bn}.

$$\Delta V_{bp} + \Delta V_{bn} = 0$$

The base current is averaged by the equation:

$$I_{ba} = (I_{bp} + 2I_{bs} + I_{bn})\,/\,4 \quad (9)$$

where I_{bp} is the most positive base current, I_{bs} the base current at the intersection of the static and dynamic load lines, and I_{bn} the most negative base current. This equation is valid as long as the sum of I_{bp} and I_{bn} is approximately twice I_{bs}. If this condition does not exist, a more complex method of averaging is required. The current I_{bs} has a smaller magnitude than I_{bo}, the starting base current. Either I_{bp} or I_{bn} must be very large, otherwise the average will not limit to a value of I_{ba} equal to I_{bo}. Trial changes in base voltage amplitude are increased until the proper value of I_{ba} is obtained. The resulting points represent the positive and negative limits along the individual load contour. The calculation may be repeated along each load line.

When the limit contours have been located and plotted, loop amplifications at the static point and at the limit points can be calculated for each of the load contours. The average amplification, assuming that no sharp breaks in the plot of K as a function of e_b are encountered, is given by the equation:

$$K_a = (K_p + 2\,K_s + K_n)/4 \quad (10)$$

and the loop gain by

$$K_a\,K_f = K_L \quad (11)$$

As always with oscillators, the load contour giving a value of unity for K_L is the one which represents the limit cycle.

The limit contours shown in Fig. 2 show that the operating point has not been properly selected (or the wrong load impedance has been selected), causing the transistor to cut off for part of the cycle. The average amplification for the load line at which the minimum base current reaches zero is 1.4, indicating that eq. 10 does not give accurate results. Linear operation can be obtained by changing the value of K_f from 0.05 to 0.033 or changing both K_f and Z_L to provide better characteristics.

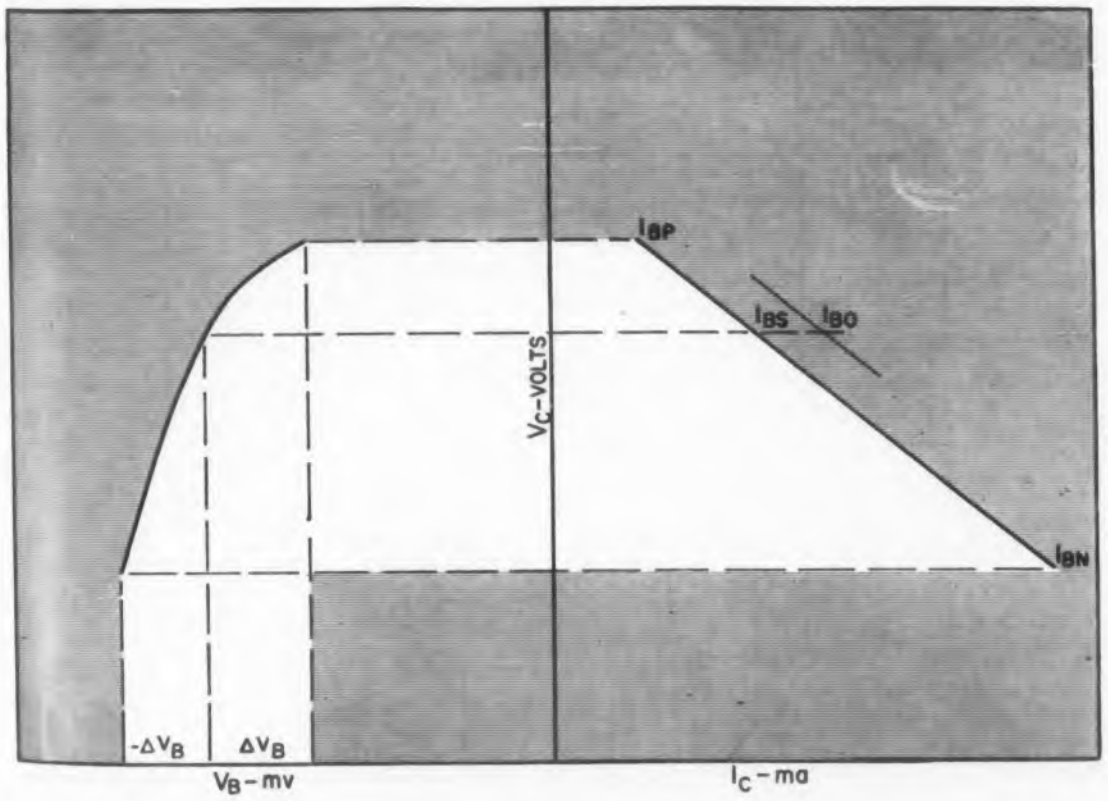

Fig. 3. Operating limits along the load line give the same average base current as that chosen at the starting point and equal positive and negative excursions of the base voltage.

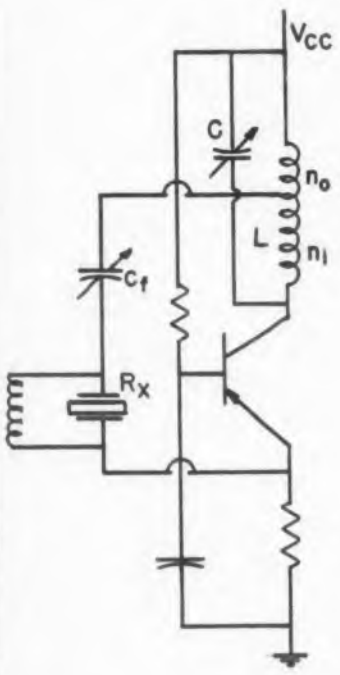

Fig. 4. Crystal oscillator. Operating in series resonant mode. Variable capacitor C_f trims the phase of the feedback.

Crystal Oscillator

An excellent crystal-controlled oscillator can be constructed using the SB-100 transistor. The circuit is shown in Fig. 4. The crystal is used in the series resonant mode and has the variable capacitor C_f in series with it to trim the phase of the feedback. A coil in parallel with the crystal is used to tune out the shunt capacitance of the crystal and its holder.

When a transistor is used as a grounded base

oscillator, an impedance stepdown (current stepup) is required to provide the current gain needed to make the necessary emitter signal current available. The very low input impedance of the emitter also makes a voltage step-down necessary. Maximum turns ratio in the inductance L is given by:

$$n_i/n_o = g_{fe}\, Z_L/[1 + (g_{ie} + g_{fe})\, R_x]^2 \qquad (12)$$

where R_x is the series resistance of the crystal, n_i is the total number of turns in L, and n_o the number of turns from the collector supply to the feedback tap. A ratio value about half the maximum given by eq. 12 should be used to assure effective starting with average transistors. For a crystal having a series mode resistance of 100 ohms, a typical value for the complete denominator would be between ten and twenty, since $(g_{ie} + g_{fe})$ has a value between 0.02 and 0.03 mhos. The maximum value of the ratio n_i/n_o is between two and twenty, depending on the crystal used.

Current limiting in a grounded base oscillator is obtained in a manner similar to the method described for a Colpitts oscillator except that limiting is on the emitter current instead of the base current. Exactly the same technique is used to average the emitter current, which is the sum of the base and the collector currents. The limit points are points having equal changes of base to emitter voltage with reference to the static voltage. (If the crystal impedance is very high, the emitter current changes will be equal rather than the voltages).

An oscillator can be built around the static conditions used for the Colpitts oscillator just discussed. With $Z_L = 2000$ ohms, and resistance of the crystal, 50 ohms, the feedback ratio should be approximately four. Use of a coil with several taps is desirable, since measurement of the series resonant resistance of the crytal is quite difficult with ordinary equipment.

Magnetic Coupled Oscillators

Transistorized oscillators using magnetic coupling in the feedback path are constructed with the tuned circuit in the collector rather than in the base circuit. Otherwise oscillator starting and frequency stability will be difficult to obtain. Impedance of the base coil, L_b in Fig. 5, is adjusted so that $g_{ie}\, X_b < 1$, where X_b is the reactance of the base coil L_b. Cou-

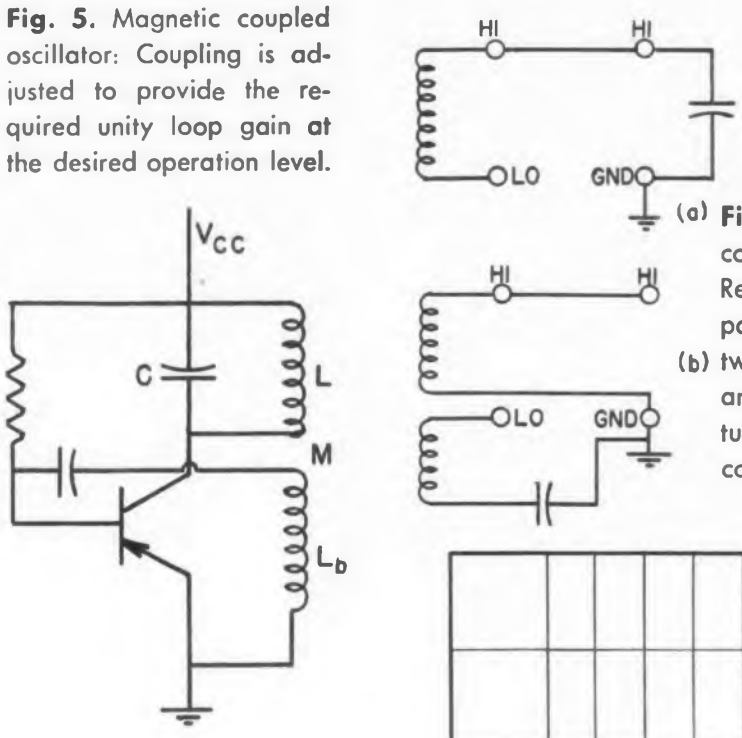

Fig. 5. Magnetic coupled oscillator: Coupling is adjusted to provide the required unity loop gain at the desired operation level.

Fig. 6. Determination of coupling coefficient: (a) Required coupling capacitance is added between the "Hi" terminal and ground. (b) After tuning the circuit is reconnected as shown.

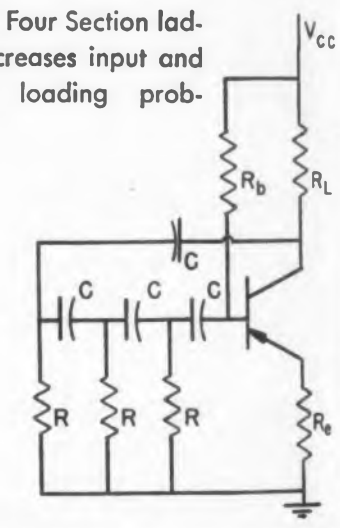

Fig. 7. Four Section ladder decreases input and output loading problems.

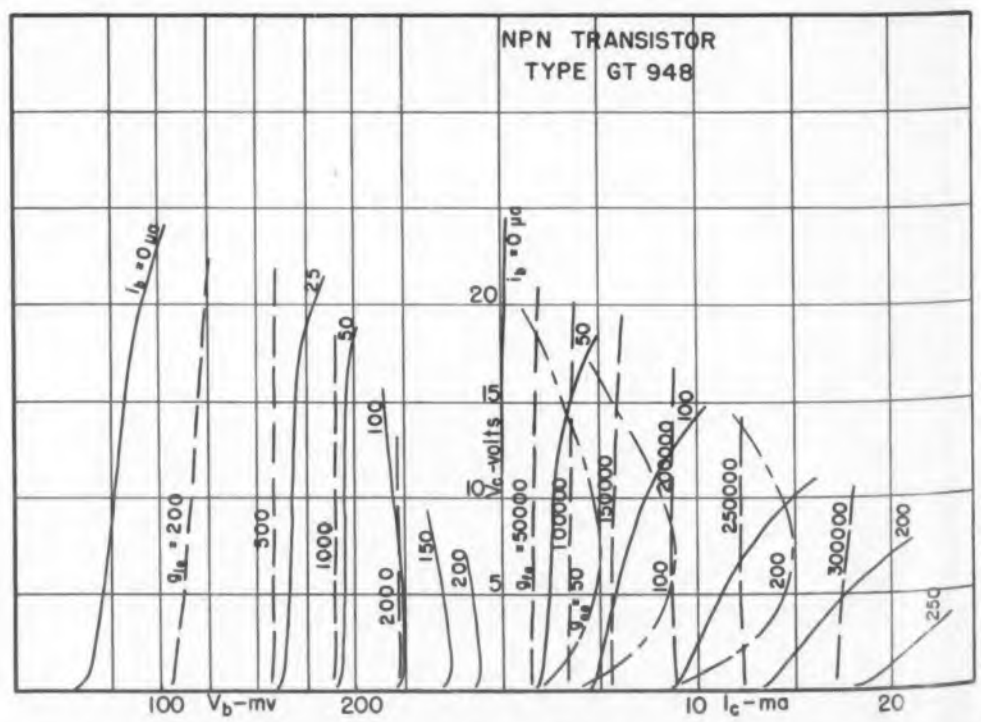

Fig. 8. Characteristic curves for a GT 948 transistor with limit contours.

pling is adjusted to provide the required unity loop gain at the desired operation level.

The main design advantage of a magnetic coupled oscillator is the additional degree of freedom—the coupling factor. The reactance in the base circuit is first adjusted to be small compared to the input conductance. Inductance of the base coil should also be low enough so that $\omega^2 L_b C_b < 0.2$, where ω is the angular frequency at which the oscillator operates, L_b is the inductance, and C_b is the capacitance of the base circuit, including, if necessary, the effective capacitance from base to collector.

The impedance level of the tuned circuit serving as the collector load impedance should be sufficiently small to permit stable operation. A practical value is 2000 ohms. The equation for this relation is written:

$$Z_L = Q\,X_c = 2000 \text{ ohms} \tag{13}$$

where X_c is the reactance of the capacitor C, and Q is the overall Q of the collector circuit.

Coupling Adjustment

Experimental adjustment of the coupling can be accomplished with a Q meter. First the collector inductance L is connected to the Q meter, Fig. 6a, and the required capacitance obtained by adding fixed mica capacitors between the *"HI"* terminal and ground to tune the circuit to the proper frequency. (At one megacycle a C of about 5600 μμfd is required). The Q of the combination is read, and the circuit reconnected as shown in Fig. 6b. The position of the coil L_b is adjusted until the new reading on the Q scale satisfies the relation:

$$K_f = Q_b/Q_c \tag{14}$$

where Q_b is the reading with L_b connected to the *"HI"* terminal (Fig. 6b), and Q_c the reading when the tuned circuit L-C is connected to the *"HI"* terminal, (Fig. 6a). If, after the adjustment is made, the transistor gain satisfies the relation

$$K_a = g_{fe}\,Z_L > 1/K_f \tag{15}$$

oscillation will result. (At very high frequencies g_{fe} may be reduced below the dc value, with the result that near cutoff frequency K_f may have to be larger than calculated).

Transistor R-C Oscillators

Transistor R-C oscillators are more difficult to design than their vacuum tube equivalents because of the relatively high values of g_{ie} characteristics of transistors. As a consequence, a design which may appear to be excellent on paper may not function properly even when loop gain and phase appear to be correct. A circuit, such as shown in Fig. 7, requires considerable emitter degeneration to function as an oscillator. Without the four-section ladder, input and output loading become difficult to design problems.

Collector load impedance should not be greater than 1500 ohms with a GT-948 transistor operating at point A, Fig. 8. Since forward conductance of the transistor is 0.075 mhos at point A, the maximum permissible value of R_e is 82 ohms. Amplification is therefore about 15. Emitter resistance also increases the input impedance of the transistor through emitter degeneration.

The approximate input conductance for a degenerative transistor amplifier (g_{ie} and $g_{fe} >> g_{oe}$ and g_{ce}) is:

$$g_{id} = \frac{g_{ie}\,(1 + g_{ce}\,(R_e + R_L)}{1 + (g_{ie} + g_{fe})\,R_e + g_{oe}\,R_L} \tag{16}$$

Since the forward amplification is

$$K = \frac{-g_{fe}\,R_L}{[1 + (g_{ie} + g_{fe})\,R_e + g_{oe}\,R_L]} \tag{17}$$

the loop amplification, assuming proper termination on the ladder is:

$$K_L = \frac{g_{fe}\,R_L}{13\,[1 + (g_{ie} + g_{fe})\,R_e + g_{oe}\,R_L]} \tag{18}$$

As a result, the effective value of g_{fe} is reduced by 13 by the feedback net, lowering correspondingly the permitted value of g_{ie}; A correspondingly larger value of beta is required in a transistor for a phase-shift oscillator.

The ladder network must simultaneously have negligible effect on the load impedance in the collector circuit, and an output impedance which is at most equal to the input impedance of the transistor. If input conductance of the transistor is used as the output shunt element of the ladder, the input resistance of network reduces the load impedance just enough to give a marginal operation with transistors having betas less than 100.

Design of oscillators using transistors is slightly more complicated than with vacuum tubes. For low power requirements the excellent results obtained are easily worth the effort. As was pointed out in the opening paragraph, transistors are highly stable elements and offer considerable savings in equipment cost.

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High Speed

Analog-to-Digital and Digital-to-Analog

Converter

MULTIPLICATION and division can be performed during conversion of information from analog-to-digital and digital-to-analog by the Multiverter. Speeds in excess of 15,000 per sec for analog-to-digital conversion and 300,000 per sec for digital-to-analog conversion are possible. Accuracies of better than 0.01 per cent can be obtained. In systems that require multiplication or division of analog and digital functions the converter will perform the operation directly, eliminating additional equipment.

The Multiverter, developed by Packard-Bell Computer Corp., Los Angeles, Calif., is the first commercially available high speed converter to be fully transistorized. The principles involved in design permits the construction of digital-to-analog converters which are about the size of a pack of cigarettes. At the electronic speeds with which the Multiverter operates—over 15,000 analog-to-digital conversions per sec and 300,000 digital-to-analog conversions per sec—the 0.01 per cent ac-

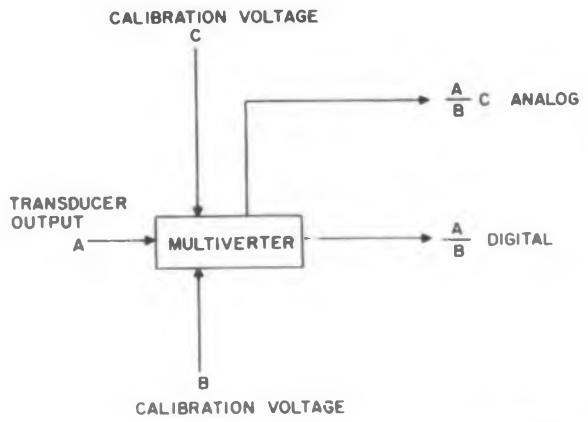

Fig. 1. Multiverter used for reading transducers. Calibration voltages B and C may represent temperature, barometric pressure or any other correction that must be applied to transducer output.

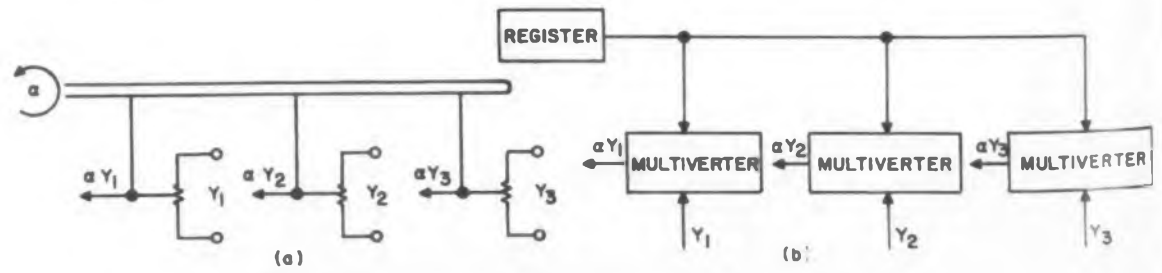

Fig. 2. Employment of Multiverter in a control system.

curacy of the rack-mounted version is better than any previous converter. Greater accuracy has been obtained before, but only with relays or other electro-mechanical devices.

When used to convert a number n to a voltage, the product nx is formed simply by supplying the variable voltage x. When used to convert a voltage a to a digital number, the quotient a/v in digital form is effected by supplying the unit with a second voltage v. Multiverters are also available which will form aw/v as a voltage where w is a third variable voltage input.

The importance of being able to perform multiplication and division in the process of conversion can be gauged by considering Fig. 1 & 2.

Fig. 1 is a configuration that occurs in the reading of transducers. B and C are calibration voltages. They may represent temperature, barometric pressure or any other correction that must be applied to the transducer output. An analogous situation—not shown—arises in employing an analog plotter for plotting digital information. The converter in this case can introduce scale changes and other corrections during the process of conversion.

Fig. 2 illustrates the employment of the Multiverter in a control system. Common practice in an analog control system is to produce some of the outputs as shaft rotations and to couple to each shaft several potentiometers to effect a series of multiplications Fig. 2 (a).

Often a digital computer is used to replace a portion of the control system. When multiplication is to be performed digitally and the result take the form of a control voltage, two conversions are necessary. A single conversion and an analog multiplier are required when the multiplication is performed analogwise. In addition to eliminating the difficulties involved in conversion and multiplication, the Multiverter permits a digital output and an analog voltage to be multiplied directly Fig. 2 (b).

Accuracy requirements of most computing systems vary inversely with the frequency content of the data. This is because the contribution of higher frequencies to the over-all operation is proportionally small in most physical systems. Since speed and accuracy can be interchanged in the Multiverter, it will adjust to varying speed and accuracy requirements. This is particularly important in incremental conversion. Speed can be increased by a factor of several hundred in those portions of a solution where only low accuracies are needed. Because the adjustment of accuracy to frequency can be automatic, it is possible to use a single converter for both high and low frequency regions without manual intervention. For further information on this converter, turn to the Reader's Service Card and circle 38.

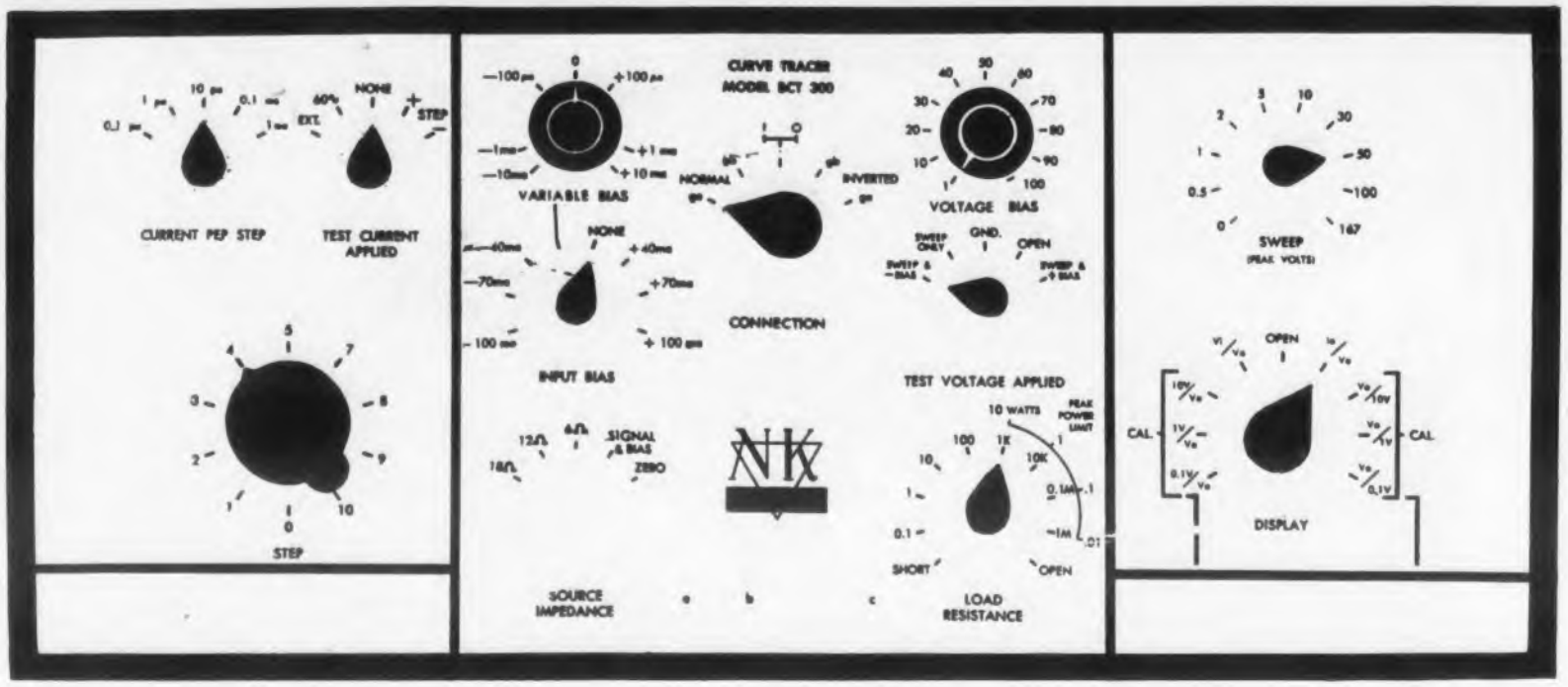

Fig. 1. A transistor analyzer showing the controls for biasings, etc. not found on a simple curve tracer.

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Using A Curve Tracer for Transistor Circuit Design

A TRANSISTOR curve tracer supplies stepped input current and swept output voltage to the device under test. It uses an oscilloscope face to compare families of curves with a calibration grid. It is superior to other methods of measurement in that it checks transistors over the full range of their characteristics giving more data, more accurately, faster, and with less chance of damage to the transistor if the tracer is properly designed and used.

Good circuit design requires that biases applied to the transistor be no larger than necessary to handle the expected signals with adequate margins. But at small biases gain goes down, feedback goes up, and distortion is introduced. The biases to give a reasonable compromise are determined on the collector family plot of the curve tracer. The relations are expressed quantitatively. The collector family curves are also used in determining cutoff current variation with voltage and the constant and temperature dependent portions of this current. The exponential relation between junction voltage and current simplifies some of the measurements and makes others almost unnecessary. The small signal coefficients are read on the displayed curves by slopes or intercepts. Translation of the display facilitates this.

A transistor analyzer is a curve tracer with input and output biases also supplied. The controllable biases allow interpolation between the steps and sweeps and permit direct reading of the small signal coefficients as on a meter. At frequencies high enough for reactive effects to be significant, the alternating current measurement is necessary for accuracy. The biases from the analyzer are also used to power a breadboard of the stage as designed for check of the design.

The data taken with the curve tracer is adapted to design by the method of successive approximations. In general, as the coefficients become difficult to measure they become unimportant in practical application. The complete consideration of the effect or reverse (feedback) voltage ratio is too extensive to be treated in this paper.

The manufacturer's published data on transistors has a limited number of coefficients given, usually at one bias or other parameter value. The range of the individual coefficients is seldom given. A transistor analyzer is generally the best instrument to supply the additional data necessary to design the individual transistor stage. A tracer having a full calibration grid is more accurate than the inexpensive transistor tester, and faster in a survey of the operating area than a precision small signal tester.

Setting Up the Curve Tracer

The full face of the oscilloscope should be checked for linearity and calibration by using the internal calibration circuits of the tracer. Check of just two axii across the face of the oscilloscope is inadequate to show up some of the weird types of deflection found too often even in the best of oscilloscopes. The cathode ray tube acts as an interpolating surface and a transfer device between the transistor curves displayed and the calibration grid. The scopeface calibration need only be made once a day and takes only a few seconds. The check of the origin (no deflection voltage in either direction) should be made every few minutes because most all oscilloscope amplifiers show appreciable zero drift.

The tracer should be set to limit the power into the transistor that is to be tested to its rated or other safe value. This protects the transistor having unexpectedly high leakage current or current gain, and also that incapable of withstanding normal voltages. If the tracer is capable of supplying the large power needed to test some transistors, only the operator can be sure it is set so as to protect those with lesser capabilities.

The Small Signal RC Coupled Stage

It is possible to operate a transistor just at the bias values at which the manufacturer choses to give its characteristics, but for small signal work this is seldom advisable. Power generally needs to be conserved to lengthen the life of the battery supply. Even with unlimited power available, lim-

iting the power into the stage to the amount required is good design procedure. It limits the heating within the transistor, and increases the range of temperatures over which the circuit will operate, the stability of the circuit, and the life of the transistor. The desirability of keeping the temperature low to minimize I_{CO} is adequately discussed elsewhere.

On the other hand, operation at miniscule powers is seldom advisable. At low currents the current gain of the transistor is quite small, and it is also small at low voltages. Note the region below 0.2 volts in Fig. 2. Furthermore, the high frequency performance suffers. In Fig. 3 the apparent alpha cutoff frequency is plotted against collector voltage at two current levels. The apparent alpha cutoff frequency is taken as the common emitter current gain multiplied by the frequency of its measurement where the frequency of measurement is so chosen that the current gain is greater than unity and less than half of its low frequency value. Such an estimate may be low by one part in ten. The collector capacitance also increases at low voltages thus reducing high frequency power gain. Fig. 4, which shows the collector susceptance, was made with an adapter for the BCT 300 which allows measurement of the high frequency small signal output and reverse transfer coefficients h_o and h_r.

The maximum peak signal excursion is an obvious limit to the reduction in bias that is permissible. In the RC coupled stage the greatest distortion is probably introduced where the signal is from a voltage source. The distortion arises because of the exponential characteristic of the input impedance of the transistor. For a signal of ten millivolts peak-to-peak the second harmonic at the output is one-fifth of the signal or 0.2 fractional and the third 0.08 fractional. The fraction of second harmonic decreases directly as the signal decreases, while that of the third decreases as the square of the signal.

The first purpose of the transistor curve tracer is to set forth the family of collector-current collector-voltage curves so that an operating region and bias point can be selected to give a reasonable compromise between these conflicting demands. As the preceding photographs show, the curve tracer allows one to pick an operating point such that any desired fraction of the possible current gain or other criterion is achieved. A more useful selection of the operating point is based upon an allowance for operating point or characteristic shift, say by a factor of two, in any direction. From the plots on the curve tracer the bias boundaries for the minimum performance of the stage are determined. The operating point is then chosen to differ from the bias at these boundary-of-performance points by the safety factor (see references 1 and 2).

The collector cutoff current I_{CBO} (see reference 3) is given by the curve of collector current versus collector voltage with the emitter open. This is

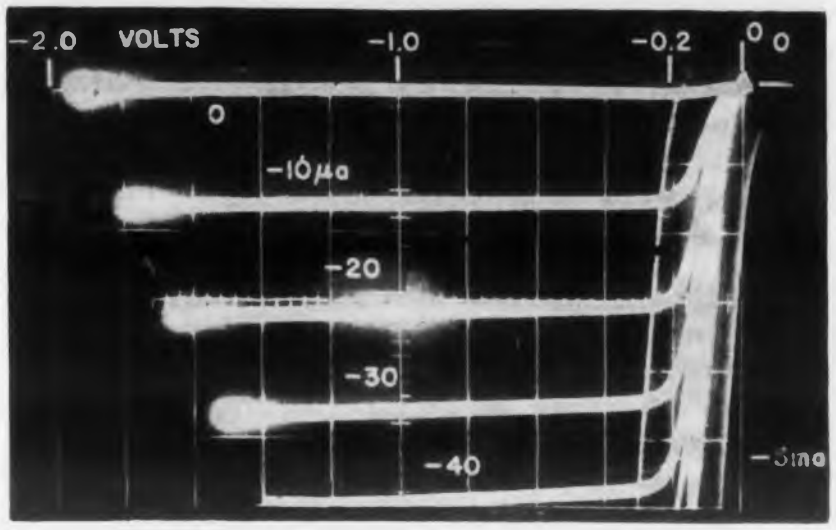

Fig. 2. Curve tracer display of collector current at 1 ma/cm as a function of collector voltage at 0.2 v cm. Input current of 10 μa per step to a GT 92 transistor with common emitter. Note how the current gain beta falls below 100 at voltages below 200 mv.

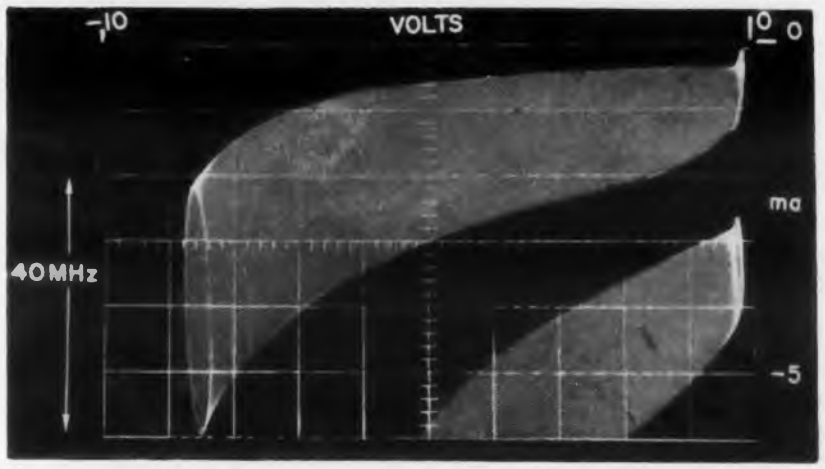

Fig. 3. Collector current at 1 ma/cm and collector voltage at 1 v/cm. A GT 764 with 100 μa peak to peak at 1 mc per second applied to base superimposed on two fixed input biases and collector voltage sweep. Emitter is common. The indicated frequency of alpha cutoff at 8 v is approximately 40 MHz.

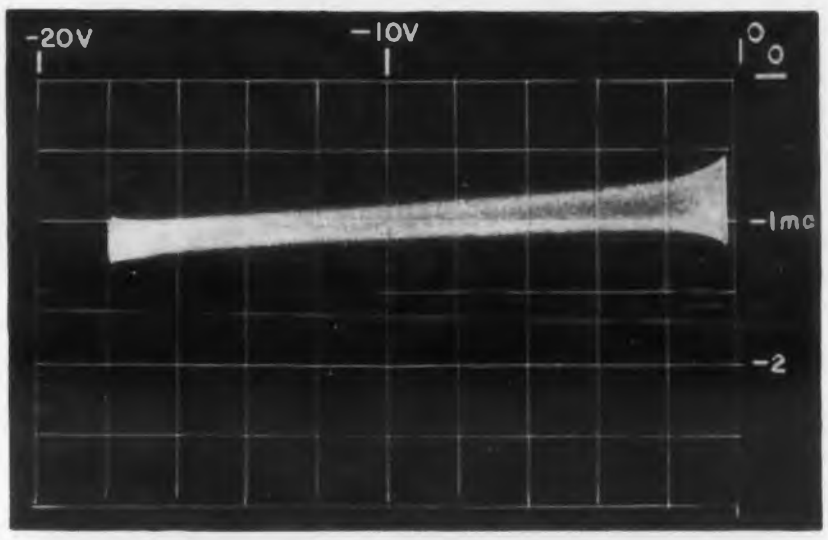

Fig. 4. Collector family for GT 222 with 1 v p-p of 1 MHz applied to the collector. Common emitter. 500 μa/cm and 2 v/cm.

shown in Fig. 5 together with the saturation current, I_{CBS}, and the common emitter cutoff current I_{CEO}. The scale for the latter is ten times that of the others. Note that I_{CBO} consists of a constant portion plus a portion increasing linearly with voltage plus a portion increasing almost exponentially with voltage. The constant portion I_{CBOO} may be measured at small voltages, is the current that should theoretically flow, and is the component that doubles every nine Celsius degrees. The proportional current I_L is measureable by the slope on the display of the curve tracer and varies but little with temperature. This is the leakage current. The curve tracer allows these components of I_{CBO} (I_{CO}) to be determined separately so that its value at any temperature and voltage can be forecast by the equation $I_{CBO} = I_L \times V_C + I_{CBOO}\exp(C°/9)$.

When the collector cutoff current is too small to measure with the oscilloscope or meter at hand, it can be measured indirectly. The transistor is put into the common emitter connection and reverse base current applied and increased until the collector current no longer decreases at the voltage of interest. The collector current and base current are now each very nearly equal to the collector cutoff current. The value is read from the dials setting the input current to the transistor under test. With silicon transistors, and a few germanium units, the constant portion may be found more easily by calculating it from the saturation current. $I_{CBOO} = I_{CBS}(1\text{-}h_{FO}h_{RFO})$ The saturation current, if not measureable directly, is determined from the fact that it increases tenfold for each input bias voltage increase of roughly 60 millivolts. With the Norden-Ketay BCT 300, thermally compensated resistors to set multiples of this voltage into the base are available. The transistor is measured in the inverted connection to put the applied bias across the collector junction. Ten or 100 milliamperes of nominal input current are applied to the resistor to produce the junction voltage giving the appropriate multiple of collector current. The output current is read, with its decimal shifted appropriately, as the saturation current I_{CBS}. This method is a last resort; as it becomes most useful it also becomes most sensitive to voltage bias errors. The exponential relationship between junction voltage and current that makes this method of measurement possible also causes the error sensitivity.

The exponential relation also determines the large and small signal input impedances. The input bias voltage is proportional to the logarithm of the ratio of the operating emitter current to the emitter diode saturation current. The input bias voltage at the operating current is read with the curve tracer by switching to the display of input voltage.

With the curve tracers having a floating sweep voltage power supply, proper termination for the hybrid coefficients h_o and h_r will generally exist. Proper termination for measurement of h_i and h_f

requires a collector load resistance that is small. The load resistance is satisfactory when (for full display of the collector characteristics) the sensitivity of the oscilloscope for the current axis is one hundred times as great as for the voltage axis.

Small Signal Coefficients

Next the small signal coefficients are determined in the vicinity of the chosen operating or bias point. The forward current gain is determined directly from its definition as the increment in collector current for a unit increment of base current at a constant collector voltage. At the voltage under consideration, the increment in collector current is read directly on the face of the oscilloscope. If the deflection system of the oscilloscope is uniform and linear, the pattern may be offset for convenience in reading. This is shown in Fig. 6. Restore the no-signal display point to the zero-zero scale point immediately after reading.

Reading of the small signal current gain at a given operating point can be made more simply or more accurately by the use of an analyzer. See Fig. 1. With this, the stepped and swept biases are removed and potentiometers used to set in biases to the chosen operating point. A smaller increment of stepped input current can now be superimposed, or a power frequency sine wave, or an alternating current wave of most any form at the frequencies of interest (superimposed from an external oscillator). High gain ac coupled amplifiers may now be used in the indicating oscilloscope or voltmeter. The alternating current is calibrated by switching it directly into the precision load resistor instead of through the transistor. The gain of the system is adjusted to give unit indication. A flick of the switch and the transistor is inserted into the circuit between the voltage dropping resistor and the load resistor, so that the meter now reads the current gain. These alternating current techniques are necessary where the heating of the transistor at its operating point causes drifts that would invalidate the curve-to-curve measurements, and also where the frequency of interest is high enough so that the transistor's coefficients differ from their low frequency and direct current values.

Cascaded RC Coupled Stages

In cascaded RC coupled stages the overall current gain is but little less than the product of the current gains of the individual stages. The amount by which the current gain of each cascaded stage falls short of the transistor current gain can be expressed by a correction factor, F, multiplying the current gain, B, of the transistor. The overall current gain of a four stage amplifier is then $B_1F_1B_2F_2B_3F_3B_4F_4$. Other loading effects and losses can be similarly accounted for. This is the method of successive approximations. The first approximation to the gain of the amplifier is the product of the current gains of the individual transistors. For the interstage coupling the second approximation correction factor is factored into that existing because the collector load resistors are only finitely larger than the input impedance of the following stage and that existing because of effects contributing still smaller losses. The third approximation is in the assumption that the output impedance of the transistor is large relative to the load resistor, R_L, and the input impedance in the same interstage network. The correction for this approximation is often unnecessary and the correction for the residual losses is usually unnecessary. It is easier to calculate the corrections separately and insert them if they are large enough to warrant than it is to solve the complete network equations. The factor F_2 in the above example is then made up of

$$F_{2a} \times F_{2b} \times F_{2c} = \frac{(1/h_i)}{(1/R_L) + (1/h_i)} \times \frac{h_o}{(1/R_L) + (1/h_i) + h_o} \times F_{2c}$$

Input Impedance

At low frequencies the input impedance of a transistor is most easily found by calculation. For either base or emitter input the resistance is given by the thermal voltage divided by the input current. (proof supplied on request). The thermal voltage V_θ is defined as kT/q and is about 25 millivolts at room temperature. In the common emitter connection the collector cutoff current is part of the input current to be used in this calculation, and must be added to the external input current. The input current is best found by dividing the collector current by the current gain. The transistor input resistance is then given by; $h_i = V_\theta h_f / I_C$. The curve tracer is used to check this value by setting the display to show the transistor input voltage V_1 and stepping the input current. The input voltage increment for unit input current increment at constant output voltage is by definition the input resistance, h_i. This may be difficult to read on the face of the oscilloscope or may be wanted at a frequency at which it is different from the dc value. The methods used for h_f apply here with the substitution of input voltage for output current. The analyzer is particularly useful if a measured value of h_i or h_o is desired.

Output Impedance

The correction for the output impedance being less than infinite requires the measurement of it. Restated in terms of the hybrid coefficients, "the correction for the output admittance being greater than zero." The small signal ouput admittance is the increment in output current for a unit increment in output voltage with the input current held constant. The measurement is made on the family of collector current as a function of collector voltage curves. The measurement is made along the tangent to the curve of constant base current passing through the point of interest. See Fig. 6. The portion of the curve intercepted by a unit increment of collector voltage is noted and the increase of collector current from one end of this segment to the other is the output conductance h_o. One saving factor for the curve tracer is that as this measurement becomes more difficult to make because of the small size of it, the need for accuracy in the measurement de-

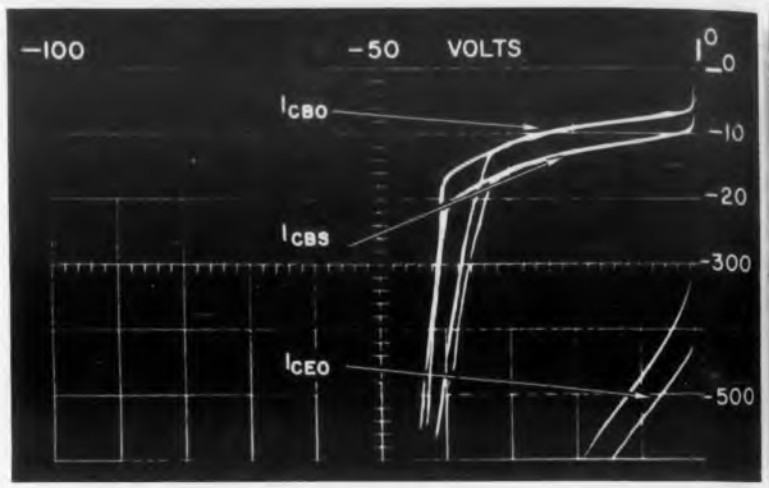

Fig. 5. Collector family GT 222 with 10 μa/cm for I_{CBO} and I_{CBS} but 100 μa/cm for I_{CEO}. For all, 10 v/cm. Collector cutoff current is the smallest of these three. Subtract 1 μa/10 v from all curves to allow for the input conductance of the oscilloscope.

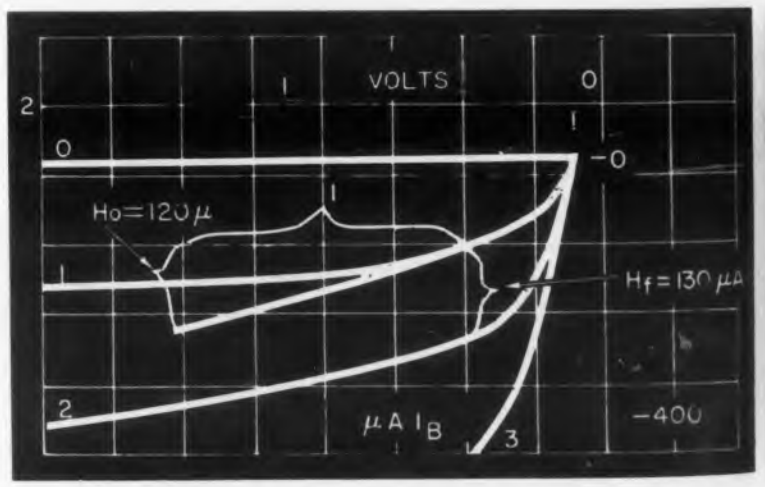

Fig. 6. Offset of the zero point for ease in reading small signal values by increments.

creases. The correction factor for it approaches unity. If a measurement is essential in any case, the analyzer allows it to be made by applying steady input and output biases to put the transistor at the operating point. A small sweep voltage is superimposed on the collector bias voltage and the collector current that results observed.

Observing the input voltage under these conditions gives the reverse voltage transfer ratio h_r. The foregoing design procedure has assumed that the effect of this reverse voltage transfer is negligible. This is often the case. If it must be considered the first approximation is to add a correction factor which is close to but may be greater or less than unity. A plot of h_r as a function of collector voltage at intermediate frequency is shown in Fig. 7. The considerations in the incorporation of this correction supply material enough for two or more articles.

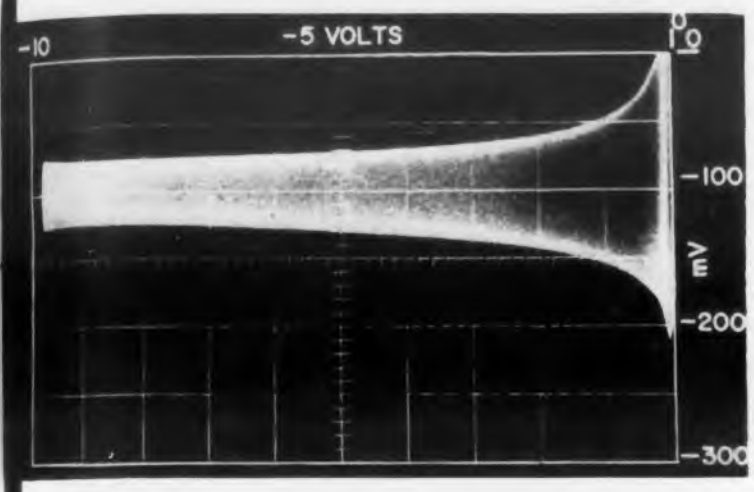

Fig. 7. A plot of input voltage at 50 mv/cm as a function of output voltage at 1 v/cm for a GT 222 with 1 v p-p of 1 MHz applied to the collector and base common.

If the stage gain arrived at in this fashion is too large either local or overall feedback may be used to reduce it. Alternatively and if it is too small, the transistor type can be changed.

The final circuit design is then haywired and connected to use the analyzer current and voltage power supplies to power it. A selection of transistors at the limits of the manufacturers' range of production can then be plugged in to check the adequacy of the margins set up.

When the engineering model of the circuit has been built, the tracer is very convenient for checking transistors suspected of damage. The curve tracer has the advantage of quickly showing all of the transistor's useful operating region. Damage to a transistor may render it unfit for use in a particular cicuit but still not show up on a beta checker. An example is shown in Fig. 8. The transistor shown is a GT 949 rated at 30 volts and 100 milliwatts. A bit more than double the rated power applied momentarily reduced the sustaining voltage to twenty volts (as shown) with no apparent change in the characterestics at lower voltages, where most single point testers operate. The curve tracer has the further advantages that the average power applied is only one-fourth to one half of the peak power and of showing momentary variation in the transistor's characteristics. An example of such a variation is failure of the retrace to fall on top of the sweep. An upward drift of current is caused by continuous heating. A smooth gross deviation repeating each sweep occurs when the transistor is overheated in each single sweep. A jittery and irregular lack of superposition is indicative of an improperly processed or subsequentially damaged transistor. Such a transistor is likely to soon show excessive noise, leakage current, and short life.

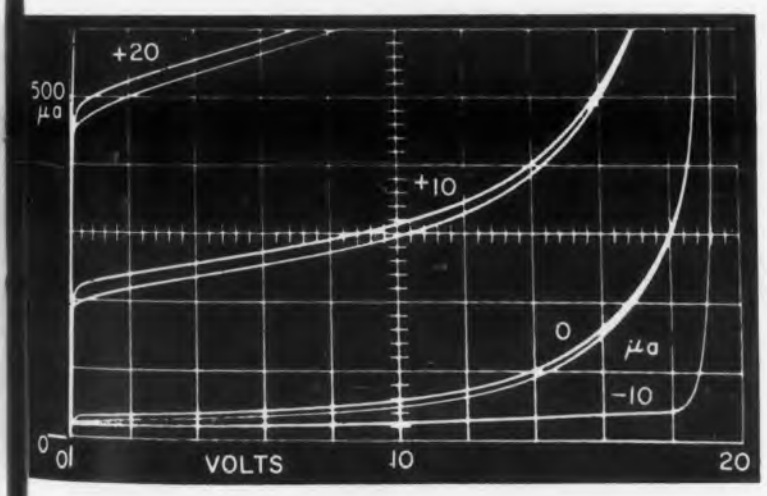

Fig. 8. Collector family 100 μa/cm and 2 v/cm for damaged GT 949 in common emitter with -10, 0, 10, 20 and 30 μA applied to the base. Overheating has reduced the saturation voltage to 18 v but the characteristics below 10 v are little changed.

Having designed the circuits of commercial wide band, precision small signal, and inexpensive testers, the author's preference is for a circuit analyzer due to its versatility. As a curve tracer it has the highest information rate for characteristics from transistor to operator.

References:

1. Norman 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.
2. Keats A. Pullen, "Using Contour Curves in Transistor Circuit Design", Electronic Design, Vol. 3, No. 7, July 1955, pp. 22-25.
3. "IRE Standards on Letter Symbols for Semiconductor Devices, 1956" Proc. IRE, Vol. 44, No. 7, July 1956, pp. 934-7.

Recent advances in the semiconductor field have resulted in the commercial availability of transistors designed specifically to handle large amounts of power. These "power transistors" are capable of dissipating up to several watts and are particularly suitable for use in audio-frequency power amplifiers. Circuit-design considerations for the application of pnp alloy junction power transistors to audio-frequency power output-stages are presented, along with a discussion of the effects of source and load impedances on distortion. Methods of obtaining a desired degree of bias stability with temperature variations are also outlined. Although a specific application is described in this article, sufficiently general remarks are made which are applicable to a wide variety of transistor power amplifiers.

Class A Transistor Power Amplifier Design

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THE CHOICE of class A or class B push-pull operation depends upon several factors, including the amount of power output and power efficiency required. The object is to obtain as much power output as possible with a minimum distortion. A single power transistor can be used in a class A circuit for moderate output. The output is developed such that collector current flows continuously throughout the cycle. Because maximum power is dissipated in the transistor at zero input signal, the maximum possible output power is one-half the maximum rated dc power dissipation, P_{max} *(dc)*.

In audio power amplifier design, the most important consideration is of course the power-dissipation capability of the transistor. The maximum power that can be dissipated before "thermal runaway" occurs depends heavily on how well the heat generated within the transistor is removed. When it is removed by conduction, the ability to do so is measured by the thermal resistance. The lower this figure, the greater the power-handling capability. Other factors which determine the maximum power-dissipation capability are the *collector-voltage rating*, *reverse collector saturation current*, *circuit stability factor*, and *maximum ambient temperature*. The maximum permissible dissipation, P_{max}, of a germanium transistor is given by:

$$P_{max} = \frac{12.5}{\Theta} \times ln\left[\frac{12.5}{\Theta s_f V_{ce} I_{cs}} - \frac{(T_a - T_{25})}{\Theta}\right] \quad (1)$$

Where Θ is the total thermal resistance of the transistor and chassis in deg C per w,

V_{ce} is the collector-to-emitter voltage in volts,

I_{cs} is the reverse collector saturation current at 25 C,

s_f is the circuit stability factor, and

T_a is the maximum operating ambient temperature in deg C[1,2].

In circuits having low values of $s_f V_{ce}$, P_{max} as computed may be greater than the power which can be obtained in practical circuits. The actual power dissipation possible in a practical circuit design is limited by the maximum safe collector-junction temperature at which the power transistor can be operated without appreciable alteration in its electrical characteristics or a decrease in its life expectancy. For most germanium transistors this is below 100 C. The maximum power-dissipation capability can be expressed in terms of the allowable junction temperature as follows:

$$P_{max} = \frac{T_j - T_a}{\Theta} \quad (2)$$

Where T_j is the maximum allowable junction temperature in deg C, T_a is the ambient temperature in deg C and Θ is the total thermal resistance of chassis and transistor in deg C per w.[3] The two equations for P_{max} can be used together to obtain power-rating curves for a given transistor provided that

- when the allowable power dissipation obtained from eq (1) is greater than that calculated from eq (2), the maximum allowable collector-junction temperature rise is the limiting condition for dissipation; and
- if the allowable power dissipation calculated from equation (1) is less than that found by equation (2), then thermal runaway is the limiting factor.

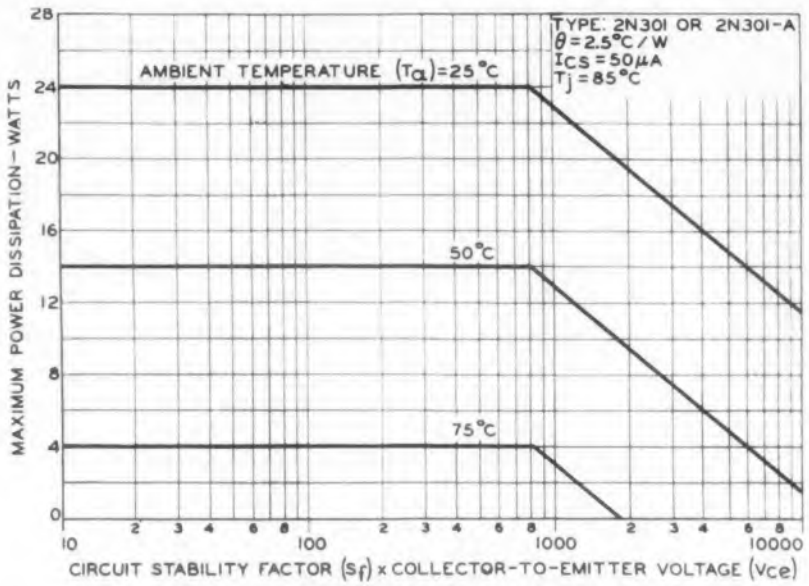


Fig. 1. Maximum power dissipation curves for the type 2N301 or 2N301-A transistor. "Thermal Runaway" occurs at any point above the sloping lines.

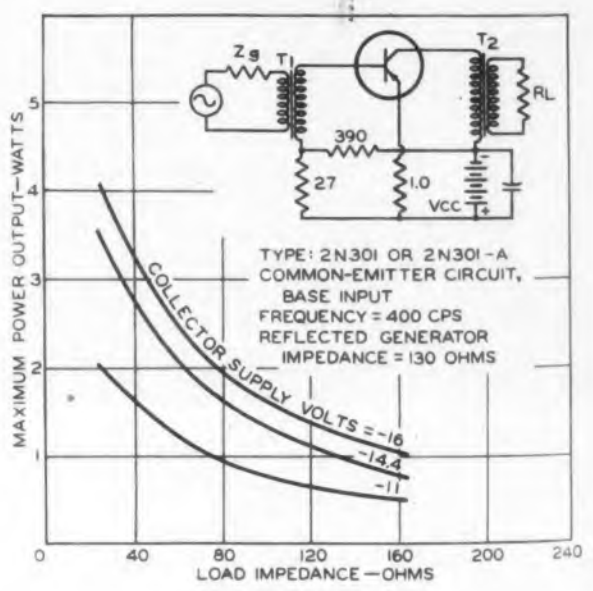


Fig. 2. Class A audio frequency power amplifier. Curves represent maximum power output as a function of collector load impedance.

Fig. 1 shows a set of maximum power-dissipation curves for the 2N301 or 2N301-A power transistor. The horizontal lines represent the maximum power dissipation for various ambient temperatures when the limiting factor is maximum collector-junction temperature rise. The sloping portion of the curves represents the maximum power dissipation before runaway occurs. The maximum power dissipation can be obtained for any value of $S_I V_{ce}$.

Class A Power Amplifiers

Fig. 2 shows a typical class A audio-frequency power amplifier for use in an automobile receiver output stage, together with curves of maximum power output as a function of collector load impedance. For the supply voltages shown, the load impedance must be kept low if large amounts of power output are to be obtained. Consequently, the possibility of impedance matching for maximum power transfer is eliminated; distortion becomes the limiting factor in selecting the output load value. In the case of output stages for automobile receivers, a maximum value of 10 per cent total harmonic distortion is usually acceptable, which the curves shown in Fig. 2 represent.

The power gain of a junction-transistor class A amplifier is a function of input resistance, load impedance, and ac large-signal current transfer ratio, and can be expressed as follows for the common-emitter circuit:

$$\text{Power Gain} = \alpha_{cb}^2 \frac{R_1}{R_{in}} \qquad (3)$$

Where α_{cb} is the ac large-signal current transfer ratio,

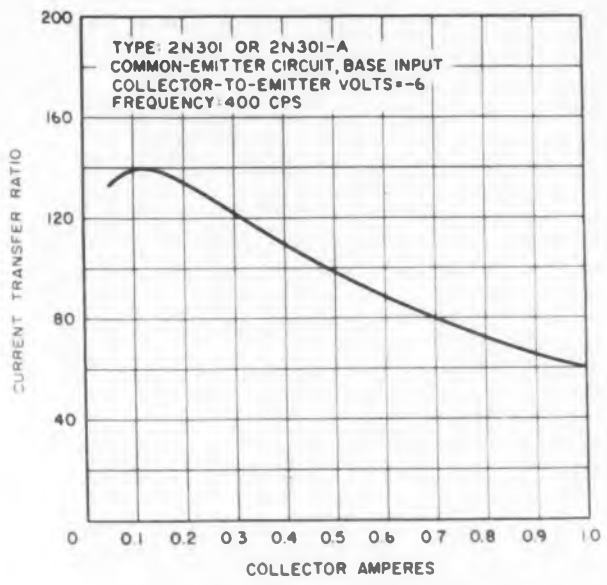


Fig. 3. Reduction of current transfer ratio (α_{cb}) with dc collector current.

R_l is the collector load impedance in ohms, and R_{in} is the ac input resistance of the transistor in ohms, i.e., r_{bb} plus the product of α_{cb} and the external emitter resistance.

At the high values of emitter current, the resistance of the emitter junction is very low and the input resistance of the transistor is approximately equal to the resistance r_{bb}. When an unbypassed external emitter resistor is used, the resultant input resistance of the transistor is approximately equal to r_{bb}' plus the product of the current transfer ratio (α_{cb}) and the emitter resistor. If this resistance is greater than the load impedance, the power gain of the class A stage will again be low unless the transistor has a high α_{cb}. Fig. 3 shows the reduction of α_{cb} with dc collector current.

Efficiency of Class A

The efficiency of a class A transistor power amplifier is defined as the ratio of the power output that can be developed with only moderate distortion to the dc power supplied to the collector circuit. A class A power amplifier has a maximum theoretical efficiency of 50 per cent. In practice, the over-all efficiency depends upon the efficiency of the output transformer and the amount of power lost in the bias network. The collector-circuit efficiency is greatest at full rated power output and decreases as the power output is reduced.

Distortion is principally a function of supply voltage, power output, nonlinearity in transfer characteristics, and source impedance. When the input (base) current is sinusoidal, the nonlinearity in the current transfer characteristic is small at low signal levels. The output current is fairly linear and low in harmonics. As the signal level increases, the input current traverses a greater portion of the nonlinear region of the transfer characteristic and the harmonic content of the output current increases considerably. Fig. 4 shows the total harmonic distortion as a function of power output for different supply voltages. The increase in distortion with increasing power output is due primarily to the nonlinearity in the base-to-collector current transfer characteristic. Clipping is the cause of the rapid change in slope of the distortion curve.

Source Impedance Distortion

The source impedance presented to the input of a class A stage which uses an interstage transformer depends on the type of driving device used and the impedance transfer ratio of the driver transformer[4]. When the transferred driver output impedance is much less than the input resistance of the transistor, the class A stage is considered to be operated from a constant-voltage source. When the reflected driver output impedance is much greater than the input resistance of the transistor, the stage is considered to be operated from a constant-current source. Fig. 5 shows the variation in total harmonic distortion as a function of the ratio of reflected source impedance (Z_g) to the input resistance of the transistor. The total harmonic distortion increases appreciably as the ratio $Z_g R_{in}$ is increased, partly because of the higher degree of nonlinearity in the current transfer characteristic. The lowest feasible value of source impedance should be used in a class A power amplifier to minimize distortion.

In some applications, it may be necessary to use negative feedback to reduce the total harmonic distortion. One method of obtaining degenerative feedback is by the insertion of resistance in the emitter lead. The amount of emitter resistance that can be used is normally limited by the power-gain requirements of the output stage.

