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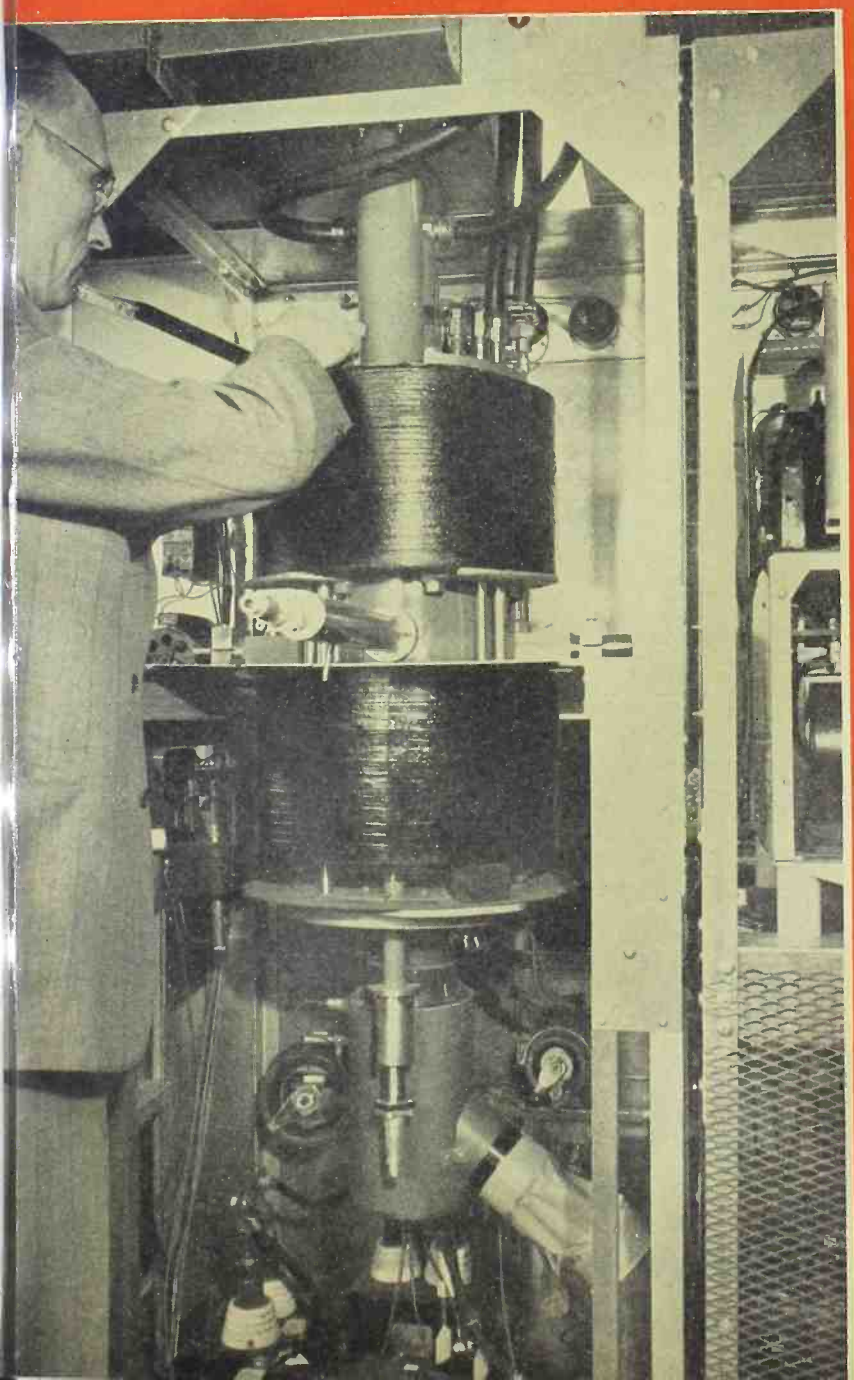

APRIL, 1952

DEPARTMENTS

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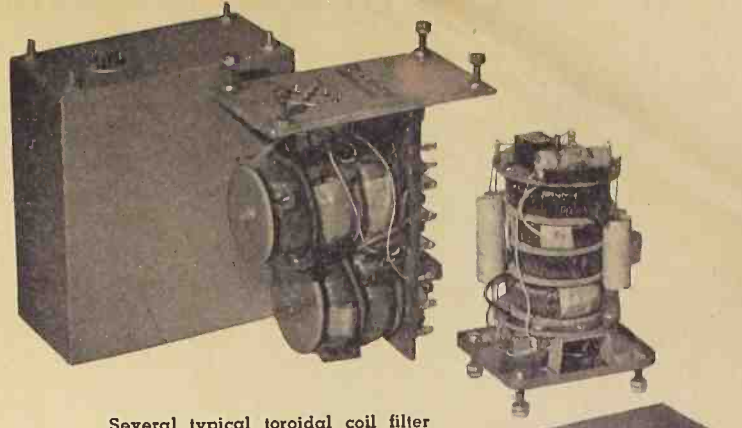
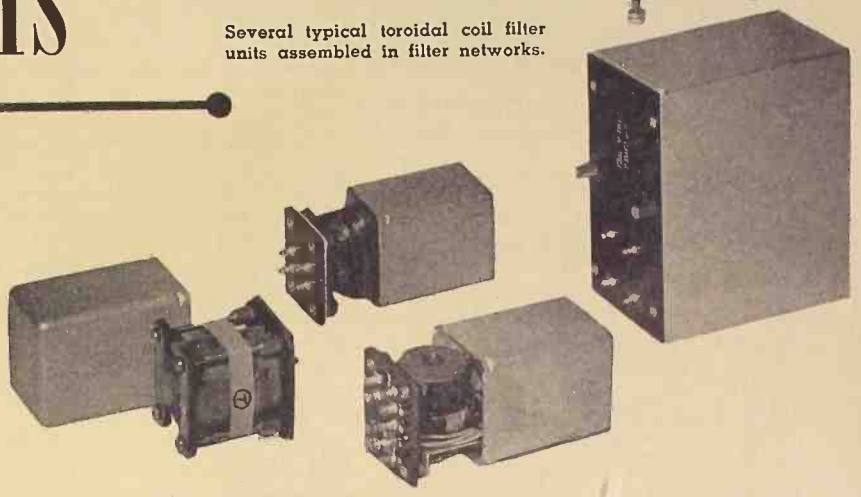
← General Electric engineer, Mr. H. M. Crosby, makes an adjustment on a new u.h.f. velocity-modulated tube around which G-E has built a 5 kw. u.h.f. television transmitter at Electronics Park, Syracuse, N. Y. The transmitter will operate in the 500-megacycle region.

TOROIDAL COIL DEVELOPMENTS



Several typical toroidal coil filter units assembled in filter networks.



By SAMUEL FREEDMAN

Toroidal coils are superior to conventional coils in many respects, but are more difficult to wind.

USE OF THE toroidal or "doughnut" type of coil is becoming increasingly popular in equipment where performance is of primary importance. Wherever employed, it yields high *Q*, energy conservation and concentration, and makes for better utilization of the frequency spectrum through channelization.

Introduced by the *Bell Telephone Laboratories* and the *Western Electric Company* principally to facilitate the handling of communication channels over wire circuits, its application has expanded into the postwar radio development programs of the United States.

Information on toroidal coils has been limited to date, particularly in radio technical literature. Unit cost and the limited production capacity of available toroidal coil winding machines have largely confined the use of toroidal coils in the past. As there is a great difference between winding a straight coil form and winding an endless circular doughnut, each toroidal winder in use today has required high ingenuity and patentable features.

Toroidal coils have been utilized in the audio range of response for some years. More recently, however, they have been developed for i.f. and r.f. coils involving miniaturization and relatively few turns of wire.

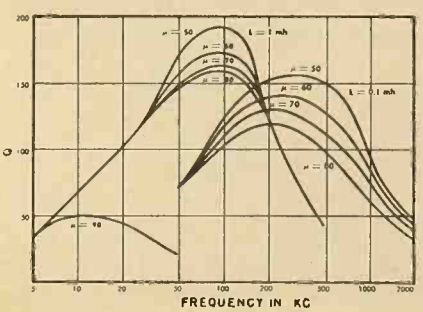
When coils are wound as toroids or doughnuts, they represent the most efficient method of winding. The space factor is the highest in all known methods of winding while the copper resistance becomes the least for the greatest inductance. A toroid requires no shielding since it possesses an extremely small external leakage field, being more favorable in this regard than any other shape known.

The principal manufacturers of toroidal coils are licensed under *Western Electric* patents, this firm having developed the original toroid coil to fill a need for sharper filters in its own channelized long distance telephone equipment.

Toroidal coils achieve improved performances in the following typical applications:

1. Filters in facsimile radio, teletype, telegraph, telephone and sonar systems, telemetering, and control equipment.
2. Saturable responding devices in magnetic amplifiers in lieu of moving parts.
3. Subminiature guided missile filters.
4. Tone filters.
5. Special applications of extremely sharp wide-band filters employing crystals and toroidal coils.
6. High inter-channel attenuation to eliminate distortion and interference in radio reception.
7. Use where magnetic shielding is not provided adequately or at all, and where components must be placed close together. By virtue of its shape, a toroidal coil is less sensitive to pickup from stray magnetic fields; therefore minimum interference or interaction is encountered.

Fig. 1. Graph showing Q vs. frequency at various permeabilities for type HP carbonyl iron powder.



The Toroidal Core

To obtain highest efficiency in any type of audio frequency coil using a core material other than air, the core must be of low-loss material having high permeability. It is also essential that there be no inductance variation with changes in electrical parameters, such as applied voltage and frequency, or with physical conditions, such as temperature or vibration.

The less costly cores are usually composed of ferromagnetic powder, such as carbonyl, in an insulating binder. The individually powdered iron grains are insulated from each other by a binding material. Alternatives are ring-shaped laminations or spirally-wound tape.

At somewhat higher cost, permalloy

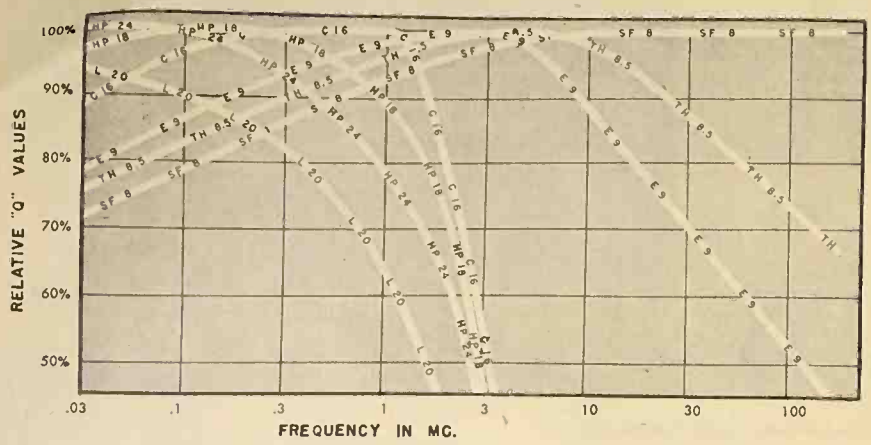


Fig. 2. Relative Q values for various carbonyl iron powders.

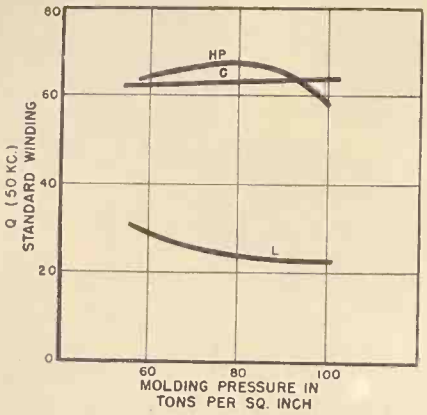


Fig. 3. Graph showing Q vs. molding pressures for carbonyl powders.

dust cores have become popular for high efficiency. One leading manufacturer uses a core material containing 2% molybdenum, 81% nickel, and 17% iron. This material, after being melted and cast, is pulverized into microscopically fine particles. It is then mixed with an appropriate amount of inert binding material, effectively coating each magnetic particle. This entire mass, compressed in hydraulic machines at 100 tons per square inch, forms a solid cohesive toroidal form. After proper annealing at temperatures of 2000° F, the core is checked for permeability and losses.

Carbonyl powders are molded powders of high permeability and low losses at frequencies up to a few megacycles. Cores composed of such powders have a permeability of 40 to 70. The permeability increases with the packing factor (ratio of volume of iron to total core volume). Carbonyl iron powders were discovered in 1890 by the British chemist, Ludwig Mond, who reacted metals with carbon monoxide. Suitable iron materials are reacted with carbon monoxide to form liquid iron. This liquid is then heated to a temperature at which it decomposes iron into powdered form, liberating the carbon monoxide. The carbonyl iron powders formed by this process are pure and the particles are spherical.

Carbonyl iron powders, manufactured by *General Aniline and Film Corporation*, comprise six principal grades: L, HP, C, E, TH, and SF. Their fineness ranges from 30% retention in a 325-mesh screen for grade L, to .5 to 2.0 for grades HP and C, diminishing to only a trace for grades E, TH and SF.

Fig. 9 is a graph showing permeability versus molding pressure in tons per square inch for grades L, HP and C. Fig. 3 shows Q versus molding pressure for the same core materials at a frequency of 50 kc. Fig. 1 illustrates the various permeabilities in terms of Q versus frequency where the inductance is 1 mh. and .1 mh. The molding pressure is held constant at 90 tons per square inch with the permeabilities changed by particle insulation. All these curves are based on HP type powder. Fig. 2 shows relative Q values versus frequencies between .03 and 100 mc. The relative Q values in Fig. 2 are based on the highest of the five grades representing 100%. For example, at 30 mc., SF, TH and E type carbonyl iron powders will exhibit Q values in a ratio of 100 to 87 to 71. The numerals on the curves are permeabilities for form factor equal to 7.5.

The Wedding Ring Toroid

The "wedding ring" toroid was developed to reduce weight and bulk by the use of better core material and improved winders which could work with finer wire and operate with smaller inside diameters for the "doughnuts." Although having about a tenth of the weight of the bulkier toroids, "wedding ring" toroids are still nearly equal in performance. Their miniature size and high capabilities have done much to popularize toroidal coils. The use of the permalloy type core was very helpful in this development; the short magnetic path and relatively large cross section of this core have made it especially low in leakage field.

Fig. 6 shows sketch and performance graphs in terms of Q versus frequency for 1500 and 650 mh. wedding ring toroidal coils, where the inner diameter of the toroid is only ¼" and the outer diameter is 15/16". The weight of such coil is only half an ounce. Fig. 10 shows similar data for 12.0 henry and 5.0 henry coils where the inside diameter of the doughnut is still only ¼", while the outer diameter is 1¼" because of the increased amount of wire winding. This coil weighs 1.6 ounces. Figs. 6 and 10 are based on coils manufactured by *Communication Accessories Company* of Hickman Hills, Missouri.

Fig. 4. Various toroidal coils wound on a Boesch machine.

