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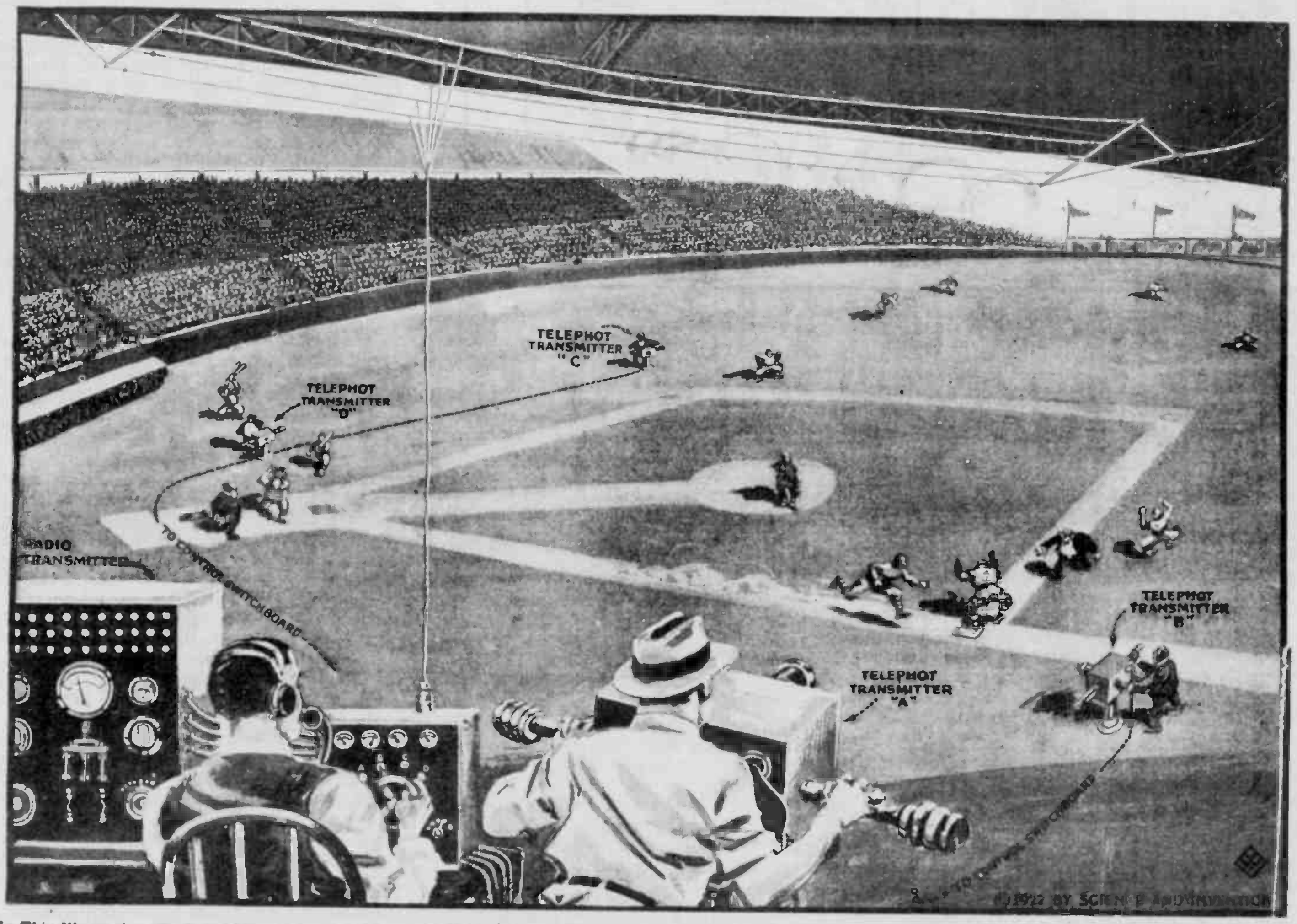
THE HORN SPEAKER

MORE AREA OF EASY TO READ CLASSIFIED ADS THAN ANY OTHER OLD RADIO PUBLICATION

Science and Invention for July, 1922



In This Illustration We Behold How Future Audiences Will See a Baseball Game Thousands of Miles Away. Here We See a Common Radio Transmitter to Which Are Connected Several Telephot Transmitters. The Operators of the Telephot Transmitters A, B, C and D "Shoot" the Interesting Parts of the Game, But They Do Not Do This Simultaneously. They Merely Point the Telephot Transmitter into Focus While the Radio Operator at His Instrument Switches from One to the Other In Order to Get Those Close-Ups Which He Wishes. The Distant Audience Then Will See Whatever Close-Ups Are Selected by the Radio Operator. It Naturally Would Not Do to Have Just One Telephot Transmitter for the Reason that at Times, the Operator Would Be Either too Far, or Otherwise too Close to the Scene. By Having a Multiplicity of Telephots, This is Avoided.

The Radiophot. Television by Radio

Coming Inventions. No. 7

By H. GERNSBACK
MEMBER AMERICAN PHYSICAL SOCIETY

SCHEMES on television are not new. Inventors have busied themselves for several generations with this invention, but so far nothing of note has been produced. The writer, in the May and June, 1918, issues of the ELECTRICAL EXPERIMENTER discussed various ideas on television and showed what had been proposed by inventors heretofore. There are many patents in existence referring to the *telephot* (*tele=far; photos=light*), but so far there has been no inventor who actually was able to demonstrate a continuous view of a moving object by electricity at a distance.

It is not that it is impossible to do this, but the great cost of such an apparatus has been prohibitive. Furthermore, one of the greatest stumbling blocks is that in nearly all schemes shown in the past, it was necessary to have hundreds and even thousands of wires between the sender and the receiver. If, for instance, we wish to talk to our friend five hundred miles away over the wire all we need is a single wire, or two at the most, if we do not wish to use a ground or return circuit. If with the schemes proposed heretofore, we wish to see our friend at a distance, it means that we would have to string several hundred wires between the two points and the idea for this reason becomes at once impractical.

The author in this article proposes a somewhat more ambitious scheme of television not only over wire, but by radio. He wishes to state in advance that no apparatus has been as yet constructed along this line, but it is believed that the scheme here shown has possibilities that would seem inviting to our constructors who wish to take the time and trouble to build such an apparatus. Engineers are of the opinion that an apparatus of this kind will actually do the work with perhaps a few minor improvements.

The stumbling block with former telephots or television schemes usually was found in the selenium cell. This was so for the following reasons: When we desire to project a picture at a distance, it is first necessary that we have some instrumentality which changes the intensity of the electric current in the same ratio as the intensity of the light that falls upon the instrument changes. A picture, as is well known, is made up of various points. Pick out any half-tone illustration in this journal, view it under a magnifying glass, and you will see that it is made up of light and dark dots. The dark dots give the picture its dark tones and the light dots give the half-tones and the white paper shades into unison with the dots.

The selenium cell has long been thought the best instrument to translate changes in the intensity of light into electrical current impulses. Imagine a screen made up of several thousand selenium cells. A picture falling upon this screen will thereby resolve itself into the various components of the picture itself. Then some selenium cells will receive more light, others less, etc.