Temperature Considerations

The effects of temperature changes on transistor behavior are due primarily to changes in reverse collector current, I_{co}, and the dc input conductance. These parameters are highly sensitive to temperature changes, and may cause a shift in operating point. In a class A circuit having low dc load resistance, the collector voltage is relatively constant, but the collector current will increase with temperature due to variations in I_{co} and dc input conductance. The resulting increase in dissipation may cause operation beyond the maximum power ratings of the transistor. For satisfactory operation over a wide range of temperatures, some form of stabilization must be used.[5, 6, 7]

The transfer characteristic curves shown in Fig. 6 illustrate the effects of temperature upon the

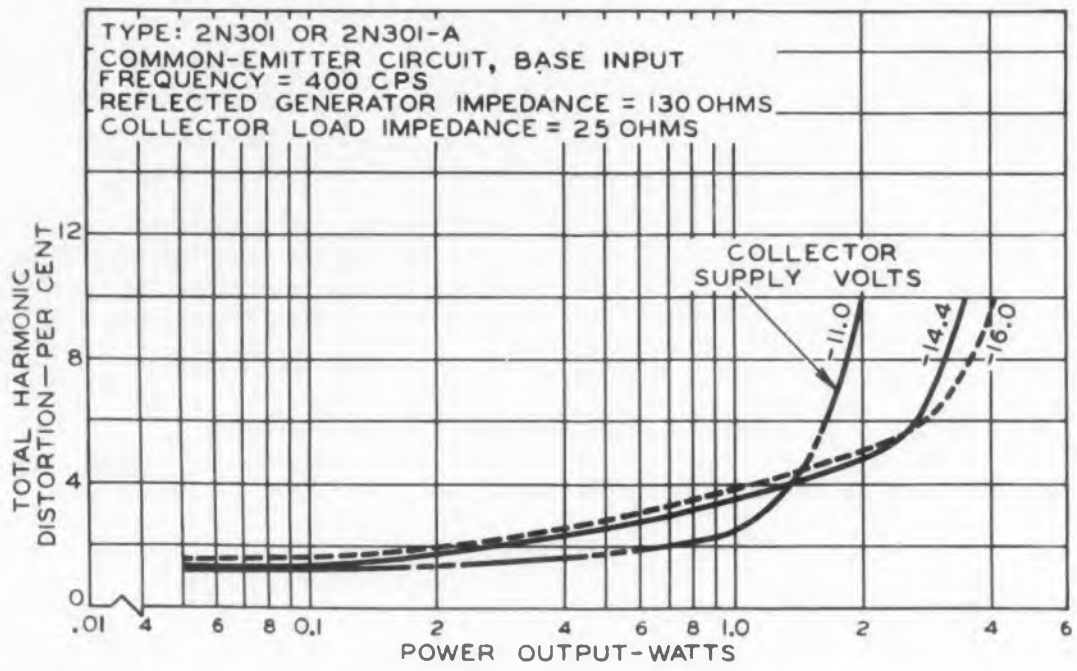


Fig. 4. Total harmonic distortion as a function of power output for different supply voltages.

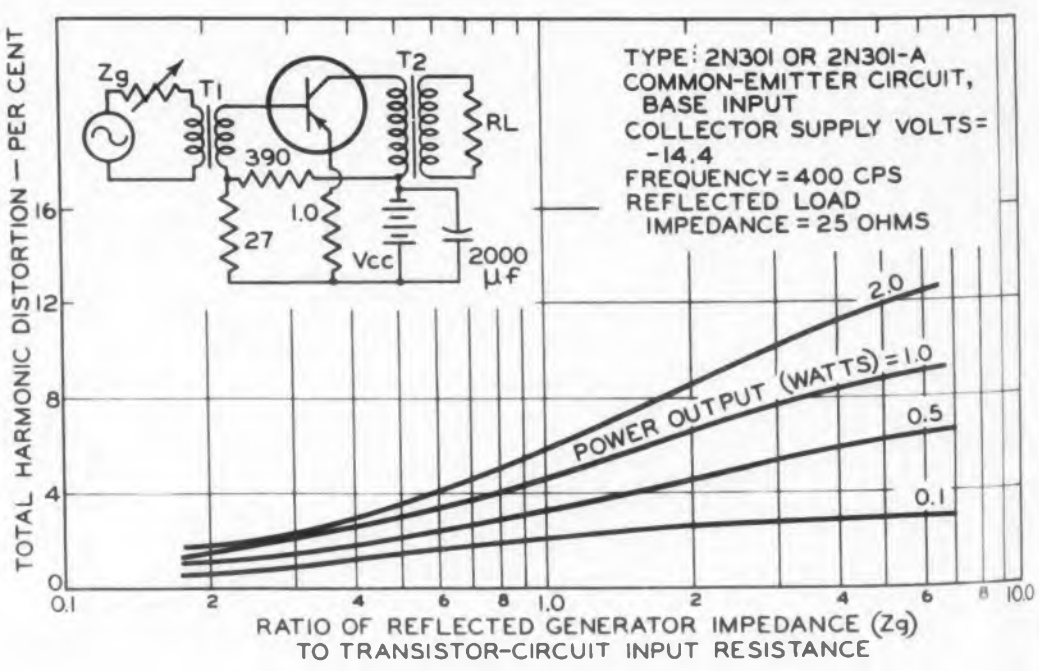


Fig. 5. Variation in total harmonic distortion as a function of the ratio of the reflected source impedance (Z_g) to the transistor-circuit input resistance.

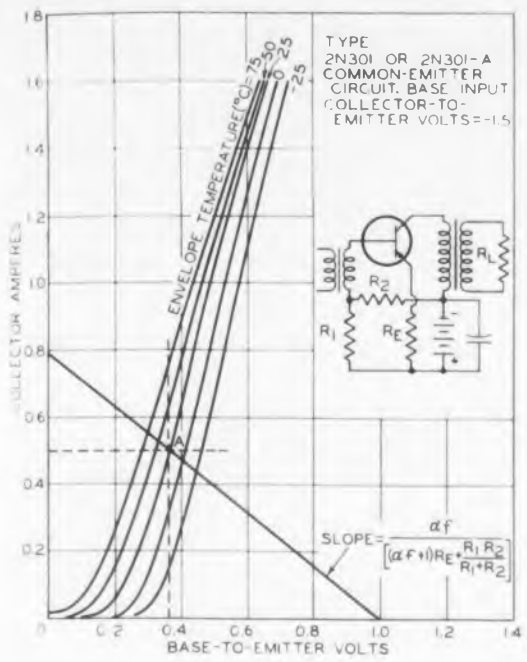


Fig. 6. Effects of temperature in a stabilized common emitter class A circuit.

transistor in a stabilized common-emitter class A circuit. The operating point is designated by point A on the 25 C curve. If this common-emitter circuit were operated with a constant base-to-emitter bias voltage, an increase in temperature would cause an appreciable increase in quiescent collector current and a consequent increase in power dissipation. In the circuit show, however, the bias voltage is determined by the voltage drops across the emitter resistor, R_e and the parallel combination of R_1 and R_2. The voltage drop across the emitter resistor is essentially proportional to the collector current, and tends to stabilize the collector current by applying a reverse bias to the transistor. For a given value of emiter resistance, therefore, the stability of the operating point is largely dependent on the resistance of the parallel combination of R_1 and R_2. Decreasing the resistance of the parallel combination of R_1 and R_2 results in an increase in stabilization.

This is the first of a series of two articles on circuit considerations for audio-output stages using power transistors. The second article will deal with class B push-pull power amplifiers.

References

1. "A 20 Watt Transistor Audio Amplifier" by H. C. Lin, Transistor I, RCA Laboratories, pp 536-537, March 1956.
2. "Private Communications" by C. F. Wheatley, April 1956.
3. "Some Aspects of the Design of Power Transistors" by N. H. Fletcher, Procedings IRE, Vol. 43 pp 558-559, May 1955.
4. "Design Principles for Junction Transistor Audio Power Amplifiers" by D. R. Fewer, IRE Transactions on Audio, Nov-Dec 1955.
5. "Temperature Effects in Circuits Using Junction Transistors" by H. C. Lin, Transistor I, RCA Laboratories, pp 309-402, March 1956.
6. "Power Transistors for Audio Circuits" by L. T. Giacoletto, Electronics Vol 27 pp 144, January 1954.
7. "Bias Stabilization" by R. F. Shea, Principles of Transistor Circuits, John Wiley & Sons, Inc. pp 102-108.

Extension and Adapter Sleeves

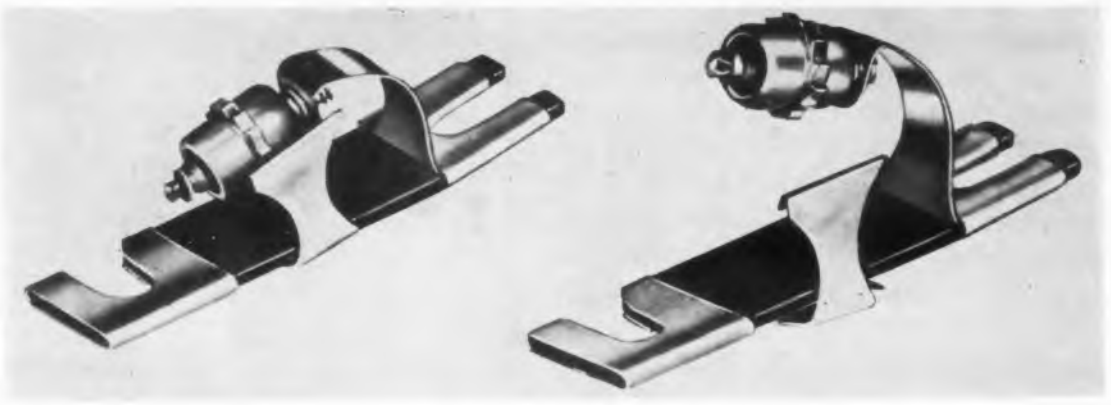
EXTENSION and adapter sleeves, which provide more enclosed space in the backshell area of connectors, and which permit the use of proper AN clamps with any given size cable and connector, increase the reliability of the electrical circuits to which they are attached.

Enclosure of wires in the standard backshell is, in many cases, possible only by crowding the wires, wherein strain and insulation damage may result. The extension sleeve replaces the standard backshell increasing the space for wire terminations at the connectors.

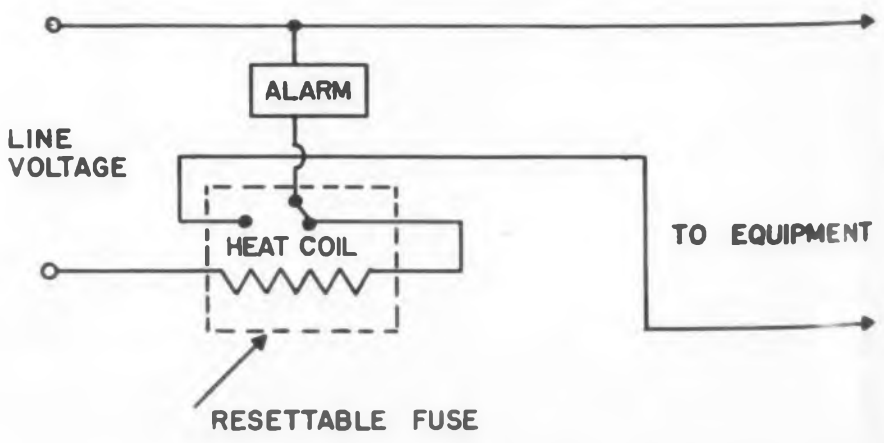
There is only one clamp to fit a given size connector and very often it is too large or too small to fit the cable. The adapter has provisions for stepping up or stepping down the thread size for attaching the clamp. The adapter mates with the connector and permits the use of any of the AN clamps with a given connector.

Developed by Pacific Automation Products, Inc., Glendale 1, Calif., the devices are threaded and fabricated of aluminum with an anodized finish. For more information on these extension sleeves fill out the Reader's Card and circle 44.

Resettable Grasshopper Fuse



Resettable grasshopper fuse. At left contact is made when operating within normal rating of fuse. At right the contact is broken and alarm circuit is closed.



How the circuit is protected. A revolvable ratchet when subjected to more than rated current releases the ground and alarm spring.

Extension and adapter sleeves. Step-up sleeve (top) and step-down sleeve (bottom).

BY COMBINING the familiar grasshopper fuse with a heat coil, a new economical and positive acting fuse, arc free, and with accurate operation time results.

Heat coil operation is simple and positive. When subjected to more than the rated current, the ratchet, which is permitted to revolve, releases the ground and alarm spring. After the trouble has been cleared, and the current flow is normal, the fuse can be reset manually by the ratchet which is again locked into position. In the case of abnormal overload or potential where the nichrome wire coil has been damaged, the heat coil can be unscrewed and easily replaced without disturbing the grasshopper fuse base.

Heat coils are manufactured to a range of ratings, notably a three hour current carrying capacity of from 0.1 amp to a 0.055 amp. The fuse will operate in 210 sec, when there is a current of 0.18 amp in the coil rated at 0.1 amp, and a current of 0.11 amp in the 0.055 amp rated coil. The grasshopper fuse bases are made to accommodate varied mountings and screw sizes. The fuses were developed by Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.

These grasshopper fuses are ideal for actuating alarm circuits or grounding out stray or excessive currents. For additional information about this resettable grasshopper fuse, fill out the enclosed Reader's Service Card and circle 45.

A Voltage Gain Nomogram for Transistor Circuit Design

AS AN aid to rapid design and application of transistor circuitry to electronic systems, these two nomograms can be used to determine gain variations when changes are made in various circuit values.

The Transistor Voltage Gain Nomogram described will enable gain variations to be easily determined. It also permits the rapid design of common-base and common-emitter amplifiers for any desired gain. Any adjustment of either the load impedance (R_L) or the external emitter resistance (R_E) will automatically plot the course that the voltage gain (VG) will take. By the same token, if any two of the values are known, the other may be found.

The nomograms are based upon the approximation formula:

$$VG \cong \frac{\alpha R_L}{R_E + re + rb(1-\alpha)} \qquad (1)$$

Which assumes:

$$R_L \ll rc$$

$$R_E + rc + rb \ll rc$$

The approximation is for all practical purposes correct if $R_L \ll rc$ by two or more orders of magnitude. In general, $rc \cong 1$ megohm for junction transistors.

$$rc = \frac{V_{CB}}{I_{ce}} \qquad (2)$$

As R_L increases and approaches rc, the inaccuracy of equation (1) and of the nomograms increases. Generally, however, R_L remains lower than $(0.01)rc$. An error of 1 per cent may be expected if $R_L = (.001)rc$; and approximately 10 per cent as R_L approaches $(.01)rc$.

Rudolph Wellsand
Convair
Guided Missile Division
Pomona, Calif.

For strict applications, and particularly where tight tolerances, great accuracy, and higher load impedances than $R_L = (0.01)rc$ are to be used, the exact expressions for VG should be used.

Nomogram Operation

Nomogram II functions with a denominator resistance R_D, where:

$$R_D = R_E + re + rb(1-\alpha) \tag{3}$$

Parameters *re* and *rb* may be found in the specifications for a particular transistor. As an aid, Nomogram I lists the transistor's alpha with its $(1-\alpha)$. A straightedge from $(1-\alpha)$ to the *rb* scale will quickly determine the $rb(1-\alpha)$ read from the center scale.

Adding $re + rb(1-\alpha)$ mentally, one gets the value of R_D.

$$R_D = re + rb(1-\alpha) \tag{4}$$

However, if in grounded-emitter orientation an external emitter resistor, R_E, is further added, then the combined total becomes R_D, as in equation (3).

When $re + rb(1-\alpha) \ll R_E$, in example by approximately two orders of magnitude, then:

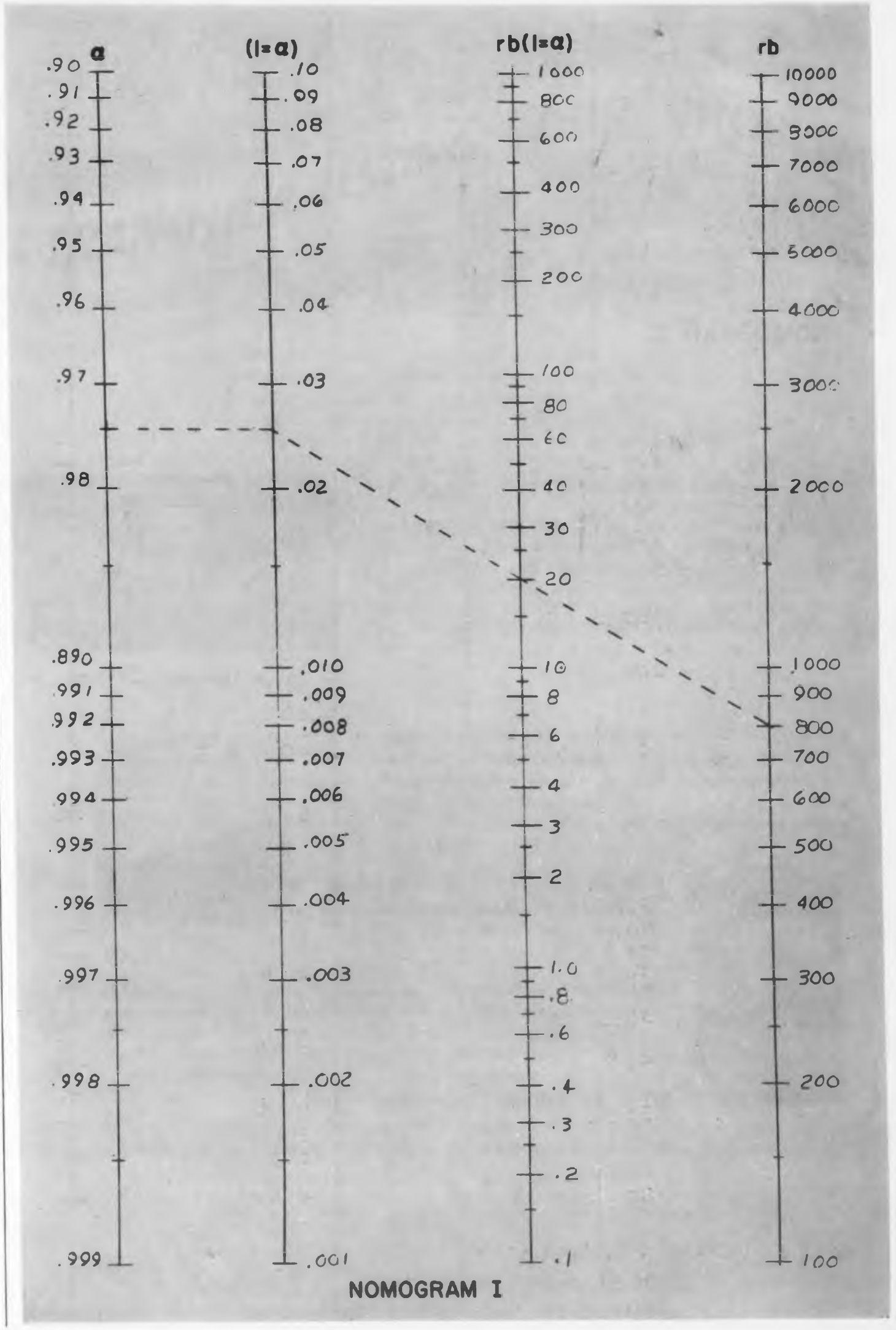
$$R_D \cong R_E \tag{5}$$

$$VG \cong \alpha \frac{R_L}{R_D} \tag{6}$$

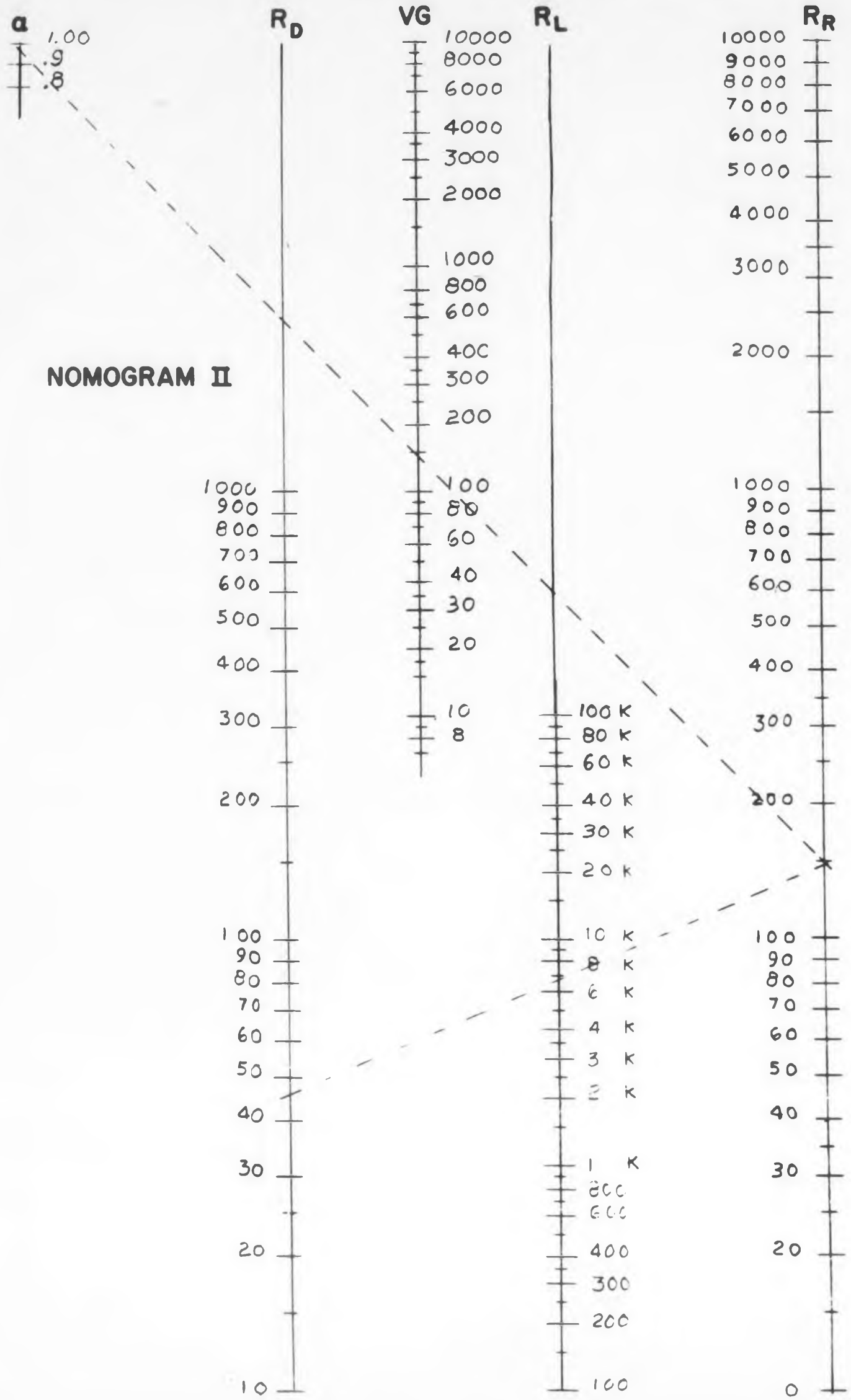
Where the resistance ratio $R_R = \dfrac{R_L}{R_D}$ (7)

Then: $$VG \cong \alpha R_R \tag{8}$$

Set a straightedge on Nomogram II, from the value of denominator resistance on the R_D scale to the value of load impedance on the R_L scale, and note the value of the resistance ratio on the R_R scale. Now set the straightedge from the R_R value to the known alpha on the α scale and read the voltage gain direct on the *VG* scale.



NOMOGRAM I



NOMOGRAM II

The reverse procedure may also be used, by setting the straightedge from α to the desired value of VG and noting the R_R obtained. If R_L is known, then R_D may be found. Knowing the value of the parameters, *re* and *rb*, from the specifications previously employed, these parameters may be subtracted from R_D, the result being the value of the external emitter resistance, R_E, which should be placed in the emitter leg.

Sample Problem

(Using a 2N35-n-p-n in grounded-emitter)

1. List the values of *re*, *rb*, *rc* and α from the specifications: $re = 26$ ohms
$rb = 800$ ohms
$rc = 2$ megohms
$\alpha = 0.975$

2. Find the value of $rb(1-\alpha)$ from Nomogram I.
$rb(1-\alpha) = 20$ ohms

3. Substitute the value of *re* and $rb(1-\alpha)$ into Equation (4): $R_D = re + rb(1-\alpha)$ (4)
$= 26 + 20$
$= 46$

4. Note the value of R_E to be used, and compare with Equation (4):
$R_E >> re + rb(1-\alpha)$ by approximately 100 times.

5. If the comparison above is true, then substitute R_E into equation (5):

$$R_D \cong R_E \quad (5)$$

If not true, then substitute R_E into equation (3):

$$R_D = R_E + re + rb(1-\alpha) \quad (3)$$

If no R_E is used, then continue using equation (4):

$$R_D = re + rb(1-\alpha) \quad (4)$$

6. Assuming that an external emitter is used, resistance of $R_E = 500$ ohms, then the comparison of $R_E >> re + rb(1-\alpha)$ would be true:
$R_E >> 46$ by approximately 100 times.
Substituting into equation (5):

$$R_D \cong R_E$$

$$R_D \cong 500 \text{ ohms}$$

7. Note the value of R_L to be used and substitute into Equation (7): (Let R_L be 6000 ohms)

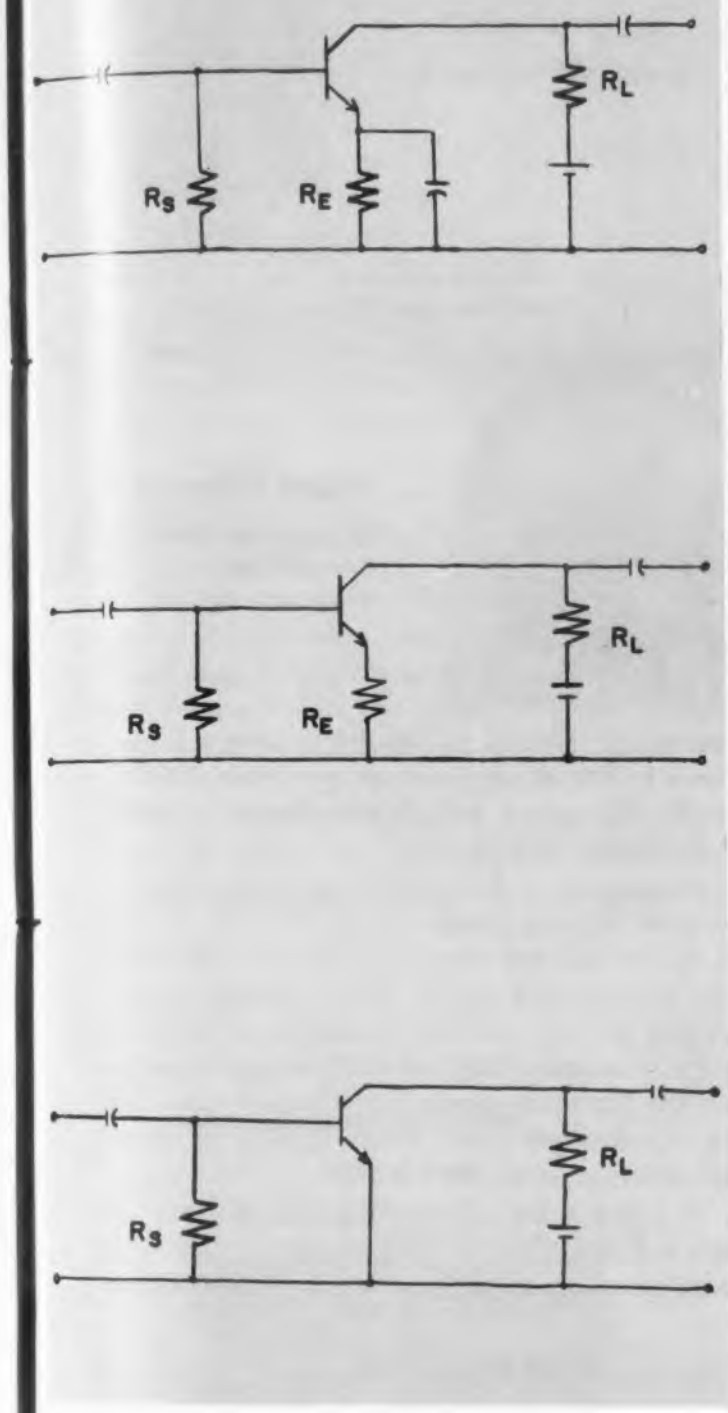
$$R_R = \frac{R_L}{R_D} \quad (7)$$

8. Since $R_L << rc$ (6500 << 2 megohms), less than 10 per cent error may be expected by use of the Nomogram.

9. Find the value of R_R from Nomogram II and substitute into equation (8):

$$VG \cong \alpha R_R \quad (8)$$
$$VG \cong \alpha(13)$$

General circuits to which the nomograms are applicable.



10. Lastly, knowing the value of alpha and R_R, find VG on Nomogram II.

$$VG \cong 12.7$$

Had no emitter resistance been used, R_R would have been 140 and VG equal to 136.

For a reprint of this article, turn to Reader Service Card and circle **499.**

References

F. R. Stansel: Transistor Equations: ELECTRONIC DESIGN: March 1953: page 156.

Nomogram for Some Transistor Parameters, H. Lefkowitz, ELECTRONIC DESIGN, 15 Oct. 1956, p. 62.

Principles of Transistor Circuits, R. F. Shea, John Wiley and Sons, Inc., 1953.

New Products

Transistor Transformers

Seven Types

Seven additional types of ultra-miniature DO-T transistor transformers are available. These units weigh one-tenth ounce and are fully hermetically sealed. Included in this group are a number of 500 mw units designed for pushpull transistor to 600 ohm line, a chopper input transformer, transistor interstage transformer, and a line to line matching transformer.

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

CIRCLE 49 ON READER-SERVICE CARD FOR MORE INFORMATION

Spectrum Analyzer

10 Cps Resolution

Designed for applications requiring extremely high resolution, such as investigation of side bands caused by low modulating frequencies, single sideband transmissions, teletype, etc. The SB-12 Panalyzor can be used to observe signals anywhere in the spectrum up to 1000 mc by means of an external signal generator and an internal aperiodic mixer which translate the spectrum segment to be analyzed down to the 450 to 550 kc input band of the Panalyzor. Offering the advantages of wide scan spectrum presentation, the SB-12 at the same time permits examination of signals so closely adjacent in frequency that their corresponding deflections normally tend to merge together or completely mask one another in wide scan displays. Maximum sweepwidth is 100 kc continuously reducible to 0 kc. Scan rate is adjustable in steps of 30, 5, 1 and 0.1 cps. Resolution ranges from 3.2 kc to 10 cps. Afc is provided for narrow sweepwidths.

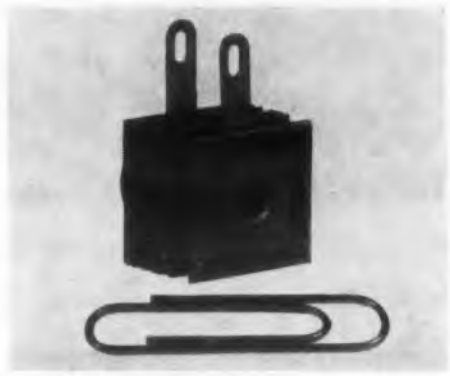
The unit can be used to investigate pulsed rf signals, analyze am and fm transmitters, spot spurious oscillations and modulation, monitor communications bands, test industrial rf equipment, diathermy and electrosurgical instruments, and is applicable to other laboratory and production test problems.

Panoramic Radio Products Inc., Dept. ED, 10 S. 2nd St., Mount Vernon, N.Y.

CIRCLE 50 ON READER-SERVICE CARD FOR MORE INFORMATION

Selenium Rectifier

65 Mil



Designated Type 1263-A for standard mounting, and 1262-B for bracket mounting, this 65 mil selenium rectifier is for use in small electronic equipment. The rectifier has the following characteristics for single phase capacitive loads: Max rms input v of 130 v; max peak inverse v of 380 v; max peak current of 650 ma; max rms current of 175 ma; max dc current of 65 ma; approx rectifier voltage drop of 7 v; min series resistance of 22 ohms, and the max plate operating temp is 85 C.

Federal Telephone and Radio Co., Dept. ED, 100 Kingsland Rd., Clifton, N.J.

CIRCLE 51 ON READER-SERVICE CARD FOR MORE INFORMATION

Rotary Solenoid

Withstands 500 F Ambient

This rotary solenoid is claimed to have a life expectancy of 300,000 snap-action operations at 500 F. It is able to operate with high wattage inputs to produce higher torques. Eight basic sizes are available, ranging from 1 to 3-3/8 in. diam. Starting torques for 45 deg. stroke range from 0.2 to 54.0 lb-in. Special magnet wire and coil insulation, lubrication, bearing and return spring materials were developed for the product. Operation is identical with the standard rotary solenoid. Magnetic action moves the armature along the solenoid axis. This action is converted into a rotary motion by means of ball bearings on inclined races.

G. H. Leland, Inc., Dept. ED, 123 Webster St., Dayton 2, Ohio.

CIRCLE 52 ON READER-SERVICE CARD FOR MORE INFORMATION

5 Mc Crystal

High Stability

Type BG61A-5 is a glass mounted, optically polished, gold plated quartz crystal operating on the 3rd overtone mode at 5 mc. The temperature coefficient of the unit is less than 0.1 ppm over a 1 C range at the preferred operating temperature (75 C or 85 C). When used with temperature control adequate to maintain ±.01 C, the resultant crystal stability is 1 part per billion at 5 mc.

Bliley Electric Co., Dept. ED, Union Station Bldg., Erie, Pa.

CIRCLE 53 ON READER-SERVICE CARD FOR MORE INFORMATION

Dish Antenna

Simplified Mounting

A one-piece, four-foot dish antenna designed for tubular mast mounting is secured to 4 in. IPS tubular masting by two heavy-duty clamps. The clamps are designed to produce an even, tight connection assuring positive orientation under extreme wind loads.

This model is constructed on a ring principle. The basic ring is a circular heavy-weight aluminum disc supporting cantilever aluminum arms, which extend to the perimeter. The parabolic surface is covered with expanded aluminum mesh, inert arc-welded to the supporting arms. The antenna is designed to operate in the range of 1000 through 4000 mc. Standard drivers are of the dipole and horn type.

Technical Appliance Corp., Dept. ED, Sherburne, N.Y.

CIRCLE 55 ON READER-SERVICE CARD FOR MORE INFORMATION

Insulation Tester

High Speed

This instrument will detect, totalize, and record insulation faults in material travelling at 400 ft. per min. with 1-in. long electrode. It will detect pinhole invisible to the naked eye at this speed.

The tester will detect and register every fault, since it does not have the inherent limitations of 60 cps testers and fault relays which do not register faults if they occur too close together in time.

Testing is non-destructive. It will not burn insulation, nor mark it in any way. The output is non-lethal. At 10 kv dc the maximum short circut current is 4 ma.

Peschel Electronics, Inc., Dept., ED, 13 Garden St., New Rochelle, N.Y.

CIRCLE 56 ON READER-SERVICE CARD FOR MORE INFORMATION

surface barrier transistors from SPRAGUE

2N344/SB101
for Medium Gain Amplifiers

	Min.	Typ.	Max.
h_{fe}	11	23	83
f_{max}	30	45	—

2N345/SB102
for High Gain Amplifiers

	Min.	Typ.	Max.
h_{fe}	25	40	110
f_{max}	30	45	—

actual size

2N346/SB103
for High Frequency Oscillators

	Min.	Typ.	Max.
h_{fe}	10	—	—
f_{max}	60	90	—

2N240/SB5122
for Computer Switching

	Min.	Max.
h_{fe}	16	—
f_{max}	30	—
T_s	—	80

IN VOLUME PRODUCTION *Now!*

For general high frequency applications, and for high speed computer switching circuits, design around Sprague surface barrier transistors. They are available now in production quantities from a completely new, scrupulously clean plant, built from the ground up especially to make high quality semi-conductor products.

The four transistor types shown are the most popular. Orders for these units are shipped promptly. What's more, surface barrier transistors are reasonably priced. High quality and excellent electrical characteristics make them an economical solution to many difficult circuit requirements.

Sprague surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type number are manufactured to the same specifications and are fully interchangeable. You have *two* sources of supply when you use surface barrier transistors!

WRITE FOR COMPLETE ENGINEERING DATA SHEETS ON THE TYPES IN WHICH YOU ARE INTERESTED. ADDRESS REQUEST TO THE TECHNICAL LITERATURE SECTION, SPRAGUE ELECTRIC CO., 347 MARSHALL ST., NORTH ADAMS, MASS.

TRANSISTORS • RESISTORS • MAGNETIC COMPONENTS
CAPACITORS • INTERFERENCE FILTERS • PULSE NETWORKS
HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

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the trademark of reliability

CIRCLE 57 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

1500 F Insulating Fabrics

Also Used for Leak Detections

Two types of high temperature insulating fabrics for service up to 1500 F have been announced. Made of fiberfrax ceramic fiber, these fabrics are available in various widths or thickness for positive high temperature insulation. In addition, they are also supplied as instrumentation tapes for both insulation and leak detection. The high temperature tapes consist of two stranded Chromel wires covered with reinforced ceramic fiber. When wrapped around pipes carrying metallic or radioactive fluids, the tape both insulates and quickly causes an alarm-sounding short circuit in the event of a leak. This tape is designed to withstand 1500 F for 1500 hr, and is flexible enough to be wrapped in spiral form around pipe of 1/2 in. diam. The fabrics can be treated with silicone rubbers, epoxy resins or can be impregnated with phenolic resin and molded into various shapes. If desired, they can be woven in tubular form.

The Russell Mfg. Co., Dept. ED, 255 E. Main St., Middletown, Conn.

CIRCLE 58 ON READER-SERVICE CARD

Arc Resistance Tester

Quality Control for Plastics

An arc resistance tester has been designed to evaluate the arc and track resistance of plastic materials. The Model 126 is employed in measuring the resistance of insulating materials to high voltage-low current arcs. The instrument has a built-in timer to indicate arc resistance time and a specimen holder which automatically levels and sets the correct electrode pressure. The electrode enclosure permits visibility and prevents drafts from disturbing the arc during the test.

Delsen Corp., Dept. ED, 719 W. Broadway, Glendale 4, Calif.

CIRCLE 59 ON READER-SERVICE CARD

◀ CIRCLE 60 ON READER-SERVICE CARD

Stock Drawing Forms

Meet Military Specifications

A range of stock drawing forms are available for immediate delivery in small or large quantities. Drawing forms in stock are: A size—8-1/2 x 11 in., B size—11 x 17 in., C size—17 x 22 in., and D size—22 x 34 in.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., East Rockaway, N.Y.

CIRCLE 62 ON READER-SERVICE CARD

Stagnation Temperature Probe

For Flight Applications

The WCRC temperature probe provides stable measurement of stagnation air temperature. The probe has a high degree of internal, thermal equilibrium in dynamic measurement of total temperature. Heat transfer between probe and mounting is stabilized for wide temperature differentials. The aerodynamic design provides for steady-state readings from subsonic to supersonic speeds. Recovery factor is relatively insensitive to speed. Sensing is accomplished by a resistance element, a thermocouple, or a thermistor, depending on specified input impedance.

West Coast Research Corp., Dept. ED, 2371-1/2 Westwood Blvd., Los Angeles, Calif.

CIRCLE 63 ON READER-SERVICE CARD

Thyratron

Average Rating of 1 Amp.

The Xenon-filled XR-764, 3-1/2 in. high, has an octal base and top cap and a 10 v drop in use. Filament voltage and current is 5 v and 3 amp respectively, with a heating time of 120 sec. Peak forward and inverse voltages are 500 v dc, start (plus 3 v grid) is 25 v, with 25 v emission at 30 amps. De-ionization time is 200 μsec or less. The tube is claimed to be unusually rugged.

Continental Electric Co., Dept. ED, 6 N. Michigan Ave., Chicago 2, Ill.

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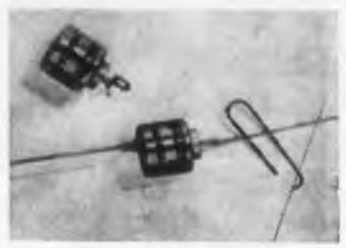
New Products



Miniature Tantalum Capacitors

175°C

Miniature tantalum electrolytic capacitors are available for operation over a temperature range from —55 to 175 C. Known as the X T M line, they are being manufactured in six capacities, from 4 to 40 mfd, at nominal working ratings from 40 to 360 v. The body diameter of the metal case (all capacitors) is 5/8 in. with case lengths from 9/16 to 1-25/32 in. All capacities employ a metal-to-glass hermetic seal and offer a choice of 2-1/4 in. axial leads or solder-tab terminals.

P. R. Mallory & Co. Inc., Dept. ED, Indianapolis, Ind.

CIRCLE 67 ON READER-SERVICE CARD FOR MORE INFORMATION

Frequency-Period Counter

0 cps-1 mc

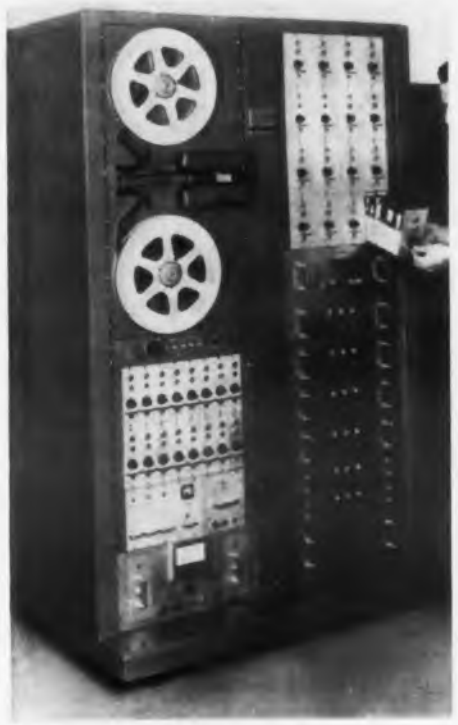
This frequency-period counter, model 203A, offers 0 cps to 1 mc direct reading operation for frequency and period (1 freq.) measurement. The counter also serves to measure pressure, temperature, velocity, acceleration, flow, rps, rpm, and displacement with the use of suitable transducers. The instrument may also be used as a secondary frequency standard. It features a continuously adjustable trigger level control which permits full rated sensitivity at any voltage level between —300 and +300 v. Small voltage increments ordinarily masked by attenuators are easily selected. Simplified color-coded controls and direct read-out in kc, mc, sec, or μsec, with automatic decimal point indication are incorporated. Oscilloscope marker signal facilities trigger level adjustment for amplitude discrimination in frequency or period measurement. The counter has a time base range of 10 μsec to 10 sec in decade steps (frequency), 1 and 10 cycles (period).

Computer-Measurements Corp., Dept. ED, 5528 Vineland Ave., No. Hollywood, Calif.

CIRCLE 68 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Tape Recorder

300 KC Bandwidth



Series 3000 Multi-Channel Magnetic Tape Recording System features a 300 kc Band Width. The system accommodates reel sizes up to 14 in. as standard equipment and has a single switch on the front panel which selects any of the six standard speeds up to 60 in. per sec. Module housings provide plug-in facilities for amplifiers, permitting instant selection of direct fm or PDM recording or playback in any combination.

American Electronics, Inc., Dept. ED, 655 W. Washington Blvd., Los Angeles 15, Calif.

CIRCLE 69 ON READER-SERVICE CARD FOR MORE INFORMATION

Ultrasonic Cleaning

50-250 W output

A series of ultrasonic cleaning units ranging in capacity from two quarts upward is available.

Power output ranges from 50 to 250 w. Designed for continuous commercial use, the generator supplies the rated output of electrical energy to a barium titanate transducer. Generators are designed to permit use of two cleaning transducers alternately. One tank may be used for removal of excessive amounts of contamination, and the other tank for final cleaning.

Alcar Instruments Inc., Dept. ED, 17 Industrial Ave., Little Ferry, N.J.

CIRCLE 70 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Flying Spot Scanner

For Test Equipment

A 5 in. flying spot scanner tube for use in television receiver test equipment has been developed. Designated type 5BNP16, the tube employs low voltage electrostatic focus, an aluminized screen of very short persistence, and operates without ion trap for simplified installation. Compared to other tube types designed for studio flying spot scanning pickup equipment, the 5BNP16 is less expensive, approximately 4 in. shorter in over-all length, and operates at lower anode voltages.

Sylvania Electric Products, Inc., Dept. ED, 1740 Broadway, New York 19, N.Y.

CIRCLE 106 ON READER-SERVICE CARD

Cap Nuts

Made of Nylon

A line of cap nuts fabricated from black Nylon comes either knurled or slotted, and may be used with rods or screws or serve as knobs. Nylon fabrication makes the nuts particularly useful where dielectric strength and resistance to corrosion are important. A range of sizes with American Standard threads includes 6-32, 8-32, 10-32 and 1/4-20.

Weckesser Co., Dept. ED, 5701 Northwest Highway, Chicago 30, Ill.

CIRCLE 107 ON READER-SERVICE CARD

Wide-Field Magnifier

For Parts Inspection

A magnifier has been developed that allows the small parts inspector to use both eyes and thus maintain a high degree of efficiency. The wide-field magnifier consists of a large oil-filled, plastic-cased lens. The lens is very clear and free of distortion from edge to edge. It will not discolor or become cloudy with age. The magnifier permits an inspector to sit comfortably while the item to be inspected is passed beneath the lens.

Curry & Paxton, Inc., Dept. ED, 866 Willis Ave., Albertston, Long Island, N.Y.

CIRCLE 108 ON READER-SERVICE CARD

◀ CIRCLE 109 ON READER-SERVICE CARD

Precision Fine Wire

0.004 In. Diam.

Through new methods developed using a centerless grinder, wire can be ground as fine as 0.004 in. diam eliminating the problem of lateral die marks which are present in most drawn wire. This is extremely important for electronic tube elements, instrument movements, and similar applications.

The TB-12 centerless grinder used for the process will production grind tungsten carbide, titanium, glass, wood, hard rubber, ceramics, cork, and other materials.

Royal Master Inc., Dept. ED, State Highway No. 23, Riverdale, N.J.

CIRCLE 110 ON READER-SERVICE CARD

Brazing Alloys

High Purity

Vacuum-tube grade silver and gold brazing alloys have been designed specifically for brazing electronic components in which the concentrates of metallic impurities must be kept to an absolute minimum. The alloys are carbon-free and meet all applicable industry specifications on maximum content of cadmium, zinc and other volatile elements not allowable for vacuum-tube work. They are supplied in wire, strip and sheet form in all the usual gages.

Handy & Harman, Dept. ED, 82 Fulton St., New York 38, N.Y.

CIRCLE 111 ON READER-SERVICE CARD

Reinforced Plastic Sheet

Flexible

A flexible grade of reinforced plastic sheet, 1/32 in. thick, with characteristics which make it suitable for such application as transformer layer insulation, is in production. Known as Grade EEF, this insulating material is expected to have use in other components besides transformers. Bulletin No. 101 containing product characteristics is available.

Reinforced Plastics Div., Dept. ED, Hays Mfg. Co., Erie, Pa.

CIRCLE 112 ON READER-SERVICE CARD

CIRCLE 113 ON READER-SERVICE CARD ➤

New Products

Remote Size and Position Indicator

Accuracy of 1 Per Cent

Remote indication of position, size, tension, strain, thickness, and other quantities which can be related to minute displacement of a feeler probe, is accomplished with the Model 100 displacement transmitter used with the Model 300 displacement indicator. The system offers accuracy of 1 per cent of scale with three calibrated ranges of ±0.1, 0.01, and 0.001 in. full scale. Drift errors are virtually eliminated by a constant current excitation system, stabilized amplifier circuitry, and integral zero and gain checking features.

An auxiliary electrical output is available which is suitable for direct operation of standard strip chart recorders. A wheel attachment is available for continuous thickness measurements of moving material. Operating temperature range is —65 to +200 F.

Daytronic Corp., Dept. ED, 216 S. Main St., Dayton 2, Ohio.

CIRCLE 79 ON READER-SERVICE CARD FOR MORE INFORMATION

Voltage Regulator

400 Cycle, Single Phase

This automatic voltage regulator for 400 cycle, single phase service gives instantaneous correction of line voltage variations with 0.25 v bandwidth for line voltage variations and 0.35 v bandwidth for load current and load power factor changes. The unit is designed for an input of 95-130 v for nominal output voltage of 115 v, adjustable from 110-120 v and a load of 1.0 kva. It has a waveform distortion of 3.5 per cent max at 400 cycles. The power factor rating is from 0.7 lagging to 1.0. The size of the regulators is 7-3/4 x 5 x 14-3/8 in. including front panel handles.

The Superior Electric Co., Dept. ED, 83 Laurel St., Bristol, Conn.

CIRCLE 80 ON READER-SERVICE CARD FOR MORE INFORMATION

Step Input Unit

Plots Bar Graphs

Data plotting at any number of pre-set increments up to 999 steps along one axis is possible with the model 51 Step Input Unit. The unit provides means for producing bar-type graphs to any scale on standard or non-standard graph paper and visually displays by means of illuminated numbers the content of the mechanism at any point in a test series thus facilitating start and stop operations without losing track of position at any time. Calibration to any scale factor is possible by adjusting both size and number of steps to conform to the data being plotted. Zero may be set at any point.

F. L. Moseley Co, Dept. ED, 409 N. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 81 ON READER-SERVICE CARD FOR MORE INFORMATION

Coaxial Turret Attenuators

30 db

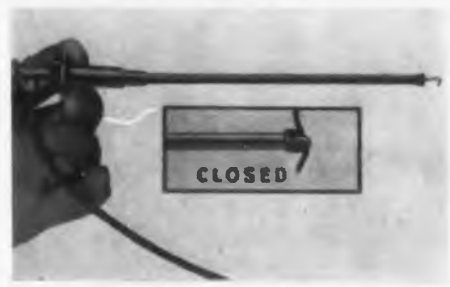
Three new coaxial turret attenuators, Models 705, 706, and 707 offer twelve steps of attenuation in the uhf range from dc to 1500 mc. A single unit can give a maximum of 30 db. Two units can also be used in series to permit a wide range of control in small steps. Designed for either bench use without further mounting, or for mounting into a test equipment package, the turret attenuators are housed in a cast case which is provided with tapped mounting holes. All models use type BNC connectors and have twelve snap-in attenuator pads in a convenient turret arrangement. The units have a zero insertion loss position for use in applications where it is necessary to obtain the full output of the signal source into the load. This zero insertion loss position also provides a convenient point for calibration without physically removing the attenuator. A spring-loaded detent assures alignment of the pad selected. An engraved dial indicates the attenuation values.

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

CIRCLE 82 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Test Probe
Grips Wires



The Griprobe is a test probe of durable plastic for gripping terminals, tube sockets, lugs, and wires thus freeing the hands of the operator to handle other tools or test equipment. It features an interior spring mechanism which by pressing the thumb, opens the hook-shaped metal probe and, by removing the thumb, closes it in a self-lock grip.

Standard Electronics, Inc., Dept. ED, 5523 Satsuma Ave., Burbank, Calif.

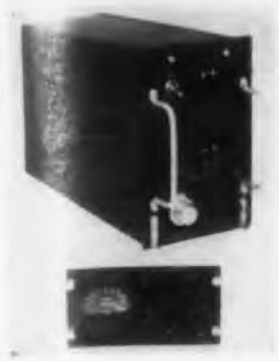
CIRCLE 85 ON READER-SERVICE CARD FOR MORE INFORMATION

Brushless Converter
1 KVA - 10 KVA

Nobrush, a 40-pole, brushless, 400 cycle converter operates from standard 60 cycle supply. The unit employs a generator, direct coupled to 1200 rpm, 60-cycle synchronous motor. The generator is direct mounted on motor, making the unit two-bearing. With input variation up to 15 per cent, output for steady load, without regulator, will remain within 1 per cent. Any standard voltage, single or three phase, can be supplied. Three phase machines can be loaded asymmetrically, without impairment of performance. For unity power factor, voltage will depart no more than 2-1/2 per cent from slated value for any load within rating of machine. With correction of power factor to high leading value, voltage will hold within better than plus or minus 1 per cent. For other load conditions, or for closer regulation, regulator can be supplied, holding voltage within 1/2 per cent for all conditions of load. Units from 1 KVA to 10 KVA are available.

Georator Corp., Dept. ED, Manassas, Va.

CIRCLE 86 ON READER-SERVICE CARD FOR MORE INFORMATION



Aircraft Safety Device

Monitors Critical Temperatures

Model CTI-10D is powered and operated entirely by magnetic amplifier circuitry, monitoring up to 10 channels of temperature, simultaneously. Balance and sensitivity adjustment enable each channel to be set for any desired critical temperature range and trip point. This point may be set accurately to within 1 per cent of the operating range established. Units comprising a complete temperature-monitoring system are: indicator panel, for mounting in a convenient location clearly visible to pilot or flight engineer; balance and power unit; temperature probes; and interconnecting cabling. Power requirements are 105-125 v, 380-420 cps, 25 w. System accuracy is ±1 per cent under specified environmental conditions. The warning panel measures 5-3/4 x 3 x 3 in.; the balance and power unit, 5-1/8 x 9-1/4 x 19 in.; the total system weighs 15 lbs. The device meets MIL-E-5272 for temperature, acceleration, vibration, altitude and humidity.

Armoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

CIRCLE 87 ON READER-SERVICE CARD FOR MORE INFORMATION

Thyratron

Xenon Filled

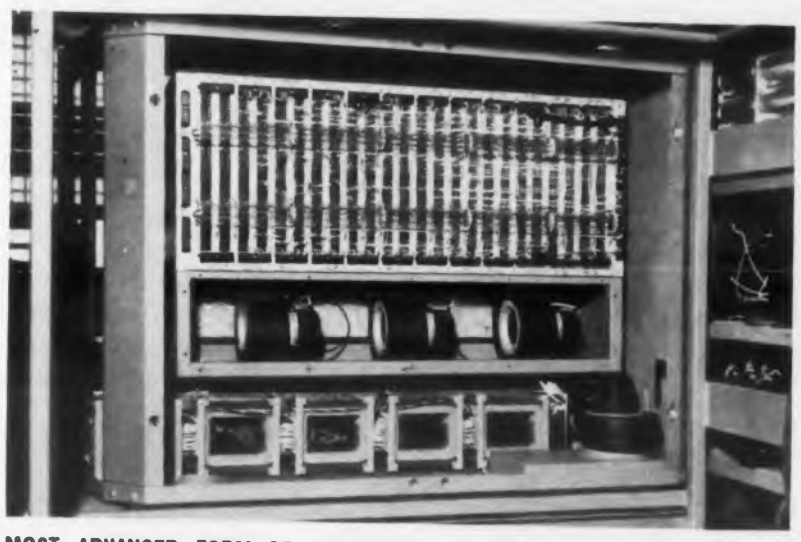
A Xenon filled, 18 amp dc thyratron provides quick starting and wide temperature limits. It is especially designed for motor speed control, resistance welder control, and incandenscent light control. Designated as the NL-5665/C16J, its ratings are: filament volts, 2.5; filament current, 31 amp; maximum peak inverse volts, 1250; maximum peak forward volts, 1000; average anode current, 18 amp; peak anode amp, 100 amp; anode current averaging time 4.5 sec; and filament heating time, 60 sec.

National Electronics Inc., Dept. ED, Geneva, Ill.

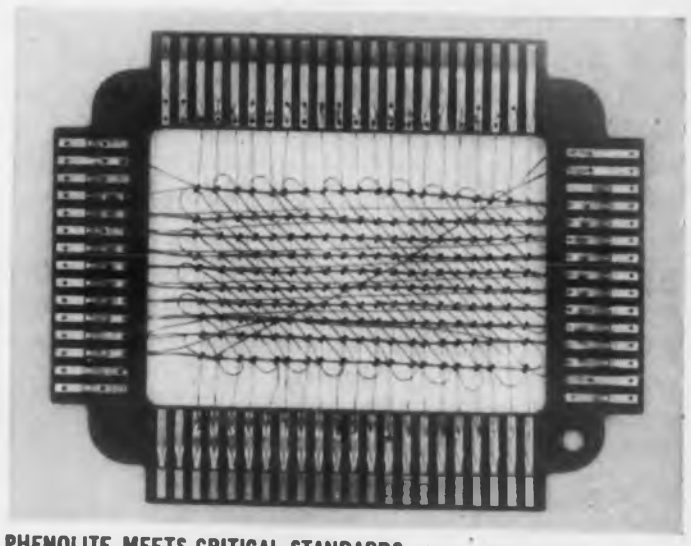
CIRCLE 88 ON READER-SERVICE CARD FOR MORE INFORMATION

THE NATIONAL SCENE

KEEPING "ELECTRONIC BRAINS" FROM LOSS OF MEMORY. One of science's greater marvels is IBM's 705 Electronic Data Processing Machine—which makes intricate calculations and logical decisions in millionths of a second. Heart of this electronic "wizard" is its main magnetic core memory. Designed for use with the machine's high-speed printer is the IBM 760 Control and Storage Unit containing its own core memory of 1,000 positions which allows central processing to continue in the 705 while other data are being printed. Helping the 760 remember what information is to be printed is a job for PHENOLITE* Laminated Plastic. PHENOLITE's unique combination of properties makes it ideal for this application.



MOST ADVANCED FORM OF ELECTRONIC STORAGE. The 1,000-position core memory for the IBM 760 Control and Storage Unit—a portion of which is shown here—consists of pinhead size cores strung on copper-wired frames of PHENOLITE. Electrical impulses, passing through wires, alter the magnetic state of cores so that a group of them stands for a word or figure. Reversing the process recalls information from storage. PHENOLITE frames safeguard the circuit and permit stacking of core planes as shown.



PHENOLITE MEETS CRITICAL STANDARDS. Core frames like the one shown are punched out of laminated PHENOLITE by IBM. Each frame has printed circuit type terminal strips and soldered connections. PHENOLITE proves an ideal material for this application because it is mechanically strong and stiff, punches cleanly, etches well, remains flat, has high dielectric properties and withstands the heat of dip soldering.

New Products

Hexagon Nut Drivers

Miniature Sizes

Starting where normal size nut drives leave off and going down to the no. 00 hexagon nut, this set of nut drivers is available in sizes, measuring across the flats, of 5/64, 3/32, 7/32, 1/8, 5/32 and 3/16 in. Approximate overall length of the nut driver is 2-1/2 in. Drivers are available in sets containing their individual permanent plastic handles, and also in replaceable sets with a swivel type jewelers handle.

Hunter Tool, Dept. ED, Box 564, Whittier, Calif.

CIRCLE 90 ON READER-SERVICE CARD FOR MORE INFORMATION

Signal Generator

900-2100 Mc

The SHF Signal Generator (Model SG-161) operates over a frequency band from 900 to 2100 mc, with an accuracy of better than 1 per cent, providing signals for a variety of measurements on radar and communications receivers. It can be used to energize slotted lines for vswr measurements and to measure conversion gains of receiver front ends, while its low residual rf leakage makes possible overall receiver gain measurements at fractional microvolt levels. Either cw or pulse modulated output may be obtained and the output continuously varied between 0.2 and 200,000 mv into a 50 ohm load. The signal generator provides for a choice of either internally or externally generated pulses for modulation of Klystron oscillator tube. Circuits and controls are included for adjusting the repetition rates and width of pulsed rf signals when such signals are derived from the internal modulator. The internal modulator may be operated either free running or synchronized with pulse or sine wave signals from an external source. In addition to the rf output signal, the SG-161 also provides two separate output synchronizing signals for external use in synchronizing pulsed rf signals with external equipment.

Transitron, Inc. Div. of Van Norman Indus., Dept. ED, 186 Granite St., Manchester, N.H.

CIRCLE 91 ON READER-SERVICE CARD FOR MORE INFORMATION

Subminiature Relay

High Contact Rating

This subminiature relay has full 1/8 in. silver or palladium contacts, which handle 3 amps resistive load standard and 4 amp intermittent. The basic design incorporates a permanent magnet in an electro-magnetic circuit of high efficiency and performance. This arrangement provides the extra armature torques necessary to overcome high contact pressures and actuate large contacts. Relay is constructed with a balanced armature having no pivots, hinges or bearings.

Three types are available. Model M-1000A is a dc spdt relay with standard pull-in 1/2 w. Vibration resistance is 10 g to 2000 cps. Greater sensitivity can be achieved by derating the vibration resistance to 500 cps. The standard coil for 24 v operation has a 550 ohm resistance, with special coils available up to 10,000 ohms. Model M-1000AA has identical characteristics except that pull-in power is 2/3 w, and vibration resistance is 30 g to 500 cps and 20 g to 2000 cps. Model M-1000P is a two-position dc polarized relay for use as a versatile control element. This relay provides sensitivities from 15 mw to 500 mw, and 2 to 3 amp contact rating. Vibration resistance is 10 g's to 2000 cps with 500 mw models and 10 g to 500 cps with the more sensitive models. Coils are available to 10,000 ohms.

Luther Mfg. Co., Dept. ED, 7312 Varna Ave., No. Hollywood, Calif.

