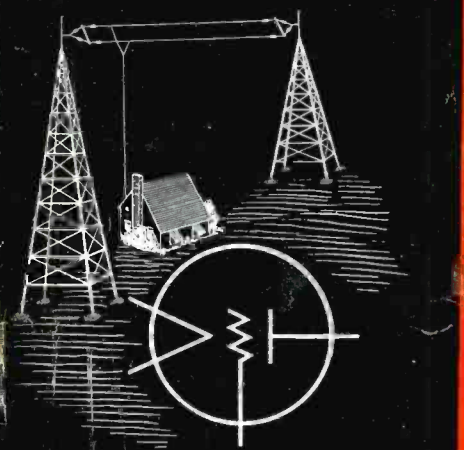
NOVEMBER, 1932

Radio Engineering



IN THIS ISSUE

TWELFTH YEAR OF SERVICE

The Journal of the Radio and Allied Industries

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F. WALEN

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Departments

HALL MARKED RADIO

FROM a radio sales viewpoint, down in New South Wales they appear to have matters well in hand. An organization known as the Electrical Apparatus Safety Board functioning through a committee of representatives of organizations in the electrical industry, places a Hall Mark of approval on radio receivers so designed and made that they have the minimum of dangerous hazard.

A distinctive seal is used for the Hall Mark. It carries the information that the set so marked has been "approved for connection and use."

Such procedure and inspection should further the use of properly designed and constructed receiver elements, to that extent raising the standard of dependability and performance.

In the United States it may be that nothing short of rigidly enforced State laws would be effective in this situation, and this is unthinkable because of the entailed additional forty-eight commissions.

There is a suggestion in this for the R. M. A. Let us see who will be first to make a practical proposal along this line.

BRYAN S. DAVIS
President

JAS. A. WALKER
Secretary

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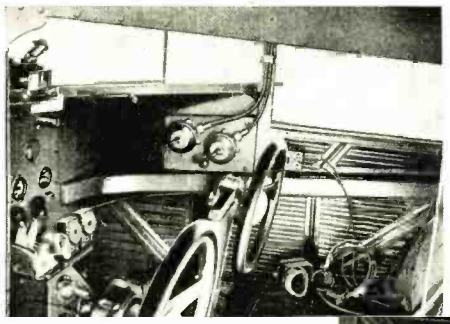
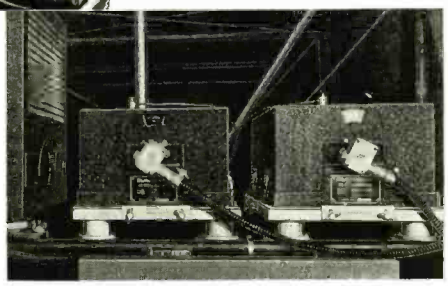
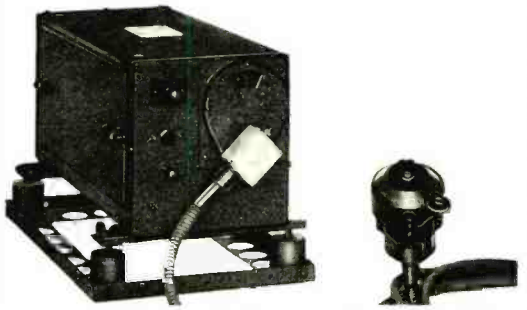


S. S. WHITE Flexible Shafts accurately transmit the finest movements of the control handles (above) to the receivers mounted in the fuselage (right), in this installation of WESTERN ELECTRIC high and low frequency airplane radio receivers.





S. S. WHITE Flexible Shaft provides sensitive, reliable remote control of STROMBERG-CARLSON airplane radio receivers (above), even when, as often happens, tuning control and receiver are mounted as far apart as 50 ft.

A FLEXIBLE SHAFT *specifically designed for* REMOTE CONTROLS

S. S. WHITE Flexible Shaft No. 150L50 was developed for use on instruments and equipment of all kinds requiring remote control. It is suited particularly for this application because its torsional deflection in operation is so slight as to be negligible, and deflection is equal for either direction of rotation.

This shaft is used on leading makes of airplane and automobile radios, and has amply demonstrated its ability to accurately transmit the most sensitive movements of the tuning dials to the receiving sets, often over long distances.

It is used also for remote control of switches, thermostats, etc., for synchronized operation between talking motion picture recording and projecting machines and similar applications.

A new type of flexible metallic casing of small outside diameter (.255") has also been developed by S. S. WHITE for use with this shaft.

Full details, prices, etc., furnished on request. If you have a remote control problem, put it up to us . . . we'll be glad to help you work it out . . . no obligation. This holds also for any other application of a flexible shaft.

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INDUSTRIAL DIVISION
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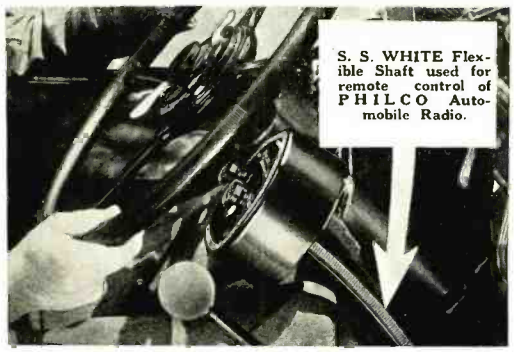
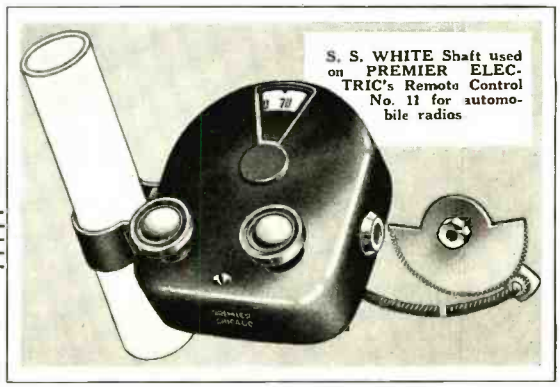


S. S. WHITE Flexible Shaft used for remote control of PHILCO Automobile Radio.



S. S. WHITE Shaft used on PREMIER ELECTRIC's Remote Control No. 11 for automobile radios

Editorial

NOVEMBER, 1932

A QUARTER CENTURY OF THE TUBE

FOLLOWING the contributory steps taken by Elster and Geitel in 1882, Edison in 1883, Hittorf in 1884, J. J. Thompson in 1899, Richardson in 1901 and Fleming in 1905, Dr. Lee de Forest in 1907 introduced the third element (the grid) into the vacuum tube.

The first public announcement of the invention of the Audion was given by de Forest at the October 20, 1906, meeting of the American Institute of Electrical Engineers, New York. The name "Audion" was given to the device by C. D. Babcock, one of Dr. de Forest's technical aides; "aud" being Latin, and "ion" Greek, signifying "audible ions." This was the filament and two-plate tube of 1906. In 1907 one of the plates was replaced by a mesh grid. This improvement, after its function was fully understood, was destined to give impetus to extensions of radio telegraphy; make radio telephony possible, and revolutionize long distance land line telephony.

Throughout the period 1907-1912, the powers which, behind the veil, direct the destinies of human progress had opportunity to reflect upon the limitations of human perception, for, during those five years the tube's full utility was not sensed by any of the hundreds of scientists who were tinkering with it. It was not until in 1912 de Forest, Logwood and Armstrong, in America, and simultaneously or shortly thereafter, numerous investigators in Europe, were able, as Macbeth:

"To look into the seeds of time,
And say which grain will grow and which will not."

Thenceforth, however, the tube came into its own. A long list of illustrious names are identified with its advance: R. von Lieben, Eugen Reisz, O. von Baeyer, Irving Langmuir, W. D. Coolidge, S. von Strauss, C. S. Franklin, A. Meissner, and others.

The advent of radio broadcasting called for development along the line of reducing the current and voltage required to give a sufficiently dense electron stream from the filament. In 1921 "dull emitter" tubes were introduced into service. Then followed a bewildering succession of improvements: a-c. heater, screen-grid, multi-mu, pentode, and so on down to the latest "duplex-triode-diode" contraption.

Although the vacuum tube has for a quarter of a century been almost exclusively identified with the advance of radio, its principles are now being applied, or are being investigated, for application to other arts:

"Man-blown bubble of glass and wire!
Thy thread-fine filament
Still glowing with the God-like fire!
What does thy coming mean?"

▲

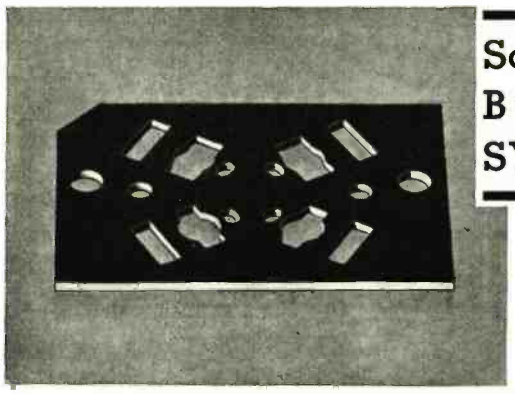
THE PRICE OF PARTS

THERE are no doubt two sides to all questions, but in the matter of supplying radio receiver parts to large and to small manufacturers of receivers, there appears to be much dissatisfaction. The larger plants believe it unfair that any fly-by-night outfit can procure many of the main elements for receiver manufacture at the same price for small quantities that the larger manufacturer pays for large quantities. Particularly does the grievance appear justified when it is considered that in certain instances the parts, although not patented, are designed and developed in the laboratories of the larger manufacturers.

The subject is one well worth the immediate attention of the proper committee of the R.M.A.

Donald McNicol

Editor.



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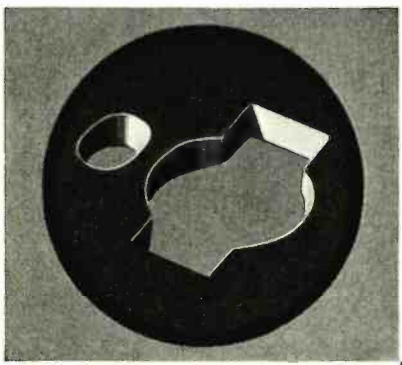
Less Waste Fewer Rejections Minimum Tool Wear With SYNTHANE

SYNTHANE uniform laminated Bakelite punching stock gives you better looking edges, no surface cracking between holes, lowered waste due to thinner skeletons and minimum wear on tools. No hard spots nor gum pockets. Notice the clean edges, absence of surface cracks and the thin walls in the microphoto of a SYNTHANE tube socket base.

This is possible with SYNTHANE because only best grade paper stock is used for the base. It is free from foreign particles that cause trouble in punching and wear on tools. Complete lamination eliminates lift and pulling around punched holes.

Save money by using SYNTHANE laminated insulation. Send us your specifications for samples and quotations. There's nothing to lose—much to gain. Prove it to yourself.



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SYNTHANE Canvas Base—Long fibre cotton, equal strength of warp and fill give exceptional resiliency, structural and impact strength.

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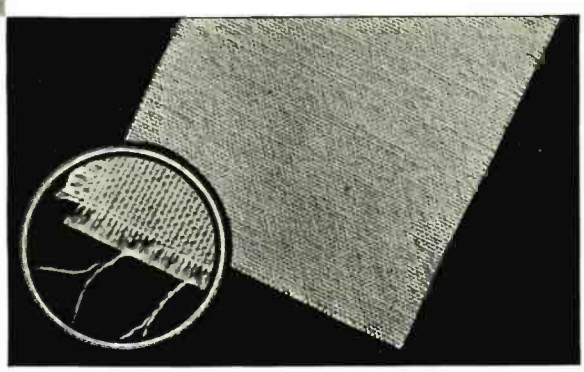
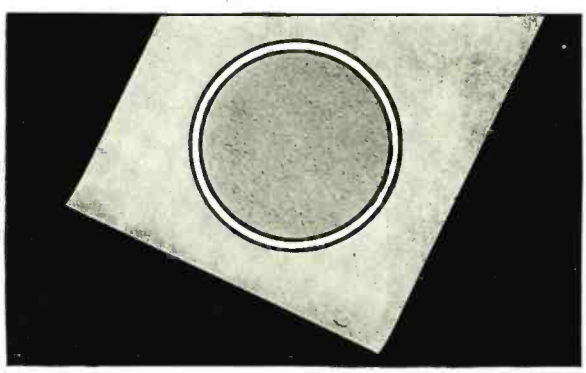
Notice the smooth, uniform texture and absence of impurities in the paper illustrated.

Save money by using SYNTHANE laminated insulation. Send us your specifications for samples and quotations. There's nothing to lose—much to gain. Prove it to yourself.





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RADIO ENGINEERING

Production, Administration, Engineering, Servicing

Vol. XII NOVEMBER, 1932 No. 11

Modulation and distortion measurements by means of the cathode ray oscilloscope

By SAMUEL BAGNO and SAMUEL S. EGERT*

THE importance of a complete visual check of modulation and distortion in broadcasting work cannot be over-emphasized. These checks do not necessarily have to be extremely accurate, but the operator must have some idea of how his instruments are behaving. There are several ways of doing this, but the best method uses a cathode ray oscillograph, as a cathode ray oscillograph not only shows the percentage of modulation, but gives a fairly good visual indication of the distortion. A great deal has been written on the theory and use of this type of oscillograph for wave measurements, but there is very little technical information available as to its particular use in broadcasting stations, especially at the transmitter. It was with the purpose of obtaining photographic records and other complete data on the use and behavior of this instrument in a bona fide broadcasting station that we obtained permission to run a complete set of experiments at the transmitter of station WLTH. Traces of modulation were obtained showing the radio wave as it was being transmitted. It was quite startling to see diagrams that had been theoretically predicted in radio texts, actually transmitted into space. The instrument enabled one to see a recurrent phenomenon that lasted less than one-millionth of a second. Not only was it possible to see a complete wave train in a modulated carrier, but the unmodulated wave form of the transmitted frequency could be observed. This frequency was 1,400 kilocycles.

The Federal Radio Commission requires each broadcasting station to be capable of 100 per cent modulation. This makes it necessary for each transmitter to have some means of measuring the percentage modulation. The fundamental theory involved in any method of making these measurements consists of the use of a peak-voltage voltmeter to read the maximum r-f. voltage amplitude of the unmodulated wave and the r-f. voltage amplitude of the unmodulated carrier. The difference between the modulated peak-voltage and the average or unmodulated carrier voltage divided by the unmodulated carrier voltage, gives the exact percentage modulation. It is assumed that there is no distortion of the audible frequencies in modulating the carrier. When these measurements become complicated by distortion in the modulation measuring instrument, it is extremely difficult to obtain an accurate knowledge of the results. The average meter type indicator of modulation does not take this distortion into account, and if distortion does occur there is no way of detecting its presence. Since the cathode ray oscill graph is nothing more than an electro atic voltmeter that can act instantly, w can obtain a trace of the modulated v ive, an indication of its distortion and a true record of the percentage modula on.

The cathode ay oscillograph consists of an electron enerator in the form of a heated cathoc that emits a very narrow beam of ectrons. This beam is converted into a point source of light by impact agai st a fluorescent screen. This beam of e ctrons can be deflected either by an el ctrostatic field or magnetic field place in its path. Deflecting the beam caus s the point of light to move along th fluorescent screen. The total deflection of this electron beam is proportional to he strength of the field acting on it. S nce the beam or pointer consists entirel of electrons, its inertia is negligible a l it can follow a radio-frequency volt ge as easily as it can follow an impu se of several cycles per second. The ommercial cathode ray tube has two f lds deflecting the beam, acting at righ angles to each other. One field is r ade proportional to the amplitude of tl impulse intended to be measured, wh eas the other field is varied at some desired function of time. If this functic of time is made linear an exact trace of the incoming wave is obtained on th fluorescent screen.