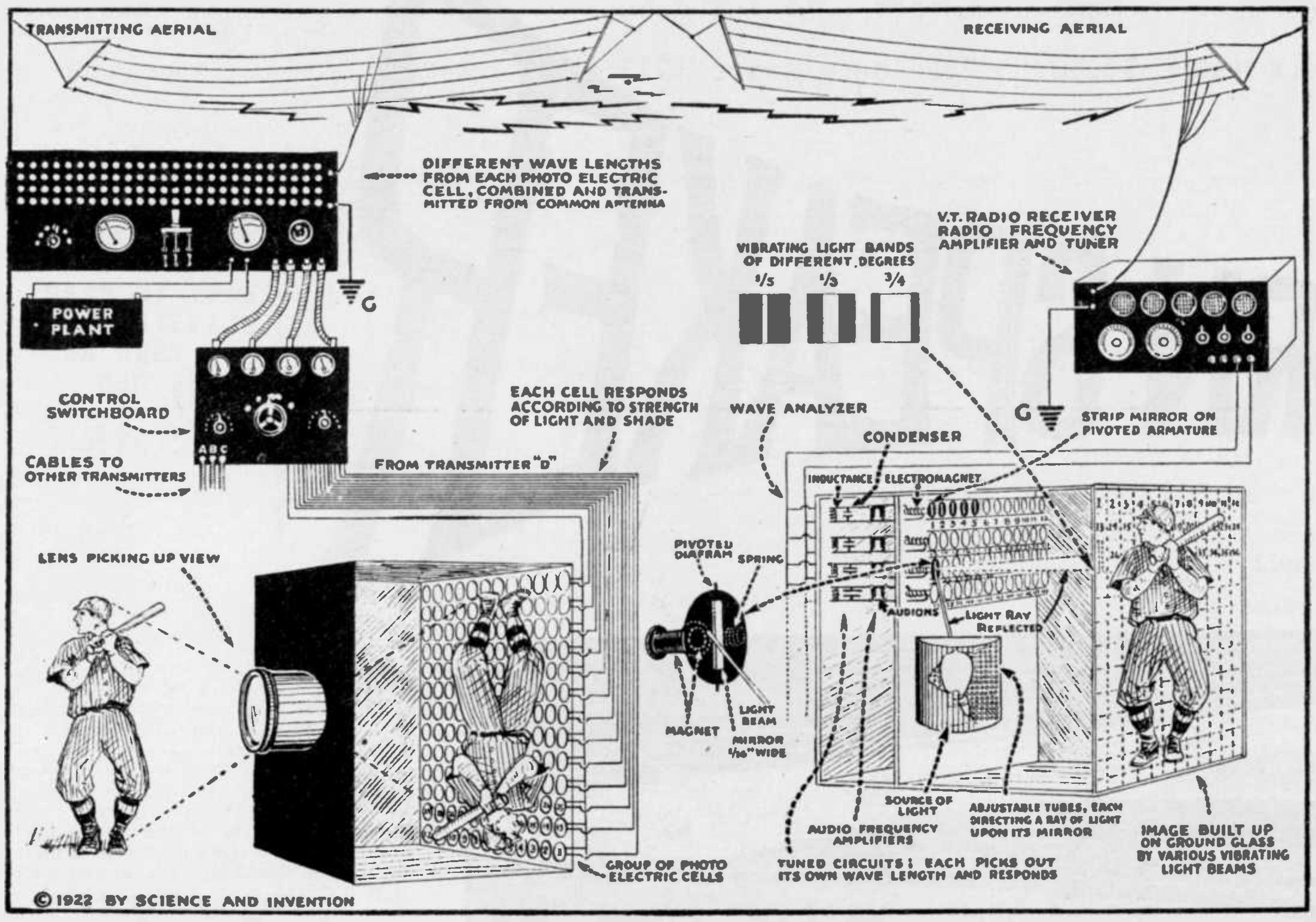
The electrical impulses are then sent out over the wires to be reconstructed later into a picture at the receiver. The trouble with the selenium cell is, however, that it is sluggish. In other words, the selenium cell takes a large fraction of a second in which to change its resistance. Light is instantaneous, and all reconstructed selenium pictures are always lagging behind; if we actually could obtain a reconstructed picture, it would be imperfect.

This trouble is done away with in the author's radio television scheme whereby instead of the selenium cell, we make use of photo-electric cells. There have been lately developed a number of such cells, which are available and which are highly light-sensitive. Moreover, they are not sluggish in action as are selenium cells. In other words, *they vary their resistance almost instantly* as the light falls upon them, or as it is removed.

Referring to our main illustration, the author's scheme resolves itself into the following. At the transmitter we have an ordinary camera-like box in the back of which we have a great number of tiny photo-electric cells. Each cell responds according to the strength of light and shade. The lens in front of the camera picks up the view and throws it inverted upon the group of photo-electric cells in the rear. All dark parts of the picture, as for instance, the shoes of the baseball player will, therefore, *not* affect the light sensitive cells *and these remain inactive*. The other parts of his body, as for instance the white uniform, will affect only those cells upon which rays of light from the white fall. These cells then send their impulses into a vacuum tube modulator and synthetizer. This vacuum tube modulator is a regulation radio transmitter such as is used in all broadcasting stations today. Each photo-electric cell is made to operate a separate vacuum tube, and each of these vacuum tubes sends out its own wave. For instance, photo-electric cell number one will send out on a wave let us say of 500 meters; photo-electric cell number two transmits on a wave of 500¼ meters; photo-electric cell number three sends out on a wave of 500½ meters, and so on down the line.

From the radio transmitter all of these waves are sent out from one and the same aerial, which is quite feasible, for it has been demonstrated years ago that one aerial can be used to send out many messages, each on a different wave length, and there is no trouble in doing this very thing today. To resume, what have we done in our transmitter? We have transformed light impulses into electrical ones. These in turn are being shot out into space at different wave lengths, each retaining its own identity.

Now let us see what happens at the receiver. The distant aerial picks up all the different waves on a regulation radio receiv-



This Shows the Modus Operandi of the Latest Proposed Telephot Scheme. First We Employ a Group of Photo-Electric Cells Which Are Light-Sensitive, and Which Transmit Light Impulses into the Radio Transmitter. Whenever Light Falls Upon the Photo-Electric Cells, These Cells Transmit an Impulse. Where No Light Falls, as for Instance the Socks of the Baseball Player, Such a Photo-Electric Cell Remains Dark, and Consequently Sends Out No Impulse. All the Cells Send Out Impulses Which Are Transmitted at Different Wave Lengths from a Common Transmitting Antenna. These Are Picked Up at a Distant Receiving Aerial, Where We Have Also an Instrument Which Consists of a Great Number of Inductances, Condensers, Audio Frequency Amplifiers, and Electro-Magnets. Each Such Unit Responds to a Certain Wave Length. In Front of the Electro-Magnet, Which is Energized, We Have a Pivoted Diafram. On the Diafram We Have a Narrow Mirror. When the Diafram is at Rest, the Light Beam Falls Upon it, and Just Misses the Mirror. The Smallest Vibration of the Mirror, However, Intercepts a Light Beam From a Common Source, Which Light Beam Plays Upon the Ground Glass. The Combination of All These Diaframs in Reflecting Each One a Light Beam, Reconstructs a Picture on the Ground Glass, as Shown.

ing outfit, which, of course, must be able to tune very sharply; otherwise, it will not be possible for us to receive a clear picture.

In our television receiving box proper, we have the following: There is a bank of inductances with their respective condensers, together called the wave analyzer. These inductances and condensers are tuned circuits, and each picks out its own wave length and responds. In the circuit of each inductance and condenser, we have also an audio frequency amplifier, which operates an electro-magnet, simila to a telephone receiver. This wave analyzer is already in use today and is not a new development at all. Any owner of a vacuum tube set knows that he can tune in or out almost any wave length that comes along, within reason. It is also possible by means of certain arrangements to let several people listen in to several broadcast concerts from different stations, all on the same outfit. This already has been accomplished.

Coming back to our wave analyzer, let us see what happens now. Inductance number one, condenser number one, and audio frequency amplifier number one, are tuned to a wave length of 500 meters. This circuit, therefore, will respond only to 500 meters wave length, and to no other wave. Consequently, when at the distant sender, photo electric cell number one is energized, it sends out a wave at 500 meters, which wave is received in our wave analyzer, and will only affect inductance number one, condenser number one, and audio frequency amplifier number one. All the other inductances, condensers, and amplifiers are not affected because they work on different wave lengths.

We shall now see how the picture is reconstructed. The electro-magnets connected with each of the many audio frequency amplifiers are equipped with pivoted diaframs in the center of which are mounted vertical strips of mirror, which are very narrow. These mirrors may be 1/16th of an inch wide, or thereabouts. The best width will probably be found by experimenting. From a common source of light also shown in our illustration a single ray of light falls just outside of each mirror. See diagram. The common source of light may be a powerful tungsten lamp enclosed in a box perforated with many holes. Each hole lets a ray of light pass and each hole sends a ray of light upon a different diafram.