CIRCLE 93 ON READER-SERVICE CARD FOR MORE INFORMATION

Precision Gears

For Servo Systems

Spur, spring and clutch gears, and bevel and miter gears are among the types available, especially for servomechanism use. Presently in stock for immediate delivery are 48- and 64-pitch spur gears, in tooth multiples of 8 and 10, with 14-1/2 deg pressure angle, and minimum and maximum pitch diameters of 9/16 in. and 4 in. respectively. Stock gears have clump hubs with 1/4 in. bores.

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

CIRCLE 94 ON READER-SERVICE CARD FOR MORE INFORMATION

For high-quality vacuum-tight seals at low or high temperatures...

...specify Centralab Metallized Ceramics

Centralab offers you unmatched facilities and experience to produce fired or pressed-on metallized components for all your mechanical and electrical uses.

Steatite bodies with low-temperature seals or High Alumina components with special high-temperature alloy seals are available.

Properly matched metal-ceramic combinations facilitate brazing . . . prevent bake-out. And integrally formed metals and ceramics minimize destructive motion and vibration, maintain close tolerance, and provide excellent electrical characteristics.

Centralab offers you modern facilities and the services of ceramics specialists to help improve your product's efficiency.

Send your inquiry to Centralab today. And ask for Bulletin 42-221 showing complete facilities.

X-2658

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Discuss your special requirements with your Centralab representative

CIRCLE 95 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Floated Integrating Gyros

Measuring 1 In. Diam

Known as series 101G, these gyros retain all of the precision construction of the larger series of the company's floated gyros, the 2-in. 201G and the 3-1/2-in. HIG-5. Measuring 1 in. in diam, the new gyros are fully floated to keep friction and uncertainty torques to low levels and to give the unit resistance to vibrational shock. Trimmed drift rates as low as 0.1 milliradians/sec can be expected. Both signal generator and torque generator are provided for use in closed-loop operation, and a range of impedances and sensitivities are available to meet specific requirements.

The unit is arranged in a flanged housing for easy mounting, with the input axis located by a notch in the flange. Power requirement is less than 1/3 w. Connections are made through 11 pin plugs at each end of the gyro. Total weight exclusive of connectors is 3-3/4 oz.

Reeves Instrument Corp., Dept. ED, 215 E. 91st St., New York 28, N.Y.

CIRCLE 96 ON READER-SERVICE CARD FOR MORE INFORMATION

Potentiometer

Miniaturized Wirewound

Measuring 3/4 in. diam x 3/4 in. long, this 2 w precision wirewound potentiometer is composed of a one piece anodized aluminum housing securing a low loss phenolic terminal board and winding assembly. Shaft torque is 0.05 oz-in. standard, 0.02 oz-in. on special request. Independent linearity of 1 per cent is standard, better linearity can be provided. The precision potentiometer is available in a servo mounting, 75-M27, or threaded bushing, 75-M7, with a selection of shaft lengths.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

CIRCLE 97 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Explosion-Proof Cases

For Airborne Equipment

This line of explosion-proof cases, to house airborne electronic equipment, is designed for use in an environment of explosive atmosphere. Flame and explosion arresting characteristics meet test procedure 2 of Military Specification MIL-E-5272A. Weighing about 10 per cent more than standard MIL-C-172B cases, these units fit shock mounting racks listed on military standard sheet MS91405 of the same specification. Thirteen case volumes are available.

Churchill Lighting Corp., Dept. ED, 344 Franklin St., Melrose 76, Mass.

CIRCLE 101 ON READER-SERVICE CARD FOR MORE INFORMATION

Oscillogram Reader

For Data Reduction

This Oscillogram Reader reads opaque or translucent oscillograms, automatically correcting for nonlinearity in the record, and prepares data for recording by plotting, type-writing, tap-perforating, or card-punching devices. Either linear or nonlinear calibration is possible without overlays. Curves may be quickly and accurately traced. Editing, notating, and reading are all possible over the entire area of the exposed record. X and Y motions are separately inhibitable. This equipment is incorporated into a desk-type console 54 in. wide and 59 in. high and constructed of walnut and formica panels on a metal frame. The 12 x 14 in. exposed reading area accommodates records 13 in. wide with a roll diam of 6 in. Other specifications include a 40-400 count per inch resolution, total travel ± 999 counts, and accuracy calibrated to ± 0.010.

Telecomputing Corp., Dept. ED, 16217 Lindbergh St., Van Nuys, Calif.

CIRCLE 102 ON READER-SERVICE CARD FOR MORE INFORMATION

Wire-Wound Resistors

Vitreous Enamel

These wire-wound axial-lead resistors offer compact size and are designed to withstand high temperatures. A vitreous enamel coating affords environmental protection. Standard tolerances are ±5 per cent for 50 ohms and higher and ±10 per cent for below 50 ohms. Power ratings are based on temperature rise of 300 C in free air with ambient temperature of 40 C. Available in 3, 5 and 10 w ratings for up to 50 K.

Hardwick Hindle Inc., Dept. ED, 40 Hermon St., Newark 5, N.J.

CIRCLE 103 ON READER-SERVICE CARD FOR MORE INFORMATION

Coaxial Switch

Direct Scope Measurements

This coaxial switch transforms an ordinary oscilloscope into an instrument that takes accurate, quantitative measurements, offering the simultaneous display of two channels or voltages on an oscilloscope. The high-speed switch unit utilizes two Clare "Mercury-Wetted" switch elements mounted in a coaxial circuit. The switching unit has a maximum current rating of 5 amp at 500 v and can be supplied for either 50 or 75 ohms with a vswr of less than 1.08 from 0 to 250 mc. The switching functions are controllable by circuitry at a 30, 15, or 10 cps rate, locked with the 60 cycle line. A phase reverse switch and a phasing control are provided for adjusting the phase in respect to the line. By switching rf energy up to 250 mc, it is possible to use one detector for the reference circuit, as well as for the unit being tested. This avoids the possibility of error caused by non-identical detectors. Suggested applications for the unit are: measurement of attenuation—0 to 250 mc; measurement of amplifier gain—0 to 250 mc; measurement of return loss (vswr); comparison of production unit with standard—up to 250 mc; general purpose oscilloscope switch; display of diode or transistor characteristics; square wave generator.

Jerrold Electronics Corp., Dept. ED, 23rd & Chestnut Sts., Philadelphia, Pa.

CIRCLE 104 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Digital Clock

Time Source

This digital clock is a multiple output unit designed to serve as a time source for data loggers, data handling systems, computers, digital time displays and other applications where a digital representation of time is required. It also functions as a twenty-four hour program controller, providing a contact closure for every minute of the day. The output is a parallel, decimal contact closure pattern, based upon twenty-four hour time, i.e., 2:26 PM is represented as 14:26. As many as three completely independent parallel outputs can be supplied in one unit. Designed for 19 in. wide relay rack mounting, the digital clock requires 3 1/2 in. of panel height. The depth behind the panel is 12 in. Top and bottom covers are removable, permitting full access to all components. The clock utilizes printed circuit techniques for the digital circuitry; no stepping switches are used.

Supply voltage is 110-120 v, 60 cycle, as standard; other voltages and frequencies are available. Power consumption is 6 w continuous with peak power requirements of 200 w. Average power is about 7 w.

Chrono-Log Corp., Dept. ED, P.O. Box 4587, Philadelphia 31, Pa.

CIRCLE 73 ON READER-SERVICE CARD FOR MORE INFORMATION

Battery Eliminators

6 v or 12 v

The model "A" Battery Eliminator is designed for use with transistor or vibrator operated auto radio sets. It provides 6 v or 12 v dc output operation at negligible ripple current, featuring 8 position voltage control voltmeter, ammeter, and completely automatic operation.

American Television & Radio Co, Dept. ED, 300 E. 4th St., St. Paul, Minn.

CIRCLE 74 ON READER-SERVICE CARD FOR MORE INFORMATION

Delay Line

100 μsec Delay

The model F-186 delay line has a delay of 100 μsec with low attenuation and is tapped every 2 μsec. At the full delay of 100 μsec, the risetime is 5.5 μsec and the attenuation is 1.4 db. The characteristic impedance is 2000 ohms. The unit comes in a hermetically sealed box with dimensions of 10-1/2 long x 4 wide and 6-3/8 in. high. Twenty-five tap terminals are brought out on each of the 10-1/2 x 6-3/8 in. sides for total of 50 taps. The delay line can be cascaded with additional units to provide longer delays. Four such units will provide a delay of 400 μsec with a risetime of 17 μsec and an attenuation of 6 db. The unit is provided with studs for mounting.

Control Electronics Co., Inc., Dept. ED, 1925 New York Ave., Huntington Station, N.Y.

CIRCLE 75 ON READER-SERVICE CARD FOR MORE INFORMATION

Phase Angle VTVM

Measures Phase and Magnitude

This VTVM includes a phase sensitive rectifier which can measure both magnitude and phase of a signal as well as perform other test functions. It permits measurement of 400 cps signal phase angles, E cos Θ, E sin Θ and vector sum. Measurements are unaffected by quadature. Total harmonic rejection can be obtained by optional filters in signal and/or reference channels. Factory modifications adapt the instrument to 60, 1000 cps and other frequencies. Major applications are phase sensitive null indication, testing synchros, servo-mechanisms, magnetic amplifier carrier amplifiers, notch networks and transducers.

As a conventional VTVM, measurements are 1 mv to 300 v full scale at frequencies of from 10 cps to 50 kc.

North Atlantic Indus., Dept. ED, Instrumentation Div., 603 Main St., Westbury, L.I., N.Y.

CIRCLE 76 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Slide-Back VTVM

0.05 Per Cent Accuracy

The TS-E6 is a slide-back VTVM which measures dc voltages in two ranges. The first range from 0.01 to 110 v, and the second range from 110 to 1100 v. An accuracy of 0.05 per cent is maintained on both ranges. The equipment operates equally well on 60 cps and 400 cps at 110 v ac. The maintenance and cycling time on the TS-E6 is held to a minimum because the meter contains a built-in standard cell for instant on-the-spot calibration. This unit contains no motor or stepper-switches that can burn out and complicate maintenance problems.

Accuracy of measurements is in no way dependent upon the deflection sensitivity of the meter movement, since it is a zero current operated device; the meter is used strictly as a null indicator.

George Vincent McMahon, Dept. ED, 381 W. 7th St., San Pedro, Calif.

CIRCLE 115 ON READER-SERVICE CARD FOR MORE INFORMATION

Digital Tachometer

Accurate to 0.001 RPM

Accuracy of this instrument is only limited by read-out method employed, and can be better than 0.001 rpm, with a scale of zero to 10,000 rpm. Output can be by sharp pulse or sine wave with signal set 1 to 100 per revolution. The tachometer is available with either single-ended or feed-through shafts, for mounting on drive pads.

Nacimco Products, Inc., Dept. ED, 2300 National Ave., National City, Calif.

CIRCLE 116 ON READER-SERVICE CARD FOR MORE INFORMATION

Video and Pulse Switch

Up to 4.5 Mc

This rotary switch, No. 5583, is designed for use at frequencies up to 4.5 mc, and is intended for video and pulse switching. The electrical characteristics of this switch call for DPDT operation of 10 separate circuits with very strict isolation requirements. The 10 rear decks of this switch are all completely isolated from each other by the use of sectional shielding and rf grounding fingers. Each of these 10 decks is also designed to eliminate capacitive or inductive coupling effects within each deck. The three front decks of this unit are used for switching filament voltages, line voltages and B plus voltages, etc. The entire switch is silver plated; all contacts and wipers are of coin-silver to minimize contact resistances. Overall dimensions are 4 1/2 x 3 x 22 in.

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

CIRCLE 117 ON READER-SERVICE CARD FOR MORE INFORMATION

Programmer Counter

Control of Test Limits

The Programmer Counter is used to turn on and off test apparatus whose limits are sensed by strain gages, thermocouples or any other transducers that have a maximum output not exceeding 100 mv dc. The unit eliminates the need for manual control of test cycling and simplifies the setting up of equipment each time a test is to be made. It is a precision, millivolt electronic relay having adjustable energizing and release thresholds and DPDT 15 amp contacts. Its two adjustable, stable thresholds provide for precise selection of upper and lower operating limits and a counter, which may be of the preset type, registers each cycle. The instrument operates on 110 v ac. Other models provide up to 5 sets of adjustable limits with automatic switching by preset counters. A signal of a flashing light or ringing bell can be supplied to indicate when the counter is registering.

Spar Eng. & Devel. Inc., Dept. ED, Wyncote, Pa.

CIRCLE 118 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Variable Power Supply
0.01 Voltage Variation

Model 700-A 1.5 amp power supply, features less than 500 mv ripple, less than 0.01 output voltage variation from no load to full load, and uses 5-1/4 in. of rack height. Voltage across the series tubes is kept constant by a secondary feedback loop, while the primary feedback loop controls the output voltage. Varying the line voltage, changing the load, or manually varying the output voltage does not affect the average series tube dissipation. As a result, the regulator does not lose regulation with a full 1.0 amp step change in load.

Harrison Labs. Inc., Dept. ED, Berkely Heights, N.J.

CIRCLE 121 ON READER-SERVICE CARD FOR MORE INFORMATION

Salt Spray Test Chamber
Lucite Construction

An All-Lucite test chamber is used for determining salt fog corrosion resistance of materials and components. The chamber, when connected to a low pressure air supply produces fine mist, and reaches test conditions within 15 min. Specimens to be tested are then suspended from Lucite hanger rods which are supplied with the chamber. Bulkier components can be placed on the bottom of the chamber supported by rods to avoid contact with the salt solution. The Lucite construction assures complete visibility from all angles of the test in progress. The unit is equipped with temperature controllers and indicators for both the chamber and the air saturation tower. Dimensions of the chamber are 20 x 20 x 20 in.

Assoc. Testing Labs., Dept. ED, 412 Clinton Road, Caldwell, N.J.

CIRCLE 122 ON READER-SERVICE CARD FOR MORE INFORMATION

Waveguide Switches

Rotary Channel Type

This miniature waveguide switch provides switching of signals from any one of three positions to either of the remaining two and will not change to another position upon failure of its power supply. The characteristics of the 1 x 0.5 in. OD size switch include a frequency range of 8500 to 9600 mc with a maximum vswr of 1.10 and a minimum isolation of 40 db. The maximum switching time is 0.25 sec. for 240 deg operation and 0.15 sec. for 120 deg operation. It operates at 3 amp maximum at 28 v dc nominal and employs 20 lb of pressurization throughout. Available in Xs and X_L band series, Airtron switches are of the rotary channel type using a circular bend in the rotor and a broadband internal choke design. Other frequency bands and special designs can be supplied. The three position switch can be designed with the circular bends in the H plane on special order.

Airtron, Inc., Dept. ED, Linden, N.J.

CIRCLE 123 ON READER-SERVICE CARD FOR MORE INFORMATION

Packaged Filter & Blower

Reduced Size

Packaged blowers are available in several sizes to utilize the minimum of valuable panel height in an electronic rack by designing the filter and blower section to protrude into the normally unused base section of the rack. The blower is normally the bottom component on a relay rack. Models 2P408 and 2Q408 require 5 1/4 in. of panel height but have the performance of Model 2E408 blower which is 7 in. high throughout, and will dissipate at 1.5 kw heat load with an air temperature rise of 10 C. A total of 25 models are available.

McLean Engineering Labs., Dept. ED, 70 Washington Rd., Princeton, N.J.

CIRCLE 124 ON READER-SERVICE CARD FOR MORE INFORMATION

FUNDAMENTAL DESCRIPTION OF GENERAL PURPOSE SLIP RING ASSEMBLIES

NO. **1**

of a Series of Data Sheets

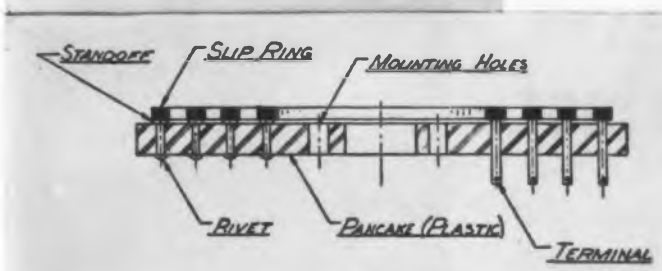
General Purpose Slip Ring Assemblies are those which are used in relay, lighting and power supply circuits. These circuits are characterized by lack of sensitivity to external electrical influence induced by electro static or electro magnetic fields from other circuits. Another usual characteristic of these assemblies is their limited power-handling requirements. For higher current and power requirements, the rings are usually classified as power rings.

Design techniques have been developed for small size and light weight. These are drum type, pan type, and electro formed assemblies.

The drum type are brushed on the surface bounded by the outside diameter. Another drum type ring is brushed on the flat surface. In this instance the brushes project between the ring surfaces.

Pan type construction consists of a concentric, nested set of rings on one plane.

It is relatively easy to make electro formed rings of the first mentioned drum type and the pan type, and they perform well as general purpose rings. However, choice of materials is limited.



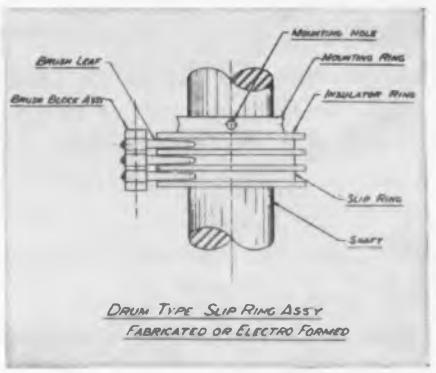
PAN TYPE
FABRICATED

The fabricated type construction will be superior and will surpass all the usual requirements of general purpose rings over the electro formed construction for universal applications.

Fabricated ring stacks are metal rings separated by plastic laminate insulators. The plastic laminate should be treated with an insulating varnish to seal the machined edges against the entrance of moisture. The rings may be continuous and machined from plate stock or stamped from sheet. The standard hardness for the rings is 125 BHN minimum.

Brush contact materials for slip rings are usually sintered silver-graphite; the silver provides the low contact and brush resistance, and the graphite provides lubrication for long wear.

As the brush moves with respect to the ring, and with current flowing from brush to ring (or vice versa), there are variations in current flow resulting from the imperfect contact between the moving elements of the circuit. Even for general purpose slip ring applications, this current variation is kept to a minimum by proper selection of compatible materials. The resistance variation seldom exceeds .005 ohms for double contacts on a ring. This is equivalent to about 1 ft. of #16 AWG copper wire.



DRUM TYPE SLIP RING ASSY
FABRICATED OR ELECTRO FORMED

General purpose rings are usually limited to slow rotating speeds, not more than 1,000 rpm or less than 1,000 feet/minute. If this speed is exceeded, the assembly is no longer considered a general purpose ring assembly, because special brush materials or even air cooling may become necessary.

Additional considerations for this type slip ring assembly come under the other type assemblies to be discussed at a future time.

MAKEPEACE complete staff of specialized design engineers are available to discuss your slip ring problems.

Makepeace SLIP RINGS

D. E. MAKEPEACE COMPANY Attleboro, Mass.

ENGELHARD INDUSTRIES

CIRCLE 125 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Wiring Duct

Snap Slot

This plastic wiring duct, which requires no special fasteners, features a snap-in open slot design allowing wires to be installed in the duct with lugs already attached. The snap-in design eliminates operation of threading wire through duct holes. To insert a wire, the plastic finger separating the slots is pulled out, laid in the duct, and the finger released. A duct cover is snapped in place on the duct after wires are laid. The duct is also available in an overlapping closed-slot design which allows wire insertion over full length of the duct with no dead spots. Duct and cover are non-flammable dark grey vinyl plastic meeting J.I.C. specifications. Cutting is easily accomplished with snips or ordinary wood cutting tools.

Panduit Co. Dept. ED, 10132 S. Washtenaw Ave. Chicago 43, Ill.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

Miniature Magnetic Pickup

No Physical Contact

A magnetic pickup, Model 3055, provides minimum weight and size with a maximum voltage output. Weighing about 4 grams, the pickup is a sensitive transducer which translates the movement of ferrous objects, without physical contact, into measurable ac voltage. The output, proportionate to the rate of the object's movement, can indicate motion, torque, rpm and vibrations.

Heart of the pickup is an Alnico magnet which energizes a pole device surrounded by a coil of wire. The pickup creates an external magnetic field, which when interrupted or distorted by the movement of an external ferrous metal object, generates the ac voltage. Operable in temperatures up to 250 deg F., the pickup has a 7/8 in. overall length and 1/4 in. diam. Six inch output leads are provided. The mounting end of the pickup has been threaded to screw into a 1/4 in.-40 NFS tapped hole.

Electro Products Labs., Inc., Dept. ED, 4501 N. Ravenswood Ave., Chicago 40, Ill.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Potentiometer

0.5 Per Cent Linearity

A magnetic potentiometer for transmitter and/or receiver in servo systems. Directly interchangeable with may for models of synchro's for increased reliability, and offering infinite resolution. No electrical contacts, slip rings, etc. Output is linear with shaft rotation to better than 0.5 per cent. One to ten turn models are available in standard servo mountings from 0.937 in. and larger.

Instrol Inc., Dept. ED, 722E. Gutierrez St., Santa Barbara, Calif.

CIRCLE 168 ON READER-SERVICE CARD FOR MORE INFORMATION

Sub-Miniature Terminals

Direct Assembly to Panels

The terminals, measuring 0.17 in. diam x 1/4 in. outside height x 1/16 in. inside height, have a Teflon coated outer insulator, and are available in either feed-through or turret head styles. They can be assembled directly to the panel, thereby allowing unlimited patterns and eliminating the necessity of soldering in headers.

Sphere Co. Inc., Dept. ED, Eagle Rock Bldg., 25 Amity St., Little Falls, N.J.

CIRCLE 169 ON READER-SERVICE CARD FOR MORE INFORMATION

Analog to Digital Converter

70 Counts per Sec

Model 100A has an accuracy of ±1 count and readings as high as 70 per sec. Input is 0 to 130 v. Unit supplies power for external scale changing amplifier. It can be used as a counter, timer or an events per unit time instrument. Contains decimal point locater and both decimal and binary coded output. Four digit 0.01 per cent accuracy models are also available.

Electronic Computer Co., Dept. ED, 6191 Ridge Ave., Philadelphia 28, Pa.

CIRCLE 170 ON READER-SERVICE CARD FOR MORE INFORMATION

Regulated dc power supplies

with unique features that simplify and speed research

model 3-150B

FITS INTO SMALL AREA OF RELAY RACK

Size: 5¼"x19" panel—9" depth.

Output: 0-300 V.D.C. continuously variable without switching. Current: 0-150 MA.

Regulation: 105-125 V. line: 0.15%; NL to FL: 100 MV change.

bulletin 1020

model IK-500B

WIDE RANGE, HIGH PERFORMANCE

Output: 3-1000 V.D.C. continuously variable without switching.

Current: 0-500 MA.

Output current needs no derating throughout full range.

Regulation: 105-125 V. line: 400 MV change; NL to FL: 800 MV change.

bulletin 1021

model D3-300E

MANY POWER SUPPLIES IN A COMPACT PACKAGE

Outputs: 0-300 V.D.C. at 0-300 MA; 0-300 V.D.C. at 0-150 MA—both continuously variable without switching.
Bias voltage 0 to −145/155 V.D.C. at 0-5 MA.
Low ripple on D.C. outputs.
0-10 V.A.C.—controlled by Powerstat.

Size: 8¾" x 19" panel—17" depth.

bulletin 1022

model 5-300XA

150W... SMALL SIZE, WIDELY ADJUSTABLE

Output: 500 V.D.C. at 300 MA—adjustable by simple internal changes.

Regulation: 105-125 V. line: 0.5%; NL to FL:

Ripple: 0.1% change below 10 MV RMS for any rated voltage or load.

Size: W: 5"; L: 12½"; H: 5⅜" above deck.

bulletin 1017

model .6-IMB

FOR TRANSISTOR AND STRAIN GAUGE CIRCUITRY

Output: 0-60 V.D.C.; current: 0-1 amp. Provides full output current throughout entire range with no derating.

Regulation: 105-125 V. line: 0.1%; NL to FL: 20 MV change.

Recovery: NL to FL: 0.5 millisecond; FL to NL: 0.25 millisecond.

bulletin 1024

model .28-5MXR

28-V.D.C.—5 AMPS—REGULATED BY MAG. AMPL

You get the dependability and long life of a magnetic amplifier in this unit. Regulation—for 105-125 V. line: ± .25V.; NL to FL: ±0.5V. Size: 4" wide, 12½" long, 7" high.

bulletin 1019

Each unit features simplified design, highest quality components, easy-to-trace wiring, and ample working room under the chassis. Components are derated to run cool and last longer. Write for literature on any or all models.

dressen-barnes

DRESSEN-BARNES CORP.
250 N. Vinedo Avenue, Pasadena, Calif.

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Twin Triode Oscillator

470 to 890 Mc Use

The 3AF4-A is a medium-mu twin triode of the seven-pin miniature type designed especially for use as an oscillator in tuners of uhf television receivers, covering the frequency range from 470 to 890 mc. It is like the popular 6AF4-A but utilizes a 3.2 v/450 ma heater having controlled warm-up time. The 3AF4-A features a small mount structure with small elements to provide low interelectrode capacitances; short internal leads to reduce lead inductance and resistance; silver-plated base pins to minimize losses caused by skin effect at the ultra-high frequencies; and double base-pin connections for both plate and grid. The double connections are arranged so as to facilitate use of the 3AF4-A with either series of parallel resonant lines.

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

CIRCLE 132 ON READER-SERVICE CARD

Strain Gage Bridge

Operates Off Line Voltage

Indicators and recorders available in the 10 mv range work in well with the B-1 bridge without the need for further amplification. Because the B-1 operates off the line rather than batteries, there is power to drive higher resistance gages fully and thereby get increased sensitivity. The bridge handles SR-4 strain gages and similar transducers, and drives indicators, recorders, and oscilloscopes. Dc power on the bridge is regulated. One feature of the B-1 is the use of higher resistance internal bridge arms. These go in series with the external gages on the two arm connection, and thereby give practically double the output for the same gage current that would be obtained with the internal arm equal to the resistance of the external arm.

Ellis Associates, Dept. ED, Box 77, Pelham, N.Y.

CIRCLE 133 ON READER-SERVICE CARD

◀ CIRCLE 134 ON READER-SERVICE CARD

Transistor Data Chart

General Purpose, Low Frequency

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)	β or α
Amperex Electronic Corp., Hicksville, N. Y.							
2N284	p-n-p, alloy, hi-current switch	167[1]	75		32	250	45
2N284A	p-n-p, alloy, hi-current switch	167[1]	75		60	250	45
OC65	p-n-p, alloy, hearing aid	50		1.54(a)	10	10	30
OC66	p-n-p, alloy, hearing aid	50		1.54(a)	10	10	47
2N109/2N217	p-n-p, alloy, audio driver, out.	125		2.5(a)	32	70	70
2N279	p-n-p, alloy, audio pre-amp.			2.5(a)	30	10	40
2N280	p-n-p, alloy, audio driver			2.5(a)	30	10	75
2N281/2N282[2]	p-n-p, alloy, audio output	167		3.33(a)	32	125	70
2N283	p-n-p, alloy, audio			2.5(a)	32	10	55
British Thomson-Houston Export Co., Ltd. Rugby, Warwickshire, England							
GT1	p-n-p, alloy	50	65[4]	1.25(a)	−9	−10	
GT2	p-n-p, alloy	50		1.25(a)			
GT3	p-n-p, alloy	50		1.25(a)			
GT11	p-n-p, alloy	25		0.75(a)			
GT12	p-n-p, alloy	25		0.75(a)			
GT13	p-n-p, alloy	25		0.75(a)			
CBS-Hytron, Lowell, Mass.							
2N180	p-n-p, alloy, gen. purp.	250[5]	75	3(a)	−30		60
2N181	p-n-p, alloy, gen. purp.	250	75	5(a)	−30		60
Fretco Inc., Pittsburgh, Pa.							
2N34	p-n-p, fused, lo-pwr., lo-freq.	50	30		−25	+8	0.98
2N35	n-p-n, fused, lo-pwr., lo-freq.				+25	−8	0.98
2N36	p-n-p, fused, lo-pwr., lo-freq.				−25	+8	45
2N37	p-n-p, fused, lo-pwr., lo-freq.						30
2N38	p-n-p, fused, lo-pwr., lo-freq.						15
General Electric Co., Syracuse, N. Y.							
2N43	p-n-p, fused, audio	150	100	2(a)	−20	50	50
2N43A	p-n-p, fused, audio						50
2N44	p-n-p, fused, audio						22
2N45	p-n-p, fused, audio						12
2N186	p-n-p, fused, audio out.	75	85	1.25(a)	−25	200	24
2N186A[6]	p-n-p, fused, audio output	180	85	3(a)	−25	200	24
2N187[6]	p-n-p, fused, audio output	75		1.25(a)			36
2N187A[6]	p-n-p, fused, audio output	180		3(a)			36
2N188[6]	p-n-p, fused, audio output	75		1.25(a)			54
2N188A[6]	p-n-p, fused, audio output	180		3(a)			54
2N189	p-n-p, fused, audio driver	75	85	1.25(a)	−25	50	24
2N190	p-n-p, fused, audio driver						36
2N191	p-n-p, fused, audio driver						54
2N192	p-n-p, fused, audio driver						75
2N241	p-n-p, audio	100		3(a)		200	73
2N241A	p-n-p, audio	180	85	3(a)	−25	200	73
2N265	p-n-p, alloy, audio	75		1.25(a)	−25	50	110
2N319	p-n-p, audio	200			−20	200	36
2N320	p-n-p, audio	200	85		−20	200	54
2N321	p-n-p, audio	200	85		−20	200	73
2N322	p-n-p, audio	75	85		−16	50	36
2N323	p-n-p, audio	75			−16		54
4JD1A17	p-n-p, fused, audio	150			−20		40
2N324	p-n-p, audio	75			−16		75
General Electric Co., Ltd., London, England							
GET3	p-n-p, alloy, audio	150[8]	55	5(a)	−12	−50	50
GET4	p-n-p, alloy, audio				−30		
GET6	p-n-p, alloy, audio				−12		
GET5	p-n-p, alloy, audio	200			−30	350	40
GET10	p-n-p, alloy, switch	250			−40	500	15
GET15	p-n-p, alloy, audio	200			−15	350	40

A Survey of Transistor Characteristics

Characteristics			
I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
4.5	15		0.35
4.5	15		0.35
5	9		0.45
5	9		0.47
4.5	15		0.35
5	10		0.3
4.5	8		0.3
4.5	15		0.35
2	4		0.5
−5	12		0.8[3]
	12		0.9
	12		1
			4
			6
			9
10	12	25	0.6
10	12	25	0.6
−12	50		0.27kc
	50		
	40		
15	22	40	1.0
	10		
	22		
	22		
16	15	35	0.8
16	15	35	0.8
	10	35	1.0
	10	35	1.0
	10	25	1.2
		35	1.2
16	15	35	0.8
			1.0
			1.2
			1.5
			1.3
16		35	1.3
			1.3
			3
16		35	3
16		35	3
16		35	3
		35	3
		40	1
		35	3
6[7]	9	60	1.5
	9		
	6		
		42	1.3
		65	1.0

IN THE past eight years since the discovery of transistors at the Bell Telephone Laboratories, great strides have been made in raw material handling and transistor production techniques. This survey of the present state of junction transistor technology is a digest of many reports present in the literature.

Available Gain Per Stage

The amplification from a transistor depends upon the configuration in which it is operated. The transistor may be used as a voltage gain device (grounded base), as a current gain device (grounded collector), or as a power gain device (grounded emitter). These gains per stage, neglecting interstage loss, are approximately as follows:

grounded base	30 db
grounded collector	20 db
grounded emitter	40 db

The grounded base configuration is essentially a voltage gain device; the grounded collector configuration is a current gain device; while the grounded emitter configuration must be considered a power gain device.

The input and output impedance of the three configurations are radically different and may therefore be used for impedance matching. The order of magnitude of these impedances are listed in Fig. 1.

These impedances vary with the termination at the other end and may be varied over approximately an order of magnitude. The impedance levels may also be adjusted with the proper use of feedback.[1] An unbypassed emitter resistor in the grounded emitter configuration will increase both input and output impedances. A feedback path from collector to base in this configuration will de-

[1]Riddle, R. L., "Hybrid Parameters for Grounded Emitter Amplifiers with Feedback," Electronic Design, April 1, 1956.

1. With heat sink at 25 C.
2. Matched pair of 2N281's.
3. Grounded base.
4. Storage.
5. With heat sink.
6. Matching not required for class B push-pull.
7. At $V_c = 6$ v.
8. At 25 C.

R. L. Riddle
Haller, Raymond and Brown, Inc.
State College, Penn.

crease both input and output impedances. A combination of these forms of feedback may be used for impedance stabilization.

Frequency Response

There are two effects in a transistor which tend to limit the upper frequency response. They are the transit time of minority carriers across the base region, and the capacity of the collector junction. The capacity of the collector junction is similar to the plate capacity of vacuum tubes and may be compensated for to a certain extent by external circuitry. The transit time for minority carriers across the base region is similar to the transit time for electrons from cathode to plate in a vacuum tube. External circuitry can do little to help the situation and a different design of the transistor is required to improve the frequency response.

There are many designs which tend to extend the upper frequency at which amplification may occur. These are listed below with their approximate upper cutoff frequencies, $f\alpha_b$.

Conventional n-p-n or p-n-p:	5 to 10 mc
N-p-n or p-n-p with very thin base regions:	50 mc
Surface barrier transistor:	200 mc
Double base transistor:	200 mc
Diffused base transistor:	1000 mc

Power and frequency response seem to be inversely related. Plotting frequency versus power handling (see Fig. 2) reveals approximately a straight line relationship. The low frequency re-

General Purpose, Low Frequency (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)	β or α	Characteristics I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
General Transistor Corp., Jamaica, N. Y.											
GT14	p-n-p, alloy, audio	125	85		25	100	28[21]	6	16		
GT20	p-n-p, alloy, audio	″	″		″	″	42[21]	″	16		
GT34	p-n-p, alloy, audio	″	″		″	″	15[21]	″	16		
GT74	p-n-p, alloy, audio	″	″		″	″	75[21]	″	<12		
GT75	p-n-p, alloy, audio	″	″		″	″	150[21]	″	<12		
GT81	p-n-p, alloy, audio	125	85		25	100	75[21]	6	16		
GT81H5	p-n-p, alloy, audio	150	″		″	″	120[21]	″	″		
GT82	p-n-p, alloy, audio	125	″		″	″	150[21]	″	″		
GT109	p-n-p, alloy, audio	″	″		″	″	120[21]	″	″		
GT222	p-n-p, alloy, audio	″	″		12	″	120[21]	″	30		
GT14H	p-n-p, alloy, hearing aid	90	75		12	50	28[21]	6	12		
GT20H	p-n-p, alloy, hearing aid	″	″		″	″	42[21]	6	12		
GT81H	p-n-p, alloy, hearing aid	″	″		″	″	80[21]	6	12		
GT210H	p-n-p, alloy, hearing aid	″	″		″	″	250[21]	<25	>29		
GT35	n-p-n, alloy, audio	100	75		25	100	40[21]	12	16		
2N43A[13]	p-n-p, alloy	150	85		45	50	65[21]	10	<20		>0.4
2N44[13]	p-n-p, alloy	150	85		45	50	32[21]	15	<33		>0.4
Intelex Systems Inc., New York, N. Y.											
TS1	p-n-p, alloy, low freq.	50			1.5	2	>10	10	15		0.5
TS2	p-n-p, alloy, low freq.	″			″	″	>30	″	″		″
TS3	p-n-p, alloy, low freq.	″			″	″	>50	″	″		″
TJ1	p-n-p, alloy, low freq.	200			″	″	10	″	25		″
TJ2	p-n-p, alloy, low freq.	″			″	″	>30	″	25		″
TJ3	p-n-p, alloy, low freq.	″			″	″		″			″
Lansdale Tube Co., Div. Philco Corp., Lansdale, Pa.											
2N207	p-n-p, alloy, low pwr. audio	50	65	0.8(b)	−12	−20	100	15[1]	5		2
2N207A	p-n-p, alloy, low pwr. audio	″	″	″	″	″	″	10[1]	2		″
2N207B	p-n-p, alloy, low pwr. audio	″	″	″	″	″	″	10[1]			″
2N223	p-n-p, alloy, audio driver	100	65	0.12(b)	−18	−150	95	20[5]	10	90[4]	0.8
2N224, 2N225[2]	p-n-p, alloy, audio output	150	75	″	−25	″		25[5]		125[4]	0.5
2N226, 2N227[3]	p-n-p, alloy, audio output	100	65	″	−25	″		25[5]		140[4]	0.4
Motorola, Inc., Semiconductor Product Div., Phoenix, Arizona											
MN13A	p-n-p, fused, aud. driv., sw.	350	90	14.3(a)[7]	40	150	15	30[6]	32		0.01
MN13B	p-n-p, fused, aud. driv., sw.	″	″	″	″	″	30	″	″		″
MN13C	p-n-p, fused, aud. driv., sw.	″	″	″	″	″	60	″	″		″
Mullard (International Electronic Corp.), New York, N. Y.											
OC70	p-n-p, alloy, audio	25	45	0.4(b)	10	10	30	5	10		10
OC71	p-n-p, alloy, audio	25	45	0.4(b)	10	10	50	4.5	10		10
OC72[8]	p-n-p, alloy, audio	100	75	0.3(b)	16	125	55	4.5	15		12
OC73	p-n-p, alloy, audio	25	65	0.4(b)	30	10	40	4.5	10		10
OC76	p-n-p, alloy, converters	50	65	″	30	125					
OCP71	p-n-p, alloy, photo[9]	25	55	″	25	10					
Pye Indust. Electronics, Ltd., Newmarket, England											
V10/15A	p-n-p, alloy, audio	100	75	2(a)	−10	−30	20	10[11]	16		0.6[10]
V10/30A	p-n-p, alloy, audio	″	″	″	″	″	40	″	″		0.7[10]
V10/50B	p-n-p, alloy, audio	″	″	″	″	″	75	″	″		1.2[10]
RCA, Somerville, N. J.											
2N77	p-n-p, alloy, audio	35	85		−25	−15	55[14]	−10[16]	6.5	40[17]	0.7[20]
2N104/2N215[12]	p-n-p, alloy, audio	″	″	2.5(a)	−30	−50	44[14]	−10[16]	12	36[17]	0.7[20]
2N105	p-n-p, alloy, audio	″	″	″	−25	−15	55[14]	−5[16]	16.5	27[17]	0.75[20]
2N109/2N217[12]	p-n-p, alloy, lge. sig. audio	50	″	″	−25	−70	70[14, 15]	−10[16]			
2N175/2N220	p-n-p, alloy, class A, low noise	20	″	″	−10	−2		−12[19]	6	36[17]	0.85[20]
2N206[13]	p-n-p, alloy, class A	75	″	3.3(a)	−30	−50		−10[16]	9	35[17]	0.78[20]
2N270	p-n-p, alloy, lge. sig. audio	150	″	″	−25	−150	70[14, 15]	−10[19]			

1. Maximum.
2. Matched pair of 2N224's.
3. Matched pair of 2N226's.
4. C_{ob}
5. Maximum at 12 v, 2N223 at 9 v.
6. $V_{cb} = 30$ v, $T_j = 30$ C.
7. Junction to case.
8. Matched pair.
9. Sensitivity 0.3 A/lumen.
10. Grounded base.
11. $V_c = 4.5$ v.
12. Same type, flexible leads.
13. Military type.
14. Current transfer ratio, common emitter.
15. Large signal.
16. At -12 V_{cb}, common emitter.
17. $C_b'_c$
18. Common base.
19. At -25 V_{cb}.
20. Common base circuit.
21. All data referred to common emitter circuit.

General Purpose, Low Frequency (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)	Characteristics β or α	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
Raytheon Mfg. Co., Newton, Mass.											
2N63	p-n-p, fused, audio, low rf.	100	85		−22	−10	22	6	15		
2N64	p-n-p, fused, audio, low rf.				−15		45		13		
2N65	p-n-p, fused, audio, low rf.				−12		90		11		
2N106	p-n-p, fused, audio, low rf.				−6		45		4.5		
2N130	p-n-p, fused, audio, rf.	120			−22		22		15		
2N131	p-n-p, fused, audio, rf.	120	85		−15	−10	45	6	13		
2N132	p-n-p, fused, audio, rf.				−12		90		11		
2N133	p-n-p, fused, audio, low-noise				−15		45		4.5		
2N130A	p-n-p, fused, audio, rf.	100			−22		22		15		
2N131A	p-n-p, fused, audio, rf.	100			−15		45		13		
2N132A	p-n-p, fused, audio, rf.	100	85		−12	−10	90	6	11		
2N133A	p-n-p, fused, audio, low-noise	100			−15		45		4.5		
2N138A	p-n-p, fused, audio output	130			−12	−100	140				
CK751	p-n-p, fused, audio output	240[2]			−12	−100	140				
2N272	p-n-p, fused, audio, rf.	150			−20	−100	90		12		
2N273	p-n-p, fused, audio output	150			−12	−100	140				
CK870	p-n-p, fused, audio, sw.	130	85		−25	−100	10	6			0.4
CK871	p-n-p, fused, audio, sw.	130	85		−20	−100	15	6			0.5
2N327	p-n-p, fused, Si, audio, sw.	150	160		−50	−50	14	0.005	18	60[1]	0.3
2N328	p-n-p, fused, Si, audio, sw.				−35		24				0.35
2N329	p-n-p, fused, Si, audio, sw.				−30		50				0.6
2N330	p-n-p, fused, Si, low-noise				−45		30		12		0.5
Sprague Electric Co., North Adams, Mass.											
10A	p-n-p, alloy, audio driver	180	70	4.5(a)	50	100	33	5000	20	35	1.2
10B	p-n-p, alloy, audio driver						53	5000			
10C	p-n-p, alloy, audio driver						>53	5000			
8F	p-n-p, alloy, audio	100	80	2(a)	−45	−50	15	16	20	28	0.7
8E	p-n-p, alloy, audio						30				
8D	p-n-p, alloy, audio						99				
8G	p-n-p, alloy, audio						>100				
Sylvania Elec. Products Inc., Woburn, Mass.											
2N229	n-p-n, alloy, gen. purpose	50	75	1(a)	−10[3]	40	0.96	200			0.55[4]
2N306	n-p-n, alloy, low freq.				−20[3]		0.96				
2N34	p-n-p, alloy, low freq.				−40[3]	100	0.975			15	0.3[4]
2N35	n-p-n, alloy, low freq.				40[3]		0.975			18	0.6[4]
2N213	n-p-n, alloy, audio driver						150				
2N214	n-p-n, alloy, audio output	125		2.5(a)	25		70			15	0.6
2N228	n-p-n, alloy, audio output	50		1(a)	25		7.5			15	0.6
Texas Instruments Inc., Dallas, Texas											
2N185	p-n-p, alloy, audio amp.	150	50		−20	150	35	8			
2N238	p-n-p, alloy, audio amp.	50	60		−20			8			
2N291	p-n-p, alloy, audio amp.	180	50	0.25(b)	−25	200	30	10			
Tung-Sol Electric Inc., East Orange, N. J.											
TS616	p-n-p, alloy, med. pwr. audio	200	85	0.2(b)	−25	200	36[5]	8			
TS617	p-n-p, alloy, med. pwr. audio						54[5]				
TS618	p-n-p, alloy, med. pwr. audio						72[5]				
TS620	p-n-p, alloy, low-noise	100		0.35(b)		50	0.98		8	50	1.0
TS621	p-n-p, alloy, low-noise	100		0.35(b)		50	0.99		8	50	1.0
SN63T	p-n-p, alloy, audio	100	85	0.35(b)	−25	25	0.96	8	25	50	0.6
2N64	p-n-p, alloy, audio						0.98		22		0.8
2N65	p-n-p, alloy, audio						0.99		20		1.2
2619	p-n-p, alloy, driver amp.					50	50				
S615T	p-n-p, alloy, hi-volt, amp.				−45	50	0.98		22		1.0
Western Electric Co., New York, N. Y.											
1N85[6]	p-n, grown, photo, coding	50	85		−90	−1		6[7]		5	0.1
2N29[6]	n-p-n, grown, linear audio	120	85	2.0(a)	35	100		4	15	8.5	2.0
GA52829[6]	p-n-p, alloy, gen. purpose	120	85	2.0(a)	−65	50	0.98	4.5	<10	17	3.0
GA53149[6]	p-n-p, alloy, gen. purpose	120	85	2.0(a)	−65	−50		4.5	10	22	3.0
GA53270[6]	n-p-n, alloy, gen. purpose	120	85		30	30		3		20	3.0

sponse of transistor amplifiers depends upon passive elements in the circuit and therefore may be controlled at the designer's discretion.

Power

The maximum power dissipation of a commercially available transistor is about 25 watts. Experimental transistors have been constructed which dissipate over a hundred watts. Power handling capabilities of typical transistors are presented in Figs. 2 and 3. It is noticed that $f\alpha_b$ (Fig. 2) decreases with increasing power handling capabilities and that h_{fe} (grounded emitter current transfer function) decreases in a somewhat similar manner (Fig. 3).

The main drawback to large power handling capabilities is the internal temperature rise within the transistor. When a junction temperature of about 100 C is reached, a germanium transistor will not operate correctly (see section on temperature). Silicon is slightly better in this respect. A junction temperature between 150 and 200 C may be achieved.

Transistors are usually de-rated linearly in power as the temperature increases such as,

$$P_T = P_r\left[1 - K(T - T_r)\right]$$

where

P_T = power dissipation at temperature T,
P_r = power dissipation at room temperature,
T_r = room temperature, 25 C,
K = de-rating constant.

The higher current density across the emitter to base junction affects the emitter efficiency, thereby reducing the parameter alpha, which in turn reduces the gain of the device. Therefore, power transistors usually have lower gain capabilities than transistors of other types (see Fig. 3).

Noise

Although noise is a drawback of point contact and early types of junction units, the noise figure of present junction transistors is as low as 4.5 db measured for a one-cycle bandwidth at 1 kc. Typical commercial units specify 10 to 12 db maximum noise figure.

Impedance	grounded base	grounded emitter	grounded collector
Input	100 ohms	1500 ohms	30,000 ohms
Output	100,000 ohms	20,000 ohms	100 ohms

Fig. 1

1. Maximum.
2. With heat sink.
3. V_{cb}
4. Alpha, minimum.
5. I_c = 150 ma.
6. Military Type.
7. Dark current. Sensitivity—0.35 μa/mw.

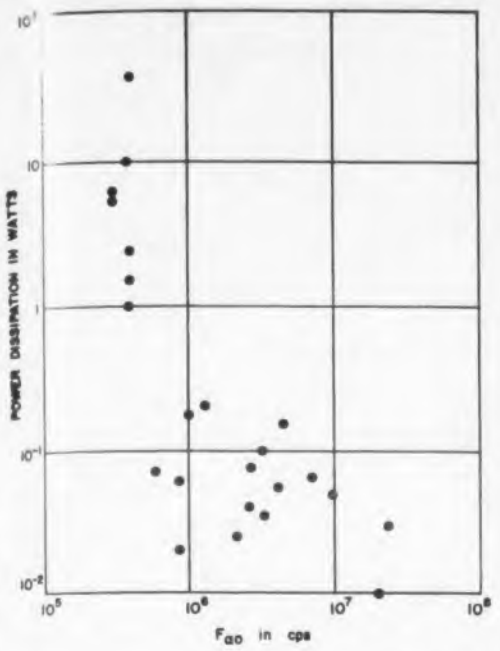


Fig. 2. Average $f_{\alpha o}$ vs. power dissipation for commercially available transistors.

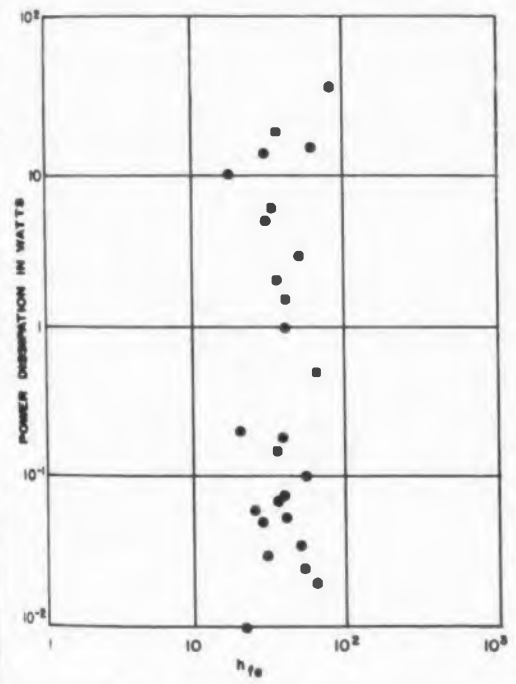


Fig. 3. Average h_{fe} vs. power dissipation for commercially available transistors.

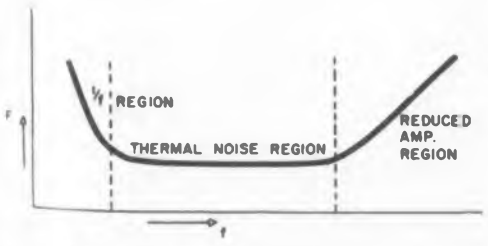


Fig. 4. Typical noise factor versus frequency curve for transistors.

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General Purpose, Low Frequency (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)	Characteristics β or α	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
Westinghouse Electric Corp., Youngwood, Pa.											
XD5081/XD5082	p-n-p, fused, switch, amp.		85		−35		48[1]				0.01
2N59	p-n-p, fused, class B audio out.	150		3.25(a)	−25	−150	80	10 ma	15	40	1.0
2N60	p-n-p, fused, class B audio out.						66				
2N61	p-n-p, fused, class B audio out.						45				
2N403	p-n-p, fused, class A audio out.						50				
2N402	p-n-p, fused, audio driver					50	50				
Bogue Elec. Mfg. Co., Paterson, N. J.											
2N347	n-p-n, grown, Si, audio, servo, sw.	750	175	3.0(a)	60	60	20		24	10	0.2
2N348	n-p-n, grown, Si, audio, servo, sw.				90	50					
2N349	n-p-n, grown, Si, audio, servo, sw.				125	40					

High Frequency, Switching

Amperex Electronic Corp., Hicksville, N. Y.											
OC44	p-n-p, alloy, rf conv.	100	75	2.0(a)	15	10	100	0.5		40	15
OC45	p-n-p, alloy, if amp.	100	75	2.0(a)	15	10	40	0.5			6
Bogue Elec. Mfg. Co., Paterson, N. J.											
RD316	n-p-n, grown, Si, audio, comp. servo	100	175	1.0(a)	20[2]	20	10	0.5	25	10	2
2N160/2N160A[3]	n-p-n, grown, Si, audio, comp. servo	150			40[2]	25	15				4
2N161/2N161A[3]	n-p-n, grown, Si, audio, comp. servo						30				5
2N162/2N162A[3]	n-p-n, grown, Si, audio, comp. servo						35				8
2N163/2N163A[3]	n-p-n, grown, Si, audio, comp. servo						50				6
2N97	n-p-n, grown, audio, if, osc. comp.	50	75	2.0(a)	30	10	0.93	2	15	14	1.0
2N98	n-p-n, grown, audio, if, osc. comp.				40		0.975			10	2.5
2N99	n-p-n, grown, audio, if, osc. comp.				40		0.975				3.5
2N103	n-p-n, grown, audio, if, osc. comp.				35		0.80	5			0.75
CBS-Hytron, Lowell, Mass.											
2N182	n-p-n, alloy, switch	100	75	2.0(a)	25		25	3		10	5
2N183	n-p-n, alloy, switch						40				10
2N184	n-p-n, alloy, switch						60				>10
Fretco Inc., Pittsburgh, Pa.											
2N32	pt. contact, pulse, osc., sw.	50	30		−40	−8	2.2	−12	40		50
2N33	pt. contact, pulse, osc., sw.	30	30		−85	−7		−12	40		50
General Electric Co., Syracuse, N. Y.											
2N78	n-p-n, grown, hi-gain rf-if	65	85	1.1(a)	15	20	40	5	12	2.4	8
2N123	p-n-p, alloy, hi-fi switch	100		1.67(a)	−15	125	50			15	8
2N164A	n-p-n, grown, mix.-osc., if	65		1.1(a)	15	20	40	5		2.4	8
2N165	n-p-n, grown, if	55	75		15	20	72	5		2.4	4
2N167	n-p-n, switch	65	85		30	75	36	1.5	8	4	8
2N168A	n-p-n, grown, if	65	85	1.1(a)	15	20	40	5		2.4	8
2N169	n-p-n, grown, if	55	75		15		72				4
2N169A	n-p-n, grown, if	55	75		25		72				5
2N292	n-p-n, grown, if	65	85		15		25				5
2N293	n-p-n, grown, if	65	85		15		25				8
2N313	n-p-n, grown, if	65	85	1.1(a)	15	20	25	5		2.4	5
2N314	n-p-n, grown, if	65		1.1(a)	15	20	25	5		2.4	8
4JD1B3	p-n-p, switch	200			−30	1000	15	20		45	0.8
4JD1B4	p-n-p, switch	200			−30	1000	20	20		45	0.8
4JD4A2	n-p-n, Si, hf	150	150	1.0(a)	15	20	14	0.15		14	25
4JD4A3	n-p-n, Si, low-level sw.	150	150	1.0(a)	10	20		0.15		14	25
4JD4A4	n-p-n, Si, hf amp.			1.0(a)	15		15				
4JD4A5	n-p-n, Si, hf, amp.			1.0(a)	15		40				
4JD5A1	n-p-n, Si, unijunction	250			45[4]	50[4]		50[4]			
3N29	n-p-n, tetrode	50	85		7[5]	20		25		4.2	40
3N30	n-p-n, tetrode									5	80
3N31	n-p-n, tetrode									3.1	20

The typical noise figure characteristic (see Fig. 4) of a transistor has a $1/f$ characteristic at low frequency; is flat over the intermedaite range; and increases at the higher frequency. The $1/f$ noise at lov frequency is predominantly semiconductor and surface recombination noise. The middle range is thermal noise, and the increase in noise figure at high frequencies is due to the decrease in amplification of the device.

Reliability

When transistors were first produced in any quantity their reliability was very questionable. The effects of humidity and temperature were very disheartening. However, today with hermetically-sealed units the effects of humidity have been eliminated.

The most recent reports on reliability indicate that for transistors operating in computers and hearing aids, the number of unit-hours per failure is of the order of 10^5 to 10^6. If this rate of failure continued, the average life of a transistor would be from 10 to 100 years. This sounds slightly fantastic but is not impossible.

The effects of vibration and shock on transistors are almost negligible. They will hold up as well as passive circuit elements.

Temperature

Temperature, however, still has a detrimental effect upon transistor operation. At the present time the upper operating temperature limit on germanium devices is approximately 85 C. The devices must be de-rated as mentioned earlier. Silicon transistors have an upper operating temperature limit of approximately 150 C. The factor controlling the upper temperature limit is the width of the forbidden region in the energy band structure of the material from which the transistor is fabricated. The reason silicon is better is because it has an energy gap of 1.1 volt as compared to germanium with 0.7 volt. An inter-metallic compound, e.g., Gallium Arsenide, has a larger energy gap than either germanium or silicon and thus should work at higher temperatures, if and when suitable single crystals are made.

With proper circuit design the effect of temperature upon I_{co} may be swamped out. That is, if the current flowing in the collector is large with respect to any expected I_{co} change, the operating point will not change appreciably.

1. I_c=1.5 A, V_{ce} =2v.
2. 1 v emitter voltage.
3. Same as basic type, but emitter voltage 5 v.
4. V_{bb}, I_e, I_{eo}
5. V_{cb}

Irradiation Effects

Another environment besides high temperature that is detrimental to transistor operation is that of a gamma or neutron flux field.

Neutrons react on transistors by producing imperfections in the crystal structure of germanium or silicon from which the transistor is fabricated. These imperfections appear as p-type impurity centers in germanium. After prolonged irradiation n-type germanium has been converted to p-type; p-type germanium remains p-type. The imperfections produced reduce the mobility and lifetime of the carriers in either type of material. In silicon the defects produced appear at an energy level in the center of the forbidden region. This material thus tends to become intrinsic under irradiation. The effects on mobility and lifetime are also present.

The general figure reported to date for the amount of integrated flux that a transistor will withstand is in the order of 10^{12} to 10^{13} nvt. This is the region in which the parameters of the transistors start to deteriorate. With the aid of feedback the useful range on a transistor amplifier might be extended an order of magnitude higher in integrated flux.

There is some evidence that indicates that it is the fast neutrons that do the majority of the above damage. Thermal neutrons are thought to produce substitutional impurities by *K* capture and beta emission. For the isotope $_{32}Ge^{70}$, this process is: $_{32}Ge^{70}$ plus thermal neutron transmutes to $_{31}Ga^{71}$ by K capture. For the case of the germanium isotope $_{32}Ge^{74}$, the process is: $_{32}Ge^{74}$ plus thermal neutron transmutes to $_{33}As^{75}$. The half-life of $_{32}Ge^{71}$ is 11.4 days, and for $_{32}Ge^{75}$ the half-life is 82 minutes.

This would indicate a gradual degradation in characteristics after irradiation, which does not seem to be present. In fact, improvement in the parameters after irradiation is stopped is more often noticed. This is explained by an annealing process which can occur even at room temperature. The annealing process results in removal of interstitials or other lattice defects by thermal vibration.

Gamma irradiation produces interstitial defects as well as ionized atoms within the crystal structure. The ionization appears as an increased temperature with its resulting degradation in transistor performance.

Transistors have now taken their place alongside vacuum tubes as a useful tool for designers of electronic equipment. With careful design based upon the known limitations of transistors, reliable operation of transistor circuitry may be obtained.

High Frequency, Switching (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)
General Transistor Corp., Jamaica, N. Y.						
GT759R	p-n-p, alloy, rf-if	90	75		12	100
GT760R	p-n-p, alloy, rf-if				10	
GT761R	p-n-p, alloy, rf-if				10	
GT762R	p-n-p, alloy, rf-if				6	
GT83	p-n-p, alloy, lo-speed comp.	125	85		25	200
GT87	p-n-p, alloy, lo-speed comp.					
GT88	p-n-p, alloy, lo-speed comp.					
GT122	p-n-p, alloy, lo-speed comp.					
2N311	p-n-p, alloy, lo-speed comp.	100			15	
GT758	p-n-p, alloy, lo-speed comp.	100	85		>20	200
GT123	p-n-p, alloy, hi-speed comp.				>20	
GT153	p-n-p, alloy, hi-speed comp.				>30	
GT269	p-n-p, alloy, hi-speed comp.				25	
GT759	p-n-p, alloy, hi-speed comp.				>20	
GT760	p-n-p, alloy, hi-speed comp.	100	85		15	50
GT761	p-n-p, alloy, hi-speed comp.				15	50
2N356	n-p-n, alloy, switch, comp.				>30	200
2N357	n-p-n, alloy, switch, comp.					
2N358	n-p-n, alloy, switch, comp.					
2N312	n-p-n, alloy, switch, comp.	100	85		15	200
GT792	n-p-n, alloy, switch, comp.				20	100
GT903	n-p-n, alloy, switch, comp.					200
GT904	n-p-n, alloy, switch, comp.		75			
GT905	n-p-n, alloy, sw tch, comp.		85			
GT947	n-p-n, alloy, switch, comp.	100	85		15	200
GT948	n-p-n, alloy, switch, comp.				20	
GT949	n-p-n, alloy, switch, comp.				30	
GT762	p-n-p, alloy, hi-speed comp.				6	50
GT763	p-n-p, alloy, hi-speed comp.				6	50
GT764	p-n-p, alloy, hi-speed comp.	100	85		>20	200
2N315	p-n-p, alloy, switch, comp.				20	
2N316	p-n-p, alloy, switch, comp.					
2N317	p-n-p, alloy, switch, comp.					
GT167	n-p-n, alloy, switch, comp.				25	
GT229	n-p-n, alloy, experimental	100	85		>10	200
GT345	p-n-p, alloy, bi-directional	125			40	
GT34N	p-n-p, alloy, neon light	125			100	
GT34HV	p-n-p, alloy, hi-voltage	150			50	
2N318	p-n-p, alloy, photo[1]	50			12	20
Intelex Systems Inc., New York, N. Y.						
TP1	n, point contact, switch	150			−30	30
TP2	n, point contact, amp., osc.	150			−30	30
Lansdale Tube Co., Div. of Philco Corp. Lansdale, Pa.						
T0031	p-n-p, alloy, Ne ind., rel. driv.	25	65		−50	−10
T0033	p-n-p, alloy, rf switch	50	85	0.8(b)	−20	−20
2N128[2]	p-n-p, sbt, rf, video	30		0.75(b)	−10	−5
2N129[2]	p-n-p, sbt, rf, if	30			−10	−5
2N299[2]	p-n-p, sbt, rf tuned amp.[7]	40			−7	−20
2N300[2]	p-n-p, sbt, video amp.[7]	40			−7	−20
2N344/SB101	p-n-p, sbt, hf	20	55	0.75(b)	−5[9]	−5
2N345/SB102	p-n-p, sbt, hf					
2N346/SB103	p-n-p, sbt, hf					
2N240	p-n-p, sbt, hf switch	10			−6[9]	−15
2N393/T1166	p-n-p, microalloy, hf, switch	50	85		−6[9]	−50
2N354/T1025	p-n-p, alloy, Si, hf amp.	150	140	0.77(b)	−25[9]	
2N355/T1159	p-n-p, alloy, Si, hf switch	150	140	0.77(b)	−10[9]	
T1164	p-n-p, alloy, sym. switch					

Fifth Annual Transistor D

	Characteristics			
β or α	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
*	*	*		*
25	6			2.5
40	|			5
70	|			11
120	|			17
49	10	16		<0.7
38	|	|		0.5
80	|	|		
80	|	|		1.5
	<60			
15	<5	16		<0.5
150	<6			>5
>20	<5			
	<4			>4
>20	<5	16		3
40	1.0	16		5
75	1.0	16		10
	<5			3
	|			6
	|			9
	<60			
	6			4.8
	<25			
	|			>4
	<25			
	<20			>4
	<25			>0.7
100	1	16		20
120	1	16		30
200	<5	16		>25
	1.0			5
	1.0			12
	1.0			20
>25	<10			>5
>10	<10	30		
15	15	24		
18	<450			
10	10	16		
100	10	20		
>2	1 ma			
5	2 ma			2
	15			
100	10	5		2
35	3[5]	9	3[4]	65[3]
25	|	9	|	60[3]
	|	8[6]	|	105[3]
0.94	|	8[6]	|	105[3]
22	3	4[8]	3.5	50[3]
35	|	|	|	50[3]
30	|		|	75[3]
32	|		|	55[3]
155	5	3.5[8]	3.5	60[3]
18	0.1		7	15[3]
18	0.1		7	25[3]
			20	0.8

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*All characteristic data for General Transistor. Corp. is referred to CE operation.
1. Sensitivity 0.16 v/ft candle.
2. Military type.
Max. freq. of oscillation.
4. C_{ob}
5. Max. at $V_c = -5$ v.
6. At 10 MC.
7. Characteristic data given for GB circuit.
8. At 1 MC.
9. V_{ce}

Data Chart

This year's data chart has been designed as a quick and comprehensive reference for the transistor circuit designer. Only the most significant characteristics have been tabulated in an effort to keep the chart within reasonable proportions. Each transistor's operating characteristics depends on a particular circuit used, the frequency of operation, the temperature, and other conditions so that the operating characteristics given are typical ones, usually for the grounded emitter circuit. A general idea of operation under varying conditions can be had by scanning the maximum ratings.

