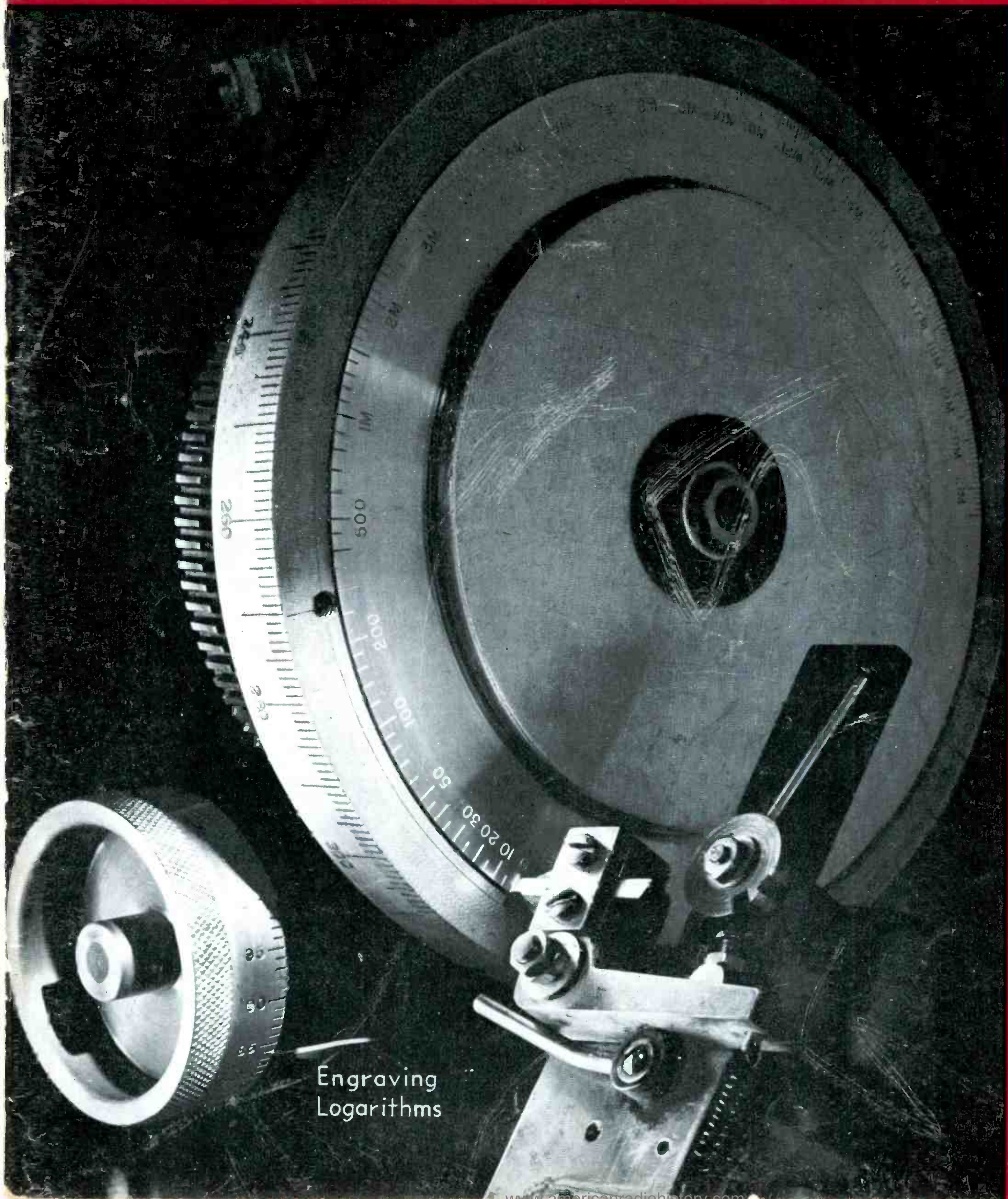
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



FEBRUARY
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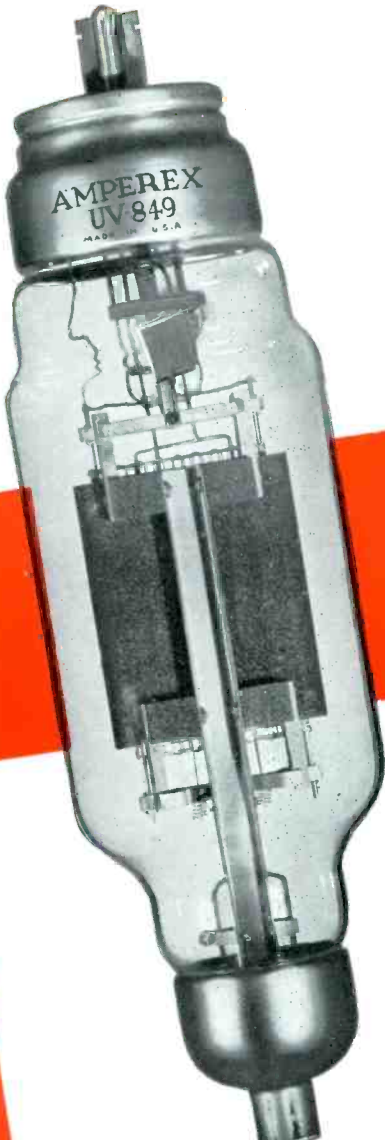

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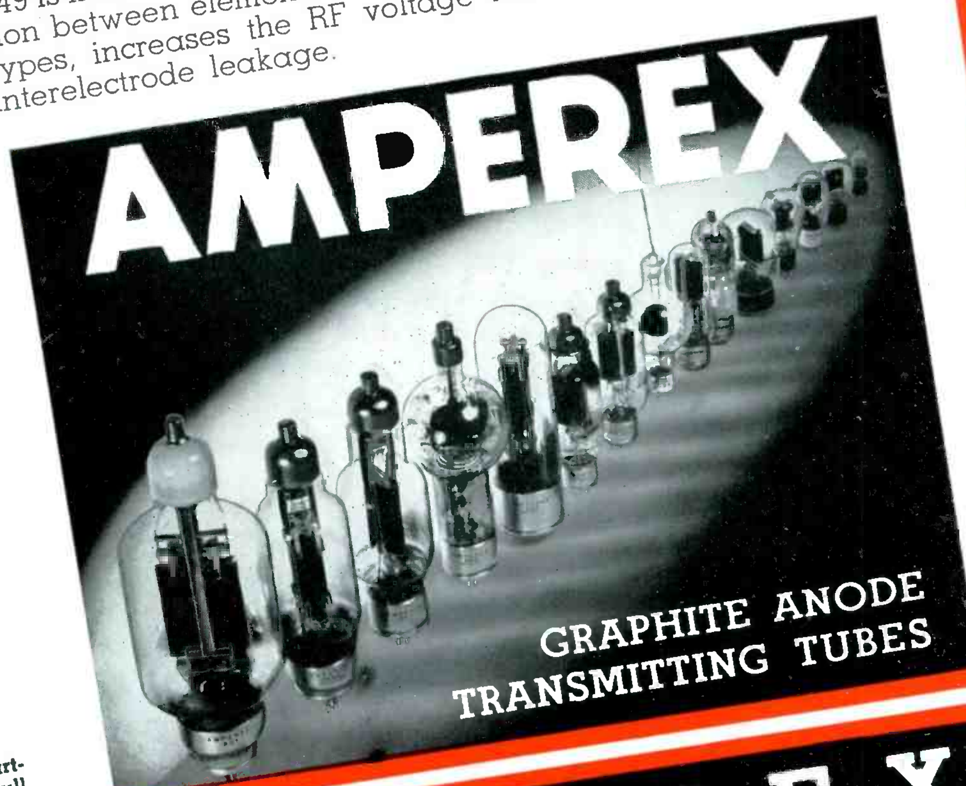

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ELECTRONICS

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Contents • February 1937

COVER: *Hand-operated precision dial engraving machine putting logarithmic scale on beat frequency oscillator dial. Photograph by Leo McGrath of Benjamin Morse, courtesy of General Radio*

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DEPARTMENTS

Volume 10 . . . Number 2

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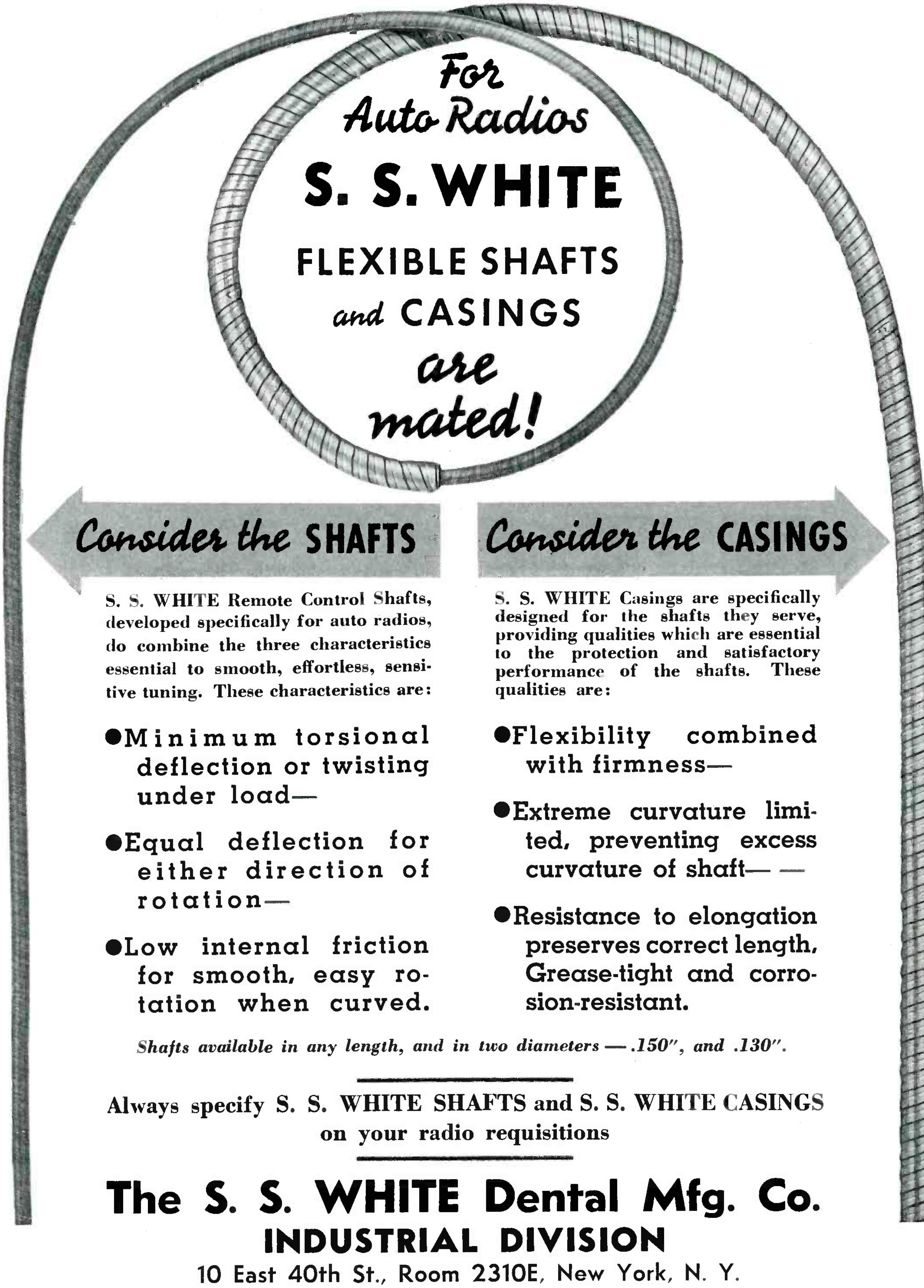
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We took plenty of time—

to do a thorough job of designing the 12H. Months were spent to develop it in the laboratory and before it was released we made sure that it had every facility that you need to do a really COMPLETE job. We are talking, of course, about the new COLLINS CONSOLE TYPE SPEECH ASSEMBLY. It doesn't cost any more but it does a lot more things — and does them better.

the 12H, alone, has these features---

★ UNIVERSAL INPUT IMPEDANCE

This feature, available only in Collins Speech Equipment, was first introduced in the well-known 12X Remote Amplifier. "Universal Input" means that any type of microphone and transcription equipment can be used interchangeably. The best conditions of impedance match are maintained without the use of external transformers or matching pads.

★ AUDITION CHANNEL

The 12H has two main amplifiers providing dual channels for program, monitoring, and audition. When the second channel is used for rehearsal it is available for instant talk-back to the audition studio. A regular program may be carried through the program channel of the 12H without interruption during auditions.

★ COMPLETE TRANSCRIPTION FACILITIES

A two-way mixer with universal input impedance connections is used in combination with a separate one stage pre-amplifier to give complete control of two turntables. No external switches, faders or mixing controls are required, and the pre-amplifier included assures adequate gain for proper use of any modern transcription equipment.

★ LOWEST NOISE LEVEL

All a-c fields which would be detrimental if present in the 12H cabinet are eliminated by use of an A.C. Isolation Unit, which is a small case built for mounting under the control desk. An interconnecting cable is furnished to simplify installation. Many other features of the design contribute to the extremely low overall noise level.

★ AUTOMATIC SPEAKER AND WARNING LIGHT CONTROL

Three speaker control relays are arranged for interconnection with microphone keys to silence studio and control room speakers when corresponding microphone circuits are in use. In addition, circuits are provided for connection of an auxiliary external relay (furnished as standard equipment) to control studio "On the Air" lights.

★ INTERCHANGEABLE UNIT CONSTRUCTION

The 12H is not an oversize receiver chassis, but is in effect a horizontal rack cabinet with individually mounted amplifier and control units. The wiring between units is formed as a separate removable cable. The many proven advantages of rack type assembly are retained.

★ COMPLETE SHOCKPROOFING

Even the best audio tubes available are slightly microphonic. The effect of table vibrations and jars due to fast operation of switch keys would seriously impair operation of a console type speech assembly which did not have the shockproof protection used in the 12H. Each amplifier is floated on special rubber mountings so designed that the weight of the amplifier components and the resiliency of the mountings completely eliminate microphonic effects.

★ FULL MONITORING FACILITIES

The second main amplifier in the 12H is also available for loudspeaker monitoring across the program line. Headphone monitoring of program line and incoming remote lines is also possible.

★ LARGE SCALE LEVEL INDICATOR

A new type extra large level indicator, with a correctly damped high speed movement is conveniently located directly above the main program gain control. Range extension from 0 to +20 db in steps of 2 db is provided.

★ FINGERTIP SWITCHING

Twelve positive key switches are arranged to give control over all circuits as completely and flexibly as if an elaborate jack and patch cord system were used. The key switches control six incoming lines, four microphones, two turntables, signal lights, main amplifier input, monitor-audition amplifier input, headphone monitor, speaker cut-off relays, and two outgoing lines.

★ HIGH LEVEL MIXING

In spite of its compact design, the 12H uses five pre-amplifiers for the individual microphone and turntable inputs. No compromise is made with the proven Collins policy of using high level mixing and switching to assure high fidelity performance at all times. Low level mixing is unavoidably at a disadvantage in respect to noise level when compared with Collins high level mixing.

COLLINS

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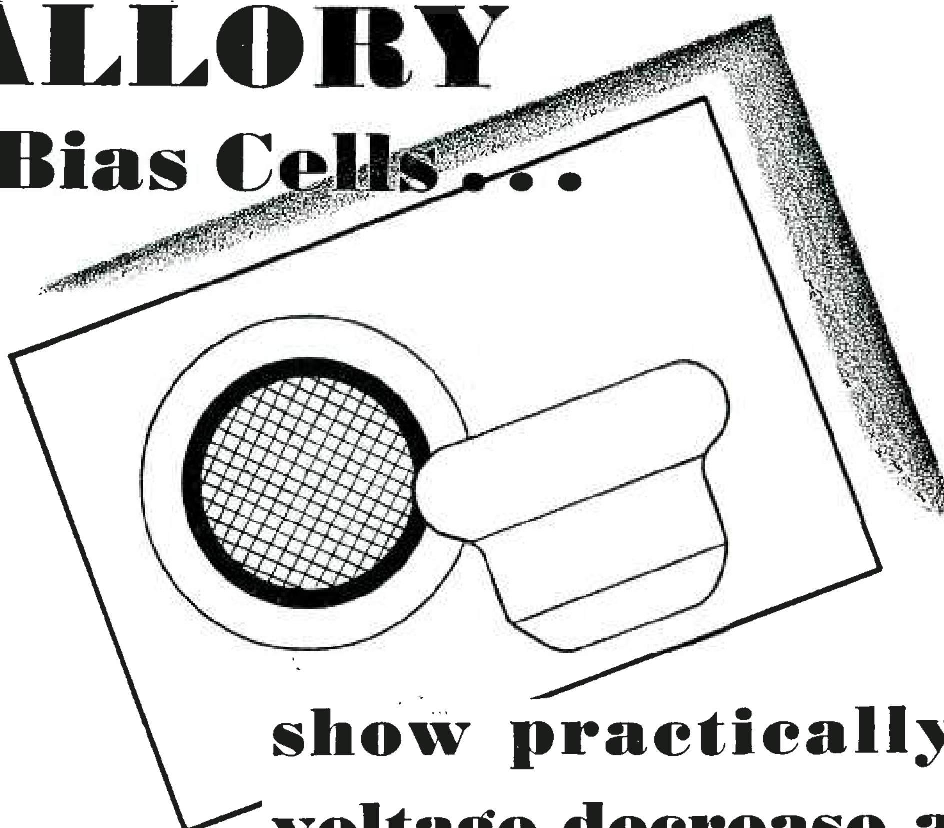
MALLORY

Grid Bias Cells . . .



show practically no voltage decrease after three years of service

MALLORY Grid Bias Cells, tested in the Mallory-Yaxley laboratories, show only the slightest decrease in voltage after continuous usage during 1934, '35 and '36. In countless home and automobile radio receivers thousands of Mallory Grid Bias Cells are establishing equally remarkable records for satisfactory service. Last year *more* Mallory Grid Bias Cells were used by *more* set manufacturers than ever before. This year the advantages of their superior characteristics, advanced design and unusual flexibility are winning an even greater recognition.

As a means of providing a constant bias voltage in which no grid currents are required or desired, this Mallory-Yaxley grid bias cell development has been everywhere regarded as an outstanding achievement. Particularly adaptable to receiver chassis layouts because of its small size, the characteristics of the Mallory Grid Bias Cell are unaffected by superimposed AC as high as 360 micro-amperes of any frequency. It is non-reactive at audio frequencies, and the DC resistance ranges between 11,000 and 50,000 ohms on standard production cells.

The Mallory Grid Bias Cell is unaffected by ambient temperatures in the range from minus 40-deg. F. to plus 120-deg. F. There is no change in its characteristics when exposed to a relative humidity of 90% at 120-deg. F. It is easily mounted. It does not develop noise effects.

The success of the Mallory Grid Bias Cell—like all Mallory-Yaxley successes—is based on the willingness and ability to adapt products to manufacturers' specific applications. Put *your* grid bias problems up to Mallory.

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YAXLEY

ELECTRONICS

FEBRUARY
1937

KEITH HENNEY
Editor

Crosstalk

▶ WHAT WE DON'T KNOW ABOUT RADIO . . . There are several questions which the FCC has asked radio engineers to answer. So far we feel that engineers have not realized the importance of this opportunity to aid the Commission, and it seems to us that the RMA and the IRE and any other bodies interested in broadcasting should get busy at once and get the answers to these questions.

Having got the answers, the industry might find itself in much better condition to ask certain equally important questions of the FCC.

First, what constitutes a favorable ratio between desired and undesired signals? Engineers do not seem to know. There is a superstition that a voltage ratio of 20 to 1 (26 db) is proper. But the answer to this question controls the allocations of stations, the questions of high power, of high fidelity transmission and reception, and the erection of new stations in the already congested broadcast band.

Station WQXR (New York's high-fidelity station on 1550 kc.) ran tests recently in which two signals were put on the same carrier. One was made stronger than the other. Seventy-three reports from listeners were received. Thirty-four of them stated that the ratio should be more than 30 db. Twenty-nine felt that 30 db was satisfactory or nearly so. Only 8 believed that 25 db difference was tolerable. Evidently only these 8 out of 73 reporters would agree with the present viewpoint that 26 db is ok.

Why cannot the industry appoint a committee or an engineer to make enough tests on enough people to determine once and for all what the desired ratio should be for music and for speech? Two phonographs with calibrated controls would do the trick.

Having determined this ratio, engineers could build selectivity into their receivers on a somewhat more scientific basis. At present the aim seems to be to provide as much selectivity as the price of the set demands on the basis that the public is more critical of interference than it is of tone fidelity.

The FCC also wants to know what constitutes a blanketing voltage. At present it considers a field of 125 to 175 millivolts to be a blanketing value. But, the question arises, what constitutes blanketing? Is it cross modulation produced because the receiver cannot tolerate more than a certain input, or is it the TRF phenomenon by which the skirts of the resonance band widen to include more spectral territory as the power of the incoming signal goes up? Cannot the IRE or the RMA, or somebody, determine the limiting voltages that can be placed on sets of vintage 1930, 1933 and 1936? Would it be unreasonable to decide now what this voltage might be in 1940 so that FCC and set engineers could work toward something definite?

Present selectivity tests prove nothing when it comes to high-fidelity transmission. Two 400 cycle notes are sent into a receiver via two r-f carriers. The carriers are varied in strength until the 400 cycle outputs differ by 30 db. This is the danger point so far as input is concerned. But in high fidelity transmission we are concerned, not with 400 cycles, but with 10,000 cycle modulation. The former frequency is not far from the carrier of the undesired station; 10 kc. modulation however, sticks out into the next fellow's channel. Cannot an RMA-IRE committee do some work on this problem?

Another question involving power and station locations is that of noise level in various types of communities, and of desired signal to noise ratios. This question, if answered, would define exactly service areas.

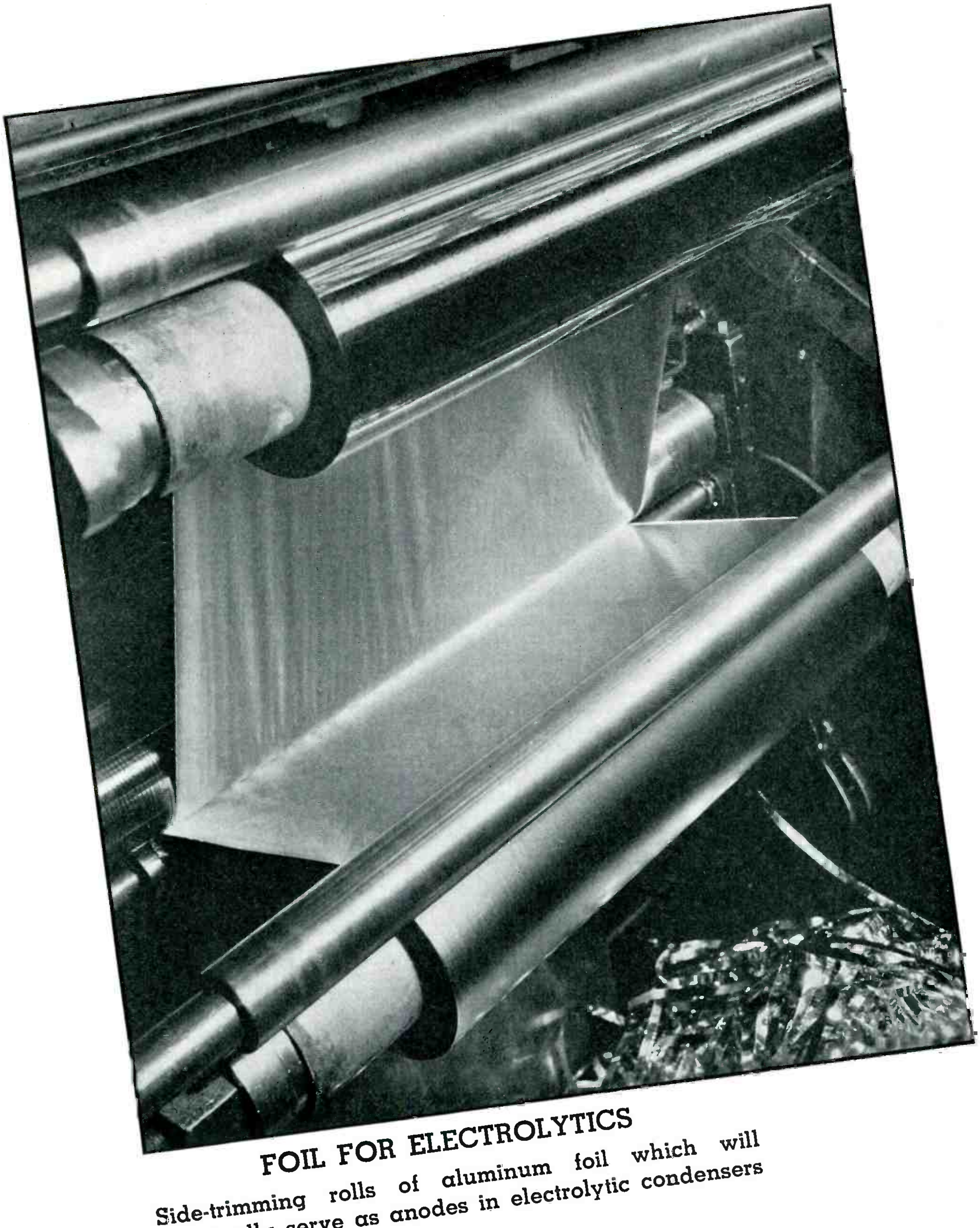
At present FCC seems more interested in inter-station interference than it does to interference produced by non-radio noises. By some provincialism of thought, there seems to be a belief that high-fidelity and high-power transmission are mutually exclusive. There ought to be an engineering manner of settling this uncertainty.

Certain cases have been reported of interference set up by non-linear conductors in the vicinity of a listener near a high power station. Our proposed engineering committee might do some work on this line to determine if 500 kw. is going to be more bother than it is worth—or if simple means can be found of preventing trouble of this nature before it occurs.

Thus it seems that an industry engineering committee might provide the answers to several knotty, but engineering, problems. It might even plan ahead and furnish, say a 5-year program for broadcasting advancement toward which FCC and radio receiver and broadcast engineers could work.

▶ IDEA? . . . Is there anything to the idea that electric power transmission lines, which stretch all over this country, could carry r-f which would radiate over a mile or so, and which could be used by an aviator to determine his location when off his beacon course? This radiation could carry distinctive modulation according to the territory, and could be turned on by remote control during bad weather.

▶ WHITE LINE . . . In a demonstration of the efficacy of light-sensitive devices for protection of machinery or workers, a certain piece of equipment was placed within a square of white paint. Anyone crossing the white line caused an alarm to ring, and power to be turned off the equipment. It was done with invisible beams of light (infra red).

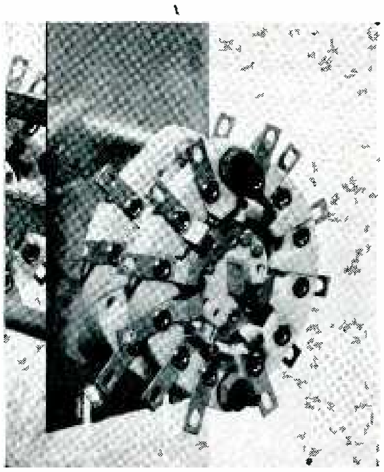


FOIL FOR ELECTROLYTICS

Side-trimming rolls of aluminum foil which will eventually serve as anodes in electrolytic condensers

Ceramics as Insulators

The use of inorganic insulation is growing rapidly in the electronics field, especially in high frequency service. Herewith is an up-to-date review of the available ceramic insulation materials, their properties and uses in radio and allied fields



Ceramics are finding increasing use in radio set components. Above is a band-change switch which shows the intimate association between metal parts and ceramic body.

IN the rapidly growing field of specialized insulation for use in electronic circuits there are two important divisions, the plastics and the ceramics. Each type of material has its special field of usefulness, depending upon the electrical and mechanical nature of the application and upon the cost factors involved. The plastics are flexible, inexpensive at least in ordinary grades, and have good electrical properties in the middle range of radio frequencies.[1] The ceramics are mechanically rigid; they are somewhat more expensive per pound, especially in fabricated form. The newer forms have outstanding electrical properties, especially at the higher radio frequencies. The ceramics are comparative newcomers to the field of electronic circuits, with the exception of electrical porcelain, which is one of the oldest insulators, long in use in radio. The newer ceramics are highly specialized products developed to have low losses, especially at high frequencies, and to have the mechanical properties desirable in any insulation.

The word "ceramic," in the minds of most laymen, means a clay-product which has been specially heat-treated or "fired". But according to present ideas, this definition is too restricted. Ceramics, in the eyes of the trade, are inorganic compounds which can be "fired" to form a vitreous product, whether it be a clay-product or not. Ceramics, in this wider sense, are usually materials having a silica base of some sort, although other materials, such as alumina and magnesia, which contain no silicon, are also "ceramic materials". This broad classification includes the following materials in the radio field: electrical porcelain, magnesium silicate (steatite or "talc") porcelain, glass, glass-bound mica, fused quartz, magnesia, and alumina. Of them all, the only product containing clay is electrical porcelain.

Ceramics used in radio vary in form from a huge porcelain antenna-base insulator capable of supporting the full load of a 150-ton vertical tower (including the tension of the supporting guy wires) to a tiny magnesia tube 1/32nd of an inch across, used to insulate the heater wire in a radio tube. Stand-off insulators, tube bases and sockets, guy and wire-suspension insulators, lead-in insulators, switch parts, bushing inserts, condenser insulation, spreader insulators, coil-forms, straight and flexible shaft-coupling insulators, vacuum-tube element insulators, heater-wire coatings, water-coils for the cooling system of high-power transmitters—these are but a few of the applications of ceramic materials in radio and electronic work.

Electrical Characteristics—Loss Factor

Insulators in radio work are often subjected to radio frequency fields of considerable strength. Under such conditions a current will flow in the insulator, especially if it forms a dielectric between two conductors, and the current flow will be directly proportional to the dielectric constant of the insulating material. The current flow, acting through the effective "resistance" of the insulator, gives rise to a power loss, which can be expressed in terms of the power factor of the material (the ratio of the power lost to the volt-amperes applied). The product of the dielectric constant and the power factor gives, therefore, a figure-of-merit, called the *loss-factor*. All other factors being equal, the material with the lowest loss factor will heat up the least in a given r-f field, will display the highest efficiency, and be least subject to changes due to thermal effects. However, in comparing insulators, all other factors are usually not equal, so the loss-factor is only a part of the picture. But it is generally conceded to be a valuable index of the electrical properties of the material. Other electrical characteristics of importance are the volume resistivity, surface leakage resistivity, and dielectric strength, the latter being measured in terms of the voltage necessary to puncture a definite thickness of the material. Nearly all these electrical characteristics change rapidly as the frequency of applied r-f field increases, and therefore the frequency must be specified.

Mechanical Properties

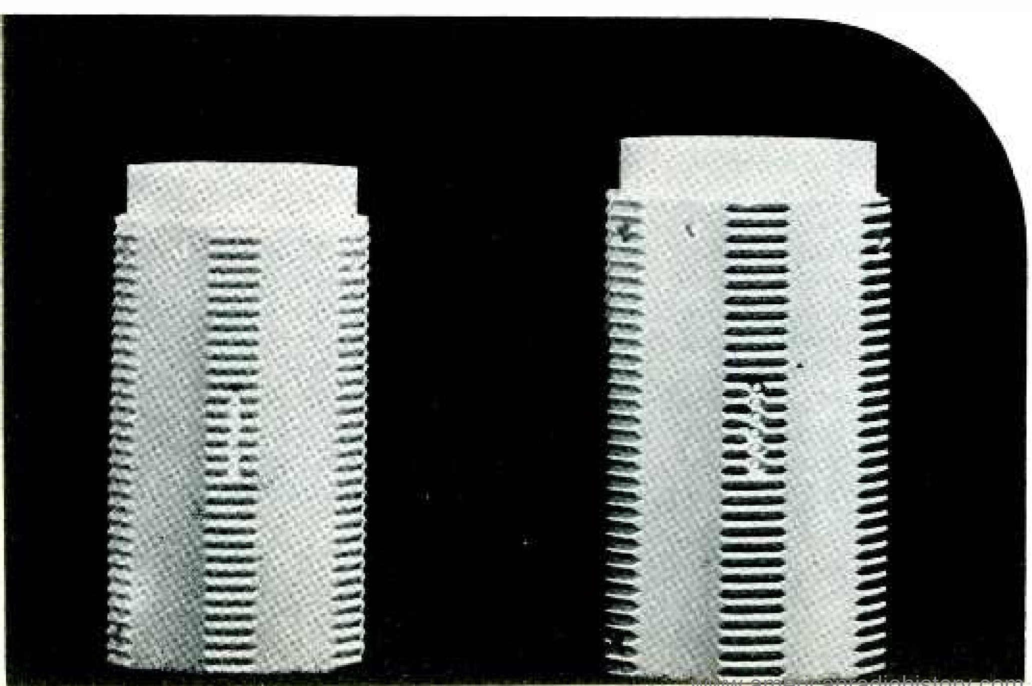
The strength of a material (tensile, compressive, cantilever, and transverse) is important not only from a purely mechanical point of view but also from the electrical point of view. The overall electrical characteristics of a given insulator depend its size, since the total resistance and total loss depend on the volume and surface area of the piece. But the size of an insulator is determined almost always by mechanical requirements, in particular the mechanical strength and rigidity offered by the material itself. It often happens, therefore, that a material of comparatively poor electrical properties will produce a good insulator because its mechanical properties make possible a small volume and long length, both of which improve its overall electrical properties. It is evident, therefore, that choosing the proper insulator for a given application is a complicated business, especially when cost is an important factor, and that no general rule can be given for choosing between insulator materials. However, the standard data on each material is the basis of any comparison, and it is worth-while therefore to collect as much information as possible on the mechanical and electrical properties of the available materials.