The instant that the audio frequency amplifier energizes the electro magnet the diafram in front of it begins to turn on its axis, and the ray of light normally at rest begins to vibrate back and forth. This ray of light falls upon a ground-glass plate in the rear of the receiver.

At this point, we wish to call the readers' attention to the fact that the diafram in front of the electro magnet is not the ordinary telephone diafram but is one that is pivoted. In other words, the more current flows in the electro-magnet, the more the diafram will turn. Of course, this diafram is attached in such a manner that it will not turn thru a great angle. A small fraction of a degree is sufficient. It can be readily understood that we have here to do with a lever action, and if the mirror turns only a minute angular measurement or less, the beam of light that plays on the ground glass will move for quite a distance.

If the diafram vibrates violently, the flat pencil of light will illuminate a square upon the screen which is predetermined by experimentation. If the diafram does not vibrate at all, the light pencil is not visible at all because, as we stated before, the light ray can only be reflected when the narrow mirror begins to vibrate. At rest there can be no reflection of the light ray, because the latter does then not fall upon the mirror at all. The more the mirror vibrates, the wider the light band becomes, as is shown in our separate insert illustration. In other words, if at the sender photo-electric cell number one is fully illuminated, it will send out a strong impulse, which strong impulse is received at the receiving end exactly as if at the present time a broadcasting station was sending out a loud note, you would hear it in the telephone receiver loud. If it was sending a weak note, you would receive it weak in the phones as well. Just so in the author's television scheme. The more light there falls upon the photo-electric cells, the more the tiny mirror in front of the receiver electro-magnet will swing back and forth. Therefore, the entire imaginary small square upon the ground glass will be illuminated.

If, on the other hand, a black object falls upon photo-electric cell number one it will not send out an impulse and for that reason the electro-magnet number one at the receiver will not energize the tiny mirror and, consequently, the square of the unit number one on the ground glass will remain black. It will be seen from this that any shade from either darkest black to lightest white will be transmitted instantaneously.

The entire picture is made up by such impulses and is thus reconstructed upon the screen where we can view any picture, whether it be at rest or animated. In other words, it makes no difference, if we turn the sender on a scene that is at rest, or whether we turn it at a horse race; the effect will be of the same degree of perfection.

There is no doubt that this scheme can be made to work, and we would be very much surprised if television by radio were not an accomplished fact during the next two or three years. The author wishes it distinctly understood that the proposal has not been worked out and exists only in theory so far, but there is no point in it which is not sound, and which cannot be turned into practice today. It is simply a matter of building the device, and making minor improvements as would be found necessary in actual practice. It should also be understood that this idea is not only applicable to radio, but it is possible to use the same instruments on wire lines with equal facility.

This television scheme would then resolve itself into wired wireless with which we are all familiar. One may ask if the voice currents and the radio currents will not mix up and distort the picture at the other end, or even make it impossible to receive it. This, however, is not the case at all, since we can use such widely different lengths of waves as we are already doing today with the Squier wired wireless, where no mixing up ever occurs in a well-balanced outfit.

NOTE.—The television scheme, discussed in this article, is the basis of a patent applica-tion of the author.

Science and Invention for July, 1922

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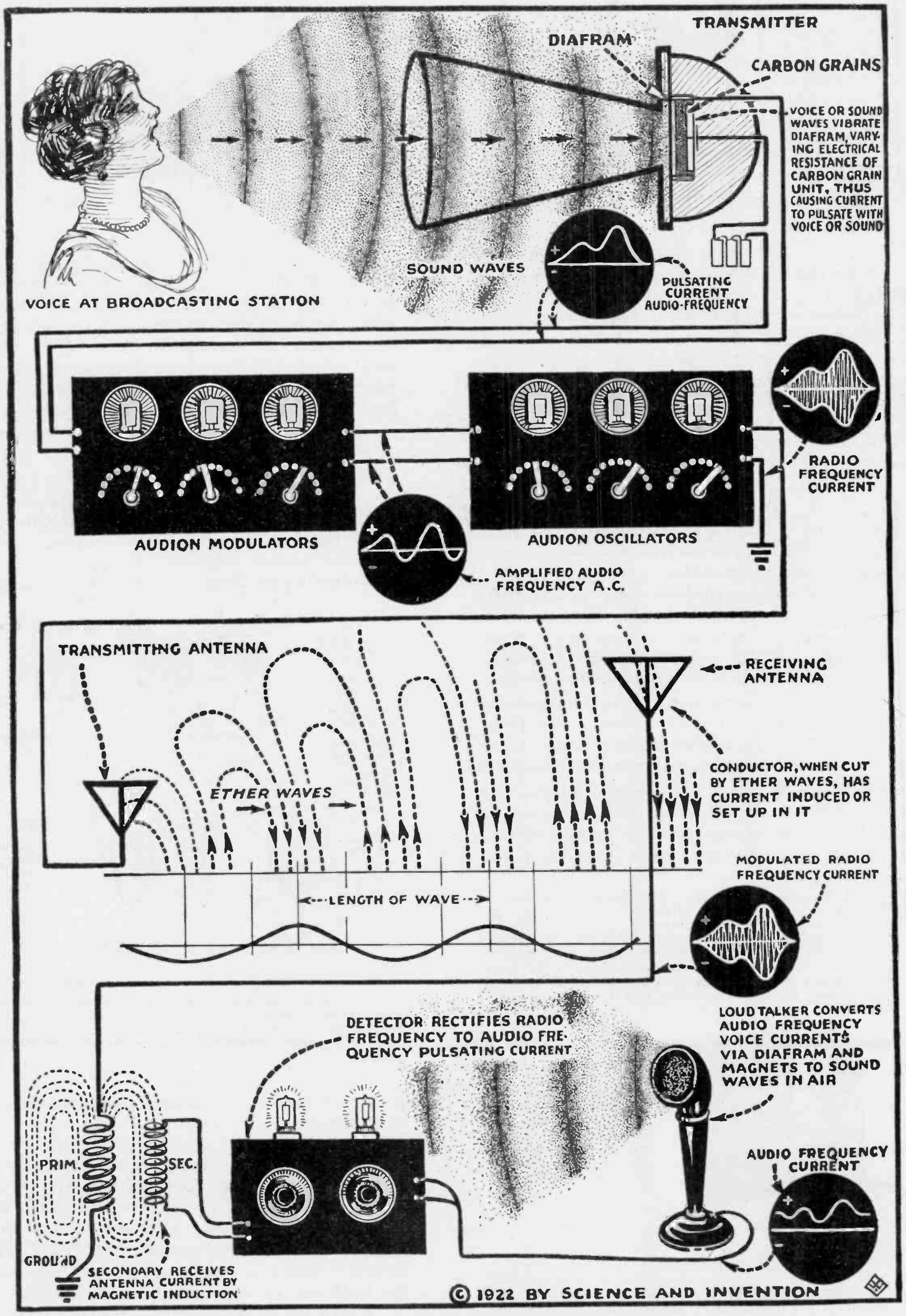
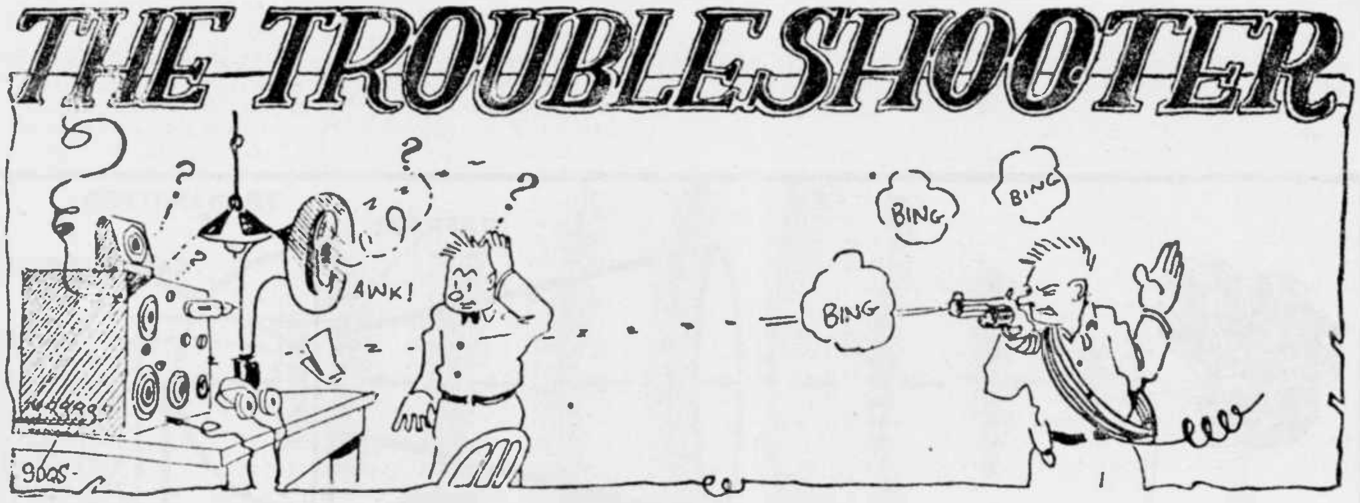