Measurement of Modulation

There are veral ways of applying the principle irectly to the measurement of modu ation. The simplest by far consists i not making use of the time axis at al The r-f. wave is put on the two defle or plates which tend to indicate ampli ade. On the fluorescent screen we se a line whose length is proportional twice the r-f. peak-voltage. This line varies in density

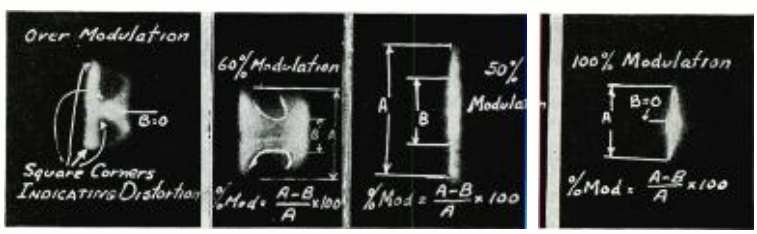

Fig. 2. Fig. 1.

Photograph by Robert Atkin

Fig. 2. The elliptical method. Fig. 1. The straight line method.

*Egert Engineering, Inc., New York.

along its length, and near its center there are two very dense portions depending on the minimum amplitude of the modulated wave. If we measure the length of this line and the distance between the two bright portions near the center of the line, we obtain the percentage modulation by the following formula.

The total length of a line less the distance between both bright portions (which become unity at 100 per cent modulation or over) divided by the length of the line, is equal to the percentage modulation. This method is entirely inaccurate when the station over-modulates as will be apparent from later discussion. The line that is seen consists of r-f. impulses superimposed on each other. These r-f. impulses vary in amplitude according to the way they are modulated. The only way to observe the minimum amplitude of the modulated wave is to observe the brightest portion of this line. A photograph of modulation indicated by this means is shown in Fig. 1.

This method has the disadvantage of being ineffective when the transmitter over-modulates, since it will at all times read 100 per cent modulation when the modulation is 100 per cent or over. In order to overcome this difficulty the time axis can be controlled from the audio-frequency amplifier that feeds the modulator. Instead of having no time axis we can use one that is almost sinusoidal. The resulting trace on the fluorescent screen will be in the form of a double ellipse, one slightly below the other, and both ellipses interconnected by the r-f. trace. Here again the distance between the highest point on the top ellipse and the lowest point on the bottom ellipse (as shown in Fig. 2) is twice the peak amplitude of the r-f. wave. Similarly the distance between the bottom portion of the top ellipse and the top portion of the bottom ellipse is twice the minimum amplitude of the r-f. wave.

The average amplitude which is roughly equal to the amplitude of the unmodulated carrier is one-half the sum of these two amplitudes. The percentage modulation is the peak-voltage minus the average voltage divided by the average voltage. This method has the particular advantage of following the frequency of the modulating impulse at all times so that the images on the fluorescent screen are continually super-

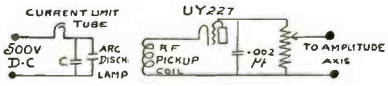

Fig. 4. Fig. 5.

imposed on each other. If distortion occurs, the traces, instead of showing ellipses, will show deformed ellipses whose corners tend to become square. This method has the disadvantage of not showing an actual picture of the r-f. trace.

Sweep Frequency

In order to avoid this difficulty we may introduce the sweep frequency which is merely a linear time axis on the field which is at right angles to the amplitude field in the tube. Then we obtain a trace of the wave just as it occurs. The envelope of the area representing the r-f. impulses is a modulated wave. This method not only enables one to see what the minimum and maximum values of the r-f. are at any given time, but it also enables one to watch distortion and over-modulation. It may be of interest to explain the sweep circuit which gives a linear time axis.

The circuit is shown in Fig. 4. A constant current device is used to charge a condenser. The resulting charge builds up a voltage across the terminals of the condenser which is directly proportional to the time of charge. When the condenser has been charged to a given fixed value it causes an arc in the gas-filled tube. This arc instantly discharges the condenser and the process starts all over again. If we use the voltage across the condenser to generate the field at right angles to the field which indicates amplitude in the cathode ray tube, we get a deflection of the beam that is proportional to time. This method is extremely advantageous when the modulating frequency is constant. If, however, the modulating frequency varies and the sweep frequency or linear time axis does not change exactly in proportion to it, the image of each wave will not be superimposed on the next, and as a result the image will be a continual blur. Although the sweep frequency can be tied in with the modulating frequency to follow it within small limits, it is impossible to obtain a synchronous condition at all times. This is especially true when the frequency of the modulating wave keeps varying continually. Several traces of modulation obtained by this method are shown in Fig. 3 with percentage of modulation shown.

The Radio-Frequency Trace

The methods herein described for observing modulation on the cathode ray tube do not produce a clear picture due to the fact that the r-f. trace covers a complete area. The envelope of this r-f. trace is not very sharply defined. If greater accuracy is desired a linear detector can be used to feed the plates of the cathode ray tube that determine the amplitude of the voltage swing. This enables one to see only the amplitude of the radio-frequency wave. In order to run calculations of percentage modulation by this method the position of the cathode ray beam at zero r-f. voltage must be determined.

The proper linear detector that gives good results is shown schematically in Fig. 5. A type 227 tube is used as a rectifier. Its cathode is placed in series with one end of the pickup coil. The other end of the pickup coil goes to a 25,000-ohm potentiometer which is connected to the grid and plate of the rectifier tube. The resulting amplitude of the d-c. voltage across the potentiometer is proportional to the average amplitude of one-half of the r-f. wave. The potentiometer arm is used to give a conveniently spaced amplitude swing on the screen of the cathode ray tube.

Probably the best indication of distortion with the cathode ray tube is obtained by the use of the sweep circuit. Here we get an actual picture of the wave. If a sine wave is used to actuate the modulating system of the oscillator we can easily obtain a comparison between the original sine wave as thrown on the oscillograph and the modulated wave. By superimposing a tracing of one wave on the other the resulting difference between both images must be the distortion. This distortion may consist of odd harmonics, even harmonics or a combination of both.

Without a great deal of work and by using a planimeter to analyze the pictures we cannot obtain the exact percentage of distortion. However, several things are evident from a careful examination of an oscillograph. Even harmonics are due most probably to satu-

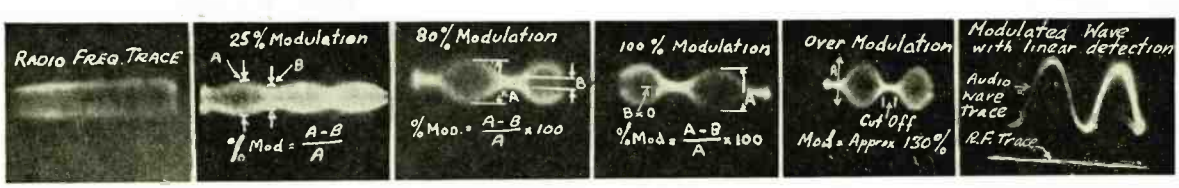

Fig. 3. The sweep method.

Photograph by Robert Atkin

rated tubes, or to transformers which have too great a direct-current component. These even harmonics give a trace that is unsymmetrical. The portion of the wave above the zero axis is dissimilar to the portion below the zero axis. All odd harmonics distort the sine wave, but the distortion is exactly symmetrical for the upper and the lower portion of the wave. This is due to the fact that even harmonics have their full positive and negative swings during each half cycle of the fundamental. Take the case of a strong second harmonic added to the fundamental: When both are in phase, that is, start from the same point, the first half cycle of the harmonic adds to the fundamental, whereas the second half cycle subtracts from it. When we get to the second half cycle of the fundamental the third half cycle of the harmonic is positive, whereas the second half cycle of the fundamental is negative. Here again we obtain a subtraction of amplitude and by a similar process of reasoning it becomes evident that the fourth half cycle of the second harmonic will add to the second half cycle of the fundamental. This gives the unsymmetrical wave. The same process of analysis can be used to show that all even harmonics when added to the fundamental will generate waves whose positive and negative nodes are dissimilar.

Fig. 6. Oscilloscope equipment complete.

All odd harmonics start and finish in the same direction as each half wave of the fundamental, thereby producing a wave that is symmetrical. A similar method of analysis can be applied to elliptical figures obtained with a sinusoidal time axis.

Unlike a mechanical system, a radio system gives no visible signs of its operation, except in unusual cases. The operator does not actually see what is happening. At best the meters give a static indication of what is happening. However, the ideal system would give a dynamic indication, that is, it would enable one to see each electron as it passes from one part of the circuit to the next. The cathode ray tube is the closest approach to this, for it enables us to see what actually happens. As a result of the experiments conducted at Station WLTH it seems evident that a cathode ray tube is indispensable for this work.

We are greatly indebted to J. Burch, chief engineer of Station WLTH, and Robert Atkin, without whose active cooperation these experiments would not have been possible.

Connections for Various Methods of Studying Modulation

Method	Time Axis	Amplitude Axis: Without linear detection	Amplitude Axis: With linear detection
R-F. without time axis.	Both time axis plates short-circuited.	Connected to pick-up coil placed near antenna coil.	Both plates connected to output of linear detector which is fed by r-f. pickup coil.
R-F. with sinusoidal time axis.	Both plates connected through potentiometer to output of line amplifier.	Both plates connected to pickup coil placed near antenna coil.	Both plates connected to output of linear detector which is fed by r-f. pickup coil.
R-F. with linear time axis.	Both plates connected to sweep circuit. Input to sweep connected to output of line amplifier.	Both plates connected to r-f. pick-up coil.	Both plates connected to output of linear detector which is fed by r-f. pickup coil.

▲ ▲ ▲

Taxes on Radio

A NUMBER of important rulings have recently been announced by the tax department with respect to the tax on radios and phonograph records. The following is a digest of these rulings prepared by J. S. Seidman, tax expert of Seidman & Seidman, New York, certified public accountants.

1. Ornamental metal pieces which are placed on the front of a radio cabinet around the window in which the dial appears, known in the trade as bezels or escutcheons, are not subject to tax when sold to manufacturers of radio cabinets. They are, however, subject to tax when sold by the radio cabinet manufacturer in connection with the sale of a radio cabinet.

2. A power transformer sold to public utilities for use in the distribution system is not subject to tax. The small type of transformer is not subject to tax when sold separately. However, where it is sold in connection with any of the taxable radio parts, the tax will attach to the sales price of the assembled article.

3. Photophone sound systems for recording and reproducing sound in connection with motion pictures are not taxable as such.

4. Motion picture records, on the other hand, that is, records on which are recorded the sound effects which, when synchronized with a motion picture film through a suitable apparatus, produce so-called talking movies, are taxable if they are in the form of electrical transcription phonograph records, inasmuch as the tax is upon the records themselves and not on the manner in which they are used.

5. Broadcast transmitter equipment and power tubes or accessories therefor are not taxable unless they form one of the articles specifically enumerated in the law.

6. Vacuum tubes sold for use in connection with broadcast transmitters or photophone sound systems are taxable if they are of the same type as those used in the radio receiving set or combination radio and phonograph sets. The fact that they are sold for a non-taxable use does not exempt them.

7. Radio tubes of the same general types as those in radio receiving sets, bought for testing or experimental purposes, are subject to tax, as the privilege of purchasing tax-free under an exemption certificate extends only where the taxable article is used as a material in the manufacture or production of another taxable article, and not where it is consumed by the manufacturer himself.

Photoelectric relays †

By W. R. KING*

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Equipment for usual types of application—a-c. and d-c supply circuits.

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PHOTOELECTRIC relays, or light relays as they are sometimes called, are being used in an increasing number of new and successful applications in the United States and Canada. Many machine designers and plant engineers have learned that they are justified in considering the beam of light along with their cams, levers, limit switches, and other mechanical contrivances. The fact that the beam of light does not wear out, offers no resistance to moving objects, and cannot mar or scratch finished parts, makes its use highly advantageous in many operations.

Although many specialized applications of photoelectric tubes have been made, involving more or less special equipment designed to meet the particular requirements, in this article consideration will be given only to those applications and equipments in which a relatively large change of light on a photoelectric tube causes the opening or closing of an electric circuit.

The mode of operation of the photoelectric tube has been described many times in technical literature; and for this reason only brief mention will be made here that light, falling on the sensitized cathode, causes an electron emission which allows a current flow proportional to the light flux, and furthermore, that this current is of such a low order of magnitude that it requires amplification, generally by some other electronic device, to increase it to a useful value.

Various types of photoelectric relays to meet the different operating conditions, power supplies, and speed requirements have been made available to industry by the electrical manufacturers. These devices are generally complete in themselves; that is, the photoelectric tube, a means of amplifying the photo-current, the necessary amplifying circuit components (transformers, resistors, capacitors, etc.), and a relay or contractor are all included, mounted, and connected. The user has only to select a proper type of photoelectric relay, make connections to the power supply and to the circuit to be controlled. The selection of a suitable light source is also an important point and should obviously be considered at the time of selecting the photoelectric relay.

One of the simplest types of photoelectric relays is that employing a pliotron. This device operates from an a-c. supply. The output current of the pliotron amplifying tube energizes the coil of a sensitive relay which in turn controls a contactor. The user may adjust the device to suit the amount of light on the photoelectric tube by means of an adjusting potentiometer which controls the bias voltage of the pliotron tube. In this device, the photoelectric tube is mounted in a separate housing and connected to the amplifier circuit by a flexible cable. This makes the device quite flexible in its application. The length of the cable, however, cannot be increased unduly without sacrificing sensitivity. The reason for this is that the interconductor capacitance constitutes an impedance paralleling the photoelectric tube. Since the impedance of the photoelectric circuit is many megohms, it is obvious that the capacitance of the two leads does not have to be large to represent an impedance (at sixty cycles) low enough to effectively short circuit the photoelectric tube. By using shielded cable and taking precaution to keep the interconductor capacitance as low as possible, the cable may be increased to many feet if necessary.

A cable length of four or five feet is suitable for most purposes and can be used without any appreciable sacrifice in sensitivity.

Margin

One photoelectric relay operates on light changes of the order of 40 to 50 per cent and may be successfully operated with light intensities as low as ten foot-candles; that is, with an illumination of ten foot-candles the contactor is open, but if the light is decreased to five foot-candles the contactor will close. With higher illumination values the per cent change required decreases somewhat, but the actual change in illumination required, expressed in foot-candles, is greater than at the lower illumination values. The figures given neglect voltage variation which will be taken up later.

A similar device, but for operation from d-c. industrial circuits, requires a tapped resistor to provide the various necessary voltages which, in the a-c. unit, are provided by several secondaries on a small transformer. Since the pliotron tube filament is designed for low voltage, and requires approximately one ampere, the voltage divider must be designed for this current. Consequently, some power is wasted. A 125-volt unit, for example, uses 125 watts (contactor de-energized), as against about 10 watts for the a-c. device. Obviously, if the d-c. supply voltage is higher the power consumption increases accordingly since the current is fixed by the pliotron tube filament rating.

The d-c. unit, however, has some advantage to compensate for its increased power consumption. The problem of capacitance in the lead to the photoelectric tube does not appear, so the lead may be extended to many feet. Of course, proper precautions must be taken to prevent actual leakage occurring between the two conductors.

The d-c. photoelectric relay may be operated by an illumination change of about two foot-candles, this value remaining practically constant up to approximately 20 foot-candles; that is, at 16 foot-candles the contactor is open and a decrease to 14 foot-candles causes it to close; at 10 foot-candles, the contactor is open and a decrease to eight foot-candles causes it to close. The minimum illumination for operation is about five foot-candles. These figures neglect the effect of voltage variations.