Transistors fall easily into three categories: Low Frequency, High Frequency, and Power. A cut-off frequency of 1 Mc is used as a rough dividing line between high and low frequency units, and a collector dissipation of 1 w or more can define a power transistor. In addition, many transistors are recommended for switching purposes, both power switching and high frequency switching, and their operating characteristics are given in two separate tables. The new class of silicon transistors are not easily characterized since many of them are capable of high frequency power applications, as well as switching.

A total of about 430 different types of transistors are available this year, as compared to about 270 last year. Many new manufacturers have entered the field including many European firms and some Japanese. Most companies have given their own designation to their transistors, and may also have a RETMA number. In the cross-index, equal or equivalent types are listed after the type number designated by the company. For an additional copy of this chart, turn to the Reader Service Card and circle 500.

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)
Mullard (International) Electronic Corp. New York, N. Y.						
OC44	p-n-p, rf conv.	100	75	2.0(a)	15	10
OC45	p-n-p, alloy, if amp.	100	75	2.0(a)	15	10
Pye Industrial Electronics, Ltd., Newmarket, England						
V6/R2	p-n-p, alloy, if amp.	25	75	0.5(a)	−6	−12
V6/R4	p-n-p, alloy, if, osc.-mix.					
V6/R8	p-n-p, alloy, if, osc.-mix.					
RCA, Somerville, N. J.						
2N139/2N218[1]	p-n-p, alloy, 455 kc if amp.	35	85		−16	−15
2N140/2N219[1]	p-n-p, alloy, 540-1640 kc conv.				−16	−15
2N247	p-n-p, alloy drift, class A rf				−35	−10
2N269	p-n-p, alloy, lo-level switch				−20	−100
Raytheon Mfg. Co., Newton, Mass.						
2N111	p-n-p, fused, if-rf	150	85		−30	−200
2N111A	p-n-p, fused, if					
2N112	p-n-p, fused, if-rf					
2N112A	p-n-p, fused, if					
2N113	p-n-p, fused, rf, switch					
2N114	p-n-p, fused, rf, switch					
2N271	p-n-p, fused, mix.-conv. bdcst.					
2N271A	p-n-p, fused, if					
CK768	p-n-p, fused, if-rf	150				−100
Sprague Electric Co., North Adams, Mass.						
2N159	n, point contact, pulse, sw.[5]	100	80	2.0(a)	−50	−40
PC6	n, point contact, comp. sw.[5]	150	80	3.0(a)	−80	−60
SB101	p-n-p, sbt, if-rf osc., amp.	10	85	0.18(a)	−5	−5
SB102	p-n-p, sbt, if-rf osc., amp.			0.18(a)		
SB103	p-n-p, sbt, if-rf osc., amp.			0.18(a)		
SB5122	p-n-p, sbt, hi-speed switch		65	0.28(a)	−6	−15
Sylvania Electric Products, Inc., Woburn, Mass.						
2N94	n-p-n, alloy, hf	50	75	1.0(a)	20	50
2N94A	n-p-n, alloy, hf, switch				20	
2N193	n-p-n, alloy, hf osc.				15	
2N194	n-p-n, alloy, hf mixer				25	
2N211	n-p-n, alloy, hf osc.				10	
2N212	n-p-n, alloy, hf mixer	50	75	1.0(a)	10	50
2N216	n-p-n, alloy, if amp.				15	
2N233	n-p-n, alloy, hf				10	
2N377	n-p-n, alloy, hf, switch	150	85	2.5(a)	20	200
2N385	n-p-n, alloy, hf, switch				25	
2N388	n-p-n, alloy, hf, switch					
Texas Instruments Inc., Dallas, Texas						
2N332[9]	n-p-n, grown, Si, gen. purpose	150	175	0.116(b)	45	25
2N333[9]	n-p-n, grown, Si, gen. purpose					
2N334[9]	n-p-n, grown, Si, gen. purpose					
2N335[9]	n-p-n, grown, Si, gen. purpose					
2N336[9]	n-p-n, grown, Si, gen. purpose					
903[9]	n-p-n, grown, Si, gen. purpose	150	175	0.116(b)	30	25
904[9]	n-p-n, grown, Si, gen. purpose					
904A[9]	n-p-n, grown, Si, gen. purpose					
905[9]	n-p-n, grown, Si, gen. purpose					
910[9]	n-p-n, grown, Si, gen. purpose					
2N263[9]	n-p-n, grown, Si, switch	125	150	0.166(b)	40	20
2N337[9]	n-p-n, grown, Si, switch					
2N338[9]	n-p-n, grown, Si, switch					
925[9]	n-p-n, grown, Si, hi-freq.				30	10
926[9]	n-p-n, grown, Si, hi-freq.					
3N32[9]	n-p-n, grown, Si, hi-freq.					
3N33[9]	n-p-n, grown, Si, video, rf					
3N34[9]	n-p-n, grown, Si, video, rf					

Transistor Parameter

E. K. Novak

	Characteristics			
β or α	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
100	0.5		40	15
40	0.5			6
25	1.0		35	3
50	|		|	5.5
80	|		|	10
48[2]	−6	4.5	9.5[3]	4.7[4]
48[2]	−6		9.5[3]	7[4]
60[2]	−16		1.7[3]	30[4]
	2.5			4[4]
25	1.0	10	12	3
25	|		|	3
30	|	10	|	5
30	|		|	5
45	|	10	|	10
75	|	10	|	20
45	|		|	10
45	|		|	10
20	|		15	2.5
3	0.5 ma	43	0.5	5
5	1.0 ma	43	0.5	5
23	500	20	3.5	45
40	|	|	|	45
>6	|	|	|	60
	1000			
0.97[6]	50[7]		10	2
0.98[6]	50[7]		10	5
7.5[6]	40[7]		11	2
8.0[6]	40[7]		11	|
10[6]	20[7]		10	|
10[6]	20[7]		10	4
7.5[6]	40[7]		11	2
4.5[6]	150[7]			
30[8]	20[7]		15	4
60[8]	35[7]		15	4
80[8]	20[7]		15	8
0.925	4	20	7[10]	4
0.960	|	|	|	5
0.975	|	|	|	8
0.980	|	|	|	6
0.990	|	|	|	7
0.925	0.1	25	7[10]	4
0.960	|	34	|	5
0.975	|	25	|	8
0.980	|	25	|	6
0.990	|	20	|	7
0.975	1.0		3	30
0.950	1.0		|	20
0.975	1.0		|	30
	0.2		1.8	12.5
	|		1.8	30
	|			4.3
	|			12.5
	|			30.0

TRANSISTOR characteristics are usually now given by most manufacturers in h parameters. Occasionally however, characteristics are available only in r parameters. Also, in some transistor circuit design problems, a more familiar physical representation of the transistor is permitted if the small signal parameters of the transistor are expressed as resistances. Both systems of representation are useful and a typical design problem usually requires the application of both h and r parameters. The time required to perform these conversions may be considerably reduced by application of these tables. All equations given are in the exact form and are derived from the basic equivalent circuits given in Fig. 1. The r parameters are given for the common base, common emitter and common collector connections; the z and h parameters are given in their general form and will represent the CB, CE or CC connection when the subscripts b, e or c, respectively, are added to each parameter. For example, the input impedance in the general four terminal network h parameters form is h_{11}; h_{11b} is the input impedance for the common base connection, h_{11e} is the input impedance for the common emitter connection, h_{11c} for the common connector.

The h parameters are given by manufacturers in either of the two following forms:

For common base:
h_{11b} = input impedance $= h_{ib}$
h_{12b} = reverse transfer, or feedback voltage ratio $= h_{rb}$
h_{21b} = forward, or current transfer ratio $= h_{fb}$
h_{22b} = output admittance $= h_{ob}$

Since the majority of the literature is written in the nomenclature of the left hand column it is used in these tables.

Use of the tables is illustrated by the following simple example.

The characteristics of a Type 903 grown junction

1. Has flexible leads.
2. Current transfer ratio, common emitter circuit.
3. $C_{b'c}$
4. CB circuit.
5. All characteristic data for Grounded Base circuit.
6. h_{fe}—small signal current gain.
7. Maximum, emitter open.
8. h_{fe}—dc current gain.
9. All characteristics given for design center, grounded base.
10. 1[MC design center.

Conversion Tables

silicon transistor are given in the manufacturer's data sheet as follows:

$$h_{11b} = 42 \text{ ohms}$$
$$h_{12b} = 120 \times 10^{-6}$$
$$h_{21b} = -0.925$$
$$h_{22b} = 0.4 \times 10^{-6} \text{ mhos}$$

Since these parameters are given for the common base connection, calculation of the characteristics of a common emitter amplifier, for example such as in Figure 1c, requires conversion of the given values to their common emitter equivalent. Using Table I:

$$h_{11e} = \frac{h_{11b}}{(1 + h_{21b})(1 - h_{12b}) + h_{11b} h_{22b}} = 560 \text{ ohms}$$

similarly:

$$h_{12e} = 104 \times 10^{-6}$$
$$h_{21e} = 12.3$$
$$h_{22e} = 5.33 \times 10^{-6} \text{ mho}$$

Also from Table I, the common collector h parameters are:

$$h_{11c} = 560 \text{ ohms}$$
$$h_{12c} = 1.0$$
$$h_{21c} = 13.3$$
$$h_{22c} = 5.33 \times 10^{-6} \text{ ohms}$$

When calculations in terms of r parameters are required, Table II and the above results give:

$$r_b = 300 \text{ ohms}$$
$$r_c = 2.5 \text{ megohms}$$
$$r_d = 0.187 \text{ megohms}$$
$$r_e = 19.5 \text{ ohms}$$
$$r_m = 2.3 \text{ megohms}$$

Other conversions are carried out similarly.
For the transformation of g parameters, the following relations can be used in conjunction with the tables:

$$h_{11} = \frac{1}{g_{11}}, \quad h_{21} = \frac{g_{21}}{g_{11}}$$

$$h_{12} = \frac{-g_{12}}{g_{11}} = \frac{(g_c - g_{22})}{g_{21}}$$

$$h_{22} = g_c = \frac{1}{r_{22}}$$

Continued on page 12

High Frequency, Switching (cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (mw)	T_j (C)	(a)mw/C (b)C/mw	V_c (volts)	I_c (ma)
Texas Instruments Inc. (cont.)						
2N252	p-n-p, grown diff., conv.	30	55		16	5
2N308	p-n-p, grown diff., if amp.				20	
2N309	p-n-p, grown diff., if amp.				20	
2N310	p-n-p, grown diff., if reflex				30	
2N172	n-p-n, grown, conv.	65	75	0.7(b)	16	5
2N145	n-p-n, grown, 455 kc if				20	
2N146	n-p-n, grown, 455 kc if					
2N147	n-p-n, grown, 455 kc if					
2N148	n-p-n, grown, 262 kc if				32	
2N149	n-p-n, grown, 262 kc if	65	75		32	5
2N150	n-p-n, grown, 262 kc if				32	
2N253	n-p-n, grown, 455 kc if				12	
2N254	n-p-n, grown, 455 kc if				20	
Transitron Electronics Corp., Melrose, Mass.						
ST10	n-p-n, grown, Si, gen. purpose	200	175		15	
ST30	n-p-n, grown, Si, gen. purpose				30	
ST40	n-p-n, grown, Si, gen. purpose				45	
ST11	n-p-n, grown, Si, med. gain				15	
ST31	n-p-n, grown, Si, med. gain				30	
ST41	n-p-n, grown, Si, med. gain				45	
ST12	n-p-n, grown, Si, hi gain	200	175		15	
ST32	n-p-n, grown, Si, hi gain				30	
ST42	n-p-n, grown, Si, hi gain				45	
ST13	n-p-n, grown, Si, hf				15	
ST33	n-p-n, grown, Si, hf				30	
Western Electric Co., New York, N. Y.						
2N67[3]	point contact, switch	100			−50	−50
2N110[3]	point contact, switch	200		3.3(a)	−50	−50
3N22[3]	n-p-n, grown, video amp.	30			10	3
GA52829[3]	p-n-p, alloy, gen. purpose	120	85	2.0(a)	−65	−50
GA52830[3]	p-n-p, alloy, core-driver	500	80		−40	−500
GA53080[3]	point contact, switch	250			−100	−50
GA53242[3]	p-n-p, alloy, switch	500	80		−40	−500
GA53149[3]	p-n-p, alloy, gen. purpose	120	85	2.0(a)	−65	−50
GA53233[3]	p-n-p, diffused, vhf osc.	200		5.0(a)	−35	−30
GA53270[3]	n-p-n, alloy, gen. purpose	120			30	30

Power Transistors

Manufacturer and Type	Class and Application	Maximum Ratings W_c (W)	T_j (C)	(a)W/C (b)C/W	V_c (volts)	I_c (amp.)
Bendix Aviation Corp., Red Bank Div., Long Branch, N. J.						
2N235A	p-n-p, alloy, audio pwr.	25[4]	90	2(a)	−40	3
2N234A	p-n-p, alloy, pwr.		90		−30	3
2N285A	p-n-p, alloy, hi-gain audio		95		40	3
B-114	p-n-p, alloy, audio pwr.		100		40	3
X-140	p-n-p, alloy, audio pwr.		95		40	3
X-119	p-n-p, alloy, class B audio		90		40	3
X-145	p-n-p, alloy, class B audio		90		40	3
X113	p-n-p, alloy, hi-current sw.		100		70	4
X133	p-n-p, alloy, hi-current sw.				80	5
X134	p-n-p, alloy, hi-current sw.	50[4]		1.5(a)	40	12
X137	p-n-p, alloy, hi-current sw.	50[4]		1.5(a)	80	12

Characteristics

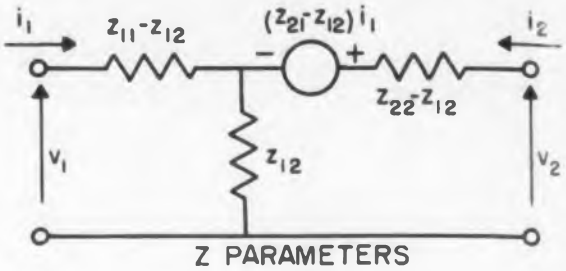
β or α	I_{co} (μa)	NF (db)	C_c ($\mu\mu$f)	f_{co} (Mc)
	10		6[1]	
	3			
	3			
25	0.005[2]	22	7	9
45		20		13
45		20		13
45		20		13
40	0.005[2]	19	7	16
60			10	17
60			10	17
	450			10
	1300			10
	1.0		2	20
0.98	4.5	<10	17	3
	10		40	4
	1000			15
	10		40	4
	4.5	10	22	3
	13	4.5	4	500
	3		20	3

Characteristics

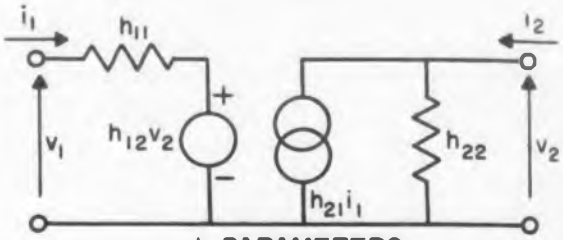
β or α	I_{co} (ma)	f_{co} (Mc)	pwr. gain (db)	pwr. out. (W)
60	1.0	0.007	35	2
30			30	2
100			38	2
50			34	5
100			34	6
50		0.008	25	9[6]
40		0.008	27	5[6]
40[5]				
40[5]				
15[5]				
15[5]				

Basic Equivalent Circuits

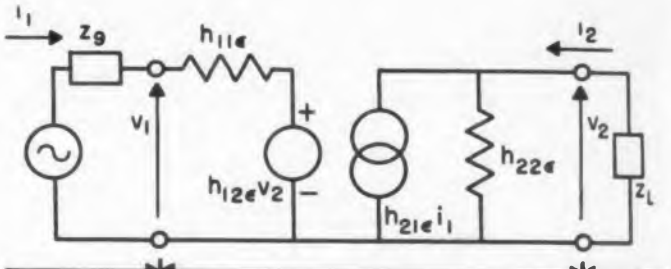
(Small Signal Parameters)



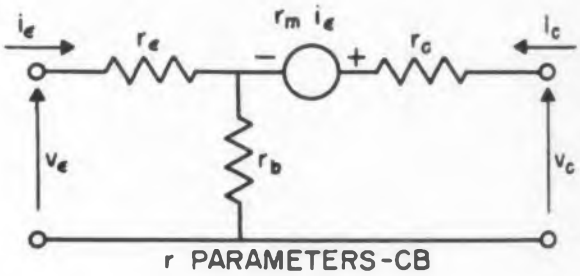
Z PARAMETERS
(a)



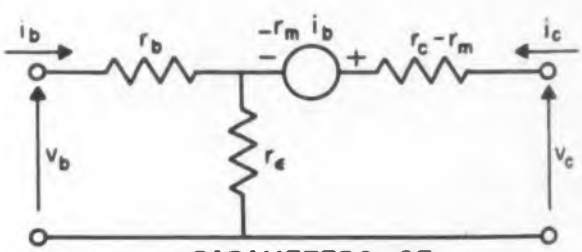
h PARAMETERS
(b)



SINGLE STAGE TRANSISTOR AMPLIFIER
(c)



r PARAMETERS-CB
(d)



r PARAMETERS-CE
(e)

Continued on page 15

1. C_{oe} design center.
2. At 6 v, 25 C.
3. Military Type.
4. With heat sink.
5. h_{fe} dc Beta.
6. Two units.

Typical Switching Operation

Manufacturer and Type		Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt. (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}
Bendix Aviation Corp.							
Long Branch, N. J.							
X110	pwr.	100		200	2	1000	40(a)
X113	pwr.				2	8000	40(a)
X133	pwr.					2000	40(a)
X134	pwr.					4000	15(a)
X137	pwr.					4000	15(a)
Bogue Elec. Mfg. Co.							
Paterson, N. J.							
RD316					2.5		10(a)
2N160		0.3		0.4	1.25		15(a)
2N161		0.3		0.4	|		30(a)
2N162		0.2		0.3	|		35(a)
2N163		0.25		0.35	|		50(a)
X30A	pwr.						12(a)
X31A	pwr.						|
X32A	pwr.						
CBS-Hytron							
Lowell, Mass.							
2N182		0.7	0.8	0.5	0.15	7.5	25(b)
2N183		0.5	0.7	0.3	|	120	50(b)
2N184		0.3	0.6	0.2	|	180	100(b)
Clevite Transistor Prod.							
Waltham, Mass.							
2N257	pwr.					2000	100(a)
2N268	pwr.					2000	100(a)
2N297	pwr.				1.0	3000	100(a)
CTP117	pwr.					2000	60(a)
Delco Radio							
Kokomo, Ind.							
2N278	pwr.	50		80	0.6	15ma	80(b)
2N277	pwr.	50		80	0.6	15ma	80(b)
2N174	pwr.	60		100	0.6	15ma	50(b)
2N173	pwr.	50		80	0.6	15ma	80(b)
General Electric Co. Ltd.							
London, England							
GET10		1	3.5	4.5	40	6	40(a)
Lansdale Tube Co. (Philco)							
Lansdale, Pa.							
2N352	pwr.				0.47		65(a)
2N353	pwr.		0.5		|		90(a)
2N386	pwr.				|		85(a)
2N387	pwr.				|		85(a)
2N224				0.29	0.25		75(a)
2N226				0.36	0.25		55(a)
2N240	h.f.				0.06		65(a)
2N393	h.f.				0.05		93(a)
2N355	h.f.	0.038		0.09	0.08		50(a)
T1164		9					20(a)
Minneapolis-Honeywell							
Minneapolis, Minn.							
H5	pwr.	4	3	1	0.36	−500	30(a)
H6	pwr.	|	|	|	|	|	42(a)
H7	pwr.	|	|	|	|	|	60(a)
H3A	pwr.					150	12(a)
H4A	pwr.					150	22(a)
H1D	pwr.				0.5	1000	20(a)

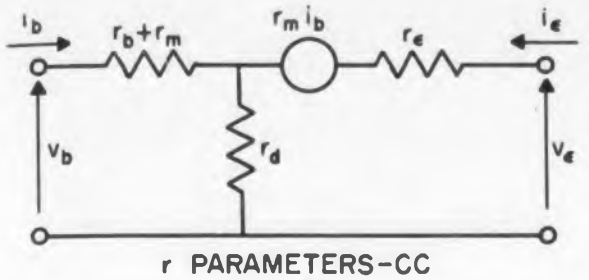
Power Transistors (Cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (W)	T_j (C)	(a)W/C (b)C/W	V_c (volts)	I_c (amp.)
Bogue Electric Mfg. Co., Paterson, N. J.						
X30A	n-p-n, grown, Si, audio, servo	8[1]	175	0.1(a)	40	0.20
X31A	n-p-n, grown, Si, audio, servo	10[1]			80	0.16
X32A	n-p-n, grown, Si, audio, servo	10[1]			125	0.14
CBS-Hytron, Lowell, Mass.						
2N155	p-n-p, alloy, pwr.	8.5[1]	85	0.14(a)	−30	−3
2N156	p-n-p, alloy, pwr.	8.5[1]		0.14(a)	−30	
2N158	p-n-p, alloy, pwr.	8.5[1]		0.14(a)	−60	
2N255	p-n-p, alloy, pwr.	6.25[1]		0.10(a)	−15	
2N256	p-n-p, alloy, pwr.	6.25[1]		0.10(a)	−30	
Clevite Transistor Products, Waltham, Mass.						
2N257	p-n-p, alloy, pwr. amp., sw.	37[1]	90	0.5(a)	40	3
2N268	p-n-p, alloy, pwr. amp., sw.	37[1]	90	0.5(a)	80	3
2N297[2]	p-n-p, alloy, pwr. amp., sw.	15[1]	85	0.25(a)	60	3
CTP1117	p-n-p, alloy, pwr. amp., sw.	43[1]	90	0.67(a)	40	6
Delco Radio, Kokomo, Ind.						
2N278	p-n-p, alloy, pwr.	70[1]	95	1(b)	50	13
2N277	p-n-p, alloy, pwr.				40	
2N174	p-n-p, alloy, pwr.				80	
2N173	p-n-p, alloy, pwr.				60	
General Electric Co. Ltd., London, England						
GET7	p-n-p, alloy, dc conv.	14[1]	75	1.5(b)	−15	8
GET8	p-n-p, alloy, audio output				−30	
GET9	p-n-p, alloy, volt. reg.				−60	
Lansdale Tube Co., Div. of Philco Corp., Lansdale, Pa.						
2N352/T1040	p-n-p, alloy, audio out., sw.	7[1]	100	3(b)	−40	−2
2N353/T1041	p-n-p, alloy, audio out., sw.	10[1]	100	2.5(b)	−40	−2
2N386/T1167	p-n-p, alloy, servo, pwr. sw.	12.5[1]	100	2(b)	−60	−3
2N387/T1168	p-n-p, alloy, servo, pwr. sw.	12.5[1]	100	2(b)	−80	−3
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.						
H5[3]	p-n-p, alloy, servo, dc conv.	20[4]	95	2.2(b)	−80	−3
H6[3]	p-n-p, alloy, servo, dc conv.	20[4]		2.2(b)	−80	−3
H7[3]	p-n-p, alloy, servo, dc conv.	20[4]		2.2(b)	−80	−3
H3A[3]	p-n-p, alloy, servo amp.	3[4]		14(b)	−60	−3.5
H4A[3]	p-n-p, alloy, servo amp.	3[4]		14(b)	−60	−0.5
H10	p-n-p, alloy, dc conv.	55[4]		0.8(b)	−60	−15
Motorola Inc., Semiconductor Product Div., Phoenix, Arizona						
2N176	p-n-p, fused, audio pwr.	10	90	1(a)	40	3
MN21	p-n-p, fused, high-volt.				80	
MN24	p-n-p, fused, audio pwr.				40	
MN25	p-n-p, fused, audio pwr.				40	
MN26	p-n-p, fused, audio pwr.				40	
MN28	p-n-p, fused, audio pwr., sw.				30	
MN29	p-n-p, fused, audio pwr., sw.				40	
Nucleonic Products Co., Los Angeles, Calif.						
2N350	p-n-p, alloy, audio pwr.	10	90	1(a)	−40	3
2N155	power	13.5		2.5(b)	−30	−3

Typical Switching Operation (cont.)

Manufacturer and Type		Rise Time (μs)	Storage Time (μs)	Fall Time (μs)	Sat. Volt. (V)	Leak Cur. (μa)	Beta (a)h_{FE} (b)h_{fe}	Characteristics β or α	I_{co} (ma)	f_{co} (Mc)	pwr. gain (db)	pwr. out. (W)
Motorola Inc.												
Phoenix, Ariz.												
2N176	pwr.	50	10	80	0.6	1000	75(a)	15			32	2
MN13A		7	2	9	0.2	30	25(a)					
MN13B				12			40(a)					
MN13C				12			80(a)					
MN21	pwr.	50	10	80	0.6	1500	55(a)					
MN24	pwr.					1000	40(a)	40	0.42	0.145	33	2
MN25	pwr.						60(a)	40	0.26	0.180	33	2
MN26	pwr.						80(a)	41	0.26	0.180	37	2
MN28	pwr.					2000	70(a)	30		0.145	19-26	1
MN29	pwr.					2000	70(a)	30		0.145	22-29	2
RCA												
Somerville, N. J.												
2N269					0.15	−4			2	0.3[3]	33	2.5
									2		31	2.5
									3			
Raytheon Mfg. Co.									2		33	5.0
Newton, Mass.												
2N113	h.f.	0.1		0.15								
2N114	h.f.	0.05		0.15								
Sprague Elec. Co.										0.3[4]	40	
North Adams, Mass.										0.3[4]	40	
2N159		0.12	1.5	0.5						0.15[4]	38	
PC6		0.05	1.0	0.5						0.3[4]	40	
SB5122		0.015	0.065	0.015	−0.1	−200	12(b)					
Sylvania Elec. Prod.												
Woburn, Mass.								20	.062	0.25	46	20
2N34		1.0	2.0	2.0								
2N35		1.0	1.5	2.0								
2N94A	h.f.	0.3	0.4	0.6			49(b)					
2N377	h.f.	1	1	1	0.75		30(a)					
2N385	h.f.				0.75		60(a)					
2N388	h.f.	0.6	0.6	0.6	0.75		80(a)					
2N325	pwr.	5	10	5	0.6							
Texas Instruments Inc.												
Dallas, Texas												
2N263		0.06	0.02	0.14			80(a)					
2N337		0.05		0.08			20(a)					
2N338		0.06		0.14			80(a)					
Tung-Sol Elec. Inc.												
East Orange, N. J.												
TS612	pwr.	25		40	1.0		35(a)	50[9]	−0.5	>0.008	31	10
TS613	pwr.						30(a)	75[9]	−0.5	>0.007	34	10
TS614							60(a)	140[9]	−0.5	>0.006	37	10
Western Electric Co.								12[9]	0.15[10]		21	2
New York, N. Y.								15[9]	0.15[10]		23	3
2N110		90		1.7								
GA52830		0.45	1.1	0.6								
GA53242		0.45	1.1	0.6								
								45	<1	0.007	34	2
								65	1.5		37	5
								40	<1		31	4
								60	<1		33	4
								80	<1		35	4
								60	2		31	2
								60	2		33	2
								60	3	0.006	33	
								50	0.3			

1. With heat sink.
2. Military Type.
3. Common base circuit.
4. Grounded base.
5. β_{co}, grounded emitter.
6. At a mounting base temp. of 50 C.
7. Two units, class B push-pull, common emitter.
8. DC beta.
9. I_{cbo} at 60 v.



r PARAMETERS–CC

(f)

TABLE I h Parameters CB-CE-CC

	CE	CC
CB	$h_{11e}=\frac{h_{11b}}{(1+h_{21b})(1-h_{12b})+h_{11b}\,h_{22b}}$	$h_{11c}=\frac{h_{11b}}{(1+h_{21b})(1-h_{12b})+h_{11b}\,h_{22b}}$
	$h_{12e}=\frac{h_{11b}\,h_{22b}-(1+h_{21b})\,h_{12b}}{D_{eb}}$	$h_{12c}=\frac{1+h_{21b}}{D_{cb}}$
	$h_{21e}=\frac{-h_{11b}\,h_{22b}-h_{21b}\,(1-h_{12b})}{D_{eb}}$	$h_{21c}=\frac{-(1-h_{12b})}{D_{cb}}$
	$h_{22e}=\frac{h_{22b}}{D_{eb}}$	$h_{22c}=\frac{h_{22b}}{D_{cb}}$

	CB	CC
CE	$h_{11b}=\frac{h_{11e}}{(1+h_{21e})\,(1-h_{12e})+h_{11e}\,h_{22e}}$	$h_{11c}=h_{11e}$
	$h_{12b}=\frac{h_{11e}\,h_{22e}-(1+h_{21e})\,h_{12e}}{D_{be}}$	$h_{12c}=(1-h_{12e})$
	$h_{21b}=\frac{-h_{11e}\,h_{22e}-(1-h_{12e})\,h_{21e}}{D_{be}}$	$h_{21c}=-(1+h_{21e})$
	$h_{22b}=\frac{h_{22e}}{D_{be}}$	$h_{22c}=h_{22e}$

	CB	CE
CC	$h_{11b}=\frac{h_{11c}}{h_{11c}\,h_{22c}-h_{12c}\,h_{21c}}$	$h_{11e}=h_{11c}$
	$h_{12b}=\frac{h_{11c}\,h_{22c}+h_{21c}\,(1-h_{12c})}{D_{bc}}$	$h_{12e}=(1-h_{12c})$
	$h_{21b}=\frac{h_{12c}\,(1+h_{21c})-h_{11c}\,h_{22c}}{D_{bc}}$	$h_{21e}=-(1+h_{21c})$
	$h_{22b}=\frac{h_{22c}}{D_{bc}}$	$h_{22e}=h_{22c}$

Power Transistors (Cont.)

Manufacturer and Type	Class and Application	Maximum Ratings W_c (W)	T_j (C)	(a)W/C (b)C/W	V_c (volts)	I_c (amp.)
Pye Industrial Electronics, Ltd., Newmarket, England						
V15/10P	p-n-p, alloy, pwr., 6v dc conv.	10[2]	75	0.2(a)	−15	−3
V15/20P	p-n-p, alloy, pwr., 6v dc conv.				−15	
V15/30P	p-n-p, alloy, pwr., 6v dc conv.				−15	
V30/10P	p-n-p, alloy, pwr., 12v dc conv.				−30	
V30/20P	p-n-p, alloy, pwr., 12v dc conv.				−30	
V30/30P	p-n-p, alloy, pwr., 12v dc conv.				−30	
RCA, Somerville, N. J.						
2N301[4]	p-n-p, alloy, lge. sig. audio pwr.	12[2]	85		−40	−2
2N301A[4]	p-n-p, alloy, lge. sig. audio pwr.	12[2]	85		−60	−2
Sylvania Electric Products Co., Woburn, Mass.						
2N68	p-n-p, alloy, pwr.	4[2]	75	0.08(a)	−30	1.5
2N95	n-p-n, alloy, pwr.					
2N101	p-n-p, alloy, pwr.					
2N102	n-p-n, alloy, pwr.					
2N141	p-n-p, alloy, pwr.				−60	0.8
2N142	n-p-n, alloy, pwr.				60	
2N143	p-n-p, alloy, pwr.				−60	
2N144	n-p-n, alloy, pwr.				60	
2N155	p-n-p, alloy, pwr.	8.5[2]	85	0.14(a)		3
2N176	p-n-p, alloy, pwr.	10[2]	90	1(a)		3
2N235A	p-n-p, alloy, pwr.	5[2]	85	0.5(a)	−40	2
2N242	p-n-p, alloy, pwr.	25[2]	100	0.33(a)	−45	
2N250	p-n-p, alloy, pwr.	12[2]	80	0.22(a)	−30	
2N257	p-n-p, alloy, pwr.	25[2]	85	0.41(a)	−40	
2N296	p-n-p, alloy, pwr.	25[2]	100	0.33(a)	−60	2
2N307	p-n-p, alloy, gen. purp. pwr.	15[2]	75	0.3(a)	−35	1
2N325[8]	p-n-p, alloy, pwr.	12[2]	85	0.2(a)	−35	2
2N326[8]	n-p-n, alloy, pwr.	7[2]	85	0.12(a)	35	2
Texas Instruments Inc., Dallas, Texas						
951[10]	n-p-n, grown, Si, med. pwr.	0.75[2]	150	116(b)	50	.060
952[10]	n-p-n, grown, Si, med. pwr.				80	.050
953[10]	n-p-n, grown, Si, med. pwr.				120	.040
2N243[10]	n-p-n, grown, Si, med. pwr.				60	.060
2N244[10]	n-p-n, grown, Si, med. pwr.				60	.060
2N339[10]	n-p-n, grown, Si, med. pwr.	1.0			55	.060
2N340[10]	n-p-n, grown, Si, med. pwr.	1.0			85	.050
2N341[10]	n-p-n, grown, Si, med. pwr.	1.0	150	116(b)	125	.040
2N342[10]	n-p-n, grown, Si, med. pwr.				60	.060
2N343[10]	n-p-n, grown, Si, med. pwr.				60	.060
970[10]	n-p-n, grown, Si, power	8.75		166(b)	120	.140
2N389[10]	n-p-n, grown, Si, power	37.5		166(b)	60	
2N250	p-n-p, alloy, audio amp.	25	85	1.1(b)	−30	3.0
2N251	p-n-p, alloy, audio amp.	25	85	1.1(b)	−60	3.0
Transitron Electronic Corp., Melrose, Mass.						
2N83	p-n-p, pwr. amp.	10	85	0.16(a)	−66	2
2N83A	p-n-p, pwr. amp.				−66	3
2N84	p-n-p, pwr. amp.				−50	2
2N84A	p-n-p, pwr. amp.				−50	3
Tung-Sol Electric, Inc., East Orange, N. J.						
TS176	p-n-p, alloy, audio pwr.	10[2]	85	3(b)	−30	2
TS612	p-n-p, alloy, pwr. sw.	15[2]			−40	3
TS613	p-n-p, alloy, pwr. sw.	15[2]			−80	3
TS614	p-n-p, alloy, pwr. sw.	15[2]			−60	3
2N307	p-n-p, alloy, audio pwr.			5(b)	−35	1
Western Electric Co., New York, N. Y.						
2N66[8]	p-n-p, alloy, pwr. amp.	5[2]	80	0.5(a)	−60	−0.8

Characteristics				
β or α	I_{co} (ma)	f_{co} (Mc)	pwr. gain (db)	pwr. out. (W)
18	0.03	0.1		12[1]
24				
38				
18				
24				
38				
70[3]	−0.22		30[5]	12[5]
70[3]	−0.2		30[5]	12[5]
40[6]	5	0.4	23	0.6
			26	
	1	0.145	33	2
60[7]	3.0	0.01	32	3
60[7]	2	0.007	35	2
	5	0.005	35	2.5
60[7]	1	0.006	33	1.5
	2	0.007	30	
27[6]	0.2	0.004		
25[7]	15	0.003		
40[6]	0.5	0.15	28	3[9]
40[6]	0.5	0.15	28	3[9]
0.94[11]	.005		30	
	.006			
	.008			
	.001			
0.97[11]	.001			
0.94[11]	.001			
0.94[11]	.001			
0.94[11]	.001		30	
0.94[11]				
0.97[11]				
3[12]	.01		28[13]	
10[12]	.01			
30	0.3	.012[14]	31	1.5
30	0.3	.012[14]	31	1.5
18	0.1	0.35		
17	0.08	0.4		
21	0.11	0.4		
20	0.09	0.45		
50	0.3	0.009	32	2.5
			24[1]	26[15]
			23[15]	52[15]
			29[15]	54[15]
<20	15			
	0.07	0.2		

TABLE II h Parameters to r Parameters

	CB	CE	CC
r_e	$\frac{h_{11b}\,h_{22b} - h_{12b}(h_{21b}+1)}{h_{22b}}$	$\frac{h_{12e}}{h_{22e}}$	$\frac{1 - h_{12c}}{h_{22c}}$
r_b	$\frac{h_{12b}}{h_{22b}}$	$\frac{h_{11e}\,h_{21e} - h_{12e}(h_{21e}+1)}{h_{22e}}$	$\frac{h_{11c}\,h_{22c} + h_{21c}(1-h_{12c})}{h_{22c}}$
r_c	$\frac{1 - h_{12b}}{h_{22b}}$	$\frac{1 + h_{21e}}{h_{22e}}$	$\frac{-h_{21c}}{h_{22c}}$
r_d	$\frac{1 + h_{21b}}{h_{22b}}$	$\frac{1 - h_{12e}}{h_{22e}}$	$\frac{h_{12c}}{h_{22c}}$
r_m	$-\left[\frac{h_{12b} + h_{21b}}{h_{22b}}\right]$	$\frac{h_{12e} + h_{21e}}{h_{22e}}$	$-\left[\frac{h_{12c} + h_{21c}}{h_{22c}}\right]$

TABLE IV z Parameters CB-CE-CC

	CE	CC
CB	$Z_{11e} = Z_{11b}$ $Z_{12e} = Z_{11b} - Z_{12b}$ $Z_{21e} = Z_{11b} - Z_{21b}$ $Z_{22e} = Z_{11b} - Z_{21b} + Z_{22b}$	$Z_{11c} = Z_{22b}$ $Z_{12c} = Z_{22b} - Z_{21b}$ $Z_{21c} = Z_{22b} - Z_{12b}$ $Z_{22c} = Z_{11b} - Z_{12b} - Z_{21b} + Z_{22b}$

	CB	CC
CE	$Z_{11b} = Z_{11e}$ $Z_{12b} = Z_{11e} - Z_{12e}$ $Z_{21b} = Z_{11e} - Z_{21e}$ $Z_{22b} = Z_{22e} - Z_{21e}$	$Z_{11c} = Z_{11e} - Z_{12e} - Z_{21e} + Z_{22e}$ $Z_{12c} = Z_{22e} - Z_{12e}$ $Z_{21c} = Z_{22e} - Z_{21e}$ $Z_{22c} = Z_{22e}$

	CB	CE
CC	$Z_{11b} = Z_{11c} - Z_{12c} - Z_{21c} + Z_{22c}$ $Z_{12b} = Z_{11c} - Z_{21c}$ $Z_{21b} = Z_{11c} - Z_{12c}$ $Z_{22b} = Z_{11c}$	$Z_{11e} = Z_{11c} - Z_{12c} - Z_{21c} + Z_{22c}$ $Z_{12e} = Z_{22c} - Z_{12c}$ $Z_{21e} = Z_{22c} - Z_{21c}$ $Z_{22e} = Z_{22c}$

1. Push-pull class B on heat sink.
2. With heat sink.
3. Large signal current transfer ratio.
4. All characteristics for CE operation.
5. Two transistors class B push-pull.
6. h_{fe} current gain.
7. h_{fe}
8. Military Type.
9. Push-pull.
10. All characteristics for grounded base.
11. Alpha design center.
12. DC beta (min.)
13. Common emitter, 1 w. out at 100 C.
14. Design center.
15. Switch.

TABLE III r Parameters to h Parameters

	CB	CE	CC
h_{11}	$h_{11b}=r_e+r_b\left[\frac{r_e-r_m}{r_e+r_b}\right]$	$h_{11e}=r_b+r_e\left[\frac{r_d+r_m}{r_d+r_e}\right]$	$h_{11c}=r_b+\left[\frac{r_e r_c}{r_d+r_e}\right]$
h_{12}	$h_{12b}=\frac{r_b}{r_e+r_b}$	$h_{12e}=\frac{r_e}{r_d+r_e}$	$h_{12c}=\frac{r_d}{r_d+r_e}$
h_{21}	$h_{21b}=-\left[\frac{r_m+r_b}{r_e+r_b}\right]$	$h_{21e}=\frac{r_m-r_e}{r_d+r_e}$	$h_{21c}=-\left[\frac{r_e}{r_d+r_e}\right]$
h_{22}	$h_{22b}=\frac{1}{r_e+r_b}$	$h_{22e}=\frac{1}{r_d+r_e}$	$h_{22c}=\frac{1}{r_d+r_e}$

TABLE V r Parameters to z Parameters

	CB	CE	CC
z_{11}	r_b+r_e	r_b+r_e	r_e+r_b
z_{12}	r_b	r_e	r_d
z_{21}	r_m+r_b	r_e-r_m	r_e
z_{22}	r_e+r_b	r_e+r_d	r_e+r_d

TABLE VI h to z Conversion

$h_{11}=\frac{z_{11}z_{22}-z_{12}z_{21}}{z_{22}}$
$h_{12}=\frac{z_{12}}{z_{22}}$
$h_{21}=\frac{-z_{21}}{z_{22}}$
$h_{22}=\frac{1}{z_{22}}$

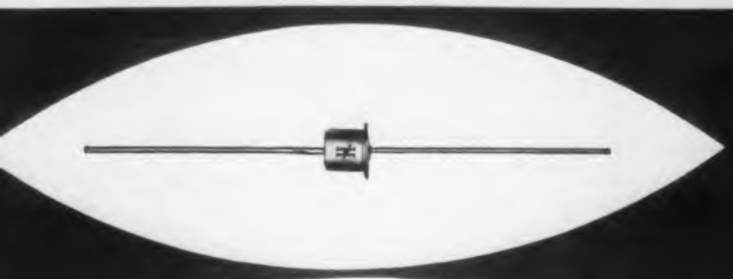
TABLE VII z to h Conversion

$z_{11}=\frac{h_{11}h_{22}-h_{12}h_{21}}{h_{22}}$
$z_{12}=\frac{h_{12}}{h_{22}}$
$z_{21}=\frac{-h_{21}}{h_{22}}$
$z_{22}=\frac{1}{h_{22}}$

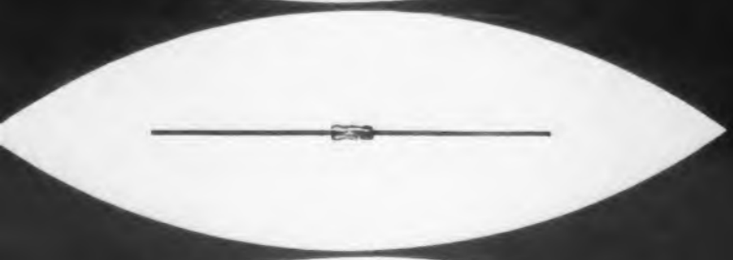
TABLE VIII z Parameters to r Parameters

	CB	CE	CC
r_e	$z_{11b}-z_{12b}$	z_{12e}	$z_{22c}-z_{12c}$
r_b	z_{12b}	$z_{11e}-z_{12e}$	$z_{11c}-z_{21c}$
r_c	$z_{22b}-z_{12b}$	$z_{22e}-z_{21e}$	z_{21c}
r_d	$z_{22b}-z_{21b}$	$z_{22e}-z_{12e}$	z_{12c}
r_m	$z_{21b}-z_{12b}$	$z_{12e}-z_{21e}$	$z_{21c}-z_{12c}$

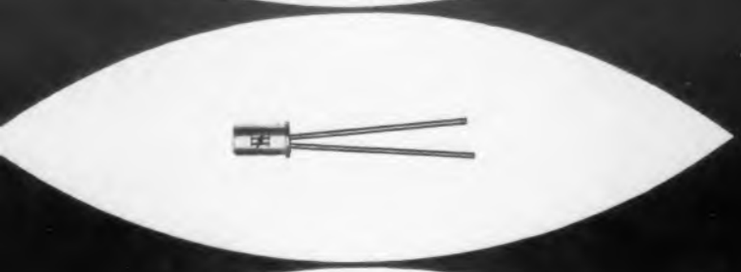
Hoffman



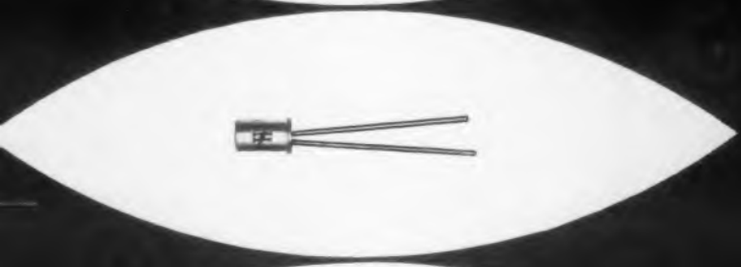
Types: IN536 thru IN540, IN1095



Types: IN456 thru IN459, IN461 thru IN464, IN482 thru IN488, A and B



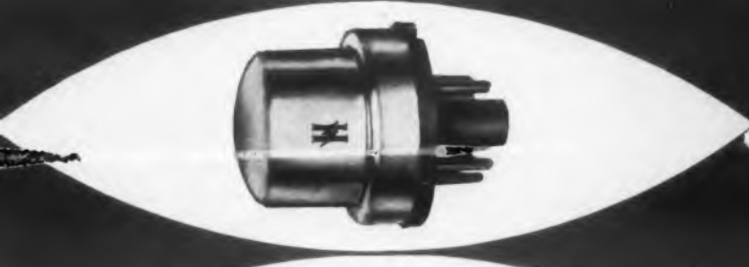
Types: IN137A, IN138A, IN200 thru IN222, IN431, IN465 thru IN470, ZA8 thru ZA125. Double anode types IN471 thru IN475, IN225 thru IN235. (Silicon Junction Diodes will also be available in axial glass package)



Type: IN429

Types: IN430, IN430A, IN430B

Types: HMP1 thru HMP5 and 1A thru 5A; HDMP4 thru HDMP10 and 4A thru 10A



Types: HFWR1 thru HFWR3

Types: HZPR in Zener Voltage, voltages between 10 and 100 volts

CIRCLE 508 ON READER-SERVICE CARD FOR MORE INFORMATION

Curve Tracers

Manufacturer and Model	Maximum Base Current	Max. Collector Sweep Current and Frequency	Max. Coll. Sweep Power	Min. Load Resistance	Max. Sweep Volts	Auxiliary Equip. Needed	Characteristics Displayed	Internal Calib.	Accuracy	Price and Delivery	Size and Weight
American Electronic Lab. 121 North Seventh Street Philadelphia 6, Pennsylvania											
126H	600 ma	3 a 60 cps	30 w	——	150 v	Scope	Output, Input	Yes	——	$1,090.00 4 weeks	19″ x 21″ x 32″ 150 pounds
126R	600 ma	15 a 60 cps	200 w	——	200 v	Scope	Output, Input	Yes	——	$1,250.00 10 weeks (Oscilloscope $425 extra)	19″ x 21″ x 32″ 170 pounds
Cubic Corporation 5575 Kearney Villa Road San Diego, 11 California											
504	.7 ma	1/30 a 600 cps	½ w	——	18 v	Scope	Output	No	——	$325.00 30 days	2″ x 3″ x 8″ 1 pound
Dunn Engineering Associates, Inc. 186 Massachusetts Avenue Cambridge 39, Massachusetts											
331	1 ma	250 cps or 25 cps Triangular Waveform	——	1,300 ohm	50 v	Scope	Output, Transfer	Yes	3%	$750.00 1 week	21″ x 11″ x 14″ 65 pounds
Fairchild Guided Missiles Div. Wyandanch, L. I., New York											
103A	10 ma	¼ a 60 cps	2.5 w	——	100 v	Scope	Output, Transfer	Yes	5%	$650.00 30 days	19″ x 13″ x 10″ 35 pounds
Magnetic Amplifiers 632 Tinton Avenue New York 55, New York											
200A	10 ma	1/10 a 60 cps	2 w	100 ohm	100 v	Scope	Output, Transfer	Yes	2½%	$685.00 10 days	16″ x 10″ x 8″ 18 pounds !
300A	200 ma	2 a 60 cps	5 w	1 ohm	100 v	Scope	Output, Transfer	Yes	2½%	$785.00 45 days	16″ x 10″ x 13″ 28 pounds
Norden-Ketay Corporation Instrument and Systems Division Wiley Street Milford, Connecticut											
BC T-300	110 ma	8 a 60 cps	20 w	1/10 ohm	267 v	Scope	Output, Transfer	Yes	2%	$795.00 30 days	19″ x 9″ x 14″ 35 pounds
Polyphase Instrument Company East Fourth Street Bridgeport, Pennsylvania											
TA-3A	1.2 ma	1/10 a 120 cps	10 w	——	150 v	Scope	Output, Input	Yes	——	$645.00 6 weeks	19″ x 19″ x 10″ 50 pounds (approx.)
TA-13	450 ma	10 a 60 cps	1,560 w	Less than 1 ohm	150 v	Scope	Output, Input, Transfer	Yes	——	$3,600.00	19″ x 60″ x 15″ 250 pounds (approx.)
TA-11		20 a	3000 w	——	150 v	Scope	Output, Transfer	Yes	——	$1,450.00	——
R. C. A. Harrison, New Jersey											
811C-1	1,000 ma	1 a, 60 cps ½ wave	300 w	——	1,000 v	None	Output, Transfer	Yes	——	$6,500.00 10 months	19″ x 21″ x 32″ 140 pounds (approx.)
Tektronix Portland 7, Oregon											
575	2,400 ma	10 a 60 cps	200 w	1 ohm	200 v	None	Output, Input, Transfer	Yes	3%	$925.00 6 months	13″ x 17″ x 24″ 70 pounds
Senex, Incorporated 73 S. State Road Upper Darby, Pennsylvania											
CT-103	0.5 ma	15 ma 60 cps	1.5 w	——	100 v	Scope	Output	Yes	5%	$135.00 immediate	10″ x 8″ x 8″ 13 pounds

Transistor Test Equipment Survey

Soren C. Ibsen
Norden-Ketay Corp.
Milford, Conn.

THE TRANSISTOR test equipment field is keeping abreast of the dynamic semi-conductor growth by providing a large variety of instruments. The equipment power handling capabilities have a spread of 1/2 watt to 1560 watts; whereas, the weight of the instruments have extremes of 1 pound to 250 pounds. The units vary in price from $125.00 to $6,500.00. This variety has been dictated by the exponential growth of transistors themselves. Point contact types have been replaced with junctions and other transistors. Power transistors with dissipation ratings above 50 watts have outclassed their predecessors.

This power handling capability is the strongest underlying trend in Transistor Test Equipment for 1957. This high power need is met by some manufacturers by offering two separate models while others have upgraded their equipment to cover the entire span.

The 33 commercially available models built by 21 manufacturers tend to align themselves into four general categories: Curve Tracers, Parameter-Analyzers, Portable Test Sets, and Miscellaneous types. In each category, many performance differences are found among the instruments and they should be compared as to their individual merits.

Curve Tracers usually employ 60 cycle sweep power to produce the transistor characteristic curves for oscilloscope display. Sweep power varies greatly among units. If large power is available in the sweep circuit, then small transistor load resistance is necessary for the proper hybrid impedance termination. On the other hand, high sweep voltage is vital for transistor breakdown measurements and a transistor collector voltage of above 250 volts may be required. The accuracy specification should be evaluated with the oscilloscope tolerance included.

Parameter-Analyzers generally operate by small signal measuring techniques. Metered input and output bias supplies provide the transistor dc operating point under consideration. The transistor is connected in either the grounded base or grounding emitter configuration, with bias approriate for pnp or npn types. A small internal audio test signal is properly applied to the transistor, detected, and converted to

hybrid parameters for meter readout. Microampere test signals and true hybrid ac termination are manudatory for precision measurements with accuracy of better than ± 5 percent.

Analyzers vary in that some require external signal generators and vtvm detection while others are self-contained. The dc bias capability is an important variation when high power transistors are to be measured. The range of parameter measurement is vital if the instrument is to test all transistors commercially available. One instrument has combined the parameter analyzing with that of curve tracing to provide a highly versatile Transistor Test Set.

Portable test sets are generally simplified parameter-analyzers in that the units provide only one or two parameters with the primary function of go-no-go testing. Some units are only dc static test instruments. The input bias current is limited and collector voltage is low. Battery operation is standard. The accuracy is normally not better than ± 5 percent.

How should a transistor be evaluated? The actual transistor user is the best judge as to what transistor characteristics are vital to his particular applications. He must further compromise as to whether a curve display is superior to a meter reading. Then questions as to instrument range, accuracy, flexibility, completeness and price become deciding factors.

Portable Test Sets

Manufacturer Model No.	Maximum DC Base Current	Maximum DC Collector Voltage	Test Frequency	Characteristics Displayed	Maximum Beta Range	Accuracy	Battery Operated	Size and Weight	Price and Delivery
Baird Atomic, Incorporated Cambridge, Massachusetts **KT-1**	10 ma	7½ v	1 kc	Beta, H_{11}, I_{co}	200	3%	Yes	6″ x 5″ x 11″	$175.00 30 days
C. G. Electronics 305 Dallas Street Albuquerque, New Mexico **TR-2**	10 ma	12 v	1 kc	Alpha, Beta, I_{co}	1 000	—	Yes	4″ x 4″ x 8″ 3 pounds	$124.50 15 days
Electronic Research Associates, Inc. 67 East Centre Street Nutley, New Jersey **AT-10**	10 ma	100 v	240 cps (External Oscillator to 5 mc)	Alpha, Beta	100	5%	No	8″ x 11″ x 8″ 17 pounds	$385.00 60 days
Davenco, Incorporated 150 Broadway New York 38, New York **TT-1**	—	4½ v	270 cps	Beta	100	—	Yes	9″ x 6″ x 6″ 9 pounds	$125.00 8 weeks
Measurements Corporation Boonton, New Jersey **505**	70 ma	12 v	DC	Ico, Beta, Gm, H_{11}	200	—	Yes	10″ x 14″ x 7″ 9 pounds	—
Metronic, Incorporated Mill Lane Waterford, Connecticut **545**	100 ma	5.2 v External to 25 v	1 kc	Beta, I_{co}	250	3%	Yes	7″ x 11″ x 7″ 8 pounds	$210.00 4 weeks
Sonex, Incorporated 73 S. State Road Upper Darby, Pennsylvania **TT-205**	2 ma	20 v	1 kc (External Osc. 0.25 to 5 kc)	Beta, I_{co}, Rc	150 (Larger as calibrated)	5%	Yes	14″ x 8″ x 8″ 19 pounds	$155.00 immediate
Quantum Electronics, Incorporated 1921 Virginia Street Albuquerque, New Mexico **Mod. V**	100 ma	5.36 v	2 kc	I_{co}, Beta	1,000	5%	Yes	5″ x 7″ x 10″ 5½ pounds	$295.00 90 days
Durson Company 10416 National Blvd. Los Angeles 34, Calif. **201**	10 ma	5 v	—	Beta, I_{co}	500	—	Yes	10″ x 7″ x 5″ 10 pounds	$190.00

CROSS INDEX

Amperex	Am	Minneapolis-Honeywell	MH
Bendix	Be	Motorola	Mo
Bogue	Bo	Mullard	Mu
British Thomson-Houston	BTH	Nucleonic	Nu
CBS-Hytron	CBS	PYE Electronics	PYE
Clevite	C	Raytheon	Ra
Delco		Sprague	Sp
Fretco		Sylvania	Sy
General Electric	GE	Texas Instrument	TI
General Electric Co, Ltd.	GL	Transitron	Tr
General Transistor	GT	Tung-Sol	TS
Intelex Systems	IS	Western Electric	WE
Lansdale Tube (Philco)	LT	Westinghouse	Wh

1N85	WE	**2N123**	GE
2N29	WE	**2N128**	LT
2N32	Fr	**2N129**	LT
2N33	Fr	**2N130**	Ra
2N34	Fr, Sy	**2N130A**	Ra
2N35	Fr, Sy	**2N131**	Ra
2N36	Fr	**2N131A**	Ra
2N37	Fr	**2N132**	Ra
2N38	Fr	**2N132A**	Ra
2N43	GE	**2N133**	Ra
2N43A	GT, GE	**2N133A**	Ra
2N44	GT, GE	**2N138A**	Ra
2N45	GE	**2N139**	RCA
2N59	Wh	**2N140**	RCA
2N60	Wh	**2N141**	Sy
2N61	Wh	**2N142**	Sy
2N63	Ra, TS	**2N143**	Sy
2N64	Ra, TS	**2N144**	Sy
2N65	Ra, TS	**2N145**	TI
2N66	WE	**2N146**	TI
2N67	WE	**2N147**	TI
2N68	Sy	**2N148**	TI
2N77	RCA	**2N149**	TI
2N78	GE	**2N150**	TI
2N83	Tr	**2N155**	CBS, Nu, Sy
2N83A	Tr	**2N156**	CBS
2N84	Tr	**2N158**	CBS
2N84A	Tr	**2N159/5A**	Sp
2N94	Sy	**2N160**	Bo
2N94A	Sy	**2N160A**	Bo
2N95	Sy	**2N161**	Bo
2N97	Bo	**2N161A**	Bo
2N98	Bo	**2N162**	Bo
2N99	Bo	**2N162A**	Bo
2N101	Sy	**2N163**	Bo
2N102	Sy	**2N163A**	Bo
2N103	Bo	**2N164A**	GE
2N104	RCA	**2N165**	GE
2N105	RCA	**2N167**	GE
2N106	Ra	**2N168A**	GE
2N109/2N217	Am,RCA	**2N169**	GE
2N110	WE	**2N169A**	GE
2N111	Ra	**2N172**	TI
2N111A	Ra	**2N173**	De
2N112	Ra	**2N174**	De
2N112A	Ra	**2N175**	RCA
2N113	Ra	**2N176**	Sy, Mo
2N114	Ra	**2N180**	CBS

Parameter Analyzers

Manufacturer and Model	Max. DC Base Current	Max. DC Collector Power	Max. DC Collector Voltage Current	Parameters Measured (gb and ge, NPN and PNP)	Range of Measurement	Transistor Bias Terminations (Output)	Maximum Frequency Range	Accuracy	External Equipment Required	Size and Weight	Battery Operated	Price and Delivery
Baird Associates 73 University Road Cambridge, Massachusetts												
GP-4	5 ma	½ w	45 v 5 ma	H_{11}, H_{12}, H_{21}, H_{22}, I_{co}	H_{11} to 3K ohm H_{21} to 1,000	——	(ge) –200 kc (gb) –1 mc	5%	Osc. VTVM	22" x 10" x 13" 70 pounds	Yes	$475.00 30 days
KP-1	200 ma	30 w	100 v 300 ma	H_{11}, H_{12}, H_{21}, H_{22}, I_{co}	H_{11} to 3K ohm H_{21} to 1,000		200 kc	5%	Osc. VTVM	22" x 22" x 15" 100 pounds	No	$795.00 90 days
Quantum Electronics 1921 Virginia Avenue Albuquerque, New Mexico												
PTA #3	1,500 ma	75 w (Regulated)	32 v 15 a	H_{21}, (ge only)	H_{21} to 1,000	——	DC Tests	—	None	47" x 21" x 24" 200 pounds	No	$3,475.00 120 days
Norden-Ketay Corporation **Instrument & Systems Division** Wiley Street Milford, Connecticut												
BCT-300 (See Curve Tracer)	10 ma	2 w	100 v 20 ma	H_{21}, H_{11}	H_{11} to 10K ohms H_{21} to 1,000	100 ohm	1 mc ge or gb	3%	Osc. VTVM	19" x 8" x 14" 35 pounds	No	$795.00 30 days
BTS-400	1,000 ma	60 w	150 v 6 a	H_{11}, H_{12}, H_{21}, H_{22} (Real and Imaginary) I_{co}, I_{ceo}, I_{ces}	H_{11} to 100K ohms H_{21} to 1,000	1 ohm	2 mc with external Oscillator, ge or gb	2%	None	19" x 14" x 15" 80 pounds	No	$2,495.00 6 months
Owens Laboratories 55 Beacon Place Pasadena, California												
210	7½ ma	——	75 v	H_{11}, H_{12}, H_{22}, H_{21}, I_{co}	H_{11} to 1K H_{21} to 1,000	5 ohms	1 mc with external Oscillator, VTVM	5%	None	15" x 13" x 4" 18 pounds	No	$475.00 30 days

Miscellaneous Test Equipment

Manufacturer Model	Description	Test Performed	Price and Delivery
Electronic Measurements Lewis Street Eatontown, New Jersey **200 Series**	Power Pack for Transistors.	Provides voltage to 100 v and 3000 ma regulated to 1/10 ohm output impedance. Input modulations jacks available for coefficient measurements.	——
Electronic Research Assoc. Incorporated 69 East Center Street Nutley, New Jersey **NET**	Transistor Noise figure meter.	Range of 60 db at 1000 cps with 1 cycle band-width. DC input bias to 10 ma.	$775.00 4 weeks
Kay Electric Maple Avenue Pine Brook, New Jersey **970A**	Alpha versus frequency Curve Tracer. Combine bias controls with "Mega-Sweep" generator (50 mc).	DC input bias to 10 ma. Output bias 25 ma and 50 volts. Auxiliary Oscilloscope required.	$1,595.00 60 days
Polyphase East Fourth Street Bridgeport, Pennsylvania **TA-15**	Alpha and Beta versus input current Curve Tracer. Metered Beta, Alpha and Ico.	DC input bias to 15 ma. Output bias to 30 ma and 100 v.	$1,225.00 4 weeks
TA-10	Unijunction transistor or diode curve tracer; power supply.	Interbase or power pack, 0-100 v, 0-100 ma. Emitter to 150 v. Scope required.	$395.00

INDEX (Cont.)