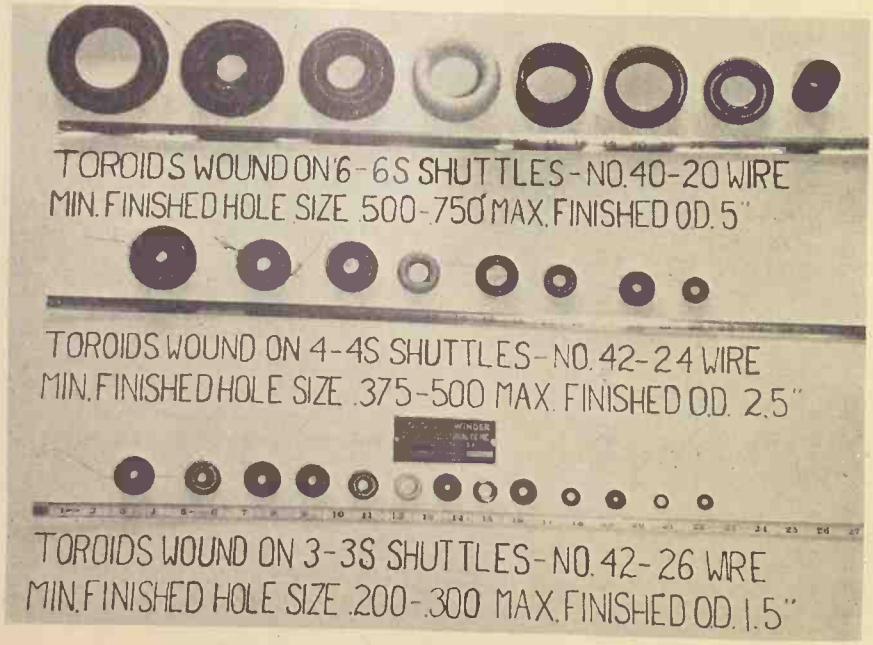


Fig. 8 is a composite, four-section set of graphs showing various types of toroidal filters developed by *Burnell and Company* of Yonkers, New York. The first section of curves gives db versus frequency, as used in subminiature guided missile filters. The six indicated channels are contained in a total volume of 18 cubic inches. The second group of curves gives db versus frequency in cycles per second for tone channel filters available in either 170- or 340-cycle spacing between channels. These are most common among manufacturers of carrier telegraph equipment. The third group of curves shows db versus frequency in kilocycles per second for crystal element channel filters. Such extremely sharp wide-band filters employ crystals and toroidal coils. They are so compact that they have been substituted in very modern equipment for ordinary i.f. transformers. The fourth group of curves shows db versus percentage of phase shift for telemetering filter use. Good linearity of phase shift and good transient suppression, as well as high inter-channel attenuation, have been achieved, thereby eliminating distortion in telemetering reception.

Fig. 7 shows the curve for two filters of a complete set of voice frequency telegraph filters, having 150-cycle spacing and 100-cycle bandwidth, which are manufactured by the same firm. A minimum reduction of 30 db exists where two channels overlap.

Toroidal Coil Winders

In order to appreciate the difficulty and novelty of winding a solid circular core, one might try winding a few hundred turns on a stale doughnut. It is a tiring and time-consuming process. In researching this article, the writer visited the factories of the three manufacturers whose winders are described below.

The pertinent details of interest and variation in anaylzing a toroidal coil winder might include the following:

1. The time it takes to set up a coil winder. Only one coil at a time can be handled, although attempts have been made to develop multiple coil winders.
2. The winding speed, which is limited by the amount of tension and the gauge of the wire used. There are models which operate with slight wire slack and negligible tension.
3. Neatness of the wire lay, depending upon whether the winder has automatic wire laying provisions or whether the toroid must be turned manually as wire deposits on the core.
4. The smallest size wire which can be handled without breakage.
5. The smallest inside diameter of the toroid which can be handled.
6. Whether the machine can wind 180°, 360° or some other amount between zero and 360° of lay.
7. Whether the counter measures length of wire or the number of turns, or both.

The greatest factors of cost in producing toroidal coils are setup time and high investment per machine. Each machine can handle only one coil at a time and it is a manual operation to remove one coil and insert the core of another ready to be wound. The alternative to the use of a machine as described is to laboriously "thread" a coil. The latter is only feasible, if at all, in producing a prototype unit or for making very small r.f. coils having only a few turns of wire.

Every toroidal coil winder utilizes a bobbin which can be opened up either by a removable section or by a split in the bobbin ring. This is necessary in order to put it through the center hole of the torodial core, and to remove the coil upon completion of the winding operation.

Fig. 5 illustrates the *Boesch* toroidal winder, licensed under *Western Electric* patents. Manufactured by the *Boesch Manufacturing Company* of Danbury, Connecticut, it is a combination of eleven assemblies and component parts. A flat base casting provides the means for mounting the various assemblies and components, and an electric motor drives a Graham transmission which, in turn, drives a reversing clutch arrangement. Between the latter two units is placed a directional driving clutch which comes into use when the motor is reversed to reel the wire onto the shuttle. This motor is of the double extended shaft type, with one extension driving the work head of the machine through the conventional pulley and belt arrangement.

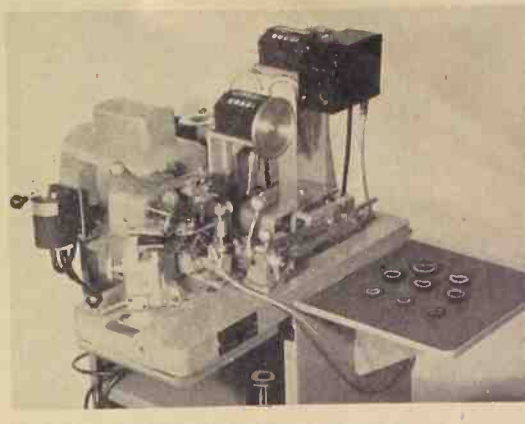


Fig. 5. Boesch toroidal coil winder, manufactured under Western Electric patents.

A "load and fire" device operated from the reversing clutch mechanism controls the reversing action of the machine. This reversing action is the oscillation of the core holder head and its column, movement of which is controlled by adjustment within the range of 45° to 180°. The connection between the load and fire device and the core holder oscillating column is made by means of a rack and pinion. Changing the speed of the Graham drive varies the speed of the coreholder oscillation, permitting close or wide spacing of wire being wound on the core. A solenoid braking mechanism is used in conjunction with the electric motor drive to avoid overrunning. Direction of rotation of the motor is controlled by a conveniently located head lever, and a foot

Toroidal coil winding operation at the plant of Lenkurt Electric Co., Inc.

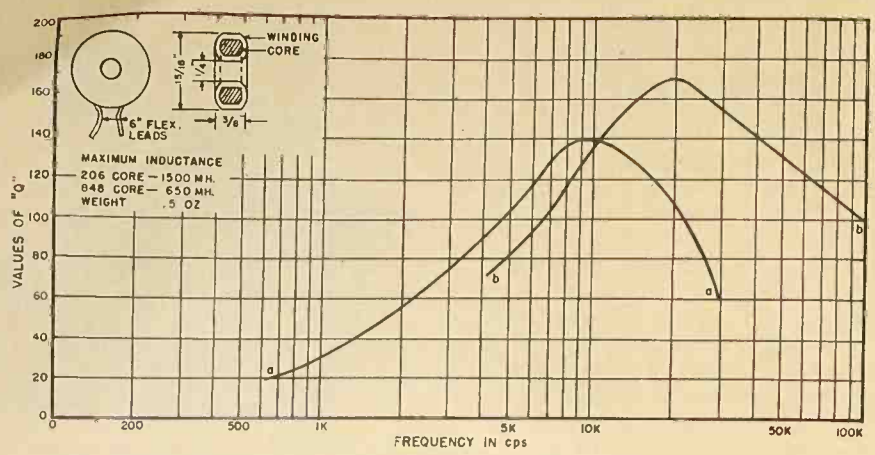


Fig. 6. Q vs. frequency for toroidal coil. Curve a—206 core; curve b—848 core.

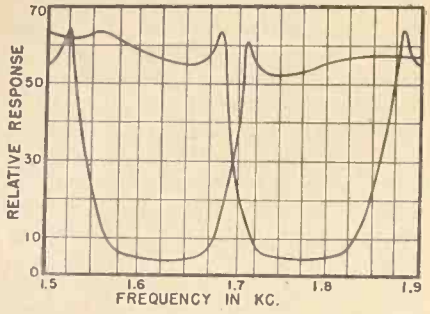


Fig. 7. Curve for two filters of a complete set of voice frequency telegraph filters having 150-cycle spacing and 100-cycle bandwidth.

switch is mounted on the floor for starting and stopping the machine during its normal winding cycle.

The two levers at the right-hand side, mounted on the base of the machine, are the control connections between the load and fire device and the oscillating core clamping head. These levers, when properly positioned, completely disconnect the core clamp head, leaving it free to be moved to any position within the angular range of its movement, which is determined by the particular setting of the load and fire device. The control is such that the point of reversal will always be in time, regardless of the position of the core clamp head at the time the load and fire mechanism is engaged. The hand lever shown directly above the shuttle provides the necessary operational means for loading and unloading the core. The wire tensioning device is shown to the immediate right of the shuttle.

Provision is made for changing the shuttle speed when winding wire of various gauges. No. 42 to No. 20 gauge enameled copper wire is successfully wound at approximately 1150 turns per minute for the finest wire, and for several of the next larger sizes. Other types of wire, such as "Litz" and cotton-covered wire, are wound with equal facility.

The machine is equipped with two separate counting devices, both of which are mounted on the base casting, are readily accessible, and are in full view of the operator. The linear counter is a pre-set assembly which provides the footage counting of wire from the spool to the shuttle. The machine is also equipped with a core loop counter for counting the turns of wire being placed on the core. This pre-set electromechanical device is so arranged that the machine automatically stops when the desired number of turns have been made.

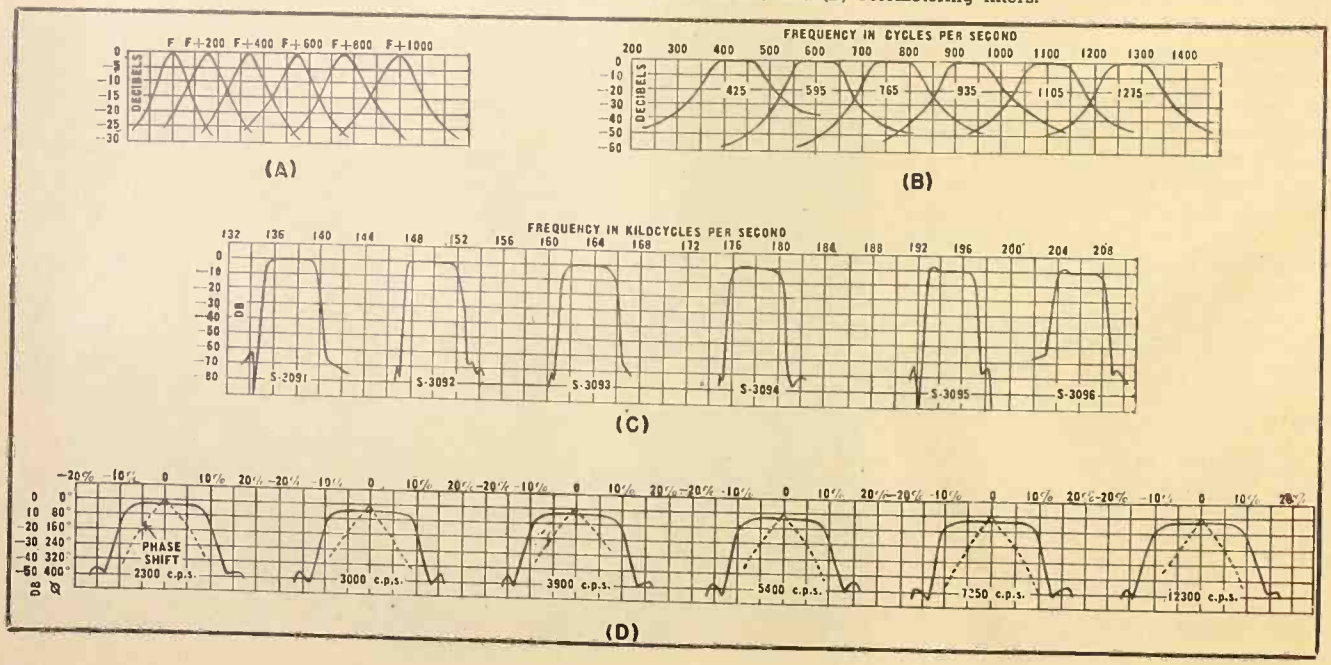
The core clamp is of the double movable jaw type, centralizing the core regardless of its thickness. Extended core clamps are provided for the winding of some of the larger size cores.

A scale and pointer, shown in the illustration immediately ahead of the core clamp, comprise the visual means for angular positioning of the unit when the load and fire mechanism is being adjusted for degree of stroke or oscillation. This scale arrangement permits adjustments within an accuracy of ±1°.

Three sizes of work heads are provided. The smallest is designated as No. 3 (or 3") shuttle capacity; the medium size as No. 4 (or 4") capacity; and the largest size as No. 6 (or 6") capacity. All are completely interchangeable by removal of the screws and are doweled into position, eliminating any adjustments for the setup of the work head

(*Continued on page* 31)

Fig. 8. Toroidal filter graphs. (A) Subminiature guided missile filters; (B) Tone channel filters; (C) Crystal element channel filters; and (D) Telemetering filters.



PRINTED CIRCUIT PRINTERS

Flat and cylindrical surfaces may be printed with these semi-automatic circuit printers.

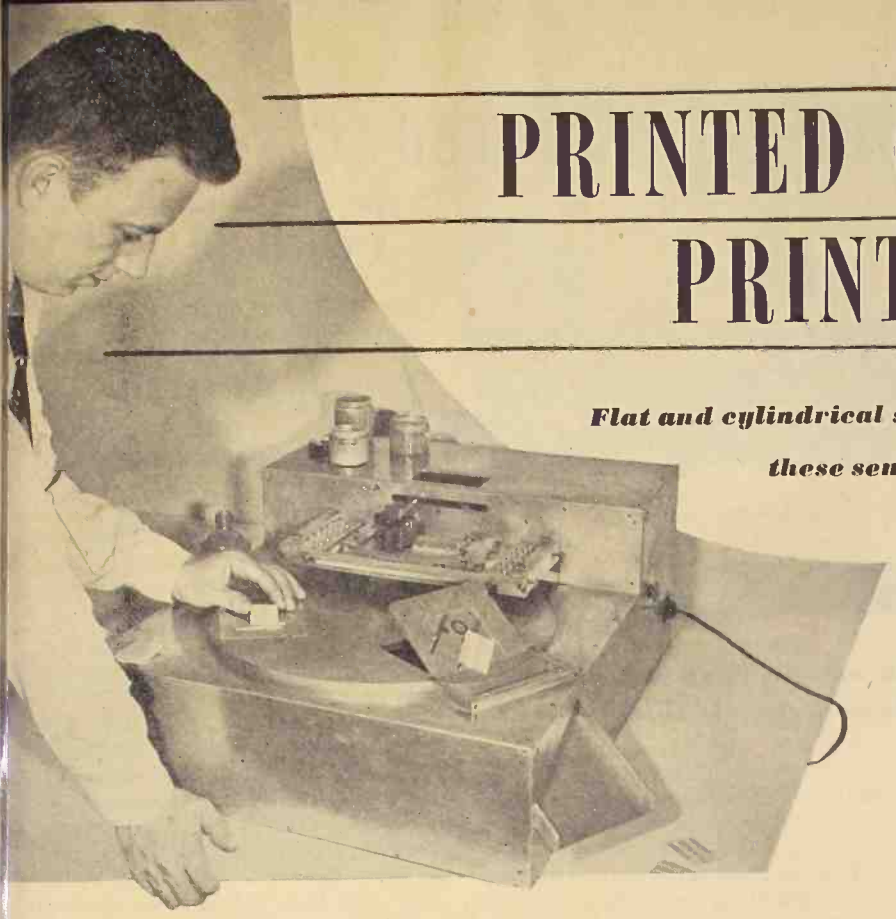


Fig. 1. Ceramic plate is placed in loading position on NBS automatic printer.

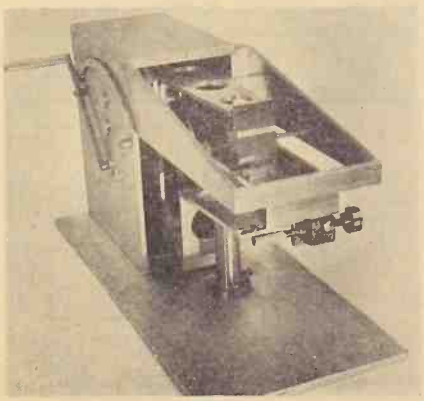
TWO SEMI-AUTOMATIC machines for printing electronic circuits, one for flat surfaces and the other for cylindrical surfaces, have recently been developed by Robert L. Henry and associates of the National Bureau of Standards. The new NBS printers are products of a continuing program of printed circuit development sponsored by the Navy Bureau of Aeronautics. Although few if any automatic printers have hitherto been developed for printed circuit applications, such printers seem to offer two important advantages. First, they are faster than hand printers and more economical for use in quantity production. Second, and perhaps equally important, they give a more uniform product.