The speed of operation of the two devices so far considered is limited by the time required to operate the two magnetic relays successively. In a typical case this time of response is of the order of one-tenth second. Many applications arise in which the light impulse (or the light interruption) does

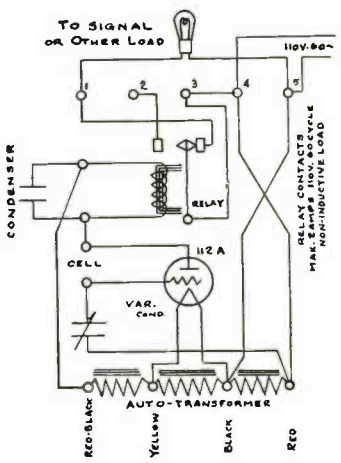

Fig. 1. Typical cell and relay circuit.

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not last as long as one-tenth second; for example, in counting objects, even though the count may total only a hundred or so per minute, the objects are often so small and pass at such a speed that duration of the light beam interruption is far less than one-tenth second. One must not be deceived by the number of "counts per minute;" the duration of both the light and shadow must be considered.

Relay Lag

Since the time lag is practically all in the magnetic devices, it was natural to try to eliminate them to increase the speed of response. This was done in one case by using the thyratron tube. Practically speaking, the thyratron tube is a mercury-arc or mercury-vapor rectifier having grid control. For this article, we need consider only the mercury-vapor thyratron tube employing a hot cathode. In this tube there is, for a given anode voltage, a particular grid voltage at which ionization will just occur, permitting the tube to pass current. Once the anode current is started, the grid has no appreciable effect on it. The grid cannot limit or stop the flow of current, but can regain control to keep it from starting again if the flow is stopped long enough for the mercury vapor to de-ionize. If an a-c. voltage is applied to the grid, the phase relation between this voltage and the anode voltage will determine the point at which the tube begins to conduct in each cycle.

In a typical small thyratron tube having an anode current rating of one-half ampere, the ionization time is of the order of 10 micro-seconds and the deionization time of the order of 1,000 micro-seconds. Since the grid requires only a very small amount of power, we have a relaying device without magnetic or mechanical lag. There are, of course, certain limitations which will be discussed later.

In the photoelectric relay first mentioned, the pliotron tube output current is definitely related to the photoelectric tube current and therefore, to the amount of light on the photoelectric tube. If the pliotron tube current is passed through a suitable resistor, the voltage drop across this resistor offers a means of controlling the thyratron tube as a relaying device. When the light, and therefore the pliotron tube current, is below a certain value, the voltage applied to the thyratron tube grid is not high enough to permit the thyratron tube to conduct. When the light is above this value, the increased voltage permits the thyratron tube to conduct. A simple reversal of connection permits operation in the opposite sense; that is, the thyratron tube will conduct on a light decrease. The contactor shown is energized by the thyratron tube, but the tube may energize the load directly if the required current does not exceed the rated anode current.

From the figures given on the ionization time of the thyratron tube, it is apparent that it will respond to amplified light impulses (or light interruptions) of very short duration. But since the tubes are all supplied with alternating current and are all rectifying devices, that is, they pass current only when their respective anodes are positive, it would be possible for light impulses or interruptions of extreme short duration to occur during a negative half cycle when no response would result. This imposes a practical limitation dependent upon the system frequency. To be positive of consistently securing an electrical impulse of at least one-half cycle duration, the light impulse or interruption must be not less than the equivalent of one cycle duration.

Time Constant

The other limitation which occurs is that of the load itself. If it is a magnetic device, its time of response rather than the system frequency will probably be the limiting factor. The practical minimum is generally from 2 to 3 cycles, although some cases will probably be found in which response may be consistently secured in a shorter interval.

At first glance, it may seem that this detailed consideration of speed of response could not be of practical importance or use. It has been found, however, that not only do a large number of applications require response in the short times so far considered, but many require response to light or dark impulses of much less duration. The solution of such problems obviously cannot be secured using a-c. equipment. The photoelectric - pliotron - thyratron tube combination, however, offers an excellent solution when operated from direct current. The system will theoretically respond to impulses of the order of ten micro-seconds and has already been used commercially to respond to impulses of less than 0.002 second. When the impulse occurs the thyratron tube conducts and, since its anode voltage continues positive, it continues to conduct until the anode circuit is opened. This permits time for a magnetic device to operate, but prohibits response to impulses recurring in anything like the same time as the duration of the impulses; that is, the time between impulses must be much longer than the duration of the individual impulses. While this difficulty might appear to be a severe limitation,

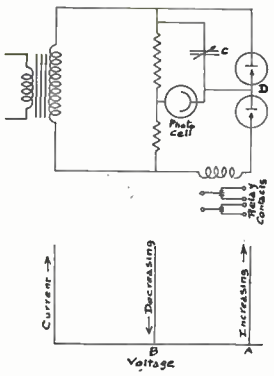

Fig. 2. Another arrangement of photocell and relay.

it has generally been found possible to arrange to open the anode circuit without interfering with the required operation.

Because of the high-speed response required of this circuit arrangement, it is important that capacitances in the high-impedance photoelectric-tube circuit be maintained even though the equipment is operating from direct current. Since the equipment will perform functions hitherto impossible, the care and expense necessary to reduce the circuit time lags to a minimum is usually warranted.

While it has been stated that the equipment operates from direct current, it may be well to mention that it is desirable to heat the pliotron and thyratron tube filaments from alternating current, since they are both designed for high current and low voltage. If only alternating current is available, the necessary direct current may be secured by a tube rectifier with suitable filter to remove the ripple.

The effect of supply voltage variations on the several types of photoelectric relays is an important consideration. In the simpler types, the resultant effect is a combination of the effects on the photoelectric tube sensitivity, the bias voltage of the pliotron tube, and the anode voltage, all tending to cause a resultant change in the same direction. Furthermore, if the light source is supplied from the same varying voltage, its effect will also cause a change in the same direction as the other factors mentioned, and generally an important one, since the light from the incandescent lamp varies more than proportionately with the voltage.

Voltage Variation

The next effect of voltage variation is to increase the required change in light necessary to produce consistent operation. The maximum-light condition must provide enough light to keep

the relay current above the pick-up value even at the minimum voltage and the low-light conditions must be low enough to permit the relay to drop out even at the maximum voltage. It is, therefore, desirable to make the light change as large as possible in all cases.

This indicates that the light source must merit serious consideration and this is exactly the case. The most convenient lamp for use in light units for photoelectric-relay application is the low-voltage concentrated-filament lamp widely used in automobile headlights. With a simple optical system consisting of a single plano-convex lens, it is possible to secure a beam of high intensity and very slight divergence. Such a light unit provides sufficient illumination at a distance of 20 to 25 feet to operate the photoelectric relay.

Since the lamp filaments operate at quite high temperatures, their life, at rated voltage, is relatively short for industrial applications and a failure of the control equipment would result in the loss of valuable production time. For this reason, the light units are commonly designed to operate the lamp below normal rated voltage. This is done, of course, only at a sacrifice of some of the light. The advantages of greater continuity of service, however, warrant this sacrifice.

For use on d-c. industrial circuits the same lamp and optical system is commonly used with a series resistor. This wastes some power, but the higher voltage, concentrated filament lamps are much larger and more fragile.

Light units employing more complex optical systems have been made for individual applications, particularly those in which the light must reach the photoelectric tube through a very small aperture.

Although there are many factors to be considered in laying out a prospective photoelectric relay application, the advantages accruing from successful installations definitely indicate that the thought and effort is warranted. As engineers throughout the world become more familiar with the use of light sensitive devices, they will find the apparent complexities to be no greater than ordinarily expected in using new types of equipment. Undoubtedly improvements in equipment design will result from the increased usage. Ultimately the photoelectric relay will probably be as commonplace as the magnetic switch and the limit switch are today.

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When the telegraph came to New York

THE projected preservation of the Audubon homestead on the Hudson shore, upper New York, has raised the question as to whether this house played a part in the history of the telegraph as the New York terminus of the first line to enter the city.

It is a matter of record that the naturalist, Audubon, and S. F. B. Morse, the inventor of the telegraph, were contemporaries and friends.

In the year 1845, and later, the Audubon house was a place of note on the New York side of the Hudson river and, being well up the river, there were not many other residences in that neighborhood.

The locality was favorable to an overhead crossing for wires over the Hudson. On each side the banks were high above the water and the bulk of ship traffic was carried on considerably to the south of that point. Thus the likelihood of schooners' high masts engaging the suspended wires was diminished.

The first Morse telegraph line in America was that erected from Washington, D. C., to Baltimore, Md., in the Spring of 1844. In 1845 the Magnetic Telegraph Company built connecting sections from Baltimore to Philadelphia and Philadelphia to Jersey City and to Fort Lee. Amos Kendall, previously postmaster general, was elected president of the telegraph company in November, 1845. The railroad companies traversing New Jersey refused to permit the telegraph company to erect poles and string wires along their right of way, presumably owing to differences with Mr. Kendall while he was postmaster general. The telegraph line, therefore, was erected by way of Morgan's Corners, Morristown, Doylestown, Somerville and on to the Hudson river. The line from Philadelphia was first operated to an office at Fort Lee. Later, an office was established in the Ferry House, Jersey City.

An early historian, writing of this situation, stated:

"For some time no effort was made to cross the Hudson with a wire. The river seemed to roll there an insuperable barrier. Many schemes were proposed: balloons, pigeons, piers in midstream, anchored ships—to serve as supports for wires, and so on."

The office at Jersey City was the telegraphic headquarters for New York City. The historian quoted, stated also: "The puny instruments in that narrow house across the river set Gotham in a buzz of excitement. Old Trinity, St. Peter's and the City Hall looked like bold adventurers standing on the shoulders of a wondering crowd to peer across the channel into that dingy sanctum where operated the greatest invention of the age."

Telegrams for persons in New York were brought over by agents traveling on ferry boats, and messages from New York were thus ferried to Jersey City.

Short sections of gutta percha covered wires were laid across the Bound Brook, and across the Passaic river, in New Jersey, in 1847. In 1848 a similar cable was laid across the Hudson river from Jersey City to New York. This worked for a short time, but was soon disrupted by a ship's anchor. A line was then built up the west side of the river to West Point and the wires strung between a mast on each side of the stream, which at this point is narrow. Poor construction doomed this line to early failure.

It was in 1850 that two gutta percha covered cables were laid across the Hudson between Washington Heights, N. Y., and Fort Lee, N. J. The conductors served fairly well for a time, but were frequently broken.

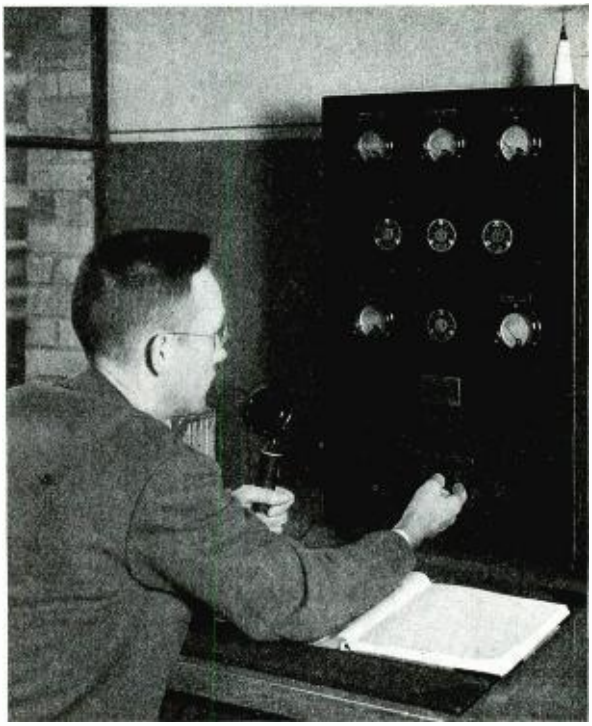
In 1851, masts were erected on Washington Heights and at Fort Lee, between which five wires were suspended for use during the summer months. For winter use gutta percha covered wires were laid along the bottom of the river between the two shore stations. During the winter the reduced ship traffic lessened the danger from dragging anchors.

In 1856, in January, storms destroyed the masts for the third time within a year.

The place in these operations occupied by the Audubon residence is not clearly recorded in telegraphic history. Inasmuch as repeaters were not employed at Fort Lee or at the Washington Heights terminus of the river crossing, there was little occasion for shore stations. The Philadelphia-New York line was simply connected through these points. The Audubon house may have been a headquarters from which operations for line building were directed.

It was in February, 1856, that a successful armoured cable of three conductors was laid across the Hudson between the Stevens estate (Hoboken) and a point directly across on the New York side.

Thus, for ten years after the telegraph reached Jersey City the "insuperable barrier" the Hudson river was, during most of the time, bridged by means of messenger boys toting messages back and forth on ferry boats.



Operating Panel of Airport Radio Transmitter

Airport radio transmitter

By W. M. KNOTT*

Standardized radio equipment is used to direct evolutions of airplanes in flight, and to direct landings.

"AL" WILLIAMS, one of America's leading stunt flyers, had taken off from the Cleveland airport to thrill the spectators at the national air races with aerial acrobatics. As he gained altitude a voice boomed out over a public address system commanding, "Al! Do a barrel roll to the right." Surprising enough was the instant response seen by the crowd as the racer snapped over as though answering the voice directly. Several other maneuvers were completed at the request of the announcer on the ground.

This rather spectacular performance indicated how an airplane pilot can receive information from the ground with radio equipment. A Western Electric 10A radio transmitter, connected to a public-address system so that those on the field could hear the messages was used to transmit the radio telephone signals which were received by the pilot with a 9D radio receiver. Both transmitter and receiver are recent developments of the Bell laboratories, and the apparatus used at Cleveland was standard with the exception of the connection of the public address system to the radio circuit.

The 10A radio transmitter, shown in the photograph at the head of this article, was designed particularly for use at airports in transmitting information to flyers to regulate their landing and to advise them of weather or field conditions with which they must be acquainted to safeguard and expedite their flight. A frequency of 278 kc. has been set aside by the Federal Radio Commission for the use of ground stations in providing this service.

Transmitter Requirements

Requirements placed on such an airport transmitter are rather severe. It must have a high degree of reliability since the lives of passengers and pilots may depend upon its performance at a moment's notice, and at the same time it should be extremely simple to operate because personnel untrained in radio operation and maintenance must handle it. It must also be protected against unauthorized adjustment or tampering, since it is frequently installed in places where people other than the operator have access to it. Despite tuning by inexperienced operators and possible changes in antenna position, it must hold accurately to its assigned frequency, and must be capable of delivering adequate power to antennas which are much smaller and less favorably located than those normally used for these frequencies. To secure a maximum operating range without exceeding the antenna power of 15 watts allowed by the Federal Radio Commission, it should be capable of substantially complete modulation.

All these requirements have been met in the design of the 10A transmitter, the schematic diagram of which is shown in Fig. 1. It will be noted from this circuit that in addition to two rectifier tubes, used to convert the ordinarily available 110-volt alternating-current supply to direct-current of various potentials, only three vacuum tubes are employed. The frequency is maintained constant by a crystal controlled oscillator to within .025% under all conditions of use. A thermostatically controlled heater unit, obtaining power from a small transformer, holds the crystal at a constant temperature. A second transformer supplies low voltage for all the filaments including those of the rectifiers, and a third transformer furnishes high voltage for the rectifiers which are of the hot-cathode mercury-vapor type.