2N181 CBS
2N182 CBS
2N183 CBS
2N184 CBS
2N185 TI
2N186 GE
2N186A GE
2N187 GE
2N187A GE
2N188 GE
2N188A GE
2N189 GE
2N190 GE
2N191 GE
2N192 GE
2N193 Sy
2N194 Sy
2N206 RCA
2N207 LT
2N207A LT
2N207B LT
2N211 Sy
2N212 Sy
2N213 Sy
2N214 Sy
2N215 RCA
2N216 Sy
2N217 RCA
2N218 RCA
2N219 RCA
2N220 RCA
2N223 LT
2N224 LT
2N225 LT
2N226 LT
2N227 LT
2N228 Sy
2N229 Sy
2N233 Sy
2N234A Be
2N235A Be, Sy
2N237 TI
2N238 TI
2N240 LT
2N241 GE
2N241A GE
2N242 Sy
2N243/2N342 TI
2N244/2N343 TI
2N247 RCA
2N250 Sy, TI
2N251 TI
2N252 TI
2N253 TI
2N254 TI
2N255 CBS

2N256	CBS	2N348	Bo		
2N257	C, Sy	2N349	Bo		
2N263	TI	2N350	Nu		
2N265	GE	2N352/T1040	LT		
2N268	C	2N353/T1041	LT		
2N269	RCA	2N354/T1025	LT		
2N270	RCA	2N355/T1159	LT		
2N271	Ra	2N356	GT		
2N271A	Ra	2N357	GT		
2N272	Ra	2N358	GT		
2N273	Ra	2N377	Sy		
2N277	De	2N385	Sy		
2N278	De	2N386/T1167	LT		
2N279	Am	2N387/T1168	LT		
2N280	Am	2N388	Sy		
2N281	Am	2N389	TI		
2N282	Am	2N393/T1166	LT		
2N283	Am	2N402	Wh		
2N284	Am	2N403	Wh		
2N284A	Am	3N22	We		
2N285A	Be	3N29	GE		
2N291	TI	3N30	GE		
2N292	GE	3N31	GE		
2N293	GE	3N32	TI		
2N296	Sy	3N33	TI		
2N297	C	3N34	TI		
2N299	LT	4JD1A17	GE		
2N300	LT	4JD1B3	GE		
2N301	RCA	4JD1134	GE		
2N301A	RCA	4JD4A2	GE		
2N306	Sy	4JD4A3	GE		
2N307	Sy, TS	4JD4A4	GE		
2N308	TI	4JD4A5	GE		
2N309	TI	4JD5A1	GE		
2N310	TI	8D/2N43	Sp		
2N311	GT	8E/2N44	Sp		
2N312	GT	8F/2N45	Sp		
2N313	GE	8G	Sp		
2N314	GE	903/2N117, 2N332	TI		
2N315	GT	904/2N118, 2N333	TI		
2N316	GT	904A/2N118A, 2N334	TI		
2N317	GT	905/2N119, 2N335	TI		
2N318	GT	910/2N336	TI		
2N319	GE	925/3N26	TI		
2N320	GE	926/3N27	TI		
2N321	GE	951/2N339	TI		
2N322	GE	952/2N340	TI		
2N323	GE	953/2N341	TI		
2N324	GE	970	TI		
2N325	Sy	10A	Sp		
2N326	Sy	10B	Sp		
2N327	Ra	10C	Sp		
2N328	Ra	B114	Be		
2N329	Ra	CK751	Ra		
2N330	Ra	CK768	Ra		
2N332	TI	CK870	Ra		
2N333	TI	CK871	Ra		
2N334	TI	CTP1117	C		
2N335	TI	GA52829	WE		
2N336	TI	GA52830	WE		
2N337	TI	GA53080	WE		
2N338	TI	GA53242	WE		
2N339	TI	GA53149	WE		
2N340	TI	GA53233	WE		
2N341	TI	GA53270	WE		
2N342	TI	GET3	GL		
2N343	TI	GET4	GL		
2N344/SB101	LT	GET5	GL		
2N345/SB102	LT	GET6	GL		
2N346/SB103	LT	GET7	GL		
2N347	Bo				

INDEX (Cont.)

GET8	GL	**OC45/2N140**	Mu, Am
GET9	GL	**OC65/2N130**	Am
GET10	GL	**OC66/2N131**	Am
GET15	GL	**OC70**	Mu
GT1	BTH	**OC71**	Mu
GT2	BTH	**OC72**	Mu
GT3	BTH	**OC73**	Mu
GT11	BTH	**OC76**	Mu
GT12	BTH	**OCP71**	Mu
GT13	BTH	**PC6**	Sp
GT14	GT	**RD316**	Bo
GT14H	GT	**SB101/2N344**	Sp
GT20	GT	**SB102/2N345**	Sp
GT20H	GT	**SB103/2N346**	Sp
GT34	GT	**SB5122/2N240**	Sp
GT34HV	GT	**ST10**	Tr
GT34N	GT	**ST11**	Tr
GT34S	GT	**ST12**	Tr
GT35/2N35	GT	**ST13**	Tr
GT74	GT	**ST30**	Tr
GT75	GT	**ST31**	Tr
GT81H	GT	**ST32**	Tr
GT81	GT	**ST33**	Tr
GT81HS	GT	**ST40**	Tr
GT82	GT	**ST41**	Tr
GT83	GT	**ST42**	Tr
GT87	GT	**T0031**	LT
GT88	GT	**T0033**	LT
GT109/2N109	GT	**T1164**	LT
GT122	GT	**TJ1**	IS
GT123	GT	**TJ2**	IS
GT153	GT	**TJ3**	IS
GT167	GT	**TP1**	IS
GT210H	GT	**TP2**	IS
GT222	GT	**TS1**	IS
GT229	GT	**TS2**	IS
GT269	GT	**TS3**	IS
GT758	GT	**TS176/2N242**	TS
GT759	GT	**TS612/2N378**	TS
GT759R	GT	**TS613/2N379**	TS
GT760	GT	**TS614/2N380**	TS
GT760R	GT	**TS615/2N44**	TS
GT761	GT	**TS616/2N381**	TS
GT761R	GT	**TS617/2N382**	TS
GT762R	GT	**TS618/2N383**	TS
GT762	GT	**TS619**	TS
GT763	GT	**TS620/2N64**	TS
GT764	GT	**TS621/2N65**	TS
GT792	GT	**V6-R2**	PYE
GT903	GT	**V6-R4**	PYE
GT904	GT	**V6-R8**	PYE
GT905	GT	**V10-15A**	PYE
GT947	GT	**V10-30**	PYE
GT948	GT	**V10-50B**	PYE
GT949	GT	**V15-10P**	PYE
H38	MH	**V15-20P**	PYE
H4A	MH	**V15-30P**	PYE
H5	MH	**V30-10P**	PYE
H6	MH	**V30-20P**	PYE
H7	MH	**V30-30P**	PYE
H10	MH	**X30A**	Bo
MN13A	Mo	**X31A**	Bo
MN13B	Mo	**X32A**	Bo
MN13C	Mo	**X110**	Be
MN21	Mo	**X113**	Be
MN24	Mo	**X119**	Be
MN25	Mo	**X133**	Be
MN26	Mo	**X134**	Be
MN28	Mo	**X137**	Be
MN29	Mo	**X140**	Be
OC44/2N139	Mu, Am	**X145**	Be
		XD5081/XD5082	Wh

Color Drafting Pencils

Draw Permanent or Temporary Lines

The first of these pencils is called the Non-Print. Its translucent, colored lead makes a line that drops out when a translucent original or master is reproduced by processes such as blueprint, brownprint, and Ozalid. The pencil provides freedom to sketch and make notes on drawings without having to worry about cleaning up before the drawings are reproduced. The pencil has a fine point and supplies a contrasting color that will not fade or smear. The function of another model, called the Lumochrom, is entirely different. The Lumochrom comes in 24 colors, including white, and all of its colors reproduce perfectly. Because of this it enables draftsmen to distinguish quickly between numerous different elements shown on their masters by means of their color contrast.

J. S. Staedtler, Inc., Dept. ED, Hackensack, N.J.

CIRCLE 136 ON READER-SERVICE CARD

Pen-Size Oiler

For Exact Lubrication

Designed like a fountain pen, this oiler delivers exact amounts of oil as small as a fraction of a drop. It operates in holes up to 7/8 in. in depth and other out-of-the-way places ordinarily difficult to reach. The oiler can be used either vertically or horizontally for both holes and surface application. The oil supply is clearly visible in the transparent reservoir, and one filling provides a supply for long periods. In operation, the spring controlled steel point of the unit is pressed against the spot to be oiled, then released. A fraction of a drop is thus automatically ejected, and if more is required, repeated pressing will deliver the exact amount.

Dill Mfg. Co., Dept. ED, 700 E. 82nd St., Cleveland, Ohio.

CIRCLE 137 ON READER-SERVICE CARD

CIRCLE 138 ON READER-SERVICE CARD ➤

THE LOCKHEED X-17 TEST MISSILE
The X-17 provides information on the problems which arise when the warhead of a ballistic missile re-enters the earth's atmosphere at high speed.

Rheem

7777 Industry Avenue, Rivera, California

New Products

Thermocouple

Higher Voltage Output

The Super-Clad thermocouple is said to generate greater electrical output than standard thermocouples. The unit, which is interchangeable on all standard pilots, is designed to eliminate service calls caused by pilot outages and to insure positive holding action. Improved thermo-electric alloys are used to gain increased voltage output. The plating protects the copper from heat and prevents oxidation. The unit has 24 cooling fins to create a greater temperature differential. Tin plating on the contact end provides good electrical conduction.

Robertshaw-Fulton Controls Co., Dept. ED. Grayson Controls Div., Long Beach 5, Calif.

CIRCLE 141 ON READER-SERVICE CARD FOR MORE INFORMATION

Wire Markers

Aluminum Foil

Speedy Marx, aluminum foil wire markers, are furnished on quick-release dispensing cards which have been precut for easy handling, and can be applied instantly without tools. Flexible aluminum markers offer users double sticking action. A thermosetting adhesive retains its bonding action up to temperatures of 350 F, and the mechanical action of the aluminum as it wraps around wiring will remain unaffected by solvents, grease or coolants. Large diameter wire and cable, or pipe and tube, can be coded with aluminum markers. A transparent plastic coating is applied to marker surfaces after imprinting to protect symbols against abrasions, water or dirt. Two sizes are available: 1-1/2 in. markers for wires over 1/4 in. OD, 3/4 in. markers for wires under 1/4 in. OD. Special sizes, shapes and colors can also be furnished.

North Shore Nameplate, Inc., Dept., 214-27 Northern Blvd., Bayside 61, N.Y.

CIRCLE 142 ON READER-SERVICE CARD FOR MORE INFORMATION

Pulling Elbow

For Corner Wiring

The Pulling Elbow permits easy wiring. Wires are slipped straight through conduit and out one hub. A big loop of wires is made and again pushed through hub and conduit. The wires are pulled out from the other end of system. The cover attaches quickly with big screws and will open easily. The Elbow is made of top quality malleable iron with heavy cadmium plated finish. Full neoprene gaskets and large cover screws designed to fit snugly in opposed corners without protruding inside. In addition, the cover is domed for greater rigidity and provides more wire area inside elbow. Smooth ground surfaces provide better cover and gasket seal. Hubs have precision tapered pipe threads and are positioned exactly 90 deg from center. The smooth inside surfaces eliminate the possibility of skinning insulation on wire when it is pulled through electrical system.

Ideal-Simplet Fittings, Inc., Dept. ED, 5098 Park Ave., Sycamore, Ill.

CIRCLE 144 ON READER-SERVICE CARD FOR MORE INFORMATION

Sweeping Oscillator

Sweeps I-F's to 280 Mc

A broadband sweeping oscillator with six switched bands, the Rada-Sweep Sr. has 24 precise crystal markers set at customer specified frequencies. Center frequencies are from 1 to 260 mc. The instrument is designed and built for sweeping radar i-f units up to 280 mc.Rf output: 0.5 v rms into nominal 70 or 50 ohms. Higher for lower frequency units. Output held constant to within ± 0.5 db over widest sweep by agc circuit. Attenuators: switched 20 db, 10 db, 2 db plus continuously variable 6 db. A true zero base line produced on the oscilloscope during retrace time. Sweep output: sawtooth synchronized with sweeping oscillator.

Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N.J.

CIRCLE 145 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Subminiature Capacitors

High Temperature

Deltaply 165 subminiature capacitors operate reliably over the temperature range —65 C to + 165 C. As an example of the size, a 1.0 mfd., 200 v unit requires 3.8 cubic inches. The same unit in teflon requires 6.4 cubic inches. Capacitance change over the full temperature range will amount to less than 9 per cent. Insulation resistance in megohms x microfarads varies from 200,000 at 250 C. The self-healing, metallized, plastic film provides unusually long life at 165 C with no voltage derating. Capacitance values from .001 to 10.0 mfd., may be obtained in hermetically sealed metal tubes or double-lock seal tubular cans. The smaller sizes are also available uncased. Standard voltage ratings are 200, 400 and 600.

Dearborn Electronics Labs., Dept. ED, 1421 N. Wells St., Chicago 10, Ill.

CIRCLE 149 ON READER-SERVICE CARD FOR MORE INFORMATION

Inductor Timing Motor

30 Oz-In. at 1 Rpm

A permanent-magnet synchronous motor with guaranteed torque of 30 oz-in. at 1 rpm and 60 cps is designed for a variety of timing applications. Basic features include: total enclosure to seal out dust, dirt and other breakdown materials; a controlled lubrication system; and the ability to operate in any position. Rotor speed of 450 rpm makes it possible to reduce the gear train and insure quieter operation and durability. The inductor motor is available with output shaft speeds from 1 to 60 rpm, for 120 and 240 v operation at 50 and 60 cps. Models for either clockwise or counterclockwise rotation can be supplied.

Haydon Mfg. Co., Dept. ED, 245 E. Elm St., Torrington, Conn.

CIRCLE 150 ON READER-SERVICE CARD FOR MORE INFORMATION

1 KVA Voltage Regulator

Magnetic Type

Type TM7101 has an accuracy of 1 v band for line voltage variations and/or load magnitude or power factor changes. Load is rated at 1 kva. Input is 95 to 135 v, single phase, 60 cps, and output is 115 v nominal, adjustable from 110 to 120 v. It is suited for applications where little or no attention is possible, such as microwave relay stations and remote installations, where a tube or transistor malfunction and replacement can be costly or not immediately possible.

Cabinet model is a self-contained portable assembly that can be carried to laboratory test apparatus or factory operation.

The Superior Electric Co., Dept. ED, 83 Laurel St., Bristol, Conn.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

Speed/Torque Unit

1-6 Output Speeds

The new Servo-Speed/Torque-Unit, an experimental gear set, may be used with the manufacturer's Servo-Kit and other servo equipment. A complete set of change gears is supplied which enables the user to select any one of six output speed and torque values. There are two models, one for each of the two Barcol motors which are supplied with the Servo-Kit. Provision is made for mounting a 3/8 in. bushing mount potentiometer, coupled directly to the output shaft. Mounting adapters can be furnished so that the units may be used with any of the other popular makes and types of servo motors and transducers.

Servo Systems Co., Dept. ED, 55 Meeker Ave., Newark 12, N.J.

CIRCLE 153 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Equipment Mount

Temperature Resistant

This mounting features load capacitance above 60 lb, temperature resistance from −80 to +250 F, vibration isolation in severe operating conditions. The Temproof mounting is designed to meet the requirement of MIL-C-172B and is self damping in its resonant range. Mountings support loads in either the upward or downward direction.

Lord Manufacturing Co., Dept. ED, Erie, Pa.

CIRCLE 157 ON READER-SERVICE CARD FOR MORE INFORMATION

Resolver

1.062 In. Diam

Measuring 1.062 in. diam, size 11 resolvers are offered with a functional accuracy of better than 0.1 per cent. Compensated units are provided for use in systems performing over a wide temperature range. Both compensated and uncompensated resolvers are available in a range of 400 to 16 cps models.

Reeves Instrument Corp., Dept. ED, 207 E. 91st St., New York 28, N.Y.

CIRCLE 158 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Clip

Beryllium Copper

This transistor clip is designed to retain all popularly used transistors under conditions of severe acceleration, deceleration, shock and vibration. Made from tempered beryllium copper, the transistor clip performs a dual function of retention and heat dissipation. Offered in a choice of cadmium, black ebanol or silver plate, clips are available in many sizes and modifications.

The Birtcher Corp., Dept. ED, 4371 Valley Blvd., Los Angeles 32, Calif.

CIRCLE 159 ON READER-SERVICE CARD FOR MORE INFORMATION

Bolometers and Thermistors

Broadband Disc Type

Two broadband disc bolometers for coaxial detectors, Models N603 and N603-4.5, covering the frequency range of from 500 to 10,000 mc, and a broadband disc thermistor, Model N335, covering the same frequency range, have been developed. The Model 603 bolometers consist of two 100-ohm Wollaston wire bolometer elements mounted on a mica disc. The mica discs incorporate the rf bypass capacitor for the ungrounded end of the bolometer as well as a blocking capacitor at the central junction between the 100-ohm elements. This provides rf contact to the transmission line center conductor while blocking the bias current. The elements are in series to present a 200-ohm resistance to the external dc or af bias circuits and are arranged to be in parallel in the rf transmission line, thus acting as a 50-ohm termination.

The Model N335 thermistor is specifically designed for use with the Model 561 coaxial bolometer mount for microwave power measurements. The thermistor is used with microwave power meters capable of supplying the necessary 12 to 15 ma bias to measure power levels from 0.01 to 10 mw. Because of the long time constant, approximately 1 sec, the thermistor is particularly suited to measurement of pulsed signals. It is not susceptible to burnout, but in any case is readily replaceable and does not require tuning.

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

CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

RF Preamplifier

35 and 50 Db Gain

Model 1 provides a gain of 35 db at band center and Model 2 provides 50 db, both with a maximum noise figure of 3.5 db. Frequency response is within 3 db over the band of 215-247 mc. The unit occupies a volume of 1/3 cu ft and weighs less than 3-1/2 lb.

Radiation, Inc., Dept. ED, P.O. Box 37, Melbourne, Fla.

CIRCLE 161 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Electromechanical Counter

300 Million Counts

A life of 300 million counts, count rate up to 60 per sec, either electrical reset or manual reset by a single-stroke push bar, and switch readout circuitry are features of an electro-mechanical counter. The unit adds, subtracts, and totalizes. If add and subtract pulses are received simultaneously, a zero count results. It is not necessary to have any specific sequence of add or subtract impulses, nor will the counter jam from an incomplete pulse. The totalizer will operate best with a counting–pulse ratio of 50 per cent on, 50 per cent off. While a square wave pattern for the pulse shapes is best, the totalizer will handle a wide variety of pulse shapes providing the leading edge of the wave is reasonably steep.

Autron Engineering, Dept. ED, 1254 W. Sixth St., Los Angeles 17, Calif.

CIRCLE 165 ON READER-SERVICE CARD FOR MORE INFORMATION

Sampling Switch

High Speed

A precision switch having radial terminals designed for military and commercial applications is available with one or two poles and up to 120 shorting channels or 60 non-shorting channels per pole. The switch is easily adapted to a variety of motor drives. It is equipped with a precision machined ball bearing output shaft, constant force perma brushes and lifetime semi-molded contact plates for long service free life. Approximate dimensions are 2.620 in. diam x 1.332 in. length plus hub extension 3/4 in. diam by 1/2 in. length and shaft 1/4 in. diam by 3/4 in. length. Applications include special oscilloscope displays, error indicating systems, and multichannels data systems.

General Devices, Inc., Dept. ED, P. O. Box 253, Princeton, N.J.

CIRCLE 166 ON READER-SERVICE CARD FOR MORE INFORMATION

VHF Directional Antenna

Gain of 23 Db

For 100 to 500 mc use, this directional antenna has a low vswr at any frequency in the band, accomplished through a rear adjusting balun and reflector assembly. The model CF-121M is a 12 ft. diam. antenna and utilizes a dipole exciter. Gain is 23 db or better at 500 mc, with minimum side lobes and cross polarization of 20 db or better. The antenna is of lightweight, all-aluminum mesh construction, fully weatherized and corrosive resistant. It is available in both the 12 ft. diam model CF-121M, and a 14 ft. diam model CF-141M.

Ainslie Corp., Dept. ED, 312 Quincy Ave., Quincy, Mass.

CIRCLE 129 ON READER-SERVICE CARD FOR MORE INFORMATION

X-Band Stabilization System

High Short-Term Stability

In combination with the VA-201B Klystron, the BA-1280B Stalo Cavity achieves a short term frequency stability of better than one part in a billion. The stabilization factor of the cavity is completely independent of the oscillator fluctuations or external disturbances. According to the manufacturer, this feature provides an advantage over stabilization systems utilizing the feedback principle. The elimination of all electronic components except the klystron oscillator provides reliability and longer life. The cavity tunes over the range of 8200 to 10,000 mc, depending on the klystron used. A method is utilized to suppress all undesired modes within this range.

Varian Assoc., Dept. ED, 611 Hansen Way, Palo Alto, Calif.

CIRCLE 130 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Air Dielectric Cable
Low Capacitance

This Teflon-air dielectric coaxial cable has a nominal overall diameter of 0.22 in. The conductor is No. 30 AWG, 7/38 silver plated copperweld. A choice of outer jackets include Teflon, lacquered nylon braid, and Teflon or silicone impregnated glass braid. The low attenuation of the 10 μμf cable makes it useful for high frequency, low level applications and as a low capacitance probe. Capacitance values of less than 10 μμf, with somewhat larger overall diameters are also available on request.

Flexibility is one of the features of the coaxial cable. Among the other characteristics are solderability, light weight, small size, and ready adaptation to a variety of connectors.

Tensolite Insulated Wire Co., Inc., Dept. ED, 198 Main St., Tarrytown, N.Y.

CIRCLE 173 ON READER-SERVICE CARD FOR MORE INFORMATION

DC Power Supply
200 to 325 v, 0 to 100 ma

Continuously variable output from 200 to 325 v dc for load currents of 0 to 100 ma can be obtained from the Model 3. Regulation is better than 1 per cent for loads of 0 to 100 ma and line voltage variations from 105 to 125 v. Ripple is less than 10 mv rms. Both positive and negative sides of the ouput are isolated from ground. Either side may be grounded or the output may be left floating. An isolated output of 6.3 volts ac at 3 amp is available at the output terminal connections. Net weight is approximately 20 lb, and it measures 5 wide, 7 high, and 16 in. deep.

Associated Specialties Co., Dept. ED, 1751 Main St., Orefield, Pa.

CIRCLE 174 ON READER-SERVICE CARD FOR MORE INFORMATION

Snap-In Vise

For Connectors

Round connectors are securely held during soldering operations by the Model V-3 Snap-in Vise. A spring loaded jaw provides the necessary pressure to hold the connector. Adjustment of the vise for any desired diameter may be done quickly. Once this adjustment is made, slight pressure on a lever engages or disengages the connector from the vise. This feature is especially useful in production assembly where repetitive operations are carried out.

Jaws are covered with a tough non-skid cork and synthetic rubber compound which protects threaded portions from damage. The vise can be adjusted anywhere within an arc of 180 deg. Connectors up to 2 in. in diam. are tightly held in the vise. Screws are provided for easy mounting on a work bench or plywood base.

Western Electronic Prod. Co., Dept. ED, 655 Colman St., Altadena, Calif.

CIRCLE 176 ON READER-SERVICE CARD FOR MORE INFORMATION

Standard and Null Meter

Model 301

This variable DC standard and null meter, Model 301, utilizes a chopper stabilized circuit which constantly compares the output with an internal standard cell to provide stability and accuracy. Direct-reading, calibrated dials provide instant voltage selection. Power supply output voltage is 1 to 501 v at up to 20 ma. It has 4 decaded null meter ranges from 50 v to 501 mv full scale. The meter can also be used to read input voltage or the output voltage of the supply. The unit features 0.01 per cent stability, 0.2 per cent accuracy, 0.022 per cent line and load regulation, less than 100 mv ripple, 0.2 msec response time, and less than 0.01 output impedance.

Kin Tel, Dept. ED, 5725 Kearny Villa Rd, San Diego, Calif.

CIRCLE 177 ON READER-SERVICE CARD FOR MORE INFORMATION

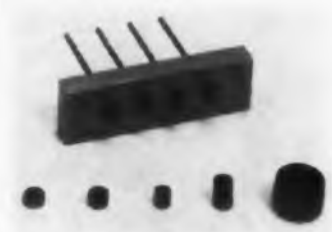
New Products

Rate Gyroscope
Miniature

Known as the Golden Gnat Rate Gyro, Type GX has the following features: size of 1 in. diam, 2-1/4 in. length; weight of 3.8 oz; range of full scale rates up to 600 deg per sec; threshold and resolution of 0.01 deg per sec; inertia ratio of 0.00045 sec (ratio of gimbal inertia to angular momentum); temperature-compensated viscous damping for controlled dynamic performance; variable reluctance pickoff for high signal-to-noise ratio with infinite pickoff resolution; linearity of 0.1 per cent of full scale to 1:2 range, within 2 per cent to full range; ambient temperature range of −55 to +85 C; linear vibration of 10 g peak, 0 to 2000 cps; linear acceleration up to 100 g depending upon range; and shock up to 100 g depending upon range.

Minneapolis-Honeywell Regulator Co., Dept. ED, Boston Div., 1400 Soldiers Field Rd., Boston 35, Mass.

CIRCLE 181 ON READER-SERVICE CARD FOR MORE INFORMATION



Ceramicite
For Hermetic Seals

Ceramicite is a leak-tight ceramic hermetic seal used in relay bases, transformer bases, transistor bases, diode closures and other such component in continuous operation at temperatures up to 700 F. The heating required by the sealing process causes changes in the linear expansion properties of the materials resulting in a common coefficient permitting crystalline migration between interfaces of the materials involved during the cooling cycle. Thus an actual molecular bond exists between the metal and the Ceramicite. Ceramicite is available in two forms: as pre-formed pieces, ready for firing by the user in fabrication of seal components and as completed seal components, such as single and multiple pin terminals and headers.

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

CIRCLE 182 ON READER-SERVICE CARD FOR MORE INFORMATION

Punched Card Sensor

Multiple Switching Device

This static reader for punched cards, a multiple switching device that simultaneously senses the entire card, is adaptable to any combination of 540 switching operations. The card reader accepts a standard punched-card with 540 holes, arranged 12 wide by 45 high, which is read or sensed when the handle is closed. In each hole position is a spring-loaded pin and a corresponding normally closed switch with each side isolated. The pin remains static where there is a hole in the card. Where there is not a hole in the card the pin moves forward and opens the corresponding switch. The card reader measures approximately 6-1/4 x 10-1/4 x 9 in., and weighs 18 lb. It may be installed in any circuitry by means of standard connectors.

Metron Corp., Dept. ED, Union and Elm Sts., Lambertville, N.J.

CIRCLE 184 ON READER-SERVICE CARD FOR MORE INFORMATION

Variable Delay Line

Model 502

This continuously variable delay line, Model 502, is designed for use as a component or as test equipment in advanced computer and radar systems. The entire delay range, from zero to maximum delay, is covered by a single control shaft, in ten turns. The unit may be locked at the desired delay by a locking device which is available from the manufacturer. It can then be used as a component in equipment with a fixed delay, or as a continuously variable test unit. Attenuation in the new unit is 1.2 db. Resolution is better than 1/1000 of maximum delay. Termination is external. Maximum delay is 2.0 μsec. Maximum rise time is 0.38 μsec. Impedance is 470 ohms. Outside dimensions are 7 1/4 x 1 x 1 5/8 in. Four other variable delay lines which feature maximum delays from 0.9 to 15.0 μsec., Maximum rise times from 0.18 to 2.8 μsec., and impedance from 56 to 1000 ohms are available.

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

CIRCLE 185 ON READER-SERVICE CARD FOR MORE INFORMATION

Dearborn

polystyrene capacitors

worth their weight in GOLD!

You'll find Deltaply "85" capacitors ideal for applications involving such critical factors as small uniform capacitance change with temperature . . . high Q . . . very high insulation resistance . . . very low dielectric absorption . . . and high stability. The "85" offers exceptional electrical properties in temperature range —55°C to +85°C. Temperature-capacitance co-efficient is —120 PPM/°C and is very nearly linear. Insulation resistance in megohms x mfd. varies from 10 million at 25°C to 200,000 at 85°C.

Capacitance values from .0001 to 10.0 mfd. are available in hermetically sealed metal tubes or CP-70 cans in six standard voltage ratings from 50 to 1000 volts.

WRITE FOR BULLETIN RL-1

DEARBORN ELECTRONIC LABORATORIES
1421 NORTH WELLS STREET • CHICAGO 10, ILLINOIS

CIRCLE 188 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Packaged Power Supply

Hermetically Sealed

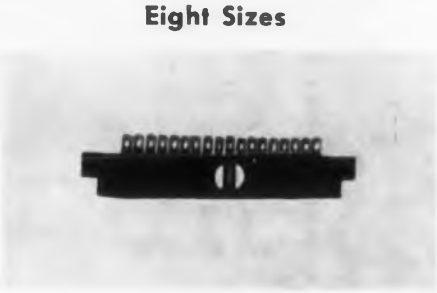
These hermetically sealed high voltage power supplies are convenient means of supplying high voltage to devices such as cathode ray tubes, oscilloscopes, TV equipment, and precipitators. The units are made by hermetically sealing all components in a metal can with suitable insulating oil. The advantages of this unitized power supply are greater reliability, long use life, more compactness and greater convenience. Different models give output voltages of 2 kv at 2 ma, 5 kv at 5 ma, 10 kv at 1 ma, 15 kv at 1 ma, 30 kv at 1 ma, and 50 kv at 1 ma.

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

CIRCLE 189 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Connectors

Eight Sizes



These printed circuit connectors are available in eight different sizes, 6, 8, 10, 12, 15, 18, 22 and 38 and feature .058 wide coined beryllium copper contacts, heat treated to retain contact force after hundreds of insertions. Wide contact pads insure minimum abrasion under maximum contact force. Excessive contact mass insures lower heat rise at rated loads. Barriers between terminals insure high voltage break down ratings exceeding 2500 v rms at sea level and 700 v rms at 60,000 ft. Present models are available for printed circuit board thicknesses from .061 to .071. Polarizing pins may be located in any slot desired. Materials and construction match requirements called out in MIL-C-8384.

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

CIRCLE 190 ON READER-SERVICE CARD FOR MORE INFORMATION

Protective Coating

Dip Applied

A strip-off plastisol coating for the protection of metal parts and products can be applied by heating the parts and dipping them in the plastisol. The plastisol can be peeled off readily by hand and serves as a protective coating for any metal parts which are subject to rust, corrosion, dirt or damage while in storage or transport. The coating provides resilient cushioning which reduces shock and breakage, and is a defense against nearly all chemicals including most acids, alkalis and solvents. It also has high thermal and electrical insulating qualities and is completely unaffected by extreme cold or hot weather. It resists mold, mildew, salt air and water and is not deteriorated by time or exposure.

Auburn Button Works, Inc., Dept. ED, Chemical Div., Auburn, N.Y.

CIRCLE 193 ON READER-SERVICE CARD

Teflon Film

Thin Film Laminate

Type CSC cast Teflon film is a cured, semicured film or Teflon in its sintered and partially sintered forms. It is comprised of a composite laminate of a minimum 2 mils of fully-cured cast Teflon superimposed by a 0.25-mil layer of semicured Teflon in particulate form bonded together to resist normal handling. Final insulation thickness is maintained after fusion because of the use of fully-cured Teflon. It is also offered in a 1.25-mil thickness. Suggested applications may include high-temperature wire insulation or the construction of thin-wall flexible Teflon tubing. Available in continuous roll lengths of 100 and 500 ft, in widths from 1/4 to 1 in. in increments of 1/16 in. Packaged on 3-in. ID cores.

Dilectrix Corp., Dept. ED, Allen Blvd. and Grand Ave., Farmingdale, N.Y.

CIRCLE 194 ON READER-SERVICE CARD

CIRCLE 195 ON READER-SERVICE CARD ➤

New Products

Power Rectifier Junctions

330 Amp

This 330 amp germanium power rectifier junction is one of a series of six rated at 330 amps rectified output current with voltage ratings from 20 to 66 v rms. These low current density high capacity junctions have corrosion and moisture resistant cast-aluminum housings with airfoil type cooling fins for maximum heat dissipation. The unit size is 4 3/32 x 3 x 3 1/4 in. Six 330 amp germanium junctions connected in a three-phase bridge circuit will deliver 85 kw, (1,000 amps @ 85 v) while occupying 1/2 cu ft of space. Its efficiency rating is to 98.5 per cent.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 198 ON READER-SERVICE CARD FOR MORE INFORMATION

Double Stub Tuner

Locking Collets

This double stub tuner, Model DS-1-12, has an impedance of 50 ohms and a frequency range of 1000 to 12,000 mc. A pair of collets locks the tuner securely in any pre-set position. The device employs silver plated contact springs, rugged stub junction construction and smooth acting, non-slip tuning elements. The tuning elements can be furnished with or without collet-type locking caps. The hex shaped body of the tuner facilitates holding or mounting in any position.

Uniwave, Inc., Dept. ED, 2 Marine St., Farmingdale, N.Y.

CIRCLE 199 ON READER-SERVICE CARD FOR MORE INFORMATION

Phasemeter
60 Cps-20 Kc

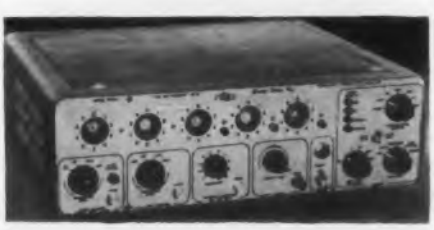
The PM-1B Phasemeter offers accurate measurement and calibration of phase relationships in complete systems and in electronic instrumentation at audible and supersonic frequencies. Featuring a passive system utilizing neither tubes nor semiconductors, the PM-1B phasemeter will retain its calibration accuracy of better than $\pm$ 1/2 deg for very extended periods. The meter is available in two models: a single frequency unit which can be provided for any single frequency between 60 cps and 20 kc; and a three frequency unit which can be provided for any three selected frequencies between 60 cps and 20 kc. Continuous measurement of the phase angle from 0 to 360 deg may be obtained, while lead and lag angles may be measured directly from any reference desired. High impedance input with low impedance output; a large direct reading dial with adjustable zeroing and a constant amplitude output are other features.

The size of the unit is 7 x 7 x 7 1/2 in. and it weighs approximately 6 lbs.

Statham Development Corp., Dept. ED, 12411 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 203 ON READER-SERVICE CARD FOR MORE INFORMATION

Frequency Interval Meter
Period and Time



Model 7550B features only one glow transfer counting tube per decade for both counting and indication, 200 mv input sensitivity, a self-test function switch for checking internal time base and counter decades, measuring capacities from 0.1 to 100 kc and 10 μs to 1.5 days, and a counter tube life expectancy of over 10,000 hours. Applications include flow measurement, filter characteristic determination, oscillator calibration, rpm monitoring, and timing of physical events.

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

CIRCLE 204 ON READER-SERVICE CARD FOR MORE INFORMATION

AMERICAN ELECTRONICS, INC.

ANNOUNCING
RADIFLO

...a revolutionary system for detecting leaks in transistors, diodes and other sealed units for pennies each!

RADIFLO offers a vast improvement over present leak detection methods because it measures the leak after the final sealing operation is completed. RADIFLO eliminates most of the expensive labor cost... *yet gives the same or greater accuracy in a fraction of the time!*

Here is how RADIFLO works. One or many parts are immersed under pressure in an inert, non-toxic radioactive gas. After air washing, the parts are passed over a scintillation counter which measures the molecular leakage to a normal sensitivity of one cc per 500 years.

Tests have shown that transistors can be checked at a cost as low as two cents each with corresponding savings on other types of parts. RADIFLO can also be easily set up on an assembly line for automatic parts inspection.

Even the initial cost of RADIFLO is low. Why not write today for complete technical information to Dept. No. 734Jy.

AMERICAN ELECTRONICS, INC.

655 W. Washington Blvd. Los Angeles 15, California

Have you heard about the amazing engineering opportunities at AMERICAN?

CIRCLE 205 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Concentric Dial Assembly

Separate or Geared Inputs

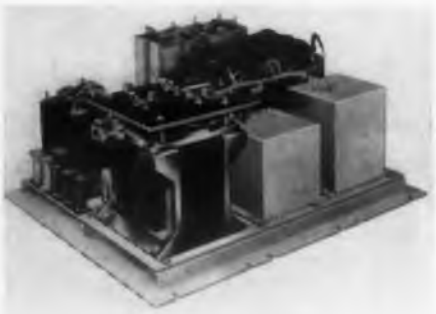
This low inertia concentric dial assembly may be mounted so that the dial face is either parallel or perpendicular to the mounting surface. Input can be made perpendicular to the axis of rotation of the dial by the incorporation of a pair of miniature spiral mitre gears. Separate inputs to the two dials are provided permitting the comparison of two separate readings. Gears used are AGMA Class II. A hair-line indicator ensures accurate dial reading The dial assembly is a two-speed indicator, with standard ratios of 10:1 or 36:1 available. Other ratios are available on special order.

Reeves Instrument Corp., Dept. ED, 207 E. 91st St., New York 28, N.Y.

CIRCLE 208 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Voltage Regulator

5 KVA



The 5 kva automatic voltage regulator type TM7105 is designed for an input of 95-135 v, and an output of 115 v nominal, adjustable from 110-112 v. The accuracy of the unit is 1 v band for line voltage variations and/or load magnitude and power factor changes. It has a waveform distortion of 4 per cent maximum and a response time of less than 1/2 sec for ordinary line and/or load changes. The size is 21-9/16 x 19 x 12-3/16 in., weighing 215 lbs. Both input and output connections are made to the terminal board inside the cabinet.

Superior Elec. Co., Dept. ED, 83 Laurel St., Bristol, Conn.

CIRCLE 209 ON READER-SERVICE CARD FOR MORE INFORMATION

Low Voltage Power Supply

Regulation ± 0.2 Per Cent

These telemeter and strain gauge power supplies are designed for 400 cps operation, but are also available for 60 cps circuits. Hermetically sealed, the supplies have no moving parts and are self-protected for shorted output. Characteristics include a regulation of ±0.2 per cent, ripple of 1 per cent rms, recovery time of 0.5 sec, and a variety of outputs. Gulton Industries, Inc., Dept. ED, Engineered Magnetics Div., Metuchen, N.J.

CIRCLE 213 ON READER-SERVICE CARD

Modulators and Demodulators

For Tape Systems

FM-1A Modulators and FD-1A Demodulators are available for use with the modulator tape recording systems. The modulator produces an fm carrier suitable for magnetic tape recording and data transmission from a low-frequency signal. Each unit requires less than 6 ma at 180 v dc and 0.6 a at 12 v dc. Carrier output level is 100 v across 100,000 ohms; demodulator output level is 1 v across 20 K.

Electrodynamic Instrument Corp., Dept. ED, 2508 Tangley Rd., Houston 5, Texas.

CIRCLE 214 ON READER-SERVICE CARD

High Voltage Terminals

15 Kv to 50 Kv

Terminals in the 15 kv to 50 kv range have been developed. In addition to standard items, complete facilities to build custom terminals are in operation. The terminals are all twist-free, gasket type, and feature oil-filled design. Emphasis has been placed on raising the corona threshold.

Sphere Co. Inc., Dept. ED, Eagle Rock Bldg., 25 Amity St., Little Falls, N.J.

CIRCLE 215 ON READER-SERVICE CARD

MOTOR OPERATED

Available SP2T thru SP6T—also DPDT and DP transfer. Frequencies thru 11,000 MC. AC or DC operation.

MANUALLY OPERATED

—same contact arrangement and R F head as the 1460 Series. For chassis or panel mounting.

TRANSCO

COAXIAL SWITCHES

SOLENOID OPERATED

Miniature - SPDT

HN or Type N connectors. Frequencies thru 11,000 MC. AC or DC operation. Weight 6 oz.

—they simplify design of R F systems

With TRANSCO switches, you can cut down the number of components in a system—one switch handles up to 6 circuits. TRANSCO switches are small, and light in weight. Each is supplied in a choice of configurations to simplify installation.

Adds versatility to a system. All channels on a TRANSCO can be operated independently, and there's a wide variety of make-and-break arrangements available. TRANSCO switches operate through 11,000 MC —a standardization which cuts your stocking requirements to only one switch for this entire R F band width

High-efficiency switching is due to minimum insertion loss, low VSWR, and high isolation between channels. TRANSCO units are qualified to applicable military specifications. Performance has been fully confirmed in the field, where thousands of units are giving dependable service.

Technical data on any unit or the complete line sent on request. Send us your coaxial switching problems.

PROJECT ENGINEER OPENING FOR R. & D. ELECTRONICS

Engineer on Microwave Antenna Systems with Southern California leader in Avionics. Excellent company benefits. Address inquiries to Personnel Director.

TRANSCO PRODUCTS, INC.

The Finest in R F System Components

12210 NEBRASKA AVENUE, LOS ANGELES 25, CALIFORNIA

REPRESENTATIVES IN MAJOR AREAS

CIRCLE 227 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Logarithmic Counter

5 Decades

This logarithmic count rate meter, based on the Cooke-Yarborough circuit, is a wide-range instrument for use with all types of radiation detectors. Typical applications include gamma monitoring with scintillation counter, beta-gamma monitoring with Geiger counter, and gamma ray spectrometry. It incorporates a Schmidt trigger circuit for discrimination. The meter eliminates the necessity of manual or electro-mechanical switching as is required in linear-type rate meters. The meter circuit consists of a series of diode pump circuits where the signal is fed into a coupling condenser which charges through one diode and discharges through another into an integrating capacitor once each cycle. Range is from 10 to 1 million counts per min. in 5 decades on a single scale. Accuracy is within ± 2 per cent over the entire decade and is better than 1 per cent in the vicinity of the calibration point. Drift is less than 1 per cent in 24 hours. The unit operates on 150 v, 60 cycles and draws 135 w. Relay rack panel is 8-3/4 x 19 in. and shipping weight is 60 lb.

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

CIRCLE 218 ON READER-SERVICE CARD FOR MORE INFORMATION

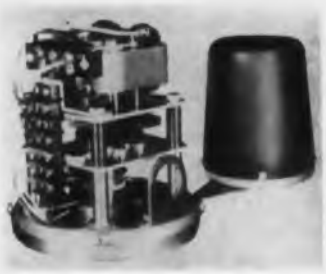
Utility Oscillator

4.5 to 220 Mc Range

Incorporating self-contained attenuators, power supply and output meter, the Utilator provides a high level rf output agc controlled for ±0.5 db flatness over the 4.5 to 220 mc range. A direct reading frequency dial is accurate to ±1 per cent. Rf output is 0.7 v rms into nominal 75 ohms. Attenuation is produced by switched steps of 20, 10 and 6 db, plus continuously variable 6 db. The instrument weighs 19 lb.

Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N.J.

CIRCLE 219 ON READER-SERVICE CARD FOR MORE INFORMATION



Control Gearmotor

Built-In Potentiometer

Shaftrol, shaft mounted gear motor includes a built-in potentiometer that provides remote control for valves, variable speed drives, gates, jacks, and variable displacement pumps. The potentiometer may also serve in bridge circuits of automatic control systems. Control may be by dial control, by push button or it may be automatic from limit switches, controllers or proportioning devices. The mounts on shafts from 1/4 to 1 in. in diam. A wide range of operating speeds and torques can be had by specifying the desired ratio of the 3 or 4 stage reduction gearing. A variety of potentiometer gear ratios may also be had so that full scale deflection of the calibrated meter may be obtained for rotation of the driven shaft from 1/6 revolution to 40 or more. Limit switches, which are optional, may be set to limit travel to any desired amount. Shaftrols can be furnished with built-in single or multi-turn precision potentiometers having a wide range of specifications. When the potentiometer is used as a part of a bridge circuit, the standard Shaftrol provides follow-up accuracies of plus or minus 1/5 per cent of full scale. With precision multi-turn potentiometers accuracies of 1/25 of 1 per cent can be had with counter read out if preferred. Shaftrols are available for use on single or 3 phase circuits with drip proof, totally enclosed or explosion proof enclosures.

Jordan Co., Inc., Dept. ED, 3235 W. Hampton Ave., Milwaukee 9, Wis.

CIRCLE 223 ON READER-SERVICE CARD FOR MORE INFORMATION

Spin-Lock Nuts

Will Not Loosen

Spin-lock unts combine the function of nut and lock washer in one piece. Available in sizes ranging from no. 8 to 1/2 in., the nut provides a rachet-like structure on its base which bites into the bearing surface of the metal to be joined, resisting any tendency to loosen. The teeth provide excellent contact for electric equipment. The nuts are hardened to make them capable of carrying heavy loads, and the teeth are not deformed by use.

Russell, Burdsall & Ward Bolt and Nut Co., Dept. ED, Port Chester, N.Y.

CIRCLE 224 ON READER-SERVICE CARD FOR MORE INFORMATION

AN OPPORTUNITY AND A CHALLENGE
FOR COMPONENT AND SYSTEMS DESIGNERS

SIMPLIFY AND INCREASE SYSTEM RELIABILITY

BY DESIGNING TO CHARACTERISTICS OF LOW IMPEDANCE A-C DIFFERENTIAL TRANSFORMERS

infinite resolution • no sliding contact nor bearings
frictionless • unlimited life, nothing to wear out
temperature stable • high signal to noise ratio
small, compact, lightweight

Recommended for hydraulic servo valve feedback, rate gyros, accelerometers, hydraulic servo motors, pressure, flow, position and level detectors, Atcotran Differential Transformers are setting the pace for improved reliability of components in existing systems by replacement of sliding contact pickups.

New systems designs incorporating the full advantage of inherent characteristics of these transducers promise outstanding benefits:

1) The low impedance characteristics of differential transformers can reduce or eliminate the need for filter circuits.

2) Ratio winding techniques and simple interconnection for algebraic functions frequently can be accomplished without intermediate components.

3) The reliability and precision of differential transformers makes possible a new order of performance.

EXPERIMENTAL KIT

To enable designers to familiarize themselves with the application of differential transformers in the laboratory, the Atcotran Differential Transformer Experimental Kit has been made available. It contains seven standard coils of various characteristics, a flexure plate and clamp, a demodulator and a 32-page HANDBOOK containing theory and application data on differential transformers.

A $324.00 value specially priced at only $189.50 for lab investigation.

Start exploring this new opportunity now. Order your kit today.

atc®

THE WORLD'S LEADING DESIGNERS AND MANUFACTURERS OF LOW IMPEDANCE DIFFERENTIAL TRANSFORMERS

AUTOMATIC TEMPERATURE CONTROL CO., INC.
SUBSIDIARY OF SAFETY INDUSTRIES, INC.
5239 Pulaski Avenue, Philadelphia 44, Pa.

Please send me an Atcotran Differential Transformer Experimental Kit and invoice $189.50 against our purchase order No._____

NAME_____

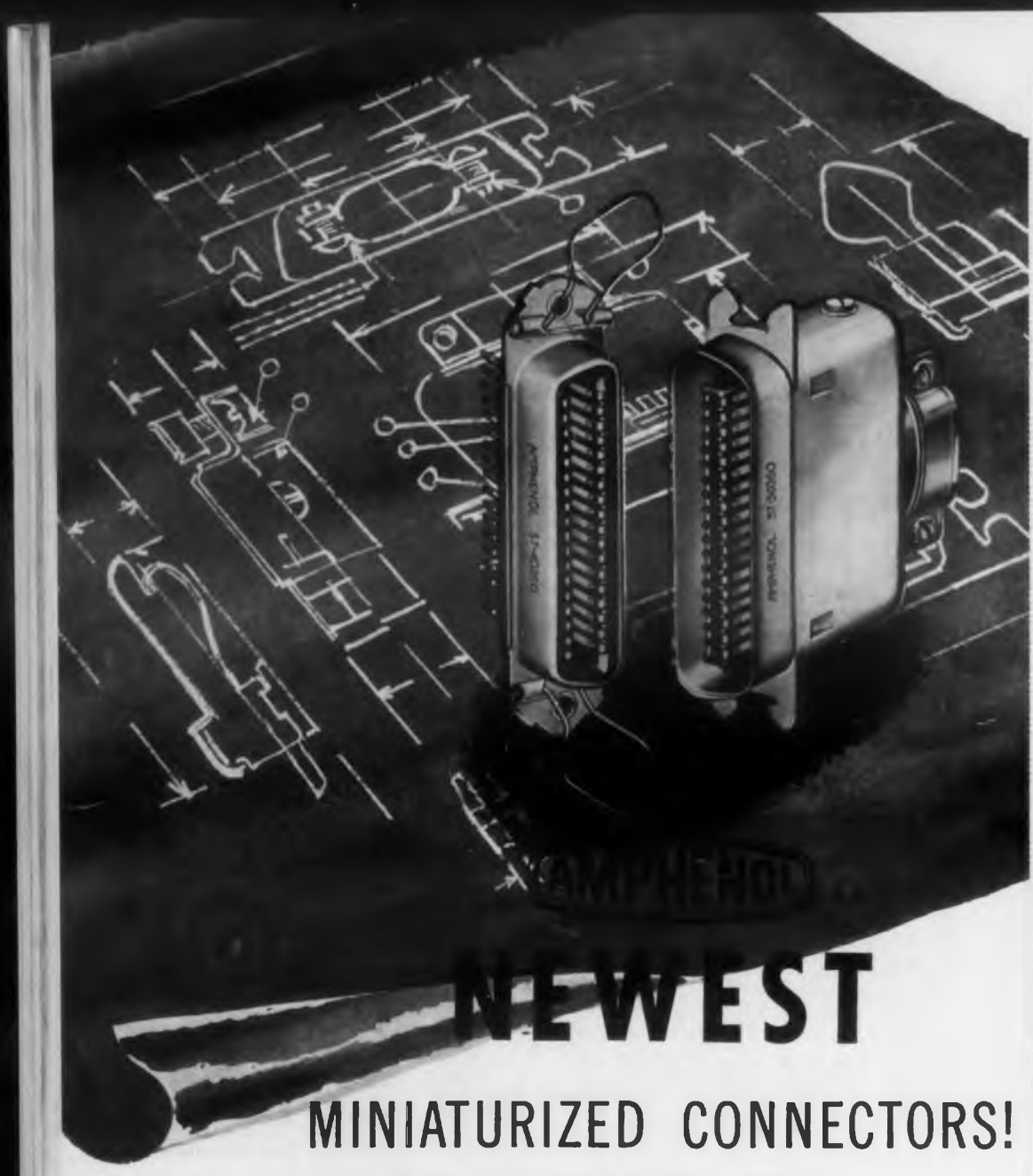
COMPANY_____

ADDRESS_____

CITY_____ STATE_____

FOREIGN SALES: ATC EXPORT DEPARTMENT, 1505 RACE ST., PHILA. 2, PA.

CIRCLE 225 ON READER-SERVICE CARD FOR MORE INFORMATION



NEWEST

MINIATURIZED CONNECTORS!

AMPHENOL's super-reliable Micro-Ribbons are now available in cable-to-chassis mountings. Providing all of the remarkable Micro-Ribbon advantages for this needed application, these new types feature cadmium-plated brass shells with clear chromate treatment, gold-over-silver plated contacts, diallyl phthalate dielectrics.

If you are cramped for space, here is how these connectors work for you. The *largest* cable-to-chassis pair contain 50 contacts—yet, mated, measure only 3.8 square inches!

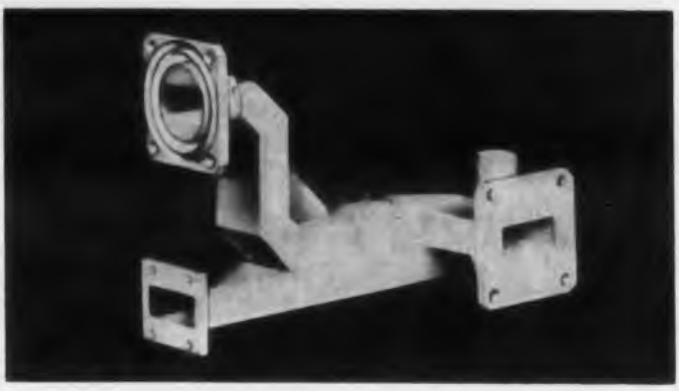
At 5 amps Micro-Ribbon connectors are rated at 700 Volts D. C. at Sea Level, 200 Volts D. C. at 70,000 feet. They are available in 14, 24, 36 and 50 contacts.

AMPHENOL ELECTRONICS CORPORATION
chicago 50, illinois
"BUILDING TO THE FUTURE OF ELECTRONICS"
AMPHENOL CANADA LIMITED *toronto 9, ontario*

Services for Designers

Flux-Dip Brazing of Aluminum Assemblies

Flux-dip brazing, a new technique for joining complex, multi-joint aluminum assemblies in one operation, is now available through Waveline, Inc., of Caldwell, New Jersey. This revolutionary process eliminates the many drawbacks of hand brazing, and assures unmatched high volume, low cost production. The major benefits of flux-dip brazing are: Mechanical accuracy, due to controlled uniform heating, warp and distortion of the assembly are eliminated; close tolerances are maintained; high strength, quality finish, and economy. Flux-dip brazing has proven ideal for brazing waveguides, antennas, chassis and microwave assemblies. It also has found application in the aviation, missile and instrument industries. Additional information may be obtained by writing to Mr. John Morris, Production Engineer in charge of development, Waveline, Inc., Caldwell, N.J.



Typical complex multi-joint aluminum assembly flux-dip brazed in one operation.

Research and Development Laboratory

A new laboratory which offers research and development services on a contract basis has been established in Madison, Wisconsin by Trionics Corporation, P.O. Box 548. The services of the laboratory are available to both industrial and government sponsors. It will employ more than 30 persons at the Madison laboratory and plans call for an increase in staff to more than 70 persons.

The research program of the new laboratory is primarily designed to develop new and improved materials to meet the requirements of specific technological advances. Special fields in which the laboratory will be active include high and low temperature resistant materials, magnetic materials, ceramics, coatings and surface treatments, plastics, electronic component materials, high strength-low weight materials, packaging materials, corrosion inhibition, metallurgy, radiochemistry, and microwave physics.

Physics Research and Consulting Service

A privately-financed organization to offer full-scale physics research and consulting service based on use of a Van de Graaff particle accelerator has completed installation of its "atom smasher." The new company, Texas Nuclear Corp., Austin, is initially using its 2-million-volt positive-ion accelerator in programs dealing with elastic and inelastic scattering of neutrons.

The company is now staffed and equipped to provide complete coverage in such programs as analysis of compounds by nuclear methods, neutron activation cross section studies, investigation of radiation damage, study of radiation damage by electrons, electron sterilization and well-logging research. A 3600 square-foot facility has been constructed to house the Van de Graaff accelerator, and auxiliary equipment including a multichannel analyzer and related specialized counting and recording devices.

Plastic Coating Operation

The Polymer Corporation, Reading, Pa., announces the establishment of a plant at 3030 Oak Street, Santa Ana, California, to perform custom coating by the new Whirlclad coating process. The process is a new coating technique which primarily involves dipping preheated articles into a bed of finely divided dry powders which are fluidized by ascending currents of gas or air. The powders heat fuse to form the coating.

The process permits use of a wide range of plastic materials such as nylon, polyethylene, cellulosics, epoxies and polyethers to be applied to metals and other base materials. Materials such as nylon and polyethylene, can be utilized. The single dip technique applies coatings for chemical and corrosion resistance, wear resistance, electrical insulation and decorative purposes. The new Santa Ana operation is expected to provide new availability of coatings to the aircraft, electronics, and other West Coast industries.

Preheated metal parts being dipped into a tank containing fluidized coating powders.

What makes a relay RELIABLE?

BASIC DESIGN

UNION engineers have been designing relays noted for highest reliability for more than 75 years. This experience has been applied to miniature relay design with outstanding success.

MANUFACTURING TECHNIQUES

To obtain reliable performance in every relay, UNION has developed excellent techniques for precision manufacture on a high-volume basis. Workers are provided with ingenious tools, jigs and fixtures for consistent accuracy. Special processes such as high-temperature baking and hermetic seal by welding of steel cases assure top relay performance.

QUALITY CONTROL

Scientific quality control practices and 100% testing to critical Military Specification requirements, including a hermetic seal test by mass spectrometer, assure standard quality in every relay.

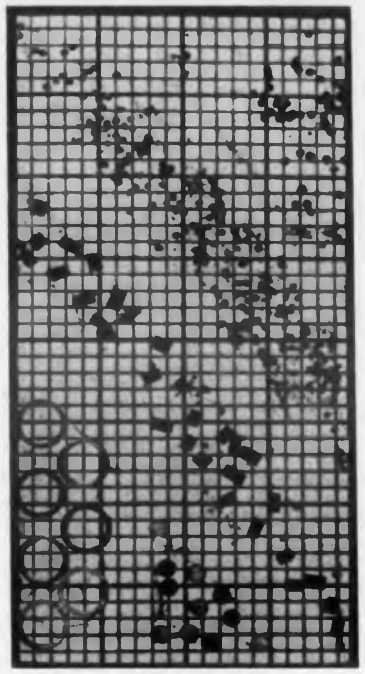
See our exhibit at the Wescon Show, Booths 810-811

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18, PENNSYLVANIA

CIRCLE 233 ON READER-SERVICE CARD FOR MORE INFORMATION



Microforms for Semiconductors

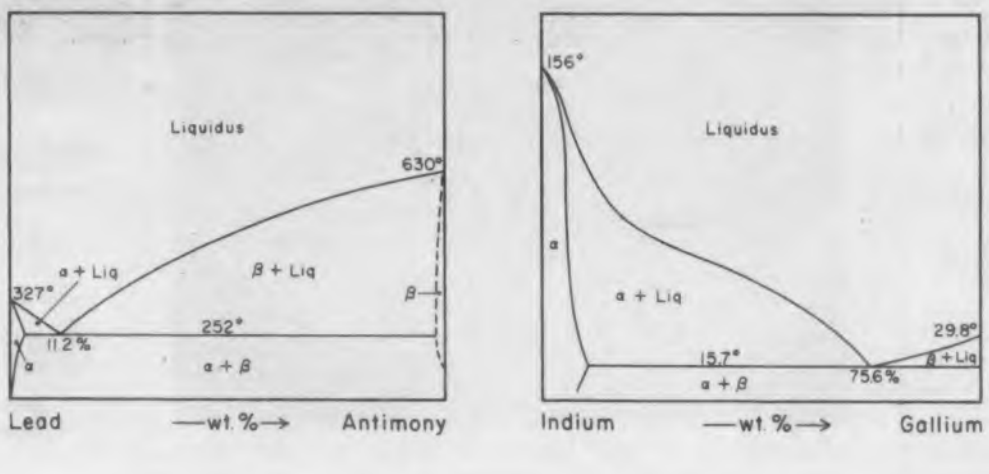
Herbert Drapkin
Anchor Metal Co., Inc.