Printed circuits—in which wiring and components are superimposed directly on insulating bases—are being used increasingly because they can be economically produced in quantity and because they facilitate miniaturization of equipment. Circuits are usually printed manually by a stenciled-screen process in which a rubber squeegee forces silver paint onto the insulating base through openings in a fine silk or metal screen. Firing of the printed plates then drives off the paint vehicle and leaves an adherent silver film of high conductivity.

The NBS printer for flat plates is motor-driven and more fully automatic than the printer for cylindrical surfaces. In the flat plate printer, a turntable accepts the unprinted plate at a loading position, carries it to a printing position, and after printing carries it to an unloading position, where it is automatically flipped into a chute.

In regular operation, three plates are processed simultaneously: while the first plate is unloaded, the second is printed, and the third is loaded. The turntable stops while these operations are performed, then advances the plates one-third of a revolution, stops again, and so forth. The usual production rate, about 1000 plates per hour, can be increased to 1500 per hour without loss of printing quality but at the expense of excessive wear and tear on the machine.

Fig. 2. Semi-automatic printer for cylindrical surfaces developed by NBS.



As the turntable advances the plates from position to position, they rest on rectangular platens about 3 by 4 inches in size. These flat platens are normally flush with the turntable. However, when a plate-carrying platen reaches the printing position, the platen rises and presses the plate against the underside of the printing screen, which occupies a fixed horizontal position. While the plate is held against the screen, a rubber squeegee is automatically moved over the top surface of the printing screen, forcing conducting paint through the screen onto the plate in the desired pattern. The platen is then lowered to its flush-with-the-turntable position and is advanced by the turntable another third of a revolution to the unloading position. Here the platen is tilted, and the printed plate slides into the discharge chute.

The flat-surface printer is at present loaded by hand, one plate at a time, as the turntable moves the three platens past the loading position. Otherwise the process, including the flipping of the printed plates into the discharge chute, is entirely automatic. The loading of the unprinted plates, and also the carrying away of the printed plates, could be done automatically by conveyors.

The NBS cylindrical-surface printer was developed for the printing of cylindrical ceramic forms less than 0.5 inch in diameter. Such small ceramic cylinders are usually out-of-round and present a much more difficult printing problem than larger, more perfect forms.

The cylindrical-surface printer is loaded manually by slipping the cylinder to be printed over a mandrel. A single stroke of a hand-operated control lever then puts the machine through the entire printing cycle and operates a release mechanism which drops off the printed cylinder.

(*Continued on page* 27)

Application of Printed Circuit Techniques

Fig. 1. A view of the completed 50-60 mc. i.f. strip.

By
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and
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Design of stagger tuned 50-60 mc. i.f. strip using selective etching to form coils and chassis shield.

AIRBORNE ELECTRONIC systems have many problems in common with their land and sea counterparts as regards performance, reliability, maintenance, and spatial requirements. However, in almost every case, airborne equipment is required to operate under greater extremes of temperature, acceleration, vibration and voltage variations. In addition, it must be as light as possible and use minimum space in an already crowded vehicle. The equipment must be readily removable for servicing, replaceable, and its packaging suitable for installation in many different locations for the best utilization of available space. With the increased dependence of both military and commercial aviation on electronic equipment in navigation and communications, the search for improved methods of construction has led to many new techniques and the development of smaller and smaller components. This article describes the work done in the application of etched circuits to common radar circuits in order to illustrate the advantages which may be obtained from their application to airborne electronic equipment problems.

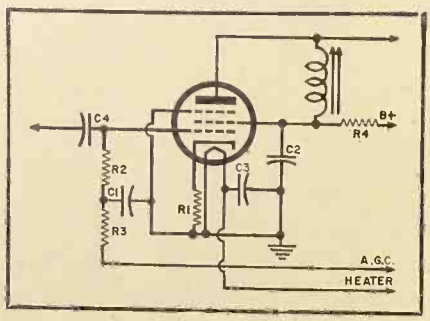
Etched circuit techniques give promise of solving some of these problems by further reducing size and weight as well as cost of manufacturing the equipment.

A broad-band stagger tuned i.f. amplifier operating in the 50 to 60 mc. region was designed and constructed to illustrate the techniques involved in the application of etched circuits. Before discussing this particular amplifier, however, a brief review of the history of broad-band i.f. amplifiers and their application to radio and radar systems will be useful for a better understanding of the problems involved in applying etched circuits to these systems.

The use of broad-band i.f. amplifiers was required in conjunction with the superheterodyne circuit in the early development of FM and television transmissions. This broadbanding was usually accomplished in two ways—first by increasing the i.f. frequency to permit greater bandwidth for the same Q factor and, secondly, by reducing the Q of the tuned circuits by means of loading resistors. The development of radar during World War II employed these techniques as it progressed from the low-frequency, low-definition systems to the microwave, high-definition systems requiring higher i.f. frequencies and wider bandwidths to pass the spectra of the narrow pulses transmitted.

The early i.f. strips were "synchronous tuned," that is, all tuned circuits were aligned to a single midband frequency and bandwidth obtained by loading each circuit equally so that the cascaded response would be as required. Later designs used "stagger tuned" systems yielding greater gain-bandwidth factors than those obtained with the synchronous tuned systems. At the present time the latter systems are being used successfully for most broadband i.f. amplifiers.

Fig. 2. Typical stagger tuned i.f. stage.



For radar systems of the past war, an i.f. frequency of 30 mc. was standardized as a suitable compromise between gain-bandwidth products obtainable with tubes such as the 6AC7. However, further developments in tube design of the miniature and sub-miniature types have permitted an increase in the optimum i.f. frequency to the 50 to 60 mc. range and additional research has indicated the practicability of standardizing at a frequency as high as 100 mc.

Suitable bandwidth for radar systems varies from 2 to 5 mc. depending on the tactical function, *i.e.*, short range high-definition systems or long range limited-definition systems. Local oscillator stability is also a determining factor in the required bandwidth since normal local oscillator variations should not be detectable as amplitude variations of the received signal.

Gains of much above 120 db are difficult to obtain due to regeneration problems and small variations in production models.

From this discussion it may be concluded that, from a performance point of view, an i.f. amplifier suitable for a radar system should operate at a midband frequency of 50 to 60 mc., have from 2 to 5 mc. bandwidth and have a gain of about 120 db.

A schematic of a typical stage of a stagger tuned amplifier is shown in Fig. 2. With the exception of a few small resistors and bypass capacitors of comparatively small dimensions, it can be seen that the major items left are the tube, socket, and tuning inductances. The major limitations therefore lie with the tube and its socket. Tubes have been decreased in size from the standard octal based tube to miniature and subminiature types. The amplifier to be described uses miniature tubes to illus-

trate the etched circuit techniques but sub-miniature types would serve equally well and provide a further reduction in size and weight.

The material used for the production of these etched circuits is a copper-clad phenolic laminate having a one-to-three mil foil banded to each side. It is commercially available in several varieties and grades of laminate, bonding material and thickness of copper foil. Although the types available at present undoubtedly are lacking in many respects in ability to withstand the rigors of airborne service, it is felt that this problem can be solved by the manufacturers of the material once the specific requirements are known. It is hoped that this example of the production and development techniques required and the type of results obtained by use of etched circuitry in electronic equipment will be useful in the further application of etched circuits to mass-produced electronic equipment.

The copper-clad laminate was used as a sub-assembly chassis with coils and wiring as well as the chassis shield produced with selective etching. Low-ohmage printed resistors were sprayed through a mask to form the decoupling impedances for the plate and a.g.c. circuits. For the tube sockets, the phenolic laminate is punched in such a manner that the holes function as the lower portion of a standard wafer-type socket. Fig. 3 shows the negative from which the etching was made. The foil directly behind the coils on the top side is also etched away to prevent decreasing the inductance and Q.

Spiral coils etched in this manner were on the order of 1 microhenry and had measured Q's of from 100 to 150, depending on the line thickness and outside diameter of the coils. Test coils were readily reproduced from the same photographic negative with small deviations in inductance and Q. Tuning is accomplished with a screw having an oversized head. A tuning range of ± 6 mc. was obtained with the use of a head diameter slightly smaller than that of the coil. The brass tuning slugs decreased the Q from about 100 to 90 and this decrease was essentially uniform over the tuning range. Tuning discs made of powdered iron were also used but were not as satisfactory, being mechanically weaker than the brass discs.

Calculations for simple staggered systems show that maximum Q factors of 60 to 70 are required for the 4-megacycle bandwidths. Thus it would appear that the etched coils produced on the XXXP phenolic laminate are quite adequate for this application. For other applications, the Q of these coils could be improved, if required, by the use of heavier gauge foil, silver plating and a lower loss backing material.

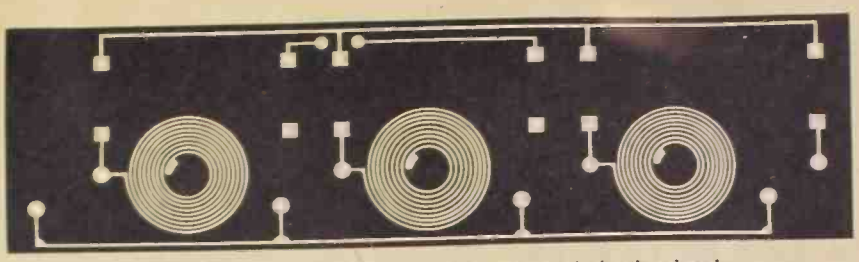


Fig. 3. Negative from which the etching was made for the chassis.

The decoupling resistors were formed with sprayed graphite-silver powder compositions which were then stabilized by baking at temperatures just below the decomposition point of the plastic base. The tolerances on these particular components are quite broad, since any value from 100 to 300 ohms will provide enough decoupling. With further development of the process techniques, sprayed resistors could be used as coil damping and cathode compensating resistors, the tolerances of which are more critical. Small resistors of the "Globar" variety were used for these applications although standard ½-watt sizes could also be used.

Bypassing and coupling condensers are of the ceramic type and their small physical size permits short leads and isolation from other components. The use of miniature components at these frequencies reduces considerably the possibilities of feedback and stray coupling. As in most i.f. amplifiers, the output circuit required shielding and was constructed of a standard double-tuned transformer within a shield can which is not shown in the photograph. A 1N34 detector and associated filter were also contained in this shield can. A view of the completed amplifier is shown in Fig. 1.

For laboratory construction of printed breadboard models, a "direct inking" method was used which permitted experimental layouts to be made using drafting instruments and an ink which resists the action of the etching solution. Since physical layout for high-frequency circuits must be planned rather carefully to reduce feedback, trial arrangements must be made and a development method such as the direct inking described is convenient in arriving at a satisfactory layout. After the physical layout has been determined, an accurate layout drawing may be made to several times scale with India ink on a background suitable for photographing. Spirals are difficult to draw without special compasses, but a close approximation can be made with four centers and 90° arcs. After the layout drawing has been photographed, the negative is reduced to scale and the etched design produced from this negative by contact printing to the surface of the copper foil which has been photosensitized, usually with cold top enamel. As in photoengraving, the convenient echant is ferric chloride and speed of etching may be regulated by strength, temperature, and agitation of the solution.

These techniques have been applied to the development of the i.f. strip with performance comparable to a standard wired model. The basic circuit is designed around the miniature type 6CB6 which was developed especially for 41.25 mc. television service. It is similar to the more familiar 6AG5, having a higher g_m and smaller interelectrode capacities. The suppressor grid is brought out separately, permitting the use of cathode compensating. Circuit design is shown in Fig. 4. The first stage is connected as a grounded grid circuit to provide a low-impedance input for a signal generator and also to simulate

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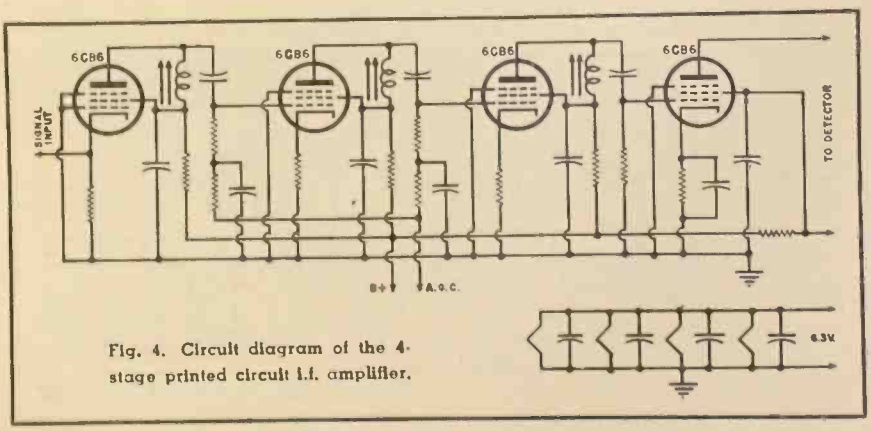


Fig. 4. Circuit diagram of the 4-stage printed circuit i.f. amplifier.

HIGH SPEED IMAGE CONVERTER

This photograph shows the exterior appearance of the Mullard grid-controlled high-speed image converter tube, ME 1201.

By HERBERT WEIL

Very high-speed and short-duration phenomena can be photographed with the aid of this tube.

A NEW ELECTRON TUBE, called an *image converter*, has been developed in the Research Laboratory of *Mullard Ltd.*, the well-known British radio and electrical components manufacturer. This image converter (trade designation ME 1201) is capable of photographing phenomena occurring in the region of one-hundred-millionth of a second (1/100,000,000 sec.). It is four million times as fast as an ordinary box camera. It is so fast in action that it has actually been used to photograph the progress of the millionth-of-a-second discharge of the world's fastest electronic flash tube which was developed during the war to study projectiles in flight. British experts believe that this amazing new electronic device may revolutionize ultrahigh-speed photography.

Many of the limitations imposed on high speed photographic techniques, it has been found, can be overcome by using an image converter as an optical shutter. In this method an optical image is transformed into an electron beam which can be deflected or shut off by conventional means. Basically, this device consists of an evacuated glass cylinder with flat ends, a semi-transparent photo-cathode being deposited internally at one end and a luminescent screen at the other. When an image of an object is focused onto the photocathode, the electrons emitted are accelerated by a positive voltage applied to the screen; the phosphor is then excited to form a visible image.

The working principle of the image converter was first put forward by G. Holst in 1934; developments after 1934 were mainly to improve the definition attainable on the fluorescent screens of the simple Holst tube. Improvements in definition were effected as a result of the inclusion of electromagnetic and electrostatic focusing systems. By 1939 several tubes of this type had been constructed, and the military applications of the infrared converter gave impetus to the development and production of new tubes to meet the demands of the armed forces. From the work carried out with existing image converters, it was concluded that the following features were desirable in the design of the tubes for high speed photography:

1. The cathode should have a good sensitivity in the region of 4000Å.

2. The luminescent screen should have a backing layer to (a) protect the phosphor from caesium vapor during processing, and (b) make the tube opaque to light coming through the photocathode.

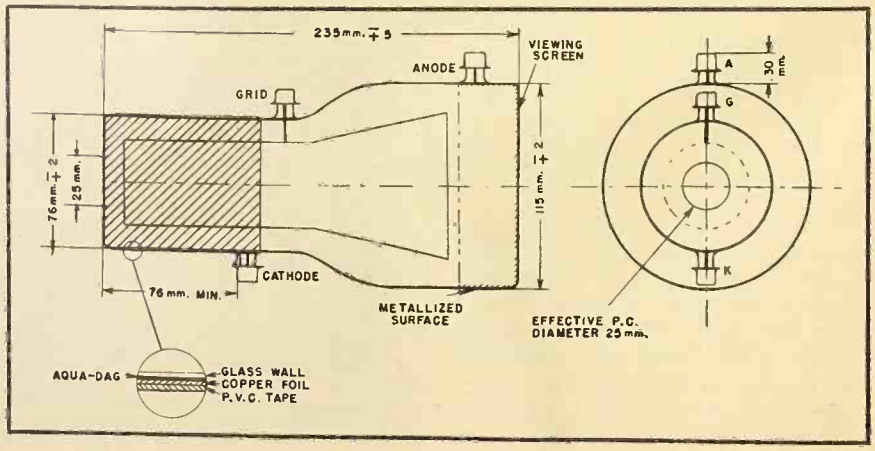
3. A grid with a good control characteristic should be incorporated in the tube in order to avoid the pulsing of very high anode voltages.