The Amplifier

At the top of Fig. 1 on the left is the audio amplifier, a 252A vacuum tube capable of supplying sufficient power for substantially complete modulation of the carrier wave. An input transformer

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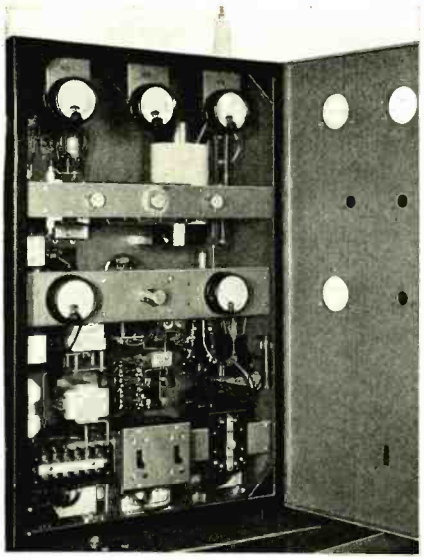

Fig. 2. The 10A transmitter is compactly arranged and when the front cover is locked shut only two control switches project.

couples the microphone to the grid of this tube. Next to the right is the crystal oscillator with its temperature control, and to the right of this, the oscillator tube with a tuned plate circuit. The modulating amplifier, next to the right, is a four-element 254A tube. The plate circuit of this tube has two branches: one containing a condenser, and the other a variometer and adjustable condenser in series. Across the latter is shunted the antenna circuit. The antenna tuning coil, on the extreme right, has sufficient range to resonate antennas of a great variety of sizes.

Unless the transmitting frequency or the antenna is changed, tuning is required only at intervals of several months. To prevent the adjustments from being changed except by authorized persons, the tuning elements are arranged for control only by a special tool that is normally locked inside the case. Meters are furnished to indicate the correct tuning positions.

For normal operation only two controls are required and these project through the lower part of the front of the case. One is the heater switch, which places the set in readiness for operation. Operation of this switch connects power to the crystal temperature control unit which maintains the crystal at the proper temperature. The other is the transmitter switch, operation of which connects power to the tube filaments and to the heater of a time-delay switch which, after an interval of about twenty seconds, connects the high voltage to the plates and grids. All the power transformers are wound for a primary voltage of from 100 to 120 volts so that an ordinary lighting circuit may be used. Only 225 watts are required in all.

Two-Way Operation

The transmitter is usually left on the air during an entire conversation, although provision is made for the addition of an external plate control switch which can be used to disconnect the plate supply without the operation of the transmitter switch, which would also interrupt the filament supply. This switch may be used to stop the carrier output during periods of reception, if necessary to avoid interference with the receiver.

Although the transmitter is operated on 278 kc. when employed for ordinary airport purposes, it can be operated on any frequency from 230 to 500 kc. It will deliver ten watts of power to antennas of the type with which it will ordinarily be used. A range of from 40 to 50 miles can be relied upon under average conditions.

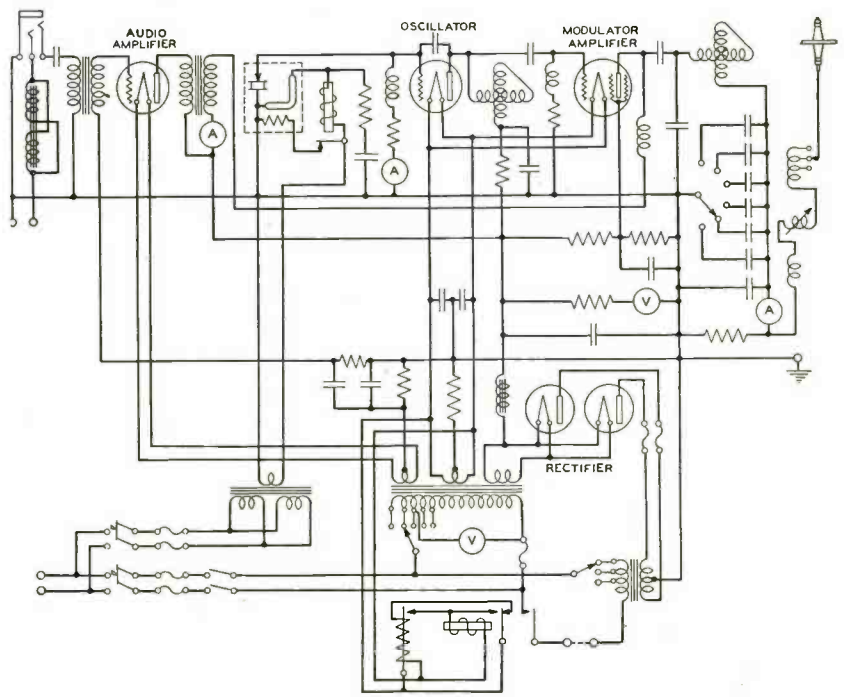

Fig. 1. Schematic diagram of the 10A transmitter.

to take a piece of red pressboard, cut an accurate hole that will slightly force-fit the peg and cement it in place on the record while record is in correct position on the turntable.

If the pull on the tone arm under load were to be shown by an indicating dynamometer, it would be seen varying in correspondence with the modulation much like an antenna ammeter. This means that there must be no lost motion between the pivot and the needle as already suggested. If this is not observed, the staccato notes will chirp ever so slightly, while longer notes will have a whining quality. This may also occur wherever the pickup armature is packed wholly in rubber instead of being mounted on a definite pivot to secure the radius of oscillation of the needle. With variations in the load due to changes in amplitude and frequency, the center of oscillation of the armature shifts up and down along its axis seeking the most natural mode of vibration, thereby introducing undesirable distortion due to harmonics. A pivoted armature is especially desirable therefore if "home" recording is to be done. For similar reasons, tone arms like the one shown in Fig. 1 should be especially rigid at the point N; otherwise vibration of the entire head may enter to give poor quality.

Vibration

The inertia of the governor weights, together with the elasticity of the governor springs, form a resonant system capable, as is usual, of various modes of vibration. With variations in the modulation load come pulses on the motor governor. They may be sufficient and of such frequency as to cause governor instability. This is true also in case the link between motor and turntable is a flexible coupling, or a long belt. The precaution to be taken here is to see that all drive shafts are so short and thick as practicable with no elastic couplings and that the turntable for 78 r.p.m. weighs not less than 10 to 15 pounds, while for 33 r.p.m. not less than 30 to 50 pounds. These values have a liberal margin of safety and may be pared down when impracticable or inconvenient. Not a bad remedy is to turn the turntable upside down on a level surface and fill it with hot lead. Heavy turntables are still more valuable in the event of recording. Still another advantage of high inertia turntables lies in the fact that hum and motor vibration are effectively damped, thereby eliminating the need for the ruse of flexible couplings and elastic suspensions heretofore resorted to, and, permitting the use of more solid and direct connection of motor to turntable, free from the evils of elasticity.

Concerning the matter of lost motion along the horizontal axis of the tone arm: In some cases it is the practice to mount the tone arm on a baseboard or casting and give the motor an elastic suspension. The evils that follow need not be discussed in view of what has already been said. The resulting resonant system is "bowed," as with a violin bow, into all its natural modes by the drag of the needle on the record. In still other cases the motor and arm are mounted on a highly absorptive composition baseboard, but which allows enough flexibility to destroy the rigidity between tone arm and motor. It is best to make the base a heavy casting from ½ inch to 1 inch thick, and mount motor and tone arm solidly thereon. Such a mounting, together with high inertia turntables, gives a noise pickup far less than the surface noise of the record and which is therefore entirely inaudible. The final touch to secure stability of tone is to give the pickup head, *not the tone arm*, an excess of inertia by loading it with at least a pound of lead, a half on each side, as low as practicable and counterbalancing the arm to prevent excessive pressure on the record. This procedure will give an improved response on the low frequencies on the order of 16 to 50 cycles per second. The improvement on organ records is sometimes very marked.

Position of Needle

The ideal position of the needle is vertical. It then will give the most accurate tracing of the wave in the groove. However, in this position the surface noise is excessive and the wear on the record and needle is greatest. Therefore, the angle with the record plane should be decreased until it no further reduces the surface noise. Usually the head is already mounted just about right in this regard. The tone arm should be mounted so that the needle is in a vertical plane tangent to the groove. Since the radius of the groove is constantly changing, this is not exactly possible. The correct method is to mount the tone arm so that the needle will pass directly over the peg in the center of the turntable. The longer the tone arm, the nearer will the needle remain tangent with all the grooves during reproduction.

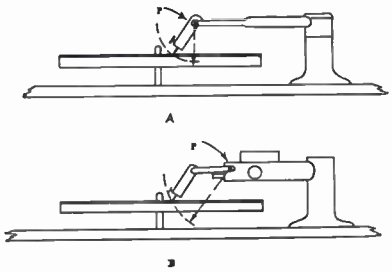

Fig. 2. Horizontal tone arm.

It has been stated that the instantaneous velocity of reproduction must at all times be the same as that of recording. This does not mean that without exception the angular velocity must be constant. If a "home" recording is played back without disturbing the record, the turntable irregularities per revolution, if periodic, will repeat themselves in the reproduction and so far as velocity is concerned will be perfect. Random irregularities in velocity will spoil the reproduction, however. It is desirable to have a mark on the edge of the table and mark the record accordingly; then advantage may be taken of this principle whenever the record is played any time later.

It may be assumed that recordings by reliable manufacturers are made with constant angular velocity. The problem, therefore, is limited to designing or selecting an inexpensive motor that will give reasonable constant angular velocity. Manufacturers have in some cases gone to excessive expense in the design and construction of constant speed turntables when recognition of the simple principles discussed would have avoided this. The ear has considerable "margin of safety" so that it is only necessary to secure *apparent* perfection of operation. The flaws introduced into reproduction by the evils already considered are small, but taken cumulatively result in lowering the qual-

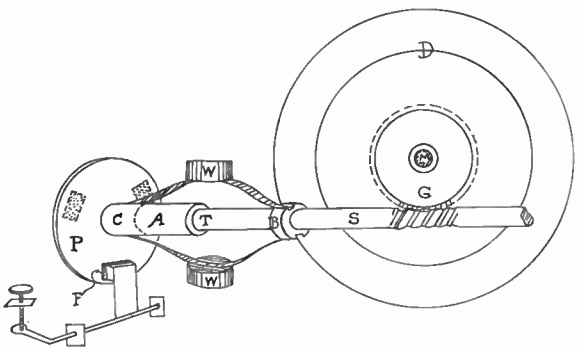

Fig. 3. Typical form of governor.

Turntable design and operation

The increasing use of phonograph type records in radio broadcasting has necessitated studies of and improvements in turntables. In this complete article Mr. Gunsolley goes thoroughly into the subject and makes various practical suggestions.

By V. V. GUNSOLLEY*

THE fundamental principle of perfect reproduction is: *At all points along the record groove, the instantaneous velocity during reproduction must be the same as the corresponding instantaneous velocity during recording.*

Any departure from this principle, however small, causes a corresponding degradation and serves to put highly engineered amplifiers to naught. Unless engineers can achieve mechanical as well as electrical perfection, without excessive cost, audiences will continue to complain of record broadcasting. It is their duty, therefore, to see that purchases of phono-equipment do not have the undesirable features to be noted herein.

Momentary inspection of the extreme example in Fig. 1 shows unmistakably that the higher the pivot P above the "Normal Record Plane," the greater will be the variation of the sine BC for any given variation of the angle ϕ caused by the rising and falling of the needle with the vertical wobbling of the turntable, and is a maximum as the angle ϕ approaches 90°. Conversely, the effect is a minimum when P is in the "Normal Record Plane," and is inversely proportional to the length of the tone arm. Since variations in the sine BC cause the horizontal component of motion of the needle relative to the record along its groove, it is also equivalent to unsteady rotation of the turntable. It is not unreasonable to require that the tone arm be not less than 18 inches long for 10-inch record reproduction and 24 inches long for 16-inch record reproduction; and for other reasons which will subsequently be dealt with. The pivot should be on a level with the normal record plane, and the tone arm should be incapable of any lost motion along its horizontal axis. The turntable should have no perceptible vertical wobble, thereby limiting the rise and fall of the tone arm to that due to the warp of the record, if any. A wobbling turntable is most easily corrected by shimming up the felt or velvet cover on the low side. The expert mechanic who has the facilities may correct the trouble with a 1-lb. hammer applied to the hub with skill and judgment, but not with the turntable on the machine.

The Tone Arm

For the reasons given in Fig. 1 the type of tone arm shown in Fig. 2A is unsuitable. Here the tone arm is held horizontally at all times, only the head dangling on the pivot P. The equivalent is that of a very short tone arm high above the record surface, which all the more varies the value of the sine ϕ for any rise and fall in the record surface during rotation. A modification of this model, Fig. 2B, has an automatic device for starting the pickup in the groove. When it must be used, see that the turntable runs true; if possible, remodel it so that its pivot is as close to the record as possible, or, put an extension on the pickup so that the head is farther away from the pivot and set the lengthened assembly back so that the needle comes into the old position.

Records

For years manufacturers have turned out records moulded off center by various amounts up to one-eighth inch or more. Obviously this means a variation of speed both above and below, each revolution, from that at which the master was recorded. If it is not obvious that this is true, try cutting a second hole along side the first one and see if the music is intelligible. The wobbling sound on sustained tones is perceptible for even the slightest eccentricity of record motion. To some people this gives an effect of an instrument that is out of tune; since there is no definite part of the varying tone that the ear can set upon as the true pitch. No record should be accepted that is not moulded exactly on center. Records on hand should be centered up by scraping out the side of the hole on which the radius is short until there is no perceptible side motion of the pickup during playing. This side of the hole should then be marked with white paint and the announcer instructed to place that side against the peg. To insure that this is done, it may be better

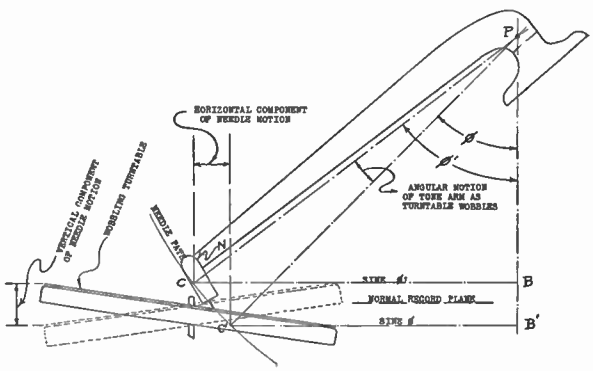

Fig. 1. Illustrating motion of needle, tone arm and table.

*Consulting engineer.

EDUCATIONAL BROADCAST FROM KQV

COOPERATING with the Pittsburgh pubic schools, Station KQV will assist in the development of the radio for general educational work. The plan to be followed is arranged and the first subject selected is music. Six half-hour periods will be used beginning Wednesday, October 19th, at 1:00 p. m., and each succeeding Wednesday at the same hour.

Each program will be complete in itself and will be of interest not only to the classes in the schools, but the public as well. At the given hour the pupils in all the schools in Pittsburgh will be assembled in groups in the auditoriums of their several buildings.

The orchestra and choruses for each lesson will be taken to the studios of KQV where the broadcast will originate. The talent used will be groups selected from the various schools who are specially trained so that the performance they give will definitely emphasize and illustrate the points in the lesson given by the professor in charge. One lesson, for example, requires a group of eighty voices; another four groups of fifty voices each.

The plan for these educational broadcasts has been developed by Dr. Ben H. Graham, superintendent of public schools and the carrying out and supervision of the program is under the direction of Dr. Will Earhart, director of music. Dr. Earhart, along with Walter Damrosch and others, was a member of the advisory board to National Broadcasting Company in developing the popular musical appreciation hour broadcast by Dr. Damrosch.

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ACCURACY OF BROADCAST INFORMATION

WHILE it is probably true that information broadcast by radio will not ordinarily be subjected to as close a check for accuracy as published statements, nevertheless as time goes on broadcasting is sure to gain position as a medium of communication having news and educational status in some degree related to that long held by the printed word. That there will be growing tendency on the part of listeners to have confidence in the accuracy of broadcast information will impose upon agencies using the medium responsibility for care in preparing material for microphone presentation.