Mechanically, ceramics divide themselves into two main divisions: Those which are fabricated into parts before firing into vitreous form, and those which are fabricated after the material is vitrified. This distinction has an important bearing on the accuracy with which insulators can be made to meet mechanical specifications of length and volume. In the pre-fabricated form (porcelain and steatite porcelain, alumina and magnesia), allowance must be made for considerable shrinkage (as much as one-third the total volume of the piece, corresponding roughly to one-eighth in linear dimension) which occurs during the firing process. This reduction in size is clearly shown in one of the accompanying illustrations. Considerable ingenuity has been shown by the manufacturers in estimating the degree of shrinkage to a very fine degree. It is possible to manufacture ceramic insulators to within one one-thousandth of an inch in several inches of length. Pieces fabricated before firing may also be ground to exact size after firing, provided the ground surface is flat or of simple configuration. Tapped holes and similar items cannot be ground after firing (except at great expense) and must be "shrunk-to-size" by proper design and accurate firing. The type of material which is fabricated after firing (the glass-bound mica materials are the important members of this group) are worked in much the same manner as metal (although they are much harder on tools) and can be ground, drilled and tapped, to exact size.

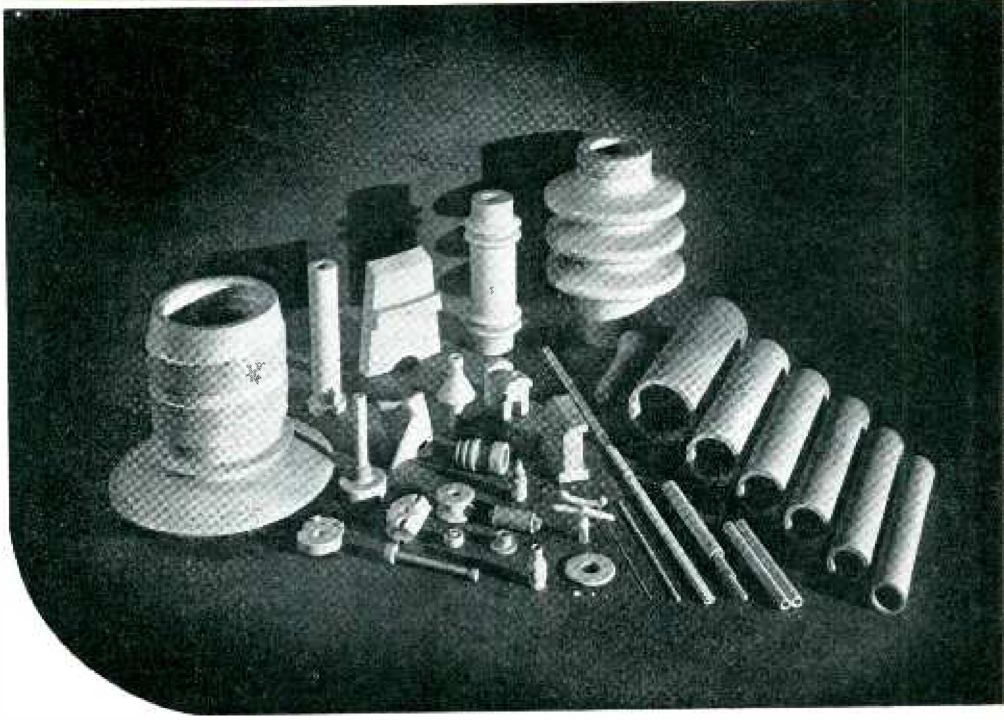
The thermal action of nearly all the ceramics is highly satisfactory. Pyrex glass melts, but only at a high temperature. The porcelains begin to lose their resistance at about 1000° C., but for the general run of operating temperatures the heat-problem is not serious. For very high temperature service, as in insulating heater wires and other tube parts, magnesia or alumina are used. Much progress has also been made in removing occluded gasses from ceramics so that they may be used in tubes without contributing to their gas content.

Electrical (clay-bearing) porcelains

Electrical porcelain (that manufactured under the vacuum process) is used widely in 60-cycle service throughout the electrical industry, including power supply applications in radio. For high frequency service the material must be produced with great care to produce low loss-

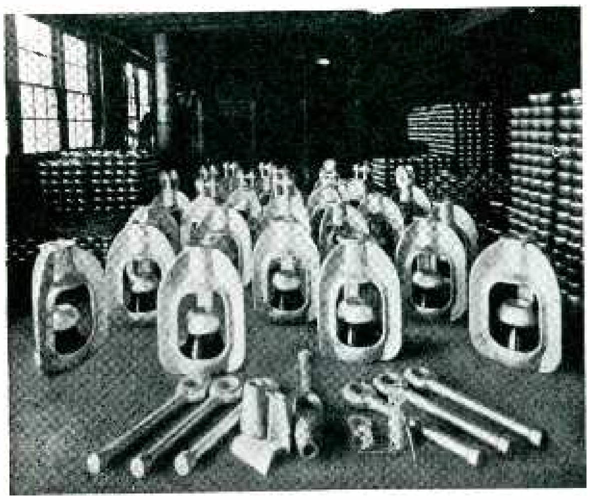


A typical Isolantite coil form, after (left) and before firing. The readily apparent shrinkage must be carefully accounted for in ceramic design



Right, Sillimanite forms, a high grade of porcelain used for chemical as well as electrical applications

Below, porcelain is used under compression for strain-type insulators used in antenna guy-stays



factor. Its applications in radio are principally in large strain-type insulators for tower supports and guy insulation, and in water-cooling coils for dissipating heat in high voltage r-f amplifiers. A typical material used has an average tensile strength of 6000 lbs. per square inch, but this figure varies with the nature of the piece. Over the frequency range from 100 kc. to 1500 kc. the power factor is 0.85 per cent. and the dielectric constant 6.2, giving a loss-factor of 5.27. The volume resistivity is very high, above 10^{14} ohms per cm. cube. The surface resistivity depends on the surface itself, whether glazed or unglazed. In outdoor applications the glaze surface is highly desirable since it is as nearly self-cleaning as any surface available. In applications where the relatively high loss factor can be tolerated, the material is highly satisfactory as a general purpose insulator, particularly for outdoor and large scale applications.

The Sillimanite porcelains are another high grade type used to some extent in radio applications. They have a very high resistance to chemical corrosion, a tensile strength of from 10,000 to 12,000 pounds per square inch, and specific gravity of 2.77. The dielectric constant varies from 5.76 at 60 cycles to 6.4 in the range 853 to 890 kc. The loss factor is about the same as the other clay-body porcelains. This particular ceramic is widely used in ignition spark-plugs.

Aluminum - magnesium - silicate (steatite) porcelains

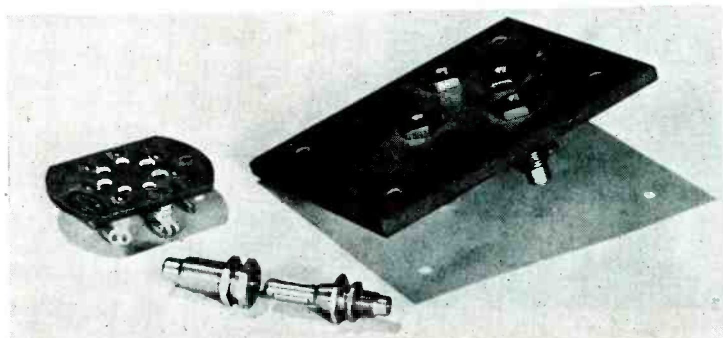
Some 25 or 30 years ago it was found that the inclusion of a percentage of talc (magnesium-silicate in natural forms) in porcelains greatly improved their hardness and strength. Increasing percentages of this material were used until by 1926 methods had been developed for using this material alone as the body of the porcelain. The "mineral" magnesium silicate exists in nature as soapstone, or "steatite", and is the same base from which talc cosmetics are made. The steatite "porcelains" made from this material (under the names Alsimag, Isolantite, Krolite, Lava and Steatite), have unusual mechanical and electrical properties. In the range of frequencies from 1 to 3100 kc. their dielectric constant ranges from 6.0 to 6.4, their power factor from 0.2 to 0.4 per cent, and the loss factor from 1.2 to 2.5, depending on the voltage and temperature. The dielectric strength is in the neighborhood of 200 volts per mil. for a piece $\frac{1}{4}$ inch thick. The volume resistivity is about $2.0\ (10)^{14}$ ohms per cm. cube. A tensile strength of about 6000 pounds per square inch is attained in small sections. The specific gravity is about 2.5. Its thermal coefficient of expansion is about $6(10)^{-6}$ to $7(10)^{-6}$ per degree Centigrade.

The material is fabricated into parts by extrusion or by molding, the former process usually forming a somewhat stronger and more uniform product. After forming the material is machined, using hard tool-steel or carborundum for shaping, drilling, tapping, etc. The pieces are then fired to a final temperature of about 2500° F. The "firing" range (temperatures in the firing process) is extremely narrow, necessitating a high degree of temperature control. Glazing is done where a self-cleaning surface is necessary, but otherwise glazing does not improve the properties of the insulator. Surface treatment using waxes or polystyrol plastics is sometimes used to reduce the tendency of the ceramic to hold dirt. The steatite group of ceramics is a highly popular material for general high-frequency insulation, and is widely used.

Glass-bound mica

Glass is not a very important insulator in itself in radio (although its loss factor is good, in the neighborhood of 3.5) because it is highly fragile and difficult to work. But combinations of glass and finely divided mica, originally developed in England, have become of considerable importance in the radio field. These materials go under the general name of Mycalex, although there are at least two different forms manufactured by different concerns. Mica and glass are both limited in physical strength but when finely ground, mixed, and pressed under heat and high pressure (about 2½ tons per square inch at 750° C.) they produce a very dense, gray-colored material which has considerably greater strength than either of the constituents. One form of Mycalex uses lead borate as a binding agent; another (the so-called "lead-less" variety) uses potassium iodide, which acts as a catalytic agent during the formation process. Mica itself contains silica, alumina, and potash; glass is a combination of various silicates. The material is commonly pressed into rods or sheets, but may be molded to include metal inserts. Its specific gravity is 2.45 for the lead-less variety, and 3.42 for the lead-borate type. The lead-type has a dielectric strength of about 9.0, and a power-factor of about .55 to .60 per cent., giving loss-factors of roughly 5.0. The lead-less variety has a considerably lower loss, according to the claims of the manufacturer. Tests made by the National Physical Laboratory in England on the lead-less variety give values of dielectric constant of 6.1, power factor of 0.2 per cent. and loss-factor of 1.2. This loss factor compares favorably with the best steatite porcelains.

The Mycalex ceramics can be machined readily after the material itself is formed by conventional shaping drilling, and tapping machinery. Extremely hard tool steels are necessary, however, due to the nature of the material. The tensile strength is about 6000 to 7000 pounds per square inch. It begins to yield plastically at about 450° C.



Mycalex (lead-less variety) machined into tube and coil-socket forms

Other types: Fused quartz, alumina, magnesia

Of all the materials known for insulation, fused quartz has long been known as the best from a purely electrical point of view. However, it is very costly and the sources of supply are few and far between. For precision radio instruments, where cost is of no importance, quartz is occasionally used.

The power factor of pure transparent fused quartz is 0.02 per cent., nearly as low as that of dry air itself. Its dielectric constant, about 4.0, is likewise low as ceramics go, resulting in a loss-factor of 0.09, better than the next best material by about 10-to-1. Opaque quartz has a loss factor about twice or three times as great. The quartz itself is silica (SiO_2) fused at 1750° C. It is strong mechanically, resistant to thermal shock, and has the lowest thermal expansion of any solid material known. Unfortunately its great cost has prevented wide use.

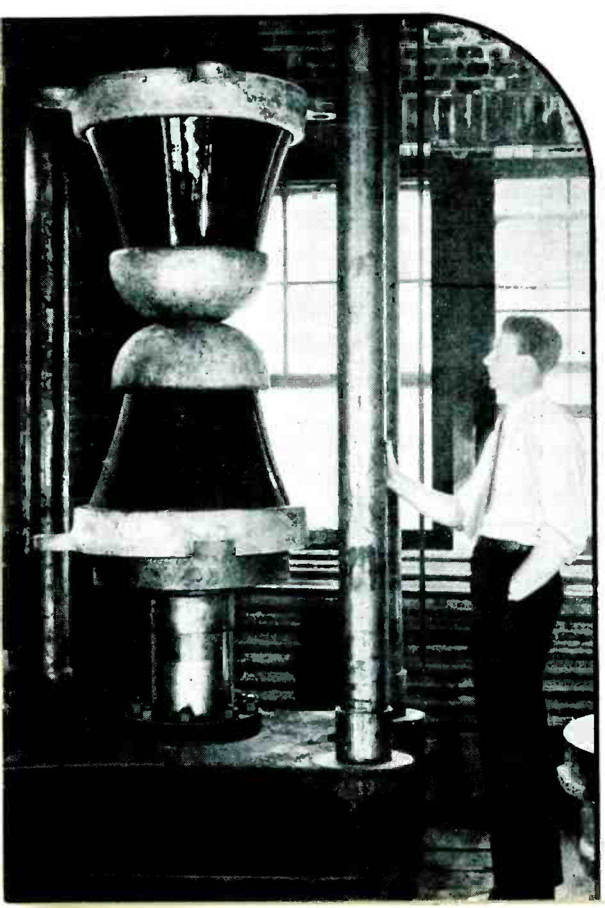
Extruded forms of alumina and magnesia are manufactured for use in high temperature service. Such forms are now widely used as insulation for the heater wires of radio tubes, but current practice is tending toward the application of the material directly to the wire in semi-liquid form and firing it in continuous-flow furnaces. The coating thus formed on the wire is strong and adheres well. Magnesium oxide and aluminum oxide both have very high melting points and retain their properties at temperatures as high as 2000° C.

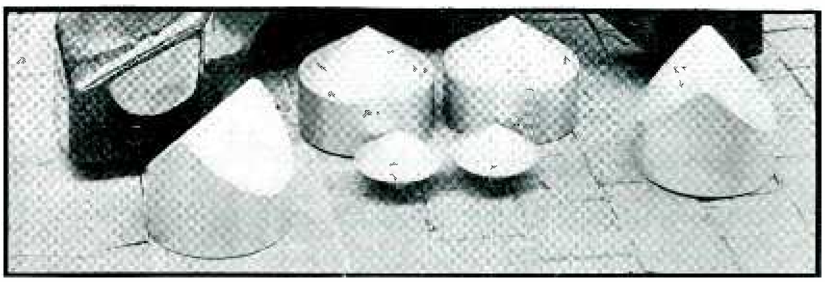
Extruded magnesia forms can be made in the most delicate shapes imaginable. A typical form is a cylinder about 1/16 inch in diameter and pierced with six individual holes running the length of the cylinder. The mechanical strength of the material is not great, however, unless specially processed with heat-resistant binders.

Editor's note: The editors are indebted to the following manufacturers of ceramic products for information supplied in the preparation of this article: American Lava Corporation, Champion Spark Plug Corporation, Henry L. Crowley, Inc., Dielectric Products Corporation, Electronic Mechanics, Inc., General Ceramics Company, General Electric Company, Isolantite Incorporated, Lapp Insulator Company, Mycalex Corporation of America, Stupakoff Laboratories, The Thermal Syndicate, Ltd.

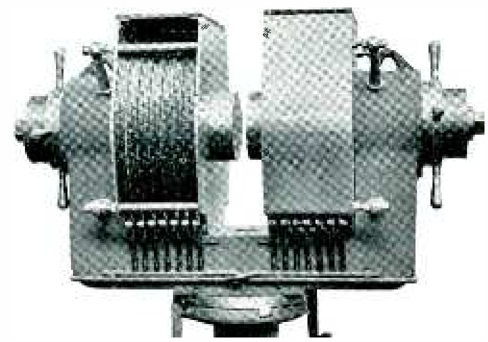
[1] Special plastics (polystyrol types) have good electrical properties at high frequencies as reference to *Electronics*, p. 10, March 1936, will show.

This massive tower-base insulator, consisting mainly of porcelain, is being tested at the Lapp laboratories under a pressure of 1,500,000 pounds





Interchangeable pole pieces, often of alloy, 25 per cent cobalt, 75 per cent iron



Magnets and Magnetic Materials

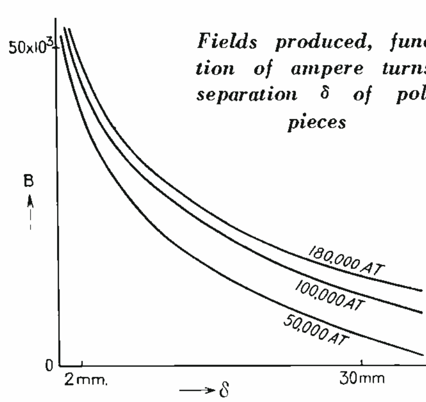
By DR. A. STÄGER
Physicist, Zurich, Switzerland

Magnet producing 50,000 gauss

THE metals iron, nickel and cobalt, pieces of which are strongly attracted by steel magnets, are called ferromagnetic. Other substances, among them manganese, chromium, palladium, platinum and aluminum, are attracted less strongly, but distinctly. All of these elements form the group of paramagnetic substances. Ferromagnetism is only a form of paramagnetism.

There are other materials, the magnetic properties of which are quite different. For instance, small pieces of bismuth, antimony, zinc, lead, silver, copper, gold, sulphur, quartz crystal, and most salts (if free from iron) are more or less repulsed by magnetic poles. Such substances form the diamagnetic group.

In strong fields some liquids and gases show a paramagnetic and others a diamagnetic behaviour. A soap-bubble filled with oxygen will be deformed when brought between the poles of a strong magnet proving that oxygen is paramagnetic compared with atmospheric air. The flame of a burning tallow candle shows a diamagnetic behaviour.



Fields produced, function of ampere turns, separation δ of pole pieces

A quite different sort of physical experiment necessitates strong magnetic fields, namely, the research of corpuscular radiations. The Wilson cloud-chamber, in which the tracks of single corpuscles can be made visible, has been developed in recent time to a high peak of technical perfection. It is the most important instrument for making visible atomic disintegration processes and for detecting the small particles ejected by the bursting nucleus. When applying a strong magnetic field the tracks are bent and form curves, the analysis of which gives valuable information as to the velocity of the particles and their electrical charge. In this way Anderson discovered the positron for which he was awarded the Nobel prize in physics, 1936.

P. L. Kapitza, of Oxford, has conducted strong currents from a battery through a coil to get an intensity of field of 500,000 gauss. T. F. Wall discharged high voltage condensers to get an intensity of 1,400,000 gauss.

Although these methods are suitable for producing extremely high intensities of field, the duration of the field is only a fraction of a second. To produce a constant magnetic field, P. Weiss (Strassburg, France) constructed a strong magnet in co-operation with the Maschinenfabrik Oerlikon. This apparatus has recently been further developed. The essential point in the new construction is the conic form of the iron core within the coils. When using such conic cores the magnetic saturation remains in moderate limits and only the points of the poles are over-saturated.

Above is shown the normal type of the latest Oerlikon magnet. The distance between the poles can be adjusted by turning the wheels with handles. The coils consist of copper tubes through which water flows.

The current consumption is 8 to 10 kw. With a water pressure of 3 to 4 atm., 7 to 10 litres per minute are consumed. The water flowing out of the magnet is only 15 to 20° C. warmer than when flowing in. Therefore it would be possible to overcharge the magnet, but the strength of field would not increase proportionately to the amperes.

If the soft iron points of the pole pieces used (see above) are exchanged for others made of ferrocobalt the intensity of field increases 8 to 10 per cent, thus exceeding 50,000 gauss.

The cores are bored through in axial direction. Through these cylindrical holes, for instance, light rays can be passed in order to study the magnetic influence exercised on them.

The Strobotron

A new cold-cathode gas-filled control tube capable of carrying large peak currents. The tube is ready for instant operation without time delay for cathode heating

By K. J. GERMESHAUSEN and H. E. EDGERTON

*Massachusetts Institute of Technology
Cambridge, Massachusetts*

IN THIS paper a tube, named the Strobotron, is described which has been developed primarily for producing stroboscopic light. Its unique characteristic is a cold cathode which under certain conditions is capable of carrying very large peak currents with a low tube drop, and with a life sufficient for its uses.

The Strobotron has applications other than that of a stroboscope, such as its use as a relay, or trigger tube, for various purposes. Its particular value in such cases is the lack of power and time delay required for cathode heating, and the effectiveness with which the tube operates.

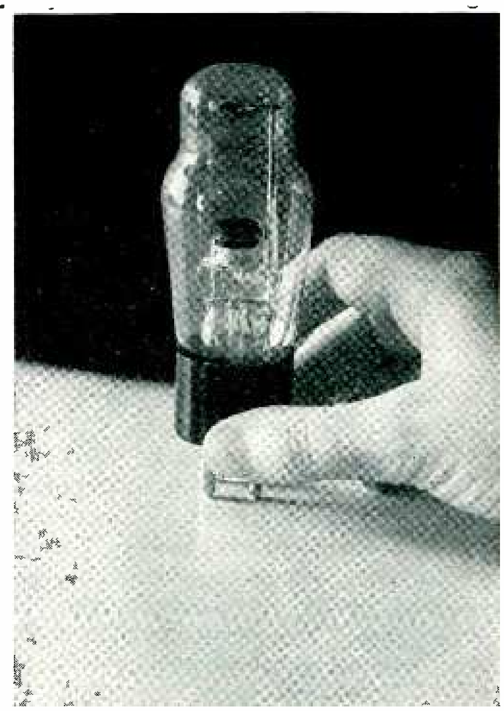
Circuits for the proper use of the Strobotron are quite unusual, since they are designed to put very large peak currents through the tube to start the arc discharge.

The Strobotron Tube

Figure 1 is a photograph and diagram of the Strobotron No. 631-P1 as used in the "Strobotac," an adjustable-frequency stroboscope manufactured by the General Radio Company. This particular instrument has been designed to be used as a tachometer and has a dial reading directly in speed with a fundamental range of 600-14,500 r.p.m.

The Strobotron is shown with two grids, although this is not necessary in the usual circuit application. Both grids are needed in the Strobotac because of the peculiar output waveform of the oscillator that is used. The grids may be tied together and used as a common element, or the inner grid may be connected to the cathode through a resistor.

The cathode consists of a caesium compound which breaks down under the action of the cathode spot and liberates free caesium. Caesium was chosen because of the ease with which it permits spot formation, and to facilitate further the formation of the cathode spot the surface of the cathode is made rough and irregular. Surrounding the cathode is a ceramic insulator which concentrates the discharge on the active portion of the cathode, and also serves as a support for the inner grid. During the treatment of the tube some caesium metal is sputtered on the inner grid, located just above the cathode, and this materially reduces the breakdown voltage between it and other elements of the tube. This is an advantage, since it makes the tube



easier to start; that is, it requires a lower starting voltage on this grid to initiate the main discharge. The inner grid may also be treated in other ways to reduce the breakdown voltage and thus assist in starting the tube. The outer grid in the tube shown is of graphite, and it effectively shields the cathode and inner grid from the anode. Graphite has been used, since the breakdown voltage between it and the anode is not seriously reduced by condensed or

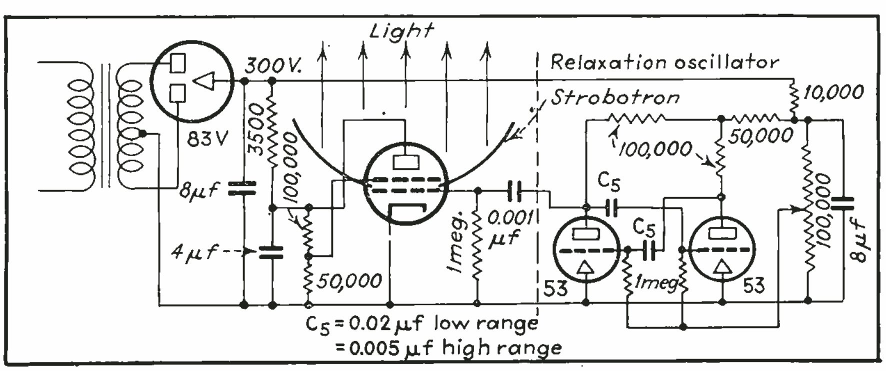


Fig. 2 *Wiring diagram of an adjustable-frequency stroboscope using a Strobotron tube as employed in General Radio "Strobotac"*

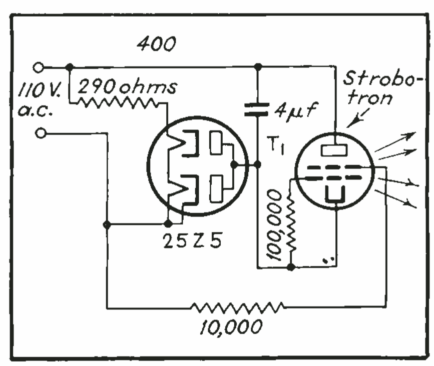


Fig. 3 *Diagram of a 60-cycle stroboscope used at M.I.T.*

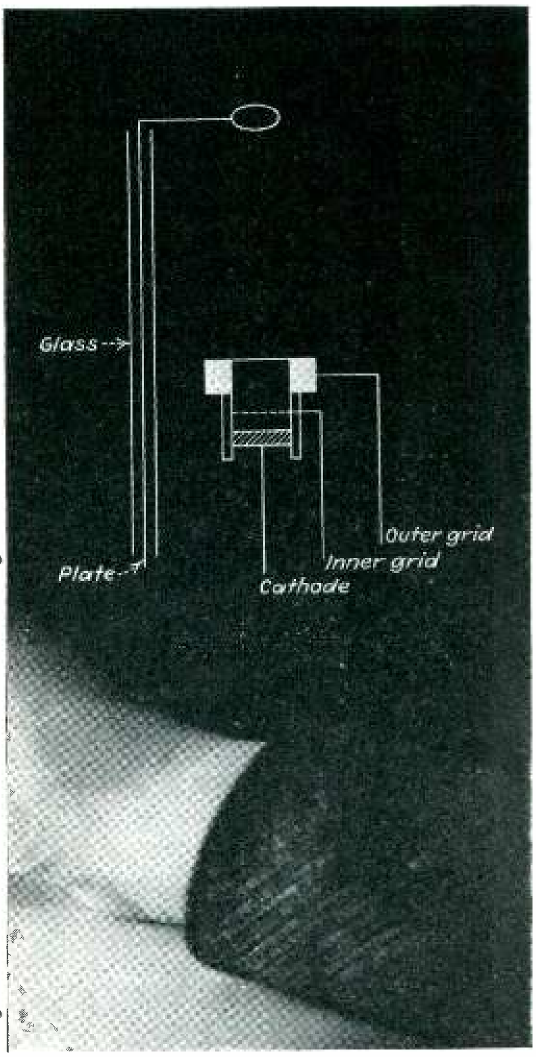


Fig. 1 *Photograph and drawing of Strobotron showing arrangement of the elements*

sputtered caesium from the cathode during the life of the tube.

Above the grid-cathode structure is located the plate upon a vertical glass-insulated support. The discharge of a condenser through the tube produces a luminous column of light about three-eighths of an inch in diameter from anode to cathode.

Neon gas at a pressure of 1.5 cm. is used in the tube illustrated. Argon gas has also been used, and operates very satisfactorily, but does not produce as much visual effect as neon.

A companion paper, with Professor W. B. Nottingham and Mr. A. B. White as co-authors, is to follow, which describes in detail the electrical characteristics of the Strobotron. In particular the conditions for starting are discussed, from the standpoint of applied voltage and required grid current, for different circuit conditions. A brief discussion of the characteristics of the Strobotron and a few circuit applications have been given in a paper by the present authors.[1]

As mentioned before, the Strobotron is useful as a source of stroboscopic light. The essential diagram of the circuit in the General Radio Company's "Strobotac" is shown in Fig. 2. A flash of light is produced from the Strobotron each time that the 4 μf condenser is discharged through the Strobotron. Control of the flashing rate is effected by impulses from the relaxation oscillator[2] whose circuit is shown at the right of the diagram. A negative potential is suddenly impressed on the inner grid when the left tube in the oscillator begins to conduct current in the course of the oscillation cycle. The potential difference between the inner grid and the outer grid at this moment exceeds the starting potential, and the Strobotron flashes. The frequency of oscillation is controlled by the potentiometer instead of the usual method of varying grid R or C_5 with the grid resistors connected to the cathode. Changes of scale are effected by changing the circuit constants in the grid circuits of the oscillator. (With C_5 as 0.02 μf the range of frequency is approximately 10-60 cycles per second; with C_5 as 0.005 μf, 40-240 cycles.)

A simple stroboscope that produces one flash per cycle of the supply voltage is conveniently arranged according to Figure 3. During the half-cycle that the rectifier charges the condenser the grid-bias voltages on the Strobotron are such as to prevent starting. On the other half of the cycle, however, the inverse voltage across the rectifier is applied to the outer grid and reaches the critical starting potential at a given part of the a-c voltage wave. Several small stroboscopes of this type are in use in the Electrical Machinery Laboratories at the Massachusetts Institute of Technology for measuring the slip of induction motors and the power angle of synchronous motors.

A counting circuit that has proved useful for recording the pulses from Geiger-Muller tubes is shown as Fig. 4. The counter, Western Electric message-register type No. 5T, is actuated when the condenser is charged from the

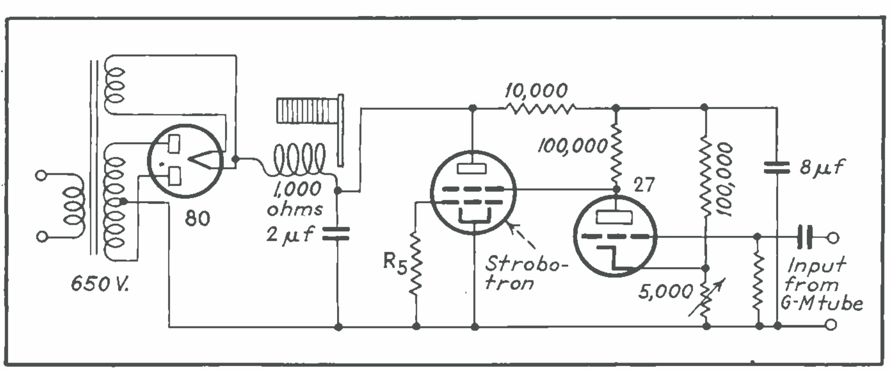


Fig. 4 *Circuit diagram for a circuit to operate a message counter register for recording cosmic rays by a Geiger-Muller tube*

Completely assembled 60-cycle stroboscope in use at M.I.T.

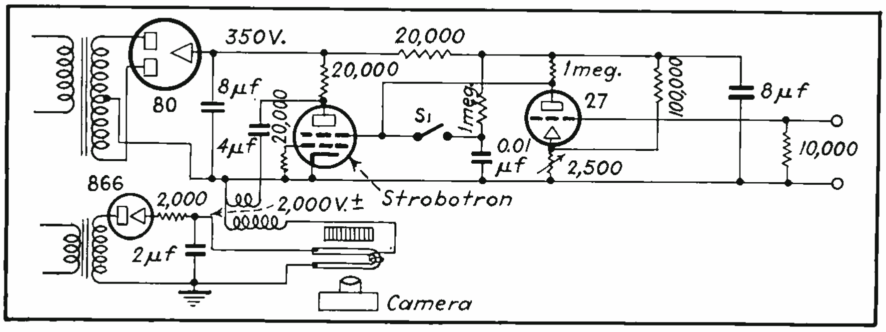


Fig. 5 *Circuit diagram of a light-flashing apparatus for the photographic recording of spectral data*

transformer through the 80 tube. Tests show that the condenser is fully charged in 1½ or 2 cycles of the 60-cycle supply, and the ballistic effect of the force resulting from this charging-current surge in the recorder causes it to register. The steady current to the amplifier is not enough to hold the counter in a closed position.

A negative surge on the grid of the amplifier tube causes the plate voltage, and thereby the outer-grid voltage, of the Strobotron to increase to the critical value at which the Strobotron starts. Once a glow is started, it immediately transfers into an arc and discharges the 2 μf condenser to almost zero voltage. A count is recorded when the condenser is again charged from the rectifier and transformer.

Sensitivity control is effected by the adjustable resistance. This resistor is increased to as large a value as can be used without the self-operation of the Strobotron. The drop across the amplifier tube is used as a positive bias for the Strobotron, and the larger it is, the smaller will need to be the surge to reach the critical potential at which the tube starts.

The counting speed of the above circuit is determined by the counter, that is, about ten a second with the Western Electric Type 5T. With higher-speed counters the same type of circuit can be used, utilizing if necessary a direct-current source instead of the rectified alternating-current supply.

A Strobotron is used in an apparatus for recording data in the automatic wave-length comparator[3], a new model of which is now being constructed by Professor G. R. Harrison, of the Physics Department at the Massachusetts Institute of Technology. The function of the Strobotron is to turn on an intense light source which photographs a high-speed rotating counter that shows the wave-length of the spectral line. A quick flash is needed, since the counter wheel rotates 1000 times a minute. Figure 5 is a circuit diagram of the Strobotron circuit and the amplifier with it for timing the flash. A negative surge to the grid of the type 27 amplifier tube increases the positive bias on the outer grid of the Strobotron, and turns it on at the instant a spectral line centers on a slit as the plate moves along. The resulting surge of current in the Strobotron circuit passes through the primary of a spark coil and produces a high voltage on the secondary, which in turn starts the argon stroboscope lamp. Either the voltage or the pressure of gas in the argon lamp is adjusted until the lamp does not flash by itself but is always flashed by the spark coil.