4. An electromagnetic or a combination of electromagnetic and electrostatic focusing systems should be incorporated in order to insure high definition pictures.

The *Mullard* grid-controlled image converter has been specially designed for high speed photographic applications. The photocathode and screen of this tube are optically flat plates. An internal glass rod supports and insulates the grid electrode, which consists of a layer of aluminum on the glass. Contacts to the photocathode, grid and luminescent screen are brought out for standard tube caps. The luminescent screen is aluminum-backed.

The photocathode of this tube is of the caesium/antimony type. It has a high sensitivity in the blue region of the light spectrum and is, on this account, most suitable for high speed

Line drawing showing the basic construction of the converter tube.



photographic work. A green luminescent Willemite screen is normally used, giving a picture approximately 4½ inches in diameter. The diameter of the photocathode is a little over 1⅛ inches so that the tube can conveniently be used at an image magnification of four times.

During the development of this tube it was found necessary to devise a special technique to make caesium/antimony cathodes with a very low resistance on the order of a few hundred ohms per square unit as compared with megohms in the case of normal semi-transparent caesium/antimony photocathodes used in photomultipliers, supericonoscopes, etc., these new photocathodes having an average sensitivity of 20 μamp/lumen to tungsten light at 2700°K. There are two main types of screen available for the *Mullard* ME 1201: Willemite, giving a green trace with a light emission peak at 5200 Angstrom units and a persistence of several milliseconds; and a nickel-killed zinc sulphide giving a peak output at 4300 Angstrom units and a fast decay on the order of 5 microseconds. Both types of screen can resolve 50 lines per mm., and the light in each case can be efficiently recorded on high speed orthochromatic or panchromatic emulsions.

The *Mullard* image converter normally requires an anode voltage of 6 kv. and a grid voltage of 3 kv., thus making it possible—for static operations—to use any conventional power pack having a high output impedance. A number of ways may be suggested in which the ME 1201 can be used for dynamic operation. For example:

1. Single shot exposures pulsing the cathode negative
2. Single shot exposures pulsing the grid and cathode sequentially
3. Scanning
4. Stroboscopic operation
5. Multiple shots

In method 1, a line is charged to 5 kv. and is then shorted by a hydrogen thyratron through a resistance equivalent to the line impedance, whereupon a negative pulse of approximately 2.5 kv. appears at the cathode. In spite of a number of difficulties, this system has been found to work reasonably well and records can be obtained for exposures in the region of 1/10 microsecond (10^{-7} sec.).

The technique of method 2 was developed by Dr. R. F. Saxe, of the Armament Research Establishment at Fort Halstead, England. This has several advantages over the first method, the principle of operation of the apparatus being as follows: the tube is 'opened' by dropping the cathode voltage to 60 v. and is closed again by grounding the grid, hydrogen thyratrons being used as switches. When using the image converter for viewing non-luminous objects, it is normally sychronized to the peak light output of a *Mullard* LSD2 microsecond flash tube. No difficulty is experienced in synchronizing to the peak of the flash tube discharge with an exposure of 1/20 microsecond (5×10^{-8} sec.).

In scanning, the possibility exists that, by the use of suitable external deflector coils, the electron beam in the image converter can be moved across the luminescent screen. Thus, records similar to those obtained with drum cameras can be secured. For scanning requirements, a special tube was recently designed by *Mullard Ltd.* in co-operation with Dr. J. S. Courtney-Pratt, of Cambridge University. This tube, the ME 1200, is similar to the ME 1201 but has no grid electrode. Using this tube for photographing the birth and growth of an explosive reaction, writing speeds of 60,000 meters per second have recently been achieved, giving a resolution of 1600 lines across the field of 3½ inches in diameter, or approximately 460 lines per inch.

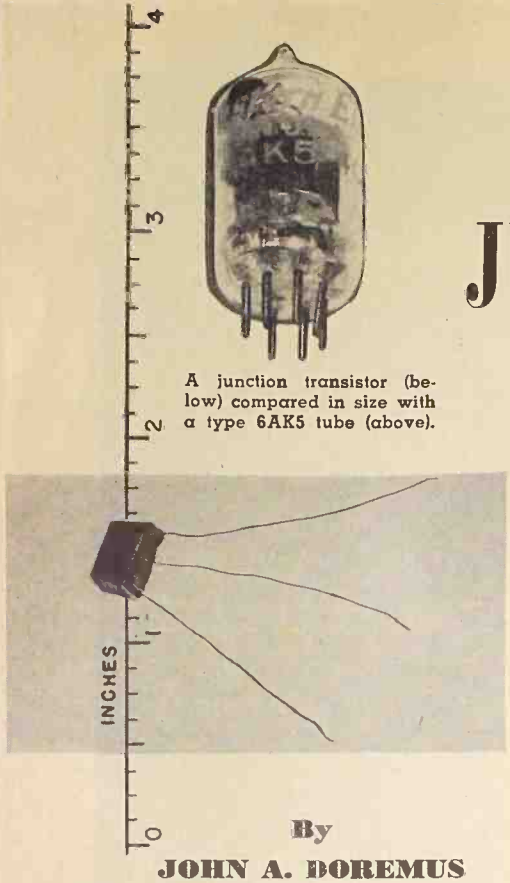
The visual examination of stroboscopic effects (method 4) is another field in which the image converter has possibilities. For instance, a recent demonstration given by the Physical Society in London showed the movement of stress waves in a transparent medium. In this demonstration the 'shutter' or grid of the image converter was working at 20 kc., giving one-microsecond exposures. By the use of high speed drums to transport the film, it is possible that a series of 1/10 microsecond (10^{-7} sec.) exposures could be recorded at the rate of 200,000 frames per second or faster, as against a maximum of 100,000 frames per second obtainable with the Marley camera in previous demonstrations.

Method 5—a further development of the scanning technique which has also been demonstrated by Dr. Courtney-Pratt—makes it possible to take a limited number of pictures in quick succession. In these experiments the event under observation was focused onto the center of the photocathode of the image converter in such a way that the image was confined to one-third the useful cathode diameter. Two deflecting coils at right angles were used giving field strengths of H, O and —H. By means of a mechanical commutator these fields were applied in suitable phase to deflect the whole picture successively to any of nine discrete positions. A frame interval on the order of

(*Continued on page* 25)

Progress in the explosion of a firework as photographed from the screen of the Mullard image converter tube.

POINT-CONTACT and JUNCTION TRANSISTORS



A junction transistor (below) compared in size with a type 6AK5 tube (above).

Transistors are superior to vacuum tubes in many respects, but also have certain limitations which must be considered in designing new equipment.

By
JOHN A. DOREMUS
Motorola, Inc.

THOSE WHO work in the communication phase of this industry sometimes have the feeling that "there's nothing wrong with electronics that the elimination of a few vacuum tubes would not fix!" This is a sordid thought to have concerning the element around which the industry revolves. Yet many basic short-comings can be traced back to the vacuum tube.

A vacuum tube has a limited and unpredictable life. A piece of communication equipment is often called on to operate continuously for years, and it is desirable that this equipment be completely unattended; yet tube failures require constant and costly maintenance.

The fact that a vacuum tube consumes power inefficiently is well known in the television industry. Very large power transformers are required for many television sets, a good share of the size being required to provide heater power for 15 to 20 tubes. Mechanically, too, a tube is bulky and fragile.

Now, for the first time, there is an alternative device which can be considered a legitimate contender to the throne that has been occupied by the vacuum tube for over 35 years. It can do many of the jobs now done by vacuum tubes and do them more efficiently and more dependably. This device is called a *transistor*.

What is a Transistor?

Transistor is the name given to a crystal-type amplifying element made of a semi-conductor such as silicon or germanium. It is interesting to note that the name was derived from the fact that this device had been called a "transit resistor" by early workers in the field who were really searching for new ways of making nonlinear resistors. At present, a transistor is equivalent to a triode. Its physical embodiment can be extremely small, since its ability to amplify does not depend upon its size. It is very rugged.

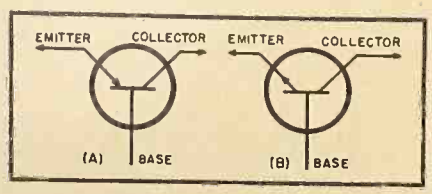
The ability of a transistor to amplify depends upon the unusual property of semi-conductors to support two kinds of conduction simultaneously: one, the travel through the material of excess electrons, and two, the travel through the material of "holes," which are really the lack of electrons and therefore constitute an equal positive charge. In a semi-conductor, electrons travel much more slowly than they do in a conductor and "holes" travel even more slowly than the electrons.

Transistors are constructed in two distinctly different types. One is called the point-contact type; the other is called the junction type. Their construction results in different performance characteristics which will become apparent as this story unfolds.

What Can It Do?

In most circuits, the transistor will do the same job as a vacuum tube while consuming 1/1000 as much power. Take, for example, a radio or television set. In all stages up to the second detector the signal level is less than a milliwatt and in most of them less than a microwatt. Yet an average of a watt or more heater power and a watt of plate and screen power are burned up in order to obtain the desired amplification.

Fig. 1. Schematic representation of (A) the point-contact transistor and (B) the junction transistor.



Transistors can give 20 to 50 db of gain, depending upon the type, while consuming less than two milliwatts of power. The junction type of transistor is about ten times more efficient than the point-contact type for small-signal amplification.

As the transistor has no filament or heater, there are no problems of filament burn-out. Transistor life has been predicted in several ways, all of these predictions pointing toward a figure of 70,000 to 90,000 hours, or approximately ten years. Since a transistor does not stop working suddenly, there being nothing to burn out, the life figure above has been based on the time at which its gain will drop 3 db. For most applications, this is not necessarily the end of its useful life.

Table 1 gives a tabulation of the properties of both the point-contact and junction types compared with vacuum tubes. As will be seen from this tabulation, transistors can do a better job than tubes within the limits of power and temperature up to 30 mc.

Photo Transistors

The boundary in a junction type transistor is extremely photosensitive and therefore can be made into an attractive photocell. The first photocells of this type were simply diodes.

One important characteristic of a transistor photocell is its spectral sensitivity which is most strong in the red and infrared regions. A second important characteristic is its efficiency. A PN junction unit (diode) has a sensitivity of 30 ma./lumen, and 10 to 15

milliwatts of a.c. can be obtained from a simple circuit using this type of unit. An NPN photo transistor can give a light conversion efficiency about 30 times greater than this, or about 1 ma./millilumen.

Why the Excitement?

Transistors are causing a great deal of excitement at this time because:

1. Production of practical quantities of the point-contact units has begun.
2. Large advances in circuit design have been made in the past year.
3. The bringing of the junction transistor out of the laboratory and the readying of it for production opens even newer and broader fields of application.
4. Stability of design has been established.
5. Dependability of units has been assured by uniform production.
6. Designability has been established. Units can now be designed to a certain set of parameters.
7. There is a need to alert the industry to the impact of this element so that circuit design work can now be done to take advantage of transistors.
8. Manufacturers believe that most rapid progress can be made under pressure of circuit designs to stabilize types.
9. Five manufacturers are already "in the business." These are *Western Electric, General Electric, Raytheon, Sylvania* and *RCA*.

How Does It Work?

The operation of the transistor can best be understood by reviewing some of the characteristics of semi-conductors. Certain elements in the fourth column of the Periodic Table exhibit properties whereby they seem like insulators under certain conditions, while under other conditions they seem like conductors. These elements have been called semi-conductors.

In the molecular structure of a material like diamond, all valence bonds are satisfied, so the material behaves like an insulator. If the crystal is heated, the thermal excitation can cause a valence electron to be knocked out of its usual place, leaving this electron (negative charge) free to move about in the crystal. The place from which the electron came is called a "hole," and this area exhibits a local positive charge. Under this condition, the diamond behaves somewhat like a conductor. Eventually, the electron and the hole may recombine. At all times, however, the entire crystal is electrically neutral.

Certain other elements in the fourth column of the Periodic Table, like silicon and germanium, require less energy to knock electrons out of the valence bond positions; in fact, at normal temperatures, electrons and holes are being liberated and recombined continuously. These are called intrinsic semi-conductors.

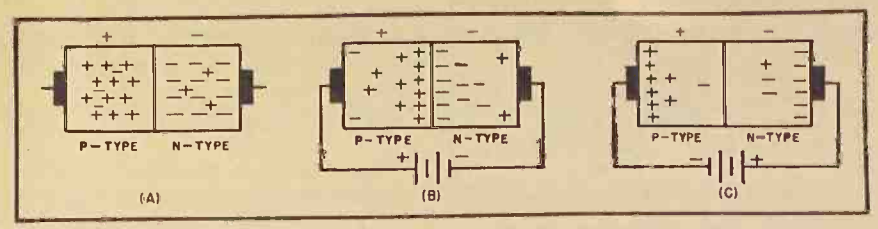


Fig. 2. Schematic representation of a junction between P-type and N-type germanium, showing action of electrons and "holes" with various battery polarities.

If an electric field is applied to an intrinsic semi-conductor, the electrons move toward the positive terminal and the holes move toward the negative terminal. Holes can be treated exactly like electrons except that their charge is of opposite sign.

It was learned early that the presence of certain impurities in a semi-conductor greatly changed its conductivity. These impurities were identified and the following two effects catalogued.

If an impurity from the fifth column of the Periodic Table is present, atoms of this impurity replace atoms of the semi-conductor in the crystal structure. Since fifth column elements have five valence electrons, the extra electrons are free to migrate throughout the crystal. This is called an N-type (negative) semi-conductor and the impurity atoms are now called donors or donators.

If an impurity from the third column of the Periodic Table is present, the impurity atoms similarly replace atoms of the original material in the crystal. Third column elements have only three valence electrons and, consequently, one valence bond is left unsatisfied. The holes thus formed are also free to move about in the crystal, and the material is now called a P-type semi-conductor. These impurity atoms are generally referred to as acceptors.

It is interesting to note that only a few donor or acceptor atoms are required to produce substantial changes in the resistivity of a semi-conductor.

Two other properties of semi-conductors are important:

1. Holes can be introduced into an N-type semi-conductor, and electrons can be liberated in a P-type semi-conductor by passing current into it.
2. Electrons travel much more slowly in a semi-conductor than they do in a conductor, and holes travel even more slowly than electrons.

Now, examine the operation of a PN junction rectifier (Fig. 2). This may be made up of a single crystal of germanium, for example, the two parts of which contain different impurities. One part is N-type and the other part is P-type. If a potential is applied to the two ends of this rectifier so that the positive terminal is connected to the P material and the negative terminal to the N material, the electrons and holes move toward each other and recombine. The voltage source keeps this going. The apparent resistance is very low, and a high current flows.

If we reverse the polarity of the applied potential, the effect is much different. The holes and electrons are pulled away from the junction and away from each other, and the unit tends to become an insulator. Very little cur-

Table 1. A tabulation of the various characteristics of the point-contact and junction transistors compared with the characteristics of conventional vacuum tubes.

	Point-Contact Type	*Junction Type*	*Tubes*
Gain	20 — 30 db	30 — 50 db	20 — 50 db
Efficiency (Class A)	30%	45 — 49%	.1 to 25%
(Class C)	90%	95%	70%
Life	70,000 hrs.	90,000 hrs.	5000 hrs.
Vibration	100 g.	100 g	
Shock	20,000 g	20,000 g	
Uniformity	± 3 db	± 2 db	± 3 db
Minimum powers	1 mw.	1 microwatt	1/10 watt
Temperature	70°C	70°C	500°C
Frequency	30 — 70 mc.	3 — 5 mc.	60,000 mc.
Gain × bandwidth	1000 mc.	120 mc.	1000 mc.
Noise figure	45 db	15 db	10 — 30 db
Power	100 mw.	1 watt	1 megawatt

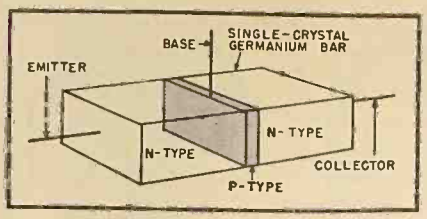


Fig. 3. Basic construction and nomenclature for junction transistors.