One of the broadcast events which has prompted the foregoing observation was the very interesting occasion on an evening in October when Mr. Clarence H. Mackay, of the Postal Telegraph Commercial Cable organization, broadcast a talk on the subject of the one hundredth anniversary of the conception of Morse's telegraph. In his address Mr. Mackay stated that Mr. Morse (on the packet ship *Sully*, returning to the United States in October, 1832) had with him an electromagnet given to him by Faraday. He stated also that in the first public, commercial demonstration of the Morse telegraph (on the line from Washington to Baltimore, on May 24, 1844) that Mr. Morse was at the Baltimore end of the line.

The question of the accuracy of these statements may seem trivial, but if the educational value of radio broadcasting is to approach that of textbooks, then the matter of accuracy is very important.

The recorded history of Morse's invention tells us that it was on the ship *Sully* that he conceived the idea of the electromagnet telegraph, and that a fellow passenger, Dr. Jackson, in conversation with Mr. Morse, stated that he (Jackson) had an electromagnet packed away in his luggage. There is no conclusive evidence that this magnet was exhibited on the *Sully*, nor does the history say that Mr. Morse had a magnet given him by Faraday.

With reference to the circumstances surrounding the sending of the message of 1844, the message, "What Hath God Wrought!" was written by Miss Annie Ellsworth (daughter of the then Commissioner of Patents), handed to Mr. Morse (at the Washington end of the line) and by him transmitted to Baltimore, where it was received by Alfred Vail.

It is noted that in the present broadcasts such as "Decisive Moments in History," the scripts are referred to and checked by accredited historians as to accuracy of detail. This procedure will make for dependable and accurate broadcasting.

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MAJOR BOWES AND CAPITOL "FAMILY" CELEBRATE TENTH ANNIVERSARY

JUST ten years ago—November 19, 1922, to be exact—the first radio program to emanate from any theatre was broadcast from the Capitol theatre, New York, and in honor of this memorable occasion, an anniversary program by the members of the Capitol "Family" will be heard over the air on Sunday morning (Nov. 20).

On November 19, 1922, a red letter day in the annals of radio history, the Capitol Grand Orchestra, playing "Ein Heldenleben" was broadcast directly from the stage. So gratifying were the results that the broadcasting of regular musical programs direct from the stage became a regular weekly feature, and since that date not a week has passed without a radio program being broadcast from the Capitol Theatre.

"Roxy and his Gang" were heard from the Capitol Theatre every Sunday night for two and one-half years, Roxy then leaving the Capitol to erect his own theatre. Major Bowes' "Family" took over the microphone at that time, and in all those intervening years the "Family" in the studio has entertained weekly its great "Family" of listeners throughout the world.

In addition to Major Bowes, members of the Capitol "Family" include Yasha Bunchuk, conductor and cellist of note; Maria Silveira, soprano; Westell Gordon, lyric tenor; Hannah Klein, young pianiste, who recently celebrated her fifth anniversary with the "Family;" Waldo Mayo, solo violinist; Tom McLaughlin, baritone; and Nicholas Cosentino, operatic tenor.

The program will be broadcast through the NBC's chain of stations, on a coast-to-coast hookup with WEAF the New York outlet from 11:30 a. m. until 12.30 p. m.

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RADIO RESEARCH IN AUSTRALIA

THE Council for Scientific and Industrial Research, of the Commonwealth of Australia, through the Radio Research Board, has published several bulletins, which disclose that in Australia for some time past a considerable amount of investigation has been carried on looking to the solution of practical problems in radio in that country.

Report No. 2 contains 80 pages and presents reports on "The State of the Polarization of Sky Waves," and "Height Measurements of the Heaviside Layer in the Early Morning," both by A. L. Green. Report No. 3, 32 pages, contains a paper: "The Influence of Earth's Magnetic Field on the Polarization of Sky Waves," by W. G. Baker and A. L. Green. Report No. 4, 60 pages, presents reports on: "A Preliminary Investigation of Fading in New South Wales," by A. L. Green and W. G. Baker. "Studies of Fading in Victoria; A Preliminary Study of Fading on Medium Wave Lengths at Short Distances," by A. L. Green and W. G. Baker; "Studies of Fading in Victoria: Observations on Distant Stations in which No Ground Wave Is Received," by R. O. Cherry.

Each treatise is a thorough mathematical presentation of the subject dealt with.

For cooperation and aid in the various investigations the authors of the reports acknowledge the advice of Professor J. P. Madsen of the University of Sydney; Professor T. H. Laby, of the University of Melbourne, and governmental agencies.

A power amplifier pentode tube

ADVANCE information on the RCA Radiotron 48 (Cunningham C-48) tube discloses that the rib structure fastened to the inner surface of the plate serves to suppress the effects of secondary emission which limit the power output of four-electrode, screen-grid types.

The 48 is a power amplifier tetrode, having pentode characteristics at the recommended screen and plate voltages, for use in supplying exceedingly large power output from receivers designed for operation on the 115-volt d-c. power line. This tetrode is exceptional in its ability to deliver power at the low plate and screen voltage obtainable in such service. Two 48's in a push-pull amplifier will supply several times the power obtainable from tubes hitherto available.

The large power-delivering ability of the 48 is made practical by the unique features of its electrical and structural design. Among these are the big cathode with its large emitting surface, the control-grid structure with its heat radiator, and the plate with a rib structure fastened to its inner surface. The rib structure serves to suppress the effects of secondary emission which limit the power output of four-electrode screen-grid types.

The heater of the 48 is designed for series operation at 30 volts d-c. It is

RCA Radiotron 48 (Cunningham C-48).

possible, therefore, to operate the heaters of two of these tubes in series with the heaters of 6.3 volt types with a minimum of auxiliary resistance in the heater circuit, and with consequent reduction of heat-energy to be dissipated in the receiver.

Installation

The base pins of the 48 fit the standard six-contact socket which may be installed to operate the tube either in a vertical or in a horizontal position. For horizontal operation, the socket should be positioned with the plate pin opening at the top and the cathode pin opening at the bottom or vice versa.

The bulb of this tube will become very hot under certain conditions of operation. The surface temperature on the hottest part of the bulb should not exceed 150° F. as measured by a small thermo-couple. Sufficient ventilation should be provided so that air circulates freely around the tube.

The heater is designed to operate under the normal conditions of line voltage variation. Due to the heater-cathode design, the heater voltage may range between 26 and 34 volts during line voltage fluctuations without affecting to any great extent the performance or serviceability of this tube.

In a series-heater circuit employing several 6.3 volt types and one or more 48's, the heaters of the 48's should be placed on the positive side. Under these conditions, heater-cathode voltage must not exceed the value given below.

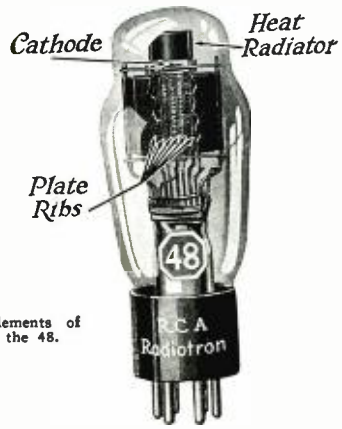
The cathode circuit in most d-c. receivers is usually tied in either directly or through biasing resistors (or C-battery) to the negative side of the heater circuit. The potential difference thus introduced between heater and cathode of the 48 should not exceed 90 volts, as measured between the negative heater terminal and the cathode.

Application

The 48, because of its large power-delivering ability at low plate and screen voltage, enables the designer of d-c. power line receivers to achieve easily superior d-c. receiver performance.

As a power amplifier (Class A), the 48 is recommended for use either singly or in push-pull combination in the power output stage of d-c. receivers.

If a single 48 is operated self-biased, the self-biasing resistor should be approximately 360 ohms. This resistor should be shunted by a suitable filter network to avoid regeneration effects at low audio frequencies. The use of two 48's in push-pull eliminates the necessity for shunting the resistor. The self-biasing resistor required for the



Elements of the 48.

push-pull stage is approximately 180 ohms.

Any conventional type of input coupling may be used provided the resistance added to the grid circuit by this device is not too high. Transformer or impedance coupling devices are recommended. In any case, the sum of the resistance of the coupling device in the grid circuit and the resistance of the filter network (if used) should not exceed 10,000 ohms.

An output transformer should be used in order to supply power to the winding of the reproducing unit. The optimum value of load resistance for a single tube is 2,000 ohms. For push-pull operation, the plate-to-plate load resistance should be 4,000 ohms. For best results, as in the case of power amplifier pentodes, the impedance in the plate circuit of the 48 over the entire audio-frequency range should be as uniform as possible.

For design purposes, the average plate characteristics given below shows the load line corrected to compensate for the effect of rectification. An explanation of this effect and a method of compensating for it are given in a paper by C. E. Kilgour in the January, 1931, issue of the "Proceedings of the Institute of Radio Engineers."

Tentative Rating and Characteristics

Heater voltage (d-c.) ...		30 volts
Heater current ...		0.4 ampere
Plate voltage	95	125* max. volts
Screen-voltage ...	95	100 max. volts
Grid voltage	—20	—22.5* volts
Plate current	47	50 milliamperes
Screen current	9	9 milliamperes
Plate resistance (approx.) 10000		10000 ohms
Amplification factor (approx.)	28	28
Mutual conductance	2800	2800 micromhos
Load resistance ..	2000	2000 ohms
Power output (9% total harmonic distortion)	1.6	2.5 watts
Maximum overall length		5-3/8"
Maximum diameter....		2-1/16"
Bulb		ST-16
Base		Medium 6-pin

*Recommended conditions for operation with auxiliary C-battery which permits utilization of full d-c. power line voltage (110-125) for plate supply.

ity perceptibly. If each is taken individually and eliminated effectively, the overall result is a great improvement, which leaves reproduction up to the amplifiers and lines.

Motors

While a discussion of motor design may seem out of place for any but the manufacturer, it is to be remembered that a knowledge of such is essential to the proper selection of phono-equipment. The reputation of a manufacturer is not always to be relied upon. The known quality of some brand of amplifier is only presumptive evidence that the same brand of phono-equipment is equally good. Perhaps the agency has had little to do with the design of either and the latter was not designed by those who know most about it. Then, too, although the design is the best, the buyer may make a wrong selection of apparatus.

For instance: No matter how perfect a synchronous motor may be, it should not be used on any but large power networks which are supplied by a multiplicity of prime movers. Small systems, using only one or more generators do not have a frequency regulation close enough for phono-equipment of this type. Induction motors are usable, for the governor keeps the speed reasonably constant regardless of small changes in frequency and voltage; that is, in spite of quite sharply shifting loads on the system. The inherent regulation of most small prime movers, and especially Diesel engines, is not good enough for the use of the synchronous motor. Nor is this true where a master clock is used to regulate synchronous clocks on the system. The clock merely guarantees that 5,184,000 cycles per day will be delivered to the system clock, but does not guarantee delivery at a constant rate. Large systems are not so affected by changes in load; the voltage may drop without a change in frequency. Since the synchronous motor torque will vary with voltage, but not its speed, it is satisfactory on large interconnected power systems. Any sudden change in load may cause a local drop in voltage, but is seldom if ever large enough relative to the total capacity of the network to affect the speed of the combined generators.

While on the subject, it may be noted that an objection to the use of the synchronous motor is its fixed speed. It should have a gear shift permitting the use of 78 r.p.m. and 33⅓ r.p.m. It is a mistake to play 78-speed records at a speed of 80, and vice versa. This is especially true when voice is reproduced. Further, a synchronous motor is liable to mechanical phase shifting, or hunting, under variations in load, and unless the motor is fully loaded artificially so that modulation is a small percentage of the load, or, unless the voltage is as high as the heating will permit, in the original design, irregular motion may result in lowering quality. A high inertia turntable may be a good precaution, or remedy, if this trouble is experienced.

Of all types, the induction disc motor is perhaps the least desirable. Its torque is too low in the designs the writer has met. This leaves too little drag permissible in the governor, which therefore has to be delicate, and thus the modulation load and needle drag is too high a percentage of the total load. These motors are sensitive to the difference in drag between the start and the finish of a large record with few exceptions. Sometimes the difference in drag between a new and an old record is sufficient to alter the speed. For steady operation it is desirable to have the governor load large so the governor may be built with great sturdiness in its springs and brakes, and so that the useful load which is variable; and so that small irregularities of friction due to any temporary cause will not throw off the speed of the turntable perceptibly. Another danger with the induction disc motor is that of accidentally bending the disc. It is generally unprotected mechanically. When this happens there will be a periodic variation of the velocity as the bend varies the gap between the pole pieces twice each revolution. If the governor is extremely alert this may not be noticeable, especially if the records used are not exactly moulded on center.

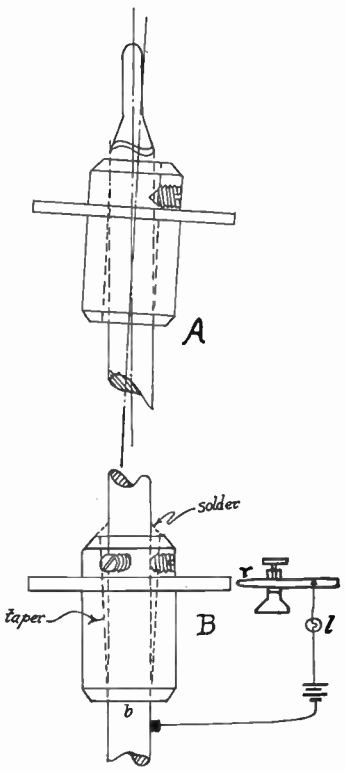


Fig. 4A. Gear strained off center. 4B. Correction of alignment.

Speed Governors

Fig. 3 is a sketch of a typical form of governor universally used. The induction disc (or other armature) D, drives the shaft M on which is the worm gear G meshing with the worm on shaft S and on which is set a collar B. The friction plate P is made to revolve with S through the linkage of the springs on the flyballs W. The centrifugal force of W causes the springs to bow outward, thereby pulling in on the sleeve A, which is in turn free to slide along S at T, but which is held from revolving on T by the reaction of the springs to edgewise stress. As the plate P is pulled in, it comes to bear against the felt friction block F. This slows down the speed of P, which, acting through the springs edgewise, in turn slows S. The lessened force on the weights W lets the springs contract, shoving P away from F slightly, whereupon P again speeds up. The action then repeats itself.

It is at once apparent that the governing action is one of alternate decrements and increments of velocity. The rougher the plate P, the larger and more irregular these are apt to be. Ideally they should be less than any assignable value, however small. Practically this is closely approximated by making the plate P mirrorlike in smoothness and giving it proper lubrication, although oftentimes the frequency of the increments is that of the natural frequency of the governor weights and springs considered as a mechanically resonant system. Unsteady operation may be sometimes cured by doping the felt with glass polishing rouge or flour carborundum and letting the motor run until the disc is polished. Do not get any of this material in bearings. The oil used on the governor will in time throw off the polishing medium.

Should the sleeve A happen to be no longer than as shown by the dotted line—that is, no longer than as indicated by the section C—and, if the sleeve be bored or worn a little large, the pressure at F will tend to tip the plate outward point by point as it revolves by. The sleeve will bind on the shaft, especially in the absence of proper lubrication, and irregular running results. If the springs are not properly set in snug slots on collar and sleeve, this action will loosen the screws

and let the springs fly free, sometimes wrecking the governor, and, possibly in the middle of a program. The springs should be sufficiently heavy to withstand the torque and velocity increments and decrements without torsional vibration between A and B. The screws on the springs are preferably to be set with lock washers, or even soldered in place.