The Strobotron has been used in the Aberdeen chronograph spark-recording apparatus. A circuit of the type shown in Figure 5 is used, except that the output from the spark coil is connected directly to the marking electrodes that direct the spark through the moving waxed paper. Instantaneous control of the starting of the spark is thereby obtained without requiring an appreciable amount of electrical power in the control circuit.

As a final example of typical uses of the Strobotron Figure 6 shows a satisfactory method for starting mercury-arc rectifier tubes. The function of the Strobotron in this example is the same as in the one described in connection with Figure 5, that is, to impress (momentarily) a very high potential to start the main discharge. A condenser (3 μf) is quickly discharged into the spark coil V_1 at the instant the potential on the tube inner grid reaches the critical potential. The high voltage from the spark coil when connected to the external starting band of the mercury tube starts a cathode spot at the junction of the mercury and glass. At the end of the half-cycle the tube goes completely out, but is restarted at the desired portion of the next cycle by another surge of voltage from the Strobotron circuit. The phase-shift method of controlling the output is effected by varying the phase of the tripping voltage with respect to the applied plate voltage on the mercury-arc tube. This same type of circuit has also been used for starting ignitrons.

Professors Gray and Nottingham at the Massachusetts Institute of Technology have used a circuit of the type shown in Figure 6 to operate a spot welder for half-cycle welding. A paper describing the circuit arrangement will be published by them in the *Review of Scientific Instruments*.

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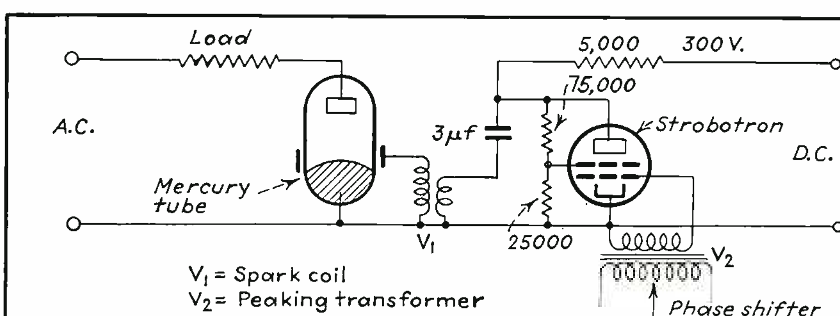

Fig. 6 *Circuit showing the use of a Strobotron for starting a mercury pool rectifier used in a half-cycle welding circuit*

Universal Performance Curves for Tuned Transformers

By J. E. MAYNARD
General Electric Co.
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THE DESIGN and calculation of tuned transformers for a particular purpose is a somewhat involved and complicated process which, very fortunately, can be greatly simplified through the use of two families of curves which give the attenuation and the phase displacement of the transformer as functions of a selectivity variable and a parameter. These universal performance curves may be applied to any physical situation when the proper conversion factors are used, and can be used in design work, or to determine quickly the selectivity and band pass performance of a given set of coupled coils.

The assumptions on which the mathematical work underlying this article depend are:

(1) The Q of the transformer circuits over a narrow frequency range may be considered constant.

(2) The Q of the circuits is sufficiently high so that parallel and series resonance occurs at the same frequency, i.e., that for which $\omega L = 1/\omega C$.

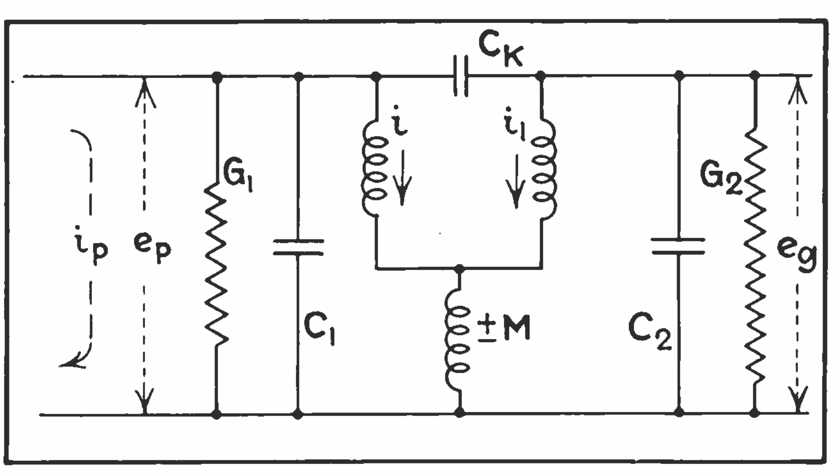
(3) No feed-back exists in the tube circuits.

(4) The coupling between the two coils is purely reactive.

These assumptions may readily be accepted for most practical situations or allowances may be made in cases for which these assumptions are violated. Assumption (3) will not always be strictly tenable.

The equivalent circuit of the transformer which was used in the analytical work is shown in the schematic wiring diagram and closely approximates the circuits used in practice, in which both inductive and capacitive coupling exists between the coils. Under assumption (3) all circuit losses may be represented by the inclusion of these losses in the parallel conductances, G_1 and G_2. For instance, the loading on the primary of the transformer due to the internal plate resistance of the driver tube will be included in G_1, or the loading on the secondary of a transformer used to drive a diode will be included in G_2. The losses in shielding and coils will also be considered as part of these conductances.

By writing the Kirchoff equations for the various meshes of the equivalent circuit and making the proper substitutions and transformations, it can be shown that for positive values of mutual inductance, M, between the transformer coils there is a frequency of infinite attenuation, f_∞, for which the inductive and capacitive coupling are equal and opposite or for which $K_L/\omega L = K_C\omega C$. It can also be shown that for the cases in which either type of coupling predominates (or the two types of coupling are of like sign) the resultant coupling, K, may be treated as a total or net coupling,



Equivalent circuit upon which the mathematical analysis is based the absolute value of which is constant near resonance. Under these conditions, which will be assumed hereafter, performance of the transformer near resonance is the same regardless of the type or combinations of coupling employed. This enables us to obtain a symmetrical performance curve, so that only one half of the curve need be given in the charts.

Calculations for Determining Universal Selectivity and Universal Phase Shift Graphs

The performance of the transformer is given by

$$i_p/e_g = \pm jy/A_o n^2 \quad \ldots\ldots\ldots\ldots (1)$$

in which y is a complex expression determining the selectivity of the network near resonance, A_o is a real coefficient which is a function of resonant circuit impedance, coupling between primary and secondary, primary to secondary inductance ratios and circuit quality factors, and n, which we may treat as unity near resonance is the ratio of any frequency f, to the resonance frequency, f_o. It can be shown that i_p as used is directly proportional to the grid voltage of the tube driving the transformer. If we let the absolute magnitude of y be designated as Y, then

$$Y = [t^2(1+a)^2 + (1 - at^2 + aK^2Q^2)^2]^{\frac{1}{2}} \ldots (2)$$

where t is the tangent of the phase angle between secondary voltage and current and is a function of frequency defined by $t = \left(n - \frac{1}{n}\right) Q$, where a is Q_1/Q_2, K is the total or net coupling given by $\pm \frac{K_L}{n} - n\, K_c$, and Q is the quality factor of the secondary circuit.

This equation has the advantage that it may be reduced to a form containing an independent variable associated with the circuit selectivity, S, a dependent attenuation variable, u, and a parameter, b. In order to effect this transformation, it will be convenient to adopt a somewhat more abbreviated notation. For example, let

$$t = S\left(\frac{1+a}{2a}\right) \ldots\ldots\ldots (3)$$

$$Y = u\left(\frac{1+a}{2a}\right)^2 a \ldots\ldots\ldots (4)$$

and

$$aK^2Q^2 = \left[\left(1 + b^2\right)\left(\frac{1+a}{2a}\right)^2 a\right] - 1 \ldots (5)$$

Substituting Eq. (3), (4) and (5) into Eq. (2), we obtain for the attenuation, the expression,

$$u = [4S^2 + (1 - S^2 + b^2)^2]^{\frac{1}{2}} \ \ldots (6)$$

Let u_o be the attenuation at resonance, for which $S = O$. The attenuation, u, at any frequency, f, compared with the attenuation at resonance, u_o, is then given by

$$u/u_o = [4S^2 + (1 - S^2 + b^2)^2]^{\frac{1}{2}}/(1+b^2) \quad (7)$$

The values of Eq. (7) are plotted as the universal selectivity curves, page 17.

It is desirable to determine the attenuation in terms of some stated band width, and the relation

$$\Delta f = (1 + a) f_o S/4aQ \quad \ldots\ldots\ldots (8)$$

which may be derived from Equation (3) and the definition of t, permits interpretation of the selectivity curves in terms of band width, $2\Delta f$. The curves have been plotted for positive values of S only, since the assumptions which have been made lead to curves symmetrical about the resonance point.

The vector form of Eq. (6) is

$$u = (1 - S^2 + b^2) + j2S \quad \ldots\ldots (9)$$

in addition to which we have a $\pm 90°$ phase rotation ($\pm j$ Equation (1)) from which the phase shift of the transformer becomes

$$\theta \pm 90° = [tan^{-1} 2S/(1 - S^2 + b^2)] \pm 90° \quad (10)$$

the polarity of the additional 90° rotation being positive for the negative values of K or negative for positive values of K.

A family of curves representing Eq. (10) is shown as the universal phase shift curves. The universal selectivity and universal phase shift curves determine the performance of a transformer, under the assumptions which have been made, and enable us to determine the attenuation and phase shift (relative to resonance) when we know a, f_o, S, and Q.

A convenient set of formulas which enable us to estimate quickly the selectivity and band pass performance of a given set of transformers operated in cascade may be obtained from these universal curves. For adjacent channel attenuation of three or more ($u/u_o \geqq 3$), and for values of b between 0.2 and 1.41 (which includes most cases of usual design), Eq. (7) may be approximated by

$$u/u_o = S^2/(1 + b^2) \ [\text{for } b \geqq 1] \ (11)$$

$$u/u_o = (1 + S^2)/(1 + b^2) \ [\text{for } b < 1] \ldots\ldots (12)$$

The following formulas for the "nose" of the curve, based on an overall attenuation of $\frac{u}{v_0} = 2$ may be derived from Eq. (7):

For $u/u_o = 2$,
$$S^2 = b^2 - 1 + 2(1 + b^2 + b^4)^{\frac{1}{2}} \quad (13)$$

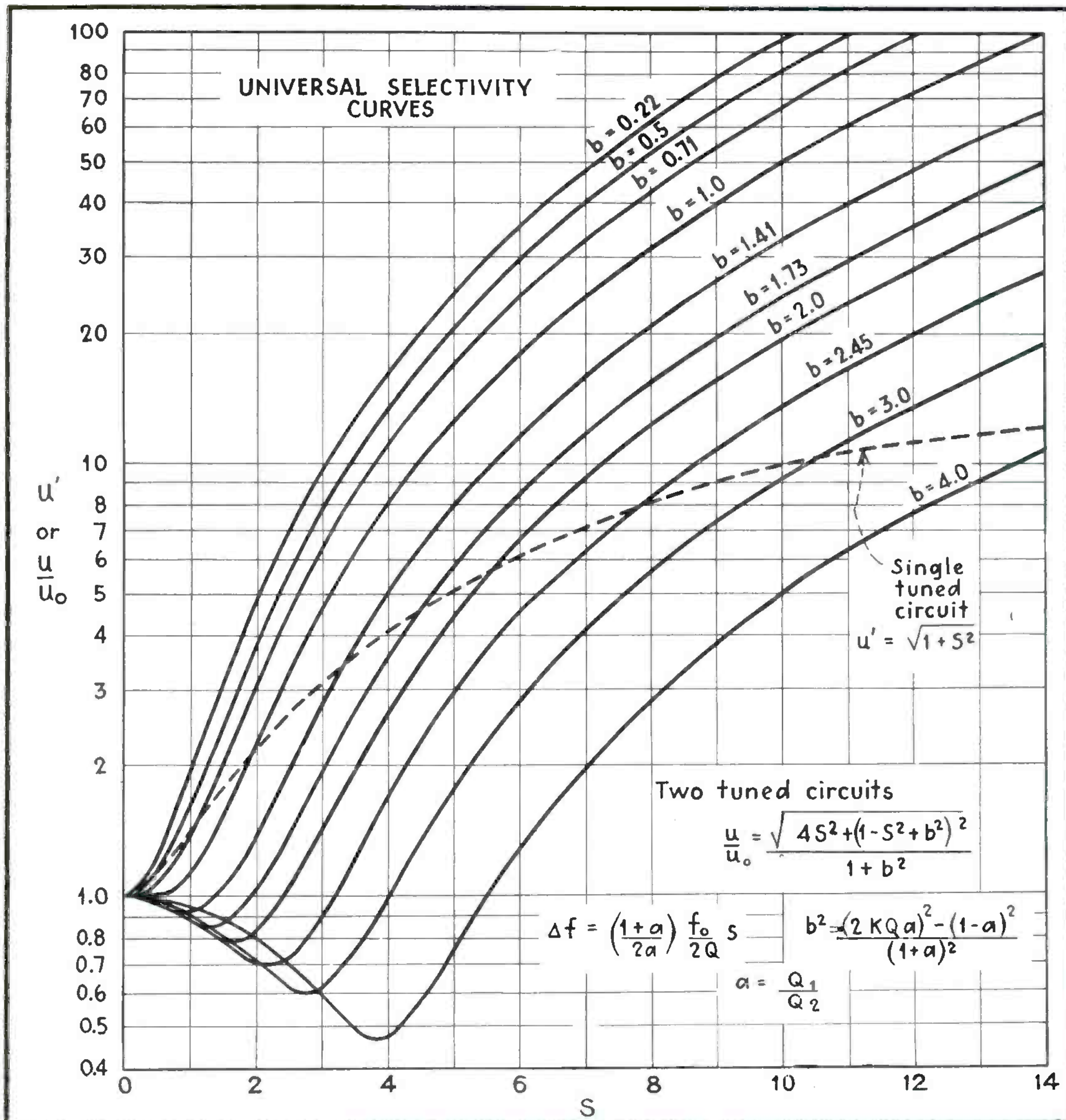
For $u/u_o = \sqrt[2]{2}$
$$S^2 = b^2 - 1 + (2 + 2b^4)^{\frac{1}{2}} \ \ldots\ldots (14)$$

For $u/u_o = \sqrt[3]{2}$
$$S^2 = b^2 - 1 + (1.59 - 0.82b^2 + 1.59b^4) \ldots (15)$$

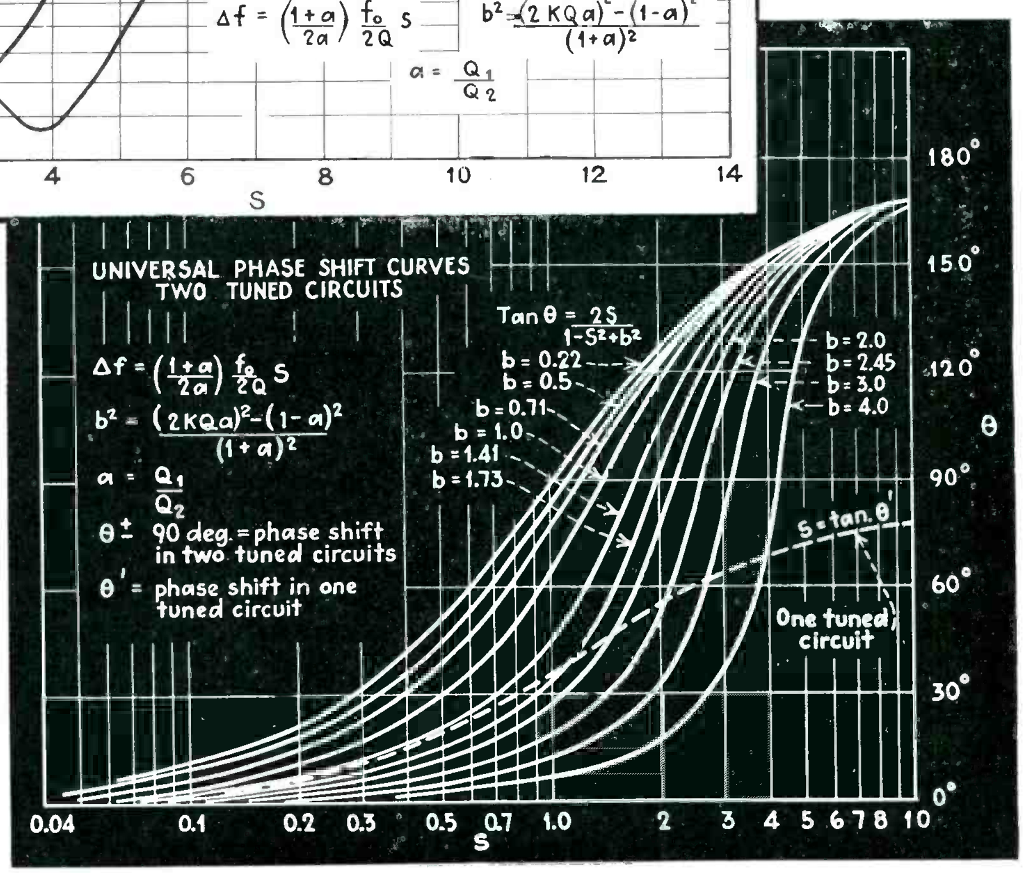
These equations allow calculations based on an equivalent single transformer whose attenuation, raised to a power corresponding to the number of transformers used, will provide an estimate for the overall performance of the system. Our known quantities are an adjacent channel attenuation figure for u/u_o, and definite band widths by means of which S becomes a numerical linear function of Q. The unknown quantities are then b and Q. Eliminating b between Eq. (11) and any one of the last three equations permits determination of the Q required to meet the specified performance. The corresponding value of b will then indicate the shape of curve by reference to the universal chart. Of course the problem to be solved may be set up for any two unknowns in the above system of equations, and each transformer may be solved individually rather than assuming all transformers identical, but Eqs. (14) and (15) only apply for two or three identical transformers.

It is often desirable to know the performance of a single tuned circuit, and this may also be expressed by means of a universal curve.*

* Radio Engineering, by F. E. Terman, p. 52



Solid curves for two tuned circuits show attenuation, u/u_o, and parameter, b, plotted against S. By interpolating, curves for other values of b may be determined. Dashed line shows similar information for single tuned circuit



Phase shift curves showing θ plotted against S for various values of the parameter, b. Dashed curve applies to single tuned circuit

The equations for selectivity and phase shift for a single tuned circuit are given by

$$\theta' = tan^{-1}\ S \ \ldots\ldots\ldots\ldots\ldots (16)$$

for phase shift, and

$$u' = (1 + S^2)^{\frac{1}{2}} \ \ldots\ldots\ldots\ldots (17)$$

for attenuation off resonance in terms of the variables already used. The phase shift and attenuation curves for the single tuned circuit are given in dotted lines on the two families of curves.

Use of Universal Selectivity and Phase Shift Curves in Practical Applications

Some numerical examples will serve to illustrate the use of these curves and formulas.

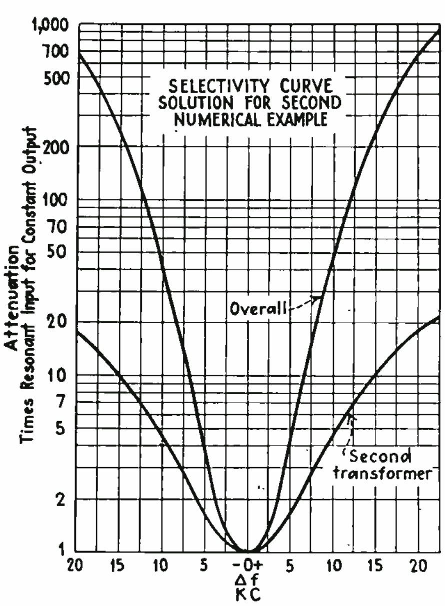
Let us take a two-stage amplifier operating at 465 kc resonant frequency for the first case. We will assume that all three transformers are identical; tuned circuit impedances may be kept low enough so that this will be a reasonable approximation. Suppose we desire to design an amplifier to have critical curve shape ($b = 1$) with all coils identical and to obtain an adjacent channel attenuation of 100, what Q will be required and what will be the band width at an overall attenuation of 2?

The equivalent single transformer will have an adjacent channel attenuation of $\sqrt[3]{100}$ or 4.65. From the universal curve for $b = 1$ we find, for $\frac{u}{u_o} = 4.65$, that S is 3.02. At the adjacent channel $\triangle f$ is 10 kc. Since $a = 1$ solving Eq. (8), Q is 70 for these values of $\triangle f$ and S. Solving Eq. (15) with $b = 1$ we have $S = 1.24$. With this value of S and a Q of 70 Eq. (8) gives us $\triangle f = 4.13$. Our band width ($2\triangle f$) for $\frac{u}{u_o} = \sqrt[3]{2}$ is then 8.26 kc. This will be the band width at an attenuation of 2 for three of these transformers in cascade with a Q of 70 in each circuit. We might have used equation (11) instead of the curve to obtain our first value of S which would then have been $S = 3.05$.

Let us take a slightly different problem. Suppose we have coils of 120Q available (in shield) and wish to design a single stage amplifier using these coils to obtain an adjacent channel attenuation of 50, what will be the shape of curve and band width at an attenuation of 2, using a resonant frequency of 480 kc?

In single stage design high tuned circuit impedances are normally used to obtain high gain. We will assume in this case that circuits reduce the effective Q of the first transformer primary to 80 and of the second transformer secondary to 40. This leads to two transformers which are not identical. The overall attenuation of 50 at the adjacent channel will be the product of the attenuations at this frequency in each transformer. Since the second transformer has lower Q circuits we will call for less attenuation in this transformer. Let us require an attenuation of the adjacent channel of 10 and 5 in the first and second transformers respectively. This defines our problem and we may now solve for each transformer.

The solution for the first transformer gives $a = Q_1/Q_2 = 80/120 = 0.067$, and from Eq. (8) we find $\triangle f$ to be $2.5S$ (in kc.). Then for $\triangle f = 10$ kc, we have $S = 4$. Solving Eq. (12) with $S = 4$, and $u/u_o = 10$ we find that $b^2 = 0.7$, and substituting this value into Eq. (14) we find for $u/u_o = \sqrt{2}$ that $S = 1.19$. For this value of S, we have $\triangle f = 1.19 \times 2.5$ or 2.98 kc. and the curve shape is defined by $b = 0.84$.



Second transformer and overall attenuation curves for second illustrative problem

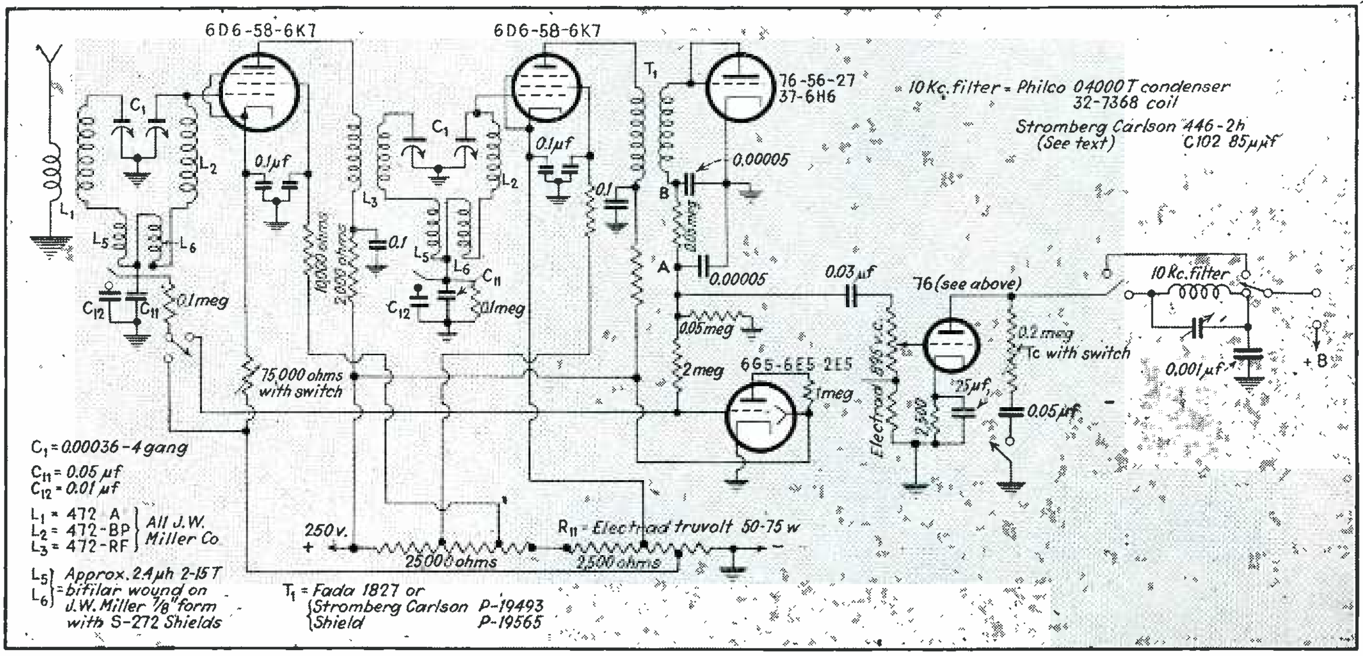
For the second transformer, $Q_1 = 120$, $Q_2 = 40$, and therefore $a = 3.0$. From Eq. (8) we determine that $\triangle f = 4S$ (in kc.) so that for $\triangle f = 10$ kc. the value of S is 2.5. Solving Eq. (12) for $u/u_o = 5$ and $S = 2.5$ we find that $b^2 = 0.45$. From Eq. (14), which applies for $u/u_o = \sqrt{2}$, the value of S becomes 1.0 for which value $\triangle f = 4.0$ kc. The curve shape is defined by $b = 0.67$. We may conclude from this solution that the overall band width for an attenuation of 2 will be about 7 kc. and the curve shape will be somewhat less than critical.

The universal curves for $b = 0.67$ and $b = 0.84$ may be obtained by interpolation from the universal curve chart and redrawn with a frequency scale for abscissas from the conversions $\triangle f = 2.5S$ and $\triangle f = 4.0S$. The products of attenuation on these curves at discrete frequencies will then provide the overall selectivity curve of the system as shown. It will be noted that the adjacent channel attenuation is slightly less than 50. This is due to the approximation in Eq. (12).

For the last case, assume a single tuned circuit with $u/u_o = 4$. For this attenuation we can determine from the universal selectivity curve that $S = 4$, and for this value of S we determine from the phase shift curve that $\theta' = 75°$. Actually, for $u/u_o = 4$, the value of S is 3.87 and $\theta' = 75.5°$ but the results obtained graphically are sufficiently accurate for most purposes. For greater accuracy the single tuned circuit equations on page 17 may be used.

The use of these curves is not, of course, limited to intermediate frequency amplifier systems such as were used for illustration. For instance, band pass audio filters may be designed in this manner as suggested in a previous issue of *Electronics**. R. f. amplifier circuits often contain preselectors consisting of tuned coupled circuits which vary in resonant frequency with the tuning of the receiver. In fact any system in which we wish to select a relatively narrow band of frequencies from a given spectrum lends itself to treatment by tuned coupled transformers conforming to the universal curves presented herewith and within the premises on which the analysis rests.

* Resonant Circuits in Audio Service, *Electronics*, May, 1936.



Circuit diagram, r.f. to output of first a.f. This tuner employs the selective circuits used in the well known Western Electric 10A receiver

A Wide-band Tuner

Designed for reception of programs from local stations, this TRF tuner delivers sufficient output to drive push-pull 2A3 tubes, passes sidebands of approximately 7.5 to 10 kc., and has sufficient adjacent channel selectivity

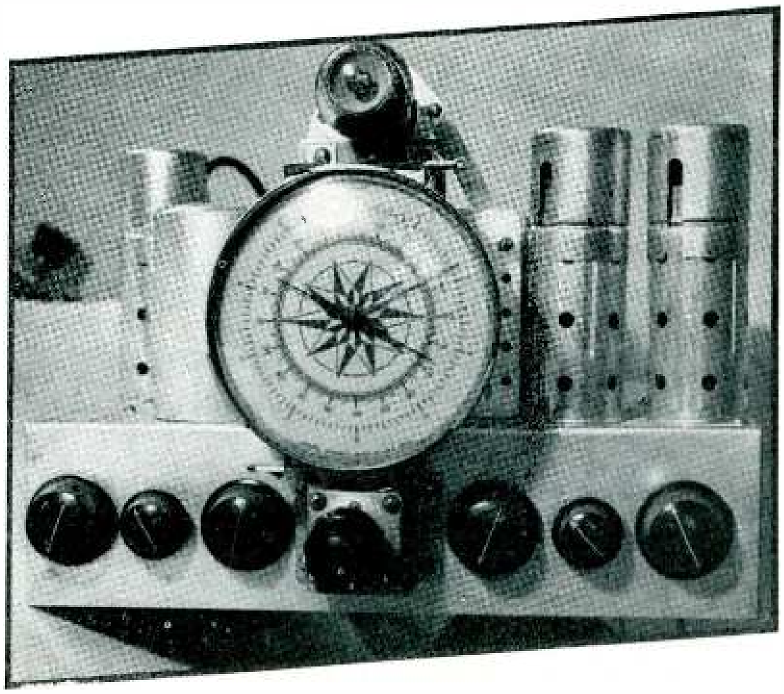
By W. N. WEEDEN

THIS tuner was designed to meet the requirements of those who wish high fidelity radio reception from high power local stations. Many people have been in the market for a high fidelity receiver for some time but have not felt like paying the money for a one-microvolt, all-wave receiver when they wished to restrict their listening to not over a half dozen stations delivering several millivolts of signal. The tuner may also be used as a monitor for broadcast programs by advertisers or any others interested only in local programs.

The selective element is made up of 4 tuned circuits in pairs of coupled or band pass filter circuits. The coupling of negative mutual inductance and capacitance insures a sensibly constant band width which can be varied simply by changing the capacity of the coupling condenser. A diode detector is fed from this selective system through an untuned transformer. The detector is followed by a single stage of triode a-f amplification which provides sufficient voltage output to load up push-pull 2A3 tubes through a proper coupling transformer.

The tuned circuits are overcoupled and exhibit the usual curve of peaks separated by a dip at resonance. This dip amounts to about 2 db and is not considered serious, considering the variation in response of the usual loud speaker. A 10,000 cycle filter made up of a tuned trap is located in the output of the first a-f tube. In this particular receiver, the trap can be removed at will, but in general it is advisable to have it in the circuit. On any good night in the New York suburbs the beat notes between stations makes it quite necessary to use the trap. With a 7,500 cycle side-band an attenuation of 60-70 db is necessary to eliminate monkey chatter.

The diagram shows that the coupling impedance consists of a negative mutual inductance, a resistance and capacity. The negative mutuals must be wound by hand. For checking coil inductance and condenser matching, a simple test method is to make the coil or condenser section under test part of the oscillatory circuit of a simple oscillator. The



Front view showing dial, knobs controlling gain, tone, etc.

simplest battery-operated, unshielded oscillator will serve although it is preferable to include a variable condenser of 15 to 25 micro-microfarads in parallel to the main oscillator tuning capacitor. With this auxiliary condenser set at midscale the main control may be varied until a beat is produced with a broadcast station (picked up by the receiver) at approximately the frequency desired for the test.

By cutting the various sections of the tuning condenser into the oscillatory circuit, it is possible to retune to zero beat by the auxiliary condenser and the discrepancy in capacity may be readily noted. By bending plates it is possible to bring the capacity back into line. As most midget condensers are of the straight line capacity type the capacity per dial degree can be calculated roughly. Coils may be checked by a similar method. The accuracy of alignment by this method depends upon the patience of the operator. An accuracy of 0.1 per cent is not unattainable.

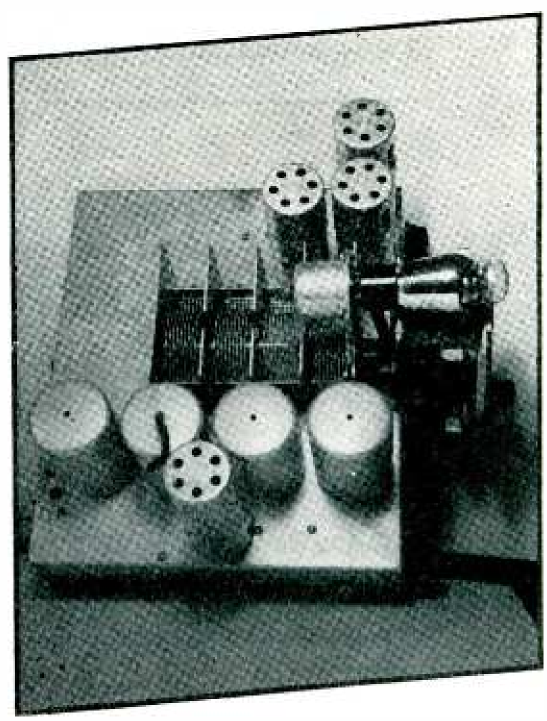
The interesting circuit using the negative mutual inductance was first described by E. A. Uehling in *Electronics*, September 1930, and was used commercially in the well known 10-A wide-band receiver of Western Electric. That receiver, however, used a square law detector so that modulation peaks affected the AVC action. The present tuner utilizes a linear detector, the AVC operates only on the carrier and is unaffected by the modulation. When the AVC is removed for manual r-f gain control, modulation does affect the input to the tuning indicator (6G5 on the diagram) so that a slight wavering of the shadow is seen. This does not bother the tuning, however.