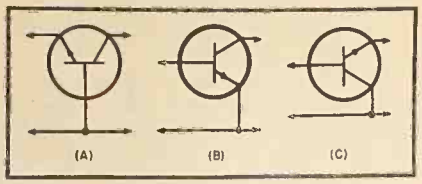


Fig. 4. Three possible methods of connecting the junction transistor: (A) Grounded base; (B) Grounded emitter; (C) Grounded collector.

rent flows. Therefore, this type of junction is a very good rectifier.

Next, pass on to the junction type transistor (Fig. 3). Here, there are two junctions made very close together —usually from a single crystal of the semi-conductor.

The left-hand junction is biased in its forward direction, forming a very low resistance path for the flow of current. To insure an efficient emitter, the N-type material is more strongly N than the P-type is P. An excess of electrons is generated, and these travel into the center region.

The right-hand junction is biased in its non-conducting direction. The electric field across this junction makes it attractive for the excess electrons liberated at the emitter junction to continue on across the collector junction to the collector terminal.

Variations in the emitter current will cause variations in the number of free electrons available and thus cause variations in the collector current. The Greek symbol alpha (α) has been established as the transfer current gain of the transistor. α may be defined as the change of collector current for a specific change in emitter current at a constant collector potential.

$$\alpha = \left(\frac{\Delta I_c}{\Delta I_e}\right)_{V_c}$$

The factor α is dependent upon the efficiency of the emitter, the transport ratio and the efficiency of the collector.

$$\alpha = \gamma \times \beta \times A$$

γ = emitter efficiency
β = transport ratio
A = collector efficiency

If the emitter current were all electrons and none recombined with holes in the center, P-region, and all of them reached the collector, then α could attain a maximum value of unity. In practice, α values of .95 to .98 can be achieved.

As mentioned previously, the emitter (or input) junction has a very low impedance, but the collector (or output) junction has a very high impedance. The variation of a current through the high impedance collector circuit by an almost equal current variation in the low impedance emitter circuit constitutes an appreciable power gain. Junction transistors have been made with up to 50 db of power gain.

Now, consider the point-contact type of transistor. This is basically a block of semi-conductor material, such as germanium or silicon, where two pointed probes are placed very close together on top of the block. During manufacture, the contact areas are "formed" by passing current pulses through them. This creates small areas of P-type material directly under the points, and the resulting transistor is essentially a PNP unit.

Operation is similar to that described for the NPN transistor except that all supply potentials are of opposite polarity and the important conduction is principally by holes instead of electrons. However, because of the geometry of this unit and the relative mobilities of holes and electrons, α values as high as 3 to 4 can be obtained in commercial units.

A transistor, therefore, possesses two mechanisms whereby power gain can be obtained when it is used as an amplifier. One of these is due to the fact that the output impedance is considerably higher than the input impedance; the other is due to α, the current gain possible in point-contact types and the newer hook-collector types of units.

Transistor Characteristics

The transistor is definitely a three-terminal device. Unlike the vacuum tube, the fact that the transfer characteristics are bilateral cannot be forgotten, even for equivalent circuits. Changes in output conditions affect the input characteristic as changes in input conditions affect the output characteristic.

The transistor is definitely a voltage amplifier. By varying an input voltage, a much larger variation in an output voltage is obtained. Too, transistors like best to see constant current power supplies whereas tubes work best with constant supply potentials.

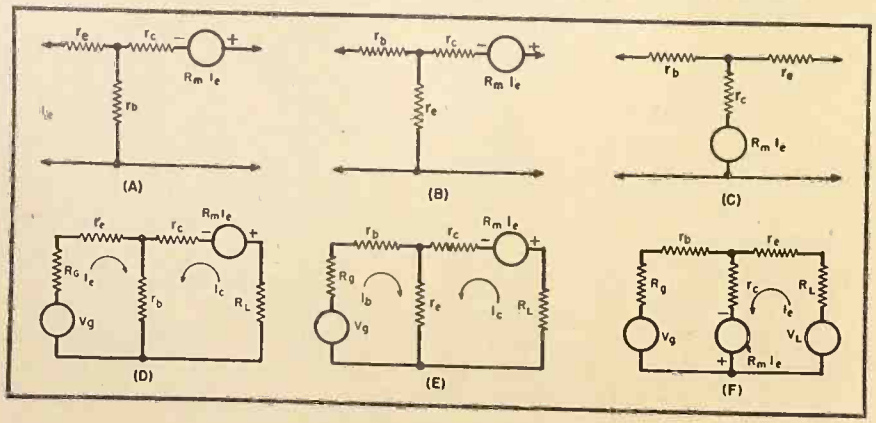
As mentioned previously, the emitter circuit of a transistor is a diode biased in its forward or conducting direction. The bias supply for this element must be of a constant current nature to prevent self-destruction.

The alternating current equivalent circuit of a transistor for most applications is represented as a three-terminal network with two series resistances, r_e and r_c, and one shunt resistor, r_b, as shown in Fig. 5. These parameters are resistive at normal audio frequencies. The truest representation of the transfer generator would be a current supply having the value αI_e shunted across r_c. Since it is inconvenient to work with current generators, this may be replaced with an equivalent voltage source in series with r_c having the value $R_m I_e$.

The input impedance of a transistor is equivalent to the sum of r_e and r_b and has practical values from 200 to 600 ohms. The output impedance is equivalent to r_c plus r_b. This may be from 20,000 ohms to over a megohm.

Like a vacuum tube, a transistor has an upper frequency limit caused by the capacities between the elements. Because of the close spacing, these capacities are somewhat greater than in vacuum tubes. Capacity effect on the emitter is not serious because of its inherently low impedance, but the capacity effect upon the collector is somewhat more important, especially in junction types. The principal frequency limitation in a transistor, however, is due to another cause, namely, the slow transit speed of the electrons and holes in the semi-conductor material. These two effects define an upper frequency limit for junction type units at 3 to 5 mc., while point-contact units have been used up to 70 mc.

Fig. 5. Equivalent circuits for the various junction transistor connections: (A) & (D) Grounded base; (B) & (E) Grounded emitter; (C) & (F) Grounded collector.



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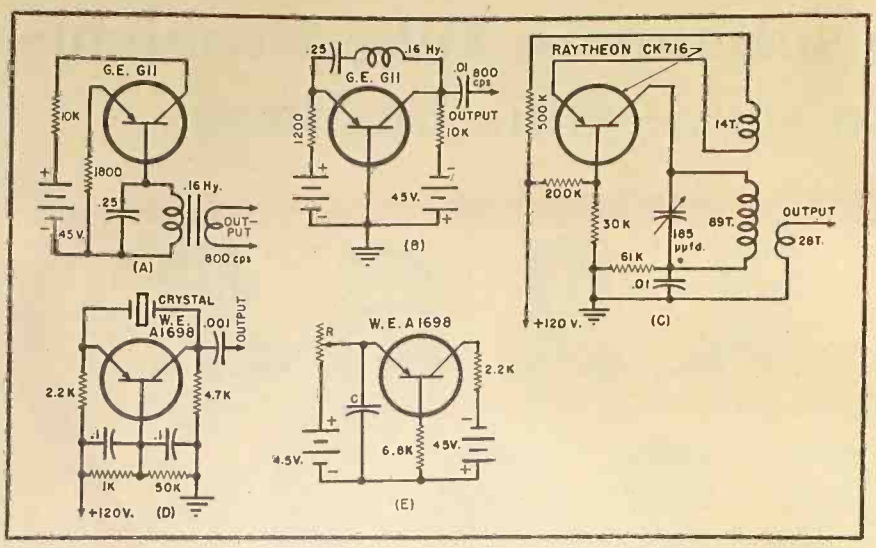


Fig. 6. Several practical point-contact transistor circuits: (A) and (B) are oscillators having an output of 800 cps. (C) is a broadcast superhet oscillator. (D) is a crystal-controlled oscillator. (E) is a multivibrator in which C is adjusted for the desired frequency and R is adjusted for proper operation.

Temperature provides another serious limitation to the environment of a transistor. At elevated temperatures, the noise generated within the unit becomes important in magnitude, and the thermal agitation causes a large change in the collector impedance, thereby affecting the amplification.

Much has been said about noise in transistors, which is evidence that research has only begun on the fundamental causes of this noise. This noise, like other random noise, decreases as frequency increases. A point-contact type unit shows a noise factor of 40 to 50 db while junction type units have a much better noise figure, 10 to 15 db, which compares favorably with tubes.

Practical Circuits

Like the vacuum tube, the transistor lends itself readily to all types of circuits including amplifiers, oscillators and switching circuits. In many cases, the transistor shows improved flexibility since there is no common filament supply to consider. Low input impedance minimizes shielding problems.

The commonly used grounded base connection is equivalent to a grounded grid vacuum tube circuit. In this connection, the principal problem is stability. Base resistance is common to both input and output circuits. Since there is no phase reversal in the transistor element, the common base resistance constitutes a regenerative feed-back path—most important in units with an α greater than unity.

The value of r_b has been controlled in all units currently being manufactured to provide inherent stability when no external resistance is added to the base circuit.

In the grounded base connection, between matched impedances, up to 20 to 30 db gain per stage is easily achieved. Because the impedance transformation through a transistor amplifier is a step-up, it is always necessary to use an interstage stepdown transformer to realize full power gain.

At a large sacrifice in gain, it is possible to cascade grounded base transistor stages directly. In this sort of an amplifier, 6 to 8 db gain per stage is possible.

Another popular circuit is the grounded emitter circuit, equivalent to a conventional grounded cathode tube circuit. Input and output impedances are both on the same order of magnitude —from 4000 to 10,000 ohms. Output impedance is negative if α is greater than one and must be stabilized with external resistance in the collector circuit.

This circuit has a transfer phase shift of 180°. Practical amplifiers can be built with 20 to 30 db gain per stage. Cascaded stages without interstage transformers show an improvement over the grounded base connection.

The transistor may also be used in a grounded collector circuit. This circuit, which has a high input impedance and a low output impedance, is equivalent to a cathode follower tube amplifier.

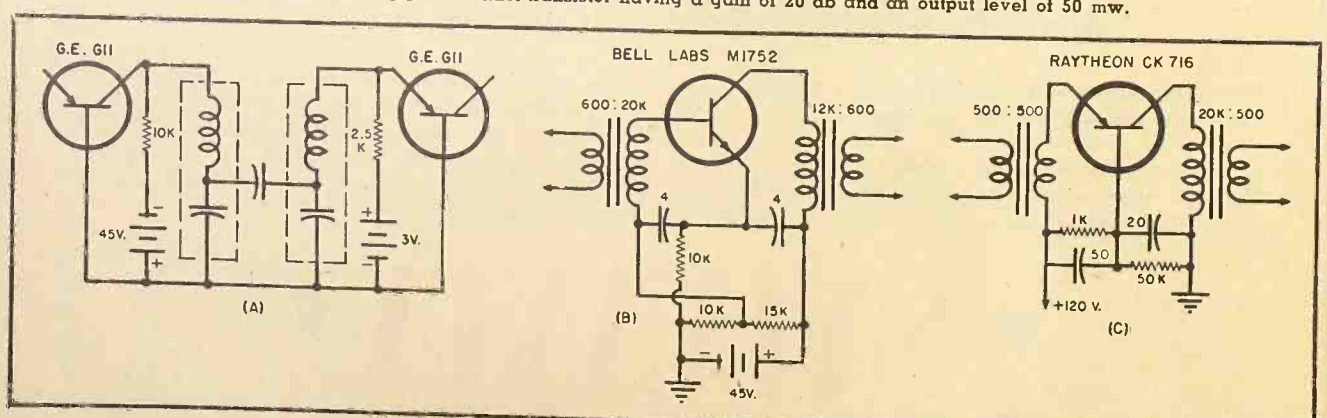
Both input and output impedances may be negative in this connection, but the circuit can be stabilized with external resistors. It is interesting to note that this circuit has a phase reversal going through it in one direction while it has no phase shift going through it in the opposite direction. It is possible to make an amplifier of this type with 15 db of gain in both directions.

To produce low noise input, higher power output and more gain per stage without interstage transformers, combinations of grounded base followed by grounded collector stages and grounded emitter followed by grounded collector stages may be used.

For oscillators, several circuits have shown good performance. A parallel resonant circuit in the base is a very popular circuit. Coupled series-resonant circuits in the emitter and collector leads produce a TE-TC oscillator.

A few conventional circuits that have

Fig. 7. (A) A practical 455 kc. i.f. amplifier. Note that the two i.f. coils are in separate cans. (B) An audio amplifier using a junction transistor. Output level, 10 dbm; gain, 30 db; battery power, 0.2 watts. (C) Audio amplifier using point-contact transistor having a gain of 20 db and an output level of 50 mw.



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been used in practice are shown in Figs. 6 and 7.

Another important application of transistors is in switching circuits. With a vacuum tube, plate impedance can be controlled from several megohms to a few thousand ohms, while a gas tube can provide a switch from several megohms to a few hundred ohms. The transistor, on the other hand, can provide a switch which is capable of several megohms in its non-conducting condition to a fraction of an ohm in its conducting condition. This is the most effective electronic switch known to date. It can be made to operate in a fraction of a microsecond and be stable in either the open or closed condition much like a flip-flop circuit.

This application makes the transistor extremely useful in computers, telephone switching circuits and many industrial control operations. Experimental circuits have been built using transistors to replace the vibrator in an automobile radio power supply.

The transistor provides miniaturization of the major element of electronic circuits, thus shifting the impetus for improvement back to the transformer manufacturers and, more particularly, to the condenser manufacturers. Transistor circuits require the use of high-capacity, low-voltage coupling capacitors which at present are neither small, inexpensive, nor dependable.

The transistor also throws out an interesting challenge to the battery manufacturers to produce a constant current source rather than a constant potential source. At the present time, 80% of the power used in transistor circuits is wasted in the dropping resistors required to provide the constant current supplies from a constant voltage source.

Amplifier and oscillator circuits are limited at the present time to about 70 mc. This is a problem which is being worked on by all those engaged in transistor research.

The elimination of heat in the equipment employing transistors is a problem which does not have a very attractive solution. Obviously, it is not desirable to locate a transistor next to a red-hot 6L6. On the other hand, in equipment using all transistors and no tubes, the heat dissipated will be extremely small and will solve some of the currently existing aspects of the problem.

Summary

In conclusion, it can be said that the transistor is an adequate substitute for the vacuum tube with attractive improvements in power required, efficiency and dependability. At the present time, its application is confined to the limits of 70°C, 70 mc. and about 70 milliwatts.

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Table 2. Data sheet showing characteristics of several point-contact and junction transistors.