When a single brake shoe is used at F, the reaction, as just noted, travels around the plate in waves, especially when the length of the sleeve C is short relative to the radius of P. This wave motion is best removed by the use of three shoes tri-spaced around the plate as shown by the additional dotted areas on P. Some manufacturers use a ring of felt so that the pressure is continuous around the disc; see Fig. 5. This method is good, but since the felt then bears all the way around the plate P, there is a chance for the bearing points to shift around the felt ring and cause varying friction. This will not be perceptible, provided the plate has a mirrorlike surface for the felt to bear on, and that the felt is securely mounted at all points around its circumference. Sections of the ring may be pared down out of contact, leaving three tri-spaced high points to form the desired three-point equalization of pressure.

Where the governor has a large motor to hold down, it may be best to be content with assuring that the plate surface is polished, and applying the remedy if not, as the governor needs much more bearing surface in order to handle the load imposed by a powerful motor. The interior of the cone may then be filled with vaseline, which is at once a damper and lubricant and therefore a stabilizer. A heavily loaded governor is not sensitive to slight changes in friction from any cause, as is the lighter loaded governor of an induction disc.

When felt shoes are used the effect of lubrication is generally to slow down the governor temporarily, possibly due to the greater suction of the porous felt on the plate. Since light oil easily drains away, means of constant oiling should be provided, as with a reservoir and wick; else the motor will constantly gain speed. Hot vaseline used to soak the felt gives a satisfactory speed constancy after the first few hundred revolutions. If rouge has been used or the plate is already polished, one charge of vaseline will last five months or more and no irregular governor action will result from this cause. When rawhide shoes are used no great speed variation is noted, but if any it will increase.

With the governor in good condition and properly loaded, the speed of P will remain constant. Therefore if the gear G is slightly off center its angular velocity will vary periodically with its

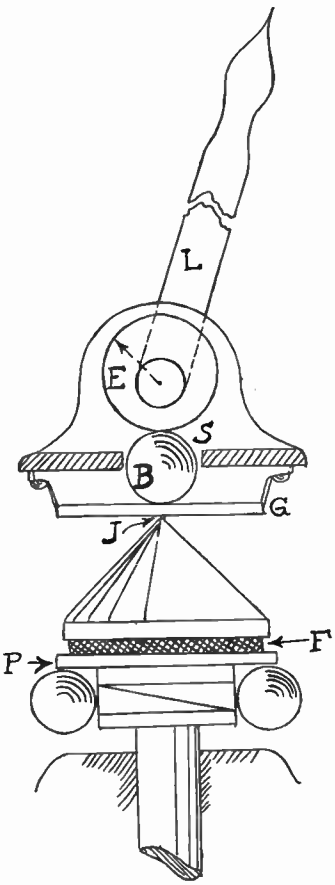


Fig. 5. Speed control system.

revolutions. If it is off only two thousandths of an inch and is small in diameter, an error mounting into several per cent of the normal speed of the turntable may result. This trouble occurs on every gear that is cut inaccurately and on every gear that is put on with a set screw unless the gear is a drive-fit on the spindle. It also occurs if the spindle is bent ever so slightly. Gear G should be a force-fit, and pinned or soldered, never riveted in place. The worm gear must be cut to an accuracy of two or three ten-thousands else vibrations will be transmitted to the turntable. Here again is seen the value of high inertia turntables. A better plan is to cut the worm on a bushing not less than a half to three-quarters of an inch. A small nominal error in cutting is then a smaller error in per cent.

Fig. 4A shows an exaggerated view of the gear strained off center by pressure on the set screw. Fig. 4B shows how the gear may be corrected. It is tapered slightly with a reamer, using care to not enlarge the bottom of the bore b, which, still fitting the spindle snugly, is to act like a pivot for the swing in the top adjustments made by the three set-screws. The top is then fitted with two additional set-screws tri-spaced with the first one to permit the perfect centering of the gear on the same principle as the universal type of lathe chuck. Centering may be made to about 5/10,000 with a screwdriver, after which, closer adjustments may be made by the judicious use of a light hammer on the top of the hub near the screws. If there is much play in the upper spindle bearing, the spindle should be held on the side away from the measuring contact at each measurement. The measuring contact may be a round pointed rod r, pointed at the teeth of the gear and so connected to the temporary electric circuit that contact with the gear teeth will light a small bulb l. Regular lathe centering methods are then employed. This will require patience. When the centering is well enough done, the load should be shared with the set-screws by the application of solder to collar and shaft, using a very hot, large clean soldering iron so as to sweat the surface quickly and avoid overheating the gear and upsetting the accuracy of the assembly.

Because irregularities in gears result in irregularities in motion, it is easily seen that as few gears and as large gears as practicable be used, and that to avoid vibration they have small teeth.

The speed control levers must be positive in action. The slightest motion of the adjustment screw or lever, whichever the case may be, should affect the speed in that direction. Some levers "float" the speed; that is, slight "fast" adjustment gives "slow" speed regulation until the lever is moved so far as to overcome indefinite regulation and take positive control in the right direction. It is difficult to obtain accurate adjustment when this is the case.

An example of such control is shown in Fig. 5. Motion of the lever L drives eccentric cam E, pushing the ball-bearing B through the hole in the casting S, against the governor lever G, against the universal joint J, bearing on the felt ring F, which varies friction on the revolving plate P. The cause of irregular control is that, though B may fit the hole when half way through it, when pushed through partly it does not, and may roll along G enough to delay action on the governor or to make it indefinite. The roughness of the surface of G, or, any lack of parallelism with the variable tangent at the point of contact between E and B as the eccentric varies, causes negative control while L is being moved sufficiently to take positive control. That is, when the ball B strikes either side of its hole in the frame S. A better plan is to use a fine threaded screw against the lever G, fitted in the casting S, where the hole now is. This alteration is easily made on any existing machine.

TROUBLE AHEAD IF MERCURY VAPOR TUBE IS IMPROPERLY USED

By WALTER R. JONES*

WITH the announcement of a full-wave mercury vapor rectifier tube employing a 5 volt filament, it becomes necessary to again warn servicemen and others engaged in servicing radio sets to refrain from attempting to use this new 5 volt full-wave mercury vapor rectifier tube to replace the 280 tube.

Warning has been published against attempting to use the 82 as a substitute for the Type 80. In order to do this, of course, since the 82 has a 2.5 volt filament, it is necessary to make some slight adjustment in the receiver as to voltage supplied to the rectifier tube.

With the new tube, however, since it also employs a 5 volt filament the same as the 80, much damage may be done by inserting the tube in the 80 socket without thinking. If this is done, providing nothing burns out in the receiver or blows up, the receiver will give considerably better performance than it did in the past. This performance, however, is not likely to last long, since the increased voltage will sooner or later blow one or more of the filter condensers in a power unit. If this condenser simply opens up, a very loud and annoying hum will result. If, however, as is more than likely to occur, the condenser shorts, the power transformer in the receiver will be burned out unless the tube is instantly removed from the receiver. In addition to this, if anything should happen to the tube for even an instant it is quite likely that it would burn out the transformer before the tube could be removed. For this reason practically all receivers which are designed to employ the new mercury vapor rectifier tube are provided with a fuse, so that in the event of any momentary tube failure the fuse will be blown instead of ruining the power transformer.

In the past there has been some advertising which recommends the substitution of a mercury vapor rectifier tube for the Type 80 tube which is now in the receiver. This type of advertising is extremely short sighted, since its only ultimate object is to sell a considerable number of these tubes without regard for the difficulties which will confront the prospective user of these tubes. A safer way, if you are not satisfied with the performance of your present receiver, is to buy a new receiver which is equipped with the new and modern tubes rather than to attempt to change the receiver over to haphazardly use some of the new tubes. This sort of change is much like the change which often is made with the Model T Ford of substituting a Model A hood and expecting your car to run as a Model A or a Model B car does.

*Hygrade Sylvania Corpn.

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TELEPICTURE SERVICE IN AUSTRALIA

WHAT is reported to be the first newspaper operated picture transmission service in the Southern Hemisphere was started on June 1, 1932, between the *Herald* in Melbourne, Victoria, and the *Advertiser and the News* in Adelaide, South Australia. So far, the service is being operated in one direction as the *Herald* in Melbourne is the only paper equipped with a transmitter, but a two-way service is expected to be in operation in the near future.

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MAGNETIC STRUCTURE

A MAGNETIC core having subdivisions transverse to the direction of the magnetic lines of force, characterized in that a substance having a permeability higher than that of the core material is applied on the dividing surfaces of the core subdivisions.

Fischer, E. (Assigned to Siemens und Halske, Akt. Ges.) United States Patent 1,832,290.

MANUFACTURERS OF "B" BATTERY SUBSTITUTES

Burk Electric Co., Scranton, Pa.
Hutch-Gard Co., San Francisco, Cal.
Pines-Winterfront Co., Chicago, Ill.
Universal Auto-Radio Co., Chicago, Ill.
Holmes-Jordan Co., St. Paul, Minn.
Electric Specialty Co., Stamford, Conn.
Howard Radio Co., South Haven, Mich.
Jannette Mfg. Co., Chicago, Ill.
United American Bosch Co., Springfield, Mass.
P. R. Mallory & Co., Indianapolis, Ind.
Utah Radio Products Co., Chicago, Ill.
Emerson Electric Co., St. Louis, Mo.
Motor Car Devices Co., Los Angeles, Cal.
United States Electric Works, Chicago, Ill.

BROADCAST EQUIPMENT MARKET

THE Bureau of the Census, Washington, D. C., reports that in 1931 were manufactured on order in the United States 1,106 radio transmitters, including all associated equipment. The factory price of the equipment totaled $2,400,257.

The number of microphones manufactured totaled 10,225, with a factory value of $187,035.

Radio transmitting tubes for the year totaled approximately 62,562, the factory value being $1,410,188.

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WCCO, MINNEAPOLIS

RECENTLY, in Minneapolis, Minn., Henry A. Bellows, of broadcasting Station WCCO, and former Federal Radio Commissioner, presided at a dinner attended by four hundred guests, which was in celebration of the completion of WCCO's new 50-kw. transmitter.

This broadcast station has for several years past satisfactorily served the interests of the people of the northwestern states. The increase in transmitter power will enable the station to enlarge its coverage area and to serve with more assured continuity its present listeners. Local radio history in Minneapolis began on April 4, 1902. At that time the only known "wireless" sending and receiving outfit in the city was that constructed by Donald McNicol, at that time a youth employed by one of the telegraph companies.

The *Minneapolis Times,* issue of April 6, 1902, contained an account of the early experiments and successes. The elementary transmitter and receiver used in 1902 are still in existence.

It is of course a far cry from the "half-inch spark oscillator" outfit of thirty years ago to the modern 50-kw. transmitter recently completed for WCCO.

▲

A NEW RADIO TUBE IN ENGLAND

A THERMIONIC tube of novel design, with reported improved characteristics, has been developed by Standard Telephones & Cables, Ltd. This tube is to be known as the "Micromesh," and its outstanding feature is the utilization of extremely close spacings between the emitter and control element, resulting in a marked advance in performance. A robust nickel cathode is employed, which, it is said, gives perfect electrical heating combined with adequate rigidity.

▲

BROADCAST STATION POWERS

The National Broadcasting Company's eighty-six affiliated stations, at the present time have a total wattage of 824,600. Stations in the Columbia System total 453,100 watts.

PLANE RADIO NOW ESSENTIAL TO NIGHT FLYING OPERATIONS

INAUGURATION of an overnight tri-motored six and one-half hour passenger plane service between Chicago and New York, and a "one business day" flight across America are striking proofs of the part that radio is playing in the development of the nation's air transport system, says a bulletin of United Air Lines which has an investment of several hundred thousand dollars in its thirty-five two-way radio stations and in the two-way telephony equipment installed in its 100 airplanes.

The maximum efficiency of air travel is obtained when there is night as well as day flying and without the availability of radio the newly inaugurated night passenger plane service would not have been undertaken.

Night Flying Equipment

In describing the important role of radio in its night flying operations. which aggregate 6,000,000 miles annually, United Air Lines states:

"The planes have special night flying equipment, electric lights, retractable landing lights in the wings, and four 400,000 candle power flares, each of which can illuminate one square mile for three minutes. Airports are flood lighted. As the United pilot takes off, amid the lights that flood the field, for a division point 300 miles away, a code message goes out over the communication circuit reading:

" 'United Air Lines plane license No. ...., Pilot Lewis, departed .... twelve midnight for .....'

"This message is automatically reproduced on receiving machines at strategic points on the airways to check the plane's progress.

"Every ten miles there is a 2,000,000 candle power revolving beacon and every thirty miles a lighted emergency field. At intervals of about 100 miles the Department of Commerce maintains directive radio beam stations which discharge dots and dashes.

Directive Radio Beacons

"Through earphones the pilot listens to the signals from these radio beacon beams to keep him on his course at all times. If a little off his course to one side, the dot-dash signals predominate, or if on his course the signals merge into one long dash. Every group of signals is followed by the identification signals of the station to which he has been listening.

"The pilot continues on his route watching the beacon lights, listening to the radio range beacon and checking his flight and engine instruments. He listens to the radio telephone and reports his position to ground stations every ten minutes. Sometimes he talks to other pilots flying perhaps 100 miles away. Occasionally the radio beacon signals cease, followed by a voice announcing the station, the time, the ceiling at the field at which the plane will next land, the condition of the weather, wind velocities, temperature, barometer reading and all other information of value and assistance to a pilot flying in the night or day. The broadcaster is a Department of Commerce employee, supplying Weather Bureau information.

"With such aids, night flying, when done with the proper equipment and experienced personnel, becomes commonplace, with radio giving dependability only dreamed of a few years ago."

▲

BOOK REVIEW

ELECTRONICS is the name of a new book published by John Wiley & Sons, Inc., 440 Fourth Ave., New York. The author is Ralph Gordon Hudson, Professor of Electrical Engineering, at M. I. T. The book is cloth bound, has 135 pages, illustrated, and sells for $2.00.

In view of its title, this new book, quite correctly, does not go into the engineering details of radio receivers or of other radio equipment, except the vacuum tube.

The theoretical chapter on electrons and electron emission are authoritative and instructive, including an understandable review of the Quantam principle and Planck's theorem.

There are several chapters dealing clearly with the application of electronics principles in the operation of photocells, vacuum tubes, rectifiers, inverters, oscillograph recorders, television, and telephotography.

A reading of the book will bring the practical engineer up to date in this modern subject.

RADIO TRANSMISSION CHARACTERISTICS OF OHIO AT BROADCAST FREQUENCIES. By J. F. Byrne, assistant professor of electrical engineering, The Ohio State University. 18 pages, 6x9 inches. Published by The Ohio State University as Bulletin 71 of the Engineering Experiment Station. Price 25 cents. (Limited number available for free general distribution.)

That available broadcast channels for radio transmission are natural resources and should be conserved and used to best advantage is clearly brought out in *Radio Transmission Characteristics of Ohio at Broadcast Frequencies,* by J. F. Byrne, assistant professor of electrical engineering at The Ohio State University.

Bulletin 71 presents a number of measurements of the signal intensity of broadcasting stations in Ohio, Pennsylvania, Kentucky and Indiana, and shows the relative effectiveness and economy of the various transmission frequencies used in broadcasting. The signals of nine stations, frequencies ranging from 550 to 1,490 kilocycles, were investigated in this survey. The correlation between measured field strengths and Sommerfeld's radio transmission formula is shown to be quite good. The demonstrated superior covering power of low frequency stations is the basis for Professor Byrne's recommendation that the lower frequencies be conserved for powerful stations of great range and the higher frequencies be used for numerous small stations whose primary interest is intensive coverage of the localities in which they are situated.

PHOTOCELLS AND THEIR APPLICATIONS. Zworykin and Wilson. 330 pp.; cloth. John Wiley and Son, New York. Price, $3.00.