Additional data on the negative mutual inductance coupling circuit may be found in the "Radio Engineering Handbook," 2nd Edition, page 158, in *Wireless World*, February 18, 1931, and in *Radio Engineering*, December 1936.

Because this tuner was to be operated by an engineer several controls were placed in it, which would not be necessary or desired, perhaps, for more general use. For example the slight amount of AVC secured from the detector is fed back to the first stage and a switch makes it possible to remove this voltage and to control the r-f gain of the receiver manually. Selective fading seems to be tolerated with somewhat more enjoyment when the receiver is not under AVC. A tone control has been included in the receiver but has never been used by the engineer for whom the set was made. When static is so bad that a tone control is necessary, receiving is no fun anyhow. For general use the tone control might as well not be included.

The second r-f stage must be operated with sufficient bias, say 7 to 9 volts to prevent amplitude distortion when it is supplying 60 volts peak at 100 percent modulation to the diode circuit, the impedance of which is about 50,000 ohms. The audio frequency stage is conventional except that its grid is connected to one-half the diode load to improve the modulation capability of the detector. If insufficient output is secured, the a.f. may be connected across the entire diode load. When 20 volts are applied to the diode, approximately 100 volts (rms) will be applied between the grids of a push-pull amplifier when fed by a 2-1 transformer from the first a-f stage.

There are two untuned transformers available. Both are replacement items and may be secured from jobbers or factory branches handling these lines. One is a Fada unit which gives somewhat greater output above 1200 kc. and the other is a Stromberg Carlson unit which is slightly more efficient below 650 kc. The Fada unit is more compact.



View of the chassis showing general layout

In such a receiver it is necessary to reduce as far as possible any chance of noise entering the circuits. Grid and plate leads must be short and direct; separate leads should run from each brush of the gang condenser, a single point on the chassis should represent ground for diode and a-f stages. This point should be near the diode.

After antenna, ground and power supply have been connected, the 1st r-f screen voltage should be adjusted (by moving clip on Electrad Truvolt voltage divider) to 125 and the cathode to plus 3. Then the 2nd 6D6 screen voltage should be set at 125 to 150 (depending on signal strength) and its cathode to plus 8 volts.

Then, with micro-ammeter or magic eye, proceed to align or trim the gang condenser (Wholesale Radio Service YH9705) at 1400 to 1500 kc.

After aligning carefully, the screen voltages may need to be reset so that with AVC operating, the weakest of the local network stations will impress 8 to 10 volts across the diode input (80-100 microamperes through the 100,000 ohm load). If the AVC fails to hold down the signal with greatest field strength to 20 volts, readjust screen-grid voltages, and if no satisfactory compromise can be made—shift the AVC connection to point B from A, thus impressing twice the control voltage on the first r-f tube, at the expense of a slight increase in harmonic distortion. Although these adjustments may sound tedious, it will probably be found that they can be accomplished in less time than that necessary to read this portion of the paper.

Although the diagram shows the 10,000 cycle filter (Philco) in the first a-f plate circuit, experience has shown that a Stromberg Carlson filter is somewhat more satisfactory. It is higher in impedance and should be placed in the diode load. The connecting leads must be very short.

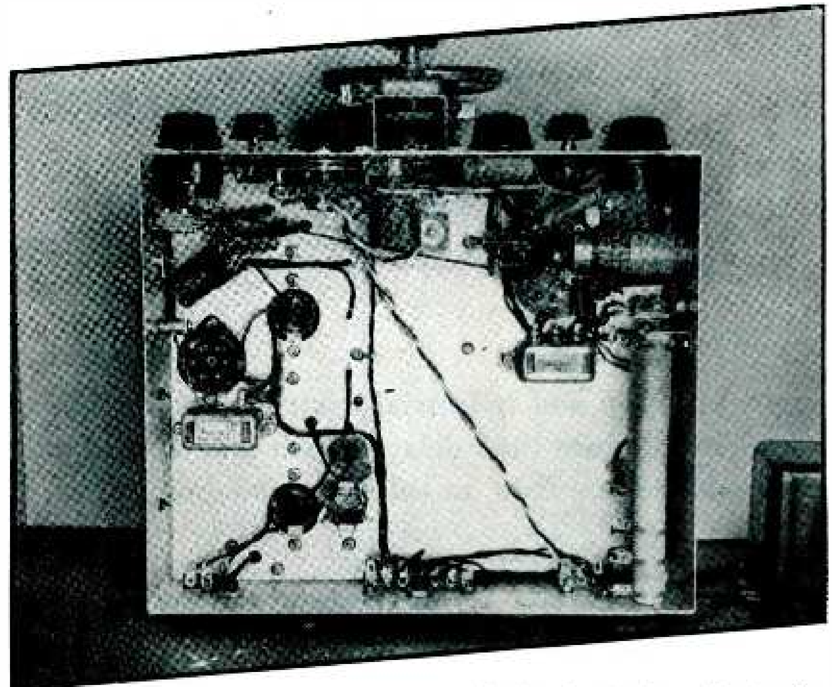
With coils as described and coupled with condensers of 0.05 μf the band width is approximately 20 kc. and when shunted by an additional 0.01 μf this band width becomes approximately 15. The coils are special and to the best of the writer's knowledge may be obtained only from J. W. Miller Co., 5917 South Main St., Los Angeles. While it is desirable to check the inductance and the capacity of the several units, it is true that reasonable variation between values of the several units will not cause great departure from symmetry of resonance curve nor appreciable change in fidelity.

A Yaxley switch may be employed to change not only the band width but in the narrower position to insert the whistle filter as well. This refinement is unnecessary unless using loud speakers which are flat to 10,000 cycles or better. With most single speakers, even the so-called high-fidelity units, sharp cut off usually takes place between six and eight thousand cycles, and little or no difference will be noted between a 7,500 and 10,000 cycle band width.

This tuner has been designed to operate with an efficient signal collector, because wide-band reception is worthless unless the signal to noise ratio is high. The antenna should be at least 20 feet away from wiring, other antennas, metal roofs, gutters, etc., and as long as possible —at least 75 to 150 feet. A good ground plus a noise-reducing leadin or transmission line with a transformer at each end are very desirable. A metal cabinet to prevent direct pick-up by leads or condenser stators will be desirable.

The loud speaker presents a problem. There are several fine speakers now available which are satisfactory up to 6000 cycles or so, but the writer has found that it takes one of the few double-unit speakers to really make a wide-band tuner show up its capabilities. The natural resonance of the cone of the speaker should be in the neighborhood of 30 cycles, if possible. This calls for one of the 18 inch or similarly large dynamic types with plenty of field excitation.

Many listeners state that they find little advantage to extending the audio range into the high frequencies unless the low end is extended at the same time. Thus a small baffle with a cut-off near 100 cycles is distinctly not good enough for faithful reproduction. The several acoustical systems recently developed—such as the labyrinth of Mr. Olney, the resonant pipes of RCA Victor, the resonating cones of Philco or the "bass reflex" principle of Hugh Knowles of Jensen—may be effectively employed. In the latter system, use is made of ports in the speaker cabinet which are approximately resonant in the extreme low frequency range of the cabinet so that in relation to the cubic content, the phase of the back radiation of the cone is reversed.



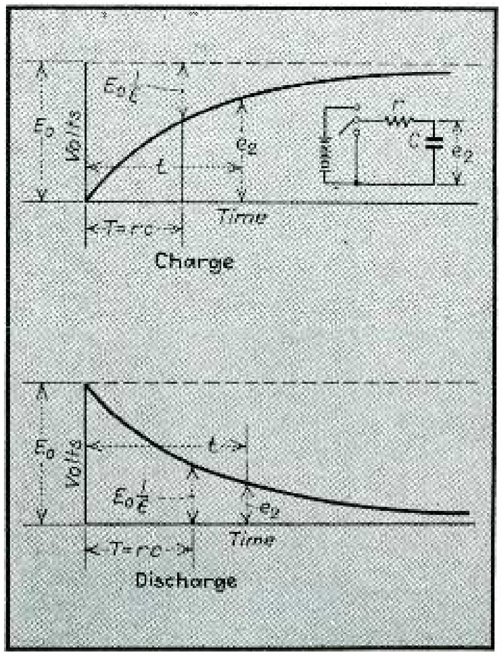
Under chassis photo showing how little is needed for a local receiver

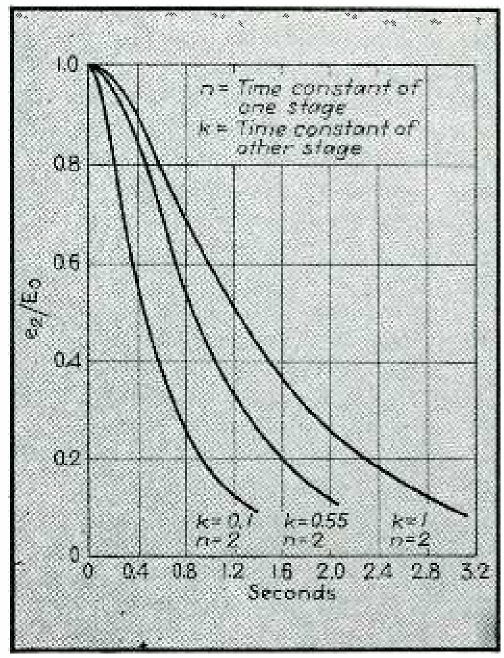
LEFT

Fig. 1—Single stage charge and discharge

RIGHT

Fig. 2—Uncoupled case, with various time constants





Time Delay in

In communication and industrial control vacuum tube circuits, combinations of resistance and capacity produce time delays which play important—although often uncalculated and unexpected—roles. How to calculate and how to use these delay networks.

By E. W. KELLOGG and W. D. PHELPS

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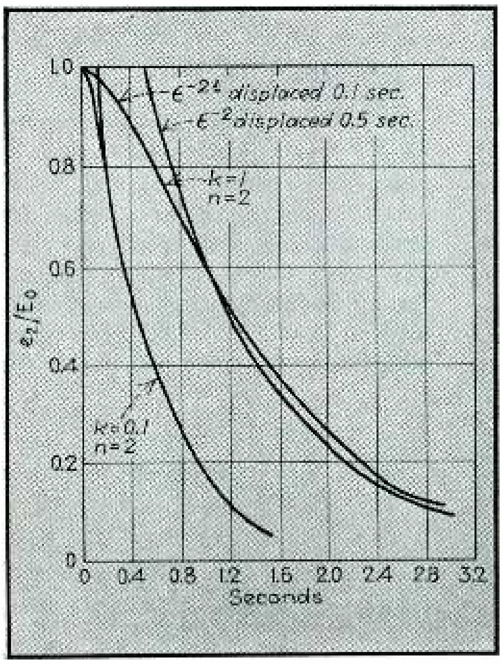
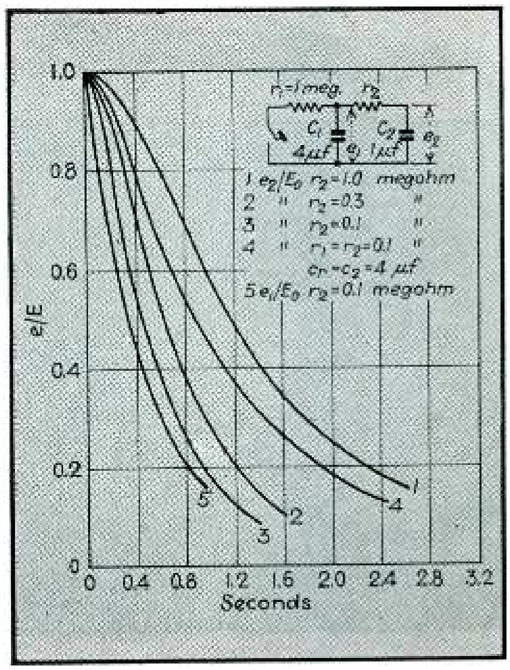
THERE are many purposes for which it is necessary to obtain a current proportional to the amplitude of a modulated alternating current, but with the alternating current filtered out. A rectifier and a low-pass filter accomplish this. One of the most recent of such applications is the volume expander used in the RCA Model D-22 and R-99 radio-phonographs in which loud passages are given greater amplification than soft passages, thus providing wide volume range[1]. Other examples are the shutter or galvanometer bias systems for reducing ground noise from photographic sound records[2], compressor or automatic volume control circuits, and the detection or demodulation of modulated radio-frequency currents, to give audio, television, facsimile or signaling currents.

For some purposes the time lag introduced by the filter is either inconsiderable or unobjectionable. In other applications, such as volume compression and expansion, or ground noise suppression, the lag in action constitutes an imperfection in the functioning of the system, which may be serious unless the filter action is fast in comparison with the maximum rates of growth or decrease in the modulation. For example, in the ground noise suppression system used with photographic sound records, if there is a rapid increase in the amplitude of the recorded waves, the galvanometer bias may not change fast enough to avoid cutting the tops off the first few waves, or in the case of a volume compression system, delay in action may result in failure for a brief interval to hold down the amplitudes, with consequent overloading.

It is thought that the curves and approximate formulas given here may prove convenient and useful to engineers concerned with the design or use of such filtering circuits, in showing the manner in which the output voltage or current of a resistance-capacity filter changes in response to a sudden change in input, and giving a simple way of estimating the effective time constant for two stages.

If a condenser c (charged to a voltage E_o) is discharged through a resistance r the voltage e_2 will fall to $(1/\epsilon)\ E_o$ or .368 E_o in $T = rc$ seconds. Similarly the time required for it to charge to within 36.8% or $1/\epsilon$ of the supplied voltage is rc seconds. A corresponding definition of the "effective time constant" for a





LEFT

Fig. 3—Uncoupled case, actual and approximate curves

RIGHT

Fig. 4—Coupled case curves

Resistance–Capacity Circuits

two-stage filter, may be adopted, and although such a definition may be more or less arbitrary, it is useful in estimating the rapidity of action of filters of the resistance-capacity type.

Two cases are considered, (1) in which the second stage is either isolated from the first by a tube, or else the connecting resistance is so high as to prevent material reaction on the first stage, and (2) in which the stages are cascaded in the usual manner and reaction of the second stage on the voltage across the first condenser is taken into account.

Only filters of the resistance-capacity type have been considered, although the general conclusions might be applied to numerous other combinations. For example we might be interested in the current through an inductance in the plate circuit of a tube having a resistance-capacity filter in the grid circuit; or in the velocity of a mass, actuated by a magnet, the current through which is controlled by resistance and inductance. In the last case there would be some coupling between the stages, and mechanical resistance would have to be present if the same formulas are to apply.

Case I. Uncoupled Filters

If the voltage applied to the first stage of the filter is suddenly changed from E_o to 0, the voltage applied to the second stage will be

$$e_1 = E_o\epsilon^{-nt} \quad \text{.......... (1)}$$

where $n = 1/r_1c_1$.

If the second stage has a time constant $1/r_2c_2 = k$, the voltage across the second condenser will be

$$e_2 = E_o\left[\frac{1}{1-n/k}\epsilon^{-nt} + \frac{1}{1-k/n}\epsilon^{-kt}\right] \quad (2)$$

It will be noted that if $n = k$ this is indeterminate and for this special case

$$e_2 = E_o(nt+1)\,\epsilon^{-nt} \quad \text{...... (3)}$$

For all other cases, Eq. (2) is applicable. The two terms of Eq. (2) are of opposite sign, the smaller term being negative, and the larger exponent goes with the negative term. The value of e_2 is thus represented by a larger term with a decrement corresponding to the slower of the two filter stages, from which is subtracted a smaller term with higher decrement, and therefore fairly rapidly becoming negligible (unless n and k are nearly the same).

Using "effective time constant" to mean the time required for e_2 to fall to $(1/\epsilon)E_o$ or .368 E_o, it may be said in general for the uncoupled case, that the time constant for the two stages is approximately equal to the sum of those for the filter stages taken separately. Table I shows the degree of approximation. The same is true, but with somewhat more error in the approximation, if the stages are coupled. If the stages are uncoupled, it makes no difference which stage comes first. If they are coupled the order makes a difference.

If we are concerned with the time required for the voltage to drop to a lower value than 36.8% of the initial value, or with how quickly it executes a smaller change, it will not be sufficient to depend on the effective time constant. The calculation of the curves from the formulas indicated is comparatively simple, but there are some approximations which may be of use.

If, in the case of uncoupled filters,

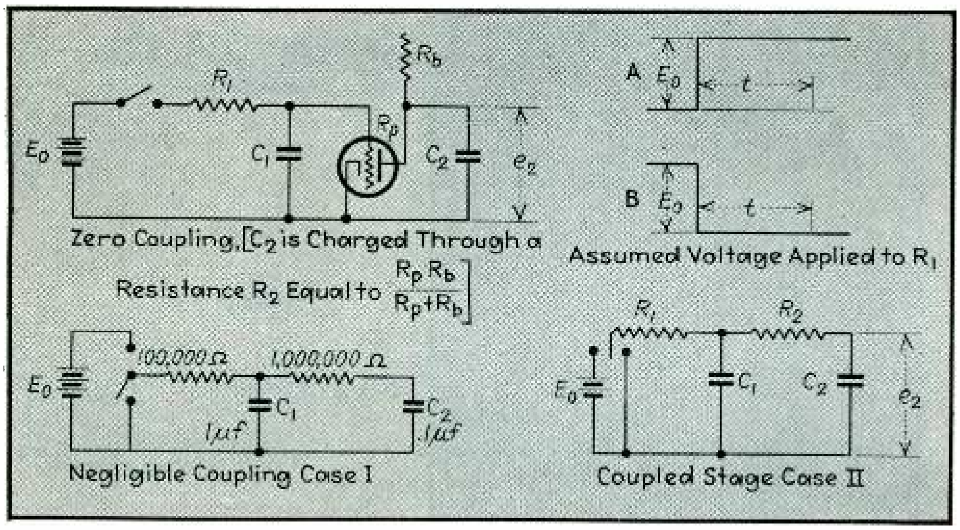


Fig. 5—Coupled and uncoupled two-stage filters

the time constant for one filter is short compared with the other, the lower part of the curve may be approximated by a single exponential having the exponent of the slower filter circuit and displaced along the time axis by the time constant of the faster filter. This approximation, which is equivalent to ignoring the smaller term in Eq. (2), becomes poorer as the time constants of the two filters approach equality, and can hardly be recommended unless one time constant is at least twice the other. A good approximation for the case of equal time constants consists in a simple exponential curve of time constant equal to 1.4 times that for one filter, and displaced along the time axis by .7 of the time constant.

TABLE I. $1/n = 0.5$

Uncoupled case. Comparison of actual and approximate time constants.

t	$1/k+1/n$	$r_2c_2=1/k$
10.45 sec.	10.5 sec.	10.0 sec.
1.15	1.05	0.55
0.61	0.60	0.1

Since in the uncoupled case the relative impedance of the two filter sections is not a factor in determining the buildup or decay curve, the cases illustrated are representative of about all of the conditions likely to be encountered. In the coupled case there are so many variables that only a few of the many possible combinations can be illustrated, and it will have to suffice to give the formulas, and a few illustrations, together with some approximate expressions for the effective time constant for the two stages.

Case II, Coupled Stages

If an e.m.f., E_0, of the form shown in Fig. 5-B is applied to the two-stage filter e_2 and e_1 are given by the following relations:

$$e_2 = \frac{E_0}{1-m_1/m_2}\epsilon^{m_1 t} + \frac{E_0}{1-m_2/m_1}\epsilon^{m_2 t} \ldots (4)$$

$$e_1 = \left(\frac{1+m_1 r_2 c_2}{1-m_1/m_2}\right)E_0\epsilon^{m_1 t} + \left(\frac{1+m_2 r_2 c_2}{1-m_2/m_1}\right)E_0\epsilon^{m_2 t} \ldots\ldots (5)$$

Also if the e.m.f. is of the form shown in Fig. 5-A,

$$e_2 = E_0 - \left[\frac{E_0}{1-m_1/m_2}\epsilon^{m_1 t} + \frac{E_0}{1-m_2/m_1}\epsilon^{m_2 t}\right] \ldots\ldots (6)$$

where $m_1 = \frac{-\lambda + \sqrt{\lambda^2 - 4\mu}}{2}$

$$m_2 = \frac{-\lambda - \sqrt{\lambda^2 - 4\mu}}{2}$$

$$\lambda = \frac{1}{r_1c_1} + \frac{1}{r_2c_2} + \frac{1}{r_2c_1}$$

$$\mu = \frac{1}{r_1c_1r_2c_2}$$

Although in the above formulas the change in impressed voltage is either from 0 to E_0 or from E_0 to 0, they show the manner in which the voltages e_1 and e_2 change from any initial to any final value. For calculating such a case, if E_a is the initial and E_b the final impressed voltage, Eq. 1, 2, 3, 4 and 5 may be used, letting E_0 in the formula stand for $E_a - E_b$, and the total voltages across the first and second stages will be $E_b + e_1$ and $E_b + e_2$, respectively.

In Fig. 4 curves of e_2, and e_1, calculated from Eq. 4, are plotted for three different values of r_2. Only one curve for e_1 is shown because the other two lie nearly on it. Also a curve is shown for the case where both filter stages are identical. The

TABLE II. Coupled case.

Actual and approximate time constants compared.

r_2	t_1	t_2	$r_1C_1+(r_1+r_2)C_2$
1.0 meg.	0.44 sec.	1.58 sec.	1.50 sec.
0.3	0.47	0.83	0.80
0.1	0.496	0.61	0.60
0.005	0.499	0.504	0.505

discharge times of C_2 and C_1, designated as t_2 and t_1 respectively, determined from the curves are shown in columns 3 and 2 of Table II. Approximate values of t_2 obtained by a combination of the filter constants are shown for purposes of comparison. It is seen that a reasonably good approximation to t_2 is obtained simply by using the equation

$$t_2 = (r_1 + r_2)\,c_2 + r_1c_1 \ldots\ldots\ldots\ldots (7)$$

The largest error obtained this way for the cases considered is 4.6%. R_1C_1 does not give a good approximation to t_1. The smaller C_2 compared to C_1 the better r_1c_1 approximates the value t_1. In any case t_2 and t_1 will lie within limits given by the relations

$$r_1c_1 \leq t_1 \leq r_1(c_1 + c_2) \ldots\ldots\ldots (8)$$

$$\infty \geq t_2 \geq r_1(c_1 + c_2) \ldots\ldots\ldots (9)$$

For the case of identical stages Eq. (4) and (5) become

$$e_2 = 1.17E_0\epsilon^{-\frac{0.382t}{rc}} - 0.17E_0\epsilon^{-\frac{2.611t}{rc}} \quad (10)$$

$$e_1 = 0.724E_0\epsilon^{-\frac{0.382t}{rc}} - 0.275E_0\epsilon^{-\frac{2.611t}{rc}} \quad (11)$$

In a following paper a number of circuit equivalents are given which are useful in estimating the net resistance of circuits by which condensers are charged.

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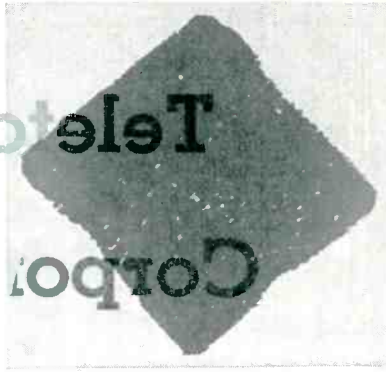
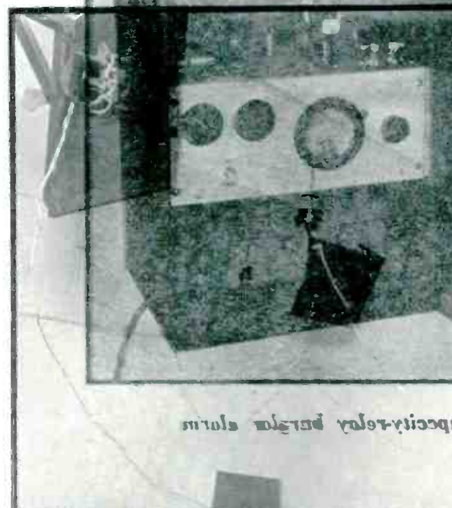
[2] The application of such systems is discussed in papers by R. H. Townsend, H. McDowell and L. E. Clark, *Acad. Motion Picture Arts & Sciences*, Feb. 1931; B. Kreuzer, *Jour. S.M.P.E.*, June 1931; E. W. Kellogg and C. N. Batsel, *Jour. S.M.P.E.* Aug. 1931; and H. C. Silent, *Jour. S.MP.E.*, May 1932.

The plant at the right was grown from seed subjected to supersonic vibrations for three minutes. The other plant was not treated but grown under identical conditions



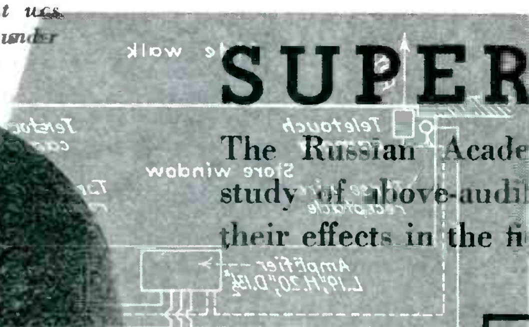
A square of tin-foil, pierced and torn by the action of high-intensity supersonic waves



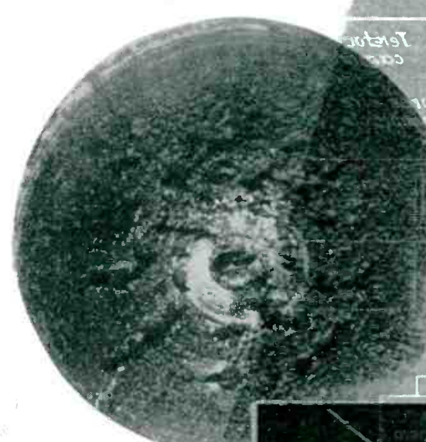
Reverberation room for study of audible and super-audible sounds

SUPERSONICS

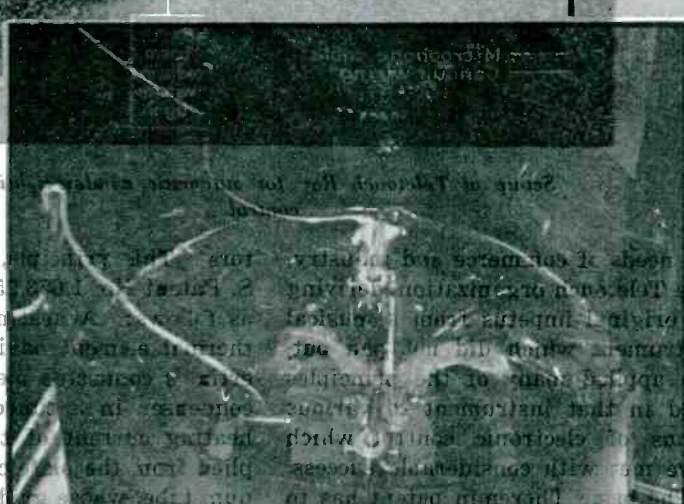
The Russian Academy of Sciences makes a study of above-audible sound frequencies and their effects in the fields of physics and biology



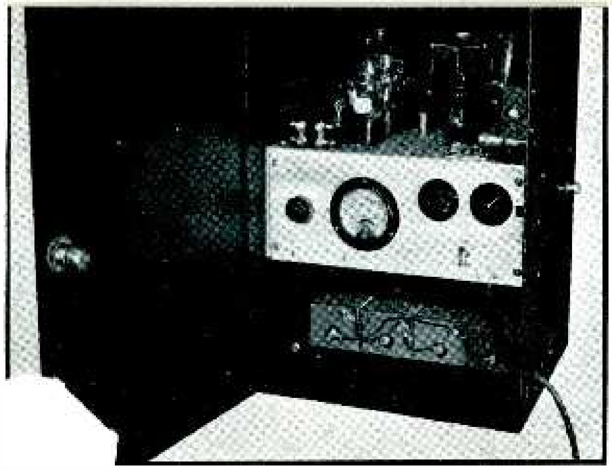
Fountain of oil caused by submerging a piezo-quartz oscillator in transformer oil



"Corrosion" of a tin plate caused by a magneto-striction vibrations at 20,000 cps



Professor S. N. Rzhevkin, director of the program, studying the formation of a sodium emulsion by the vibration of quartz at supersonic frequencies



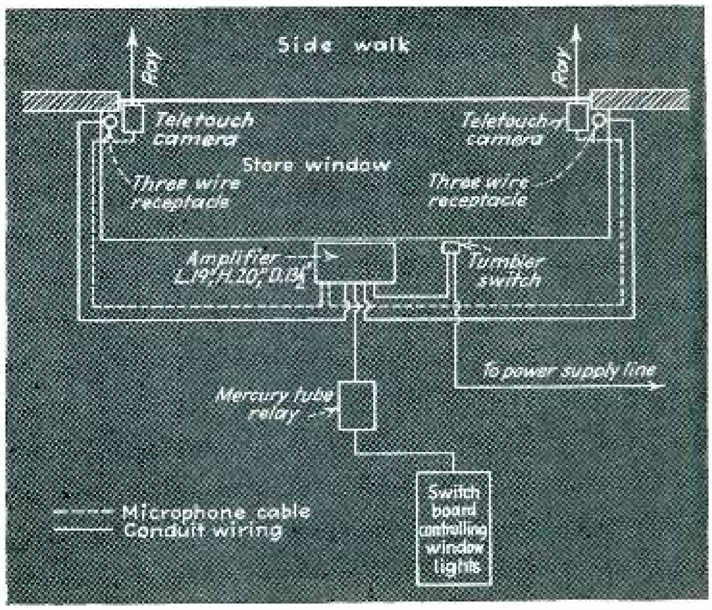
Cabinet of capacity-relay burglar alarm

Teletouch Corporation

Based on the patents of Professor Theremin, the Teletouch Corporation makes a business of supplying electronic devices for various commercial purposes. The story of an organization which makes industrial electronics pay

BACK in 1928, most readers of *Electronics* will remember, a new type of electronic musical instrument appeared. It was called the Theremin, after its inventor, Professor Leon Theremin, and for a while it seemed that it might become permanently established in the musical arts. The instrument operated on the principle of body capacity, the performing artist changing the position of his body and his hands with respect to several electrodes protruding from the instrument. These changes produced widely varying pitches of sound, generated electrically in oscillator circuits and fed to a loud speaker. Not only was it possible to change the pitch of the sound, but also to alter materially its timbre. Several concerts on the Theremin were given, and the instrument was widely publicized. However, the difficult and unusual technique required in playing the instrument, together with the effect of the depression, prevented its widespread use. Today interest in electronic music seems to have shifted to instruments of the keyboard organ type and the Theremin is still more or less a dormant issue.

But Professor Theremin is very far from dormant. As research director of the Teletouch Corporation, he is pursuing an active career in the application of electron tubes to the needs of commerce and industry. The Teletouch organization, deriving its original impetus from a musical instrument which did not pan out, has applied many of the principles used in that instrument to various forms of electronic control which have met with considerable success.



Set-up of Teletouch Ray for automatic window-lighting control

The basic Theremin patent has to do not with the use of body capacity itself, as a control element, but with the compensation of the capacity-sensitive circuit against slow changes in capacity and other disturbing factors. This principle, outlined in U. S. Patent No. 1,658,953 is essentially as follows: A heating coil or other thermal element having thermal inertia is connected mechanically to a condenser in a tuned circuit. The heating current of the coil is supplied from the plate circuit of a vacuum tube, whose grid voltage is controlled by changes in capacity in the tuned circuit. If any change in capacity occurs, the heating current is changed in such a manner as to compensate for the change, the thermally controlled condenser being brought into play to cause the compensation. If, however, the change in capacity is rapid, then the thermal delay in the coil prevents immediate compensation, so the frequency of the tuned circuit changes, thereby actuating the relay. The circuit compensates for slow changes, therefore, but not for rapid ones.

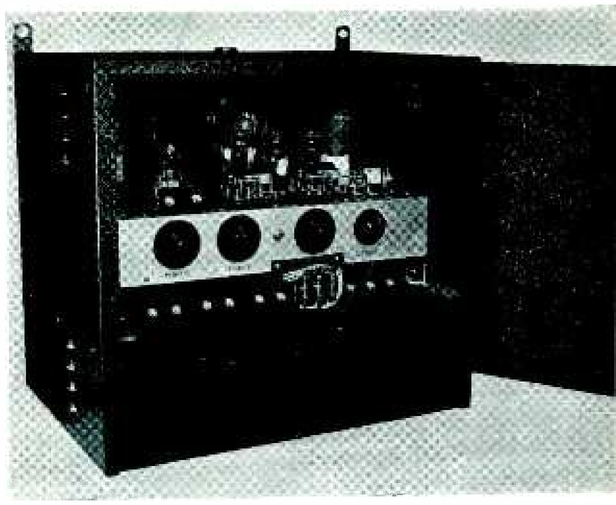
With this type of compensated circuit as the foundation, a capacity control device has been constructed by the Teletouch Corporation for various uses, particularly as a burglar alarm and for the control of commercial advertising displays such as the show-windows of retail stores. One interesting application of the latter type, publicized in the newspapers under the name "Magic Mirror" makes use of the mirror coating as the capacity-sensitive element. This mirror coating is semi-transparent when illuminated from behind, but opaque and reflecting when not so illuminated. Consequently it is possible to set up an innocent-looking mirror in a public place and to connect the capacity relay to the mirror surface so that passers-by pausing to make use of the mirror will actuate the mechanism. Thus, as a person comes close to the mirror, part of the mirror surface suddenly becomes illuminated, revealing an advertising message or product behind, while the remaining part of the mirror retains its opaque reflecting surface. The same capacity-sensitive device is used for the protection of safes, jewelry displays, and similar small volumes of great value. By using large conducting areas, underneath rugs, etc., rooms and doorways can likewise be protected.