How the Voice Is Transmitted from a Radio Broadcasting Station—Told in Pictures.



26-14. Repair of Loud Speakers.—Loud speakers are among the few audio components that can be repaired successfully. In this respect, there are two types of speakers that must be considered; the *magnetic* and the electro-dynamic (commonly referred to as "*dynamic*"). The former is characterized by the use of a stationary permanent magnet, and a movable iron diaphragm, reed, or armature. The latter is identified by the use of a stationary electromagnet and a movable coil. Even this distinction is not complete, since dynamic loud speakers are also made with a stationary permanent magnet and a movable voice coil. Such speakers are aptly called *permanent-magnet dynamic speakers*, and will be considered as *dynamic* speakers in this book.*

Before discussing the various troubles which may occur in loud speakers, it is well to point out that in many cases where the loud speaker is suspected as a cause of trouble in a receiver, the trouble is really due to something in the receiver proper itself. For this reason, unless the trouble is one that can be traced definitely to the loud speaker at once, no tests or repairs should be made on it until it has been ascertained beyond a doubt that the receiver proper is in perfect operating condition.

A quick way to determine whether it is the loud speaker or the receiver proper that is faulty is to connect a "substitute" speaker in place of the regular speaker and then listen to the reproduction. If it is still unsatisfactory, the trouble undoubtedly lies in the receiver proper, if good reproduction is obtained with the substitute speaker, the regular speaker should be checked for the trouble. An excellent portable "multi-test" speaker designed especially for such substitution purposes is illustrated in Fig. 26-7A.

This speaker is provided with a universal output transformer so that it can be properly matched to all output tubes to give the minimum possible distortion. It also contains a universal voice-coil transformer which has taps that coincide with the values of all the common voice-coil impedances of dynamic speakers. This permits the easy checking of those radio receivers and amplifiers that have the output transformer built into the chassis, and enables checks to be made on output transformers under *actual* operating conditions.

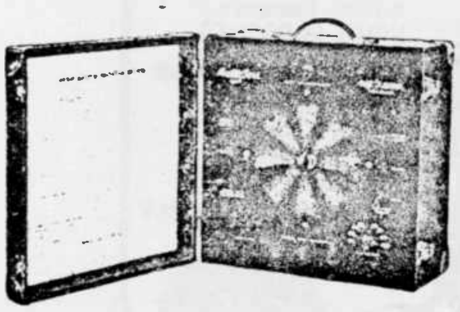


FIG. 26-7A.—A portable "universal test speaker" designed for substitution purposes. It will match all output tubes, all output transformers, and all field coil resistance values. (Model 3000.)

Courtesy Wright-De Coster Inc.

The field coil is also of the "universal type" with taps at resistance values agreeing with all the field resistances used in standard practice—even including a tap for use as a bias resistor in sets which have this feature. No "dummy" field resistance is used—all field resistance taps are taken off directly from the field coil so that the speaker can also be used to check the operation of the filter circuit. It is evident therefore, that this versatile speaker will match all tubes, all output transformers, and all field coil values.

*Note: For a comprehensive discussion of the construction and theory of operation of all types of loud speakers in common use, the reader is referred to the *Radio Physics Course*, by Ghirardi.

Many of the troubles in loud speakers are of the "obscure" type (see Arts. 23-46, 23-47 and 23-48), that is, they are not revealed by the usual voltage, current, or resistance analysis of the receiver, but an experienced service man can spot them instantly by listening to the reproduction. Such troubles as a loose cone apex, improperly centered armature, scraping voice coil, broken spider, etc., cannot be detected by any electrical measuring instruments but they can be detected quickly by the ear.

26-15. Electrical Tests on Horn-Type Magnetic Speakers.—Although the popularity of magnetic speakers has dwindled greatly and they have not been employed in recent receivers to any extent, many thousands of them are still in use in old receivers. Service men are often called upon to service them. There are two general types of magnetic speakers used with radio receivers. The first is the type which employs a diaphragm and a horn; the second is the type which employs an iron

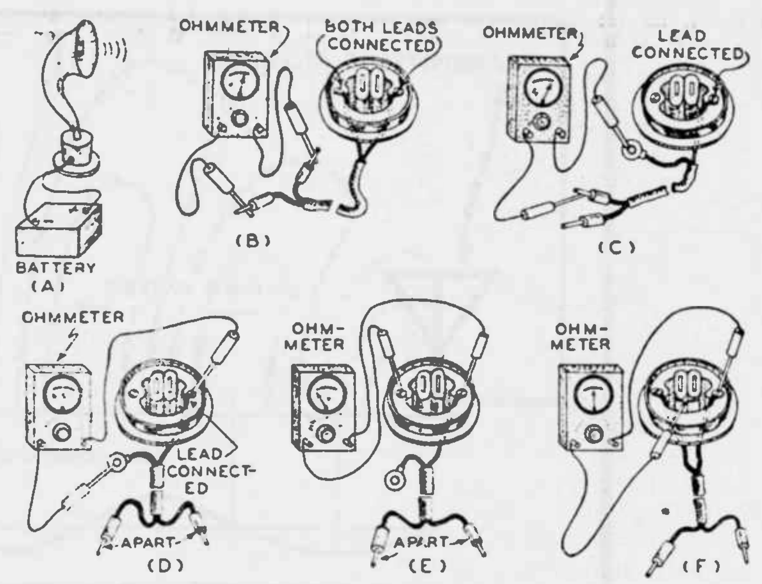


FIG. 26-8.—Various electrical tests which should be made on a magnetic loud speaker of either the *iron-diaphragm* or *balanced armature* type in order to locate electrical trouble in either the speaker cord or the coils. These tests are described in detail in the accompanying text.

reed or armature actuating a cone. Both types will be considered, separately, here.

Horn-type magnetic speakers are no longer in general use in radio receivers, and, where they are encountered with major troubles, it is usually best to replace them with one of the magnetic cone speakers which can now be obtained at low cost. However, the service man often encounters large horn-type speakers employing iron-diaphragm type units in public-address systems of small size. At any rate, it is well to know how to test and repair this type of speaker if the occasion arises.

A quick test to determine if the speaker operates at all may be made by simply touching the cord tips of the speaker across some source of low voltage as shown at (*A*) of Fig. 26-8. A *sharp* "click" should be heard each time this is done, if the speaker operates. If only a slight click is heard, the winding may be open, for a small current can flow due to the capacity between the two parts of the winding (which consists of many turns of fine wire).

If the speaker does not operate at all, the trouble is most likely an electrical one in either the speaker cord or the coils.