This is the second edition of this excellent, authoritative book on photocells and their uses. The work is of direct value to radio engineers and others desiring knowledge of the design, make-up and circuit use of all types of photocells.

▲

NEW RADIOTELEPHONE STATION IN PANAMA

CONSTRUCTION of a transmitter and power house and a receiving station for the radiotelephone system to be operated between Panama and the United States, has begun, and it is expected that the system will be inaugurated in a few months. The transmitter and power house are being built at Lindbergh Field, and the receiving station is near Old Panama, about seven miles from Panama City.——*Assistant Trade Commissioner A. Cyril Crilley, Panama City, Panama.*

▲

SUBMARINE CABLE

A LOADED signaling conductor suitable for the transmission of electric currents at audio and carrier frequencies, comprising a conducting member and a layer of loading material having a thickness not in excess of about 0.0015 inch and formed of an alloy having high specific resistance and a permeability below about 800 at low magnetizing forces.

Smith, W. S., Garnett, H. J., and Channon, H. C. United States Patent 1,819,720.

# of Course

C R C Sockets Cost More!

600

ALWAYS * * in every line of endeavor—one product has stood head and shoulders above the average, and has, naturally, commanded a higher price.

ALWAYS * * there has been a demand for the "stand out" product—and **THAT** is the demand we fill.

800

ALWAYS * * (and particularly in trying times) there is present the temptation to throw quality overboard, and make price the sole sales argument. This temptation we have resisted, and will continue to resist.

ALWAYS * * it has been more difficult to provide a fine product at a fair price than an inferior product at a cheap price. **CRC Sockets are the finest obtainable.**

500

ALWAYS * * the wisdom of our policy is confirmed by a constantly increasing list of customers whose names stand high in the equipment and receiving set field. **THEY** know that

CRC SOCKETS ARE MECHANICALLY AND ELECTRICALLY CORRECT

Central Radio Corporation

BELOIT **WISCONSIN**

A chronological history of electrical communication —telegraph, telephone and radio

▲

This history was begun in the January, 1932, issue of RADIO ENGINEERING, and will be continued in successive monthly issues throughout the year. The history is authoritative and will record all important dates, discoveries, inventions, necrology and statistics, with numerous contemporary chronological tie-in references to events in associated scientific developments. The entries will be carried along to our times.

▼

Part XI

1873—*Continued*

(407) The Dominion Telegraph Company, of Canada, at its fourth annual meeting, February 12, re-elects John McMurrich, president; J. J. McKenzie, vice-president, and James Michie, treasurer.
(408) The Southern and Atlantic Telegraph Company has in operation 1,603 miles of line; 3,002 miles of wire, and offices in twenty-three cities and towns.
(409) The Atlantic and Pacific Telegraph Company elects John Duff, president and E. D. L. Sweet, executive manager.
(410) William H. Ward, of Auburn, N. Y., suggests the erection of an electrical tower for accumulating atmospheric electricity and for employing atmospheric electricity to communicate with similar distant towers without connecting wires.
(411) The larger telegraph companies now competing with the Western Union Telegraph Company, are: The Atlantic and Pacific, in connection with Union Pacific Railroad lines, 4,500 miles of line; The Southern and Atlantic; The Franklin Telegraph Company, Washington to Boston, with 800 miles of line and 2,780 miles of wire; The Great Western Telegraph Co., with headquarters at Chicago, and the Philadelphia, Reading and Pottsville Telegraph Co., owned by the Philadelphia and Reading Railroad.
(412) On January 1, this year the telegraph systems of the United States had an aggregate capital of $60,000,000, with 80,000 miles of line, 180,000 miles of wire, and 6,300 offices.
(413) In May due to two of the transatlantic cables being broken, there is but one cable working between Europe and America.
(414) The Indo-European telegraph line between London and Teheran has four repeaters in the 4,000 mile circuit. The speed of operation is about ten words per minute.
(415) In continental Europe the Hughes printing telegraph is extensively used.
(416) Underground telegraph conduits are extensively employed in England, France and Prussia.
(417) A German-American submarine cable is projected to extend from Stettin, Germany, via the Shetland Islands, Newfoundland and thence to New York.
(418) In the United States ninety-six per cent of the telegraph traffic of the Western Union Company is handled by the Morse system; four per cent being handled by the combination House-Hughes printer.
(419) Sir Francis Ronalds dies. (Born in England 1788.)
(420) Edward Weston, in the United States, manufacturers copper-coated carbon rods.
(421) The Western Union Telegraph Company has 8,000 employees.
(422) The Atlantic cable rate to Great Britain is $1.00 per word, and to France $10.00 for ten words or less.
(423) The Franklin Telegraph Company, at the annual meeting in Boston, June 12, elects as directors: John Duff, John R. Duff, Oliver Ames, J. S. Fay, T. G. Dexter, W. H. Guion, G. B. Grinnell, S. Bowdoin and J. W. Brown.
(424) M. Meyer, of the French Telegraph Admiinistration introduces a multiplex telegraph system employing a line "distributor" for transmitting four messages simultaneously over a wire.
(425) A consolidation is completed of the French-Atlantic Telegraph Company, the Anglo-American, and the New York and Newfoundland Telegraph Company.
(426) The Western Union Telegraph Company, this year acquires control of the Pacific and Atlantic Telegraph Company, capitalized at $2,000,000, with 5,000 miles of line and 10,000 miles of wire.
(427) The Anders magneto dial telegraph printer, operated without the use of primary batteries, is introduced by E. B. Welch and George L. Anders, for use on short lines.

1874 (428) George F. Lawton, of the Eastern Telegraph Com-Company, introduces the first siphon recorder in submarine cable operation in France.
(429) Elisha Gray's harmonic telegraph invented.
(430) George B. Prescott and T. A. Edison successfully work a quadruplex telegraph circuit between New York and Boston.
(431) The Law telegraphic exchange system organized in New York, employing a dial telegraph system for private lines.
(432) The Anglo-American Company lays an additional cable between England and Newfoundland. This was the last cable-laying expedition of the Great Eastern.
(433) The Franklin Telegraph Company's lines are leased by the Atlantic and Pacific Telegraph Company.
(434) Johann Philip Reis dies. (Born in Germany, 1834.)
(435) A bill is introduced in the House of Representatives to incorporate the Submarine Cable Printing Telegraph Company by Boston and New York capitalists, to lay and operate one or more lines of Atlantic cable. The system proposed is the invention of W. E. Sawyer, a Washington journalist.
(436) Ezra Cornell dies. (Born U. S. A., 1807.)
(437) The British Association for the Advancement of Science makes its first report on nomenclature of electric units.
(438) William Orton is elected president of the Pacific and Atlantic Telegraph Company, May 5.
(439) Arrangements are made between the Western Union Telegraph Company and the American District Telegraph Company for a business alliance.
(440) In Mexico 5,000 miles of telegraph line are in operation. Seventy-three offices are controlled by the government, which owns about one-half of the lines.
(441) The American Electrical Society is organized, in Chicago, October 21. Those elected to fill the offices are all prominent telegraph officials, including Anson Stager, president; C. H. Haskins, George B. Prescott, H. P. Dwight, William Orton, James Gamble, John Van Horne, E. D. L. Sweet, vice-presidents. Executive committee: William Henry Smith, J. J. S. Wilson, George H. Bliss, F. H. Tubbs, and C. H. Summers. Directors: F. L. Pope, A. S. Brown, W. W. Smith, J. A. Swift, S. D. Field, George T. Williams, D. Flannery, C. O. Rowe, R. C. Clowry, E. P. Wright, D. H. Bates, J. J. S. Dickey, N. Hucker, A. G. Davis and J. R. Dowell. Corresponding secretary, I. N. Miller; recording secretary, C. S. Jones.

(To be continued)

It Is Easy To Replace Defective Volume Controls— But Hard to Regain Lost Customers!

ENGINEERS appreciate the sound merchandising adage "when good goes in—the best comes out." This is particularly true when applied to receiver design for 1933 models.

It is generally known that current business conditions have caused some manufacturers to stint on the quality of their componnents. They buy parts that outwardly look as good—but are inferior in price and performance.

This "wolf in sheep's clothing policy" is unsound. Production costs sheets may show that you are making a profit—but repeat business fails to come in—and you pay on the other side of the ledger.

To the members of the Institute of Radio Engineers, and other practical business men now designing 1933 radio equipment, we seriously recommend that you follow Clarostat's leadership policy of looking towards the future, while planning today!

Type P-58 Control Without Switch

This standard type control provides minimum volume at its extreme left setting, and tapers smoothly and efficiently to maximum volume by clockwise rotation. Model P58 is available in single, dual and triple control units on one shaft — with or without switches built-in.

Type P-185 Control Fitted With Switch Dustguard Cover Plate

This type wire-wound control is available with or without coverplate switches. These potentiometers are provided with three terminals and may be had in any taper desired. By using the center contact arm terminal and one of the resistance element terminals, they may be used as rheostats.

CLAROSTAT MFG. CO. INC.

285 NORTH 6th STREET BROOKLYN, N. Y.

NEWS OF THE INDUSTRY

POWER SUPPLY FOR BROADCAST TRANSMITTERS

The Delta Manufacturing Company, F. S. Dellenbaugh, Jr., president and chief engineer, 39 Osborne St., Cambridge, Mass., announces a high-grade line of transformers, choke coils, rectified a-c. power units, amplifiers and voltage regulators.

All Delta designs are based on careful study and research into wave shape distribution throughout the circuit involved. This is done by both mathematical analysis and oscillograph observations which give complete knowledge of apparatus behavior. A careful check is made by practical tests on all finished equipment both in our own laboratories and after installation.

▲

ROCKE-MINGINS COMPANY

Arthur Rocke and L. H. Mingins have formed a radio jobbing and outlet business for the Metropolitan district of New York. The Rocke-Mingins Co. is located at 5 Laight St., New York.

Both Mr. Rocke and Mr. Mingins have been associated with the radio business in its changeable phases for the past ten years and now represent several lines of parts and accessories.

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CLOUGH-BRENGLE COMPANY

The Clough-Brengle Company, with headquarters at 1134 West Austin St., Chicago, Ills., has been formed to manufacture laboratory and production test equipment, amplifiers and accessories for sound, broadcast and recording applications, and a complete line of audio and speech input transformers.

Kendall Clough formerly was chief engineer, and Ralph Brengle, general superintendent of the Silver-Marshall Company, Chicago. The new firm has identified with its engineering department Ralph P. Glover, formerly with Crosley, and Leon Worner, formerly with Silver-Marshall.

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FIRM OF COMMUNICATION ENGINEERS

L. A. Kelley, formerly with the International Communication Laboratories, New York, and J. C. Burkholder, formerly chief engineer of the Canadian National Telegraphs, Toronto, Ont., have formed a partnership with offices in New York and Toronto, for the consulting practice of communication engineering.

▲

NEW TYPE OF RESISTOR

In line with its policy to supply wire-wound resistors that afford a distinctive improvement in rating under hard working conditions, the Precision Resistor Company of 113 Frelinghuysen Avenue. Newark, N. J., announces the new type "BP" 5 watt unit with maximum resistance rating of 60,000 ohms, and the new type "VP" 10 watt unit rated at 100,000 ohms maximum.

In accuracy, Precision type resistors are rated within 3 per cent plus or minus their rated resistance. This close tolerance is made possible by a newly developed process of winding and by baking the units at low temperature.

The terminals of types "BP" and "VP" resistors are hot solder dipped. The double insulated wire receives two baked coats of enamel insulation. This process affords protection against acid, oil and moisture. Because of their compactness, these units have been found ideal as the reasonably priced high resistance unit for midget, aeroplane, automobile and other receivers where space is a prime factor. Type "BP" is ⅜" wide by 1½" long. Type "VP" is ½" wide by 2" long.

Literature describing the full line of resistance units and "T," "L" and "H" Pads manufactured by the Precision Resistor Company is available.

▲

CRC IN NEW ENGLAND

The Central Radio Corp., Beloit, Wis., manufacturers of CRC sockets, socket clips and other radio products, has appointed the H. Gerber Sales Company, 94 Portland St., Boston, Mass., sales representative in Maine, Vermont, New Hampshire, Rhode Island, Massachusetts and Connecticut.

Although the corporation's prices are such as is necessary where dependable high grade products are desired, a substantial increase in the number of orders received is reported for October.

▲

FLEXIBLE COUPLINGS

A new coupling unit announced by the Hammarlund Mfg. Co., 424 West 33d St., New York, permits tandem operation of any number of independent units without requiring exact shaft alignment. A great convenience and time saver.

The sides of the condenser are insulated from each other, allowing instruments in gang to be operated as independent elec-

trical units. Made of Bakelized canvas, with brass bushings and for ¼-inch shafts. Four rust-proofed and hardened steel set screws provide against shafts slipping. Overall diameter is 1½ inches.

▲

NEW RADIO CATALOG

Federated Purchaser, Inc., 25 Park Place, New York, has issued a new catalog which lists and illustrates about every radio part and accessory used by service men, dealers and shops. Copies may be procured upon request.

TUBE MANUFACTURING

The Kahle Engineering Company, specialists in machinery, equipment and methods for the manufacture of radio tubes and related products, announces that they have just signed a long-term lease on enlarged warehouse space at Union City, N. J., adjoining the company's present headquarters.

"Our business," said L. C. Kahle, when interviewed recently, "has been increasing at a steady rate during the past year, and more recently has received added impetus, due I think to the better feeling which is now prevalent throughout business circles.

"The radio tube industry is working on heavier schedules as to hours and employees, than in several years.

"All this activity has been reflected in the increased demand for equipment. New departments or new factories are started, old equipment is discarded, and as a result the Kahle Engineering Company has been working seven days a week, and every night, for the last few months, in an effort to supply the demand for equipment and services.

"We have taken on additional space and additional help, and every indication is that this condition will continue for some time to come."

▲

COILS FOR RADIO

The manufacturers of Inca coils have introduced a new rigid core which they have named, Tru-Form, because it holds its shape and does not bulge or buckle as some paper cores of the square type have done.

These new cores are manufactured under a patented process from a treated and reinforced wood with corners perfectly mitred by special machinery.

The manufacturers who have been using these new Tru-Form coils over a period of time claim that much labor and material is saved which heretofore has been wasted due to the difficulty of inserting the core laminations in coils where core tubes have buckled.

Complete information and samples may be secured from the Inca Manufacturing Division of Phelps-Dodge Copper Products Corporation, Ft. Wayne, Indiana.

▲

AUTOMOBILE RADIO PARTS

The Premier Electric Company, Grace and Ravenswood Avenues, Chicago, Ill., announce a dependable auto-radio remote control unit for steering post attachment. The device is of pressed steel construction—all metal parts rust-proof cadmium and black finish; small size 3½ inches by 4¼ inches by 1 inch thick; light weight; key lockswitch; micrometer volume control. 100,000 ohm (other resistances special). Illuminated celluloid dial. Furnished with steering column mounting brackets and condenser gear plate for ¼-inch shaft. 30-inch flexible shaft and casing standard. Special lengths to order.

CENTRALAB
VOLUME CONTROLS
A quality product for the manufacturer, serviceman, amateur and for Sound Projection.

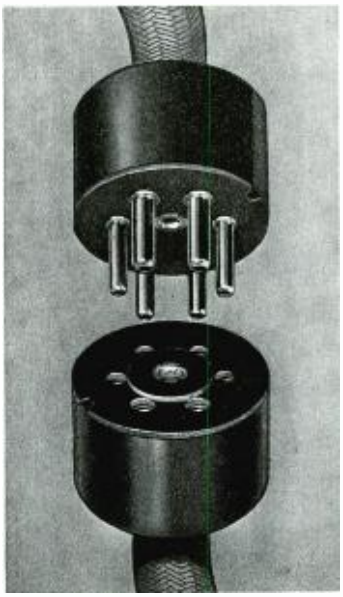
The CENTRALAB Quality Triumvirate

Three products carry the CENTRALAB banner of Quality. Even in this frantic competitive era, Centralab products are designed for highest quality, regardless of cost. Attractively low prices result from large volume production . . . not from shoddy design.