Manufacturer's number	CK 716	G11	A1698	M1689	M1725	M1729	M1752[2]	TA161B
Transistor type	Contact	Contact	Contact	Contact	Contact	Contact	Junction	Contact
Manufacturer	*Raytheon*	*GE*	*WE*	*BTL*	*BTL*	*BTL*	*BTL*	*RCA*
Type of service			Switching	Switching	Audio & Carrier	Audio & Carrier		
Diameter	.255	.16	.239	*.125	.239	.239	3/8x5/32	
Height (over-all)	.775	0.55	.750		.750	.750	7/32	
Mounting	*Cinch* 8749	5 pin sub-miniature	*Cinch* 8672	solder	*Cinch* 8672	*Cinch* 8672	solder	
Grounded Base								
Collector current, ma.	4	2	15	40	20	20	5	
Collector voltage (neg.)	40	40	100	50	50	50	50	
Collector dissipation (mw.)	100	25	120	80	200[1]	200[1]	50[1]	140
Emitter current (ma.)	10	1	15	40	15	15	5	
Cutoff frequency (mc.)		5	5		5	5		
Input (emitter) resistance, r_e	250	50		800	195	190	25	300
Output (collector) res., r_c	15K	20K		10K	8K	15K	13M	15K
Feedback (base) resistance, r_b	75		200	500	115	75	240	120
Forward resistance, r_m	25K			15K	16K	32K	13M	
Current amplification factor α	2.5				2.1	2.5	.98	2
Grounded Emitter								
Emitter current (ma.)	0.5				1.5	1/2[3]		
Collector voltage	10				5	30		20
Collector current (ma.)	1.5				4	5/7		3
Average power gain[4]	18	*19			18	20/18		22
Average power output (mw.)	3				4.5	/50		
Noise figure (db) at 1000 cps.					48	54		
Input termination					500	300		
Output termination					1000	15K/15K		

* Approximate.
[1] at 50 degrees C ambient.
[2] Specifications, not data.
[3] Lower right values are strong signal conditions. Upper left values are weak signal conditions.
[4] Grounded base connection.

NEW PRODUCTS

GAMMOMETER

The Ohmart Corporation announces the addition of the Model AH-1 gammometer to its line of radiation measuring

instruments utilizing the newly-introduced *Ohmart* cell, in which radioactive energy is converted directly into electrical energy, as the radioactive element.

With the introduction of the Model AH-1, *Ohmart* now offers a line of gammometers with ranges as low as .1 microcurie to 10,000 microcuries full scale, calibrated in terms of radium (standard), iodine-131, or cobalt-60. Full details and price information are available from *The Ohmart Corp.*, 2347 Ferguson Road, Cincinnati 38, Ohio.

LAMINATION MATERIAL

With the increasing scarcity of certain metals, especially nickel, *Thomas & Skinner's* new OrthoSil, a 4-mil iron-silicon material for laminations, is finding many applications. Designed especially for high frequency inductors, it

may be used in transformers (as shown in the photograph), chokes, saturable reactors and filters.

OrthoSil is oriented to provide directional magnetic characteristics, and although developed primarily for frequencies of 400 to 2000 cycles, this new product is readily adaptable to the audio ranges.

Additional information may be obtained direct from *Thomas & Skinner Steel Products Company*, 1120 East 23rd Street, Indianapolis, Ind.

GAS SWITCHING TUBE

According to the *General Electric Company*, a small gas switching tube which resembles a miniature cigarette lighter may play a key role in viewing objects at close range on radar screens. The *G-E* Tube Department at Schenectady, N. Y., has announced the addition of the new A-TR tube, which weighs

only two ounces, to its line of broadband gas switching tubes.

Type 6038 acts as a switch to decouple the transmitter from a common transmitting and receiving antenna, thereby allowing the antenna to receive the return signal after a radar signal has been transmitted. Speed is essential to attain full sensitivity of the system for nearby objects.

Designed for both military and commercial radar, this tube cuts recovery time—the key factor in viewing objects at close range—to only eight microseconds.

TOROIDAL LOADING CORES

Impedance matching between open wire lines and cables used in carrier communication may be achieved through the use of the toroidal loading cores introduced by *Lenkurt Electric Company*, 1105 County Road, San Carlos, Calif.

Available in several values of inductance and in a number of physical arrangements, these coils are wound on high-stability iron powder toroidal cores. (The illustration shows a lead-sleeve type of coil with 7-foot cable stub for making connection.)

The new coils are applicable to circuits using carrier frequencies of 3 to

35 kc., and in particular combinations form a tuned loading system which provides a substantially flat non-reactive impedance characteristic throughout most of this frequency range.

UNIVERSAL pH METER

Precision-built for reliable service and for quick, accurate measurements of hydrogen-ion concentrations, a new universal pH meter is now available from the Research & Control Instruments Division of *North American Philips Company*, 750 South Fulton Avenue, Mount Vernon, N. Y. This instrument is designed for all pH and rH work, for potentiometric titrations and for oxidation-reduction-potential investigations.

For laboratory research and industrial testing purposes it provides a measuring accuracy of 0.01 pH or 0.5 mv., a range of 0 to 14.15 pH and 0 to 1415 mv., absolutely currentless measuring with no phenomena of polarization, and zero indication by cathode-

ray tube. It can be used with glass, quinhydrone, hydrogen and platina electrodes and is direct calibrated for the first three.

The *Philips* pH meter is enclosed in a wood cabinet, and an auxiliary chemical assembly, similarly enclosed, is available as an accessory.

DOUBLE PULSE GENERATOR

The Model 903 double pulse generator, manufactured by the *Berkeley*

Scientific Corporation, 2200 Wright Avenue, Richmond, Calif., produces either single or double pulses such that

the amplitude or width of each pulse is continuously and individually variable. Spacing between pulses is controlled by means of a calibrated front panel knob. Developed for general laboratory work, the unit is ideally suited for designing and testing amplifier circuits, gating and gating control circuits, high speed scalers and wide-band amplifiers.

Model 903 consists of two pulse forming circuits with an integrating network to provide a time delay between pulses. It is capable of producing either positive or negative pulses. The rise time of the pulses is .035 microseconds and decay time less than .15 microseconds.

CATHODE-RAY OSCILLOSCOPE

Designed primarily for the observation and photographic recording of very fast-rising waveforms having a low duty cycle, the *Tektronix* Type 517 wide-band high-voltage cathode-ray oscilliscope is now in production at *Tektronix, Inc.*, 3627 S. E. Cooper Street, Portland 2, Oregon.

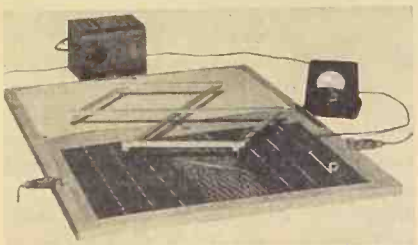
A quantitative instrument, Type 517 has all critical voltages electronically controlled to preserve the accuracy of the sweep and vertical amplitude calibrations. Distributed type vertical am-

plifiers provide a rise time of .007 microseconds with a maximum sensitivity of .1 v/cm. An accelerating potential of 24 kv. on a metallized cathode-ray tube allows photographic recording of single sweeps at the maximum writing rate permitted by the vertical amplifier and sweep circuits.

ANALOG FIELD PLOTTER

A versatile tool for rapid solution of complex two-dimensional field problems has been announced by the Special Products Division of *General Electric Company*, Schenectady, N. Y.,—a portable analog field plotter which sets up electrical field patterns in a thin conducting-paper surface on the plotting board. Analogy between the electric field in the paper and the related field problems allows an easy solution to a broad range of difficult problems.

Since the new plotter can be used for the study of air flow patterns, as well as electrical fields, fluid flow and tem-

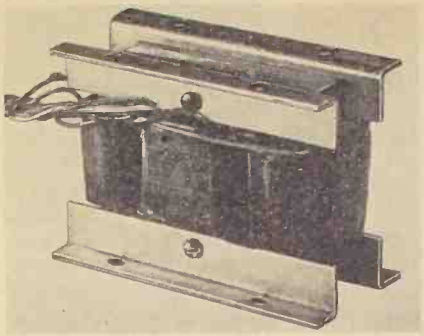


perature distribution, it may have extensive use in the aircraft industry.

The plotter consists basically of a plotting board and exploratory stylus, with d.c. power supply operated from 115 volts a.c., a high-accuracy multiturn voltage divider, and a sensitive microammeter.

SATURABLE TRANSFORMERS

Magnetic Amplifiers, Inc., announces a new standard line of saturable trans-



formers including both open type and hermetically sealed units, manufactured in accordance with military specifications. Power output is phase reversible a.c. with output levels of one watt to one kilowatt, at both 60 and 400 cps. Ambient temperature limits are from −60°C to over +80°C.

For bulletin listing applications and typical circuits with actual component

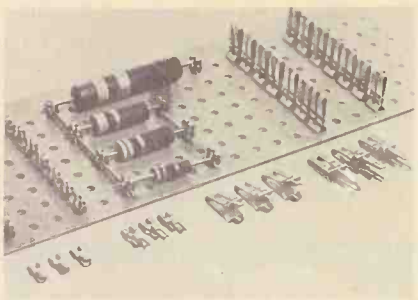
(*Continued on page* 29)

NEWS BRIEFS

TERMINAL DESIGN

The new and completely different terminal design announced by *Alden Products Company*, 117 North Main Street, Brockton, Mass., is a possible answer to the problem of putting component mounting and soldering on a production basis.

Alden 650 series terminals have a unique press configuration. Component leads snap in and are held for soldering without the necessity of twisting or wrapping with pliers. Only a minimum



of soldering is necessary, and heat is dissipated quickly, permitting use of short leads.

These new terminals make it possible to secure multiple leads with a minimum of effort and, at the same time, obtain a finished product that is neat, compact and easily accessible for test or removal.

ELECTRONICS PRODUCTION BOARD

Marvin Hobbs, electronics adviser to the chairman of the Munitions Board, has been appointed a member of the Electronics Production Board, succeeding Mr. C. W. Middleton, who is now engaged in field activities for the Department of Defense.

The Electronics Production Board was established within the Defense Production Administration several months ago and is responsible for the over-all coordination of the electronics production program.

APPOINTMENTS AT *BELL*

Dr. Ralph Bown, director of research for *Bell Telephone Laboratories* since 1946 and a member of the *Bell System* for more than 30 years, has been appointed vice president in charge of research. Dr. Bown has been internationally recognized for his pioneering research and development work in the broad field of communications engineering, much of which has been concerned with various aspects of radio broadcasting and with ship-to-shore and overseas telephony.

Other organization changes at *Bell Laboratories* include the following: Dr. J. B. Fisk is now the director of research—physical sciences; Dr. H. T. Friis has been appointed director of research in high frequency and electronics; Dr. W. H. Doherty is the new director of research in electrical communications; and Dr. R. M. Burns was appointed chemical coordinator in addition to his duties as director of chemical and metallurgical research.

ULTRASONIC VIBRATOR

Ultrasonics are now being used at *Raytheon Manufacturing Company*, Waltham, Mass., to conserve materials vital to the nation's defense program. Tungsten, high on the list of critical materials, is among those materials being salvaged by means of a new device —an ultrasonic vibrator.

This device, vibrating at a frequency of more than three times that of the

highest audible pitch, shakes glass beads off tungsten rods salvaged from vacuum tubes which have proved faulty during manufacture and which require reprocessing. Developed by *Raytheon*, the device permits removal of glass sealed to the tungsten rods ten times faster than was possible by previous methods.

Other glass-sealing alloys can also be salvaged by this method, which can be applied to a variety of tubes including those used in x-ray, Geiger counters, and radio and television equipment.

INSTRUMENT MERCURY

The *Bethlehem Apparatus Co., Inc.*, is now processing and marketing mer-

cury specifically for use in instruments requiring a high degree of accuracy. An unbreakable 5-lb. polyethylene bottle with a flexible dispensing tip delivers the mercury directly to the instruments from a dust-proof chamber in which it has been purified of all contaminants.

It is claimed that this instrument mercury goes beyond the standard chemical tests which are adequate for reagent mercury, and meets much more exacting physical tests, remaining bright indefinitely in storage and in instruments.

Also available in larger containers, it is suitable for use in manometers, polarographs, thermometers, cathode cells, meters and gauges of all types. For further information, write direct to the *Bethlehem Apparatus Company, Inc.*, Hellertown, Pa.

LORAN NAVIGATION TABLES

Since the National Bureau of Standards inaugurated a Navy Department-sponsored project devoted to the preparation of tables for the newly adopted Loran system of navigation some ten years ago, more than 100 tables, involving some 5000 pages, have been prepared to provide Loran coverage for all the principally traveled areas and important military installations in the world.

Recently a program was developed to carry out Loran computations on SEAC (National Bureau of Standards Eastern Automatic Computer), which greatly reduced the number of machine-

hours and the cost of computation required to complete a Loran project.

Loran has proved to be one of the most reliable means for navigating far out at sea or in the air because low frequency radio waves are used to carry the navigational information. Transmission is effective at distances up to 700 nautical miles during the day and 1400 nautical miles at night.

A.I.E.E. FELLOWS

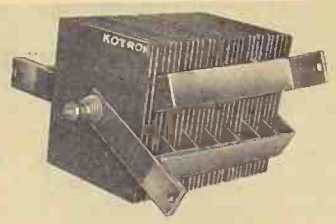
Two *General Electric* authorities in the field of mercury arc power rectification have been named Fellows of the American Institute of Electrical Engineers—Lysle W. Morton and August Schmidt, Jr. Both are employed in *G-E's* Power Electronics Division at Schenectady.

Mr. Morton joined *G-E* as a test engineer upon his graduation from the University of Minnesota in 1924, and was transferred to the General Engineering Laboratory in 1926 where he became instrumental in the development of the mercury arc power rectifier.

Mr. Schmidt, a member of the nation's atom-bomb Manhattan Project in 1943-4, also joined *G-E* as a test engineer following his graduation from Cornell in 1920.

HIGHER VOLTAGE CELLS

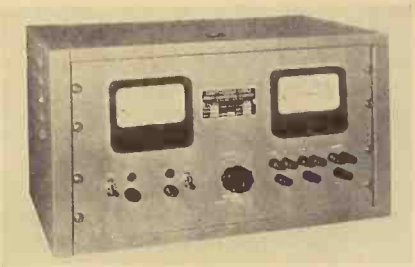
In January, 1948, *Kotron Rectifier Corporation*, Newark, N. J., began production of selenium rectifier cells capable of blocking 40 volts r.m.s. while delivering the standard current density of 0.333 ampere per square inch in a single phase bridge circuit with a maximum ambient temperature of 35°C. Three years of experience in actual use having dispelled any doubts as to the value of these high voltage cells, *Kotron* has now announced a new selenium rectifier cell with the capacity to withstand 60 volts r.m.s.



The principal advantage of employing higher voltage cells is the material reduction made possible in the size and weight of the rectifier stacks, thus effecting conservation of critical materials necessary in manufacture. Far fewer cells are required in series to withstand higher applied voltages.

POWER SUPPLIES

The new line of standard electronic power supplies recently developed by



the *Perkin Engineering Company*, 318 Kansas Street, El Segundo, Calif., is finding varied application in many of the national aircraft and electronic laboratories. Varying in rating from 100 to 500 milliamperes and from 200 to 1000 volts, these d.c. power supplies are entirely electronic in nature and have very rapid recovery times.

There are eight models, some of which have bias voltage ratings of either 0 to 150 volts or 0 to 300 volts at 5 milliamperes. Each model has a filament output voltage of 6.3 volts at either 3, 6 or 10 amperes, and is available in a universal type of construction whereby it can be used either as a 19" rack panel assembly or as a cabinet type assembly.

PATENT ABSTRACTS

Photographic copies of patent abstracts are being supplied by the *Picturesort Company* on a weekly basis as issued in the Official Patent Gazette. Abstracts are reproduced full size on 4" x 6" cards, punched for instant sorting, and the subscriber receives only the class and sub-class or type of patents in which he is interested. The cost is nominal and the saving of time in filing, finding, sorting and using may be substantial.

For more information, contact *Picturesort Company*, 246 Church Street, New Haven 10, Conn.

VARIAN LABORATORY

Varian Associates of San Carlos, California, developer and manufacturer of electronic products, is constructing a

(*Continued on page* 28)

NEW LITERATURE

TOOL STEEL HANDBOOK

"Tool Steel Handbook," a 197-page volume designed for engineers, teachers, metallurgists and others interested in tool, die and allied steels, has been published by *Alleghany Ludlum Steel Corporation.*

The material contained in this volume includes: charts and tables giving specific and comparative data on properties, analyses and applications; detailed descriptions of all important grades; the many forms and finishes of tool and die steels and allied products; discussions of heat treating and handling techniques; and a complete set of weight tables and other useful reference material.

Free copies will be sent to qualified persons on request to *Alleghany Ludlum Steel Corporation,* 2020 Oliver Building, Pittsburgh 22, Pa.