The cord should be tested first. Test for continuity across the tips of the speaker cord, as shown at (*B*). A constant deflection of the ohmmeter needle should result if the speaker winding is good. Bend the loud speaker cord back and forth at the tips; if the meter reader varies, it indicates a faulty connection at the tips. The connection should either be resoldered or, better still, the entire cord should be replaced with a new one. If no reading is obtained on the first test, open the case of the unit and remove the diaphragm and washers. Then remove one lead of the cord from the speaker unit. The ohmmeter should indicate a complete circuit from one of the cord tips to one of the lugs at the speaker end of the cord, as shown at (*C*). Repeat this test from the second tip to the second lug.

With one lug still disconnected from the unit, test for continuity across both lugs at the speaker end of the cord as at (*D*), making sure that the tips on the other end of the speaker cord are not touching each other. No complete circuit should be indicated; if a complete circuit is indicated, it shows that the two cord leads are shorted inside the covering. With one speaker cord lug still disconnected from the unit, test both unit terminals for continuity, as

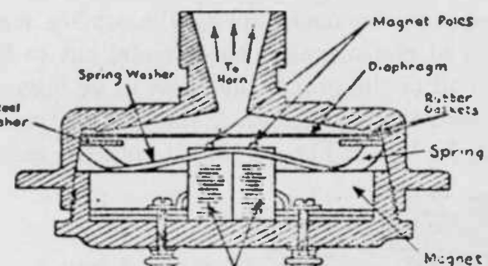
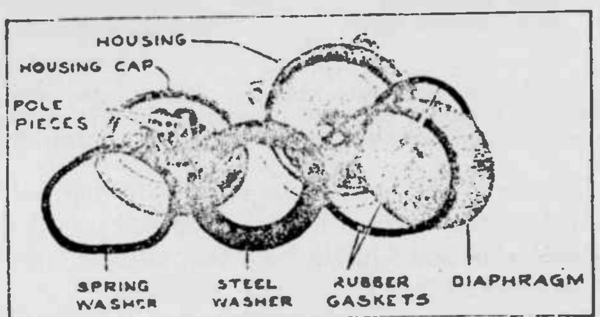


FIG. 26-9. — Cross-section view of a typical horn-type iron-diaphragm loud speaker unit, showing the relative arrangement of its parts. A disassembled unit of this kind is illustrated in Fig. 26-10.

shown at (*E*). An "open" indication obtained here points to an open circuit somewhere in one of the magnet coils, or possibly in the leads to the terminals on the unit. These leads should be inspected carefully, for the thin wire often breaks, or corrodes away at the soldered joint. A break here can easily be resoldered. If resoldering is necessary, be careful to scrape away the enamel insulation and use rosin-core solder *only*. Never use "acid" or soldering paste fluxes as they will corrode the fine wire. If the ohmmeter shows a continuous circuit when the coil test is made, but shows that the coil resistance is extremely low, there is a "short" or "ground" within either or both of the coils. The next test will indicate which one is faulty.

As shown at (*F*), *each winding* should now be tested *separately* between its terminals, and between each terminal and the case of the unit. If a winding is found to have an internal short, open, or



Courtesy Atwater Kent Radio Co.

FIG. 26-10.—A typical iron-diaphragm type loud speaker unit disassembled to show its various parts.

ground, it should be replaced. Each winding should have approximately the same resistance.

This completes all the electrical tests that may be made on magnetic units. As we shall see in Art. 26-17, precisely the same electrical tests may be made on magnetic speakers of the balanced armature type. Any other troubles will be of a mechanical nature.

26-16. Repair of Horn-Type Magnetic Speakers.—As has already been explained, horn-type magnetic speakers should be repaired only when the troubles are of a minor nature or when the owner insists on such repairs being made. Major repairs involving the removal of one or both of the coil bobbins, etc., usually take considerable time and require skill and patience. The parts of such speakers are delicate and crowded close together.

Replacement with one of the balanced-armature cone type speakers which are now available at extremely low cost will usually be much less costly and give more satisfactory performance. However, if the faulty speaker must be repaired, the service man will have to do the work. A brief description of some of the mechanical service problems which may be encountered now follows.

A cross-section view of a typical horn speaker unit of the balanced-armature type is shown in Fig. 26-9. A speaker unit of this type with the parts disassembled is illustrated in Fig. 26-10. It consists, essentially, of a case, two magnet coils mounted over the pole pieces of a permanent magnet, and a diaphragm suspended between rubber gaskets and a steel washer. The diaphragm is held in the upward position by a wavy spring washer, which is shown at the extreme left in Fig. 26-10. Of course, not all units are constructed exactly as shown here, but the illustration is typical of the majority of them, and the following service notes will, in general, hold for all types.

Iron filings or other foreign matter may collect on the pole pieces and cause rattling and low volume. The filings around the sides may be removed with a pocket knife by working outward and upward from between the pole pieces. Those filings on top of the pole pieces may be removed by simply wiping them off with a clean cloth. The thin varnish-like coating on the pole pieces is used to prevent the formation of rust. This coating often peels, so that it is necessary from time to time to remove the small flakes of it that collect on and about the pole pieces. Rubbing some light mineral oil on the pole pieces will assist in preventing the future formation of rust.

The spring which may loosen its tension and produce insufficient pressure against the diaphragm, causing rattling on high volume, may be replaced, or all of the bends may be heightened by hand to supply the desired pressure. It is important here to be certain that all bends have exactly the same height. A simple test is to place the spring on a flat table and place the diaphragm on top of it. A small level may then be placed on top of the diaphragm. The bends may then be adjusted for equal heights. It is wise to test the level of the table before bending the spring.

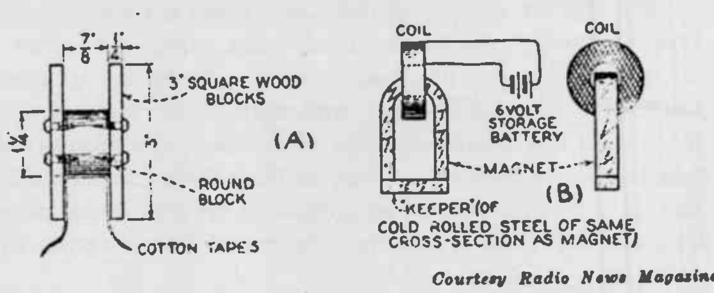
The rubber gaskets are used to damp the vibration of the diaphragm at its natural frequency. They may dry out and lose their elasticity after some use. This condition will manifest itself by rattling at some particular frequency, and by poor tone quality. The remedy, of course, is to replace the gaskets with new ones of live rubber, as they cannot be repaired.

The diaphragm may be bent, buckled or dented. If this occurs, it should be replaced. In many cases, the underside of the diaphragm has rusted, the rust clogging the small air gap between the diaphragm and the pole pieces. Unless the diaphragm is replaced in such cases, the rust spots should be cleaned thoroughly, and a coat of thin lacquer or varnish applied to protect the metal.

Weak magnets give rise to weak and "tinny" reproduction. While more elaborate tests may be made, service men usually test permanent magnets for strength by touching the magnet face or the pole pieces with a screw driver. A tenacious "pull" should be felt. Of course, experience teaches how much pull to expect for strong magnets and for weak magnets, since the size of the magnet should also be considered. If there is only a weak pull, or none at all, the permanent magnet is demagnetized and should be either replaced, or removed from the unit and remagnetized by the method described in Art. 26-18.

26-17. Electrical Tests on Balanced-Armature Magnetic Speakers.—The electrical tests to be made on balanced-armature type magnetic speaker units of either the cone or horn type are precisely the same as those outlined in Art. 26-15, and illustrated in Fig. 26-8, for iron-diaphragm type speakers. First the cords, and then the coils are tested for continuity, shorts, and grounds by means of an ohmmeter. Any electrical troubles revealed by these tests should be eliminated either by repair or replacement of the part in question. The service man should keep in mind what has already been said in Art. 26-15 about the advisability of making major repairs on these speakers.