THE CHOICE in semiconductor devices at present are germanium for its high frequency properties, and silicon for its greater efficiency at higher temperatures. Experimentally other compounds show the high frequency properties of germanium at the temperatures where silicon devices work best, but for the purpose of description these two basic elements are used as examples.

Microforms of pure germanium and silicon are cut from single long crystals grown from zone-purified metals. The crystals are first started as seeds and pulled from their melts at about 1 mm per min. Purified germanium, or silicon, must be innoculated during crystal growth with precise amounts of doping elements, which either donate electrons to cross-sections of the growing crystal or take electrons out. Donor dopes include antimony, arsenic, bismuth, phosphorus. Acceptors include boron, gallium, indium.

Junctions of types p or n are created in the crystal by letting pellets or spheres of the appropriate innoculant slide down a tube into the melt intermittently. Microforms cut from such doped germanium or silicon crystals grown by this method have either n or p, or both, junctions grown into them.

Other devices use microformed wafers of pure germanium or silicon to which the impurity is fused. For example, a pellet of indium is placed on a wafer of n-type germanium. The unit is slowly heated. At 156 C, the indium melts into a tiny blob. As the temperature continues to rise the spot of germanium on which the indium rests begins to melt and dissolve



Typical equilibrium diagrams show the proportional weight of each element of a binary alloy as it passes from the liquid to the solid phase.

up into the molten indium, making an indium-germanium alloy. At 500 C, heating is stopped and the unit allowed to cool slowly. The germanium settles out of the alloy and grows back into its original n-type crystal base. But the regrown spot of germanium is now p-type because it is contaminated with some atoms of indium, and the whole germanium wafer includes a p-n junction. The re-solidified indium blob on top makes an excellent connection to the junction.

Microforms used to alloy, solder, seal and otherwise serve in semiconductor devices must be extremely precise in the quantities of elements of which they are made. Most must be so small that they can be manipulated only under magnifying glasses. A few of the shapes in demand are discs, pellets, spheres, washers. These measure from 0.001 in. to 0.04 in. in thickness, from 0.1 in. up in diameter. In, say, antimony-doped germanium an impurity diffusion layer can be created 1.5×10^{-4} cm thick.

In addition to the simple elements many alloys heretofore scarcely known and still incompletely understood are being used in research, engineering and development. Such alloys, to list only a few binary ones, include indium with gallium, tin, lead, germanium, gold, silver, zinc and cadmium; lead with arsenic and antimony; aluminum with gallium, and indium; tin with gallium, lead, bismuth, antimony, gold, silver and arsenic; silver with arsenic and copper; gold with arsenic, antimony and gallium.

To produce the alloy prescribed for a particular use the metallurgist must know the proportions of the elements at the temperatures where their mixtures solidify out of the melts. This data has been recorded as precisely as possible for many binary, ternary and quatenary alloys, and charted as equilibrium diagrams.

Equilibrium diagrams for the systems lead-antimony and indium-gallium are shown. At 327 C lead starts to settle out of the Pb-Sb liquidus (melt). This is the alpha phase of the solidifying alloy. Antimony, as shown at the other side of the diagram, has already been settling out of the liquidus as it cooled below 630 C. This is the beta phase. At 252 C the alloy is all solid. It is a homogeneous mixture containing 11.2 per cent lead with 88.8 per cent antimony. Similarly, the In-Ga system solidifies at 15.7 C with 75.6 per cent gallium. Such equilibrium diagrams are considered guides to the engineer in calculating the quantities of the elements in the microform that he requires in the design of his semiconductor devices.

New Materials

Ferroelectric Material

Permits Low Voltage Switching

Exploration in the field of ferroelectrics has resulted in the discovery of a new ferroelectric material at Bell Telephone Laboratories. Known as triglycine sulphate, the material has a rectangular voltage hysteresis loop and other desirable properties which make it promising for switching circuits and memory devices.

The most popular ferroelectric crystal previously investigated was barium titanate. Triglycine sulphate is superior in that it has a much lower coercive field, 220 v per cm, thus permitting switching with a lower voltage. Its polarization results in a lower output pulse when switched, but the size of the pulse can be increased by increasing the area of the switching electrodes.

Triglycine sulphate is stable chemically and does not decompose when exposed to moisture or to the atmosphere. It has adequate mechanical strength to permit handling in thin sheets. Large single crystals can be grown quite easily, and a number of large area slices can be cut from each crystal.

Repeated switching does not cause any fatigue, and a given area will retain a given polarization indefinitely without deterioration. Although heating beyond the Curie point causes the material to lose its ferroelectric properties, these properties are regained in full when it is cooled.

The Curie point of the material is about 47 C. However, by replacing some of the hydrogen atoms with deuterium, easily accomplished when the crystal is grown, the Curie point can be raised to 60 C. Switching time is of the order of 1 to 2 μsec. Electrodes can be applied to a slice cut from a single crystal by evaporating thin strips of metal on each side of the slice, the strips on one side

Triglycine sulphate, a new ferroelectric, provides a low switching voltage level as well as other qualities favorable for use in switching circuits.

being perpendicular to those on the other. Using this technique, thirty or more strips per inch can be applied, resulting in a memory or switching device capable of storing 900 or more bits of information on a square inch of crystal.

Custom-Shaped Sapphire

Melting Point of 2040 C

Advances in synthetic sapphire growing techniques have produced large single crystals competitive in price with sintered aluminas and quartz. A wide variety in sizes and shapes of rods, disks, tubes, domes and balls of sapphire are now available.

Properties include extreme hardness (next to diamond); resistance to acids and alkalies even at elevated temperatures; excellent electrical insulation; strength at high heats; melting point of 2040 C; excellent transmission characteristics of ultra-violet and infra-red wave lengths. These properties, together with the variety of shapes and sizes, allow such uses as windows and domes for infra-red systems and spacers and supports for electron gun structures.

Linde Air Prod. Co., Dept. ED, Div. Union Carbide, 30 E. 42nd St., New York 17, N.Y.

CIRCLE 244 ON READER-SERVICE CARD FOR MORE INFORMATION

Zirconium

Uses and Properties

Some sources of information pertaining to the applications and the electrical, chemical and nuclear properties of zirconium and its alloys have been collected for those who may be considering the use of zirconium. Comprehensive sources of information are the following books and pamphlets:

American Society for Metals, *Zirconium and Zirconium Alloys*, Cleveland, Ohio, 1953.

U. S. Atomic Energy Commission, *Zirconium, A Bibliography of Unclassified Report Literature* (TID. 3304), Oak Ridge, Tenn., 1956.

H. K. Adenstedt, *Physical, Thermal, and Electrical Properties of Hafnium and High Purity Zirconium*, Trans. A.S.M., 44, 949, 1952.

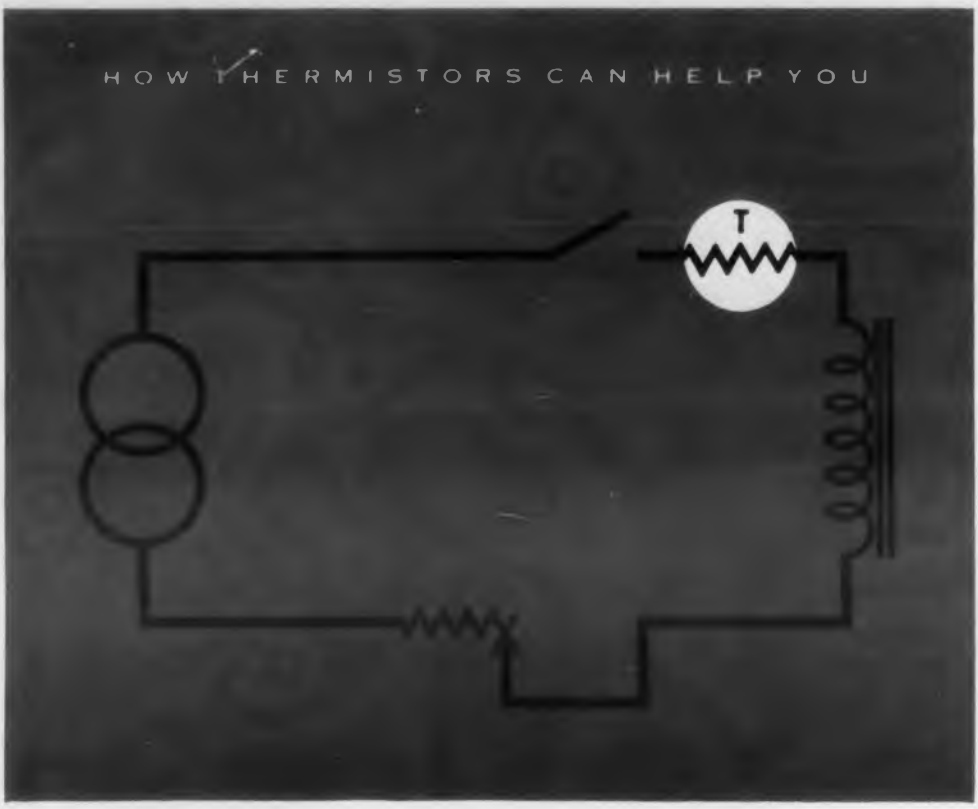
George A. Espersen, *Zirconium for Electron Tubes*, Foote Prints 18 (1), 3-7, 1946.

L. B. Golden, *The Corrosion Resistance of Zirconium and Zirconium Alloys*, A.S.M. Symposium on Zirconium and Zirconium Alloys, 305-326, 1953.

W. J. Kroll and H. L. Gilbert, *Melting and Casting Zirconium Metal*, Journal of Electrochemical Society, 96, 156, 1949.

C. F. Squire, and A. R. Kaufman, *The Magnetic Susceptibility of Titanium* and *Zirconium*, J. Chem. Phys., 9, 673, 1941.

Courtesy of Columbia-National Corp., 70 Memorial Drive, Cambridge 42, Mass., from whose bibliography on zirconium the above list was selected.



Effecting Time Delay with GLENNITE® Thermistors

An extremely effective time delay can be accomplished using Glennite Thermistors. This method shows distinct advantages over conventional time delay methods because of Glennite Thermistors' small size, long life, ruggedness and the elimination of moving parts.

The Glennite Rod Thermistor in the above schematic regulates current flow resulting in variable or fixed delay due to resistance change in the thermistor. Variable time delay can be obtained from a fraction of a second to several minutes.

Glennite Thermistors are available in bead, probe and wafer units, too — with some units offering temperature coefficients up to 7% per °C.

Complete technical specifications and typical applications are in the Brochure T-100 . . . write for your copy.

FROM RAW MATERIALS TO COMPLETE SYSTEMS • • •

Thermistor Division

Gulton Industries, Inc.

METUCHEN, NEW JERSEY

CIRCLE 248 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Electromagnetic Controls 249

Various types of electromagnetic controls are discussed in a series of seven catalogs recently released.

The booklets cover the following items: complete information on automatic transfer switches (mechanically or magnetically held) (Catalog 57-S1); remote control switches which are used to control power and lighting circuits (Catalog 57-S2); magnetically held contactors available for all normally open and closed classes of load (Catalog 57-S3); relays (Catalog 57-S4); AC and DC Solenoids (Catalog 57-S5); electric plant controls. Material includes complete systems, paralleling, changeover and alternating panels, load demand controls, battery chargers and adapter units (Catalog 57-S6); and Catalog 57-S is the complete electromagnetic control catalog, which combines the information on Catalogs 57-S1 through 57-S6. Automatic Switch Co., Florham Park, N.J.

Electrolytic Capacitors 250

Catalog 1165 presents 12 pages of data on electrolytic capacitors. It also describes a long life capacitor which eliminates the excessive leakage current and rapid shelf aging problems of conventional electrolytic units. Industrial Condenser Corp., 3243-65 N. California Ave., Chicago 18, Ill.

Screw-Lock Inserts 258

Specifications on a complete line of screw-lock inserts, including miniature size 4-40 inserts are listed in Bulletin 738. The eight page booklet contains screw-lock selection tables with thread sizes, insert numbers and sizes, and complete information on drilling, tapping, gaging and installation. Line drawings and photographs illustrate proper installation of the inserts in both blind and through holes. Also presented are basic engineering design data, military specifications, classes of fit, and assembly proportions. A variety of cost-cutting applications are cited. Heli-Coil Corp., Danbury, Conn.

Servomotor-Rate Generator 259

Data Sheet 866 covers details of the model 18 MG 690/660, a 60-cy, 115-v size 18 servomotor-rate generator. The sheet contains specifications, characteristics and other design information. It is illustrated with dimensional drawings, a schematic and a torque-speed curve. Beckman/Helipot Corp., Newport Beach, Calif.

Precision Ball 260

Catalog that serves as guide to quick and simple selection of precision balls for practically any requirement and material specification has been released. Included is comprehensive data on such items as balls of aluminum, brass and bronze, carbon steel etc., as well as information on balls of special materials.

It also includes material characteristics, type analysis, mechanical properties, temperature characteristics, corrosion resistance factors, machinability, finish, hardness, accuracy, size, weight, and quantities per pound and per shipping container.

A special feature is the Quick Ball Selector Chart that provides a comparative reference for all ball types. Hartford Steel Ball Co., 12 Jefferson Ave., W. Hartford, Conn.

Slip Ring Assemblies 261

Custom built slip ring assemblies are the topic of Bulletin S-2056. The four-page illustrated text describes complete ring assemblies, brush holder assemblies and brush contacts. Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio.

One of a kind

Among the many requirements for heat elements in industry today are those demanding virtually one-of-a-kind design.

Since such requirements normally cannot be met by loom weaving, Safeway technicians fabricate odd-shaped elements individually. Circles, half circles, cutouts, tapers and compound shapes are just a few of the elements fabricated in this fashion and produced in quantity.

Insulation, too, must provide for the characteristics of specialized applications. Safeway produces a wide variety of elements insulated with neoprene rubber, silicone rubber or reinforced plastics.

If you have a problem that requires heat, let Safeway engineers study your requirements and—without obligation to you—submit an appropriate recommendation.

For your copy of a fact-filled folder, write to:

Safeway HEAT ELEMENTS INC.

680 Newfield Street • Middletown, Connecticut

CIRCLE 263 ON READER-SERVICE CARD FOR MORE INFORMATION

FANSTEEL

S·T·A Capacitors

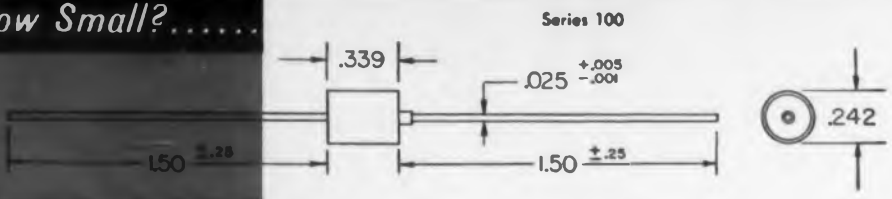
SOLID TANTALUM

Small*

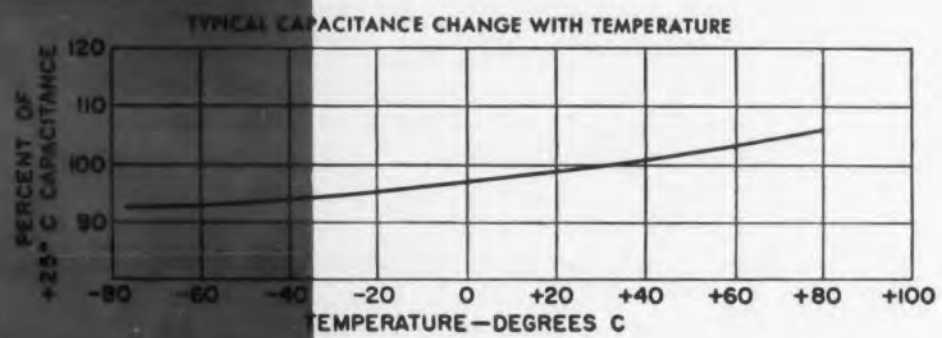
Stable**

Large Capacity***

*How Small?.....



**How Stable?.....



***How Large?....

Series 100	1 mfd at 35 volts
Series 200	5 mfd at 35 volts
Series 300	20 mfd at 35 volts

Now Available in Production Quantities
(Write for bulletin 6.112)

FANSTEEL METALLURGICAL CORPORATION
North Chicago, Illinois, U. S. A.

SEE US AT WESCON Booth Nos. 1221-1222

1907 FANSTEEL 1957 · Golden Anniversary of Progress ·

CS/SA

CIRCLE 268 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Rectifiers and Capacitors 269

ReCap, a new bimonthly journal of information on rectifiers and capacitors is now available, free, to interested engineers. The first issue, a four pager, featured an article on types and characteristics of silicon rectifiers and contained other interesting material on capacitors and rectifiers. Rectifier-Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.

Aluminum Bus Conductor Handbook 270

"Alcoa Aluminum Bus Conductor Handbook," a comprehensive work of 280 pages, presents facts and figures relative to the engineering and maintenance of bus installations. It contains 69 graphs, tables and photographs and presents essential information. These is comparatively little text. Introductory material traces the development of aluminum's use and its properties as a conductor. Subsequent chapters deal with conductor shapes, design, reactance, capacities, deflections, joints and short-circuit conditions, and the final sections explain important fundamentals of installation. A comprehensive bibliography refers the user to technical articles on related subjects. Copies of the handbook may be obtained by writing on company letterhead to Aluminum Co. of America, 793 Alcoa Bldg., Pittsburgh 19, Pa.

Data Sheets for Motors & Timers 271

To assist customers in ordering special timers or motors, two bulletins have been released.

Bulletin MS101-Applications data sheet for motors and elapsed time indicators and Bulletin MS102—Applications data sheet for repeat cycle timers and time delay relays. These bulletins are designed to aid customers in organizing their thinking when ordering or requesting information on any special units. All pertinent information is itemized with ample space to insert required values of current, voltage or life. In many cases these bulletins can be used to replace lengthy problem statements.

These bulletins will help considerably in saving time and money for the customers, since much correspondence can be eliminated by averting the omission of important details in the initial description of a timer.

The bulletin sheets are clearly blocked out with readable size type and check-off blocks and charts for laying out timing programs. A. W. Haydon Co., Waterbury, Conn.

Industrial Materials 279

This new industrial materials selection chart lists application and descriptive data on adhesives, coatings and sealers. The chart, divided into six sections, includes reclaim rubber, synthetic rubber, latices, plastics, epoxy resins, and caulkings. Miracle Adhesives Corporation, P.O. Box 466, New Philadelphia, Ohio.

High Density Felts 280

High density felts called Feutron "63," are discussed in Technical Data Sheet No. 19—a 2-page comprehensive presentation now available.

The data sheet describes the general characteristic of the new high density felts and diagrams their physical properties. Feutron "63" line felts provide an opportunity for technological advances in a wide range of applications, particularly where severe mechanical operating conditions are encountered.

Among the general characteristics of the new high density felts are high tensile strength, exceptional abrasion resistance and isotropic structure.

The bulletin declares that "special chemical and heat resistant properties are identified with the particular synthetic fiber of which the felt is composed.

A table in the data sheet refers specifically to the physical properties and performance characteristics of four representative samples included in the bulletin, which are illustrative of this class of mechanically interlocked and chemically shrunk materials. American Felt Co., Eng. & Research Labs., Glenville, Conn.

SRI Journal

The Stanford Research Institute has announced the first issue of its quarterly SRI Journal. The new publication will present scientific and economic subjects in comparatively nontechnical language. It is designed primarily for research directors and key executives in business, industry and government. Editor of the new magazine is Charles Scarlott, manager of the Institute's Publication Department. The Journal will feature articles by staff members and guest contributors. It will contain selected papers presented at SRI-sponsored meetings. Interpretive summaries of research projects will also be offered. The first issue contains illustrated articles on guided missile research; techniques for machine reading of Arabic characters printed in magnetic ink; the problem of X-ray crystal analyses and a new computer to shorten computation time; and other subjects. The Journal may be obtained for $1.00 a copy or $4.00 a year from the Editor, SRI Journal, Stanford Research Institute, Menlo Park, Calif.

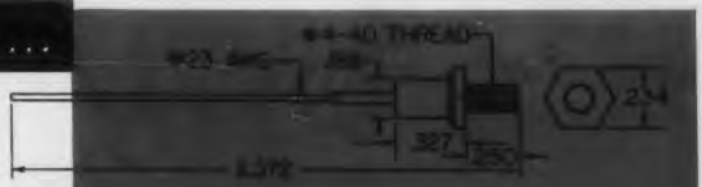
FANSTEEL SILICON RECTIFIERS

Small*

Wide Range**

High Performance***

*How Small?.....



**How Wide?.....

Available in peak inverse voltage ratings from 50 through 350 volts

***How High?.....

Rated at 500 milliamperes without heat sink

Tell Us About Your Requirements

FANSTEEL METALLURGICAL CORPORATION

North Chicago, Illinois, U. S. A.

SEE US AT WESCON Booth Nos. 1221-1222

CIRCLE 281 ON READER-SERVICE CARD FOR MORE INFORMATION

BULOVA

FAMED FOR PRECISION SINCE 1875

NEW AM-100

"MULTI-PURPOSE" OVEN

Now Bulova pioneers an entirely *new*, ultra-simplified means of temperature compensation...the "multi-purpose" AM-100 oven.

The AM-100 is designed to yield exacting temperature control of more than just crystals. *Now* entire circuits, components and/or complete sub-assemblies can be housed in one, low cost unit...the highly stable AM-100.

By eliminating costlier, less dependable, heavier and more complex temperature compensating factors, hundreds of design hours can be saved... circuits can be simplified and more dependable, and have a far wider operating range.

THE AM-100 FEATURES: Rugged lightweight construction (less than 7½ oz.); Long life expectancy due to triple insulation on heater winding; High stability ± .1°C.; Standard octal plug-in (stud mounting available); The unit draws 20 watts on initial warm-up, with average dissipation of less than 5 watts after warm-up; Meets vibration tests per MIL-E-5272; Overall 3" diameter x 5" high – cylindrical cavity 1¾" diameter x 2¾" high.

A complete line of precision Bulova ovens are available in quantity, with custom designed units available on request.

BULOVA

watch company

Electronics Division
Woodside 77, N.Y.

Write Dept. A-765
Full Information
and Prices on Ovens

CIRCLE 288 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Zinc Brightener 289

The advantages of a zinc brightener used in plating parts by the barrel method are discussed in data sheet released recently.

The new brightener makes zinc barrel plating more dependable and reduces cost by eliminating subsequent bright dipping. Smoothex, Inc., 10705 Briggs Rd., Cleveland 11, Ohio.

Angle Meters 290

Various 250 deg. arc angle meters are discussed in a 6-page folder, Form 250 now available. The illustrated folder describes meters which feature scale lengths up to 2-1/2 times as long as conventional meters and are accurate up to one per cent of full scale deflection. The meters are available from 2-1/2 in. up in ruggedized, shockproof and sealed cases. Long scale aircraft and special purpose meters are also illustrated. Hickok Electrical Instrument Co., 10525 Dupont Ave., Cleveland 8, Ohio.

Battery Connectors 291

GB6 is a catalog with 32 pages of information on battery connectors, power connectors, and heavy-duty connectors for industrial and allied applications. Several series for aircraft, sound equipment, television and other uses are described. Individual units are listed with short specifications, dimensional drawings and photographs. The booklet also contains explicit ordering information. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Special Transformers 292

In a 4-page brochure, a line of military and special commercial transformers is described. High power pulse, hermetically sealed military and open type military, subminiature binary and toroids are some of the types discussed and illustrated. Manufacturing facilities are also outlined. Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

Electronic Counters 298

A four-page illustrated brochure shows a line of electronic counters. Described are a decade scaler with a counting speed of 10 mc and a binary scaler with a counting speed of 20 mc. Other decade scalers covered have counting speeds of 20 kc, 40 kc, 100 kc and 1 mc. Three preset scalers of 20 kc, 40 kc and 100 kc counting speeds are also presented. Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

Miniature Lighting Assemblies 299

Miniature lighting assemblies, lampholders and components are covered in 16-page catalog just released. The catalog gives full application and dimensional data on the numerous units and parts, with detailed illustrations and full information on special variations and modifications of standard assemblies.

In addition, a general discussion of the purposes and construction of the component parts of assemblies is included, in order to facilitate the selection of the right unit for a given application. Drake Mfg. Co., 1713 W. Hubbard St., Chicago 22, Ill.

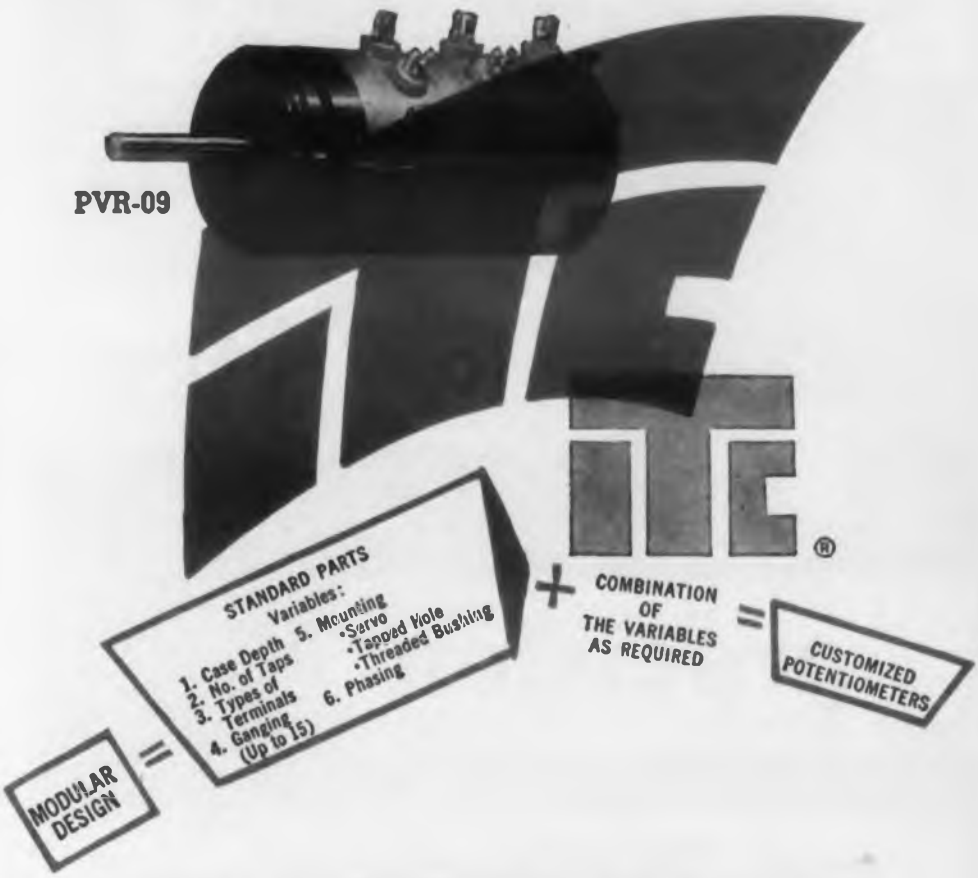
Regulated Power Supplies 300

Magnetically regulated power supplies are the topic of a recent catalog. The four-page folder describes and illustrates filament power supplies, telemetering and strain gage power supplies, computer power supplies, and miniature magnetic amplifier power supplies. Also discussed is a transistorized line which includes dc voltage regulators and inverters. Gulton Industries, Engineered Magnetics Div., 212 Durham Ave., Metuchen, N.J.

Tiny Tantalytic Capacitors 301

GEA-6065C is a 4-page booklet on microminiature tantalytic capacitors for low-voltage, dc applications where high capacitance is needed. It contains a discussion of the units' features, construction, uses and specifications. A table shows ratings and dimensions. Photographs and dimensional diagrams provide illustration. The brochure also contains photographs and short descriptions of other capacitor types together with the numbers of bulletins where they are more fully treated. General Electric Co., Schenectady, N.Y.

NEW MODULAR DESIGN
PRECISION POTENTIOMETER



FEATURES OF CUSTOMIZED STANDARD POTS

- ▶ High Temperature Operation . . . to 145 deg C
- ▶ Independent Linearity of ±0.25%
- ▶ Non-linear Functions

The newly developed TIC Type PVR-09 incorporates modular design for choice of cup depth, mounting, and number of taps. Modular design, a new concept in manufacturing, makes available all mounting types — servo, tapped hole, and threaded bushing . . . and, in addition provides extreme flexibility in customizing the standard PVR-09 design to the individual application.

Ganging up to 15 cups, without external clamps, and each individually phased at the factory also provided by the modular design technique. Up to 9 taps are available in a standard unit — others on special order. Ball bearing construction provides low torque.

With our new plant facilities and unique modular design techniques you now can get customized design without delay. Complete spec's on request.

PERTINENT CHARACTERISTICS:

- STANDARD RESISTANCES: 100 ohms to 150K
- ACCURACY OF TOTAL RESISTANCE: ±5% on standard, to ±1% on special linear functions
- INDEPENDENT LINEARITY: ±0.5% of total R above 5K standard, ±0.25% on special
- POWER RATING: 1.25 watts at 85°C
- RESISTANCE FUNCTIONS: Can be provided with a variety of non-linear functions
- TAPS: Up to 9 taps . . . with 10 deg
- TEMPERATURE RANGE: −55 to +145 deg C
- MILITARY SPECIFICATIONS: Tested to MIL-E-5272A

TECHNOLOGY INSTRUMENT CORP.

555 MAIN STREET, ACTON, MASS. P.O. BOX 3941, NORTH HOLLYWOOD, CALIF.

CIRCLE 303 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Network Components 309

Manufacturers of communications networks components recently established a regular monthly periodical entitled the Burnell Bulletin. The bulletin will contain, in addition to information about its progress, background material on the development and application of their products. Burnell & Co., Yonkers, N.Y.

Part Winding Starters 310

Bulletin GEA-6606 is a 4-page discussion of part winding starters. It points out the advantages of two-thirds part-winding starting and gives application data and part-winding characteristics of a typical motor. It also gives nomenclature and price information on the CR7050 starter designed for either one-half or two-thirds part-winding starting of standard motors or special part-winding motors for reduced kva inrush. The booklet is illustrated with connection diagrams and photographs. General Electric Co., Schenectady 5, N.Y.

Metal Instrument Cases 311

Deep-drawn and fabricated metal instrument cases, boxes and military cases are listed in a 62-page catalog. Photographs, specifications and descriptions are provided for a line encompassing more than 1400 stock sizes and shapes. The catalog has a section detailing plant facilities, among them product design, tooling, hydraulic presses, heliarc and spot welding, metal finishing, stamping and assembly. Zero Mfg. Co., 1121 Chestnut St., Burbank, Calif.

Control Cables

Publication of a brochure on supervisory and station control cables is announced. The illustrated literature introduces applications and gives complete technical information and engineering specifications. It comes in a loose-leaf cover binder to which supplemental data can be added. For copies write on company letterhead to Ansonia Wire & Cable Co., 111 Martin St., Ashton, R.I.

Slow Worm Motor 318

A one-page sheet is devoted to a slow-motion worm motor. Standard specifications on speed, rotation, shaft length, and type of application (continuous or intermittent) are listed. The sheet is illustrated with a photograph and a dimensional drawing. Brevel Products Corp., 601 W. 26th St., New York 1, N.Y.

VHF Transmitter 319

The Type T-20 building block 20-channel vhf transmitter is described in Brochure ARCBR-T20-1. The unit is designed to operate with either the ARC Type R-15 (108 to 135 mc) or ARC Type R-19 (118 to 145 mc) receiver to provide a 2-way vhf radio set. Aircraft Radio Corp., Boonton, N.J.

Industrial Heating 320

Bulletin 1331, a reprint of article entitled "How To Braze Stainless" by H. M. Webber, is now available. It discusses filler metals, wetting, fixtures, distortion, protective atmospheres, and other aspects of furnace brazing on stainless steels. General Electric Co., Schenectady 5, N.Y.

Pulse Burst Generators 321

The operation, specifications and uses of the Models 2130A and 2150A pulse burst generators are comprehensively treated in a bulletin of two pages. The text is illustrated with a diagram and a photograph. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Epiradiator 322

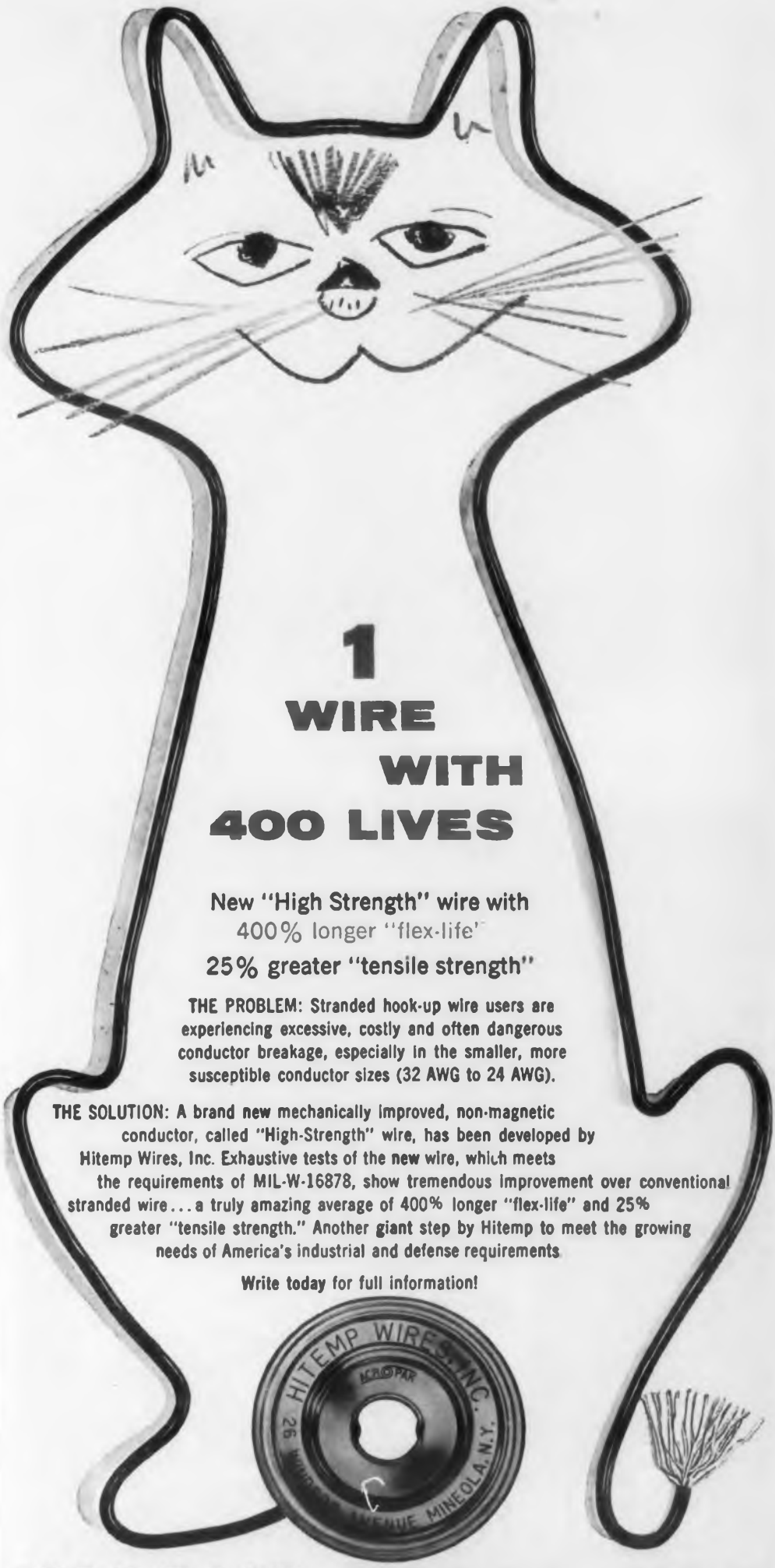
An epiradiator for remote evaporating and drying for infrared radiation is described in folder just released.

The folder gives complete description of the model as well as specifications and characteristics of the item. Quartz Products Corp., P.O. Box 628, Plainfield, N.J.

Ballast Heating 323

Basic heat problems and what causes overheating in fluorescent lamp ballasts are discussed in Bulletin 3328 entitled "Let's Talk About Ballast Heating" now available.

The 8-page two-color booklet tells what happens to an overheated ballast and gives steps to avoid ballast overheating and associated problems. General Electric Co., Schenectady 5, N.Y.



1 WIRE WITH 400 LIVES

New "High Strength" wire with
400% longer "flex-life"
25% greater "tensile strength"

THE PROBLEM: Stranded hook-up wire users are experiencing excessive, costly and often dangerous conductor breakage, especially in the smaller, more susceptible conductor sizes (32 AWG to 24 AWG).

THE SOLUTION: A brand new mechanically improved, non-magnetic conductor, called "High-Strength" wire, has been developed by Hitemp Wires, Inc. Exhaustive tests of the new wire, which meets the requirements of MIL-W-16878, show tremendous improvement over conventional stranded wire... a truly amazing average of 400% longer "flex-life" and 25% greater "tensile strength." Another giant step by Hitemp to meet the growing needs of America's industrial and defense requirements.

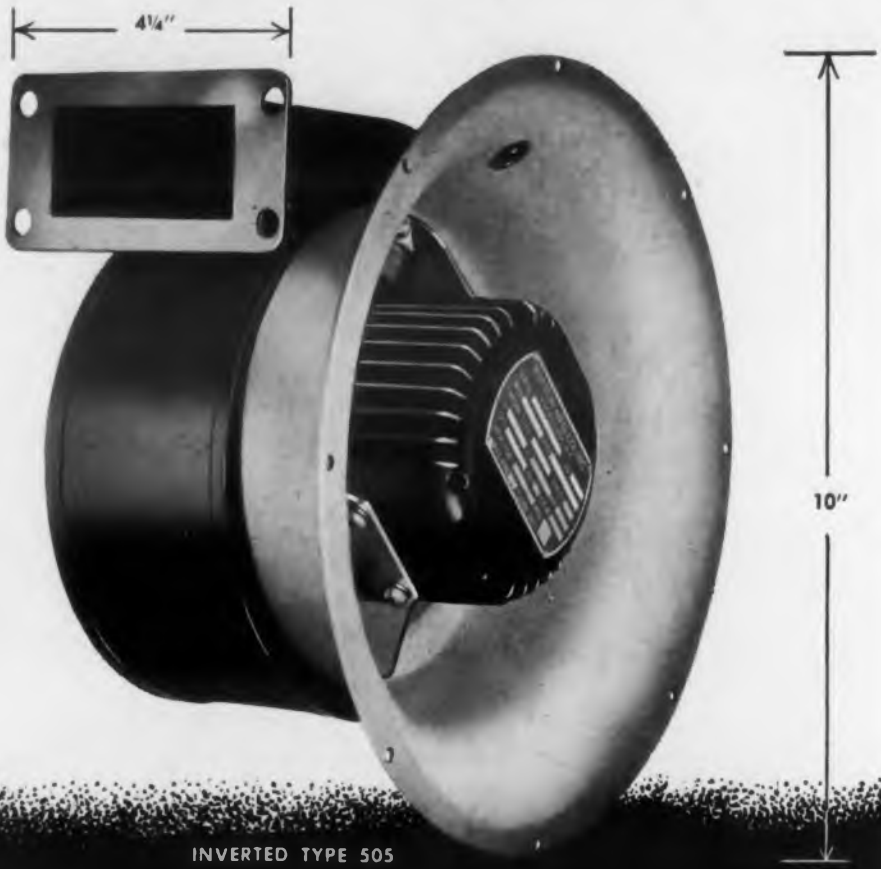
Write today for full information!

HITEMP WIRES, INC.

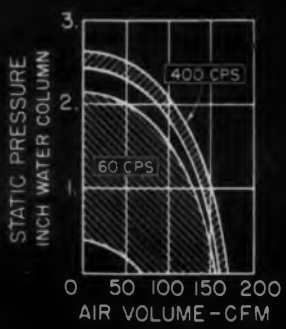
26 Windsor Avenue, Mineola, New York

CIRCLE 325 ON READER-SERVICE CARD FOR MORE INFORMATION

Cool Magnetrons and Power Tubes with Model D Blowers



INVERTED TYPE 505



Shown is one of a family of high-pressure blowers designed for turbulent cooling in Commercial and Military Electronic applications where space is at a premium and long trouble-free life is mandatory.

OPTIONAL AIR INLET & OUTLET ADAPTORS & MOUNTING SURFACES

SEE Catalog Sheets:
40102-31
40102-32
30102-3

ROTRON

ROTRON MANUFACTURING CO., INC.
WOODSTOCK • NEW YORK

CIRCLE 328 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Erasing Machine 329

Superior electric erasing machine developed for the engineer and draftsman for faster erasing with minimum fatigue is described in data sheet now available.

This new mcahine "Sovereign," operates cool under heavy work conditions, has minimum torque and automatic stall control to protect drawings against damage from too heavy pressure. The machine is lightweight and easy to handle according to the data sheet. Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.

Components and Test Equipment 330

In Short Form Catalog 57-BG, all company products are listed: pulsed and CW magnetrons, TR and ATR duplexing tubes, microwave silicon diodes, silicon power rectifiers, flange-mounted and solderable waveguide pressure windows, waveguide components, and test equipment. Operating characteristics are tabulated for a majority of the products. Microwave Associates, Burlington, Mass.

Reversible Geared Motors 331

Four pages of details on type TYAZ-CE reversible geared motors are available in Catalog GR2. Attention is given to construction, mounting, base motors and duty cycles. Standard gear reductions and control circuits are also considered. Tables show the performance characteristics of individual units. Photographs illustrate the motors and drawings show dimensions and circuits. Barber-Colman Co., Small Motors Div., 1400 Rock St., Rockford, Ill.

Miniature DC Solenoids 332

Reference material on representative miniature and subminiature dc solenoids is available. It is designed to aid in solenoid selection by type, size, voltage range, temperature range, force, weight and similar characteristics. The illustrated reference sheets give detailed data on nine units for data processing and memory units, computers, avionics and other applications. PSP Engineering Co., 6058 Walker Ave., Maywood, Calif.

Precision Potentiometers 338

Recent modifications in specifications for the series AN and CN multi-turn potentiometers are noted in Data Sheet 54-12. Issued to supersede Data Sheet 54-11, the 2-page leaflet presents detailed technical information and illustrations to show dimensions and construction. Helipot Corp., Newport Beach, Calif.

μsec Coaxial Cables 339

1957 catalog describing line of microminiature coaxial cables and connectors is available. The 32-page catalog gives specifications and applications of the items included in the catalog. Microdot, Inc., 220 Pasadena Ave., So. Pasadena, Calif.

Coaxial Terminations 340

The Model 369 Series of high power coaxial terminations are the subject of a one-page data sheet. The leaflet presents photographs, power ratings, specifications, special features and prices. The Narda Corp., 160 Herricks Rd., Mineola, N.Y.

Shaft Angle Converters 341

Shaft angle converters for binary decimal coding are the topic of a four-page folder. The instruments' features are discussed with special attention to code drums, brush blocks, and drive systems. Also provided are application suggestions, detailed performance data, and a table showing specific characteristics of available models. The folder is illustrated with photographs and dimensional drawings. Instrument Development Labs., Inc., 67 Mechanic St., Attleboro, Mass.

Lubricant Testing Machines 342

Operating information on Model LFW-1 Lubricant-Friction-Wear testing machine are included in revised bulletin 106 now available.

Included in the bulletin is a more complete description of the machine's operation as well as a revised list of specifications in the English and Metric systems.

The details of the specimen holder and lubricant reservoir are shown in photograph. Alpha Molykote Corp., 65 Harvard Ave., Stamford, Conn.

CAMLOC *low cost/light weight*

5F series

Camloc's new small, lightweight 5F Series features high strength-weight ratio plus the quick-operating advantages of a ¼-turn fastener... in a size and weight that offers new design possibilities to original equipment manufacturers! Particularly adaptable to thin materials and miniaturized equipment like airborne electronics, small electro-mechanical and computing devices and communications components. Ideal for attaching lightweight components in "packaged" equipment or for holding access panels on everything from washing machines to radar units.

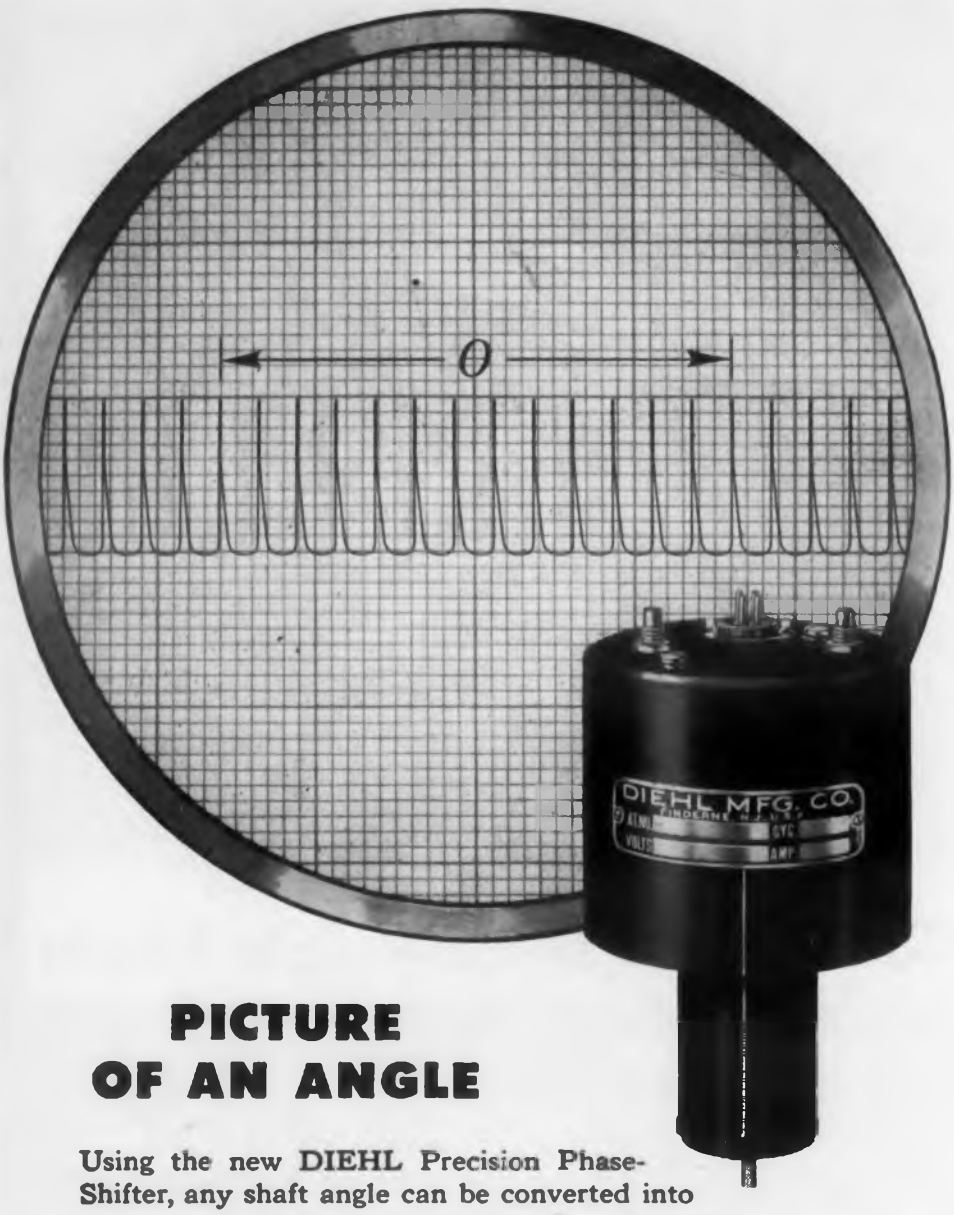
Offered in many different head styles. Complete specifications will be sent to you on request.

CAMLOC®

FASTENER CORPORATION
61 Spring Valley Road, Paramus, N. J.

WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CAL.
FORT WORTH OFFICE: 2500 W. BERRY ST., FORT WORTH, TEXAS

CIRCLE 344 ON READER-SERVICE CARD FOR MORE INFORMATION



PICTURE OF AN ANGLE

Using the new DIEHL Precision Phase-Shifter, any shaft angle can be converted into an accurate *digital* presentation like the pulse train shown above. In such use, a separate high frequency counting signal is triggered by the reference wave and shut off by the phase-shifted wave, thus identifying a shaft angle with a finite number of pulses. Small size and simplicity make this Phase-Shifter ideal for use as an Analog-to-Digital Converter component.

This is only one of many applications for the DIEHL Precision Phase-Shifter which can now be provided for any fixed frequency between 60 cps and 4 megacycles.

By combining the very accurate DIEHL Size 11 Resolver with the appropriate circuitry, accuracies of better than ¼ of a degree have been attained at frequencies up to 100 Kc. Phase shift is continuous through 360° and variation of output amplitude is held to a minimum.

To insure that the accuracy of the Phase-Shifter is not influenced by external loading, a cathode follower circuit is incorporated in the network to isolate the unit.

Send for additional engineering data.

DIEHL MANUFACTURING COMPANY

Electrical Division of THE SINGER MANUFACTURING COMPANY

Finderne Plant, SOMERVILLE, N. J.

other available components

- AC SERVOMOTORS
- AC SERVOMOTORS WITH AC TACHOMETERS
- DC SERVO SETS
- AC SERVOMOTORS WITH DC TACHOMETERS
- AC AND DC TACHOMETERS
- RESOLVERS

BOOTH 1303—1957 WESCON, SAN FRANCISCO, AUGUST 20-23

CIRCLE 348 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Transfer Storage Counter 349

"The Counter with a Difference" is a 6-page booklet about the Model TS-204 transfer storage counter and two of its accessories. The text explains what the counter can do and how it operates. The accessories described are the RR-40 relay readout and the TS-204P power supply. The booklet is illustrated with photographs and a block diagram. A list of specifications is provided for all three units. Burroughs Corp., Electronic Tube Div., Plainfield, N.J.

Ferrites 350

The magnetic properties of three ferrite materials, Ferramic O-2, Ferramic Q and Ferramic H, are discussed in separate 2-page catalog sheets. The ferrites are used as component parts in radio and TV sets, computers, automatic controls and related electronic equipment. Pertinent information is presented in tables and graphs. Photographs are provided for illustration. General Ceramics Corp., Keasbey, N.J.

Systems Manufacture 351

Facilities for systems manufacture are outlined in an illustrated brochure of eight pages. The booklet stresses the importance of systems to technological progress and names some areas where they have contributed immeasurably. It also cites a number of specific systems that the company has pioneered and supplied. McGraw-Edison Co., Thomas A. Edison Instrument Div., West Orange, N.J.

Vacuum Tube Test 352

A 16-page technical brochure deals with a quality test used in the production of power vacuum tubes. Entitled "A Positive Grid Voltage-Space Current Division Test for Power Vacuum Tubes," the paper was originally delivered by James A. Jolly at the 1957 IRE Convention. Existing test techniques and their limitations are discussed along with the new one. The description of the subject method is supported with sample data. Eitel-McCullough, Inc., San Bruno, Calif.

Wire Twister 358

A 1957 catalog and price list for the M-80 wire twister is now available. The catalog is fully illustrated and contains complete specifications. The patented action of the wire twister is shown by a motion-picture-like sequence of 9 photographs. Ralph C. Robinson Co., 2516 Crosby Way, N. Sacramento 15, Calif.

Quick Reference Catalog 359

A 16-page, 3-color Quick Reference Catalog which summarizes electrical and physical data is now available. It gives this information in a handy tabulated form for each line of triodes, tetrodes, pentodes, klystrons, heat dissipating connectors and others. Eitel-McCullough, Inc., San Bruno, Calif.

Multi-Turn Potentiometers 360

Two series of multi-turn precision potentiometers with linearity tolerances of ±0.01 per cent are specified in Data Sheet 54-23. The 2-page treatment is illustrated with a photograph, dimensional diagrams and a labeled cutaway. Helipot Corp., Newport Beach, Calif.

Pulse Generator 361

The Model 2125B pulse generator is featured in a revised two-page bulletin. Illustrated with photographs and lock diagrams, the text provides design and construction data and detailed specifications. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Thermostats 362

Two thermostats, the Model D1 for ac systems and the D10 for dc systems, are featured in Bulletin RT-803. Illustrated with photographs and diagrams, the four-page folder contains application and installation information. Robertshaw-Fulton Controls Co., 110 E. Otterman St., Greensburg, Pa.

Plastics: Fibre and Thermosetting 363

Various parts used in a wide range of industries are included in a folder entitled "Applications for Wear" now available.

The illustrated pamphlet gives a complete description of the parts, such as retainers, washers, bearings and rubbing blocks and bushings. Spaulding Fibre Co. Inc., Tonawanda, N.Y.

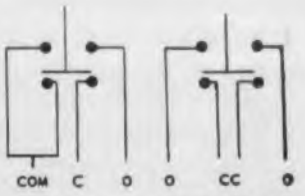
NOW-

with the

ACRO SUBMINIATURE SWITCH

ACTUAL SIZE

CIRCUIT ARRANGEMENTS



DOUBLE THROW DOUBLE CIRCUIT

Your Choice of 5 New Actuators

LEAF

FORMED LEAF

ROLLER LEAF

PLUNGER

TOGGLE

With its small size, high capacity, and newly-designed actuators, the Acro Subminiature Switch meets an exceptionally wide range of design requirements . . . provides many new development possibilities for subminiature assemblies.

The electrical rating of this precision Acro Snap-Action Switch—10 amperes at 125 or 250 volts A.C. or 28 volts D.C.—is over four times that of most switches this size. It will operate within a temperature range of from +350° to −80°F., and its terminal arrangement permits wiring double circuits.

Switching mechanism is enclosed in a durable plastic case which can also be adapted to various types of present actuators and mountings not shown.

Write for literature, engineering data!

MR. CONTROLS

Robertshaw-Fulton

CONTROLS COMPANY

ACRO DIVISION

Columbus 16, Ohio

In Canada: Robertshaw-Fulton Controls (Canada) Ltd., Toronto

CIRCLE 365 ON READER-SERVICE CARD FOR MORE INFORMATION

0 CPS to 1 MC!
DIRECT READING

new

Computer-Measurements Model 226A

UNIVERSAL COUNTER-TIMER

OUTSTANDING FEATURES:

- ★ Three independent, adjustable trigger level controls permitting full rated sensitivity at any voltage level between 300 and 300 volts.
- ★ Small voltage increments ordinarily masked by attenuators are easily selected.
- ★ Simplified color-coded controls and direct read-out in kc, mc, sec, or millisec, with automatic decimal point indication.
- ★ Oscilloscope marker signals facilitate start and stop trigger level adjustment for time interval measurement of complex waveforms.

A brand new, **multi-purpose** instrument provides precision measurement of frequency, frequency ratio, period (1 frequency) and time interval. Pressure, velocity, acceleration displacement, flow, RPS, RPM, etc., may also be measured with suitable transducers. The 226A may be used as a secondary frequency standard.

price $1,100.00

FREQUENCY • PERIOD • TIME INTERVAL • FREQUENCY

SPECIFICATIONS:

FREQUENCY MEASUREMENT

Frequency Range: 0-1,000,000 cycles per second

Input Sensitivity: 0.2 volt rms. Direct-coupled input

Time Bases: 0.00001, 0.0001, 0.001, 0.01, 0.1, 1 and 10 seconds. Also can use external 0-1 mc standard

PERIOD MEASUREMENT

Period Range: 10 microseconds to 1,000,000 seconds

Frequency Range: 0.000001 cps to 100 kc

Input Sensitivity: 0.2 volts rms. Direct-coupled input

Gate Times: 1 and 10 cycles of unknown frequency

Standard Frequency Counted: 1 mc; 100, 10, 1 kc; 100, 10, 1 cps; external 0-1 mc.

TIME INTERVAL MEASUREMENT

Range: 3 microseconds to 1,000,000 seconds

Start and Stop: Two independent or common channels Positive or negative slope

Input Sensitivity: 0.2 volts rms. Direct-coupled input

Standard Frequency Counted: 1 mc; 100, 10, 1 kc; 100, 10, 1 cps; external 0-1 mc.

GENERAL

Stability: Short Term: 1 part in 1,000,000 (temperature-regulated crystal)

Long Term: 3 parts per million per week

Display Time: Automatic: Continuously variable 0.1 to 10 seconds Manual: Until reset

Input Impedance: 1 megohm and 50 mmf

Trigger Level: Continuously adjustable from −300 to +300 volts

Accuracy: ± 1 count ± stability

Secondary Frequency Standard: 1 mc; 100, 10, 1 kc; 100, 10, and 1 cps

Dimensions: 17" W x 8¾" H x 13½" D approx.

Weight: 50 lbs. approx.

FREQUENCY • PERIOD • TIME INTERVAL • FREQUENCY

MODEL 225A 0 cps-100 kc
UNIVERSAL COUNTER-TIMER

Similar to the 226A in design. Featuring Oscilloscope Trigger Level Marker Signals; **Three Direct-Coupled Inputs of 70 mv sensitivity;** Direct Reading, Automatic Illuminated Decimal Point. Easily portable. **Price: $840.00**

Data Subject to Change Without Notice – Prices F.O.B. Factory

Write for complete specifications on the new 226A and the 225A models and the complete CMC line of electronic counting and controlling equipment.

Computer-Measurements Corporation

5528 Vineland Avenue, North Hollywood, Calif. Dept. 76-G

CC-30

CIRCLE 368 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Aluminum Foil Wire Markers 369

A line of aluminum foil wire markers are shown in a two-page, three color bulletin now available. The bulletin illustrates two sizes of foil markers furnished on quick-release dispenser cards: 1-1/2 in. markers for wire over 1/4 in. O.D. 3/4 in. markers for wire under 1/4 in. O.D.

Special properties of instant-sticking aluminum wire markers are listed: resists temperatures to 350 F; precut, fits and sticks to any wire diameter; resistant to soil, grease and water; protected by transparent coating against rubbing and abrasion, and no tools required.

Although any size, shape, color or symbols can be specified, a large stock of items for immediate delivery are listed. These include solid numbers, letters, symbols and machine tool control symbols; consecutive numbers or letters; or consecutive numbers or symbols repeated in sequence.

The catalog also contains ordering information, list of prices and delivery time. North Shore Nameplate Inc., 214-27 Northern Blvd., Bayside 61, N.Y.

Multi-Channel Oscilloscopes 37

A 28 page catalog describing complet line of standard 2- and 4-channel oscill scopes, strainalyzers and related dc ampl fiers has been issued.

A number of new items are feature including a 2-channel scope with a vertic frequency range from dc to 15 Mc, and 4-channel recording oscilloscope and ma ter strainalyzer for which input informatio may be either differential or single-ended

A portion of the catalog is devoted t explaining the advantages of multi-channe oscillography in which non-recurring event may be triggered and the resulting opera tional phenomena recorded simultaneousl from different points. In addition to th 2- and 4-channel units described in th catalog, other types including oscilloscope providing up to 8 channels or beams on single-tube face are described. The catalo lists multi-gun cathode ray tubes in 2-, 3- 4-, 5-, 6-, 8- and 10-gun types. DC powe supply units are likewise included. Elec tronic Tube Corp., 1200 E. Mermaid Lan Philadelphia, Pa.

Expansion Joints 378

Rubber, neoprene and Teflon-lined expansion joints, their construction, sizes and uses are fully explained in Bulletin AD-137 now available. The bulletin describes the characteristics and limitations of seven styles of expansion joints and flexible couplings; *1* spool-type expansion joints; *2* rectangular-type expansion joints; *3* U-type joints; *4* all-Teflon expansion joints; *5* all-Teflon flexible couplings; *6* full-faced Teflon lined rubber expansion joints; *7* expansion joints for use on piping and flanges.

It also explains that rubber expansion joints are suitable for handling hot or cold water, mild acids, mild caustic solutions, brine, air or exhaust steams, at temperatures to 180 F.

Rectangular type expansion joints as described in the bulletin are available for application in pressure and vacuum lines. These joints are frequently used as a flexible connection between a turbine and a condenser.

Metal retaining rings made of galvanized steel to be placed behind and directly against the inner face of each of the rubber flanges at the ends of the joints, as well as Teflon expansion joints and flexible couplings for fluid process piping handling strong acids, caustics, foods and halogenated solvents are outlined in the bulletin. Garlock Packing Co., 408 Main St., Palmyra, N.Y.