PORCELAIN SPECIALTIES

Various ceramic bodies used in the manufacture of electrical and electronic equipment are completely described in the 24-page brochure just published by *Star Porcelain Company,* Muirhead Avenue, Trenton, N. J. Containing suggestions for good ceramic design as well as data tables on physical properties and application information, the brochure also describes the research, engineering and production facilities behind the *Star* custom-made porcelain specialties.

"PHANTOM REPEATER"

The Model 102 "Phantom Repeater" is a bridging amplifier with an extremely high input impedance which is used to increase the accuracy of vacuum tube voltmeters and oscilloscopes on high impedance circuits.

A four-page bulletin describing this special test instrument has been released by *Keithley Instruments,* 3868 Carnegie Avenue, Cleveland 15, Ohio. In addition to listing complete specifications, the bulletin contains diagrams of typical applications, including simultaneous measurement of voltage, shape inspection, and aural monitoring with negligible loading of test circuits.

NBS RESEARCH ACTIVITIES

Established fifty years ago, the National Bureau of Standards has served both industry and science as the principal laboratory of the Federal Government in the major scientific fields of physics, mathematics, chemistry and engineering. NBS research and development activities are discussed in the feature article of the January issue of the Bibliography of Technical Reports, which may be purchased at 50 cents a copy from the Office of Technical Services of the U. S. Department of Commerce, Washington 25, D.C., or through the U. S. Department of Commerce field offices. Orders should be accompanied by check or money order payable to the Treasurer of the United States.

CARBONYL IRON POWDERS

General Dyestuff Corporation has issued a 32-page booklet covering the essential facts of production, application and performance of carbonyl iron powders. Containing a minimum of text, the booklet is studded with photomicrographs, charts, graphs, tables and pertinent mathematical formulas, and includes an extensive bibilography.

Copies are available on request to Department 99, *Antara Chemicals Division* of *General Dyestuff Corporation,* 435 Hudson Street, New York 14, N. Y.

X-RAY DIFFRACTION

A 60-page catalog entitled "X-ray Diffraction and Geiger-Counter X-ray Spectrometric Equipment" has been released by the Research & Control Instruments Division of *North American Philips Company, Inc.,* 750 South Fulton Avenue, Mount Vernon, N. Y. In addition to x-ray diffraction, spectrometry and fluorescence analysis, the catalog covers such components and accessories as tubes, rectifiers and cameras.

Information is also provided on applications for x-ray instruments, along with typical charts which show how specimens differ when analyzed by this powerful laboratory and production control equipment.

ELECTRONIC "BRAINS"

The complex electronic "brains" which control modern armaments are elaborate combinations of simple control devices called servomechanisms, or "servo systems." To develop competent service men for these electronic "brains," the Navy has prepared a "service-man's primer" on servomechanisms which is now available to the public.

This treatise, entitled "Instrument Servomechanisms," is devoted exclusively to servomechanisms used for automatic positioning. Known as PB 104 386, it contains 265 pages including diagrams, tables, photographs, and graphs, and sells for $2.00 a copy. Orders should be addressed to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., and accompanied by check or money order payable to the Treasurer of the United States.

GRAPHICAL SYMBOLS

For the first time, single line diagrams for use in both power and communication work are combined in one volume. The American Standard Graphical Symbols for Single (One) Line Electrical Engineering Diagrams, Z32.-1.1.-1951, coordinates and modifies the single line diagrams contained in the American Standard Graphical Symbols for Electrical Power and Control, Z32.3-1946, and for Telephone, Telegraph and Radio Use, Z32.5-1944. Copies may be obtained from the American Standards Association, 70 East 45th Street, New York 17, N. Y., at $1.40 each.

RADIATION INSTRUMENTS

Publication of an eight-page, two-color bulletin containing essential information on ten recent nuclear radiation instruments has been announced by the *General Electric Company,* Schenectady 5, N. Y.

Designated as GEA-5735, this illustrated booklet covers the *G-E* radiation monitor, scintillation counter, portable radiation probe, area health monitor, long-probe gamma survey meter, alpha hand counter, air equivalent ionization chamber, boron-coated counter tube, thermocouple vacuum gage, and step-motor impulse counter.

TECHNICAL DATA AVAILABLE

A condensation of the inventory of Department of Defense technical information activities has been published in Science magazine to acquaint scientists and engineers working in the National Defense Program with the current sources of available material.

A limited number of reprints of this article may be obtained from the Special Committee on Technical Information, Research and Development Board, Washington 25, D. C.

Application

(*Continued from page 9*)

The approximate gain and output impedance characteristics of the input stage used in an actual receiver, where crystal mixer and associated plumbing are located remotely from the i.f. input and connected through a low-impedance line.

The three staggered coils form a staggered triple with the first and last stages tuned above and below the midband frequency and the second stage tuned to the midband frequency and loaded to twice the bandwidth of the outer pair. The 47-ohm cathode compensatory resistor holds the input conductance of the a.g.c. controlled tubes constant over a wide range of a.g.c. voltage; hence the bandwidth does not change with signal level. Measurements showed that the gains per stage were from 16 to 20 db and were comparable to those obtained with a conventional amplifier operating at the same frequency and bandwidth.

A solder with a melting point slightly below the tin-lead eutectic was used in the construction of the unit to prevent injury to the bonding agent or laminate. Components are mounted so that they extend through the holes in the laminate, thus relieving the foil of the weight and tension a component might exert. After assembly, a coating of lacquer is used to protect the exposed etching from accidental shorting or scratching in servicing.

Conductive paint, solder, or wiring can be used between breaks in etched circuits without seriously impairing the operation of the unit.

The advantages of this method of construction are summarized as follows:

1. Units lend themselves to economical and rapid mass production techniques minimizing manual labor and wiring errors.
2. A uniform wiring layout reduces variations in performance from unit to unit.
3. Feedback problems in high-frequency applications are reduced.
4. Rigidity of coils and wiring improves stability of tuning under temperature and vibration.
5. Servicing and replacement are facilitated by the accessibility of the "two-dimensional" construction. Often repairs to damaged wiring can be made with solder or silver paint.
6. Conservation of copper and chassis metal is made possible.

A further refinement of the circuit can be seen by reference to Fig. 4. By use of combined resistor and condenser combinations commonly used in hearing aids and also in some of the newer television receivers, the total components added to the etched circuit could be reduced to one or two. Combining the cathode compensating resistor, the plate decoupling resistor and bypass capacitor in one unit, and the grid damping resistor, the a.g.c. decoupling resistor with its associated bypass condenser and the coupling condenser in a second unit would reduce the number of soldered connections from 14 to 7 per stage, thereby further reducing wiring errors, material costs and labor. Since i.f. stages of a single amplifier are in most cases identical except for the input and detector stage, these multiple units could not appreciably complicate the spare part requirements.

This work is but a step in the direction of a goal which may well result in the replacement of construction practices as we know them today, and in etched equipment which is cheaper and smaller, lighter and more durable than that used at present.

Printers

(*Continued from page 7*)

This printer differs from a conventional printer in that the squeegee remains stationary. As the control lever is brought forward, the mandrel, bearing the cylinder to be printed, rises to meet the stenciled screen. Simultaneously the squeegee, which is directly above the mandrel, drops to press against the top surface of the screen. The screen, which remains flat and horizontal at all times, then starts to move (forward on one stroke, backward on the next) over the cylinder, and the cylinder rotates in response to the horizontal motion of the screen pressing against it. While the cylinder rolls against the screen, the squeegee forces conducting paint onto the cylinder through the pervious pattern of the screen. When the cylinder has made one complete revolution, both cylinder and squeegee are moved away from the screen. As the control lever is moved back to its starting position, the mandrel carrying the cylinder is rotated from a horizontal to a downward position, a release mechanism on the mandrel is actuated, and the printed cylinder drops off.

With hand loading of the cylindrical surface printer, an operator can easily print 1500 cylinders in an 8-hour day. An automatic feed mechanism and electric drive, which could be added without much difficulty, should increase the production rate to a probable 500 or 1000 cylinders per hour. For fully automatic production at high speed, a conveyor belt system with steadying pins could also be added to carry away the printed cylinders.

Personals

JAMES DALE is the new chief TV and radio engineer at *Hoffman Radio Corporation*, Los Angeles, Calif. On the engineering staff since January, 1951, his promotion was part of a recent revamping of the organization setup. Prior to joining the *Hoffman Radio Corporation*, Mr. Dale spent five years with *Motorola, Inc.*, as project engineer, and was associated with *Belmont Radio Corporation* for 13 years in a similar capacity.

ROBERT DRESSLER, who has been in charge of various aspects of television research for *Paramount Pictures Corporation* for the past five years, was recently appointed director of research and development for *Chromatic Television Laboratories, Inc.*, New York, N.Y. Mr. Dressler's new responsibilities will include projects for the Armed Services, theater television and color television cathode-ray tubes and systems.

KENNETH A. HOAGLAND has been appointed assistant engineering manager of the Cathode-ray Tube Division at *Allen B. Du Mont Laboratories, Inc.*, Clifton, N. J., where he will be in charge of the design and development of cathode-ray tubes. Mr. Hoagland is credited with the development of the *Du Mont* "bent gun" and the new "selfocus" picture tube. An outstanding tube expert, he is well known for his technical articles in various trade journals.

GEORGE W. JERNSTEDT, presently in charge of Electroplating Projects at *Westinghouse Electric Corporation*, Pittsburgh, Pa., has been appointed manager of engineering for the Special Products Development Division as well. Mr. Jernstedt joined the Meter Division of *Westinghouse* in 1936 while he was still an undergraduate at the Newark College of Engineering. He later obtained his master's degree in chemical engineering from Michigan State College.

WALTER E. KINGSTON is the director of the new Atomic Energy Division of *Sylvania Electric Products Inc.*, Bayside, N. Y. He will head Sylvania's expanded program of research and development in the field of nuclear reactor materials for the U. S. Atomic Energy Commission. Formerly manager of *Sylvania's* Metallurgical Laboratories, Mr. Kingston has acquired an international reputation for his researches in powder metallurgy.

HOMER R. OLDFIELD, Jr., newly-appointed resident manager of the *General Electric* Advanced Electronics Center at Cornell University, Ithaca, N. Y., has been with *G-E's* Electronics Division since 1945. Active in World War II, Mr. Oldfield was awarded the Legion of Merit by the Army for his part in developing microwave fire control radar, and the Citation Ribbon from the Air Force for similar work on airborne radar equipment.

News Briefs

(*Continued from page* 25)

million-dollar research and development laboratory at Palo Alto on land leased from Stanford University.

The new *Varian* building, which will provide more than 30,000 square feet for expansion of the company's facilities, will contain electronic tube and special products development laboratories, drafting, machine shop, plating, testing and assembly facilities, and administrative offices. The company's present plant in San Carlos is being retained, and will be devoted entirely to manufacturing.

TEMPERATURE MONITOR

A temperature monitoring device was recently developed by Messrs. M. L. Greenough, F. H. Bayhe, Jr., and Melvin Martens of the National Bureau of Standards Electronic Instrumentation Laboratory, which flashes a warning if the temperature at any one of 48 remote points rises above an individually predetermined safe value.

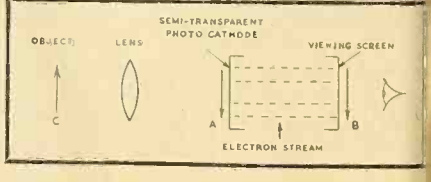
Image Converter

(*Continued from page* 13)

one millisecond was used and nine pictures of a propellor rotating at 3600 rpm were taken in less than 1/100 second. Messrs. Chippendale and Jenkins of the *Mullard Laboratory* believe that this technique is potentially one of the most important applications of image converters. It can be successfully combined with the high speed cine camera technique to give an effective multiplication of 10 to 25 on existing frame rates.

The *Mullard* ME 1201 image converter was designed for use with a Wray f/1 lens recording from the luminescent screen. This lens adequately covers the 4-in. diameter screen reducing 4:1 onto 35-mm. film. To record exposures at 1/10 microsecond (10^{-7} sec.) it is necessary to use high speed film. When this is processed to give maximum film speed, the resolution is limited by the grain size. Resolutions of slightly better than 600 lines per picture are normally possible with the fastest emulsions.

Diagram showing the optical system and electron flow in the image converter.



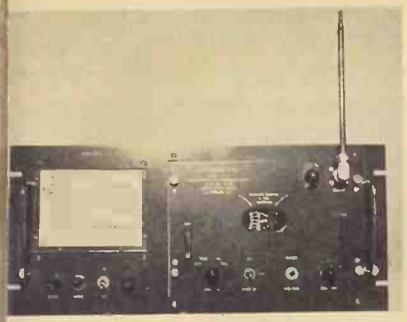
New Products

(Continued from page 23)

alues, write to *Magnetic Amplifiers, c.*, 11-54 44th Drive, Long Island ity 1, N. Y.

RECT-READING FREQUENCY METER

Now in production at *Gertsch Products, Inc.*, Los Angeles, Calif., is Model

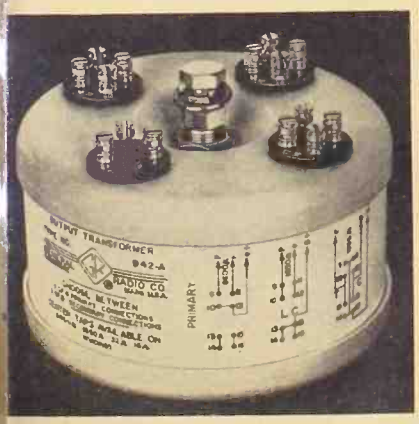


M-1A, a new v.h.f. frequency meter hich was designed to provide a direct ethod of measuring or generating any requency from 20 to 480 megacycles; requency is read direct from a dial, ithout the use of a calibration book. rovision has been made to modulate he carrier frequency at a minimum of 0% at 1000 cycles.

Model FM-1A employs a unique and riginal circuit utilizing an extremely ccurate 1.0 megacycle crystal, with ariable capacity trimming to allow ex- ct adjustment. All frequency measure- ients are referenced to the crystal, hich has a temperature coefficient of .0001% per degree C.

UTPUT TRANSFORMER

Excellent frequency response, high ower-handling capacity, a high degree f astaticism, and flexibility of imped- nce ratios have been combined in a onvenient, compact unit in the Type 42-A toroidal output transformer de- eloped by the *General Radio Company*,



275 Massachusetts Avenue, Cambridge 39, Mass.

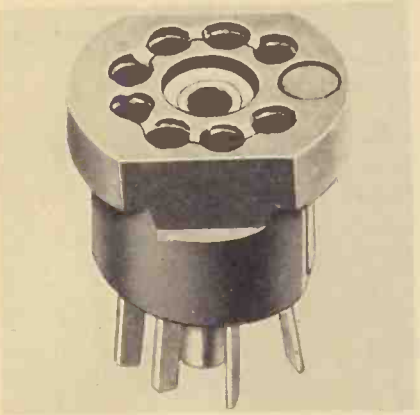
Leakage reactance between primary ections is very small to give minimum distortion from switching transients in conventional push-pull circuits, and connections to individual primaries are provided for certain single-ended push-pull circuits.

In addition to its use in regular audio amplifiers, this transformer is well adapted for use in high power modulators, and in amplifiers for electronic musical instruments and constant-voltage audio distribution systems.

SUB-MINIATURE TUBE SOCKETS

Mycalex Tube Socket Corporation now offers a complete line of sub-miniature tube sockets, designed for high efficiency service in electronic equipment where space is at a premium. These compact sockets mount without screws or rivets in shaped chassis holes.

Improved electrical performance and greater mechanical protection for the tube are provided through the use of "Mycalex 410," injection-molded, glass-



bonded mica for the socket body, than would be possible with ordinary insulating materials.

These tube sockets are available with cadmium-plated brass contact terminals or silver-plated beryllium copper terminals, assuring low contact resistance, freedom from corrosion and ease of soldering. Complete information will be supplied on request to *Mycalex Tube Socket Corporation*, 30 Rockefeller Plaza, New York 20, N. Y.

GAIN SET

An a.c. operated, rack-mounted Type 12A transmission measuring or gain set has been designed for the measurement of voice transmission systems by the *Daven Company*, 191 Central Ave., Newark, N. J. The source output and receive input of the gain set are 600-ohm balanced circuits provided with d.c. blocking capacitors so that the equipment will not interfere with the normal operation of modern dial systems.