26-18. Remagnetizing Permanent Magnets. — If the magnet test described in the last paragraph of Art. 26-16 reveals the



Courtesy Radio News Magazine

FIG. 26-11.—Construction details of a coil which may be used to remagnetize the permanent magnets of loud-speakers and phonograph pickups. The winding form for the coil is shown at (*A*). The method of magnetizing is shown at (*B*).

permanent magnet of a magnetic-type loudspeaker, or a phonograph pickup unit, to be weak, it should be remagnetized. Magneto and automobile ignition service stations are equipped to remagnetize permanent magnets quickly and at small cost. However, if the service man desires to do this work himself, the simple arrangement of Fig. 26-11 may be employed.

The magnetizing coil should be constructed first. A form on which the coil is to be wound must be made. The details of this form are shown in (*A*) of the figure. Note that the sides of the form are attached to the core of round wood by means of wood screws; this is quite essential, as the form is to be taken apart after the coil is wound. After the form is made, two layers of wrapping paper are wound over the core; then several strips of cotton tape are placed in the trough of the form, at intervals around it, as shown at (*A*), and spot-glued to the sides with a little mucilage to keep them in place while winding the coil. Now wind 196 turns of No. 16 d.c.c. wire in 14 layers of 14 turns per layer; this requires one pound of wire. After winding, the cotton tape is bent over the top of the coil to hold the turns in place. The end pieces of the form are then removed and the core slipped from the center of the coil. If desired, additional tape may be wound over the coil to hold the turns of wire in place, although impregnating the coil with paraffin or pitch will help it to withstand rough usage.

The magnet to be remagnetized is then slipped through the opening in the coil and a "keeper" of cold-rolled steel is placed across the terminals, as shown at (*B*). The coil terminals are then connected to a 6-volt storage battery for a few moments (the magnetizing process is *almost instantaneous*). The drain on the battery is about 12 amperes, which is well within the limits of an ordinary battery used for automobile starting The battery should be well charged! The magnet should be struck a few sharp blows with a small hammer while the current is turned on. This will aid the molecules to rearrange themselves to produce the magnetized condition. The coil is then disconnected, removed from the magnet, and the job is finished. This magnetizing coil is adequate to saturate all types of small permanent magnets including those of earphones, magnetic speakers, phonograph pickups, etc. The coil may be placed at any position on either leg of the magnet if necessary; it is not essential that it be placed at the bend as shown at (*B*). Permanent magnets should never be allowed to lie around unless a soft iron keeper (which may be an ordinary large iron nail) is placed across the poles.

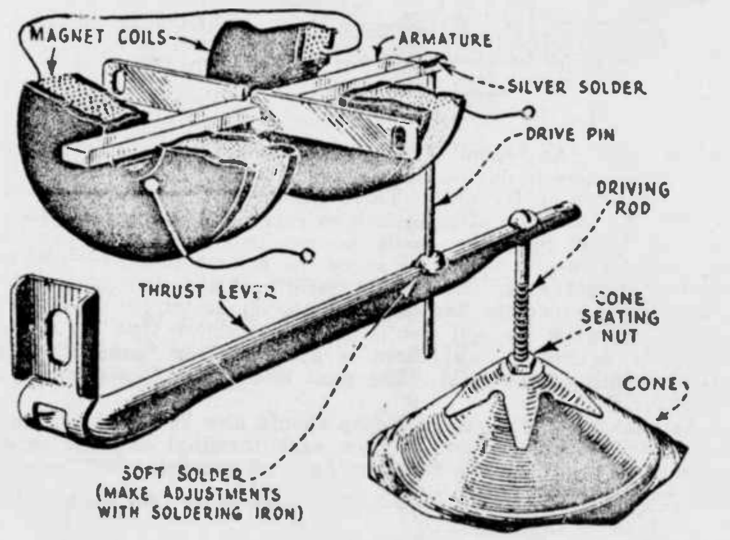
26-19. Repair of Balanced-Armature Type Magnetic Speakers.—Figure 26-12 shows a cut-away view revealing the construction details of the typical form of motor unit employed in magnetic speakers of the *balanced-armature* type. The permanent magnet and its pole pieces have been omitted purposely as they would make it impossible to see the coils and the armature. These parts may be seen in the illustration at the right of Fig. 26-13. Two magnet coils containing many turns of fine enamel-covered wire are wound over an armature which is pivoted between the pole pieces of a horseshoe-shaped permanent magnet, as shown in Figs. 26-12 and 26-13. The armature connects to the thrust lever (Fig. 26-12) through a drive pin, and the thrust lever actuates the cone of the speaker through the driving rod.

The trouble symptoms that may arise in balanced-armature type magnetic cone speakers are weak reproduction, no reproduction, distortion, noise and rattle. There are a number of causes for these symptoms, and each cause may give rise to more than one symptom. For this reason, the troubles will be listed and considered according to their causes and remedies. A summary of the common symptoms of trouble which develop in balanced-armature type cone speakers, and their causes follows:

1. No operation:
   (a) open cord
   (b) faulty tip terminal joints
   (c) open coil
   (d) open coil leads to terminals
2. Weak operation:
   (a) weak magnet
   (b) shorted coil (partial or complete)
   (c) grounded coil
3. Noisy operation:
   (a) frayed cord
   (b) internal defect in cord
   (c) poor joints at cord tips
4. Distortion or rattle:
   (a) armature striking pole pieces
   (b) sticking armature
   (c) foreign matter interfering with armature action
   (d) torn or otherwise damaged cone
   (e) improperly seated cone
   (f) loose thrust lever
   (g) bent drive pin
   (h) loose or bent drive rod

The first three trouble symptoms have already been considered in Arts. 26-15, 26-16 and 26-18. The troubles which may cause the last one, and the remedies for them will now be considered.

26-20. Recentering the Armature of a Balanced-Armature Speaker Unit.—If the armature is not centered correctly between the pole pieces, a very disagreeable rattle and distortion may result on loud notes. The space between the armature and each pole piece is different in different makes of speakers but the average is about 0.1-inch. If the armature is misaligned, it may be realigned by the following method. Two similar spacer tools are required, and may be made up by the service man. They are simply pieces of non-magnetic sheet metal cut to the proper size and shape and of the proper thickness to be inserted between the armature and the pole pieces. A sketch of a typical spacer tool is shown at the left of Fig. 26-13. It consists, essentially, of a strip of phosphor bronze or brass having a thickness equal to the spacing between the armature and pole pieces and about ¼-inch wide and 6 inches long, bent into the form shown. The ends should be tapered to a width of ⅛-inch.



Courtesy R.C.A. Victor

FIG. 26-12.—Cut-away view showing the essential components in the motor of a typical balanced-armature type loud speaker unit. The permanent magnet and pole pieces have been omitted for clarity.

Two of these tools are necessary when adjusting the armature. Insert the prongs of one tool in the spaces between the armature and pole pieces at one end of the unit, as shown at the right of Fig. 26-13. The other tool should be placed in similar position at the other end of the armature—a little to one side in the case in order to clear the drive pin which is located at this end. By loosening screws (*A*) and (*B*), any tension in either direction that may have been on the armature is released, and the spacer tools will provide the correct clearance or spacing. Now while the spacer tools are in place, a hot soldering iron is applied to the drive pin—thrust lever connection point (see Fig. 26-12), and the solder is heated sufficiently to allow the drive pin to find its normal position with regard to the thrust lever. (Since the solder used at this joint has a low-melting point very little heat is necessary.) The iron is now removed. Screws (*A*) and (*B*) are now tightened and the spacer tools are removed.

The armature is now correctly aligned and balanced so that no abnormal strain is being imposed upon it in any direction, and it is correctly centered between the pole pieces so rattling should not occur on normal signal volume.

26-21. Freeing a Sticking Armature.—Very often the armature of a balanced armature speaker is found to be sticking (by magnetic attraction) to the face of one of the pole pieces at either end. The repair in such instances is the same as for the incorrectly centered condition of Art. 26-20. The assembly must be loosened and the armature spaced properly with spacers. Be certain that all screws are tight, as a sticking armature may be caused by one or more of the tension screws working loose because of vibration and allowing the armature to sag to one side.