Aircraft Thermocouples 379

MC-153 is a four-page brochure on thermocouples for aircraft gas turbines and related aviation applications. It describes and illustrates the four basic junction tips—exposed junction, twisted-exposed junction, stagnation tip and sampling tip—which provide the starting point for hundreds of model variations. Performance data and accuracy limits for the thermocouple wire material at temperatures up to 2000 F are listed. Also illustrated are the various design features which assure the reliability and accuracy of the thermocouple series in aviation service. Fenwal Inc., Aviation Products Div., Ashland, Mass.

Between Concept and Configuration

...Save Time and Money with

PHILBRICK PLUG-IN DC AMPLIFIERS

AVAILABLE FROM STOCK

For a wide variety of instrumentation and control problems, you can facilitate rapid set-up with either one or both of these octal-based, plug-in Philbrick Amplifiers. Operational Amplifier, Model K2-W, features balanced differential inputs for minimum drift and maximum utility. In conventional applications, overall amplifier characteristics are affected solely by the feed-back networks, since the two inputs can be maintained at nearly equal potential with appropriate feed-back circuitry.

For more critical applications where long term drift must be reduced to sub-millivolt levels, Stabilizing Amplifier, Model K2-P, is paired with Model K2-W. *Write for free 28 page Plug-In Amplifier Applications Manual-13.*

MODEL K2-W	MODEL K2-P
GAIN: 15,000 dc, Open Loop	GAIN: 1,000 dc
POWER REQUIREMENTS: 4.5ma @ ±300 vdc, 0.6 amps. @ 6.3v	POWER REQUIREMENTS: 2.4 ma @ +300 vdc, 0.45 amps. @ 6.3 vac, 60 cps
OUTPUT RANGE: +50v. to −50v. at 1 ma	INPUT IMPEDANCE: 1 Megohm
RESPONSE: 2 Microseconds rise time, 100 Kc with unity feed-back	STABILITY: Below 100 Microvolts
PRICE: $24.00 Postpaid	PRICE: $60.00 Postpaid

GEORGE A. GAP/R

PHILBRICK

RESEARCHES, INC.

230 Congress Street, Boston 10, Massachusetts HUbbard 2-3225

CIRCLE 381 ON READER-SERVICE CARD FOR MORE INFORMATION

Acetrim* sub-miniature precision TRIMMERS for PRINTED CIRCUITS

Here is another new development from Ace . . . sub-miniature precision wire-wound trimmers especially for printed circuits. Designed and produced to meet your tightest specifications, the new Acetrim has flat or round tabs to facilitate production assembly. Just plug into printed circuit board, secure, and dip solder.

Featuring

- ½" size
- 10 ohms to 150 K
- weight ¼ ounce
- power 2 w. @ 60° C. max.
- temperature to 125° C.
- sealed, moistureproofed, anti-fungus treated
- withstands severe shock, vibration, acceleration
- meets applicable Military specs

Ace delivers reliability

Modern mass production techniques assure delivery to meet your schedules . . . rigid quality controls assure highest standards of performance-reliability.

Acetrim — *write for Technical Data Unit #563.*

Acepot — ½" sub-miniature precision wire-wound linear potentiometers from 10 ohms to 250K. ±.3% standard. *Write for Technical Data Unit #564.*

Nonlinear Acepot — precision wire-wound nonlinear potentiometers for sine-cosine and square-law functions and other applications. High resolution, close conformity. *Write for Technical Data Unit #572.*

X-500 Acepot — ½" sub-miniature precision potentiometers for extreme temperatures of —55° C. to 150° C. 10 ohms to 250K. *Write for Technical Data Unit #571.*

*trademarks applied for

ACEPOT*
ACETRIM*

ACE ELECTRONICS ASSOCIATES, INC.

Dept. ED, 101 Dover St. • Somerville 44, Massachusetts

Telephone: SOmerset 6-5130 • ***Engineering Representatives in Principal Cities***

CIRCLE 388 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Plastic Molding Presses 389

The redesigned 741 series of fully automatic compression presses for plastic molding is described in the 12 pages of Catalog 200. Complete specifications are given for the series' four models of 50, 75, 125, and 200 tons capacity. Photographs illustrate the 741 presses and a variety of other equipment. F. J. Stokes Corp., 5500 Tabor Rd., Philadelphia 20, Pa.

Antenna Systems 390

Engineering improvements to existing antenna systems equipment are noted in a 32-page new product supplement. Illustrated and described are a 9-in. uhf transmission line, a 3 1/8-in. uhf coaxial switch and an expanded line of microwave and communication antennas. Full specifications are given for all items. The booklet also contains ordering information and a price list for all available products. Andrew Corp., 363 E. 75th St., Chicago 19, Ill.

Bimetal Thermostats 3

Snap-acting Type M bimetal thermost are the subject of Bulletin 6000. Herme cally sealed and semienclosed types for in appliances, fire alarms, television re stations and communications equipm are described. The 2-page bulletin cov principles of operation, construction f tures and ratings. It is illustrated wi photographs showing different types available terminal arrangements and closures. Stevens Mfg. Co., Inc., Lexingt Ohio.

Electric Brake 3

An electric brake for ac motors is exte sively discussed in a folder of 4 pages. advantages, operation, performance, spe fications and uses are covered. Typi performance curves and a labeled pho graph showing construction are among illustrations. American Rectifier Co Selenibrake Div., 95 Lafayette St., N York 13, N.Y.

DC Timing Motors 398

Bulletin AWH MO 805, a 2-page insert for a current catalog, contains information on the function of the three basic dc timing motors. The construction of the 5300, 6300 and 7600 series motors are analyzed in detail. Featured is a cutaway view of the motor which shows the rotor construction and self-contained gear train. The A. W. Haydon Co., Waterbury, Conn.

Chopper Circuit Residual Noise 399

Availability of a four-page technical paper, "Measurement of Residual Noise in Chopper Circuitry," is announced. The article covers the theoretical as well as the practical evaluation of residual noise in a wide variety of chopper circuitry. Included are graphs and information helpful to design engineers. James Vibrapowr Co., 4050 N. Rockwell St., Chicago 18, Ill.

Design Services 400

Electronic research and development, equipment and systems designing, production engineering, and pilot model building are among the services announced in Bulletin 571. The four illustrated pages also give details on facilities and on completed projects. Strand Engineering Co., 1354 N. Main St., Ann Arbor, Mich.

Magnetic Tape Recorders 401

An entire line of professional magnetic tape recorders is listed in a catalog of 15 pages. Complete specifications and pertinent information are presented for all models. Also described with specifications are a variety of accessories and modification kits. Photographs are provided for illustration. Magnecord, Inc., 1101 S. Kilbourn Ave., Chicago 24, Ill.

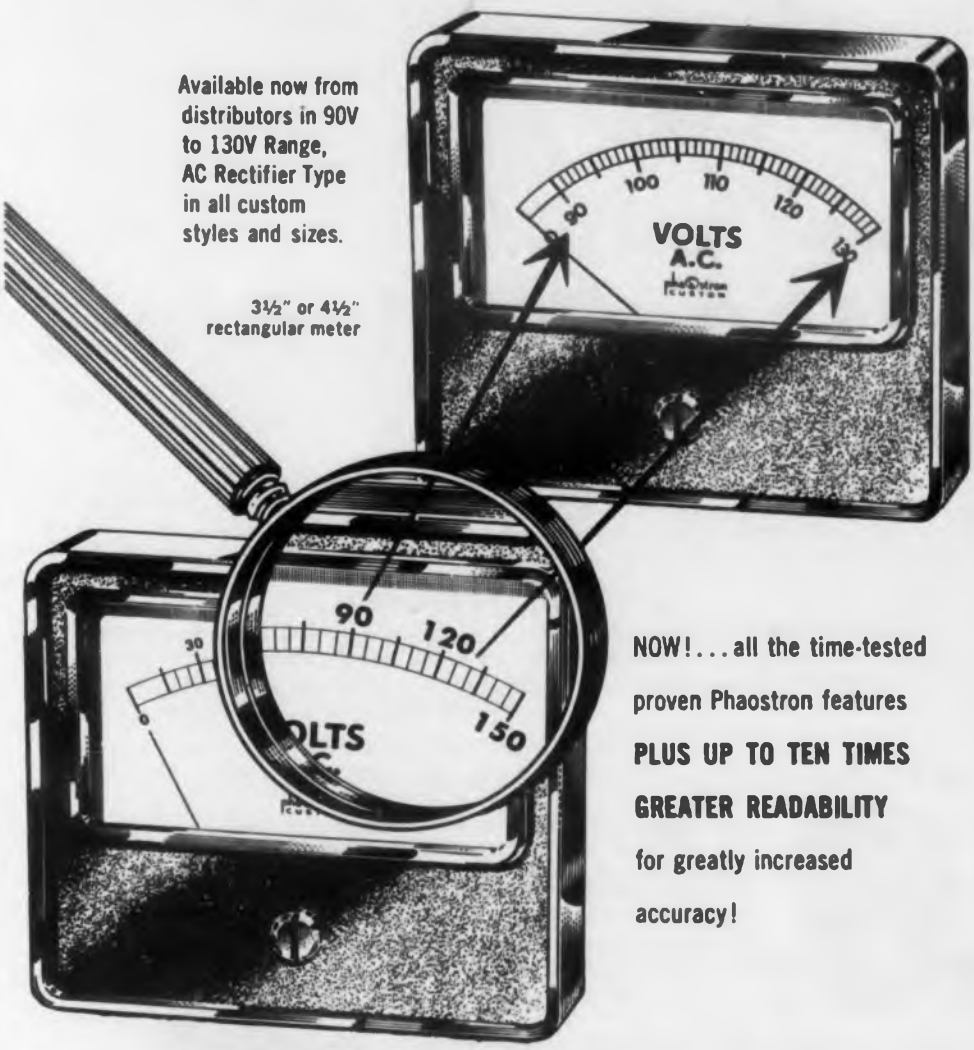
Centerless Grinder 402

The TG-12 centerless grinder is the subject of a 4-page illustrated brochure. To a detailed description of mechanical features is added a complete specifications table which gives data on capacity, equipment and accessories. Various types of grinds are illustrated. Royal Master, Inc., State Highway No. 23, Riverdale 1, N.J.

NEW PHAOSTRON
EXPANDED SCALE AC Voltmeter

Available now from distributors in 90V to 130V Range, AC Rectifier Type in all custom styles and sizes.

3½" or 4½" rectangular meter



NOW!... all the time-tested proven Phaostron features **PLUS UP TO TEN TIMES GREATER READABILITY** for greatly increased accuracy!

2½" or 3½" square meter

6" rectangular meter

2½" or 3½" round meter

All meters available with illuminated dial on special order

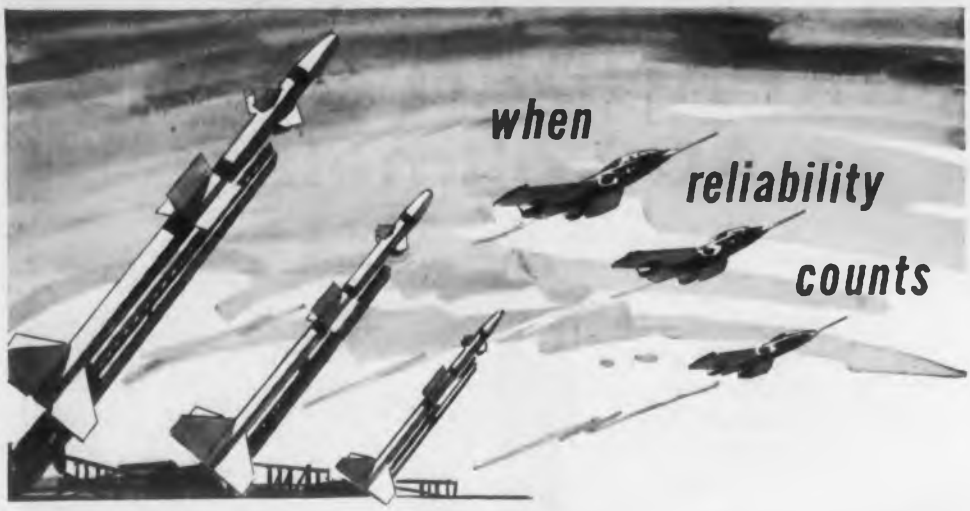
Phaostron has squeezed down that under 90V portion of the scale, where you don't need it, and expanded the section where you need it most—between 90 and 130V. Precisely calibrated 1 volt scale increments provide greater reading accuracy. Wide frequency range—linearity—true rms reading and Phaostron craftsman construction.

Phaostron Custom Panel Meters, with expanded scale, 90V to 130V AC rms, are available in nine types at your Parts Distributor. For special requirements for AC or DC expanded scale meters, write to Product Development Dept. for practical recommendations.

PHAOSTRON

PHAOSTRON INSTRUMENT & ELECTRONIC CO., 151 PASADENA AVE., SOUTH PASADENA, CALIF.

CIRCLE 404 ON READER-SERVICE CARD FOR MORE INFORMATION



RCA RELAYS

RCA Relays . . . for outstanding performance in high-speed, high-altitude missile and airborne applications, and critical requirements in industry.

Miniaturized . . . hermetically sealed . . . RCA Relays are highly reliable under the most severe operating conditions. RCA Relays *meet and exceed* the electrical and mechanical requirements of MIL-5757C and MIL-R-25018 (USAF).

GENERAL FEATURES

• Rated for operation up to 80,000 feet. • Insulation resistance better than 1,000 megohms *after* life test. • Balanced rotary motors for utmost stability. • *EXCLUSIVE*— Specially crimped mounting flanges provide *positive contact at four points on the mounting surface!*

Use the coupon for more information about RCA Relays.

RCA Type 203W2—A 6 PDT miniaturized DC relay weighing less than 4¼ ounces. Withstands 50g deceleration shock for 11 milliseconds, and 10g vibration shock from 5 to 2,000 cps. 26.5 volts DC coil. Contact rating 2 amperes. Life 100,000 cycles plus! Contact resistance less than .050 ohm. Contact Bounce less than 300 microseconds. R.F. Capacitance less than 3 $\mu\mu$f. Temperature Range —55° C to +85° C.

RCA Type 204W1—Same as the 203W2 except: Temperature Range —65° C to +125° C. Uses a "getter" which absorbs organic vapors and keeps contact clean—contact resistance will be lower *after* life test than *before* life test.

RCA Type 206W1—A 2 PDT miniaturized DC relay weighing less than 0.9 ounces. Temperature Range —65° C to +125° C. Like the 204W1 uses a "getter" to keep contacts clean. All other characteristics the same as the 203W2 except resistance to vibration shock from 5 to 2,000 cps is 15g.

ILLUSTRATIONS ARE TWO-THIRDS ACTUAL SIZE.

RADIO CORPORATION of AMERICA

COMPONENTS DIVISION — CAMDEN, N.J.

MAIL NOW FOR RCA RELAY DATA

RCA Components Division, Sect. E-84-PP, Camden, N.J.

☐ Bulletin 203W2 ☐ Bulletin 204W1 ☐ Bulletin 206W1 ☐ Have RCA Rep call

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

CIRCLE 408 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Hardener for Epoxy Potting 409

An epoxy hardener, for potting and encapsulation of electrical and electronic components, that gives good heat distortion temperature, excellent toughness, and long pot life is described in bulletin No. 13.

The physical properties of Sonite No. 41 and the physical and electrical properties of epoxy resins cured with this material are discussed.

Bulletin No. 13 gives detailed aspects of the properties, handling, mixing, pot life, and curing procedures when using Sonite 41. In addition physical properties of the cured castings, such as flexural strength, tensile strength, and resistance to impact, and electrical properties at various temperatures, such as surface resistance and volume resistivity. The physical data concerned with using Sonite 41 in glass cloth laminate systems are also included. Smooth-On Mfg. Co., 572 Communipaw Ave., Jersey City 4, N.J.

AC Output Accelerometer 41

Technical Data Sheet No. 20 provide engineering data, illustrations and information on special design and operation features of the Model GAL ac outpu accelerometer. The four-page bulletin als describes a modified version of the instru ment, designated the Model GHL, whic contains an internal thermostatically-oper ated heater for extremely close damping control. Genisco, Inc., 2233 Federal Ave, Los Angeles 64, Calif.

Electronic Parts Catalog 41

A 1957 electronic parts catalog has bee released. Prepared by Electronic Publish ing Co., Inc., the catalog contains 224 page listing components, equipment and other electronic products for industrial and ser ice use. Warren Radio Co., 1002 Adam Toledo, Ohio.

Load Calculating Nomograph 418

A load calculating nomograph has been developed to help figure cooling requirements for electronic equipment mounted in trailers, vans, consoles or stationary structures. When the type and size of a structure, the internal load, operating temperature and occupancy are selected, this nomograph will provide the required cooling load in BTU's per hour, and select the correct capacity for air conditioning equipment designed to meet rigid military specifications. The nomograph is printed on paper easily copied by any reproduction machine. Ellis and Watts Products, Inc., Monroe at Spencer, Cincinnati 36, Ohio.

Custom Molded Plastics 419

"Custom Molded Plastics for Industry" is a 12-page booklet with illustrated sections on molding facilities, finishing and assembly of components, research and development, and quality control. Chapters on injection molding, compression molding and transfer molding list examples of automatic equipment used in molding of thermoplastic and thermosetting materials. Sylvania Electric Products Inc., Warren, Pa.

Electronics—Key to Control 420

Applications of electronic temperature controls for the heating, ventilating and air conditioning field are described in colored four page bulletin, F-2287-4 now available. It explains all the features, functions and advantages of an electronic system which provide efficient and economical control for any type of heating and air conditioning equipment. All components and accessories, used in the various types of electronic systems, are illustrated and specific applications of each are discussed. Barber-Colman Co., Temperature Controls, 1400 Rock St., Rockford, Ill.

Current Limiting Fuses 421

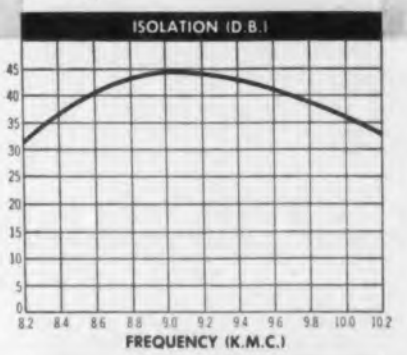
The eight pages of Bulletin GEA-6319B describe a line of CLF current limiting fuses capable of interrupting short circuit currents up to 200,000 rms symmetrical amperes. The operation and application of the fuses are outlined and dimensions and ratings are given. The booklet is illustrated with photographs and also graphs showing current characteristics. General Electric Co., Schenectady 5, N.Y.

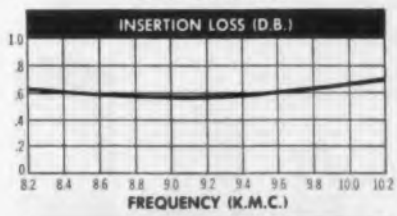
A New Broad Band Kearfott FERRITE ISOLATOR for Laboratory Test Bench Use

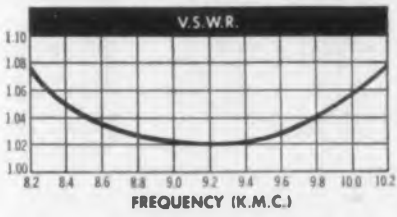
Model
W177-2C-1

Use this Ferrite Isolator in your microwave setup for maximum frequency stability.

Typical Performance Curves







CHECK THESE FEATURES:

Broad Band—Usable from 8.2 to 10.2 KMC

High Isolation—A minimum of 25 db over the band

Insertion Loss—Less than 1 db

Small & Compact—Only 2½ inches long—weighs only 1½ lbs.

Flanges—Cover type. Mates with UG39/U flanges. Will absorb up to 10 watts reflected power

Price—$135.00 each f.o.b., Van Nuys, Calif.

Delivery—From stock

Order—Model W177-2C-1

For custom-made isolators for specific radar & microwave application, you can depend on the skill of the Kearfott organization.

Kearfott, Western Division, has complete facilities for waveguide production, with qualified experts to assist in solving your problems. Let us help you.

For detailed information, ask for bulletins on new Ferrite Isolators and Radar Test sets.

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CIRCLE 423 ON READER-SERVICE CARD FOR MORE INFORMATION

performance tested...

for long life...up to temperatures of 200°C!

u s edcor *hermetically sealed*

teflon film capacitors

You can always depend on U. S. Edcor for the rigid quality control that guarantees complete and lasting reliability. For extra long service where the going is rough — under adverse conditions of vibration, widely varying ambient temperatures, extreme altitudes . . . or where requirements are critical — as in high performance missiles . . . specify U. S. Edcor Teflon Film Capacitors!

u s edcor **U. S. Electronics Development Corporation**
1323 Airway, Glendale 1, California

Our field Engineering Representatives welcome the opportunity to consult with you on standard or special capacitor requirements. For address of office nearest you — or for complete technical data —WRITE TODAY to Sales Engineering Dept., U. S. Electronics Development Corporation, 1323 Airway, Glendale 1, California.

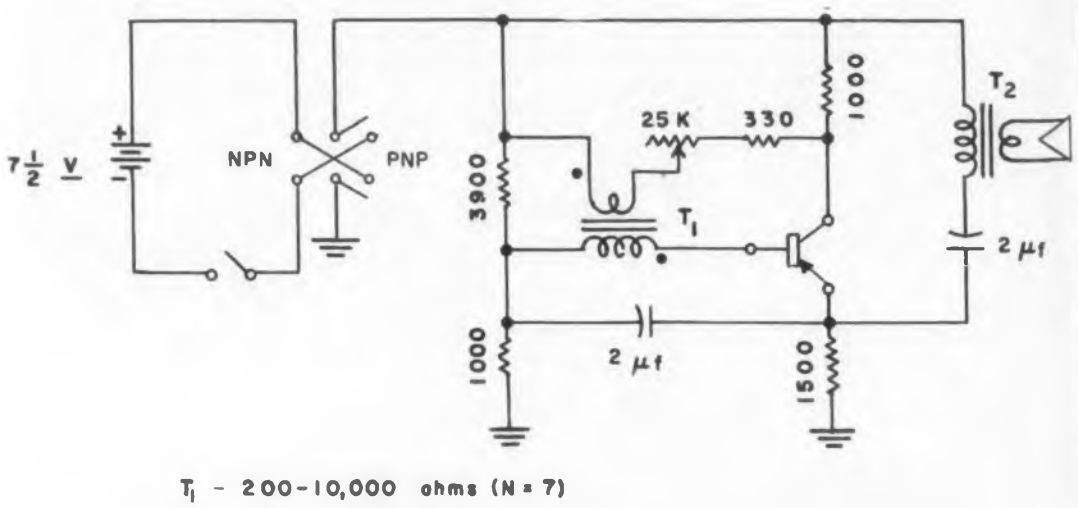
CIRCLE 428 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Beta Tester

A simple, inexpensive instrument for measuring the β of a wide variety of transistors has been developed by the National Bureau of Standards. The device measures the common-emitter short-circuit current gain of pnp or npn transistors at low audio frequency. In operation, the transistor is plugged into the instrument and a dial is adjusted to the point where a tone is heard from a loudspeaker. The β is then read directly from the dial. Properly calibrated, the instrument can measure β accurately over a range of 10 to 170.

The circuit is similar in principle to one used for measuring vacuum tube transconductance. In such a tube circuit, part of the plate voltage is fed back into the grid through resistor and transformer coupling to cause oscillation. Similarly, with the circuit for measuring transistor gain, the output is fed back into the input through a variable resistor and a transformer; when the resistor is properly adjusted, the circuit begins to oscillate at an audio frequency. The dial on the variable resistor can be calibrated through a substitution method.

To reduce the number of controls to a minimum, circuit parameters are chosen so that the transistor will adjust itself to a specified dc operating point. The resistors in the circuit were selected to fix this



T_1 – 200–10,000 ohms (N = 7)

T_2 – 500–3.2 ohms

Circuit diagram of transistor β tester. When the 25K pot is properly adjusted for a given transistor, the circuit oscillates at an audio frequency. Tone can be heard from loudspeaker.

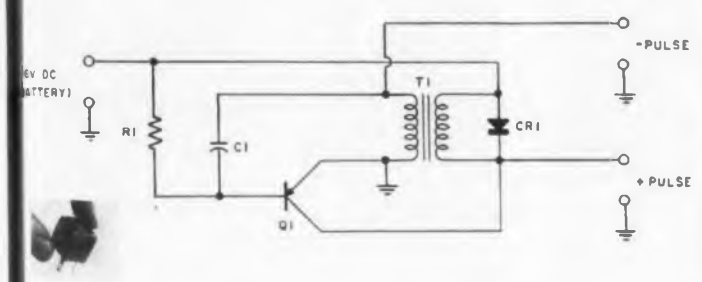
Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication. Full information and an "entry blank" can be obtained by circling 548 on the Reader's Service Card.

point at about 5 v collector potential and 1 ma collector current. For any transistor whose β falls within the measuring range of the instrument, these dc values will be closely approximated when the transistor is plugged in.

The frequency at which oscillations begin depends upon the characteristics of the transformer and the phase shift of β. The current ratio of the audio transformer has a broad maximum centered at 1 or 2 kc, and if the phase shift of the transistor is sufficiently small, oscillation begins at a frequency near this maximum. However, the transistor gain required to produce oscillation for a given dial setting is not a particularly sensitive function of frequency. Measurements accurate to within a few per cent of full scale can be expected.

Encapsulated Blocking Oscillator

Encapsulated with epoxy resin within a 3/4 in. cube shown is a complete blocking oscillator circuit which includes a subminiature pulse transformer, transistor, capacitor, resistor and crystal diode. The circuitry shown produces triggering electronic



pulses identical to those obtained from larger, more expensive pulse generators.

Designed by engineers of Allen B. DuMont Labs. Inc., a pulse of 3 μsec duration with a rise time of 0.06 μsec is obtained. The repetition rate is 25 kc. Power requirements are furnished by a miniature 6 v mercury cell which lasts approximately 1000 hours. Amplitude of pulse is from +6 to −3 v peak. The "pulse cube" can be obtained from DuMont with a fixed repetition rate of 1 kc if desired, or a variable repetition rate from 400 cps to 24 kc. It can also be obtained as a free-running blocking oscillator or for external triggering. Operating temperature range is from −55 to 60 C.

GYROS

for every application

The Kearfott miniature 4 Gimbal 3 Gyro, stable platform, provides precise azimuth, pitch and roll information—irrespective of the airframe attitude. It is hermetically sealed for environmental protection. Because of its rapid warmup characteristic, this unit is fully operational in less than five minutes. This platform provides the features of a magnetic slaved or a latitude corrected directional gyro for heading reference. Dependable, accurate single purpose Kearfott Gyros also available.

ALL ATTITUDE
3 GYRO STABLE PLATFORM

Suitable for use in both missile and aircraft, random drift rate 1° per hour in azimuth and 3° per hour in vertical. Measures only 8" Diam. x 8¾" High, weighs but 23 lbs.

Send for bulletin giving data of components of interest to you.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Indicators and other Electrical and Mechanical Components.

KEARFOTT SYSTEMS INCLUDE:

Directional Gyro Compass Systems, 3 Gyro Stable Platform Systems and Inertial Navigational Systems.

Kearfott

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GENERAL PRECISION EQUIPMENT CORPORATION

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Midwest Office: 23 W. Calendar Ave., La Grange, Ill. South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

CIRCLE 430 ON READER-SERVICE CARD FOR MORE INFORMATION

Quick-Release Fastener

The clamp design shown eliminates or minimizes the tedious and time-consuming manual manipulations of the available non-standard component clamps and at low cost.

The clamp is a powdered metal casting of stainless steel with a core of plastic partially threaded. When assembled with a screw, the remainder of the thread is cut making a tight-fitting casting on the screw threads.

This captive sub-assembly is screwed into its mounting hole until it bottoms, and it is then backed off until the flat is opposite the diameter as shown. After three clamps are set, the component is mounted with the clamps in the open position, shown in the sketch. With a screw driver, the screw is turned until the clamp is in the locked position. The integral shoulder *(1)* stops the clamp in its strongest holding position.

Further tightening of the screw does not turn the clamp, but it is pulled down to its clamping position. In allowing the screw to continue to turn, while the clamp is stationary, the plastic permits the unit

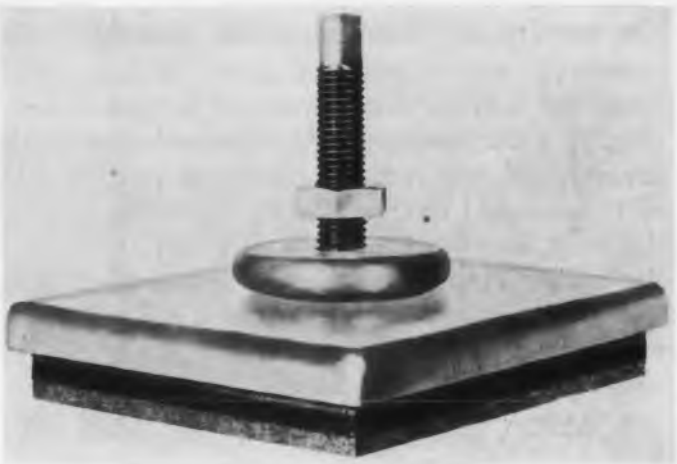
Device held by "Synclamps". Below center, clamp is in unclamped position; at right, in clamped position; left, a side view. A half-turn with a screwdriver "does the trick."

to phase itself to the pilot diameter and its own tapped hole. Seemingly, by this action, the plastic thread is stripped. However, with just a half-turn the clamp is lifted up and around to the open position, being stopped by the flat *(2)*.

The tight fit of the plastic on the screw threads is unchanged by the "stripping" action, and may be operated indefinitely. This tight fit also gives a stop-nut action by making the screw and clamp act as a unit. It is prevented from turning by the friction at the clamping point, giving a longer moment of arm. Timber-Top Inc., P.O. Box 14, Freeport, New York.

Shock Mount Provides Mobility

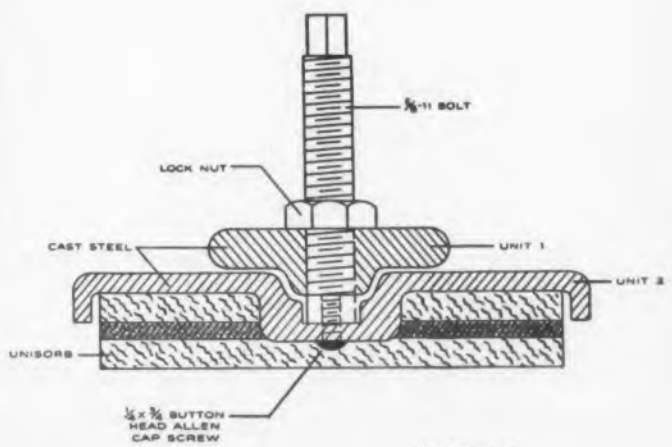
Through the use of a vibration dampener pad under a heavy steel plate, as shown, the Felters Co. of Boston has produced an equipment mount that permits ready mobility. At the same time, the equipment will remain firmly in position under vibration.



As illustrated in the cross-sectional view, leveling is readily accomplished by rotating *unit 1*, then locking in position with the *lock nut*. *Unit 2* is a steel base plate which rests on the "cushion" of *Unisorb*.

Mounts of this type are standard for loads from 800 to 7500 lb per mount, and in sizes from 4 to 10 in. square.

The *Unisorb* cushion will reduce transmitted vibration by as much as 85 per cent and is impervious to cutting fluids and cleaning compounds.



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Ideas for Design

Regulated Radio-Interference Free Generator

Described here is a generator of radio-interference-free design which produces a conventional voltage regulated output without requiring brushes, slip rings or commutator. As a result of the design, there are no sliding or arching contacts to initiate radio interference. The unique feature is the manner in which regulated excitation is supplied to the rotating field.

Brushless generators are not new. However, a machine was required which was suitable for all normal power and lighting applications and which produced a well-regulated 60 cps voltage supply. This requirement made it necessary for the generator to have a regulated dc field.

A standard engine generator set was modified for brushless, voltage regulated operation. The generator was a 30 kw., 0.8 power factor, 60 cps, 120/208/416 v, 1200 rpm diesel generator. The generator was a common type with a static armature, rotating field, and overhung dc exciter (Fig. 1). Voltage control was obtained by taking the commutated output of the exciter off through a set of brushes and feeding the dc excitation through slip rings into the main generator field. Control of the exciter output was exercised through the ex-

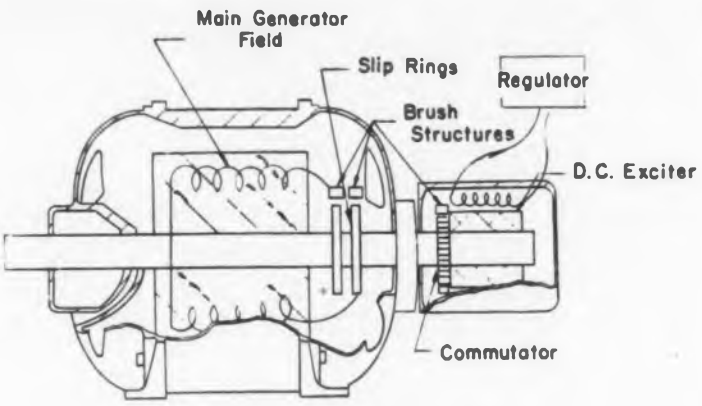

Fig. 1. Generator before modification.

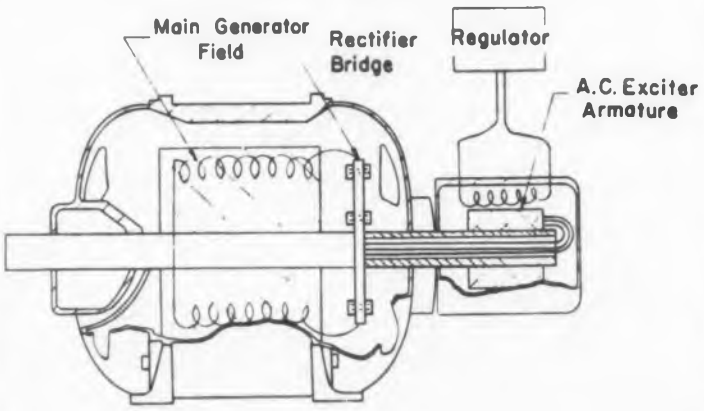

Fig. 2. Generator after modification to brushless type.

citer field. The modification made on the generator consisted of eliminating the two sets of brushes, the commutator, and the slip rings, and arranging to feed controlled dc excitation to the rotating main generator field. A sketch of the modified generator is shown in (Fig. 2).

The exciter armature, rectifier bridge, and main generator field are all rotating on the same shaft. Three phase ac exciter output is rectified in the bridge and delivered to the main field without brushes, commutators or slip rings. Thus all sources of electrical sparking and resulting radio interference have been eliminated from the generator and exciter. Control is exercised through the static exciter field which governs the exciter output, which in turn varies the main generator field to give regulated voltage output at the generator terminals.

The key development which has made this arrangement possible is the perfecting of the silicon rectifier. The relatively small size per unit of power and the more desirable temperature characteristics of the silicon rectifiers makes their use in this application very advantageous. The space required by selenium or copper oxide rectifiers would make it impracticable to mount them on the shaft of the generator. These small rectifiers will handle about one kw each. Their mass is about 1 per cent that of the old selenium or copper oxide type.

Voltage Regulation

A static type voltage regulator is used which senses the voltage output of the main generator terminals. This voltage is impressed upon two impedance type circuits in the regulator, which are in effect a voltage standard. A signal proportional to the difference between the generated voltage and the regulator voltage standard is delivered to a magnetic-amplifier control winding, and the magnetic-amplifier output is fed to the exciter field through rectifiers in such an amount as to bring the generator terminal voltage in balance with the regulating standard.

The regulating voltage standard is developed by placing across the generator terminals a linear and a non-linear circuit. There is one voltage at which the currents drawn by these circuits are equal. Above this voltage they deliver a different current to a control magnetic-amplifier in such a way as to

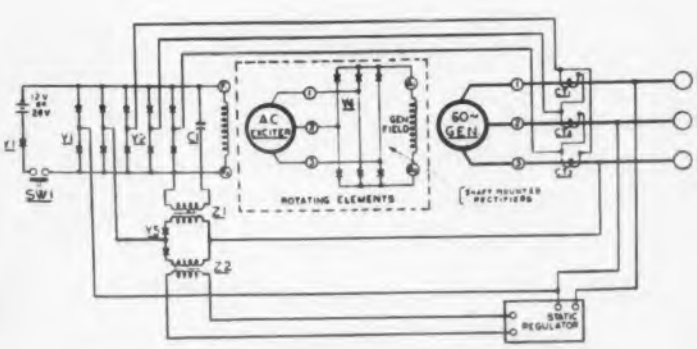

Fig. 3. Schematic of Brushless Generator.

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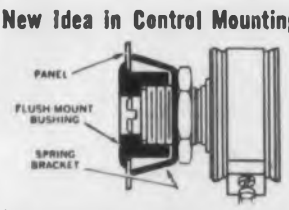

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decrease generator excitation. Below this voltag they deliver a difference current which increase excitation. The magnetic-amplifier receives it power from the 60-cycle output of the main genera tor and delivers its rectified output to the stationar field of the exciter. The regulator is frequency com pensated to hold voltage within ±2 per cent wit engine speed changes of ±5 per cent.

In order to provide fast response and ample ex citation current for motor starting loads and fo short-circuit relay tripping conditions, the excita tion system is strengthened by using current trans formers in the output of the main generator. Whe load or fault current flows from the main generator the current back through a three phase rectifie bridge directly to the stationary field winding of th ac exciter. Thus on motor starting loads or under fault conditions, which are low power factor de mands, the current transformers maintain excitation at a value which will sustain the generator voltage This arrangement insures that there will be suf ficient current flow under fault conditions to trip the circuit breakers. A schematic wiring diagram of the generator and regulating system is shown in Fig. 3. *A. M. Brown, U.S. Naval Civil Engineering Research and Evaluation Lab., Construction Bat talion Center, Port Hueneme, Calif.*

New Shock Mounting

Robinson Aviation, Inc. of Teterboro, manufac turers of all-metal vibration and shock mounting systems, recently developed a Met-L-Flex center of-gravity mounting for a pressure ratio transmit ter unit developed by Minneapolis-Honeywell for airborne applications.

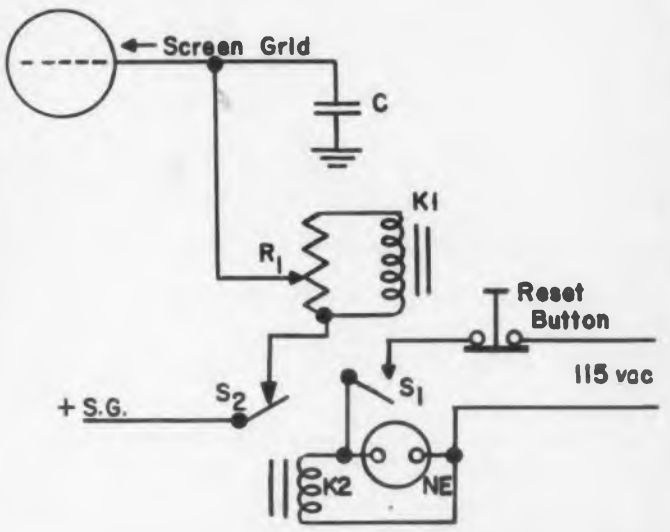
This specialized mounting system shown incorporates pressure and electrical connectors as part of the supporting structure of the mounting. It provides for ease of installation and in effect combines the equipment and mounting into an integral package.

Constructed of aluminum and steel throughout, the lightweight mounting system is a permanent type mounting unaffected by adverse operating conditions. The incorporation of Met-L-Flex resilient elements, located in the plane of the center-of-gravity, provides Model 1323 with environmental tolerance from vibration and shock, thereby insuring equipment reliability.

The high percentage of inherent damping displayed by the mounting system results in the reduction of resonant peaks and the quick dissipation of transient forces. The natural freqency of Model 1323 is between 6 to 11 cps while the amount of vibration provided is approximately 90 per cent at 40 cps. Designed in accordance with military specifications MIL-E-5272A, MIL-C-5541 and QQ-P-416, this mounting system is readily adaptable to military applications.

Tube Protection Scheme

A solution is given here to the problem of finding a reliable method of protecting the screen grids of high-power beam tetrodes and pentodes in event of bias, excitation or plate supply failure.



A very sensitive relay (k_1) of 10,000 ohms is used. When I_{sg} exceeds a predetermined value, the voltage drop across R_1 pulls in the relay K_1. S_2 closes, energizing K_2, which opens S_2. K_2 has a holding contact which prevents reapplication of screen voltage until the reset button is pushed, again closing S_2. The neon lamp across the coil of K_3 gives visual indication of the overload. *Stephen J. Goch, Director Research, G & G Electronics Labs., 1062 Virginia Ave., Bronx 72, N.Y.*

Report Briefs

Traveling Wave Tubes

Two-helix and three-helix backward-wave amplifiers of the cascade type were studied, and the latter found to have a higher gain-bandwidth product. An experimental model of a two-helix mixer in which one helix is a backward-wave amplifier and the other a backward-wave oscillator gave conversion efficiencies up to 0.57, and it is believed that the design could now be improved. Interaction between several space harmonics, originally believed to be orthogonal, was observed on the multi-helix tubes, and several studies were conducted to determine the source of the interaction. A velocity and current analyzer for the backward-wave tubes was also designed. Several studies in crossed-field tubes are described, including measurements on a forward-wave amplifier using a zig-zag slow-wave structure, and the design of a two-circuit backward-wave crossed-field tube. Several gun studies, especially on guns of the shielded type, were made. Electrostatic focusing of electron beams was studied analytically and experimentally, and attempts were made to combine rf interaction with an electrostatically focused beam. Analyses of the noise problem and the large-signal problem are discussed. Experiments were made on several novel high-density emitters, including a metallic arc, a Phillips ion gage discharge, and a shielded field emitter. *PB 123983 Traveling Wave Tubes and Related Studies, David H. Sloan, John R. Whinnery and John R. Woodyard, California Univ. Order from Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D. C. Dec. 1955, 26 pp. Microfilm $2.70. photocopy $4.80.*

Low Frequency Propagation

Study of Loran signals showed that E-layer fading rates are not always the same as those in the D-layer. Wide band multichannel equipment for the study of various kinds of atmospherics was designed and constructed. An improved intervalometer was constructed. From whistler data obtained in Seattle and Stanford during 1951 and 1952, it was found that approximately 22 per cent of the whistlers that occurred at either location were received at both locations. This result provides support for Storey's theory of whistlers. Simultaneous whistler observations made at Stanford and on the U.S.S. Atka of the Navy Antarctic Expedition in Dec. 1954 were analyzed. *PB 122359 Low Frequency Propagation Studies, Robert A. Helliwell, Stanford University, Radio Propagation Lab., Stanford, Calif., Library of Congress, Washington 25, D.C. Sept 1955, 61 pp. Microfilm $3.90, photostat $10.80.*

Anisotropic Particle Lattice

The dielectric properties of lattices composed of identical metallic or dielectric elements of various geometries, such as spheres, discs and strips have been investigated from a molecular point of view. The main objective of this note is to extend the treatment to general uniform lattice structures made of identically shaped and oriented particles of general constitutive characteristics. Thus, it includes the most general case of a uniform lattice with structural anisotropy and both element isotropy and anisotropy at the lattice points. *PB 124171 Dielectric Properties of a Lattice of Anisotropic Particles, Zohrab A. Kaprielian, California Institute of Technology, Electrical Engineering Dept., Library of Congress, Washington 25, D.C. June 1955, 29 pp. Microfilm $2.70, photostat $4.80.*

Radome Design

This report presents a general discussion of the design information which has been gathered by investigators and fabricators in developing various sizes and modular configurations of rigid radomes. The design information which is included pertains to the aerodynamic, structural, and thermodynamic analyses. Test data are given concerning climatic studies, wind-simulated loading tests, transmission tests, and installation tests. A discussion is also included on the parameters and problems involved in material selection and fabrication procedures. The applicability of the collected design and test data to Air Force requirements is discussed and conclusions and recommendations are presented. *PB 123976 Design Considerations for Rigid Radomes, J. R. O'Donnell. U. S. Air Force, Air Research and Development Command, Rome Air Development Center, Griffiss Air Force Base, Rome, N.Y., Library of Congress, Washington 25, D.C. June 1956, 73 pp. Microfilm $4.50, photostat $12.30.*

Low-Power Pulse Transformers

Analysis and design procedures are derived for application to low-power pulse transformers including, in particular, the types expected to be employed in many circuits of the electronic digital computer of Project Whirlwind. Pulse lengths considered are between a twentieth and a quarter μsec. Although optimum reproduction of pulse shape is assumed to be a leading requirement, the procedures given are presumably general enough to be extended to applications for which faithful reproduction of input voltage or current waveform is not necessary. *PB 124199 Low-Power Pulse Transformer, Thomas F. Wimett, Mass. Institute of Technology, Servomechanisms Lab., Cambridge, Mass., Library of Congress, Washington 25, D.C. Dec 1947, 114 pp. Microfilm $6.00, photostat $18.30.*

Report Briefs

Snow Measurement

Intensities of the snow echoes obtained by a zenith-pointing radar from 180 different contributing regions are compared with suitably chosen thresholds. The probability of the intensities exceeding such a threshold and the frequency with which two intensities separated in time straddle it, are used to deduce the autocorrelation coefficients of the signals. The autocorrelation coefficient, after correction for receiver noise, is shown to be the product of three partial coefficients due to the differential settling of the particles, to a uniform wind driving the particles across the beam, and to turbulence. To the extent that differential settling and cross-wind are known, turbulence can be deducted from the measured coefficient of the signal. Considerations based on the theory developed suggest that measurements of turbulence in rain or snow in the horizontal beam of a high-resolution radar at close range should be feasible. Appendix 1: Correlation coefficients of the signal intensity, and of the amplitude components; the Wiener-Khintchine theorem. Appendix 2: Auto correlation coefficients are "multiplicative." *PB 124560 Measurement and Calculation of Fluctuations in Radar Echoes from Snow, Walter Hitschfeld and Arnett S. Dennis, McGill University, MacDonald Physics Lab., "Stormy Weather" Research Group, Montreal, Canada, Library of Congress, Washington 25, D.C. 53 pp. Microfilm $3.60, photostat $9.30.*

M Type BWO

A field theory of electron beams focused by crossed electric and magnetic fields is given. The theory is basic to the understanding of the small signal behavior of crossed field electron devices. It is applied to explain the slipping stream, or diocotron, effects as a coupling of two surface waves of the electron beam, and to derive the start-oscillation conditions of the M-type backward wave oscillator. It is found that the slipping stream effect can reduce the starting current by an appreciable factor. The results are compared with the thin beam theory which neglects space charge effects. An analysis of a loaded strip transmission line is given, from which a method of representing space harmonic slow wave circuits by a surface admittance boundary condition is obtained. Forward and backward space harmonic interaction may be treated equally well. *PB 123973 Field Analysis of the M Type Backward Wave Oscillators, Roy W. Gould, Calif. Institute of Technology, Electron Tube and Microwave Lab., Pasadena, Calif., Library of Congress, Washington 25, D.C. Sept 1955, 108 pp. Microfilm $5.70, photostat $16.80.*

Magnetic Amplifiers with Feedback

Tests made on magnetic amplifiers excited by a sine-wave carrier were conducted to determine if the figure of merit could be improved by means of feedback techniques. The results are presented schematically and mathematically. In general, the investigations reveal that the power gain of the magnetic-amplifier device can be increased to an unlimited point, but that with this increase a finite rise time remains. Under these conditions the figure of merit, as it is ordinarily defined, becomes meaningless. However, investigations reveal that even under conditions in which feedback techniques are employed, the voltage-gain to magnetic-amplifier rise time ratio remains essentially constant and results in a useful figure of merit. *PB 123403 Investigations of Magnetic Amplifiers with Feedback, Remington Rand Univac, Order from Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D.C. Mar. 1956, 20 pp. Microfilm $2.40, photocopy $3.30.*

RFI in Communication

A simple method for measuring densitization of receivers caused by radio interference is presented. The use of this method for obtaining true signal to noise ratio measurements at the output of a receiver is discussed. A standard speech test signal is suggested for intelligibility evaluation by means of the concept of articulation index. *PB 123076 Evaluation of Interference Effects on Speech Communications, Arthur Gottfried and Kurt Ikrath, U. S. Signal Corps Engineering Labs., Fort Monmouth, N.J., Library of Congress, Washington 25, D.C. Mar 1956, 18 pp. Microfilm $2.40, photostat $3.30.*

Traveling-wave Tube Theory

Propagation constants have been calculated for a lossy traveling-wave tube by means of a field theory. These results have been applied to the prediction of an attenuator power loss of the order of 2 or 3 db. compared to attenuatorless operation. It is shown that the gain of the higher order modes is negligible. Admittance matching by means of radial admittance transformation is the underlying method used throughout. The Pierce-Fletcher theory in common use at this time is examined in some detail to determine its range of validity. The effects of space charge bunching on saturation has been treated. Criteria have been set for determining whether bunching is important or not in determining saturation. *PB 123173 Field theory of traveling-wave tubes with application to the study of attenuator saturation effects, William Buchman, California Institute of Technology, Electron Tube and Microwave Laboratory, Pasadena, Calif. LC. Washington 25, D.C. 136 pp. $21.30.*

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Internal Resistance, typical (ohms)			
low-voltage range	1.2	0.35	1.3
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Patents

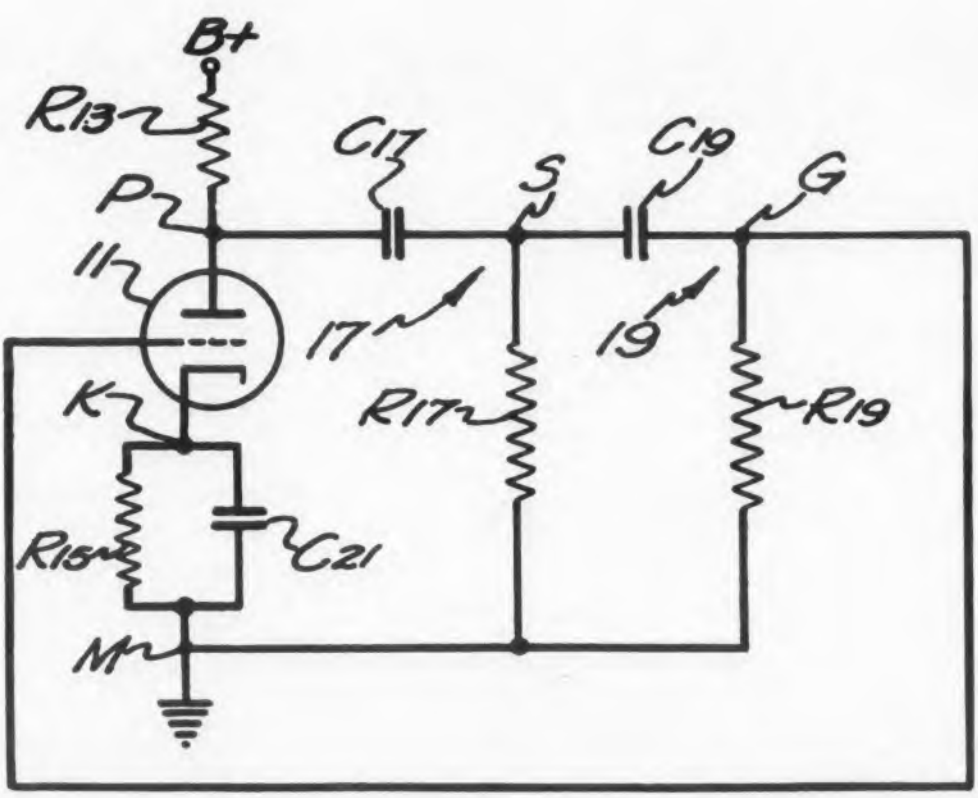
Phase-Shift Oscillator

Patent No. 2,777,952 B. F. Spencer (Assigned to Sperry Rand Corporation)

Phase-shift oscillators as heretofore designed have required more than two phase-shift networks in the plate circuit of the oscillator tube in order to secure the 180 deg phase-shift necessary for sustained oscillations. Oscillators must have enough gain to overcome circuit losses for sustained oscillations. In the usual phase-shift oscillator, the cathode circuit includes a resistor and a condenser of large value in shunt with the resistor with the result that the phase-shift achieved in the cathode circuit is negligible. As a consequence an additional phase-shift network is required in the grid plate circuit to secure the necessary 180 deg phase-shift.

In the phase-shift oscillator shown in the figure, oscillations are secured with two phase-shift networks *17* and *19* in the plate to grid connection. The networks shown are of the L type using capacitors *C17* and *C19* in series between plate and grid. These two networks secure a phase-shift of substantially less than 180 deg. The additional phase-shift necessary to achieve 180 degrees of phase-shift is secured from the reactance network K in the cathode to ground circuit. The shunting capacitor *C21* has a value that provides sufficient phase-shift to achieve the 180 deg phase-shift for maintaining sustained oscillations.

It will be noted, therefore, that the phase-shift network in the plate-grid circuit provides substantially less than 180 deg phase-shift and that the additional phase-shift required is provided by the cathode network. As a consequence, a reduction in the number of phase-shift networks necessary to secure sustained oscillations is secured. In addition, the gain of the circuit for securing sustained oscillations is reduced to a minimum since circuit losses are less. The circuit described and illustrated has good stability. The patentee illustrates two other forms of the phase-shift oscillator circuit with results comparable to the results secured with the circuit illustrated.



Semi-Conductor Network

Patent No. 2,780,752 R. W. Aldrich et al (Assigned to General Electric Company)

The network has a semi-conductor provided with spaced electrodes which are predominantly bilaterally conducting. A junction electrode having unilateral conducting properties contacts the semi-conductor in a region which is influenced by potential applied between the spaced bilaterally conducting electrodes. A potential of proper value is applied between these spaced electrodes. A capacitor connects the junction electrode with one of the bilaterally conducting electrodes, and an impedance connects the other of the spaced electrodes and the junction electrode.

Self-Saturating Reactor Circuits

Patent No. 2,780,772 B. Lee (Assigned to Vickers Incorporated)

The magnetic amplifier has the usual input and output circuits. A saturable reactor has its reactance winding in series with a half-wave rectifier between the input and output circuits for self-saturation. A second reactor winding connects with a source of alternating control current. A shunt circuit is provided across the second winding. The circuit includes a second half-wave rectifier so that induced current flow in the second winding flows in a direction to generate magnetic effects in the reactor which are oppositely related to the magnetic effects produced by current flow through the first rectifier.

UHF Signal Generation

Patent No. 2,777,062. R. J. Hannon. (Assigned to Standard Coil Products Co., Inc.)

The high frequency oscillator of the patent uses an electron tube having a plurality of electrodes. The effective inductance of certain of the leads to the electrodes is resonated by means connected between the plate and the grid terminals of the tube in order to establish the frequency of oscillation. Compensation is provided for the effective inductance of the other electrode leads, as well as a parallel non-resonant LC circuit in series with the compensating circuit element for providing a high frequency output signal. This series circuit is between the plate terminal of the tube and ground.

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CIRCLE 459 ON READER-SERVICE CARD FOR MORE INFORMATION

Patents

Switching System

Patent No. 2,782,303 E. A. Goldberg (Assigned to Radio Corporation of America)

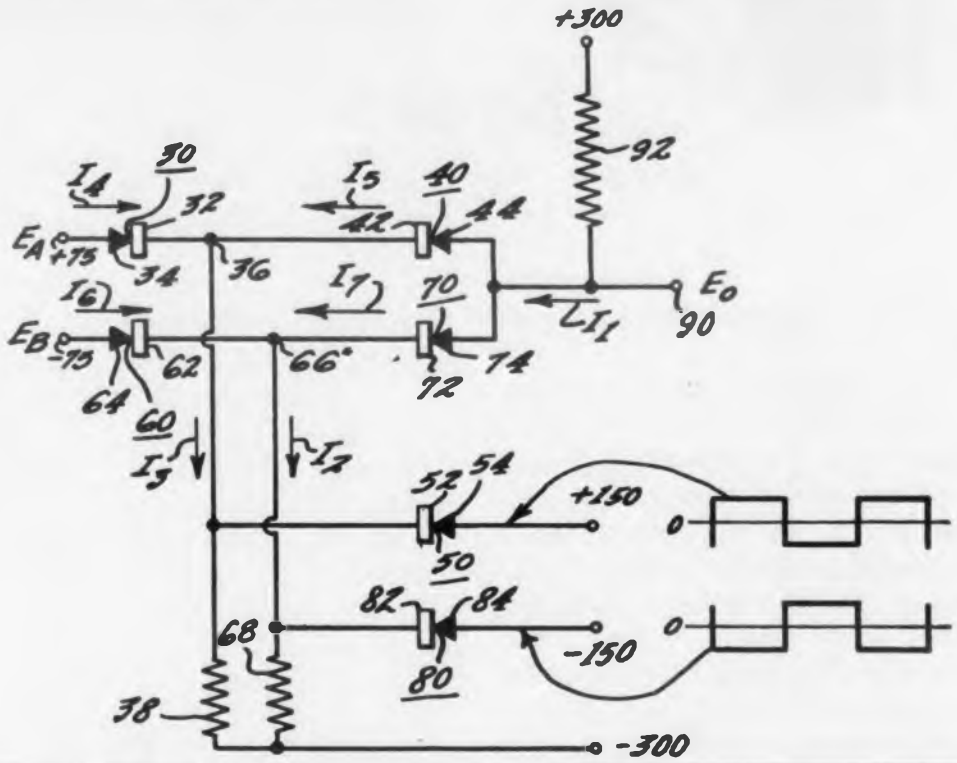
Electronic switching circuits employing semi-conductor materials are coming into increasing use since they require no filament supply and the overall circuit is simplified. The semiconductor materials are particularly desirable when there is no need for amplification of the switched signals. Switching circuits, as presently designed, are subject to two difficulties in particular. One difficulty is that of maintaining the level of the signal being switched because of losses arising in overcoming a blocking bias. Another difficulty is that occasioned by the capacity of the wiring which prevents rapid transmission of the switched signal required with electronic equipment.

The circuit in its simplest form is illustrated in the figure. The positive signal to be switched is applied to the input terminal EA and a negative signal is applied to the input terminal EB. The positive signal passes through the diode *30* and resistor *38* under the control of a switching signal which is applied through the diode *50*. Upon the application of a positive switching control signal through the diode *50*, the cathode *32* of the diode *30* is biased to non-conduction and consequently the input signal is not transmitted. A negative control signal applied through the diode *50* will render the diode *30* conducting and the signal will be transmitted. In similar manner, a positive or negative control switching signal applied through the diode *80* biases the diode *60* to non-conduction or conduction so that the negative signal is blocked or transmitted.

Biasing of the diode *30* so that it becomes conducting affects the current flow through the resistor *92* and diode *40* so that the input signal appears at the output terminal *90*. Similarly a signal conducted through the diode *60* affects the current flow through the resistor *92* and diode *70* and results in the negative signal appearing at the output terminal *90*. With the circuit illustrated, the diode power losses in diode *30* and *40* are equal and opposite so that the two losses compensate for each other. The output signal appearing at the terminal *90* is of the same value as the input signal being

switched or transmitted. The connection of the diodes through resistors 38 and 68 with a negative source of potential permits any potentials occurring as a consequence of capacitive effect of the connections to leak off and enables a high speed switching operation to be secured with the circuit.

There are two other forms of the circuit illustrated and described in the patent. In one circuit the resistor 92 is replaced by a vacuum tube and the resistors 38 and 68 also may be replaced by vacuum tubes. The other modified circuit is a refinement of the circuit illustrated herein.



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- **SERVO-MECHANISMS AND ELECTRO-MAGNETICS** Work includes the design and development of magnetic amplifier control devices and integration of components into finished systems. Servo-system analysis and performance prediction would be helpful. Complete working knowledge of electro-magnetic theory and familiarity with materials and methods employed in the design of magnetic amplifiers is required.