In connection with the uses of its devices as burglar alarms, the Teletouch Corporation has made a considerable investigation of the types of protection generally desired by merchants and similar customers. They have found that professional thieves are very quick to appreciate the presence of burglar alarm devices, and also are much more clever than is generally supposed in getting around them. For this reason the Teletouch burglar alarm system is so constructed that cutting wires, either in the capacity-antenna circuit or in the power circuit, automatically actuates the alarm, which is run by dry cells contained within the cabinet itself. Opening the door of the capacity unit has the same effect.

Another feature of interest in burglar protection is the continuity of the alarm. In the conventional tin-foil system the alarm bell or horn, once started, remains blasting continuously until the owner of the shop arrives to turn it off. By the time the police or the owner arrive often the thief has made his departure because the great clatter has scared him away. While the Teletouch alarm can be made to run continuously in this fashion, its developers have found that many customers prefer to have the alarm sounded only while the thief is in the vicinity of the protected area.

If the thief departs, the alarm thereupon ceases and the annoyance to the neighborhood is considerably minimized. If the thief, encouraged by the silence, attempts to re-enter the protected zone, the alarm again rings.

The self-contained photo-relay installed in a New York department store for window-lighting control



Amplifier cabinet used with the self-contained photo-relay

Electric Time from D-C Circuits

Another electron-tube device invented by Professor Theremin and developed by the Teletouch Corporation, is a d.c. to a.c. inverter for use in driving synchronous electric clocks. The need for such a device has long been felt in many metropolitan areas, notably those in New York City where d.c. is the only power available. The Teletouch inverter, described in U. S. Patent No. 2,047,912 derives its power from the d-c circuit. The d-c is inverted in vacuum tubes (as distinguished from the gas-triodes widely used for inverter service). The timing control of the circuit is obtained from the d-c commutator-ripple which is always present in d-c sources of supply. Since the speed of d-c machines can be regulated within close limits, it is possible to govern the frequency of this ripple (which usually takes the form of 0.1 per cent a-c component of 150 cycles per second) with great accuracy. The function of the inverter is then to remove the alternating component and amplify it sufficiently so that it may be used to control the grids of the inverter tubes and invert to 60 cycles. The unit is small enough for use in nearly all applications, and uses conventional receiving type tubes at sufficiently low operation ratings to insure long life.

The latest venture of the Teletouch organization is into the field of photoelectric relays, and in this case also they have unearthed an unusual wrinkle which adds greatly to their utility. The basic idea of the photoelectric relay developed by Professor Theremin is the inclusion of both light source and photocell in the same unit, and the actuation of the relay not by interference of a beam reflected from a mirror, but by changing the reflecting factor from any surface whatever. This system requires large amplification of very low frequencies, and brings in the corresponding problem of compensation for changes in voltage, temperature, and similar factors which become more important as the sensitivity of the device is increased. The fundamental compensation invention, previously referred to in connection with the capacity operated relay, is employed in modified form.

The Teletouch Ray, as the phototube relay is called, has the following construction: The phototube and light source are contained in a box, or "Camera," side by side but in a separate compartments. For night operation the light source is a 200-watt electric bulb of small dimensions, which is cooled by conduction through a large metallic structure with radiating fins. The light from this lamp is directed through a condensing lens and sent outward from the box toward the area over which it is desired to establish control. This area need not have a high reflecting factor; for example, a street surface or sidewalk is commonly used, especially for show-window control. The beam of light, hitting this surface, produces a round bright spot on which the phototube is focused by means of a similar lens system. The phototube current resulting from the extremely small illumination provided is then considerably amplified by usual methods except, as already stated, that the amplifier must be of exceptionally stable characteristics. The circuit is then so arranged that the relay remains inoperative so long as the reflectance of the control surface is not changed. However, if any object interrupts the beam or passes over the bright spot on the reflecting surface, the phototube current is then increased or reduced, depending upon whether the interfering object has a higher or lower reflectance factor. The circuit is arranged so that any change from the normal value of phototube current produces a positive indication and operation of the relay. By means of step-by-step relay systems very large loads (up to 20,000 watts, for example, in typical window-lighting displays) can be controlled from the output of the amplifier.

This system has many advantages over the use of a separate light source mounted opposite the phototube. In the first place it enables the operator to obtain control from an area over which he has no jurisdiction. In the window-lighting case, for example, it is not possible for the store to place a light source in the street, since the street is public property. However, there is no regulation against the shining a beam of light at the street and of using the reflectance from the street as the control factor.

The latest development in this line is a self-contained phototube relay which contains both the "Camera" and amplifier in the same unit. The window lighting model contains a separate amplifier, and thus requires a more troublesome installation by an electrician. The self-contained unit is set in operation simply by connecting to a wall outlet.

Merchandising Policies

Any organization which intends to capitalize on the development of electronic control devices has a dual problem. In the first place, it is necessary to have sound engineering and proper construction of the apparatus so that it will function as intended. In the second place, there arises the problem of merchandising the devices so that they can be put to use widely and effectively.

The Teletouch Corporation has approached this problem from several points of view. First, a wide variety of applications of the device have been conceived by the organization. In the second place the Teletouch organization has concentrated its efforts largely in retail commercial applications rather than in the more industrial applications encountered in factory work. Thus the Teletouch Ray installations have been made in the R. H. Macy store in New York, the Gimbel store in Philadelphia, the Brooklyn Edison Company, in the Sloate Chevrolet Company of Hartford, and in several other similar installations. The Magic Mirror device lends itself especially to jewelry display, and has been employed by Black, Starr & Frost, in New York City.

All of these applications have two important sales factors involved. In the first place, the apparatus operates only when the attention of the passer-by is directed toward it. Thus, while it is common practice to illuminate store windows from sundown until midnight, it often happens, especially during stormy weather, that the street crowds are extremely small and the lighting power is then largely wasted. By adopting either photoelectric or capacity control devices it is possible to restrict the lighting of the windows to such times as passers-by interrupt the light beam or actuate the capacity mechanism. This sort of economy appeals highly to retail merchants. In certain circumstances it appeals to the public utilities which supply power to retail merchants. This is particularly important in small towns, where retail establishments do not illuminate windows because of the large expense, but might readily be urged to do so if the lights are put on only when needed.

The second factor involved in retail store installations is the high publicity value which is derived therefrom both from the general public. For example, when the R. H. Macy installation was made, newspaper write-ups in practically every New York newspaper appeared immediately thereafter, resulting in well-earned publicity, both for Macy's and for the Teletouch Corporation. The restriction to commercial displays has its limitations, of course, and it is expected that many industrial applications will supplement the retail installations now made. The success which the Teletouch Corporation has derived from its policy, however, is indicative of what can be done by an aggressive merchandising organization backed up by proper engineering, and capitalizing upon the growing public appreciation of electronic control devices.

A Record-Saving Pickup

Mechanical design reduces wear on records by reducing change in tracking angle as needle moves from center to edge

By RALPH P. GLOVER
Chief Engineer, Shure Brothers, Chicago

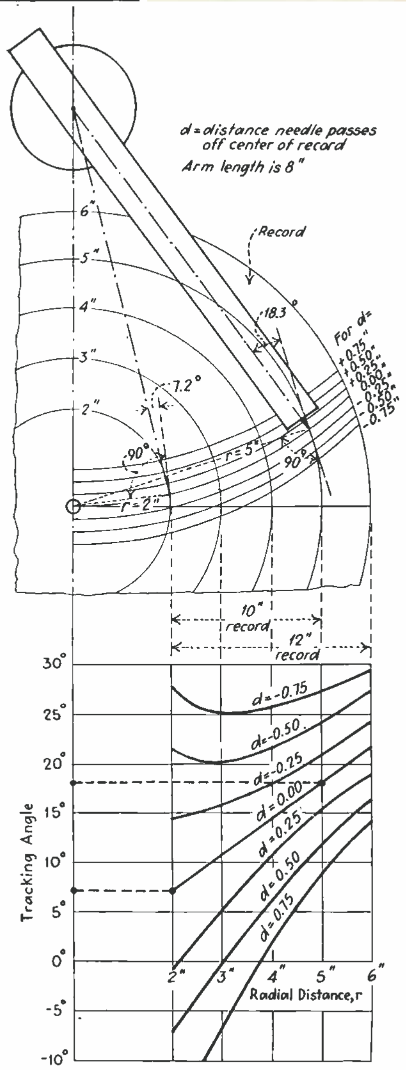


Fig. 1—Tracking angle variation

PHONOGRAPH record reproducer design in the United States in the past seems to have been based on frequency response and output voltage requirements. The amount of wear on the record, however, is a highly important consideration, especially in the cases of automatic repeating devices and home-entertainment equipment where each record is replayed many times. Acetate and other "instantaneous" records also require a reproducer which will cause a minimum of record wear for maximum service and best reproduction. The crystal record reproducer described here causes far less record wear than conventional devices with equal needle pressure, and attains excellent frequency response and transient response, together with sufficient output voltage to produce full output from a low-gain audio system such as that built into the conventional radio receiver.

For low record wear, the needle pressure and needle impedance should be low and the horizontal projection of the needle should be tangent to the record groove at all times. The vertical projection of the needle should be normal to the surface of the record also.

In recording, the cutting head is moved radially across the record and generates a close-pitch spiral groove which may be considered as a series of closely-spaced concentric circles. In reproduction, however, the pickup arm is pivoted at one end and carries the reproducing head and needle at the other end. To make the motion of the needle correspond to that of the cutting head, the length of the arm would have to be infinite. For the practical finite arm the needle describes the arc of a circle across the record, and the projection of the needle on the record makes an angle with the tangent to the groove at the point of contact. This departure of the needle projection from tangency is called the *tracking angle*.

The actual value of the tracking angle depends on the length of arm, distance between arm pivot and center of record and radial distance from center of record to needle point. Figure 1 shows curves of tracking angle for common 8" arm. Note rapid change of tracking angle when distance from pivot to record center is equal to or greater than arm length. Conventional arms are placed so that arc of travel of needle

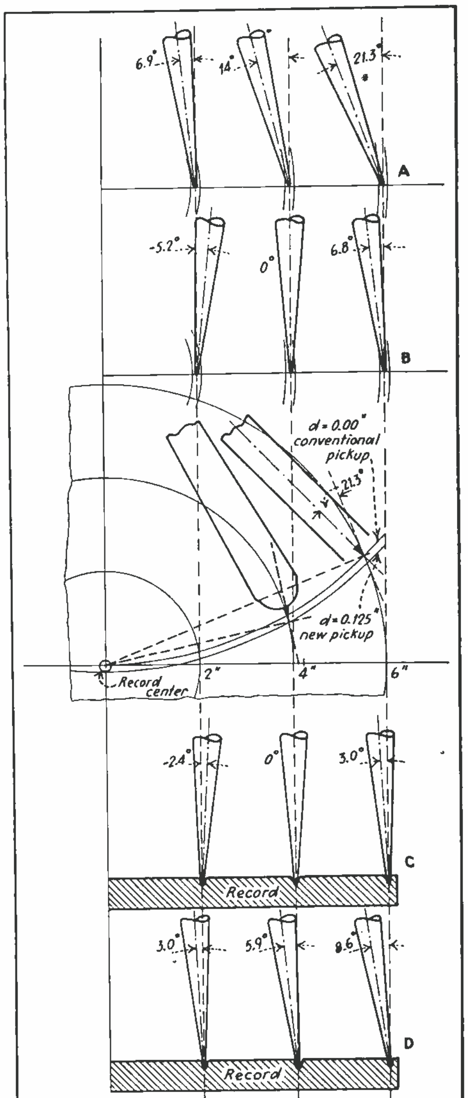


Fig. 2—Needle orientation, A and D, conventional pickup; B and C, new pickup

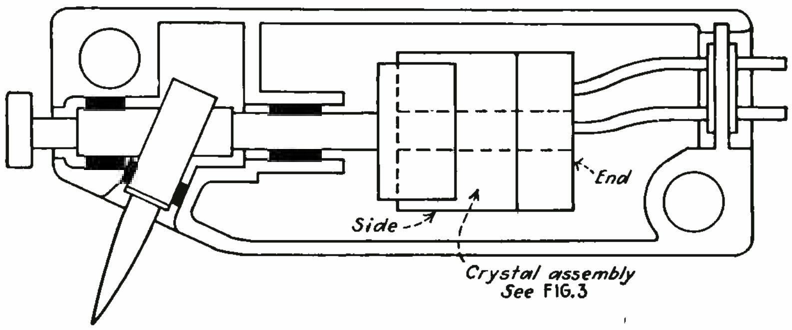


Fig. 4—Cross section of record-saving pickup

passes through center of record (d = 0). This gives maximum tracking angle at the outside of the record and a straight-line decrease in angle as the needle traverses the record. A rapid change in tracking angle is objectionable since the needle point wears out to fit the groove. The needle point is continuously reshaped at the expense of the record, producing excessive wear.

Tracking angle changes can be reduced when the arc of the needle passes the center of the record on the far side of the arm pivot. See Fig. 1, curves for positive values of "d". This increases the tracking angle itself which is highly objectionable because, due to thrust, the needle bears on one side of the groove with undesirable results from the standpoint of wear. There is also a loss of fidelity, particularly at the high frequencies.

A survey of the literature indicates that this situation has been thoroughly appreciated abroad. Notable examples of tonearms which correct for tracking angle can be found in the products of manufacturers in England, Continental Europe and Australia. All of these devices are of the "bent arm" type. Correct design involves the selection of proper arm length and value of "d" to give essentially constant tracking angle and to correct for, or eliminate, this tracking angle by bending the arm or angularly displacing the reproducing head by a corresponding angle.

The straight tonearm is the simplest and least expensive mechanical link. It is best adapted to artistic design and requires least space—an important consideration where compactness is essential.

The method of tracking angle reduction employed in the reproducer described here involves an angular displacement of the needle relative to the working axis of the reproducing head or "cartridge". The cartridge may be mounted in any suitable straight tonearm and may be used as a replacement unit which reduces the tracking error.

Figure 3 shows "end-on" and side views of the needle-chuck employed for this purpose. By simple geometry it is easily shown that the "tilt angle" ϕ is determined by the expression:

$$\tan \Theta = \frac{\cos \delta \sin \phi}{\sin \delta}$$

δ is the conventional forward inclination of the needle (usually 20 to 30 degrees) and ϕ is the angular displacement of the needle about the axis of the reproducing mechanism. The length of arm is chosen and an operating curve of Fig. 1 is selected, thus determining the tracking angle which is to be compensated. The compensating angular displacement Θ is made about equal to the average tracking angle thus determining the required tilt angle ϕ.

Figure 2 shows a comparison between needle orientations obtained with the conventional and new reproducers. Above, corresponding tracking angle variations are shown for three positions on a 12 inch record, showing the improvement obtained with the new method. The greatest tracking angle obtained with the new system is smaller than the *least* angle afforded by conventional reproducers. Below are shown vertical views of the needle ("end-on relative to the tonearm) indicating improved vertical alignment relative to the groove. The "needle-tilt" method of minimizing tracking error is not limited to crystal reproducers but can be applied to other transducers.

The axis of the needle-chuck does not pass through the horizontal axis of the mechanism. This has been purposely done to allow the use of a cone-point screw for clamping the needle in the chuck. At the same time the point of the needle comes directly below the axis of the mechanism, eliminating the torsional moment that would otherwise result from forces perpendicular to the record. This, combined with a floating mounting of the square torsion crystal between strips of viscalloid, results in an assembly which is immune to ordinary mechanical shocks. The mechanical system is designed to present low needle-point impedance which of course still further tends to reduce record wear.

The audio response is exceptionally uniform and covers the entire frequency range available on current records. Transient response is likewise "clean".

In the preparation of this article, the writer wishes to acknowledge the assistance of Mr. Ben Baumzweiger, who developed the "needle-tilt" principle.

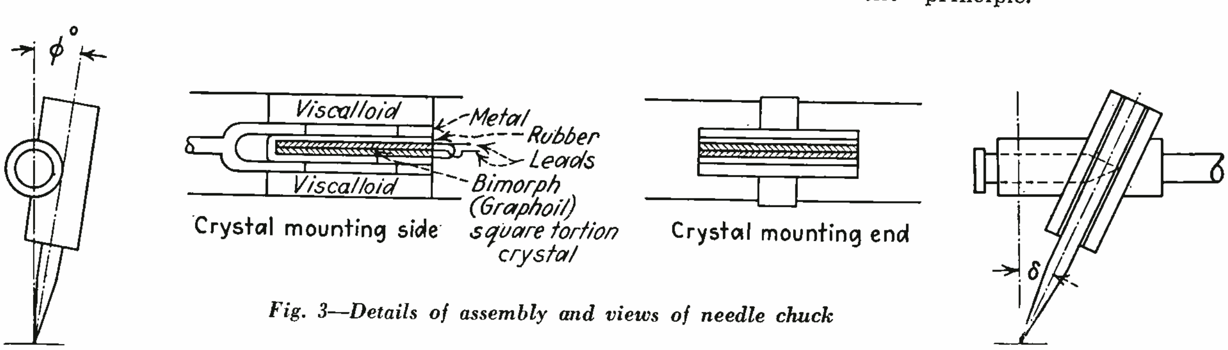


Fig. 3—Details of assembly and views of needle chuck

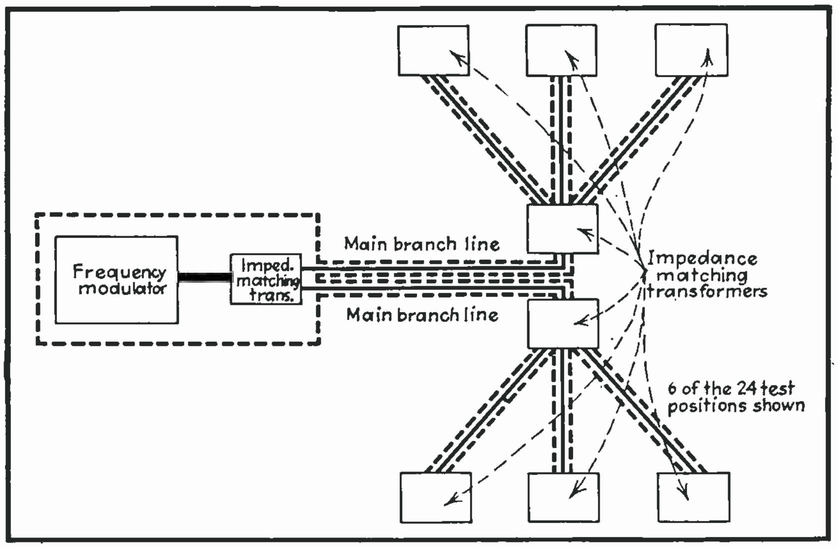


Fig. 1—General plant layout showing placement of transformers, etc.

I-F Transformer Alignment

By R. NATHAN
Chief Test Engineer
Midwest Radio Corporation, Cincinnati

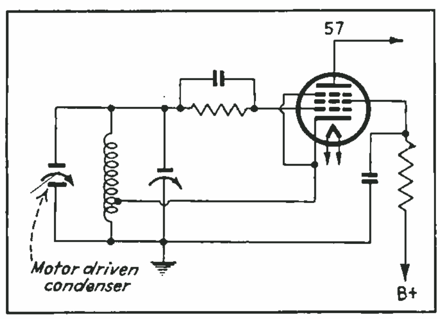


Fig. 2—Circuit of oscillator employed

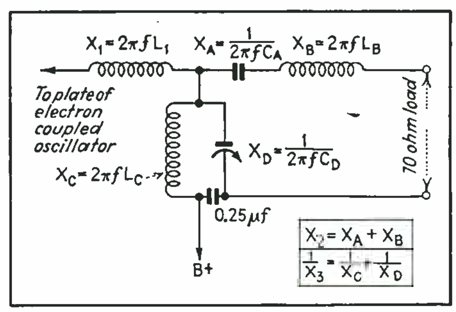


Fig. 3—Oscillator plate to line transformer

THE modern superheterodyne receiver, with its AVC amplifier, selectivity and sensitivity controls and tuning aids, each of which is associated in some manner with the i-f system, demands a technique in i-f alignment, which was not necessary several years ago. For several years after the advent of the superheterodyne, the i-f alignment procedure was to supply a modulated signal equal in frequency to the i. f. of the receiver to be aligned, to the grid of the 1st detector tube. The number of microvolts of the signal strength was predetermined. With the aid of an output meter, the circuits of each stage were in turn tuned to resonance. This condition was obtained when the output meter indicated a maximum deflection.

About the time that the various above mentioned controls made their appearance in radio receivers, cathode ray equipment was being developed very rapidly. The cathode ray oscillograph together with the frequency modulator seemed to be the answer to the complicated i-f alignment problem. At present many radio receiver manufacturers use cathode ray equipment exclusively for i-f alignment. It is the purpose of this article to describe a system which is now in operation, and which makes i-f alignment quite simple.

It was thought best to have a single frequency modulator, monitored with a crystal controlled oscillator, since all test positions would then be supplied with the same frequency. There is a constant check on the mean frequency of the modulator by means of the crystal monitor.

The use of a single frequency modulator, however, made necessary the use of a matched transmission line system. The matched line was necessary since the lines were to be of shielded cable 400 to 500 feet long.

One line was to run to a central location in each of the test departments. At each of these central junctions each line was matched to its total load, for example, the load represented by lines supplying 12 test positions. At each test position the branch line supplying that position was matched to an attenuator. This matching device along with the attenuator, is an integral part of the cathode ray oscillograph for that position.

At the other end of the line, the frequency modulator was matched to both of the main branch lines. The oscillator for the frequency modulator is electron coupled. The design for the impedance device from plate of generator to line follows. The entire design was carried through for a frequency of 456 kc.

Circuit of impedance matching transformer from plate of electron coupled oscillator to both main branch lines is shown in Fig. 3. Each main branch line represents a load of 140 ohms as determined by the impedance of the cable.

(Continued on page 71)

Backtalk

Shot Effect

I have read the report which appears in the December *Electronics* of the paper entitled "Shot Effect in Space-Charge-Limited Vacuum Tubes" which Dr. D. O. North and I presented at the Rochester Fall meeting. This report is in error.

We do not believe that the noise is zero with "complete space charge". We did not discuss "intermediate values of space charge". We did not state that the virtual cathode acts as a temperature-limited cathode. We did not say that the thermal agitations formula is used to give the noise in the case of a temperature-limited cathode. We do not think of electrons flowing from anode to cathode.

The points I tried to make clear are:

1. Shot effect is not zero in space-charge-limited currents.

2. If it were not for fluctuations in the value of the minimum potential, the shot effect would be the same in space-charge-limited as in temperature-limited emission.

3. A rigorous analysis of the mechanism of space-charge depression of shot effect shows that under practical operating conditions the fluctuations in cathode current are given to sufficient accuracy by the thermal agitations formula using the cathode conductance and 6/10 of the cathode temperature.

4. In spite of the usefulness of the corrected thermal agitations formula the fluctuations cannot properly be thought of as thermal agitations nor can the correct result be arrived at by thermodynamic reasoning such as that presented by Dr. Llewellyn.

These errors in this report of our paper would be of relatively small concern to us were it not for the wide circulation of *Electronics*, and the usual trustworthiness of its information.

B. J. THOMPSON
Research and Development Laboratory, RCA Mfg. Co., Harrison, N. J.

What's Time to a Hog?

Hamlet said the time was out of joint. Standard time still is, according to the Interstate Commerce Commission, which wants Congress to set it right with a law.

The Commission is moved by such inquiries as "What the hell time is it anyway?" from an executive in Michigan who had ordered his chain stores to open two hours late. The man was confused by Michigan's three kinds of time: Federal, state and local, complicated by daylight saving. It got so bad that Michigan threw out all three and imported Eastern standard time—except for the Northern peninsula, which is part of Wisconsin, by the clock.

A lot of other states and towns have been two- and three-timing the Government ever since Congress repealed the "Act to save daylight," over President Wilson's veto, back in 1920.

Time zones were adopted by the railroads in 1888. Congress made them law in 1918. But the law is applied only to those engaged in interstate commerce, government officials and departments, and to persons acting under federal regulations.

Strange things are done. For instance, Connecticut has a standard time law but the entire population goes by daylight saving, everywhere. In Massachusetts the Grange declared the state daylight law unconstitutional. But the Supreme Court said it *was* constitutional. So in summer the farmers still wake their cows at three o'clock in the morning.

The ICC is sure that, soon or late, something is bound to go wrong. Hunters have already been arrested for shooting ducks before six in the morning, when it was really after seven. Some day there is going to be a big lawsuit to decide whether it was noon or eleven or one o'clock when a million dollar insurance policy expired. Or a man is going to miss being hanged because the hangman was hanging by daylight saving. Question would be: Could the executioner make another appointment with the party?

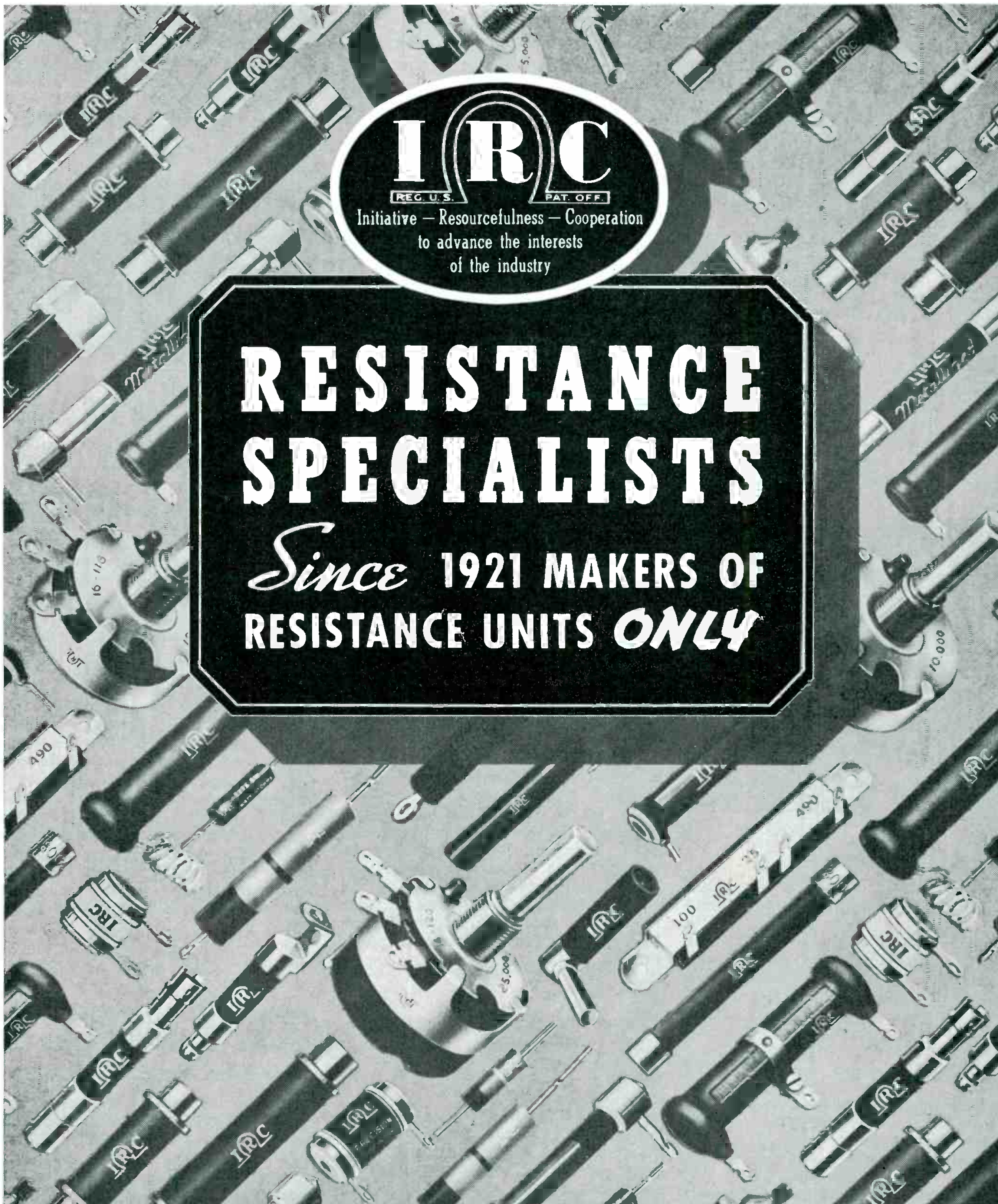
Radio broadcasting people used to schedule programs, as of the time at points of reception, but it was driving them crazy. Now they simply tell what time they will send it, by their own clocks, and the customers have to figure out when they will get it.

Railroads make a go of standard time. They invented it. But that's strictly among themselves. Between them and the public is daylight saving, and it's a headache night and day. Practically no traveler can tell whether an hour ahead means later or sooner. Clerks explain it to millions, as thousands miss the trains.

The ICC used to recommend that the federal government either "occupy the legislative field completely" or else let go of Father Time's forelock and let the states get into his hair. But now, with the nation's clocks all cuckoo, it wants Congress to say "My time is your time." If not, then there are those who hint that the Interstate Commerce Commission would like to put its old chronometer on the doorstep of the Bureau of Standards and let them try to regulate it.

BLAINE STUBBLEFIELD,
Electronic's Correspondent Washington, D. C.

H. F. Mayer, General Electric, (See Electronics, *December, 1936) shoots Empire State building from McGraw-Hill roof*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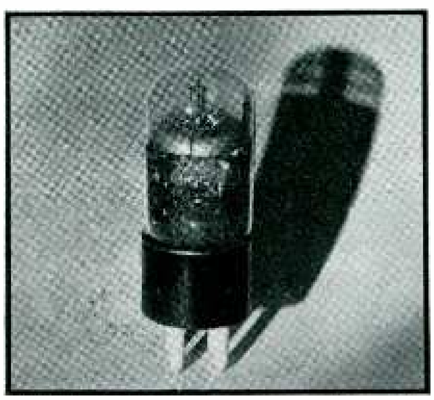
TUBES AT WORK

A NEW cold-cathode relay tube, X-raying fruit for internal defects, a combined capacity-relay and talking-machine, phonographs for teaching music, circuits for producing r-f pulses—all in this month's collection of tube uses

Cold Cathode Tube Developed for Telephone Service

ACCORDING TO AN ANNOUNCEMENT in the December 1936 issue of the Bell Laboratories Record, a new type of gas-filled tube having cold electrodes has been developed for use as a relay, voltage regulator, or rectifier. The tube, shown in the figure, has three elements, two of which are "control" electrodes (semi-circular in shape) while the third is a wire-shaped anode. The control electrodes are coated with activated barium to reduce the necessary starting voltage of the tube. The tube is filled with a mixture of the rare gases, of which neon is the principle constituent. The use of the activated cathode (control electrode) and the mixture of gases produces a low voltage drop through the tube, about 75 volts, in contrast to several hundred volts necessary in similar tubes not having activated electrodes.



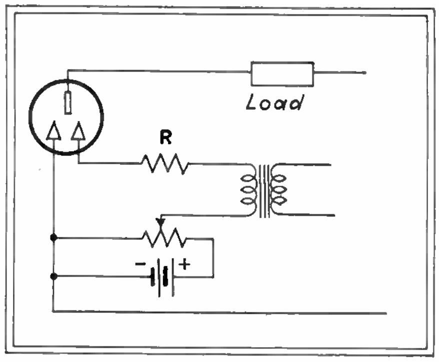
Gas-filled relay tube

In operation there are two conducting paths of interest, between the two control electrodes and between one control electrode and the anode. The voltage necessary to produce breakdown between two control electrodes is 70 volts; that necessary to maintain the discharge thereafter is 60 volts. On the other hand a voltage of 175 is necessary to break down the gap between the anode and one of the control electrodes, while the sustaining voltage in this case is 75 volts. The difference between the breakdown voltages of the two paths makes it possible to use the tube as a relay, a typical circuit for this use being shown in the diagram. A biasing voltage is placed between the two control electrodes, nearly large enough to cause breakdown. A signal voltage supplied by the transformer is then added to the biasing voltage. The positive peak of the signal breaks down the control gap and starts the discharge, whereupon currents up to 30 milliamperes may be carried between the control electrodes and the anode.

Because of the difference in shape in the electrodes, the voltage drop for forward conduction is considerably lower than for the reverse conduction, in the ratio of 75 to 200 volts (for conduction between one of the control electrodes and the anode). Rectification of alternating current may therefore be obtained with the tube, provided that the voltages supplied are of the proper range, namely, so that forward conduction will occur without reverse conduction.

The regulating action of the tube is obtained usually by the use of the two control electrodes, between which a sustaining voltage of approximately 60 volts is necessary to maintain the discharge. The voltage drop through the tube tends to maintain itself at this value of 60 volts regardless of the current flow, and this property can be used to provide a regulated source of voltage, which appears across the two control electrodes.

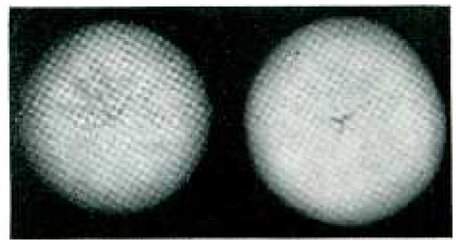
One of the most interesting applications of the new tube is connection with ringing in four-party telephone circuits. One of the new tubes (type 313A) is included in the ringing box of each subscriber's telephone set. This is the first application of an electron tube in subscriber's plant in telephone practice.