26-22. Removing Foreign Material from the Air Gap. — Foreign matter lodged between the armature and pole pieces is a frequent cause of trouble. This interferes with the movement of the armature, resulting in poor reproduction. A visual in-

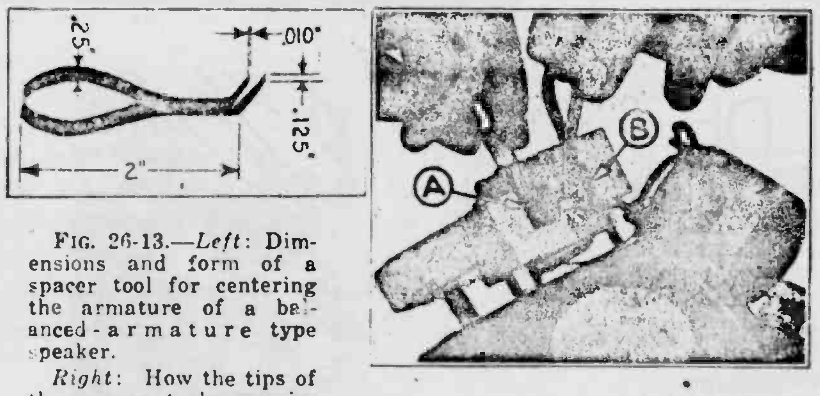


FIG. 26-13.—*Left*: Dimensions and form of a spacer tool for centering the armature of a balanced-armature type speaker.
Right: How the tips of the spacer tools are inserted (one at each end of the armature) so that the armature is held in a centered position between the pole pieces.

Courtesy R.C.A. Victor

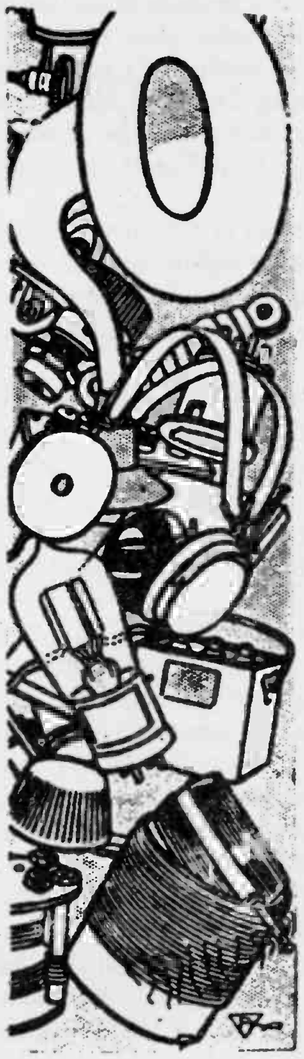
spection will reveal this condition. This foreign matter may consist of dirt and dust, small pieces of iron filings and peelings from the coating on the armature. The armatures of loud speakers are usually given a protective coating to prevent the formation of rust. In time, especially if the motor temperature becomes high, this coating has a tendency to peel, and the small flakes lodge between the armature and the pole pieces. This is the equivalent of reducing the armature spacing, with the result that the armature motion is reduced and the output is weakened and distorted. This foreign matter is best removed by working small strips of heavy paper or strips of thin copper or brass back and forth between the armature and pole pieces. Every time the paper or metal is removed, clean it off before reinserting. The spacer tools already described may also be used for this purpose. In many instances, recentering of the armature is necessary after cleaning. It is also a good idea to rub some light mineral oil over the armature to prevent the formation of rust after peeling has occurred.

26-23. Repairing the Cones of Magnetic Speakers.—Very often, the paper cone is damaged sufficiently to cause distortion or paper rattle, but not enough to make its replacement necessary. Small holes or tears in the paper may be repaired by cementing a small piece of paper over them, using Du Pont Household Cement, rubber cement, etc. Opened seams may be repaired by coating both surfaces with cement and holding them tightly together until the cement sets.

If a cone has lost its "body" or stiffness at the apex, Dupont Household Cement, or a collodion solution (which may be purchased at any drug store) should be soaked into it and allowed to harden. This will stiffen the paper and make it as good as new.

26-24. Replacing and Seating Cones.—An improperly seated cone will cause a strain to be put on the driving rod, resulting in poor reproduction. This is very likely to occur when replacing a cone. If a cone is to be replaced, extreme care should be exercised in its removal and in the installation of the new one. The screw or nut in the apex of the cone should be removed carefully, after first removing any sealing wax which may have been used to prevent it from loosening. The screws fastening the edge of the cone should be removed next.

If the speaker has a nut on the side of the cone near the thrust lever, it should be loosened (the nut screwed back) and the new cone seated. The nut or screw and washer on the outside of the driving rod should then be attached loosely. The holes at the edge of the cone should now be lined up with those of the metal frame, the outside ring put in place with the screws, and tightened one at a time (and a little at a time) to be sure that the entire periphery of the cone has the same tension. The back nut on the driving rod (if there is one) should then be screwed up until it just meets the apex of the cone. The front nut or screw is then tightened and a bit of sealing wax is placed



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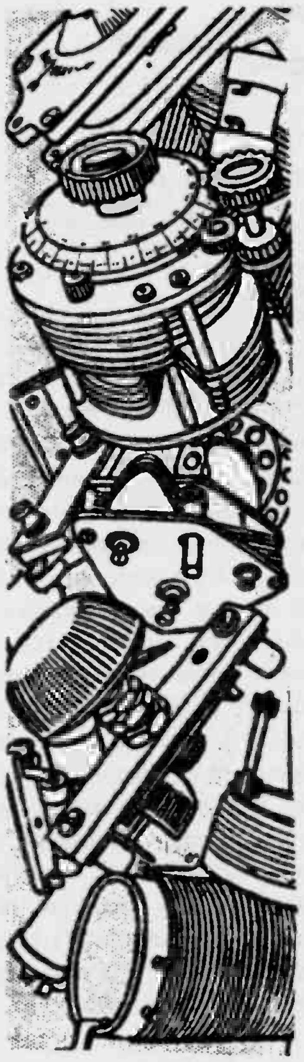

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over it to prevent the vibration from loosening it, for, if it loosens, considerable buzzing and rattling will result.

26-25. Tightening the Thrust Lever and Driving Rod.—Rattling and noisy reception are often caused by a loose thrust lever, see Fig. 26-12. The remedy for this is simply to tighten the screw that holds it to the motor assembly. Any loose screw or nut will cause an audible rattle when the speaker operates. Be certain that all parts are thoroughly secure, that all screws and nuts are tight, and that the cone is properly seated. A cone that is not properly seated may cause the drive pin to bend and displace the armature. It is best, therefore, to inspect the entire assembly before actually beginning to center the armature, if it appears to be displaced from its center position.

The drive pin is soldered to the iron armature with (hard) silver solder (see Fig. 26-12). Do not use the ordinary tin-lead alloy (soft) solder when this connection must be resoldered, as it is too weak mechanically. Silver solder may be procured in any jewelry store, and must be applied with a flame of high temperature. A special small blow torch is usually used for this work.

26-26. Dynamic Loud Speakers.—By far the most commonly used type of loud speaker, and the type which the service man is called upon to service most frequently, is the *dynamic* or moving coil speaker. In this type, the magnetic excitation of the field is secured usually by the use of an *electromagnet* instead of a permanent magnet, and motion is secured by the interaction of this magnetic field and that of the *voice coil* through which the audio signal currents flow. The internal arrangement of the various parts of a typical dynamic speaker are shown in Fig. 26-13. Common trouble symptoms which develop in this type of speaker are:

1. Weak, or no reproduction
2. Rattling
3. Chattering
4. Harshness
5. Fuzzy reproduction
6. Hum

These troubles and their remedies will now be considered in detail. The first thing to do in any case is to make electrical tests on all the electrical parts of the speaker, especially if *weak* or *no reproduction* is obtained.

26-27. Electrical Tests on Dynamic Speaker Cable.—If it is definitely established that the loud speaker is faulty, the wires of the speaker cable should be tested first, for continuity and short circuits (see Art. 26-15). (For an explanation of the standard RMA Color Codes for dynamic loudspeaker cables, see the RMA Standard Color Code section in the author's *Radio Trouble-Shooter's Handbook*). The cable will contain two wires leading to the field coil (three wires if the field is tapped) and two or three wire leading to the primary of the output transformer (depending upon whether single, or push-pull output tubes are employed). Continuity and resistance tests must be made across paired leads, i.e., across the two or three leads going to the field coil, across the leads going to the output transformer primary, etc. If the cable leads are found to be in good condition, it is fairly certain that the trouble lies somewhere in the speaker itself.