CENTRALAB
RADIO LABORATORIES
MILWAUKEE, WIS.

CENTRALAB
MOTOR RADIO NOISE SUPPRESSORS
50% to 500% more efficient in reducing spark noises. Write for descriptive booklet.

CENTRALAB
FIXED RESISTORS
Baptised with fire in the making and will withstand a greater load than any other composition resistor of equal size.



CINCH ANNOUNCE A NEW PRODUCT!

—*the New Cinch* Radio Plug

Another addition to the line of Cinch quality products. Positive, dependable contact is provided in both male and female plugs. Available in 4, 5, and 6-prong types. Neat, positive locking cap of moulded bakelite allows for easy, simple assembling. More room is provided for soldering. Female plugs have standard Cinch "Floating Contacts."

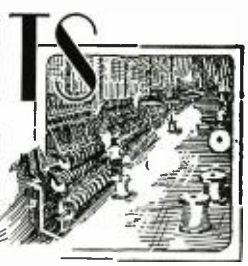
The new Cinch Radio Plugs are strong, durable, compact. Cinch Quality throughout—yet priced economically! Write at once for samples and prices. A Cinch Plug can be designed to suit *your* requirements.

CINCH PRODUCTS:

Standard and Midget Size Radio Sockets with "floating contacts"—Binding Posts—Soldering Lugs — Insulated Mounting Strips—Tip Jacks—Small Intricate Metal Stampings.

CINCH MANUFACTURING CORP.
2335 W. Van Buren St. Chicago, Ill.
SUBSIDIARY OF
UNITED-CARR FASTENER CORP.
31 Ames St. Cambridge, Mass.

NEW DEVELOPMENTS OF THE MONTH



NEW VOLUME INDICATOR

A new line of volume indicators for the broadcast field is anounced by The Daven Company, 158 Summit St., Newark, N. J. The instruments are of the copper oxide rectifier type and are furnished mounted in a box for laboratory use or on standard rack panel.

The multiplying network is of the "L"

type and is made with a constant impedance of 5,000 ohms. Standard units are furnished with 2 db. per step.

The Daven volume indicators are obtainable in two sensitivities. The standard unit, most suitable for ordinary purposes, has a range from —10 db. to +46 db. Besides this there is also available a special meter having a range from —20 db. to +36 db. The first one has a sturdy movement which will stand much abuse while the latter is extremely sensitive and should only be used where such sensitivity is expressly required.

Although the meters are calibrated to read directly on a 500 volt line they may easily be used on lines of other impedances as there is a simple mathematical relation between the losses. A chart is furnished with each meter where corrective values may be found directly without calculation.

The Daven Company also manufactures a line of output meters using similar meters as above but calibrated in volts instead of db. These meters are made in impedances of 4,000, 8,000 and 20,000 ohms and can be used to advantage for a great number of a-c. measurements.

SPAULDING POSITIVE CONTACT SOCKET

Improved radio socket features are presented by the Spaulding Fibre Company, Tonawanda, N. Y., in a new four line contact socket. This socket is made for seven

prong tubes as well as 4, 5 and 6 prong. Keen knife-edges eliminate contact resistance and render the construction self-cleaning. Contact is self-aligning or "floating." Clips of extra heavy tin plating for easiest soldering are securely locked between plates, doing away with separate riveting for each clip. Standard Spaulding sockets are made with 1-11/16" and 1-27/32" mounting centers. Midget size with 1½" centers.

▲

D-C TO A-C INVERTER

The Solar Manufacturing Corpn., 599-601 Broadway, New York, announces an inverter for operation of a-c radio receivers from d-c mains. With this unit it is necessary only to plug one end of the inverter into the a-c receiver and the other end into the d-c house current outlet.

▲

THREE-STAGE POWER AMPLIFIER

A three-stage "250" power amplifier, the Acratone, manufactured by the Acratone Products Corp., is being marketed by Fed-

erated Purchaser, Inc., 25 Park Place, New York. The amplifier has an output of 11 watts; the power consumption is 130 watts; the power supply is 110, 125 volts, 60 cycles. The amplifier employs 1, 58; 1, 56; 2, 250 and 2, 281 tubes. The price is low for this excellent amplifier unit.

NEW TAPPED BRADLEYOMETER

A new tapped Bradleyometer is announced by the Allen-Bradley Company, 1311 South First Street, Milwaukee, Wisconsin, which provides automatic tone correction with volume control. It is well known that the sound pressure representing the threshold of audibility varies greatly with the frequency and is a great deal higher at low and high frequencies than in the middle register. Therefore a type of volume control is necessary which varies the frequency characteristics of the audio amplifier so that the apparent quality of reproduction remains the same for all volume control settings. The new tapped Bradleyometer achieves this result in any one of several audio frequency networks and automatically accomplishes tone correction with volume changes.

The resistance element of the tapped Bradleyometer consists of 50 individual resistance steps molded in disc form and stacked alternately between metal discs of somewhat larger diameter. The contact arm makes contact along the edges of the large metal discs, and therefore the resistance units are not subjected to mechanical wear. A special tap on the resistance element is brought out to a fourth terminal. The network necessary to provide tone correction is usually connected between this tap and the grounded or low potential end

of the resistance element of the tapped Bradleyometer.

A single-pole line switch approved by the Underwriters' Laboratories and the Hydro Electric Power Commission of Ontario with a rating of 2 amperes, 125 volts, can be provided within the Bradleyometer and is operated by the regular control knob.

The new tapped Bradleyometer can be built up to provide any resistance-rotation curve, and in some designs each of the 50 steps may be different from the others. Controls can be provided with a logarithmic resistance-rotation curve to provide uniform decibel increments with knob rotation.

INDEX OF ADVERTISERS

THE Group Subscription Plan for RADIO ENGINEERING enables a group of engineers or department heads to subscribe at one-half the usual yearly rate.

The regular individual rate is $2.00 a year. In groups of 4 or more, the subscription rate is $1.00 a year. (In Canada and foreign countries $2.00.)

The engineering departments of hundreds of manufacturers in the radio and allied industries have used this Group Plan for years, in renewing their subscriptions to RADIO ENGINEERING.

Each subscriber should print his name and address clearly and state his occupation—whether an executive, engineer, department head, plant superintendent, or foreman, etc.

Remember this Group Plan when *Your* Subscription Expires

(Radio Engineering)

Bryan Davis Publishing Co, Inc.
19 East 47th Street
New York, N. Y.

Los Angeles Chicago St. Louis

New Transformers for New Tubes

Type 46 Class "B" Amplifier, as you know, requires carefully designed coupling transformers and a power supply unit with extremely good regulation—in order that full power may be obtained with negligible distortion. And THORDARSON engineers have developed new transformers especially adapted to these requirements. THORDARSON Transformer—T-5303—is an unusually heavy plate supply unit which greatly improves the regulation over that obtained with the ordinary power supply. T-2353A, a swinging filter choke, is especially designed to make the voltage output of the power supply constant over the required range. And T-5289 is an Input Audio of generous design for carrying heavy grid currents. For complete data on Type 46 Class "B" Amplifier, we offer our bulletin SD-144. It includes circuit diagrams, and curves. Sent free upon request. Thordarson Electric Manufacturing Company, 500 West Huron Street, Chicago.

T-5303

T-2353A

T-5289

Thordarson Replacement Transformers

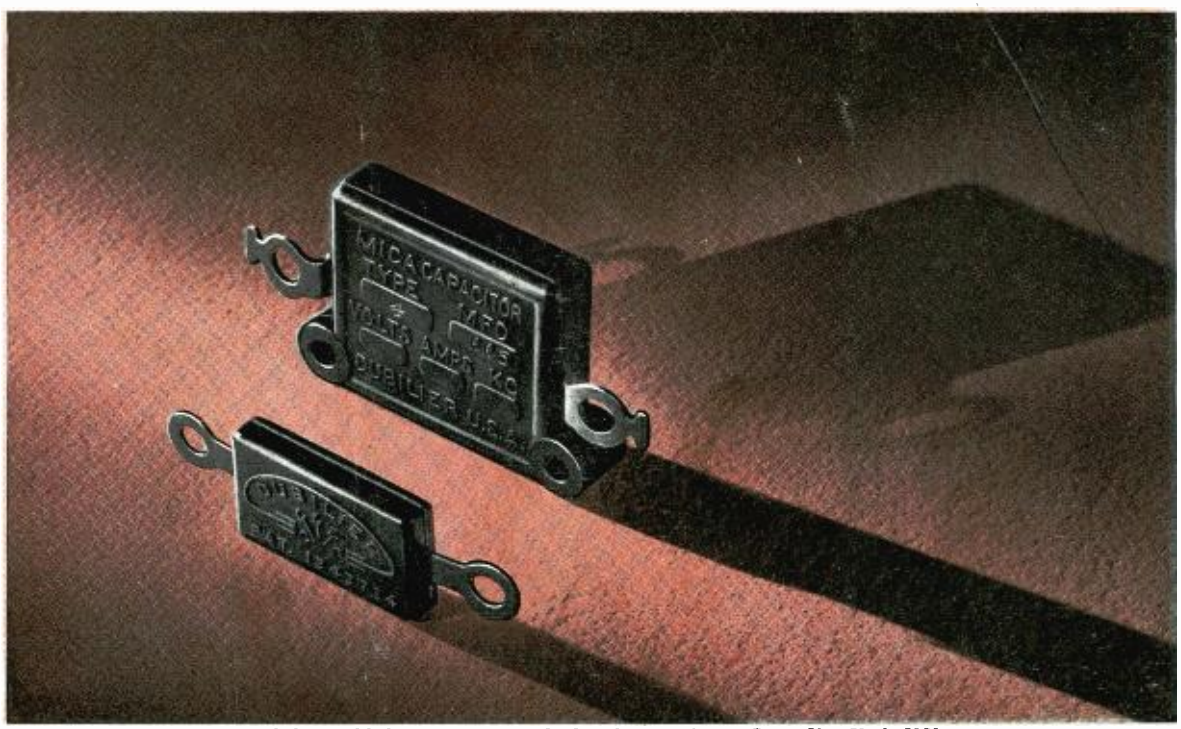
THORDARSON has developed a line of replacement transformers for practically every type of receiver. They are universal electrically and universally mounted. THORDARSON replacement transformers are completely enclosed in drawn steel housings which improve the appearance and shield the windings. THEY ARE GUARANTEED to be as good as, or better than, the original transformer installed in the receiver. THORDARSON'S years of experience in supplying leading receiver manufacturers with their transformers and their manufacturing skill and facilities insure a quality product at a low price. Ask for complete catalog of Thordarson Replacement Transformers.

THORDARSON

Reg. U. S. Pat. Off.

TRANSFORMER SPECIALISTS SINCE 1895 . . .

Exposure cannot harm *sensitive elements sealed within Bakelite Molded*



Bakelite Molded capacitors made by Dubilier Condenser Corp., New York, N.Y.

TO OPERATE successfully, a capacitor must be so constructed that even the slightest dampness is excluded from the electrical element. Through years of experience Dubilier has found that the most practical and dependable way to assure the exclusion of moisture is to seal the element within a Bakelite Molded shell.

In the capacitors shown, the Dubilier trade-mark and all necessary lettering and markings are formed in clear, sharp relief in the molding operation. The metal terminals are molded in with a moisture-tight fit. The excellent electrical insulation properties of Bakelite Molded are, of course, an additional advantage.

Development of electronic equipment and devices requiring electrical insulation immune to deterioration, is being materially aided by the use of Bakelite Molded. Our engineers and laboratories are always at the service of manufacturers in adapting Bakelite Materials to their particular needs. We also have an interesting booklet, "Bakelite Molded", and will mail a copy promptly on request. Ask for booklet 12M.

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BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario, Canada

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The registered trade marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" a the numerical sign for infinity, or unlimited quantity, it symbolizes the infinite number of present and future uses of Bakelite Corporation's products.

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No. 6551—Double Choke, for use with above transformers	**$15.00**
No. D-600—Power Amplifier Condenser Unit	**$16.50**
No. D-307—A Condenser Block, used in connection with D-600	**$10.00**
No. 1177—Straight Power Amplifier Output Transformer	**$12.00**
No. 1176—Same as No. 1177 but of Push-Pull type	**$12.00**

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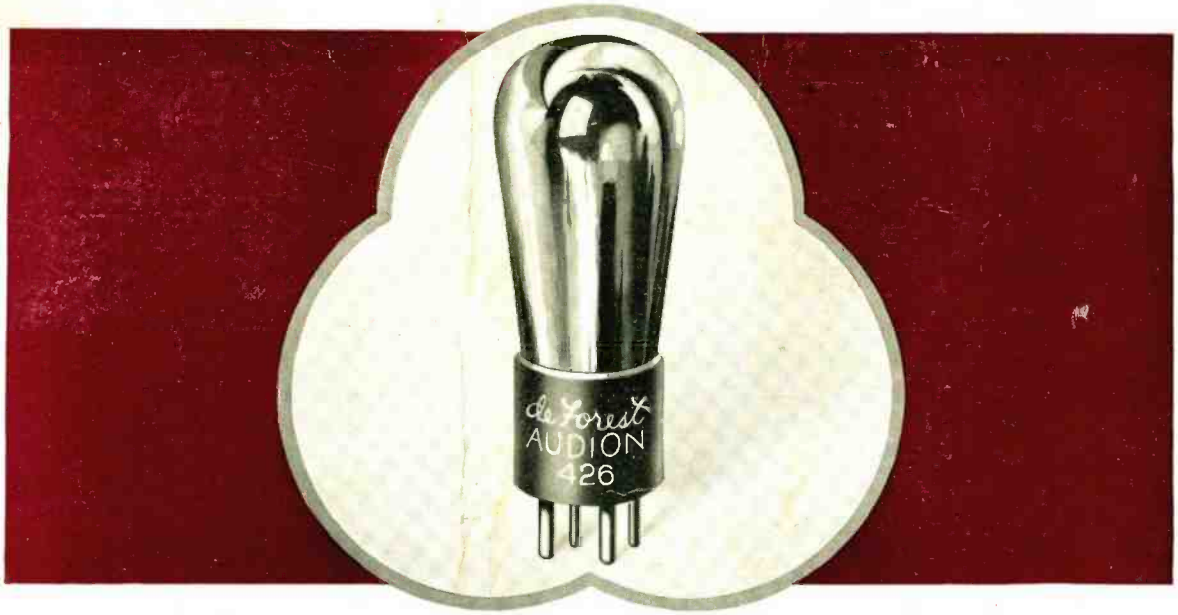

DeForest Audion No. 426, with base of Bakelite Molded. Manufactured by DeForest Radio Co., Jersey City, N. J.

Bakelite Molded provides "economy and exact suitability"

IN developing parts to provide new standards of radio performance, the laboratory engineer determines the most suitable materials. But when the new radio part is put in production, the element of economy becomes an important factor. It is indeed fortunate when a material meets the high standards of the laboratory, at a cost which makes its adoption practical. A case in point is the selection and use of Bakelite Molded for DeForest Audion bases—"because of its economy and exact suitability."

Because of its strength, the Bakelite Molded base provides protection for the vacuum tube. Because of its high insulation value, the use of this material also protects the clarity, volume and sensitivity of the Audion. The permanently lustrous black finish of Bakelite Molded adds to the quality appearance of the tube.

Bakelite Engineering Service

Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resinoids for radio uses provides a valuable background for the cooperation offered by our engineers and research laboratories.

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