Relay circuit using new tube

X-Ray Used to Study Internal Defects of Fruits and Vegetables

EMPLOYING A PORTABLE X-ray machine equipped with a fluoroscope for the study of internal defects of many vegetables and fruits is as simple as the system of "candling" eggs. Through a system developed by Dr. R. B. Harvey, plant physiologist at the University of Minnesota, it is not necessary



Two apples x-rayed by Dr. Harvey. Different degrees of internal breakdown are shown by the darkened spots

to cut the fruits or vegetables open for inspection and therefore it is possible to use larger samples of products and experimental studies may be carried on while the products are still growing.

One of the internal defects of potatoes which Dr. Harvey intends to study is the cause of the hollow heart of potatoes. Experiments in different communities will be set up so as to use several varieties of potatoes. A picture of the internal cleft in the potatoes is obtained by the X-ray without cutting the potatoes and it will be possible to examine individual potatoes at varying periods of time in the field without removing them from the plant.

An equally important feature of this system of X-ray inspection is the ability to use it in studying some of the more important storage defects in apples, such as internal decline, core flush and water flush.

• • •

"Talking Mirror" Uses Capacity Relay and Photo Tube-Film Reproduction

A RECENT APPLICATION of electronics in the field of advertising displays has been made in the "talking mirror." As shown in the picture, the device contains a mirror surmounting a loud speaker and amplifier system. The mirror surface (on the rear of the glass) is connected to a special capacity relay which operates on the body capacity of any person approaching the mirror. The capacity relay sets in operation a 16 mm. film, on which

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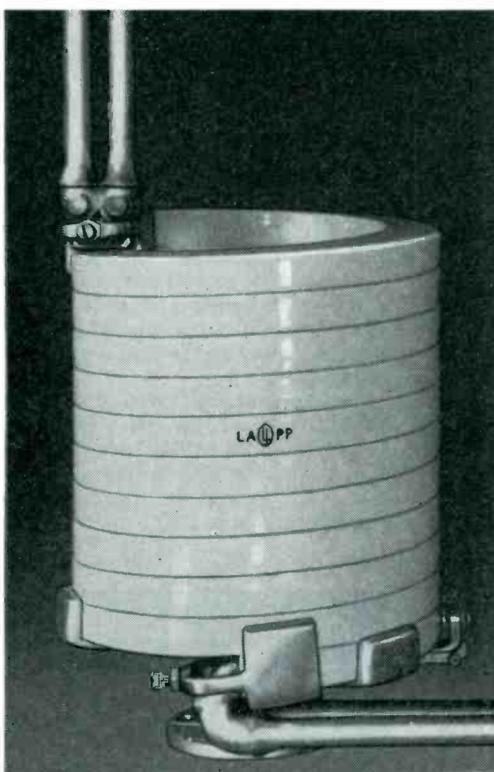
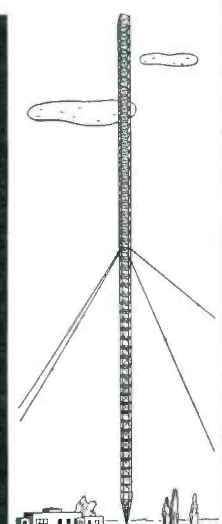
AS foremost supplier of porcelain insulation to the radio industry, Lapp realizes its responsibility for the development and production of dependable and adequate insulation equipment.

Illustrated at right is the latest development in self-supporting radiator insulation, a design which secures utmost efficiency from all materials. Tower leg footing cast integral with insulator frame—economical and easy to install. Generous porcelain cones afford maximum electrical protection. Porcelains in line with tower leg, reducing shear duty.

Below, Lapp porcelain water coil, a design that eliminates sludging. Require no cleaning, and because water is left pure, eliminates cleaning other parts of system and frequent water changes. Regularly used by all transmitter manufacturers and available for replacement in existing sets.





WRITE FOR YOUR COPY OF LAPP BULLETIN 37
DESCRIBING COILS AND STRUCTURE INSULATORS

LAPP INSULATOR CO. INC

LAPP INSULATORS

LE ROY - N.Y. - U.S.A.

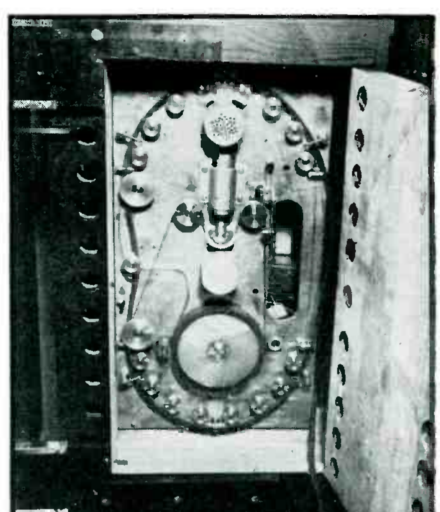
has been recorded a sound track containing the advertiser's message. A conventional phototube pick-up and amplifier feeds the loud speaker.

The capacity relay contains a 38 tube, as an oscillator, which does not

Outward appearance of the "Talking Mirror"

oscillate, however, until the person approaches the mirror surface. The period of oscillation is only about 1/20 sec., the plate potential of the oscillator tube being connected immediately after operation begins. The oscillator controls an 874 glow tube which acts as a relay, throwing the grid of a type 43 which in turn operates the mechanical relay in the film-and-phototube mechanism.

The phototube pick-up is an 868 tube amplified by two 6F5's which drive a 25B6 tube in the output, which feeds a six- or eight-inch loud-speaker. Power is supplied for the amplifier from a 25Z6.



Phototube and film mechanism which delivers advertising messages to the public

When the capacity relay operates a special holding circuit switch comes into operation, so that the announcement is made in complete form even though the person moves away from the mirror. Film travels at 16 mm. speed, and the phototube lens system is such that a flat response from 60 to 6,000 cycles is obtained. The entire device operates from 110 volts a.c. or d.c., and has operated as many as 6,000 times before any damage to the film was noticeable. The film announcement is 3 minutes in duration.

• • •

High Intensity Sound Waves

HIGH INTENSITY sound waves have provided an interesting field of research since methods of photographing them have been discovered. The sound waves to be photographed are often produced by a spark discharge, although a wire exploded by passing a current through

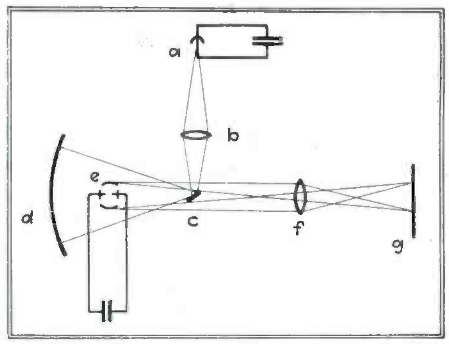


Diagram of the Schlieren method of photographing sound applied to a spark discharge

it is another common method. The waves produced by the sparks are found to consist, according to Dr. C. G. Suits whose article, "Notes on High Intensity Sound Waves" appears in the September 1936 issue of the *General Electric Review*, of a single pressure pulse which is propagated with a velocity initially greater than the normal velocity for the ambient temperature. This velocity decreases rapidly within a few centimeters from the source and approaches relatively slowly and assymptotically the normal velocity.

A common method of photographing spark discharges which is very sensitive to changes of refractive index is the Schlieren method shown above. Light from the point source, a, (which may be a spark discharge) is focussed by means of the lens, b, on a plane mirror, c, where the divergent rays are reflected to a spherical mirror, d. The spherical mirror reflects the light back to the point a through the plane mirror so that—providing the optical system is perfect—an observer

permanent

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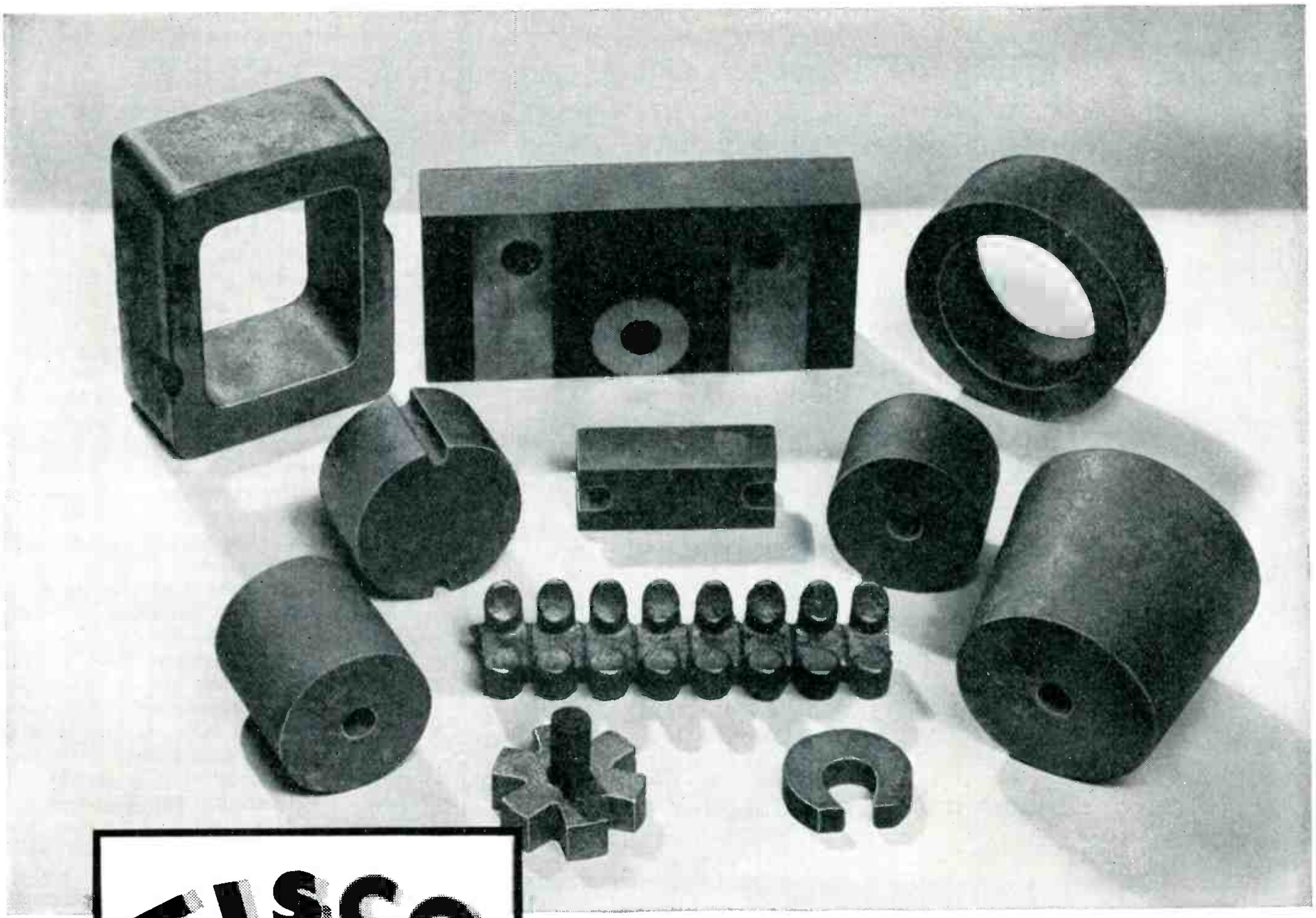
fully tested for magnetic properties



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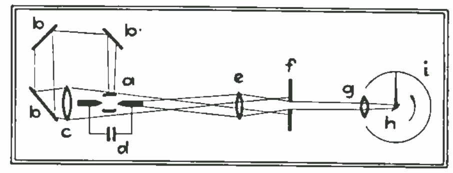


Combined shadow method and rotating camera technique for use with a spark discharge

at g and looking at the spherical mirror sees only a dark field. Any object at e, such as a spark, which will bend the rays leaving the spherical mirror provides light which is focused by a lens, f, on a photographic film at g so that a permanent record may be obtained. This method is sufficiently sensitive as to indicate a change in refractive index caused by the convection currents produced by body temperature.

By combining this shadow method with a rotating mirror camera, a continuous passage of the sound wave near its source can be provided. The spark at a provides not only the sound wave which is to be photographed, but also the light by which it may be photographed. The system of three mirrors, b,b,b, and the lens c uses the light from the discharge for parallel beam background illumination. The image is focused by the lens g on the mirror h which rotates and produces a photographic record on the film, i.

The passage of a sound wave of high intensity through an arc or spark discharge may extinguish this discharge, and photographs have indicated that the sound wave, rather than the initial pressure pulse, is very probably the cause of extinction. The theory of the mechanism of extinction by sound does not appear to be too well understood in all cases. In many cases the extinction results from a large displacement of the arc or spark atmosphere; in other cases the arc is extinguished even though the displacement of the gas molecules is slight.

Using the sound produced by exploding wires and the rotating camera technique, Dr. Suits has calculated the amount of energy which goes into sound and concludes that approximately 97 per cent of the energy radiated is in the form of sound and only three per cent is in the form of light. This calculation applies only to the initial period.

• • •

Multi-unit Phonograph for Schools

WHILE the phonograph record of present-day standards continues to exert an ever-widening appeal in the public mind as readily available material for entertainment purposes, it is of late becoming increasingly popular among educators as a valuable ally in the classroom, particularly in the teaching of music.

One of the pioneers in this phase of music pedagogy was George A. Wedge, head of the Theory Department of the Juilliard School of Music, New York City. Aware of the value of revealing to the student the structure of a composition through its actual recorded performance by eminent artists, a procedure which could be repeated as often as desired, a collection of records was started, small at first, but constantly augmented until a library of impressive size and diversity was built up.

Because the limited facilities as regards machines and available space

Pupil using phonograph unit

were soon taxed beyond capacity, it was proposed to use several individual turntable units and amplifier stages feeding a pair of headphones to each pupil as shown.

The unit comprises a table eight feet long housing the four turntable assemblies, which are separate panels faced with slate-gray formica and on which are mounted the motors and high impedance magnetic type pick-ups.

Each motor unit has a one-stage audio amplifier in the enclosing compartment utilizing a 76 tube. The output goes to a matching transformer which supplies a bank of headphones if desired.

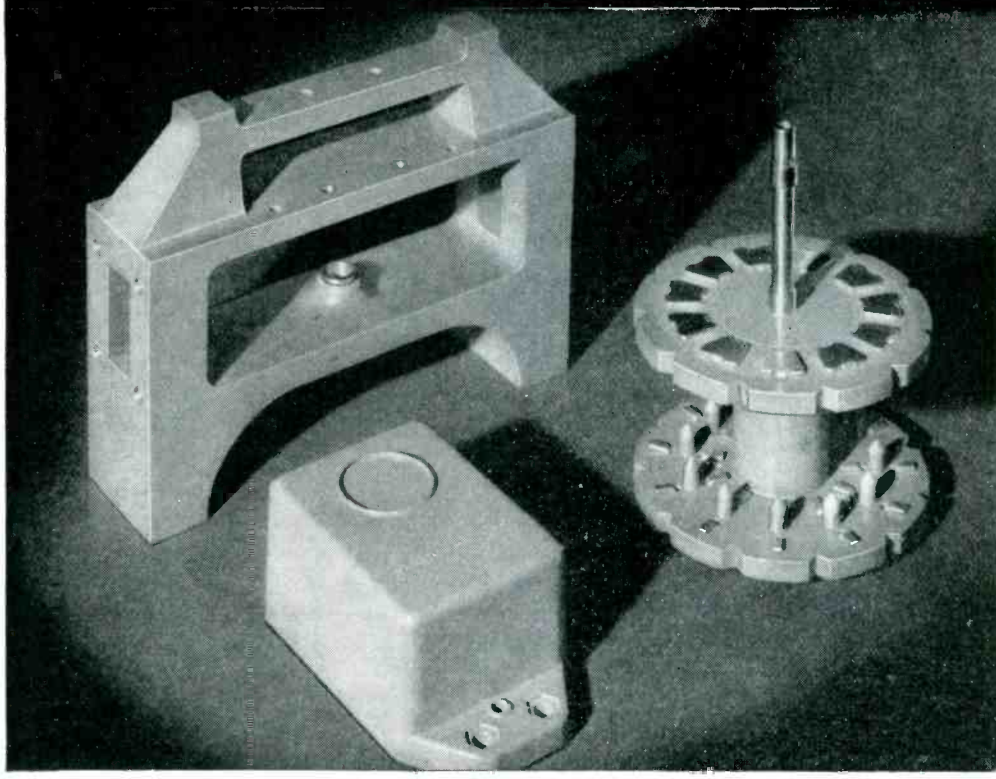
A separate volume control is furnished for each pick-up for use on extra-loud recordings, but as a rule the volume is ample at about 80 on the gain control scale. Located at each end of the table are four jacks through which students may listen in on any particular turntable, and twelve at one time are comfortably accommodated.

• • •

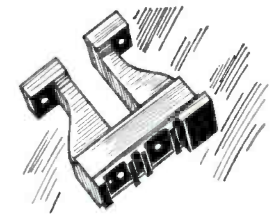
Tube Charger Used with New Battery For Hearing Aids

THE PROBLEM OF REPLACEMENT of small dry batteries in hearing aid apparatus has been considerably eased by the development of a lightweight battery of the semi-wet type, which can be recharged regularly. The charging unit is of the vacuum tube rectifier type, using a 25Z5 radio tube. The manufacturer recommends that the tube in the charger be replaced at least every

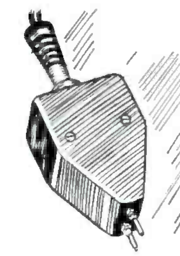
More Efficient Plastics
FOR HIGH FREQUENCY PARTS



Resistor Drum and Capacitor Frame used in Leeds & Northrup Co. high frequency equipment, molded by Tech-Art Plastic Co.; and General Radio Co. Condenser Case, molded by Bay State Molding Co.

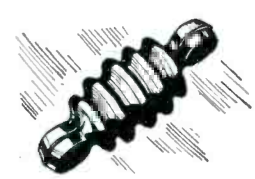


Brush Support for High Frequency Resistance Box

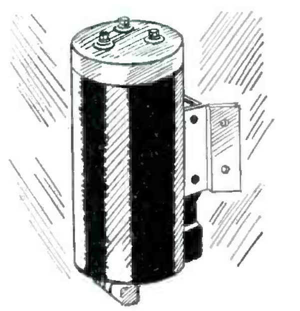


Housing for Vacuum Tube Voltmeter Probe

Aircraft Distributor Head



Automobile Running-Board Antenna Insulator



Ignition Coil Cover

Above are five of the many appropriate applications for low-loss Bakelite Molded.

IT is quite generally recognized that the dielectric efficiency of any high-frequency electrical part depends not only on the resistivity, but also on the power factor of the material from which the part is made. It is possible that careful study of power losses in many existing electrical parts may lead to significant advances in design.

For the forming of parts in which power losses must be held to a minimum, low-loss Bakelite Molded offers exceptional advantages. This material possesses high resistivity and dielectric strength, and also the lowest power factor of any molded plastic adapted to the same uses. Its power factor is only 14% that of general purpose Bakelite Materials at one million cycles.

In addition to these electrical merits, low-loss Bakelite Molded possesses other typical advantages of Bakelite Materials...moisture-proofness, chemical resistance, durability and ready adaptability to form. Manufacturers and designers of all types of high-frequency parts are invited to consult us regarding possible benefits of low-loss Bakelite Molded for their products.

Also write for our 48-page illustrated booklet 13M, "Bakelite Molded".

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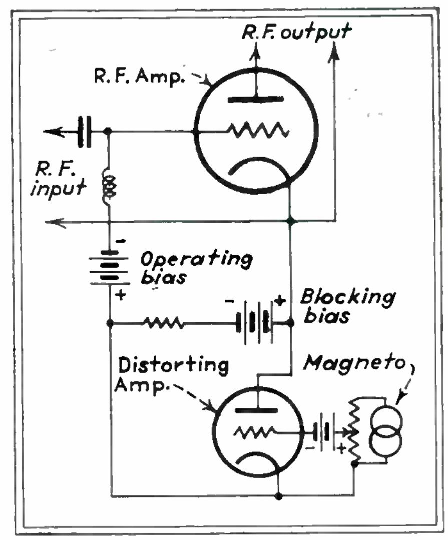
THE MATERIAL OF A THOUSAND USES

six months. Two batteries are used, one being charged while the other is used in the hearing aid unit. The charging rate is adjusted so that the battery is charged for the same number of hours that it is used, and must in any event be charged twice a week for two eight-hour periods.

• • •

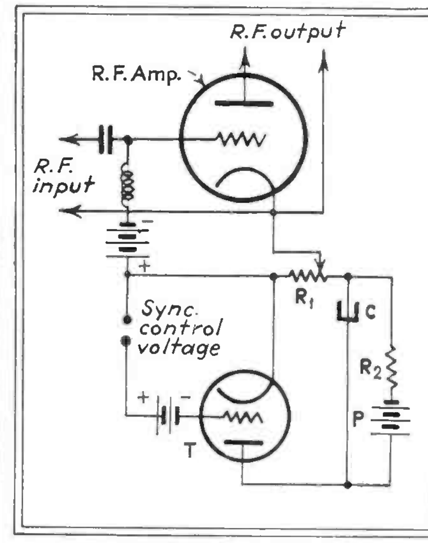
Production of Radio Frequency Impulses

A RECENT CONTRIBUTION by Colwell, Friend and Hall, in the November 1936 issue of the Review of Scientific Instruments, describes several interesting methods of producing short impulses in radio frequency amplifiers. These impulses have been used for studying the virtual heights of the ionosphere, since they are of short enough duration to permit accurate recording of reflected signals. The methods consist in varying the bias applied to the grid of the radio frequency amplifier. Various methods of producing pulses in the operating bias are suggested, from a simple mechanical chopper which short-circuits the blocking bias, to a complicated thyratron arrangement. Several of the suggested circuits are shown in the accompanying diagrams. In one, an induction coil is used as the source of blocking potential on the grid, the primary of each coil being closed by a contact arrangement. The sparking and arcing of contacts, however, is a serious difficulty in long continuous operation. A liquid contactor has been developed which gives excellent service over long periods of operation, and produces pulses of approximately 100 microseconds in length. The contacting consists of a rotating nozzle which produces a stream of fluid, under centrifugal action. The stream makes contact with a platinum wire once during each nozzle revolution. The conducting fluid may be dilute sulphuric acid, or some similar conducting medium. Other sources of blocking po-



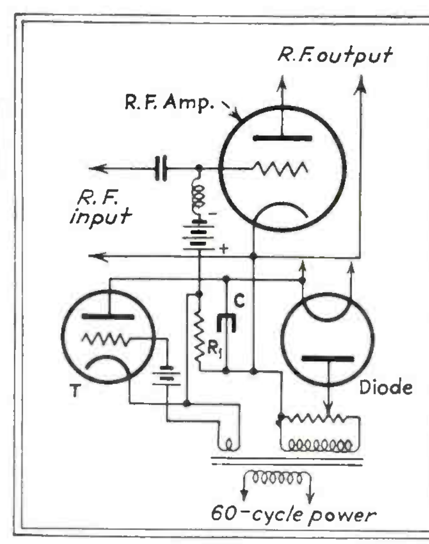
Magneto circuit

tential are the ordinary telephone magneto which is connected in series with the blocking bias, and a variation in which the output of the magneto



Gas-tride control, separately synchronized

is put through a distorting amplifier, which limits the pulse length to approximately 500 microseconds. The use of a mercury vapor triode as a relaxation oscillator is also suggested. This circuit takes two forms: in one a condenser is charged from the battery through a resistance and discharges



Self-synchronized diode circuit

through the mercury vapor triode under the control of the synchronizing voltage applied to its grid. In the second case the condenser is charged through a diode which operates only on the positive half of each alternating current cycle. The grid in the triode is operated 180 degrees out of stage of the charging potential, so the discharge takes place only when the diode is non-conducting. The result is a very high degree of reliability and accurate synchronization over long periods of operation.

THE ELECTRON ART

EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

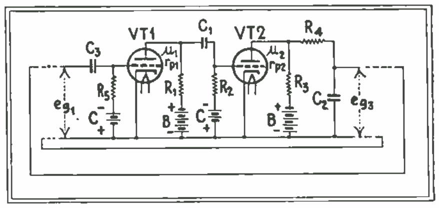
UNDER THE TITLE, "Über Rückkopplungschultungen ohne Resonanzkreise" appearing in Vol. 13, No. 4 of the *Elektrische Nachrichten-Technik* for 1936, M. Lattmann and H. Salinger present a discussion of several oscillator circuits. One of the circuits described consists of a two stage resistance coupled amplifier with the output of the second stage coupled to the input of the first stage. At first the circuit appears to be the same as the multivibrator circuit of Abraham and Bloch, but examination shows that the coupling from the output of the second stage to the input of the first reverses the RC elements of the multivibrator circuit. This simple change in coupling permits of the production of oscillations between 0.01 cycle and 100 kc. per second having sensibly sinusoidal wave form.

The schematic wiring diagram of the oscillator is that given with the feed-back connections (indicated by dotted lines). For purposes of analysis we may break the feed-back connections in which case we have a two stage resistance coupled amplifier with slightly unusual output circuit. The elements C_3 and R_5, which serve only to give proper bias to the grid of the first tube by isolating it from the plate supply of the second when feedback occurs, may be neglected.

Let an alternating voltage, e_{g1}, of angular frequency, ω, exist between the grid and filament of the first tube whose amplification factor is μ_1 and whose internal plate resistance is r_{p1}. The output voltage of this amplifier which appears across R_1 will then be, $e_{p1} = \mu_1 R_1 e_{g1}/(r_{p1} + R_1) = \mu'_1 e_{g1}$, if we neglect the effects of C_1 and R_2 which are in parallel with R_1. As a result, the voltage on the grid of the second tube will be, $e_{g2} = R_2 e_{p1}/(R_2 + X_{c1})$, which, in turn gives rise to an output voltage,

$$e_{g2} = \left(\frac{X_{c2}}{X_{c2} + R_4}\right)\left(\frac{\mu_2 R_3}{r_{p2} + R_3}\right) e_{g2}$$

By putting $R_1 = R_3$; $R_2 = R_4$; $C_1 = C_2$; $r_{p1} = r_{p2}$; $\mu_1 = \mu_2$; and, consequently, $\mu'_1 = \mu'_2 = \mu_0$ the circuit solution can be considerably shortened. It can be shown that the above equalities not only result in a simpler mathematical solution but also obtain for optimum circuit operation. With these substitutions, and combining the expressions in the preceding paragraph we obtain,



Schematic wiring diagram for the oscillator circuit using non-resonant circuit elements. By interchanging R_4 and C_2 the usual multivibrator circuit is obtained

$$e_{g1} = \mu_0^2 \frac{X_{c1} R_1}{(R_1 + X_{c1})^2} e_{g3}$$

The conditions for stable operation, and those which obtain when the feed-back circuit is closed are that $e_{g1} = e_{g3}$ so that

$$1 = \mu_0^2 \frac{R_1 \omega C_1}{(R_1 \omega C_1 + 1)^2}$$

Let $R_1C_1 = 1/\omega_0$. Then, remembering that both μ_0 and ω are positive, the solution for the above equation is,

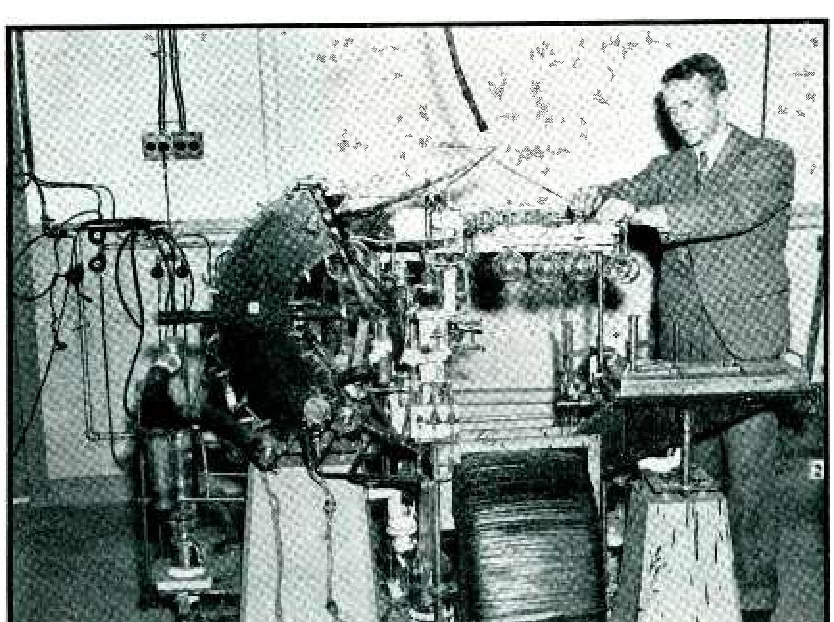
$$\frac{\omega_0}{\omega} = \frac{\mu_0^2}{2} - 1 \pm \left(\frac{\mu_0^4}{4} - \mu_0^2\right)^{\frac{1}{2}}$$

This expression can be made a pure imaginary (which is the condition for sinusoidal oscillation) by letting $\mu_0^2 = 2$, in which case we obtain $\omega = j\omega_0$. Thus, a sinusoidal oscillation of frequency, $f = 1/2\pi R_1C_1$ can be sustained although no such possibility exists in the case of the usual multivibrator circuit, where the numerator would read $(R_1\omega C_1)^2$ instead of $R_1\omega C_1$.

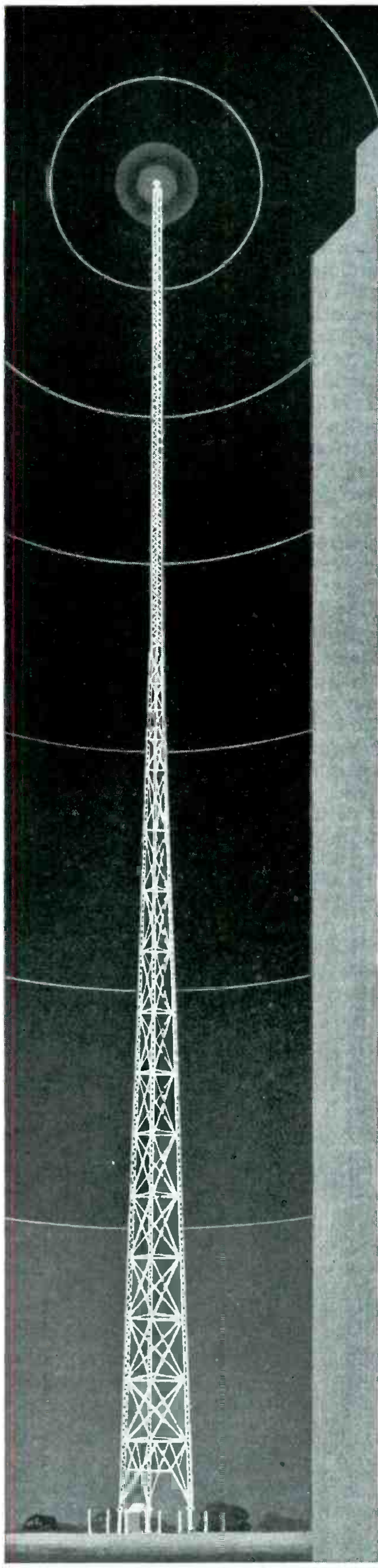
The oscillations produced by this circuit are fairly sinusoidal. In the audio range, harmonics amounting to about 4% have been measured. At very low frequencies no measurements were made of distortion, but oscillograms show a remarkably good wave shape.

The frequency can be varied by changing the values of R_1 or C_1. By providing adjustable values of R_1 and C_1 an a-c source of utmost simplicity is provided which presents some of the characteristic features of the heterodyne oscillator. Tubes having two triode structures in the same envelope can, of course, be used to produce a single tube oscillator, and by providing a switching arrangement to change the output circuit of the second stage, this sinusoidal oscillator circuit can be changed over at will to the usual multivibrator arrangement.

ATOM BENDER REVEALS RELATIVE WEIGHTS



This new mass spectrograph at Harvard University treats streams of charged atoms like cathode rays, weighs them relatively, makes discovery of isotopes easy. Professor Kenneth Bainbridge is in charge



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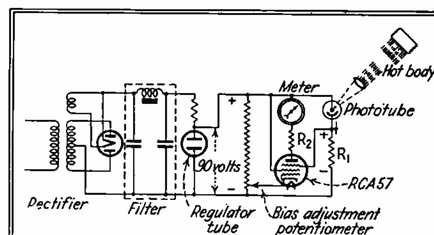
TRUSCON VERTICAL RADIATORS

Photoelectric Pyrometer

THE PHOTOTUBE has been put to work in the photoelectric pyrometer which is an instrument for indicating or recording the temperature of incandescent bodies. Essentially the device consists of a phototube, toward which the radiant energy to be measured is directed, a very stable vacuum tube amplifier, and the required and associated power supply equipment, according to W. R. King whose article "*The Photoelectric Pyrometer*" appears in the November issue of the *General Electric Review*.

The main features of this form of pyrometer is that it provides a continuous indication or record of the temperature of incandescent bodies without appreciable time lag.

The pyrometer makes use of Wein's displacement law which states that the relation between wavelength of maximum radiation intensity and the absolute temperature is a constant. Since, therefore, the wavelength of maximum radiant energy is inversely proportional to the absolute temperature, the phototube response (which varies as the intensity of the radiations impinging upon it) will vary with the temperature of the body. The exact manner in which temperature variations are related to phototube output current will depend upon the spectral sensitivity of the phototube.