Controls are provided on the front panel for adjusting the 1000-cycle fre-

TECHNICAL BOOKS

"THE RECORDING AND REPRODUCTION OF SOUND" by Oliver Read, Editor of RADIO & TELEVISION NEWS and RADIO-ELECTRONIC ENGINEERING. Second Edition. Published by *Howard W. Sams & Co., Inc.*, Indianapolis 5, Ind. 790 pages, 700 illustrations. $7.95.

The second edition of this reference manual has been greatly enlarged and expanded to make it an invaluable source of information for engineers and hobbyists in all branches of audio. Emphasis throughout is on a complete, lucid presentation of the subject matter.

Subjects covered include basic concepts; disc recording and reproduction, including microgrooves; magnetic recording; equalizers and tone controls; amplifiers; complete music, PA and recording systems; and audio measurements. Detailed information on commercial equipment is included wherever practicable. The last chapter presents the NARTB recording and reproducing standards, and a glossary of terms.

The appendix contains a wealth of miscellaneous data such as mathematical tables, color codes, bibliography of magnetic recording, nomographs, charts and mathematical formulas.

This is a standard reference work which should be on every engineer's bookshelf.

"SHORT-WAVE RADIATION PHENOMENA," in two volumes, by August Hund, Scientific and Technical Radio Consultant. Published by *McGraw-Hill Book Company, Inc.*, 330 West 42nd Street, New York 18, N. Y. 1382 pages. $20.00.

Reflecting the author's more than 37 years of experience in the field, these volumes contain an abundance of data, formulas, and theory on short-wave radiation effects. They discuss the useful applications of short-wave radiation phenomena as well as both standard and recently developed propagation theory.

Consisting of nine large sections, the two volumes together constitute one book, and are not sold separately. Among the topics covered are: fundamental concepts and relations of currents and electromagnetic fields; space electromagnetic fields of elementary electric and magnetic dipoles; fundamental methods used in electromagnetic theory; propagation characteristics; transmission lines and radiation; unobstructed space radiation; and space radiation in the presence of electromagnetic obstructions.

quency over a range of ± 30 cycles, and for adjusting the oscillator level output

to the red line of the meter. Errors due to internal distortion of the tube circuits are eliminated by filters, located at the front end of the amplifier, which provide four frequency response curves.

COMPACT AM TRANSMITTER

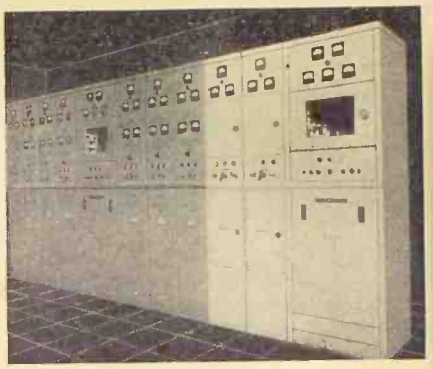
The new one-kilowatt AM broadcast transmitter which has been announced by the *RCA* Engineering Products Department, Camden, N. J., is less than half the size of its predecessor and features a single tuning control. Streamlined mechanical construction and improved circuits and components throughout reduce power consumption by approximately one-fourth, *RCA*

stated, and afford economies in space as well as in operation and maintenance costs.

LOW/MEDIUM FREQUENCY TRANSMITTER

A new type MW low/medium-frequency transmitter is available from *Westinghouse Electric Corporation* for fixed station operation. It is intended for use in public service communications, communications services operated by private companies and airlines, government services, and radio beacon service. In accordance with FCC requirements, the unit is adaptable to facsimile and frequency-shift keying types of emission in addition to c.w., m.c.w., and phone.

The design of this equipment represents a new approach to the problem encountered in using large inductors



and capacitors at the low frequencies. The type MW transmitter uses iron-core transformers for the low and medium frequencies which are small in size and eliminate the necessity for tank-circuit tuning.

For further information, write *Westinghouse Electric Corporation*, Box 2099, Pittsburgh 30, Pa.

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CALENDAR of Coming Events

MAR. 31-APR. 2—Sixth Annual NARTB Broadcast Engineering Conference, Conrad Hilton (Stevens) Hotel, Chicago, Ill.

APRIL 15-17—AIEE South West District Meeting, Jefferson Hotel, St. Louis, Mo.

APRIL 19—IRE Cincinnati Spring Conference, Engineering Societies Bldg., Cincinnati, Ohio.

MAY 5-7—RTMA, AIEE, and IRE sponsored government—industry conference on Quality Electronic Components, Washington, D. C.

MAY 8-10—Acoustical Society of America 43rd Meeting, Hotel Statler, New York, N. Y.

MAY 10—IRE New England Radio Engineering Meeting, Copley Plaza Hotel, Boston, Mass.

MAY 12-14—IRE National Conference on Airborne Electronics, Hotel Biltmore, Dayton, Ohio.

MAY 16-17—Fourth Southwestern IRE Conference and Radio Engineering Show, Rice Hotel, Houston, Texas.

MAY 19-22—Radio Parts and Electronic Equipment Show, Conrad Hilton Hotel, Chicago.

AUGUST 27-29—IRE Western Convention, Municipal Auditorium, Long Beach, Calif.

Toroidal Coil

(*Continued from page 6*)

when changing from one size to another.

The machine weighs approximately 300 pounds and is designed for bench operation with over-all dimensions of 18" in width, 24" from front to rear, and 14" in height.

Fig. 4 shows a variety of toroidal coils which can be wound on the *Boesch* type of machine.

Another type of machine, known as the "Micafil" type, is manufactured by *Micafil Ltd.* in Zurich, Switzerland, and is marketed in the United States by the *Cosa Corporation.* This machine can wind either a sector or 360°. A geared ring goes through the toroidal core which is engaged for rotation, precluding inner diameters of less than 9/16" for the smallest size version. The smallest size machine for handling the smallest toroidal coils has the following specifications:

1. Maximum outer diameter of 3⅛", minimum outer diameter of 1¼", and minimum inner diameter of 9/16".
2. Wire sizes that can handle 23 to 34 AWG, wire being under tension.
3. Maximum shuttle speed of 200 rpm while winding.
4. Shuttle capacity of 1¾ ounces copper wire.

A third type of machine is the *Harder* development, evolved by Donald Harder of San Diego, California. The original version of this machine was known as the "NEL" winder, as it was based on initial work done at the Navy Electronics Laboratory by Mr. Harder and other employees. In this machine, a hollow split ring is manually forced open and placed through the core. Wire is then unwound from a spool into the semi-opened ring. When the hollow ring bobbin is full, or contains sufficient wire to wind one coil, it is reversed and unwound on the core, rotating by frictional contact against a motor drive. This machine can wind up to 360°, but rotating the coil to control deposit of lay is done manually by approximation. An electronic counter operates with each rotation of the split ring bobbin and has minimum tension, or virtually no tension, on the wire. This permits the use of very fine wire, such as No. 44, at high winding speeds over 1000 rpm. The minimum inner diameter of the coil is limited only by the outer diameter of the split ring bobbin. Holes with less than a ¼" diameter can be handled by use of a split ring having a thickness of less than that dimension.

Several manufacturers of toroidal coils have constructed their own winders, approximating methods described for the three types mentioned above.

Although greater progress could be made in the radio art if simpler, quicker, and cheaper means existed to wind toroidal coils, the manufacturers of existing designs are to be congratulated for their achievements to date. Present machines embody patentable inventions and more are likely to emerge as efforts are made to wind more coils in less time in a single unit of equipment handled by a single person. The machines described herein have greatly reduced the price and improved the availability of these toroidal coils so that they are rapidly encountering increased acceptance and utilization afield.

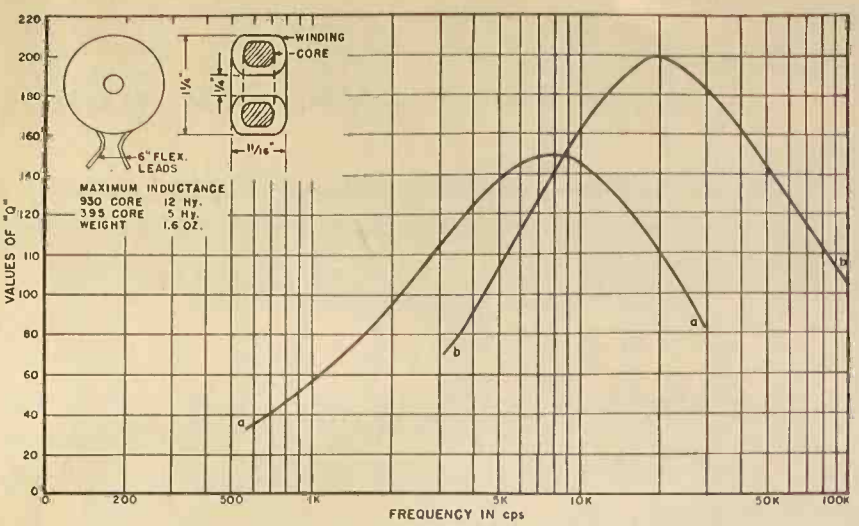
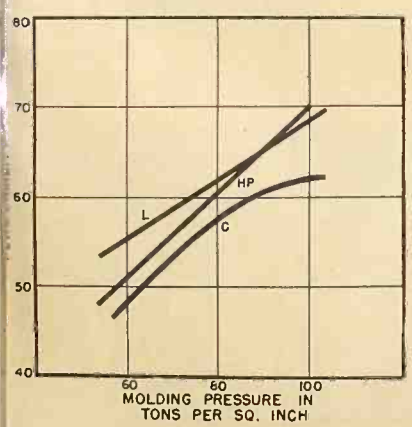


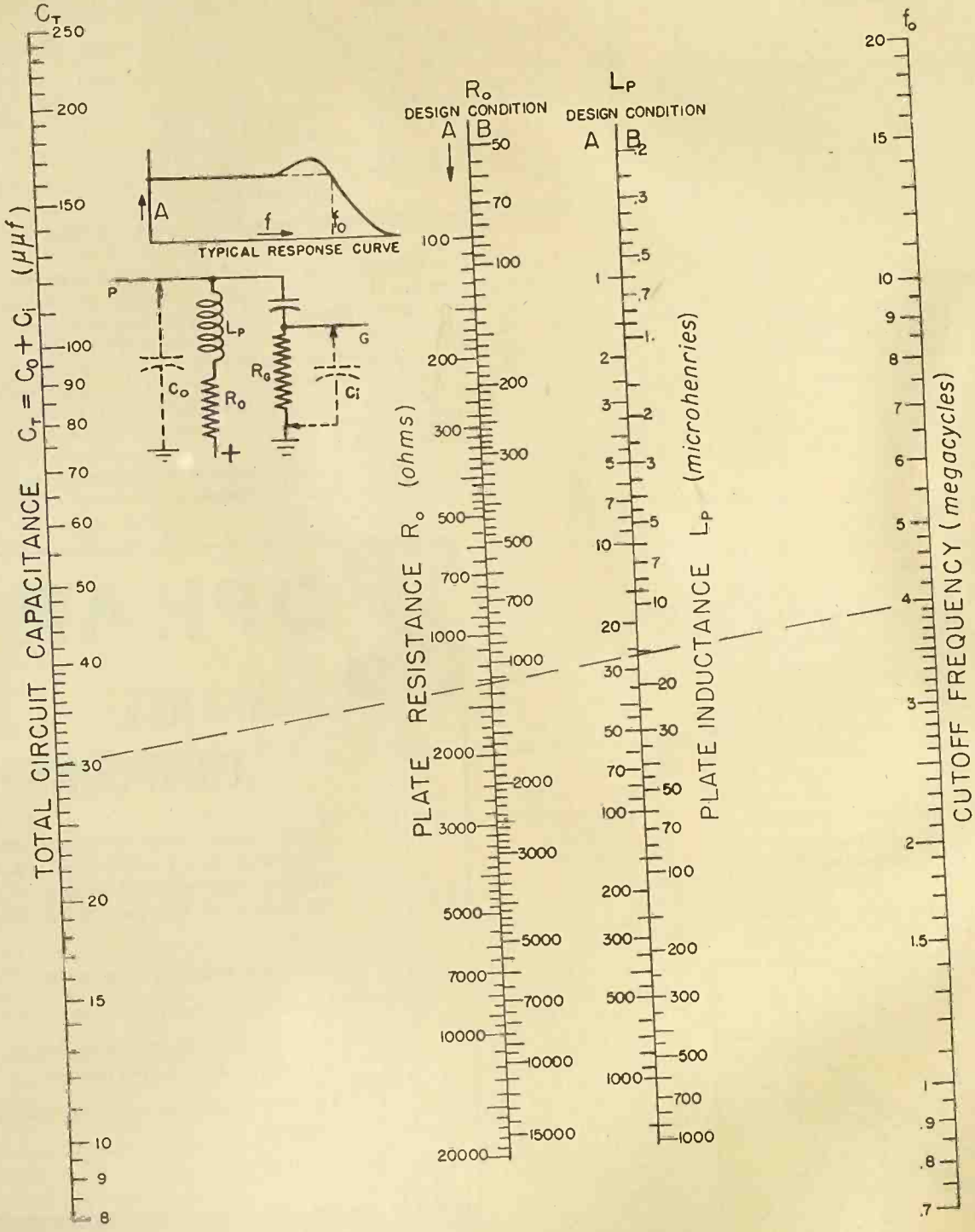
Fig. 10. Q vs. frequency for wedding ring toroid. Curve a—930 core; curve b—395 core.

Fig. 9. Permeability vs. molding pressure for carbonyl iron powders.



WIDE-BAND AMPLIFIER RANGE EXTENSION

A nomograph for determining the value of inductance to use in extending amplifier range by the shunt-peaking method.



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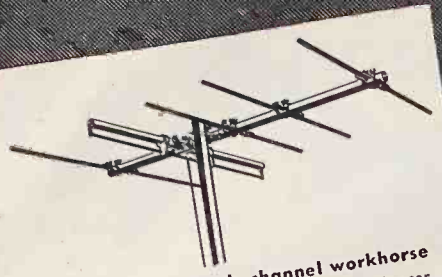

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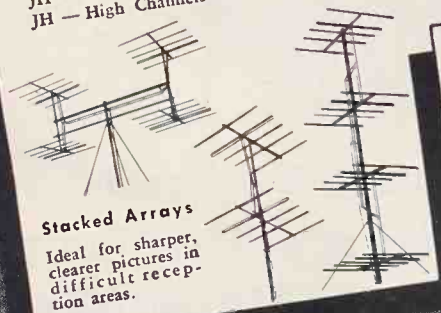

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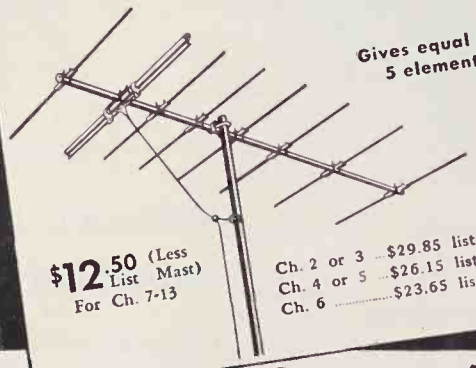

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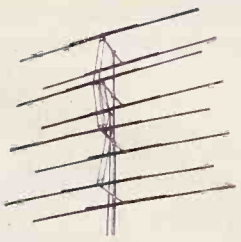

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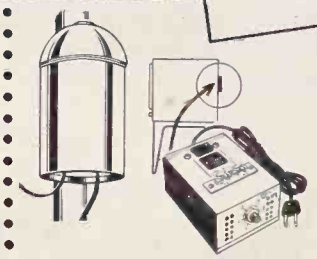

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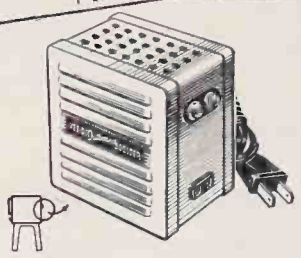

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