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Century MODEL 409

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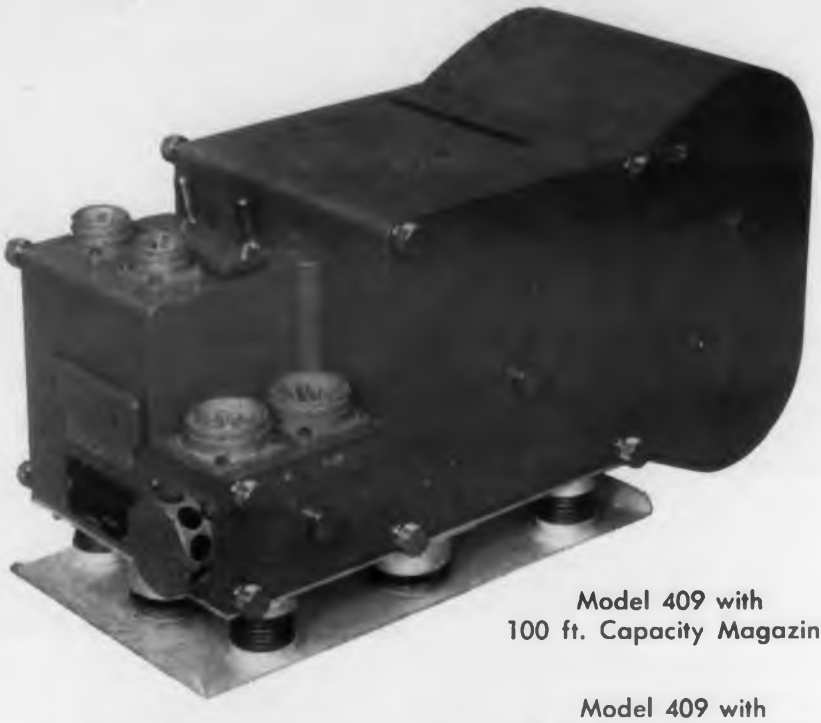
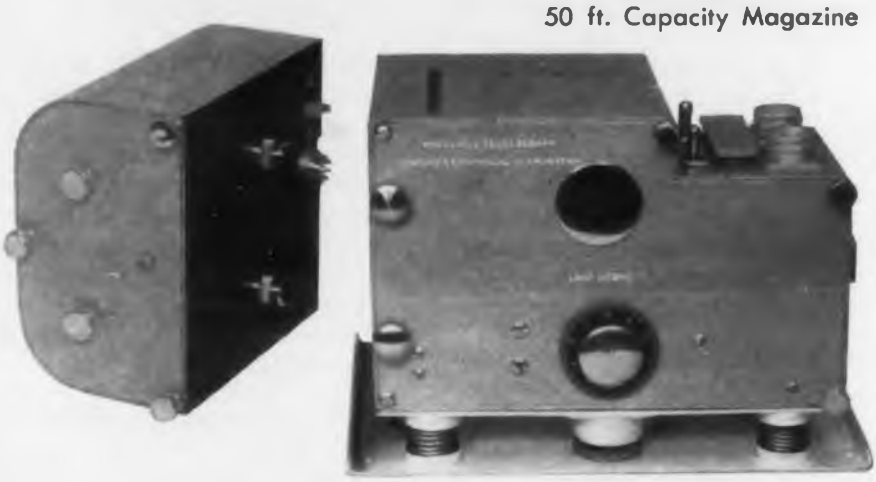


Model 409 with
100 ft. Capacity Magazine

Model 409 with
50 ft. Capacity Magazine



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Books

Annual Report 1956, National Bureau of Standards.

U. S. Dept. of Commerce, Washington 25, D.C., 15 pages, $.60.

The National Bureau of Standards Annual Report on its research and development activities in the physical sciences contains brief descriptions of the accomplishments in each area of the Bureau's responsibilities. Such subjects as the maintenance of basic standards, determination of physical constants and properties of matter, development of methods and instruments of measurement, and the provision of calibration, testing and scientific advisory services are covered.

During the past year, significant results were achieved in programs dealing with electronic computers, electronic instrumentation and the properties of matter and materials. Development work was successfully completed on a micro-image data storage and retrieval device which provides rapid access to any one of 10,000 microfilmed images located on a 10 in. square sheet of film.

The Bureau also developed a technique for capturing and storing large numbers of free radicals—highly reactive molecular fragments—at temperatures near absolute zero. In the field of optics and metrology, the Bureau completed a comprehensive dictionary of color names, which lists some 7500 individual color names and defines them in simple accurate terms easily understood by workers in different fields. A study of the effect of crystal orientation of fatigue crack initiation in metal was also completed.

Engineers in foreign countries ordering the publication must send remittances in U. S. exchange and should include an additional 1/4 of the publication price to cover mailing costs.

Semiconductor Abstracts

Battelle Memorial Institute, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 322 pages, $10.00.

As with previous issues, the principal source of information for this volume is abstract journals. Some original articles, however, have been reviewed in cases where they add to the completeness of coverage. Numerical results are included in many of the abstracts.

The engineer working in the field of semi-conductors will find these abstracts an excellent directory of the literature released during the past year. They will give him an "even chance" of keeping up with the contributions from the many branches of science which are encompassed by activities in the semiconductor field.

Television Engineering Principles and Practice

Vol. 3—Waveform Generation, S. W. Amos & D. C. Birkinshaw Philosophical Library, 15 East 40 St., New York, N.Y., 226 pages, $15.00.

A comprehensive survey of modern television principles and practice is compiled in this third volume of the four volume series. The application in television of sinusoidal, rectangular, sawtooth and parabolic waves and the mathematical relationship between them, is described. The text is devoted to the fundamental principles of the circuits commonly used to generate such signals. Treatment of the subject is primarily descriptive and considerably less mathematical than that of the previous volume. Although written primarily for the television engineer the book should prove useful to engineers interested in refreshing their knowledge on the fundamentals of pulse circuitry.

Digital Computer Programming

D. D. McCracken, John Wiley & Sons, Inc. 440 Fourth Ave., New York 16, N. Y. 253 page , $7.75.

Digital programming is discussed on a practical level. Details involved in actually *working* with digital computers are presented in a lucid, comprehensive treatment. Many of the problems which are specially troublesome to beginners are discussed in a presentation of basic programming fundamentals.

Coverage is more comprehensive than that provided by instruction manuals for specific computers, yet it is on a more practical level than broad treatments written primarily for non-users of computers. To implement his approach Mr. McCracken has devised a mythical computer combining elements from a number of different models currently on the market. This approach makes the book suitable for study even though a computer might not be available for practice or demonstration. When a specific machine is available, the applicable parts of the book can be read with profit, along with the large portion of text material that is relevant to *any* machine.

Mr. McCracken's book should prove valuable for people with no previous knowledge of computing who want to know how to prepare detailed "instructions" for a computer, as well as for people whose work is so closely related to computer applications that they need to know what is involved in programming.

Transistor Circuits and Applications

John M. Carroll. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N.Y., 283 pages, $7.50.

Articles on transistors and transistor applications have been edited and compiled by Mr. Carroll into a somewhat textbook form. Many of the articles contain typical circuits with component values. The design engineer will find this information useful as background material and for comparison with his own designs and techniques. Military, industrial and home-entertainment transistor circuits are covered in the various articles. Typical transistor operating characteristics, important circuit parameters, transistor types, problems of temperature and gain stabilization, and a large number of typical transistor circuits are also included.

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Russian Transistors

J. George Adashko

Construction features and electrical properties of Russian semiconductor devices are presented in "Parameters and Construction of Russian Transistors" by A. V. Krasilov, (8 pp, 9 figs, 3 tables). The article appeared in *Radiotekhnika i Elektronika*, No. 8, 1956, whose contents were reviewed in *ED*, May 15, 1957. These features are abstracted here in picture caption form. Also presented in the article are three tables giving the salient parameters of Russian point-contact and junction transistors.

The columns marked "80% limits" of Tables 1 and 2 show the limits, in which up to 80 per cent of the transistors of the corresponding types have been issued. The current amplification coefficient, α, is measured at audio frequency. The indices 0.5, 1.5, 5, and 10 in Table 1 indicate that the measurements were carried out respectively at 0.5, 1.5, 5, and 10 mc. I_c limit of Table 3 indicates the minimum collector current at which the gain, $\beta = \alpha/1-\alpha$ still exceeds 2 for a given type of transistor.

The tables show that the spread in transistor parameters is quite large. The article claims that one of the reasons for this is the inhomogeneity of the presently used germanium.

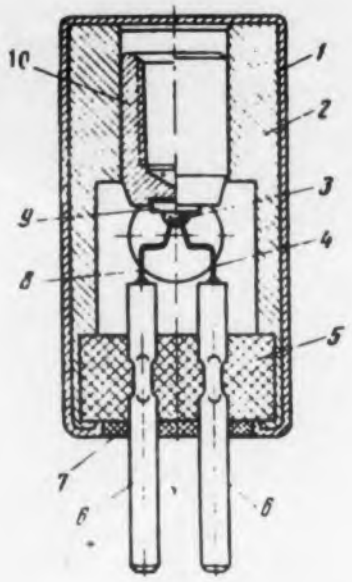

Fig. 1 Construction of point-contact transistor (types C1 and C2). 1—nickel envelope, 2—brass shell, 3—lacquer, 4—emitter, 5—plastic insulator, 6—nickel pin, 7—potting lacquer, 8—collector, 9—germanium base, 10—crystal holder.

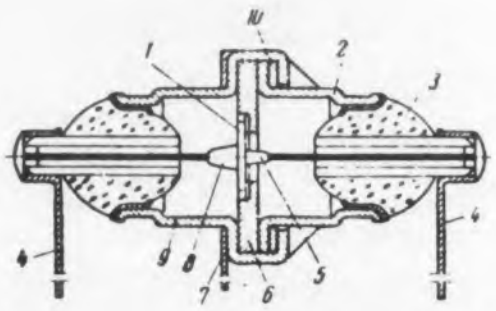

Fig. 3 Construction of junction-type transistor (types P1 and P2). 1—germanium base, 2—shell, 3—glass insulator, 4—terminal, 5—emitter, 6—crystal holder, 7—terminal, 8—collector, 9—shell, 10—lead lining.

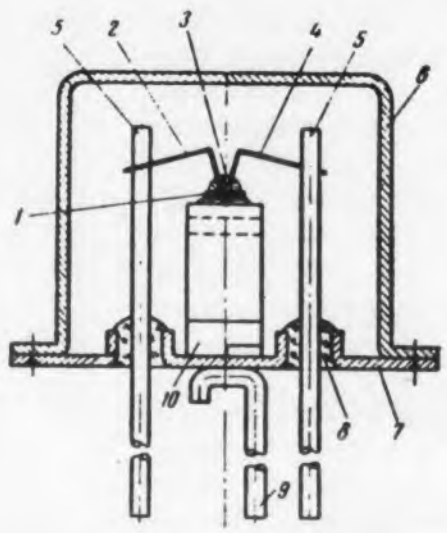

Fig. 2 Construction of hermetic point-contact transistor. 1—germanium base, 2—emitter, 3—lacquer, 4—collector, 5—pin, 6—shell, 7—mount, 8—glass insulator, 9—pin, 10—crystal holder.

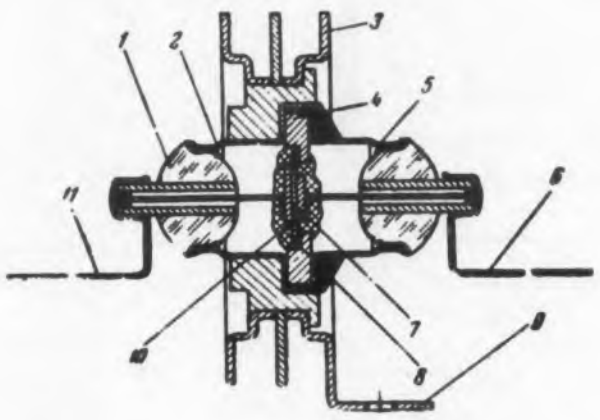

Fig. 5 Construction of P3 junction-type transistor. 1—insulator, 2—shell, 3—radiator, 4—crystal holder, 5—shell, 6—emitter terminal, 7—emitter electrode, 8—germanium crystal, 9—base terminal, 10—collector electrode, 11—collector terminal.

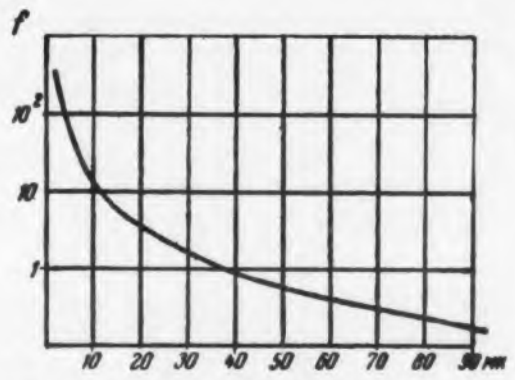

Fig. 4 Dependence of limiting frequency f of a junction-type transistor on distance between the emitter and collector.

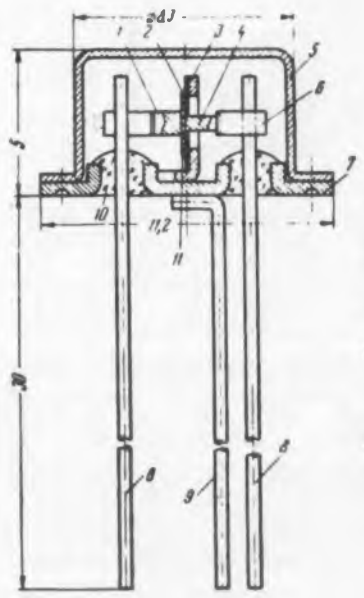

Fig. 6 New construction of P1 transistor. 1—collector, 2—tin ring, 3—nickel crystal holder, 4—emitter, 5—shell, 6—nickel lug, 7—mount, 8, 9—terminals, 10—glass insulator, 11—germanium base.

Table 1 Summary table of parameters of point-contact transistors

Type	R_{11} Ohm norm	R_{11} Ohm 80% limits min.	R_{11} Ohm 80% limits max.	R_{12} Ohm norm	R_{12} Ohm 80% limits min.	R_{12} Ohm 80% limits max.	R_{22} Kilohm norm	R_{22} Kilohm 80% limits min.	R_{22} Kilohm 80% limits max.	α norm	α 80% limits min.	α 80% limits max.	$\alpha_{0.5}$ norm	$\alpha_{0.5}$ 80% limits min.	$\alpha_{0.5}$ 80% limits max.	$\alpha_{1.5}$ norm	$\alpha_{1.5}$ 80% limits min.	$\alpha_{1.5}$ 80% limits max.	α_s norm	α_s 80% limits min.	α_s 80% limits max.	α_{10} norm	K_v norm	K_v 80% limits min.	K_v 80% limits max.	K_m (power gain) R_2 = 500 ohm, Rload = 10 kilohm Norm min.	K_m Norm max.	Measurement Conditions I_e ma.	Measurement Conditions U_c v.	Peak Values I_e ma. norm max.	Peak Values I_c ma. norm max.	Peak Values U_c v. norm max.	Peak Values P_c mw. norm max.
S1A	750	300	550	200	30	90	7	10	20	1,2	1,5	2,5	1,0	1,3	2,1	—	—	—	—	—	—	—	—	—	—	—	15	19	0,3	20	+10	—10	—40	100
S1B	750	300	500	200	30	150	7	10	25	1,5	1,6	3	1,2	1,3	2,1	—	—	—	—	—	—	—	50	75	150	18	22	0,3	20	+10	— 6	—40	50
S1V	750	350	500	200	60	120	7	10	20	1,5	1,6	2,5	—	—	—	1,2	1,3	2,1	—	—	—	—	—	—	—	15	19	0,3	20	+10	—10	—40	100
S1G	750	300	500	200	30	120	7	10	20	1,5	2	3,5	—	—	—	1,2	1,5	3	—	—	—	—	50	100	150	18	22	0,3	20	+10	— 6	—40	50
S1D	750	350	500	200	60	180	7	10	20	1,5	2	3,5	—	—	—	—	—	—	1,2	1,5	3	—	30	50	125	15	22	0,3	20	+10	— 6	—40	50
S1E	750	—	—	200	—	—	7	—	—	1,5	—	—	—	—	—	—	—	—	—	—	—	1,2	—	—	—	15	—	0,3	20	+10	— 6	—40	50
S2A	1500	300	600	1000	50	200	7	10	25	1,5	1,6	4,5	1,2	1,5	4	—	—	—	—	—	—	—	—	—	—	—	—	0,3	10	+10	—10	—30	100
S2B	1500	450	800	700	150	300	7	10	25	1,6	2	3,5	—	—	—	1,5	1,5	3	—	—	—	—	—	—	—	—	—	0,3	10	+10	— 6	—20	50
S2V	1500	450	900	1000	150	400	7	10	25	1,6	1,8	3	—	—	—	—	—	—	1,5	1,5	3,5	—	—	—	—	—	—	0,3	10	+10	— 6	—20	50
S2G	1500	—	—	1000	—	—	7	—	—	1,6	—	—	—	—	—	—	—	—	—	—	—	1,5	—	—	—	—	—	0,3	10	+10	— 6	—20	50

Table 2 Parameters of low-power junction transistors

Type	α Specified Norm min.	α Specified Norm max.	α 80% limits min.	α 80% limits max.	R_b ohm Spec. Norm min.	R_b ohm Spec. Norm max.	R_b ohm 80% limits min.	R_b ohm 80% limits max.	R_c ohm Spec. Norm min.	R_c ohm Spec. Norm max.	R_c ohm 80% limits min.	R_c ohm 80% limits max.	K_m (power gain) db Spec. Norm min.	K_m (power gain) db Spec. Norm max.	K_m (power gain) db 80% limits min.	K_m (power gain) db 80% limits max.	f_{lim} kc Spec. Norm min.	f_{lim} kc Spec. Norm max.	f_{lim} kc 80% limits min.	f_{lim} kc 80% limits max.	P_n (noise power) db Spec. Norm max.	P_n (noise power) db 80% limits min.	P_n (noise power) db 80% limits max.	C uuf Spec. Norm max.	C uuf 80% limits min.	C uuf 80% limits max.	I_c (U_c = -10 v.) ua min.	I_c (U_c = -10 v.) ua max.	Conditions of K_m Measurement I_e ma	Conditions of K_m Measurement U_c v.	Conditions of K_m Measurement R_{gen} ohm	Conditions of K_m Measurement R_{load} kilohm	Permissible Limits I_c ma	Permissible Limits U_c peak v.	Permissible Limits P_c mw
P1A	0,9	0,93	0,9	0,93	—	—	30	200	—	—	300	3000	30	—	30	40	100	—	150	300	—	15	40	—	20	35	5	25	1	—10	600	30	5	20	50
P1B	0,93	0,97	0,93	0,97	—	400	100	250	500	1200	500	1200	33	—	35	42	100	—	100	400	—	15	40	—	20	35	5	20	1	—10	600	30	5	20	50
P1V	0,93	0,97	0,93	0,97	—	400	100	250	1000	—	1200	4500	37	—	38	45	100	—	100	400	—	15	40	—	20	35	5	15	1	—10	600	30	5	20	50
P1G	0,96	—	0,96	0,99	—	600	100	400	500	—	700	4500	37	—	38	45	100	—	200	400	—	15	40	—	20	35	5	20	1	—10	600	30	5	20	50
P1D	0,94	—	0,94	0,99	—	—	100	350	500	—	1200	4500	33	—	35	45	100	—	200	400	18	7	14	—	20	35	5	15	1	—10	600	30	5	20	50
P1E	0,94	—	0,94	0,99	—	1000	150	350	300	—	300	4500	—	—	33	45	465	—	500	1000	—	15	40	40	20	35	5	25	1	—10	600	30	5	20	50
P1Zh	0,96	—	0,96	0,99	—	1500	250	1500	300	—	300	4500	—	—	35	45	1000	—	1000	1600	—	15	40	40	20	35	5	20	1	—10	600	30	5	20	50
P1I	0,96	—	0,96	0,99	—	1500	—	500	—	—	—	—	35	—	—	—	1600	—	1600	2500	—	—	—	35	—	—	—	—	20	1	—10	600	30	5	20	50

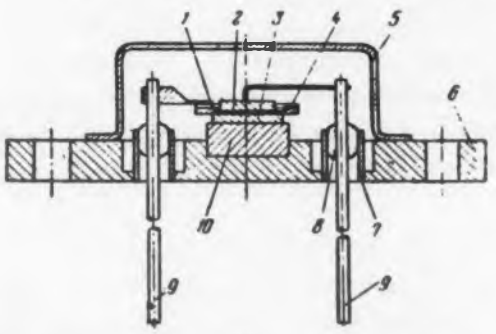

Fig. 7 New construction of P3 transistor. 1—germanium base, 2—emitter, 3—collector, 4—base, 5—shell, 6—mount, 7—cover sleeve, 8—glass insulator, 9—terminal, 10—copper disc.

Table 3 Parameters of high-power junction transistors

Type	P_{out} Watts min.	K_m (power gain) db	I_c lim. (β=2). ma	I_{co} ma. -10 v.	I_{co} ma. -50 v.	Test Conditions I_c ma	Test Conditions U_c v.	Test Conditions R_{gen} ohm	Test Conditions R_{load} ohm	Test Conditions f cps	Limiting Values I_c ma	Limiting Values U_c v.	Limiting Values $P_{diss.}$ w.
P2A	0,1	> 17	—	0,03	0,2	5	50	100	10000	1000	10	100	0,250
P2B	0,1	> 17	—	0,03	0,2	10	25	25	4000	1000	15	50	0,250
P3A	1	17—20	150	—	—	130	25	5	220	1000	150	50	3,5
P3B	1	20—25	250	0,25	5	130	25	5	220	1000	250	50	3,5
P3V	1	25—30	450	0,25	3	130	25	5	220	1000	450	50	3,5
P4	10	13—20	1500	0,5	—	1000	28	3	35	1000	2000	55	30

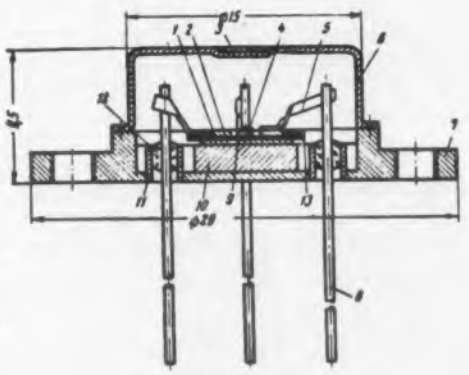

Fig. 8. New construction of P2 transistor. 1—germanium base, 2—emitter, 3—sealing (hermetic) lining, 4—central base, 5—nickel lug, 6—shell, 7—mount, 8—terminal, 9—collector, 10—copper disc, 11—cover sleeve, 12—glass insulator, 13—annular base.

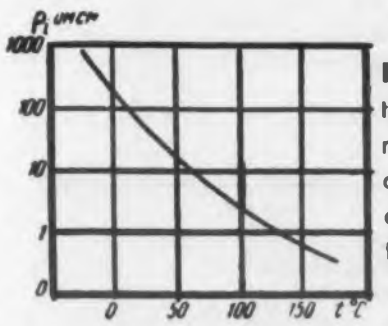

Fig. 9. Dependence of the value of the intrinsic resistance of germanium on the temperature, calculated from the equation

What the Russians Are Writing

J. George Adashko

RADIO ENGINEERING AND ELECTRONICS

(Contents of Radiotekhnika i Elektronika No. 11, 1956)

TRANSISTOR CIRCUITS

HF Transistor RC Oscillator, L. N. Kaptsov, (6 pp, 5 figs, 2 tables).

A grounded-base point-contact transistor amplifier with greater than unity gain may have negative input and output resistances and may serve as a relaxation or harmonic oscillator. Such a circuit, (essentially a multivibrator,) is analyzed in this article on the basis of the equivalent circuit of Fig. 2 over a range of frequencies comparable with the critical current-gain frequency. Fig. 3 shows the frequency and amplitude dependance on emitter current for several transistors.

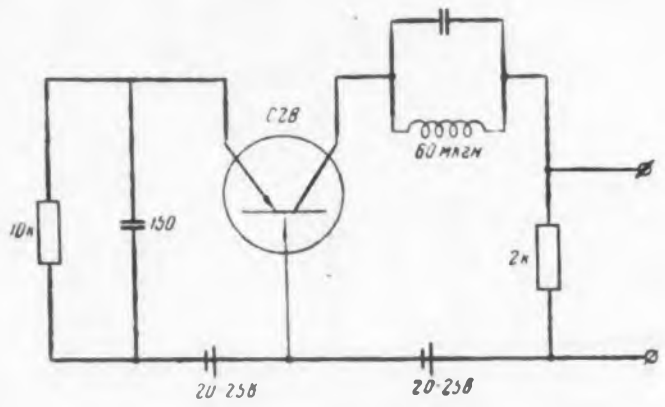

Fig. 1. Practical circuit of RC-oscillator using a type C2B transistor.

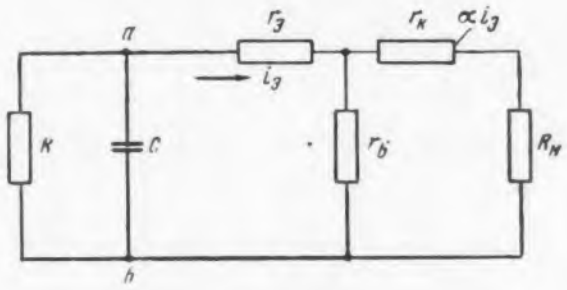

Fig. 2. Equivalent circuit of RC-oscillator.

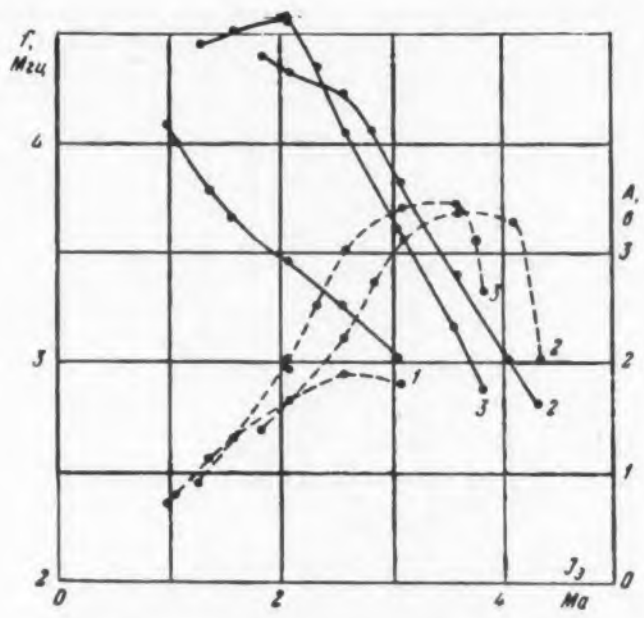

Fig. 3. Plots of frequency (solid) and output amplitude (dotted) vs. emitter current. Curves 1 and 2 are for two C2B transistors, Curve 3 is for the non-standard No. 577 transistor.

Voltage Gain of Tuned Point-Contact Transistor Amplifiers, E. F. Vorob'eva, (12 pp, 9 figs, 2 tables).

This is a simple approximate calculation applicable to common-base transistors, taking into consideration the effect of the frequency dependence of the transistor parameters and of the internal feedback on the resonant voltage gain. The analysis of the equivalent circuit leads to a set of gain vs. frequency curves for various degrees of mismatch at the input. Experimental verification of the analytical results is cited.

Study of Transients of a Triggering Circuit Using Point-Contact Transistors and Shaping of Pulses from a Sinusoidal Voltage, V. A. Kuz'min, (7 pp, 8 figs).

The study begins with the computation of the duration of the leading edge of the ouput pulse in response to an arbitrary input voltage. This is followed by computation of the part of the trailing edge of the output pulse that corresponds to the transition through the active region under the influence of the negative voltage drop. Shaping of sinusoidal voltages into pulses with the proposed trigger system is then studied. The amplitude, duty cycle, and duration of the forward front of the output pulses are calculated, and the circuit parameters are evaluated. The analysis is checked experimentally. Refers to A. W. Lo, "Transistor Trigger Circuits," Proc. IRE, 1952, 40, 11, 1531, and Lebow and Baker, "The Transient Response of Transistor Trigger Circuits," Proc. IRE, 1954, 42m 6, 938.

T W OSCILLATORS

Generation of Electromagnetic Oscillations by Traveling Wave Tubes with Double-Spiral Coaxial Lines, V. S. Mikhalevski, A. G. Dolganov, V. D. Ivanova, (11 pp, 13 figs).

A theoretical treatment of the dispersion properties of the double-spiral coaxial line was reported by V. S. Mikhalevski in the October 1956 issue of Radiotekhnika i Elektronika (*ED* June 15, 1956). The present article gives extensive experimental results on the effects of the geometry, winding direction, winding connections, and operating modes on the performance of the traveling-wave tube as an oscillator.

MEASUREMENT

Waveguide Methods for High-Temperature Measurement of Dielectric Properties of Materials, V. I. Aksenov, M. Ia. Borodin (9 pp, 6 figs).

The open-circuit method is used to determine the dielectric properties of materials at a wavelength of 3.2 cm in the 20–200° range. Equations are derived for ε' and ε'' ($\varepsilon^* = \varepsilon' - j\varepsilon''$) and the temperature dependence of ε' and tan δ of several polymers is obtained from the measurements and these equations.

Fig. 4 shows the block diagram of the test setup, while Fig. 5 shows a waveguide section used in the measurement.

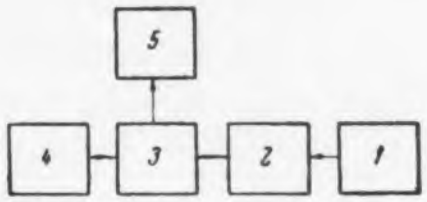

Fig. 4. Block diagram of test setup. 1—oscillator, 2—decoupling attenuator, 3—slotted line, 4—electrically-heated waveguide section, 5—amplifier.

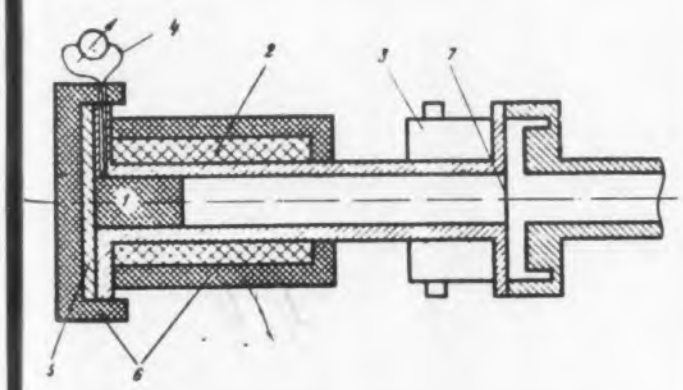

Fig. 5. Waveguide section. 1—specimen of dielectric, 2—electric heating coil, 3—cooling jacket, 4—thermocouple, 5—short-circuiting plate, 6—thermal insulation, 7—styroflex film.

Russian Translations

RADIO ENGINEERING AND ELECTRONICS, Cont.

New Measurement Method for the Parameters of Magnetized Ferrites at Centimeter Waves, V. N. Vasil'ev, (17 pp, 14 figs).

A ferrite specimen in the form of a slab is inserted in the center section of a rectangular cavity. The mode and direction of the constant magnetic field are varied to make the resonant frequency and the Q of the cavity depend only on one or two unknown parameters (such as the complex dielectric constant or the permeability tensor), which are then calculated from the changes in the frequency in the resonator Q.

The method is applicable in the 0.8–20 cm range. The necessary equations are derived and experimental results are given for several ferrites. The real components of the permeability tensor and of the dielectric constant are obtained with an accuracy of 3 per cent. The accuracy of the imaginary components depends on the losses and ranges from 7 to 30 per cent (the accuracy increases with the losses.)

MISCELLANEOUS

Systems with Centrifugal-Electrostatic Electron-Beam Focusing, Z. S. Chernov (7 pp, 11 figs).

Describes a new electrostatic electron-beam shaping and focusing system, with the electrons moving in a spiral orbit within the beam. The new system eliminates many of the shortcomings of the usually-employed solenoids or permanent magnets such as high power consumption, heavy and cumbersome magnetic systems, the need for precise tuning, and short life.

Based on the stable motion of electrons in the field of cylindrical capacitor, the Institute of Radio Engineering and Electronics of the USSR Academy of Sciences developed new travelling-wave or double-helix tubes (called "spiratrons") employing this new system and requiring no magnetic focusing.

Figs. 6 and 7 show two types of electron guns to produce a spiralling electron beam. In Fig. 6 the electron beam is shaped into a ribbon and enters the space between two coaxial cylinders at an angle. The inner cylinder is at a higher potential than the outer one. The electrons leave the cathode with both axial and tangential velocity components, and when the centrifugal force is balanced by the electrostatic field strength, they move in spiral trajectories.

In Fig. 7 an annular cathode is contained between cylindrical focusing electrodes, and a cylindrical anode is placed in front of the cathode. Since all electrodes have spiral cross sections, the electr leaving the cathode acquire an initial angular m mentum and form a solid tubular beam w th sp trajectories upon entering the field of the c lindri capacitor.

Two spiratron prototypes are illustrated in F 8 and 9. Experimental data are given on their foc ing properties and on their high-frequency behav

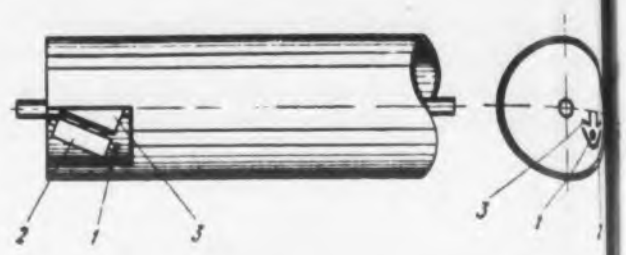

Fig. 6. Centrifugal electrostatic focusing system w flat gun 1—cathode, 2—focusing electrode, 3—ano

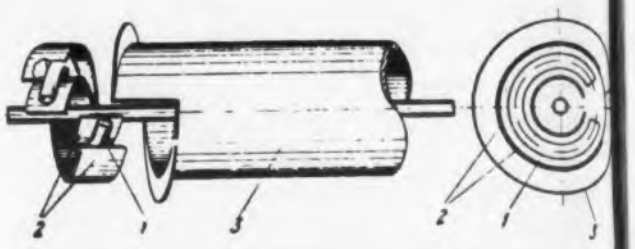

Fig. 7. Centrifugal electrostatic focusing system w spiral gun 1—cathode, 2—focusing electrode, 3 anode.

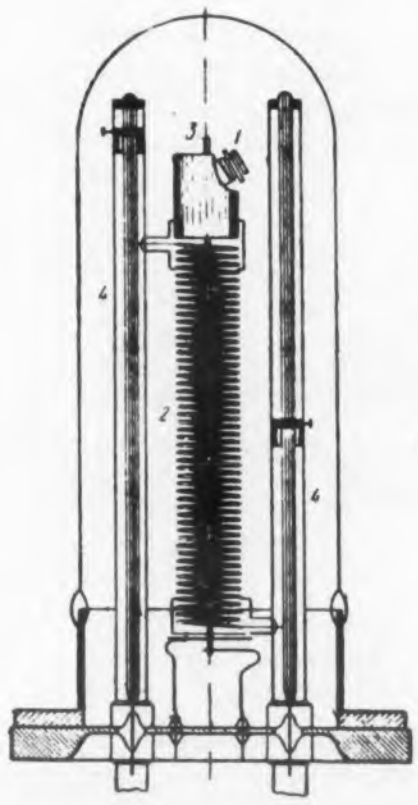

Fig. 8. Demountab construction of trave ling wave type spiratron (100-300 m 1—electron gun, 2 helix, 3 — focusi rod, 4—coaxial line

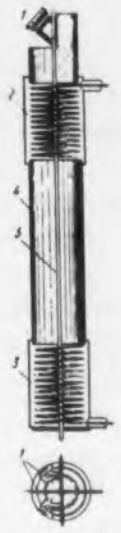

Fig. 9. Construction of double spiral spiratron (tested at 100-300 mc). 1—electron gun, 2—entrance spiral, 3—exit spiral, 4—drift tube, 5—focusing rod.

Reception of Pulses of Arbitrary Waveform with Super-regenerative Receiver, L. R. Iavich, (9 pp, 9 figs).

The principle of superregeneration has been in use for more than 30 years, yet many of its theoretical aspects still remain to be explained. This pertains in particular to non-stationary processes which have lately come into prominence by virtue of the use of superregeneration for pulse reception. The author uses the slowly-varying amplitude method to analyze reception of pulses of any waveform with a superregenerative receiver having a separate heterodyne. It is shown that the pulse area can serve as a criterion of the effectiveness of pulses of different waveforms and durations.

ELECTRICAL COMMUNICATIONS

(Contents of Elektrosviaz' No. 11, 1956)

RADIO RELAY

Type FN-675 Radio Relay Apparatus, N. N. Kamenski, (10 pp, 5 figs).

Description of a French (CSFR) system, capable of handling up to 6 trunks, each accommodating 600 telephone channels or one TV (video plus audio) channel over distances up to 2000-3000 km.

Choice of Standby System of Radio Relay Lines, V. V. Petrov, M. V. Brodski, V. D. Shoshenkov, (9 pp, 4 figs).

Probability-theory aspects of square channels and of automatic switching.

NEGATIVE FEEDBACK

Modulation Negative Feedback in Radio Transmitter Installations, V. A. Khatskelevich, L. M. Shur, (10 pp, 5 figs).

A thorough discussion of the factors that limit the amount of feedback that can be used in transmitter circuits. The rigorous treatment is based on Bode's theories.

Russian Translations

Electrical Communications (continued)

PULSE SYSTEMS

On the Theory of Linear Pulse Systems with Variable Parameters, G. P. Tartakovski, (12 pp, 2 figs).

Introduces the concept of a time-dependent transfer function of a pulse system with variable parameters. Shows, in analogy with the constant-parameter case, that this function yields the response of the system to any pulse sequence. Treats variable parameters of the linear portion of the system, variable sequence periods, and variable pulse durations. Gives examples of communication systems and elements normally subjected to pulse sequences. Refers to Zadeh's "Frequency Analysis of Variable Networks," Proc. IRE 38, No. 3, 1950, and "Time-Dependent Heaviside Operators," J. Math. & Phys. vol. 30, No. 2, 1951.

INTERFERENCE

Prevention of Interference in Steel Conductors from Other Steel Conductors or from Toll Lines, P. K. Akul'shin, (8 pp, 1 fig).

Continuation of work by the same author, reported in the January and April 1956 issues of Elektrosviaz' (*ED* May 15, and November 1, 1956).

MISCELLANEOUS

"Calculation of Errors Introduced by Speed Differences in Telegraph Start-Stop Apparatus," N. B. Zeliger, (13 pp, 8 figs, 1 table).

"Conditions under which Communication Aerial and Cable Lines can Parallel High-Voltage DC Transmission Lines," M. I. Mikhailov, K. K. Nikol'ski, (11 pp, 10 figs). (The Russians are planning power transmission at 400-800 kvdc. The inductive interference of the dc ripple with low frequency communication lines is therefore of more than theoretical interest.)

"Concerning the Mechanism of Communication-Line Loss under Icing Conditions," I. M. Metter, (2 pp, 2 tables).

AUTOMATION AND TELEMECHANICS

(Contents of Avtomatika i Telemekhanika No. 12, 1956)

SERVO SYSTEMS

Investigation of the Steady State of Pulse Servo Systems, Ia. Z. Tsypkin, (13 pp, 10 figs).

Pulse servo systems are frequently used to convert discrete (digital) data into a continuous (analog)

function, i.e., to interpolate between adjacent discrete values. To minimize the steady-state error it is necessary to improve on the customary straight-line interpolation, using suitable interpolating functions or polynomials (see Porter, Stoneman, and Lowden, "A New Approach to the Design of Pulse-Monitored Servosystems," Proc. IRE, part II, vol 97, 1950). The author gives an analytic expression for the steady-state error and discusses the transfer functions of a simple suitable system.

On the Theory of Nonlinear Solution Elements Employing Piecewise-Linear Approximation, B. Ia. Kogan, (11 pp, 7 figs).

Diode functional converters, described in an article by Talantsev in the February 1956 issue of Avtomatika i Telemekhanika (*ED* August 1, 1956) are used in conjunction with a solution (operational) amplifier to approximate a variety of nonlinear functions. The article derives some fundamental relationships for a solution amplifier employing stepwise-linearized nonlinear conductances. The relationships obtained between the slope of the original non-linear function and the slopes of the current curves of diode networks connected both in the amplifier input and in the external feedback loop. Several methods of synthesizing functional converters employing diodes are given.

The methods given make it possible to reduce the errors inherent in the functional converter and make it possible to reproduce a greater variety of functions. The article also shows how the current characteristics of the diode circuits can be plotted.

MEASUREMENT

Regenerative Measuring Transmitters, L. L. Dekabrun, (9 pp, 12 figs, 1 table).

Regenerative transmitters are vacuum-tube oscillators used to measure, say, small variations in conductivity of semiconductors by determining the change such a semiconductor introduces in the Q of the oscillator tuned circuit. A theoretical analysis of such a circuit is given, and some experimental installations are described. Reference is made to work by Trott (Journal of Scientific Instruments, No. 7, 1952) and Malling (Electronics, April 1953).

Other Articles In This Issue

"Electronic Flow Meter," D. A. Agaikin, A. A. Desova (4 pp, 7 figs). (Description of two types of electromagnetic flow meters for conducting liquids. Refers to several American designs.)

"Coding of Remote-Control Signals by Using Pulse Identification," M. A. Gavrilov, (22 pp, 18 figs). (Abstract switching theory.)

"Investigation of a Turbine-Drilled Well as an Object of Regulation," Ia. B. Kadymov, (11 pp, 8 figs).

German Abstract

Feedback

THE ADVANTAGES of feedback which are realized with vacuum tube circuits are also achieved in transistor circuits; i.e. stability and flexibility of input and output impedance values are possible. A systematic analysis of four basic resistance-feedback arrangements yield general results which can be of value to the designer.

In Fig. 1, four basic feedback circuits are shown. The calculations are particularly simple if the circuit description of the transistor is selected to suit each type of connection.

For Fig. 1a choose

$$v_1 = r_{11}i_1 + r_{12}i_2$$
$$v_2 = r_{21}i_1 + r_{12}i_2$$

For Fig. 1b choose

$$i_1 = y_{11}v_1 + y_{12}v_2$$
$$i_2 = y_{21}v_1 + y_{22}v_2$$

For Fig. 1c choose

$$v_1 = h_{11}i_1 + h_{12}v_2$$
$$i_2 = h_{21}i_1 + h_{22}v_2$$

For Fig. 1d choose

$$i_1 = g_{11}v_1 + g_{12}i_2$$
$$v_2 = g_{21}v_1 + g_{22}v_2$$

The quantities of interest are the voltage gain, β; the current gain α; the input resistance R_e; and the output resistance R_a. In addition, assuming that the input terminals are fed from a source of resistance R_Q and the load resistance is R_L, optimum values of input and output resistance are defined as those values which match source and load resistance respectively. (These optimum values result in maximum power gain.)

The results of the analysis are summarized in Table I. The notation used in this tabulation uses the superscript zero with reference to a quantity *with* feedback. In addition

R_{ek} = input resistance with shorted output terminals
R_{ak} = output resistance with shorted input
α_k = current gain with shorted output
R_{al} = output resistance with open input
$r_o = r_{11} + r_{22} - r_{12} - r_{21}$, other zero *sub*scripts have analogous meaning.

Graphically these results are presented (qualitatively) in Fig. 2. The various significant ratios of characteristic value with feedback to value without feedback are shown (not on a linear scale) for the emitter connection. (*Abstracted from an article by W. Glaser, Nachrichtentechnik, Vol. 7, No. 4, April 1957, pp. 159-162.*)

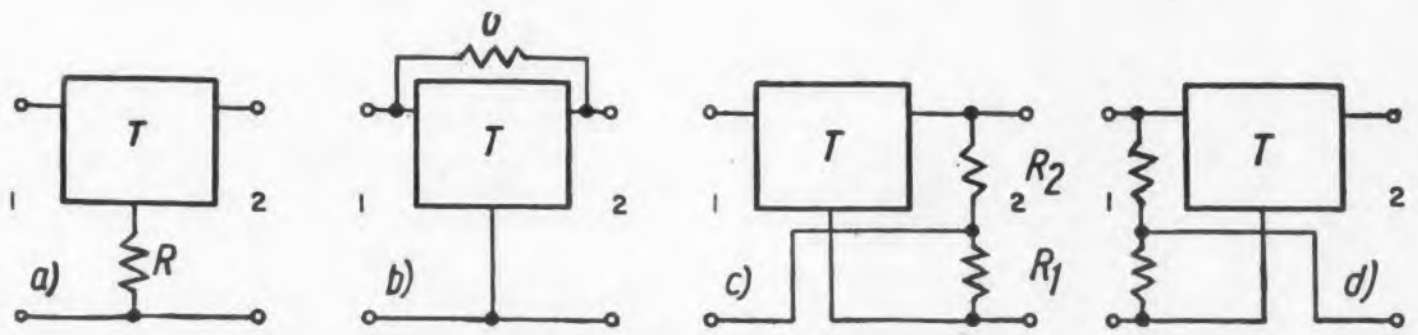

Fig. 1. Four basic feedback circuits: a) Series feedback b) Parallel feedback ($G = 1/R$) c) Series-Parallel feedback $[R_1 = k(R_1 + R_2)]$ d) Parallel-Series feedback.

Transistor Circuits

E. Brenner

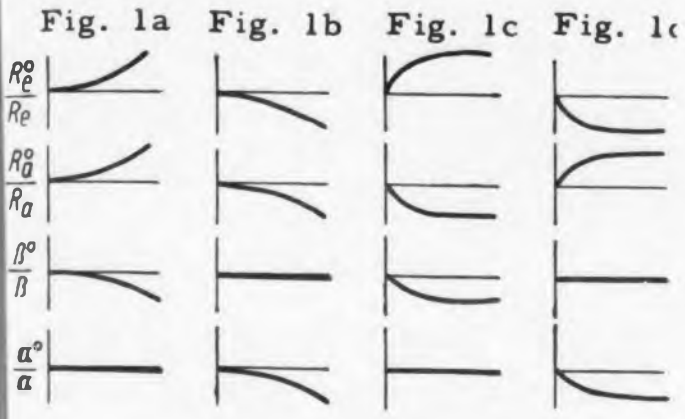

Fig. 2. Variation of parameters for the different connections.

Table 1. Characteristic values of the four types of transistor feedback circuits.

	Fig. 1a	Fig. 1b	Fig. 1c	Fig. 1d
a^0	$\dfrac{a_k R_{al} - R}{R_L + R_{al} + R}$	$\dfrac{\frac{a}{R_{ek}} - G}{\frac{1}{R_{ek}} + G + R_L\left(\frac{1}{R_{ek}R_{al}} + y_0 G\right)}$	$\dfrac{a_k + k}{1 + \frac{R_L}{R_{al}} + \frac{R_L}{R}}$	$\dfrac{a_k \frac{R_{ak}}{R_{ek}} + k}{\left(\frac{1}{R_{el}} + \frac{1}{R}\right)R_L + \frac{R_{ak}}{R_{ek}} + k g_0}$
β^0	$-\dfrac{R_L(a_k R_{al} - R)}{R_L(R_{el} + R) + R_{ek}R_{al} + r_0 R}$	$-\dfrac{R_L\left(\frac{a_k}{R_{ek}} - G\right)}{1 + R_L\left(\frac{1}{R_{ak}} + G\right)}$	$\dfrac{R_L(a_k + k)}{R_{ek} + R(k - k^2) + R_L\left(\frac{R_{ek}}{R_{ak}} + k h_0\right)}$	$-\dfrac{R_L\left(a_k \frac{R_{ak}}{R_{ek}} + k\right)}{R_L + R_{ak} + R(k - k^2)}$
R_e^0	$\dfrac{R_L(R_{el} + R) + R_{ek}R_{al} + r_0 R}{R_L + R_{al} + R}$	$\dfrac{1 + R_L\left(\frac{1}{R_{ak}} + G\right)}{\frac{1}{R_{ek}} + G + R_L\left(\frac{1}{R_{ek}R_{al}} + y_0 G\right)}$	$\dfrac{R_{ek} + R(k - k^2) + R_L\left(\frac{R_{ek}}{R_{ak}} + k h_0\right)}{1 + \frac{R_L}{R_{al}} + \frac{R_L}{R}}$	$\dfrac{R_L + R_{ak} + R(k + k^2)}{\left(\frac{1}{R_{el}} + \frac{1}{R}\right)R_L + \frac{R_{ak}}{R_{ek}} + k g_0}$
$R_{e\,opt}^{02}$	$\dfrac{R_{el} + R}{R_{al} + R}(R_{ek}R_{al} + r_0 R)$	$\dfrac{\frac{1}{R_{ak}} + G}{\frac{1}{R_{ek}} + G}\dfrac{1}{\frac{1}{R_{ek}R_{al}} + y_0 G}$	$\dfrac{R_{ek} + R(k - k^2)}{\frac{1}{R_{al}} + \frac{1}{R}}\left(\frac{R_{ek}}{R_{ak}} + k h_0\right)$	$\dfrac{R_{ak} + R(k - k^2)}{\frac{1}{R_{el}} + \frac{1}{R}}\dfrac{1}{\frac{R_{ek}}{R_{ek}} + k g_0}$
R_a^0	$\dfrac{R_Q(R_{al} + R) + R_{ek}R_{al} + r_0 R}{R_L + R_{el} + R}$	$\dfrac{1 + R_Q\left(\frac{1}{R_{ek}} + G\right)}{\frac{1}{R_{ak}} + G + R_Q\left(\frac{1}{R_{ek}R_{al}} + y_0 G\right)}$	$\dfrac{R_{ek} + R(k - k^2) + R_Q}{\frac{R_{ek}}{R_{ak}} + k h_0 + R_Q\left(\frac{1}{R_{el}} + \frac{1}{R}\right)}$	$\dfrac{R_{ak} + R(k - k^2) + R_Q\left(\frac{R_{ak}}{R_{ek}} + k g_0\right)}{1 + R_Q\left(\frac{1}{R_{el}} + \frac{1}{R}\right)}$
$R_{a\,opt}^{02}$	$\dfrac{R_{al} + R}{R_{el} + R}(R_{ek}R_{al} + r_0 R)$	$\dfrac{\frac{1}{R_{ek}} + G}{\frac{1}{R_{ak}} + G}\dfrac{1}{\frac{1}{R_{ek}R_{al}} + y_0 G}$	$\dfrac{R_{ek} + R(k - k^2)}{\frac{1}{R_{al}} + \frac{1}{R}}\dfrac{1}{\frac{R_{ek}}{R_{ak}} + k h_0}$	$\dfrac{R_{ak} + R(k - k^2)}{\frac{1}{R_{el}} + \frac{1}{R}}\left(\frac{R_{ak}}{R_{ek}} + k g_0\right)$

Standards and Specs

Sherman H. Hubelbank

Connectors

MIL-C-3989, CONNECTORS, COAXIAL, RADIO FREQUENCY, AND ASSOCIATED FITTINGS, SERIES C, 14 MARCH 1957

This spec covers weatherproof series C connectors, having a nominal impedance of 50 ohms, and associated fittings. Qualification inspection is not required. Supplement 1 references the following connectors which are part of this spec: Plug UG-709A/U; Receptacle UG-704/U; Plug UG-707A/U; Right-Angle Plug UG-710A/U; Plug UG-711A/U; Plug UG-708A/U; Bulkhead Receptacle UG-706/U; Bulkhead Adapter UG-701/U; and Bulkhead Receptacle UG-705/U.

IEC PUBLICATION 83, STANDARDS FOR PLUGS AND SOCKET OUTLETS FOR DOMESTIC AND SIMILAR GENERAL USE

This 32-page publication gives the dimensions of plugs and outlets for three electrical systems throughout the world. These three systems are: standards approved by ASA and used in Canada and the United States; standards of the British Standards Institution and used in India and the United Kingdom; and standards of the International Commission on the Rules for the Approval of Electrical Equipment and used in Belgium, Denmark, France, Germany, Italy, Japan, The Netherlands, Norway, and Sweden. Copies of this publication may be obtained for $2.40 from ASA, 70 East 45 Street, New York 17, N.Y.

Resistors

MIL-R-19A, RESISTORS, VARIABLE, WIREBOUND (LOW OPERATING TEMPERATURE), GENERAL SPECIFICATION FOR, 9 NOVEMBER 1956

Style RA10 has been added. It is a miniature type with a body diameter of 3/4 inch and is rated at 1 watt. Style RA25 has been deleted. The three styles, RA10, RA20, and RA30 are specified on detailed Military Specification Sheets MIL-R-19/1, 2, 3 respectively. Resistance tolerance of ±5% has been deleted, and only a tolerance of ±10% is now specified. Round shafts have been deleted. The number of flatted-shaft lengths has been reduced to one-2 1/2 inches. A moisture resistance test has been added to replace the humidity test. Low-temperature operation, low-temperature storage, acceleration, shock, and high-frequency vibration tests have been added. This spec supersedes JAN-R-19 and Amendment 7 thereto.

American Standards

American Standards Association has announced that the following standards have been recently released or approved:

ELECTRICAL TERMS, DEFINITIONS OF, GROUP 35, TRANSMISSION AND DISTRIBUTION, C42.35-1957

ELECTRICAL TERMS, DEFINITIONS OF, GROUP 65, COMMUNICATIONS, C42.65-1957

METHODS OF MEASUREMENT OF PULSE QUANTITIES, C16.28-1956

COLOR CODING FOR NUMERICAL VALUES OF COMPONENTS FOR ELECTRONIC EQUIPMENT, C83.1-1956

NOMENCLATURE AND DIMENSIONS FOR PANEL MOUNTING RACKS, PANELS, AND ASSOCIATED EQUIPMENT, C83.9-1956

REQUIREMENTS FOR RECTANGULAR WAVEGUIDES, C83.10-1956

REQUIREMENTS FOR METAL-ENCASED FIXED PAPER DIELECTRIC CAPACITORS FOR D-C APPLICATION, C83.11-1956

REQUIREMENTS FOR CABLE CONNECTORS FOR AUDIO FACILITIES FOR RADIO BROADCASTING, C83.12-1956

REQUIREMENTS FOR WIRE-WOUND POWER-TYPE RHEOSTATS, C83.13-1956

REQUIREMENTS FOR RIGID COAXIAL TRANSMISSION LINES—50 OHMS, C83.14-1956

REQUIREMENTS FOR ELECTROLYTIC CAPACITORS (FOR USE PRIMARILY IN TRANSMITTERS AND ELECTRONIC INSTRUMENTS), C83.15-1956

Indicators

MIL-L-3661, LAMPHOLDERS AND LIGHTS, INDICATOR; BAYONET BASE, MINIATURE AND CANDELABRA, AMENDMENT 2, 19 MARCH 1957

The type designation letter for jewel lens D now designates plain, polaroid dimmer. A new letter designation M has been added to cover the plain, shutter dimmer type. Requirements for solder-lug wiring terminals have been added. Additional requirements have been established for packaging and metal parts. Three MS sheets have been revised.

RETMA Standards Proposals

The following Standards Proposals are being circulated by RETMA for standardization approval:

S.P. 537, MICROWAVE TOWERS

S.P. 538, MECHANICAL CHARACTERISTICS FOR MICROWAVE ANTENNAS AND PASSIVE REFLECTORS

S.P. 539, RECOMMENDED PRACTICE FOR PREPARATION OF OUTLINE DRAWINGS OF ELECTRON TUBES AND BASES (REVISION TO RETMA ET-102-B)

S.P. 540, DESIGNATION SYSTEM FOR CATHODE RAY TUBES (REVISION TO RETMA ET-111-A)

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SO. NORWALK, CONN.

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ST. PAUL, MINN.

Electronics Engineers, Mechanical Engineers, Electronic Design Engineers, Engineering Writers, Physicists, Mathematicians. Send complete resumé to Mr. R. K. Patterson, Dept. SJ-3, Univac Park, St. Paul 16, Minn.

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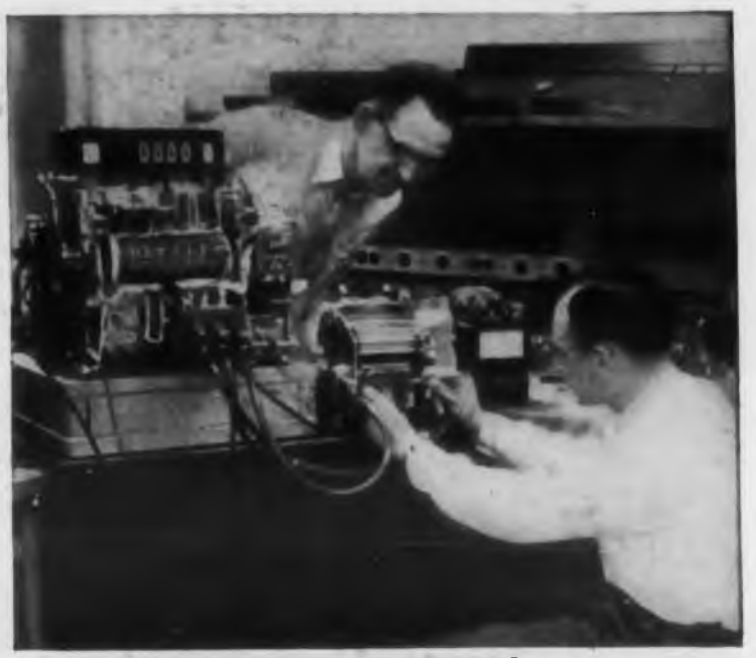
CIRCLE 550 ON READER-SERVICE CARD FOR MORE INFORMATION

MECHANICAL ENGINEERS are using their skills in the design and development of new mechanisms required for business machines and for those mechanical products which are associated with electronic data processing equipment.



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ELECTRONICS PACKAGING
SYSTEMS
MICROWAVE
ANTENNA DESIGN
TUBE APPLICATIONS
SPECIFICATIONS
TECHNICAL WRITING
AERODYNAMICS
STRUCTURES
MECHANICAL DESIGN
HEAT TRANSFER

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JULY 15, 1957

ELECTRONIC DESIGN

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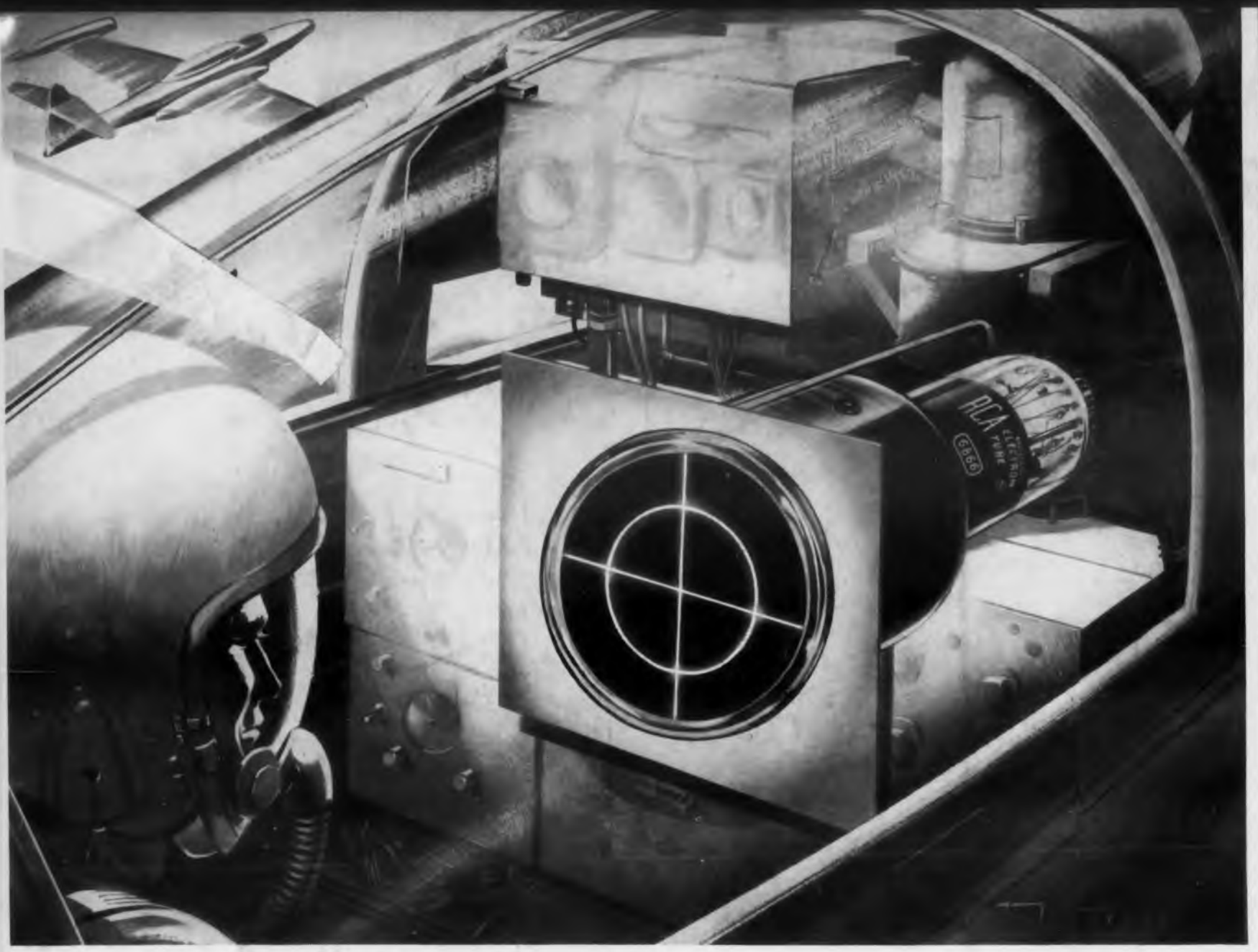

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