Schematic wiring diagram of the photoelectric pyrometer. A type 57 pentode is used to amplify the output of the phototube

A simple circuit is used in this type of pyrometer, as indicated by the schematic wiring diagram. The amplifier is required because the output current, which is of the order of a few microamperes, is insufficient to operate any control equipment. High amplification is obtained through the use of a pentode amplifier circuit. The phototube and amplifier circuits are supplied with direct current from a rectifier and filter unit contained within the pyrometer. Because voltage variations would affect the accuracy of the pyrometer appreciably a two element gas filled tube, connected in series with a resistor across the output of the rectifier and filter, is used as a voltage regulator.

Distribution of Current in Pentodes and Hexodes

[H. Rothe and W. Kleen, Telefunken Laboratory] In tubes with several grids not only the plate but at least one of the grids is at a positive potential with respect to the filament. The presence of two positive electrodes causes these tubes to differ in principle from three electrode tubes in which the grid has a negative bias. When both grid and plate in a three-electrode tube are made positive, current flows to both electrodes. Apart from the dimensions and spacing of the electrodes which are constant for a given type of tube, the ratio between the two currents depends merely on the ratio e_1/e_2 between the two potentials applied to the electrodes. Two main cases may be distinguished: either e_2, the voltage on the plate, is much larger than e_1, the voltage on the grid (Tank's case), or e_1 is much larger than e_2 (Below's case). In Tank's case all the electrons which have passed through the grid proceed straight forward to the plate. In Below's case the path of the electrons is bent toward the grid wires, and electrons having passed through the grid may still be deflected and caused to turn back..

When e_2 is lower than e_1, which is assumed to be high enough to produce the saturation current I, the distribution of the current is, therefore, determined by the number of electrons which are thrown back by the retarding field along a parabolic path. In this case

$$\frac{i_2}{I} = C_1\sqrt{\frac{e_2}{e_1}},$$

where $C_1 = 4\,a\,b\,p/s\,(a+b)$, where a is the distance between plate and grid, b the distance between grid and filament, and s the distance between grid wires. The fraction $l—p$) of the total emission I, which is collected by the grid, is nearly constant whatever the ratio e_2/e_1. The larges s and the smaller a and b, the larger the ratio e_2/e_1 necessary for preventing loss of electrons by deflection in the face of the plate. Measurements show that hexodes obey Below's law quite closely.

In Tank's case, on the other hand, a change in the ratio e_2/e_1, affects directly the number of electrons collected by the grid.

$$\frac{i_2}{i_1} = C_2\sqrt{\frac{e_2}{e_1}},$$

with $C_2 = F(b/a+b)^{1/2}$, where F is the ratio between the area actually occupied by the grid wires and the total area enclosed between the grid wire. Pentodes work in this region, at least so long ase_2 is higher than e_1. Four electrade tubes occupy a special position owing to the amission of secondary electrons by screen and plate.

Tank's law of the current distribution allows us to deduce the main properties and constants of pentodes, at least of r-f pentodes for which the plate potential e_4 has a negligible influence upon the current flowing from the cathode. The suppressor grid is assumed to be connected to the cathode ($e_3 =$ zero). The potential acting in the region occupied by this grid which collects no current is equal to Ae_4+Be_2, where the factor A expresses the influence of the plate potential, and the factor B, often overlooked, the influence of the screen potential, upon the plate current in this region. Hence

$$k = \frac{i_4}{i_2} = C_2\sqrt{A\frac{e_4}{e_2}+B}$$

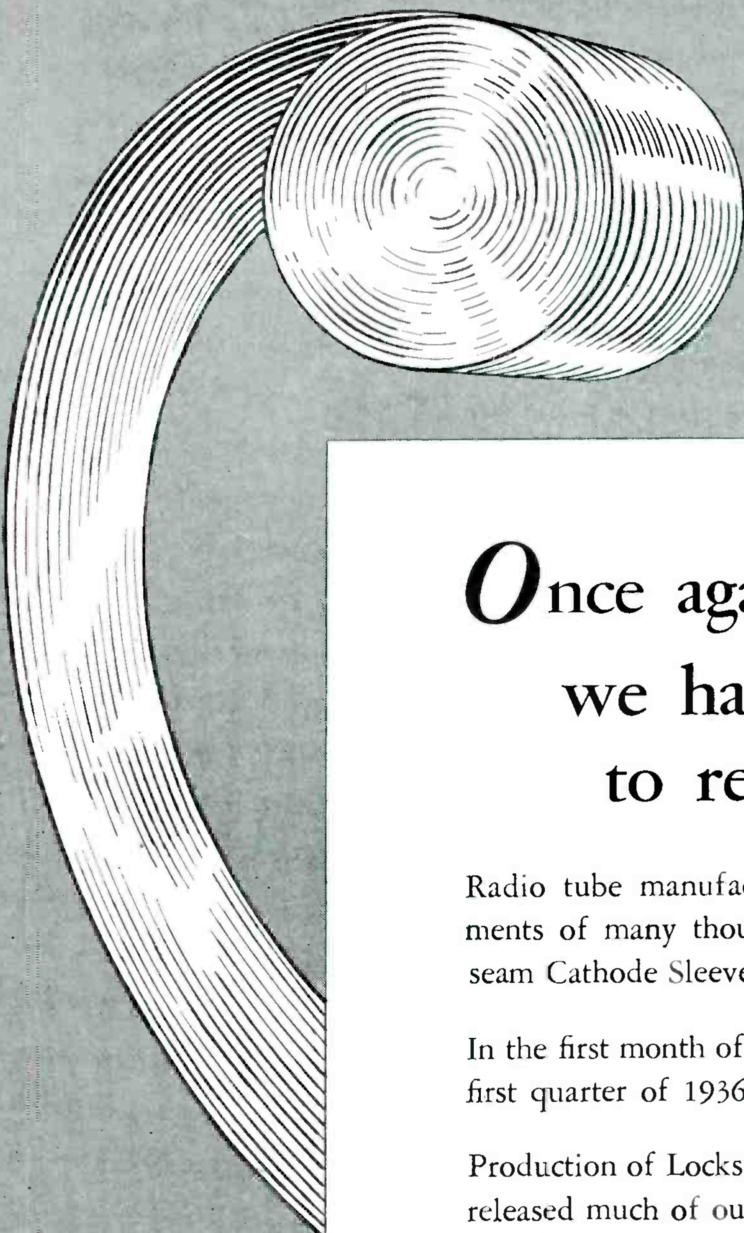
so long as e_4 exceeds Ae_4+Be_2. Since i_2 may be replaced by $(I-i_4)$ the formula expresses a relation between i_4 and e_4 when e_2 is constant. Differentiation of e_4 with respect to i_4 gives the internal resistance of the tube. The resulting formula is rather complicated but it shows that the internal resistance of r-f pentodes in normal operation is inversely proportional to the plate current, proportional to the plate voltage, and practically independent of the screen potential. Integration of $\partial e_4/\partial i_4 = be_4/i_4$ (when e_1 and e_2 are constant), leads to the equation for the plate current $i_4 =$ const. $(e_4)^{1/b}$, which represents a parabola of a higher order.

The grid-plate conductance, g_4, or ratio of plate current change to control grid voltage change when R_2 and R_4 are kept constant follows from the relation $g = aI^{1/3}$ and the law of current distribution, k,

$$g_4 = kg/(k+1) = Ai_4^{1/3}.$$

It is smaller than g, which is to be expected, but like g, proportional to the third root of the plate current.

Internal resistance and mutual conductance determine as usual the amplification factor, which in contrast with three electrode tubes is no longer defined by the electrostatic fields between the electrodes. The amplification factor $\mu = g_4R$ is larger the smaller i_4 and the higher e_4. When the influence of the plate potential upon the current I emitted by the cathode may no longer to be neglected, as is the case in output pentodes, it is further necessary to state the value D expressing the ratio between a change in control grid voltage and plate current when e_2 and I are kept constant. When D differs from zero, the tube behaves as if R_{11}, a resistance $(k+1)k$ times the ratio $\partial R_4/\partial I$ with e_1 and e_2 constant, had been placed in parallel with the resistance R defined by the current distribution.—*Telef. Rohre* No. 6:1—23, 1936.



Recent Government Publications

The 1935 census of business conducted by the Department of Commerce has included for the first time a survey of radio broadcasting activities. This material, which deals with classification and number of broadcasting stations, advertising revenue, sale of time and talent, number of employees, pay rolls, etc., is broken down according to geographical classification as well as according to the power output of the station. A considerable number of tables and charts are given. The 75 page booklet was prepared by the Bureau of Census, United States Department of Commerce, Washington.

"The Measurement of Currents at Very High Frequencies" is a translation of a German article of the same name by Herman Schwarz which originally appeared in Hochfrequenztechnik und Electroakustic, Jarhbuch der Drahtlosen Telegraphie und Telephonie, May 1932. This is a 23 page mimeographed article with 27 English and German references. Twenty half-tone and line drawings are reproduced from the original article. The errors and precautions to observe in making high frequency measurements with thermal measuring instruments, current transformers, electrodynamic instruments, and indirect methods of measurement are given.

The Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C. has recently published "A Guide to Reception of Shortwave Broadcasting Stations," which provides a simple exposition of the basic phenomena involved in the transmission and reception of shortwave radio signals as used for broadcasting. Such matters as the call letters and frequencies of the more important high-frequency broadcast stations and time differences in various parts of the world are treated and the book should prove useful to short wave radio fans interested in high frequency broadcast. The price of the booklet is 25 cents.

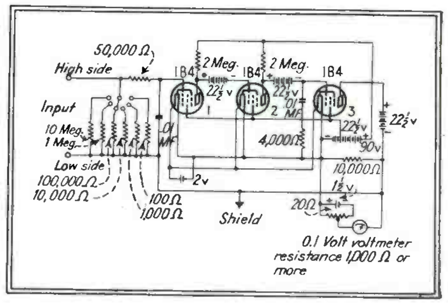
The "Directory of Commercial Testing and College Research Laboratories", which is available from the Superintendent of Documents, Washington, D. C., for fifteen cents, is divided into two parts. The first section lists the commercial testing laboratories in the United States arranged alphabetically in accordance with the geographical location, and indicates the type of service these laboratories are able to render. The second part of the directory gives similar information about college research laboratories.

Letter Circular, LC-473, entitled "Photoelectric Colorimeters" is a 19 page mimeographed circular which deals with the proper use, principles of construction, properties of filters, errors, and the various characteristics of colorimeters.

Sensitive Current Measuring Instrument

THE DECEMBER 1936 ISSUE of the "Review of Scientific Instruments" contains a number of interesting and useful articles dealing with the application of thermionic vacuum and gaseous tubes. Of these, "An improved vacuum tube microammeter" by A. W. Vance is sufficiently general as to be of interest to any who may be required to make measurements of low values of current.

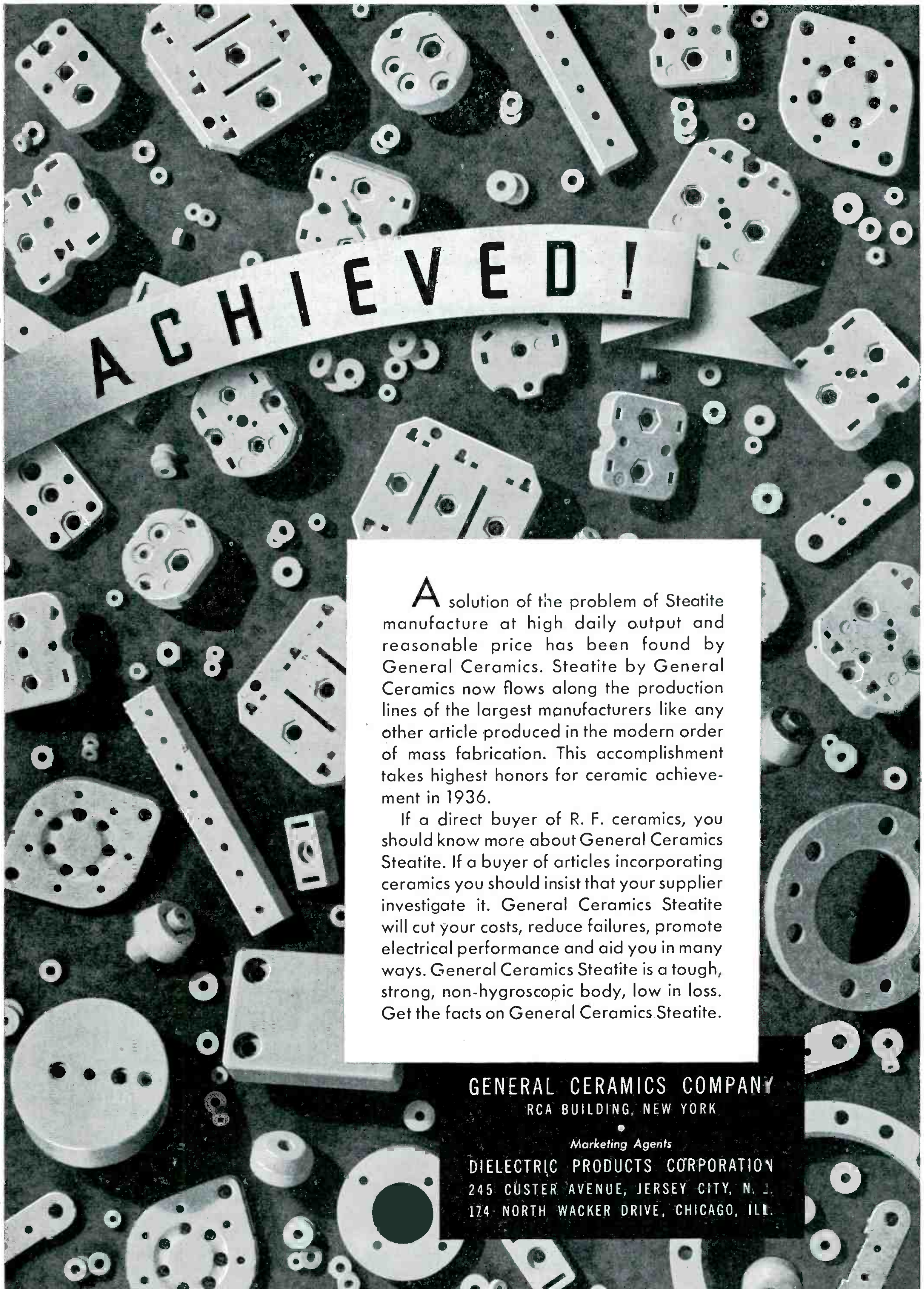
The essentials of this vacuum tube microammeter are: (a) a high resistance in the input circuit, (b) a direct current amplifier of high gain which is highly stabilized through the use of degenerative feedback, (c) a large condenser in shunt with the output circuit in order to prevent oscillation, and (d) a meter in the output circuit of the amplifier in order to measure the current in the high impedance input circuit.



Schematic wiring diagram for instrument measuring 10^{-3} to 10^{-8} ampere, full scale

The schematic diagram shown is for the battery-operated vacuum tube microammeter having a full scale range of from 10^{-8} to 10^{-3} ampere. The various current scales are obtained through the use of the several resistors in the input or grid circuit of the first tubes. By using a wide range of input resistances the device becomes an ammeter with corresponding wide range.

Any tendency for the amplifier to oscillate is prevented by the capacity-resistance series network shown shunted across the grid circuit of the third or output tube. An odd number of tubes must be used in the amplifier in order that the feedback to the grid circuit of the first tube may be of the proper polarity. If the amplifier output circuit is so designed that its saturated output is insufficient to damage the output meter, burn-outs can be eliminated.

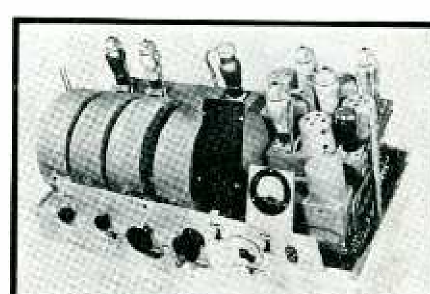

ACHIEVED!
A solution of the problem of Steatite manufacture at high daily output and reasonable price has been found by General Ceramics. Steatite by General Ceramics now flows along the production lines of the largest manufacturers like any other article produced in the modern order of mass fabrication. This accomplishment takes highest honors for ceramic achievement in 1936.
If a direct buyer of R. F. ceramics, you should know more about General Ceramics Steatite. If a buyer of articles incorporating ceramics you should insist that your supplier investigate it. General Ceramics Steatite will cut your costs, reduce failures, promote electrical performance and aid you in many ways. General Ceramics Steatite is a tough, strong, non-hygroscopic body, low in loss. Get the facts on General Ceramics Steatite.
GENERAL CERAMICS COMPANY
RCA BUILDING, NEW YORK
Marketing Agents
DIELECTRIC PRODUCTS CORPORATION
245 CUSTER AVENUE, JERSEY CITY, N. J.
174 NORTH WACKER DRIVE, CHICAGO, ILL.

Improvement in Foreign Radio Receivers

Two important improvements in radio receivers are discussed by C. J. Van Loon in the September, 1936 issue of the *Philips Technical Review.* These improvements are known as "touch tuning" and "low frequency counter coupling." A common method of indicating the correct tuning of a radio receiver is the common visual indicators such as the electron ray indicator. A similar objective has been achieved in the Philips Research Laboratory in which proper tuning is indicated by a sudden braking of the tuning knob, so that the tuning shaft is more difficult to rotate, the closer one approaches resonance. This braking action is accomplished by means of a circuit in which the current (which increases as resonance is approached) is utilized to hold the tuning shaft in position by means of a magnet. An arrangement can also be quite easily incorporated with this circuit which by mechanical means keeps the receiver completely silent until it has been correctly tuned to the desired frequency; as soon as the braking magnet is energized a contact is closed at the same time which connects up the loud speaker system. In this way touch tuning is combined with silent tuning.

Audio frequency distortion in radio receivers is reduced through the use of "counter-coupling." It turns out that the "counter-coupling" system discussed is fundamentally the same as the negative feedback or degenerative systems which have caused considerable interest in this country in recent months. With this feedback circuit distortion at the low frequency end of the audio spectrum is reduced to a small fraction of its initial value, while at the same time the frequency characteristics of reproduction are also favorably influenced.

GERMAN CHASSIS DESIGN



Unusual layout and fine attention to mechanical detail characterize the newer German radio set chassis. The coils (inside the cylindrical water-tight cans) are moved between contacts, instead of being switched, for each waveband

INTRODUCING A NEW BATTERY FOR NEW BATTERY RECEIVERS

No. 774 "Eveready" "C" Battery is a new 7½-volt "C" battery designed to supply all grid bias voltages required by the new octal base 2-volt tubes.

Socket connection for minus 1½, 3, 4½ and 7½ volts. As this battery is intended for new receivers only and does not replace any existing type, no adapter will be furnished for it. Connection plugs are available from plug manufacturers. Plug cannot be placed in socket of any other type battery.

DIMENSIONS: 4 1/32 in. long, 1 13/32 in. wide, 3 1/32 in. high.

The five cells in this battery are accurately sized and carefully compounded especially for "C" battery work. This makes its capacity bear the correct relation to "B" battery capacity, so that with proper "C" battery bleeding, the "C" voltage goes down in step with the "B" voltage, thus preserving the ideal relationship between grid and plate voltage for best receiver performance throughout the entire life of the batteries.

NATIONAL CARBON COMPANY, INC.

GENERAL OFFICES: New York City • BRANCHES: San Francisco, Chicago

Unit of Union Carbide UCC and Carbon Corporation

Magnetic Detectors

THE DETECTION OF IRON or other magnetic materials concealed in non-magnetic materials may be accomplished by some device which depends for its operation on the magnetic properties of the materials in question. A simple form of iron detector, originally designed to detect pieces of iron in bales of scrap aluminum is described by R. F. Edgar in the November 1936 issue of the *General Electric Review* under the title "Magnetic Detectors for Industrial Applications."

The G-E magnetic detector consists of a test coil through which the bales pass and a galvanometer whose deflections are used to indicate the passage of a bale containing iron. The test coil consists of a primary winding through which direct current flows to produce an unvarying magnetic field, and two secondary windings which are connected to the galvanometer. As the bales pass through the test coil, they pass through the two secondary coils in succession. Any magnetic material in the bales distorts the magnetic field, thereby producing a deflection of the galvanometer needle.

Speed of Vacuum Pumps

THE DECEMBER ISSUE of *Cenco News Chats* points out that the speed of vacuum pumps may be measured at constant volume or at constant pressure. Difficulties with the constant volume method of measurements are that if the speed varies with pressure, the result will not be clear-cut as to the pressures to which the measured speed applies. If the walls of the system yield absorbed gases and vapors the "speed" of the pump is indeterminate. The speed of the pump under this method of measuring also depends upon the manner in which the vacuum gage is connected to the pump.

Phototubes Used in Determining Color Temperature

ACCORDING TO the *Proceedings of the Physical Society* for November 1935, a phototube and two filters have been used for color matching tungsten light sources. As an empirical measure of the color temperature of the tungsten lamp, the ratio of total transmissions of the two filters, as measured by the phototube, is used. For certain lamps and phototube-filter combinations, the relation between filter ratios and lamp voltage is nearly linear.

F.C.C. Approval on Power Tubes

A RECENT BULLETIN from the Federal Communications Commission lists numerous vacuum tubes of the various manufacturers whose ratings of output tubes in modulated transmitters have been approved by the F.C.C.

Automatic Starting Resistance

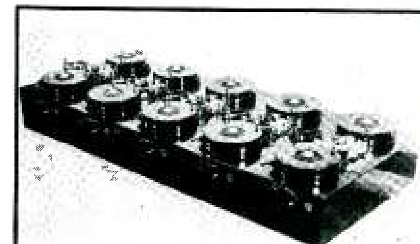
LARGE CURRENTS are frequently taken from the power lines when electrical machinery is started up. In the case of the electric motors the large current taken from the line results because no counter electro-motor force is established until the rotors start moving. In this case damage is prevented through the use of starting boxes.

A series of automatic starting resistances having a high resistance when cold and a low resistance when hot has been developed by the Philips Lamp Works and is described in the July issue of the *Philips Technical Review.*

These "starto" tubes, as the devices are called, are single element tubes consisting of a semi-conductor of silicon and a ceramic binder. The resistance of silicon itself does not possess a pronounced negative temperature coefficient, but on diluting with the suitable binder, this coefficient is considerably increased to give a very marked difference between the resistance when hot and when cold. The tubes are filled with argon since the silicon reacts with both oxygen and nitrogen.

Tubes have been developed having a maximum carrying current of from 17 to 100 amp. The time elapsing from the moment the switch is closed until the current reaches its maximum value, is determined by the time taken for an equilibrium to be reached between the heat supplied and the heat dissipated. Tubes can be designed for a given application to give a wide variety of heating time. The cooling time, likewise, depends upon the design and application of the tube, but curves given indicate that tubes have been built for which the cooling time varies from about 3 to 40 minutes for the tubes to reach two-thirds of their cold resistance.

FIVE-PLACE NOISE-EFFECT UNIT

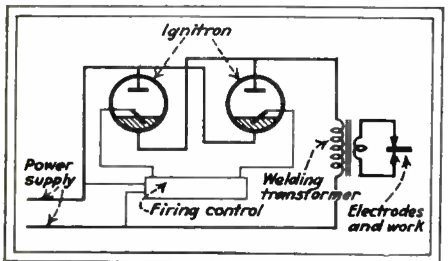


Nearly 1500 different types of noise are claimed for this German film-and-phototube device which contains five complete reproducing units. Used separately or in combination, the noise outputs are amplified and used for broadcast and motion picture applications

Ignitrons for Welding Control in Electric Welding

VERY HIGH CURRENTS are required to produce efficiency in melting metals where large welds are concerned. It is desirable to accomplish this heating and subsequent cooling very quickly, so that the melted zone does not travel from the welded joint to the welding electrode. Short timing, coupled with high accuracy of current and time control simplifies the welding process.

Two welding requirements, namely the ability to pass very high currents, and quick response can be obtained through the use of thyratrons, or, as pointed out by Packard and Hutchings in the January issue of *Electrical Engineering*, by means of ignitrons.



Two ignitrons connected for welding operation

In their article "Sealed-off Ignitrons for Welding Control," the authors point out that the ignitron is particularly suitable for welding purposes because the mercury pool cathode permits the conduction of unusually high instantaneous currents and quick and accurate response is attained through the use of the igniter electrode.

The figure shows the schematic wiring diagram using two igniters connected "back to back."

Rumbatrons

ACCORDING TO THE January 1937 issue of the *Technology Review*, the term "rumbatron" is used to describe a new atom disintegrator now under construction at Leland Stanford University. There is something so disruptive about this word that it might well be used as a generic term for the numerous atom smashers now in operation or under construction.

The Carnegie Institute, University of California, Columbia University, Massachusetts Institute of Technology, University of Michigan, Stanford University and the University of Wisconsin are among the institutions which have gone into the atom smashing business. The research laboratories of the Westinghouse Electric & Manufacturing Company at East Pittsburgh have started construction on an electrostatic generator designed along the lines laid down by M.I.T.'s Professor of Physics, R. J. Van de Graaff.

MANUFACTURING REVIEW

News

✦ The Ward Products Corporation, manufacturers of automobile antennas and sound systems, has recently moved into their new building on East 45th Street, Cleveland, Ohio. By this move, the space devoted to manufacturing has been doubled.

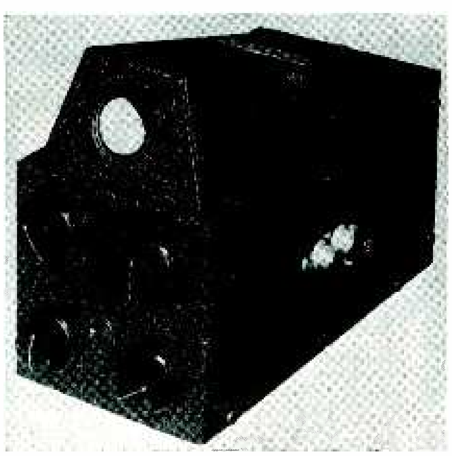
✦ The Arlab Manufacturing Company, manufacturers of magnetic and dynamic speakers, has recently rented the factory occupied by the Audiola Radio plant of Fairbanks-Morse Company, at 430 South Green Street, Chicago. The Arlab Manufacturing Company recently acquired the Varitone Radio Company and will continue the manufacture of their item under the direct supervision of Mr. Walter J. Kareden.

✦ Heintz & Kaufman, Ltd., South San Francisco announces the appointment of W. M. Eldred as engineer in charge of sales. For the past three years Mr. Eldred has been working in the development laboratories of the company.

✦ The appointment of Frank A. Arnold, active for many years in broadcasting circles, as managing director of the RCA Institute's Technical Press has been announced by Charles J. Pannill, president of the RCA Institute. Mr. Arnold comes to this new work from the Institute of Public Relations, of which he has been vice-president for the past year.

✦ The formation of a new corporation, absorbing four radio and aviation equipment companies was announced January 21 by Vincent Bendix, automotive and aeronautical leader and head of the Bendix Aviation Corporation. The new organization will specialize in radio equipment for communications and navigational purposes for the aircraft industry, with particular attention being paid to blind flying and safety in landing under adverse weather conditions. The new company, known as the Bendix Radio Corporation, will be staffed with more than a hundred engineers and technicians and will have plants and laboratories in Chicago, Dayton, Washington, and Oakland. The companies which have been brought together to form the new organization include the Radio Research Company, Inc., of Washington, D. C., the Radio Products Company of Dayton, and two Chicago firms, Jenkins and Adair, and the W. P. Hilliard Co.

New Products



Midget Oscilloscope

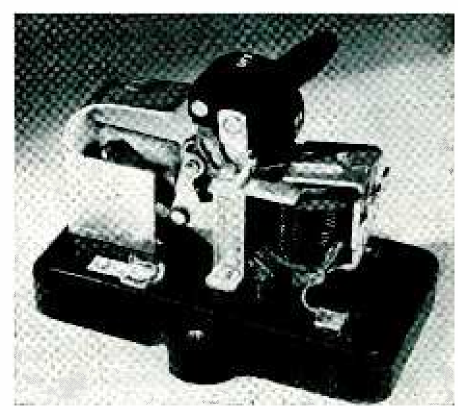
AN OSCILLOSCOPE designed especially for operation in amateur radio stations and using the new 913 cathode ray oscillograph tube has recently been made available by the National Company, Inc., Malden, Mass. Provision is made for both horizontal and vertical deflection of the beam. The oscilloscope is especially suitable in amateur transmitters for modulation measurements, but may be also used as a service instrument for the alignment of IF transformers or can be used in much the same way as oscillographs using the larger cathode ray tube.

Audiometer

THE PURPOSE of audiometric measurement is to establish accurately the difference existing between normal hearing acuity and sub-normal hearing acuity for any individual under examination. The Western Electric Company's type 6A Audiometer is designed for this purpose. Frequency range is from 100 to 10,000 cycles per second. Hearing acuity by both air conduction and bone conduction may be recorded. The 6A audiometer operates directly from the 110-volt a.c. or d.c. line.

Portable Wheatstone Bridge

A PORTABLE, precision, self-contained Wheatstone bridge making measurements from a fraction of an ohm to 10 megohms is announced by the Rubicon Company, 29 North Sixth Street, Philadelphia. The ratio resistor, decade resistor, pointer type galvonometer, and dry battery are contained in a strong walnut case measuring 9 in. by 7 in. by 6 in. The complete instrument weighs 10 lb. The four decade resistors may be used as a calibrated 4-dial resistance standard independent of the rest of the set. Accuracy to within 1/10 of 1 per cent.



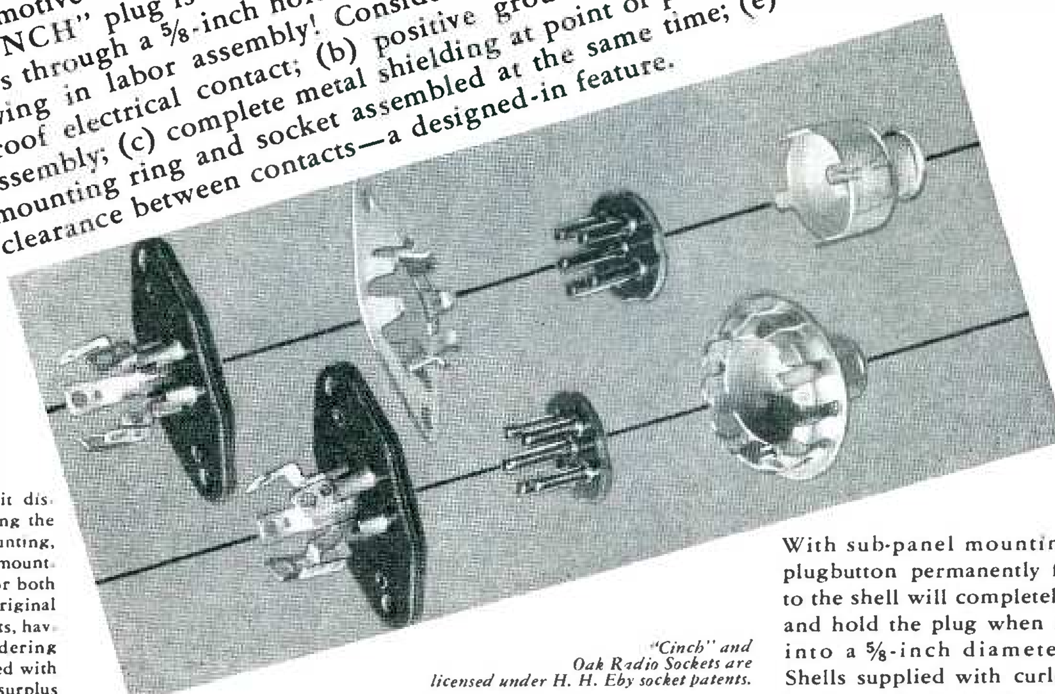
Circuit Breaker

A MAGNETIC, non-thermal, circuit breaker available in capacities from 50 milliamperes to 35 amperes is a recent contribution of safety and convenience made by the Heinemann Electric Company, Trenton, N. J. Instantaneous trip and time-delay action circuit breakers are available. The time delay unit opens the circuit in from 5 seconds up to 8 minutes on the 125 per cent load, or correspondingly faster at greater overloads, depending upon its adjustment. The circuit breaker can be immediately closed after tripping on any overload or short circuit, provided the abnormal condition no longer exists.

A CINCH to score!

A feature of the new five-prong shielded plug is the extra long center pin to act as a "finder."

NOW . . . the five-prong completes the QUINTET of popular shielded plugs; available in polarized one, two, three, four or five prongs. For speaker cables, antenna, pilot light, tone control and "A" leads of automotive receivers, use this shielded grounded plug. Small—the new "CINCH" plug is handy, efficient, a space-saving convenience—will pass through a ⅝-inch hole. Easy to attach! And with a considerable saving in labor assembly! Consider these advantages: (a) vibration-proof electrical contact; (b) positive grounding of plug and cable assembly; (c) complete metal shielding at the same time; (d) mounting ring and socket assembled at point of plug insertion; (e) maximum clearance between contacts—a designed-in feature.



Two combinations permit distinct methods of grounding the shell; one for surface mounting, the other for subpanel mounting. Socket is the same for both groups; assembled with original "CINCH" floating contacts, having a cutting edge. Soldering tail on contacts is provided with pocket or dam to receive surplus solder. With surface mounting type, shielding is accomplished by a mounting ring with eight wiping contacts which give a positive connection between the mounting panel and the plug shell.

"Cinch" and Oak Radio Sockets are licensed under H. H. Eby socket patents.

CINCH MANUFACTURING CORP.
2335 West Van Buren St. • CHICAGO, ILL.
Subsidiary: United-Carr Fastener Corp., Cambridge, Mass.

With sub-panel mounting type, plugbutton permanently fastened to the shell will completely shield and hold the plug when inserted into a ⅝-inch diameter hole. Shells supplied with curled edge for ease in gripping or with straight edge for soldering braided metal cables. Male plug is firmly and simply fastened into the shell by bending over four small fingers.

Public Address System

A 12-WATT CLASS A amplifier is the nucleus of the model 115 portable public address system manufactured by Operadio Manufacturing Company, St. Charles, Ill. One or two low-level microphone inputs may be mixed.

Variable tone controls for high and low frequencies are provided. A 10-in. electrodynamic speaker is standard equipment although provision for additional speakers is made. A suspension type crystal microphone is provided.

Condensers

THE CORNELL-DUBILIER CORPORATION, South Plainfield, N. J., announces two varieties of condensers recently introduced by them. One of these is a dry electrolytic capacitor for a.c. use where high capacity is necessary for intermittent operation. These are especially suited for use in connection with fractional horsepower motors of the

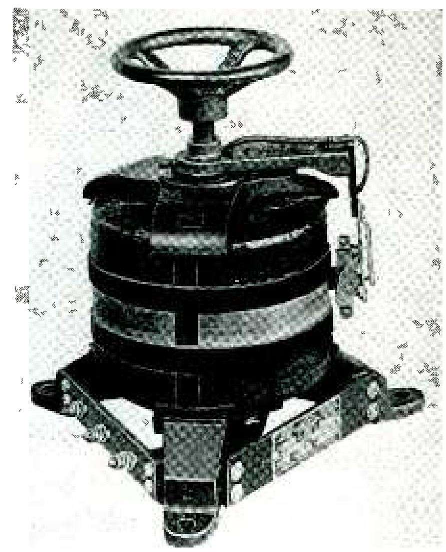
type used in refrigerators, oil burners and similar appliances. A second line of condensers impregnated and filled with dykanol is also announced. Being enclosed in non-corrosive containers these condensers are particularly suited for aircraft, marine, submarine and other purposes where space and carrying weight are at a premium. Manufactured to individual specification.

Batteries

THE C. F. BURGESS LABORATORIES, Freeport, Ill., have improved the construction of their "B" batteries to effectively protect the cell from moisture.

Voltage Regulators

AN IMPROVED VOLTAGE regulator for aligning current circuits which offers the smooth control of a rheostat plus the high efficiency, good regulation of a transformer has been announced by the American Transformer Company, of Newark, N. J. Known as the type TH "transtat" and available in various sizes up to $2\frac{1}{2}$ kva. on either 115 or 230 volt lines, the device is essentially a variable auto transformer, with rotary control of the voltage output. Transtat may be used with electrical equipment for the control of



voltage, illumination, motor speed or heat. Although standard regulators are designed for service in single phase circuits of relatively low voltage in limited capacities, various methods have been developed which permit the use of these units for regulating high voltages and for controlling polyphase circuits. Various applications of this device are presented in the company's publication No. 1177.

Consolette Recorder

A RECORDER designed for use by schools, colleges, and professional home recording has been recently introduced by the Radiotone Recording Company, 6103 Melrose Avenue, Hollywood, Calif. Features of the model A-50 recorder are synchronous recording motor, lathe type feed screw, high fidelity form of recording amplifier and studio type recording microphone.

Auto Antenna

AN ANTENNA FOR AUTOMOBILE radio receivers which fits over the top of the car and may be installed without drilling is one of the newer products released by the Ward Products Company, 2131 Superior St., Cleveland.

Inter-communicating System

The Webster Electric Company, Racine, Wis., announces a newly developed inter-communicating system. It consists of a speaker and amplifier mounted in an attractive modernistic

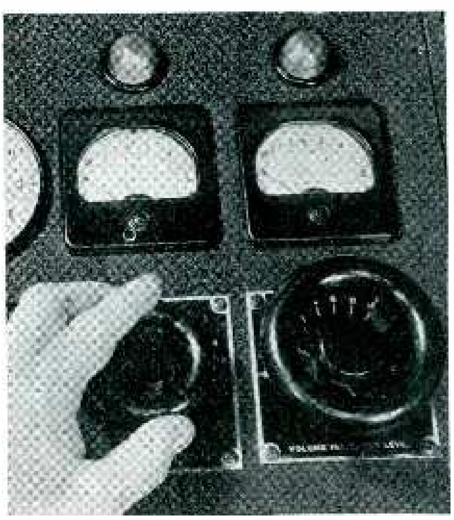
cabinet with volume control and indicating pilot light. Up to sixty stations can be operated together as a system. Operates from either a.c. or d.c. lines of 110 volts.

Amplifier Kit

A remote amplifier kit providing a three-position mixer using isolation transformers for each input to prevent cross talk has been placed on the market by the United Transformer Corporation, 72 Spring Street, New York City.

Control Knob

Durez, a product of General Plastics, Inc., North Tonawanda, N. Y., has been recently put to use as a control knob on volume indicators. The design of these control wheels is such that a symmetrical appearance is presented no matter where the pointer indicator may be.



Durez has also been used as a housing for desk microphones. The molding is designed to harmonize with the usual well appointed office.

✦ The following bulletins, technical data, and catalogs have recently been received from manufacturers:

✦ Resistors. A 12-page loose-leaf catalog giving mechanical dimensions and technical data on industrial resistors has been published by Electrad, Inc., 175 Varick Street, New York City. In addition to rotary and slide wire types of power rheostats and vitreous enameled fixed resistors, the catalog lists precision wound wired resistors and flexible wire wound resistors.

✦ Pick-up Units. A 6-page technical bulletin describing their "relayed frequency" pick-up has been issued by the Audak Company, 500 Fifth Avenue, New York. According to information supplied by the manufacturers, the relayed frequency pick-ups have a frequency response curve which is flat to within 10 db between 60 and 8,000 cycles.

✦ Insulation Tester. A 500 volt-ampere transformer with tapped secondary voltages up to 2,500 volts forms the principal element of the insulation breakdown tester manufactured by the Acme Electric & Manufacturing Company, 1440 Hamilton Avenue, Cleveland, Ohio. Bulletin 140 describes this tester.

✦ Transmitter Manual. A bulletin providing a wide variety of useful information to the transmitting amateur is made available in the 64-page amateur transmitter manual published by the Kenyon Transformer Company, Inc., 840 Barry Street, New York. More than a dozen transmitters suitable for amateur operation are described. Numerous tables, charts, and alignment charts, selected especially for amateur use, are included. The manual is priced at 25 cents.

✦ Insulation. The Spaulding Fibre Company, 310 Wheeler Street, Tonawanda, N. Y., has recently issued a 28-page engineering data book covering the various grades of insulating materials and forms manufactured by them. The processed forms are available or can be manufactured to a wide variety of shapes and have applications in a wide variety of uses.

✦ Radio Equipment. Catalog No. 190 of the Insuline Corporation of America, 25 Park Place, New York City, contains 40 pages of receiving and transmitting parts and accessories, service tools and attachments, racks, panels and chassis, and related items.

✦ Loud Speakers. A single page leaflet from the Magnavox Company, Fort Wayne, Ind., describes two new heavy duty 15-in. loud speaker models, suitable for a.c. or d.c. operation. Complete mechanical and electrical specifications are given.

✦ **60-Watt 6L6 Amplifier.** The Amplifier Company of America, 20 West 22nd Street, New York City, announces a 60-watt amplifier using the 6L6 tube. According to the manufacturers, features of this amplifier are automatic howl suppression, cathode ray indication for howl suppression action, automatic constant output for reproduction of speech, volume level expansion for reproduction of recorded programs, and high and low frequency gain control.

✦ **Amplifier Kit.** A studio pre-amplifier in kit form has been released from the United Transformer Corporation, 72 Spring Street, New York. The kit can be wired up for two, three or four-stage operation, with gains up to 100 db. Audio panel incorporates switch and milliammeter to check plate current of all tubes.

✦ **Service Instrument.** A combined volt-, ohm-, output, and milliammeter, self contained with battery and selling at $13.50 is available from the Burton-Rogers Company, 755 Boylston Street, Boston, Mass. The two resistance scales permit resistance values of 500 ohms and 500,000 ohms full scale to be read.

✦ **Output Attenuator.** Constant impedance attenuator capable of handling considerable power with low insertion loss has been developed by the Clarostat Manufacturing Company, 285 North Sixth Street, Brooklyn, N. Y. Minimum insertion loss is 1.3 db.; power dissipation 25 watts. Attenuation is linear up to 45 db. in steps of 3 db. with an end position of infinite attenuation. Impedance from load end is approximately three times the line value.

✦ **Neon Tube Oscilloscope.** A gaseous discharge tube oscilloscope for wave form analysis has been developed by the Sundt Engineering Company, Chicago, Ill. A 6L6 beam power tube operating at 100 kc. supplies power to the neon tube which is the source of illumination. The input voltage to be analyzed is amplified by a high gain audio amplifier, the amplified voltage being impressed on the 6L6 power generator. This amplified fluctuating voltage corresponds to the vertical deflection of the wave pattern. The effect of a linear time axis is supplied by means of a rotating mirror so as to sweep the image horizontally across the line of vision of the observer. The speed of rotation of the mirror is controlled by a variable speed motor.

✦ **Core Material.** Permanite, a form of granulated iron oxide having good properties as a magnetic core for r.f. and i.f. transformers is announced by the Foote Mineral Company, 1509 Summer St., Philadelphia. It is being used in cores and shields by a number of radio manufacturers and has also been used to a limited extent in carrier telephone and telegraph circuits.

✦ **Permanent Magnets.** A 4-page brochure issued by the Crucible Steel Company of America, Chrysler Building, New York City, gives the important electrical characteristics of a new series of permanent magnets made of new aluminum-nickel-cobalt alloys. These permanent magnets are furnished only in castings and are finished to final dimensions by grinding. They are not available in standard shapes for individual fabrication.

✦ **H-F Insulation.** The application of Mycalex insulation to various high frequency radio problems is covered in a technical bulletin issued by Electronic Mechanics, Inc., 201 East 12th Street, New York City. Many of the applications listed are intended for use where high voltages are encountered.

✦ **Transmitting Apparatus.** A series of monitors, amplifiers, modulators, and high frequency telegraph and telephone transmitters of relatively low power are described in a technical bulletin of the Harvey Radio Laboratories, Inc., 12 Boylston Street, Brookline, Mass. Being designed for high frequency operation, these transmitters are especially suitable for amateur operation.

✦ **Humidity in Radio.** Graphs dealing with the effects of moisture on wire insulation and trimmer condensers as a function of the circuit properties, are available in a bulletin offered by the Boonton Radio Corporation, Boonton, N. J. A copy of the bulletin "Humidity Factor in Radio Work" is available on request.

✦ **Interference Data.** In addition to listing a complete line of condensers as well as service instruments and noise-reducing aerials, the latest catalog from the Tobe Deutschmann Corporation, Canton, Mass., gives specific recommendations for quelling man-made static. Forty-two models of units intended to reduce or eliminate electrical impulses or transients which make themselves evident as noise in the output of a radio receiver are listed.

✦ **Recording Galvonometer.** Several bulletins have recently been issued by the Berndt-Maurer Corporation, 117 East 24th Street, New York City. One of these describes a sound-on-film recording galvonometer consisting of a small, sensitive and rugged galvonometer element together with a suitable optical system. Another bulletin describes an electrical motor driving unit for motion picture cameras.

✦ **Radio Cabinet.** The Beetle Products Division of American Cyanamid Company, 32 Rockefeller Plaza, New York City, has been carrying an research with the object of developing Beetleware for radio cabinets.

I-F Alignment

(Continued from page 33)

The plate impedance of the electron coupled plate was taken as 1.3×10^6 ohms.

$X_1 = 2\pi f L_1$ (L_1 was assumed as 1800 μh.)

$\therefore X_1 = 5150$ ohm for 456 kc

The problem is then one of matching a generator impedance of 1.3×10^6 ohms to a load of 70 ohms.

Let $R_1 = 1.3 \times 10^6$ and $R_2 = 70$ ohms.

$$X_a + X_b = X_2$$

$$\text{Then } \frac{R_1}{R_2} = \frac{X_1 + X_3}{X_2 + X_3} \qquad (1)$$

$$\text{and } R_1 R_2 = -(X_1 X_2 + X_2 X_3 + X_1 X_3) \qquad (2)$$

Solving Eqs. (1) and (2)

(1) becomes, $91 \times 10^6 = -5150\ X_2 - X_2 X_3 - 5150\ X_3$

(2) becomes, $X_2 = (.277 - X_3)$

Substitute (2) in (1), and solve for X_3.

$$X_3 = \pm\sqrt{91 \times 10^6} = \pm 9550 \text{ ohms.}$$

Assume the negative root for X_3 (capacity reactance) then $X_2 = \mp 9550$. The + root must then be used.

Assume X_a the reactance of 2000 $\mu\mu f$ at 456 kc. or 174.5 ohms.

$$\therefore X_b = 9550 + 174.5 = 9{,}724 \text{ ohms}$$

$$X_b = 2\pi f L_b \text{ and } L_b = 3{,}390\ \mu h$$

Now X_c is inductive reactance.

X_d is capacity reactance.

X_3 was assumed capacity reactance.

$$Y_3 = 1/X_3 = Y_c + Y_d\ ,$$

$$\therefore Y_c + Y_d = j.111 \times 10^{-3}$$

C_d was assumed 300 $\mu\mu f$.

$$X_d = \frac{10^{12}}{2\pi f C_d} = j.859 \times 10^3 \text{ ohms.}$$

$$Y_c = -j.748 \times 10^{-3} \text{ mhos.}$$

and $X_c = j.1335$ ohms. $\therefore$ $L_c = 466\ \mu h$.

The final computed values for this T pad are as listed below:

L_1 = 1800 μh	C_a = 2000 $\mu\mu$f
L_c = 466 μh	L_b = 3390 μh
C_d = 300 $\mu\mu$f	

The design of the impedance matching networks which match each main branch line to the load in each test department is identical with the above. They are designed to match 140 ohm to 140/12 ohms, there being 12 test positions in each department. The values come out as shown in Fig. 4A.

There are two of these required. Likewise the design of the pad matching each of the 12 lines to a 1,000 ohm attenuator is identical.

Air tuned trimmer condensers are used for C_3.

The main control equipment consists of a frequency modulator, with a linear time axis, and synchronizing device built in, a cathode ray oscillograph, and a crystal frequency monitor. The modulated frequency together with the output of the i-f crystal oscillator are mixed in a 6L7. The output of the 6L7 is fed into the vertical amplifier of the cathode ray oscillograph. The linear time axis is fed into the horizontal plates of the cathode ray oscillograph. When the mean frequency of the modulator is 456 kc., the resulting beat note is plainly visible on the cathode ray screen. Then all impedance matching devices are tuned so that maximum energy transfer is obtained.

The synchronized linear time axis is piped to the various test positions alongside the matched transmission line.

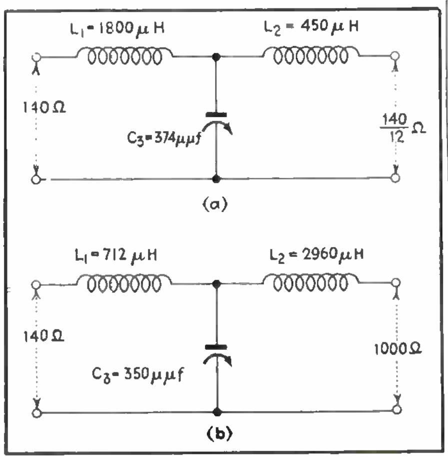


Fig. 4—Matching networks. A—Branch line to load. B—Line to attenuator

Regarding the problem of drifting of the mean frequency of the modulator, the following may be said: The linear time axis is tripped twice for each revolution of the modulator condenser. Therefore, when an i-f transformer is not aligned perfectly to 456 kc., the resonance curve appears as two separate traces on the screen. If the frequency of the modulator drifts, it becomes impossible to bring the two traces together. The tester therefore has a positive check on the frequency. However, very little trouble has been experienced along these lines.

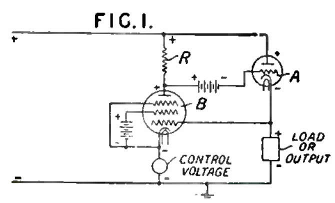
British Patents

Radio Circuits

Super-regenerator. Several super-regenerative amplifiers are quenched by a single local oscillator, the carrier frequency amplified by any one tube being different from that amplified by any other tube. L. R. Merdler, Baird Television. No. 454,945.

Anti-feedback. Undesired inter-action between the electrodes of a multigrid tube, such as is used for modulation or frequency-conversion is prevented by an external coupling, for example, a condenser between the grids. H. A. Wheeler, Hazeltine Corp. No. 454,996.

Voltage regulator. The voltage across a load is controlled by a vacuum tube in series with the load, the grid potential of the tube being de-



rived from a resistance connected across the supply in series with an auxiliary triode and a source of control voltage which is included in series with the load voltage or a part thereof in the grid circuit of the auxiliary tube. Philadelphia Storage Battery Co. No. 455,031.

High frequency circuit. In a tube connected in a Barkhausen-Kurz circuit means are provided for creating an abrupt change at two points in the characteristic impedance of the positive oscillating electrode, and external circuit connections are made to the electrode between these points and at points symmetrical with respect to them. Standard Telephones & Cables, Ltd. No. 455,125.

Navigation. The navigator of a moving vessel ascertains his location by measuring the phase-displacement of several radiated signals modulated by a single low frequency. This gives him the difference of his distance from two aerials spaced apart by a known amount. E. A. H. Honore, Paris. No. 452,235.

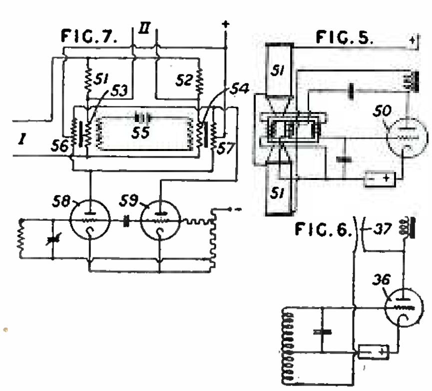
Volume expansion. In signal recording or reproduction using compression and/or expansion of the range of volume variations, the compressor or expander is designed to be ineffective at input volumes above and/ or below a definite level. ERPI. No. 452,084.

Cathode-ray tubes. The screen of a tube comprises a thin metal sheet heated uniformly by means independent of the ray and raised locally to incandescence by the ray to produce the picture. The uniform heating may be to 800 deg. K. by resistance heating, by infra-red radiation or by an auxiliary, unmodulated cathode-ray. The screen is of tantalum 50–100 x 10^{-6} inches thick or of tungsten or molybdenum, the thickness being such that an incandescent area of the screen loses heat more by radiation than by conduction to adjacent areas of the screen. F. S. Turner, San Francisco. No. 452,368. See also No. 452,406.

Automatic tuning. A circuit comprising manual tuning control and supplementary automatic tuning control for final accuracy of tuning, in which the operation of the automatic control is prevented until the manual control is adjusted to a predetermined frequency displacement from the in-tune position. G. L. Beers, Marconi Co. No. 452,585.

Saw-tooth generator. In a circuit in which a condenser is periodically charged gradually through a resistance and discharged abruptly through a tube, the rise of voltage across the condenser is made truly linear without the use of saturated tubes in the charging circuit by including in the charging circuit a voltage derived from the condenser and acting in opposition to it. Philips. No. 452,965.

Automatic Selectivity. The selectivity of a radio receiver is regulated manually or automatically by a variable

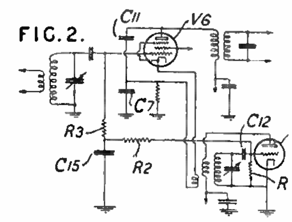


bias applied to capacities or inductances in circuits arranged to vary tuning, coupling or feed-back. Circuits are shown in which the band pass is a function of incoming signal strength. L. L. Kramolin, Berlin. No. 455,190.

Television. In a receiver for television and sound the sound energy is received on a super-regenerative receiver and the quenching frequency is obtained from the television scanning frequency. Marconi Co. No. 453,135.

Tone control. An automatic system comprising a condenser-resistance combination, the resistance having a predetermined temperature coefficient and being traversed by a current depending on the momentary gain of the receiver, with the effect of reducing high-note response during periods of high gain or weak input signals. Marconi Co. No. 453,138.

Frequency changer. To compensate for changes in the amplitude of the local oscillations in a heterodyne re-



ceiver, a regenerative mixing tube has its regeneration varied by a biassing voltage derived from the oscillations. N. P. Case, Hazeltine Corp. No. 453,-658.

Remote control. A remotely tuned superheterodyne in which the local oscillator is regeneratively back-coupled, the variable reactance element of the oscillator is remotely situated from the remainder of the frequency determining circuit and is associated therewith through a screened cable and a ferro-magnetically cased tight coupled transformer at the end of the cable remote from the reactance, the low impedance winding facing the tuning reactance while a further screened cable effects the back-coupling. Marconi Co. No. 443,637.

Transmission line. A two-conductor line carrying a wide band of frequencies as in television is coupled to an amplifier so that interfering potentials between the line and earth are removed from the amplifier output. E. L. C. White, Middlesex. No. 443,589.

Tuning indicators. Visual tuning indicators for receivers comprise an evacuated cathode-ray device containing controlling means receiving varying voltage bias to vary the angle of divergence of either an electron beam or a shadow within such beam, and so to produce corresponding changes in the illuminated area on a fluorescent anode. Ferranti, Ltd. No. 443,602.

Automatic tuning. A tube the impedance of which varies with the departure from exact tune, and which acts to vary the frequency of the local oscillator in a compensatory sense. E. K. Cole. No. 443,505.

Directive system. A radio beam for use in air-navigation is simultaneously modulated in different ways by interposing in its path ionized gas tubes. I. Wolff, Marconi Co. No. 443,992.

Power amplifier. With the object of increasing the ratio of power output to power supplied in a radio-transmitting amplifier, or in a push-pull audio-amplifier, the anode supply voltage and the grid bias are automatically regulated according to the mometary strength of the audio signal. Lorenz. No. 444,050.

Wide band amplifier. A thermionic amplifying system suitable for frequencies down to zero comprising several direct-coupled amplifiers. Scophony, Ltd. No. 444,058.

Tuning indicator. A receiver is provided with a tuning indicator, the indication of which is a function of the amplification and also of the current or voltage set up in an auxiliary sharply-tuned circuit such as a muting circuit. F. T. Lett, Buckinghamshire. No. 444,179.

Adjudicated Patents

(D. C. N. Y.) Lindenblad patent, No. 1,884,006, for antenna, claims 23 to 27, inclusive, *Held* not infringed. *R. C. A.* v. *Mackay Radio & Telegraph Co.*, 16 F. Supp. 610.

(D. C. N. Y.) Carter patent, No. 1,909,610, for electric circuit, claims 1 to 5, inclusive, *Held* not infringed. *Id.*

(D. C. N. Y.) Lindenblad patent, No. 1,927,522, for antenna for radio communication, claims 9, 10, 19, and 23 *Held* not infringed. *Id.*

(D. C. N. Y.) Carter patent, No. 1,974,387, for antenna, claims, 1, 2, 3, 4, 10, 12, 15, 16, 28, 34, 35, 36, 38 and 40 *Held* not infringed. *Id.*

Adverse Decisions in Interference

In interferences involving the indicated claims of the following patents final decisions have been rendered that the respective patentees were not the first inventors with respect to the claims listed:

Pat. 1,978,461, P. L. Hoover and E. D. Kennedy, Timing axis for cathode ray oscillograph, decided September 2, 1936, claim 5.

Pat. 1,988,486, Lester Ferenci, Photoelectric web registering device, decided November 18, 1936, claims 1, 11, and 17.

Pat. 1,908,381, Charles Travis, Radio receiving system, decided December 12, 1936, claims 1, 2, 4, 6, 7, 8, and 9.

Patent Suits

1,573,374, P. A. Chamberlain; 1,707,-617, 1,795,214, E. W. Kellogg, apparatus; 1,728,879, Rice & Kellogg; 1,894,-197, same, filed Oct. 24, 1936, D. C., N. D. Calif. (San Francisco), Doc. E 4098–L, *R. C. A. et al.* v. *C. Abel* (*Coast Radio Co.*).

SEARCHLIGHT SECTION

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Position Wanted, (full or part-time salaried employment only), ½ the above rates, payable in advance.

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Box Numbers in care of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads. Replies forwarded without extra charge.

Discount of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

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An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

COPY FOR NEW ADVERTISEMENTS RECEIVED UNTIL 28TH OF THE MONTH FOR THE ISSUE OUT THE FOLLOWING MONTH (Elect)

Do Electronics' "SEARCHLIGHT" ads get results?

Reviewing the record of replies forwarded to box number advertisers during 1936:

POSITIONS WANTED: One or more replies were forwarded to 6 advertisers. The employment sought covered radio engineer and research physicist, designing electronics devices, development or research work on audio frequency equipment design, commercial radio engineer, investigation and development work on electrical or electro-optical apparatus, and factory or laboratory engineer on electron tube manufacturing.

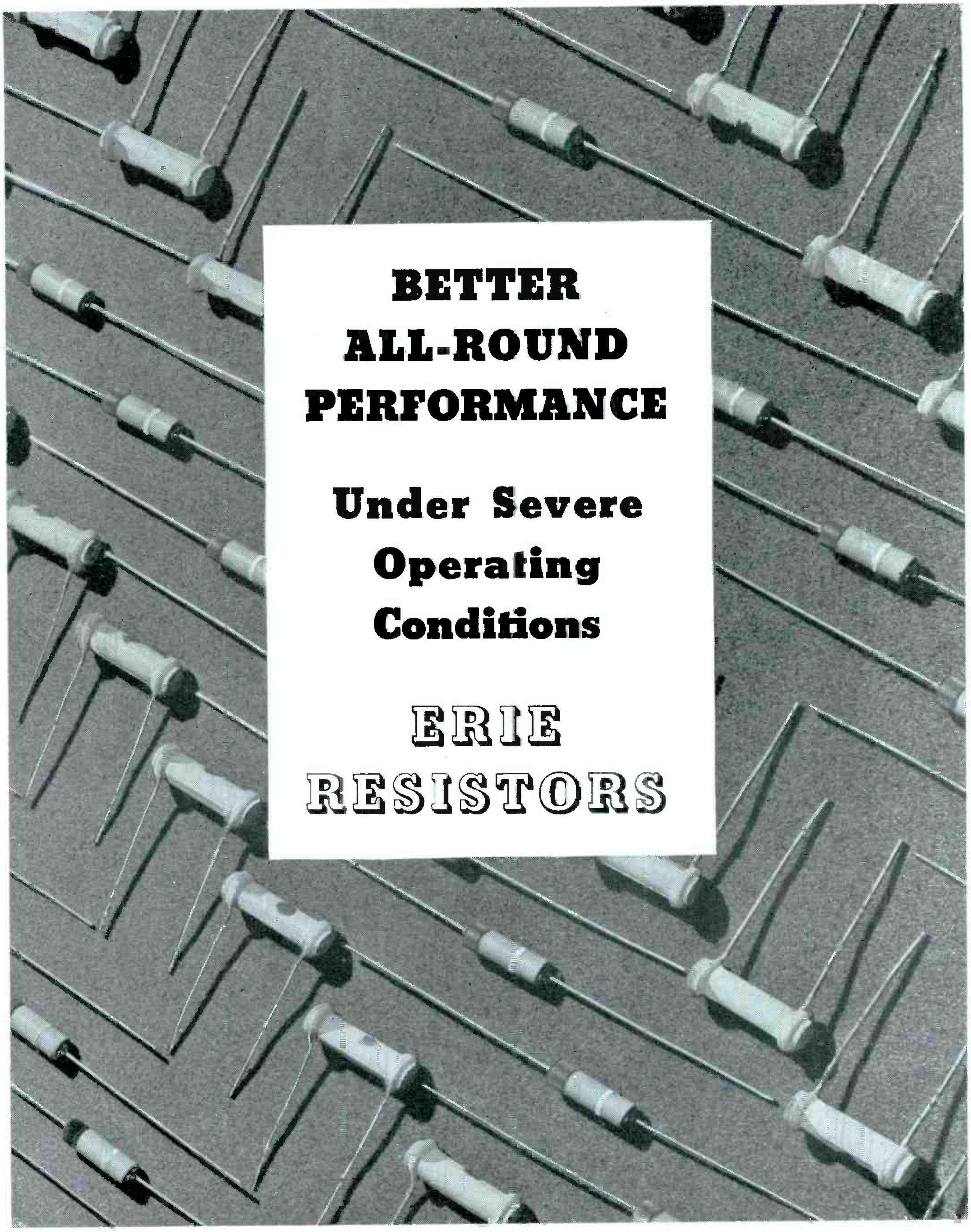
POSITIONS VACANT: From 1 to 12 replies were forwarded 4 advertisers. The employment offered covered charge of promotion work on radio sales and engineering. Chief Engineer for manufacture of broadcasting transmission equipment, as engineer with manufacturer of testing equipment with development engineer on electro-acoustic and electromechanical development.

BUSINESS and SALES OPPORTUNITIES: Replies were also forwarded to advertisements covering the purchase of licenses for television equipment and sales representation for manufacturers.

The advertising reviewed above typifies the business wants of the electronics industry and the men employed in it. The response to this advertising establishes the close contact of ELECTRONICS with the industry it serves.

Can "SEARCHLIGHT" help you Solve a current business want?

INDEX TO ADVERTISERS


BETTER
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Get the facts and features about

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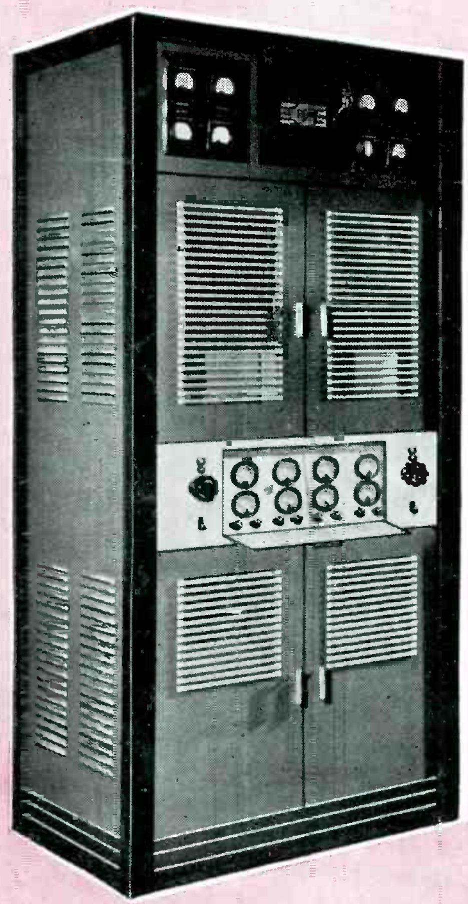
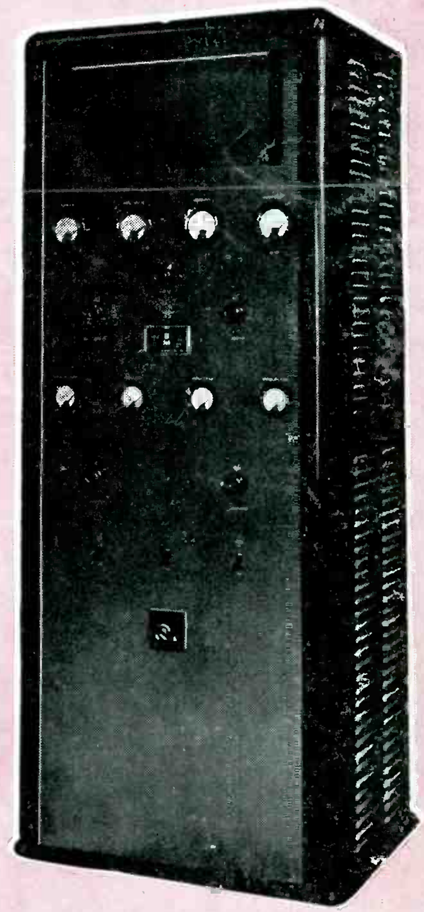


The RCA 250-G HIGH FIDELITY TRANSMITTER and RCA 250-D TRANSMITTER provide many splendid features

Space won't permit us to tell you one-tenth of all the fine features RCA has built into these two new transmitters.

Both are RCA's newest. Into them go the same quality workmanship and materials which for years have distinguished RCA equipments. They are the latest addition to a line of transmitters which have received the approval of broadcast engineers from coast to coast.

You'll want to know more about them, so drop us a line. We'll send you the facts and features about these transmitters that tell you more than a thousand fancy words. There's no obligation, of course. Just ask — and the information is yours — free!



NEW RCA TRANSMITTER 250-D... rated at 250 watts and 100/250 watts. A low power transmitter and a basic exciter unit. Simple, efficient operation. Fine performance. Easy accessibility. Low operating cost. Most modern design. 16 operating meters, conveniently located. Interlocking doors for safety. Easy installation.

NEW RCA HIGH FIDELITY TRANSMITTER 250-G

... a complete broadcast transmitter rated 100/250 watts (also available for 100 watts as "Type 100-G"). Includes space for Type 66-A Modulation Monitor. Provides unequalled performance to prevent early obsolescence and assure high fidelity. Generous safety factors and conservative tube operation make certain uninterrupted programs. Low operating cost because of low power input. Easy accessibility. Has four chassis — High Voltage Rectifier — Modulator — Low Level R.F. and Low Level Rectifier — High Level R.F. — each of which may be removed simply and quickly.

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