26-28. Trouble in the Dynamic Speaker Field Coil.—If the speaker cable tests O.K. and it has been definitely decided that the trouble lies in the speaker, the field winding should be tested for continuity and grounds at once. If it is found to be open, it should be replaced or rewound. When a replacement cannot be made, the amount of wire to be rewound may be determined as follows: Remove the faulty coil intact from the core of the unit and strip all tape and other binders from it, only the actual wire coil should be left. The size of wire employed may now be determined with a wire gauge and the type of insulation noted. The field coil is then weighed. Purchase the same weight and size of wire with the same type of insulation, and rewind the coil. A winding form should be made for this purpose, and removed after the coil is completed. The details of the winding form are somewhat the same as for the magnetizing coil form illustrated at (*A*) of Fig. 26-11.

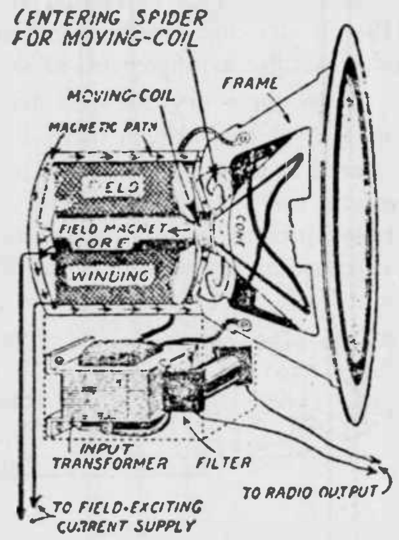

FIG. 26-13.—A cross-section view of a typical dynamic speaker with the field shown cut open to illustrate the arrangement of the field coil, field core, moving coil, cone and frame. The input transformer and high note filter (if one is used) are shown at the bottom.

If the continuity test indicates that the field has a definite value of resistance, this value should be checked with information (usually available in Service Manuals) for the particular receiver and speaker in question. If the resistance is over 10 per cent *less* than the rated value, it is possible that a partial short-circuit exists in it. In this case, the coil should also be rewound or replaced. A resistance reading much higher than the rated resistance indicates a high-resistance contact at a soldered connection.

If the field coil tests satisfactory, turn the set on and hold a screw driver as near to the pole piece as possible (how near the screw driver can be placed depends upon the design of the speaker). The screw-driver should be attracted strongly to it. If it is not, the current flowing through the field coil is less than normal. The next step depends upon the arrangement employed for obtaining the field current. If the speaker field is employed as a choke in the *B* filter system of the receiver, it is possible that one or more of the filter condensers are leaky, placing an additional load on the rectifier, and robbing the speaker field of some of its energizing current. Of course, such condensers should be replaced. If the speaker contains its own rectifier of the dry-disc or vacuum-tube type, it is possible that this rectifier needs replacement, or the filter condenser (if one is used) across it is leaky and should be replaced.

26-29. Troubles in Dry-Disc Rectifier Type Field Supply Arrangements.—In order to trace trouble in the field coil circuits of dynamic speakers, it is important to be familiar with the various common field supply arrangements which are employed,

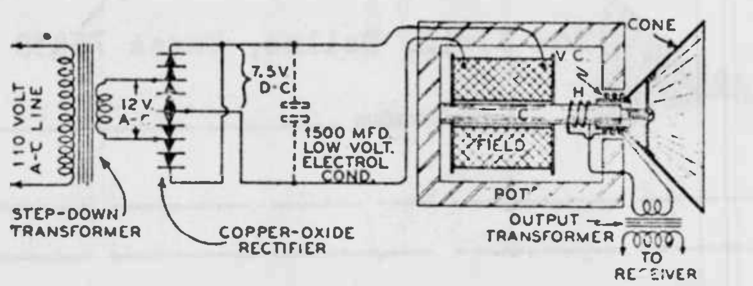

FIG. 26-14.—One arrangement for supplying low-voltage rectified current from the 110-volt a-c line for energizing the field of a dynamic speaker. A step-down transformer and low-voltage type copper-oxide rectifier are used. A "hum-bucking" coil *H* reduces the line hum.

for some troubles are traceable directly to this portion of the speaker or receiver.

In the earlier types of a-c dynamic speakers employed in radio receivers, the d-c field current is obtained from the 110-volt a-c line by feeding the a-c to a step-down transformer whose low-voltage secondary is connected to a copper-oxide full-wave rectifier which changes the a-c to full-wave rectified d-c. This d-c is fed to the speaker field, which in this case is a low-voltage type field composed of fairly thick wire. This arrangement is shown in Fig. 26-14. In some cases, the current is smoothed by a low-voltage type dry electrolytic condenser of about 1,500 mfd. capacity connected directly across the rectifier output as shown by the dotted lines. The hum-bucking coil which is shown in place on this speaker will be explained later.

In some a-c dynamic speakers the circuit arrangement shown in Fig. 26-15 is employed for obtaining field current. A field coil requiring slightly less than 110 volts d-c for its operation is employed. This energizing voltage is supplied by a pair of 110-volt dry-disc rectifiers suitably connected to form a full-wave rectifier arrangement, as shown.

When these dry-disc rectifiers have completed their useful life, the current through them diminishes and the units must be replaced in order to secure the proper and original speaker field current and magnetic strength. A certain amount of hum is always present in these speakers, but faulty rectifier "stacks" will cause an abnormal amount of hum to be heard. Breaking

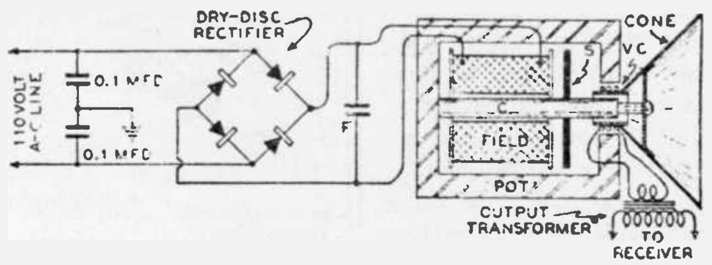

FIG. 26-15.—A high-voltage type dry-disc rectifier arrangement for rectifying the a-c voltage from the line so that d-c may be supplied to the speaker field. A "shading" ring *S* is used to prevent line hum.

down of the rectifier in the speaker of Fig. 26-14 will overload the step-down transformer—which may eventually cause either the primary or secondary winding to burn out. In the speakers employing 110-volt dry-disc rectifiers (Fig. 26-15) partial short-circuiting of the rectifier discs will often cause the line fuse to blow. In this type of speaker, the condition of the rectifier stacks may be checked by measuring the d-c resistance of each section with an ohmmeter (with the line and field disconnected), or by measuring the d-c voltage output of the rectifiers with the field coil disconnected. The latter test should give a reading of approximately 105 to 120 volts; this reading dropping to some value between 90 and 100 volts as soon as the field is reconnected (since it puts a load on the rectifier).

26-30. Troubles in V.T. Rectifier Type Field Supply Arrangements.—In some dynamic speakers, a self-contained vacuum tube rectifier arrangement is employed to change the 110-volt a-c line current to d-c current for the field coil supply. This arrangement, shown in Fig. 26-16, consists of a power transformer feeding into a full wave rectifier tube in the usual manner. The output current of the rectifier is filtered by the filter condenser, *F*, and the inductance of the speaker field winding through which it flows. Of course, when the rectifier tube has served its useful life, its output will diminish. This will cause the speaker field strength to diminish, with resulting weak and distorted reproduction. Obviously, the remedy lies in replacing the rectifier tube.

* The above service information from MODERN RADIO SERVICING by Alfred A. Ghirardi, 1935 is scheduled to be continued next month.

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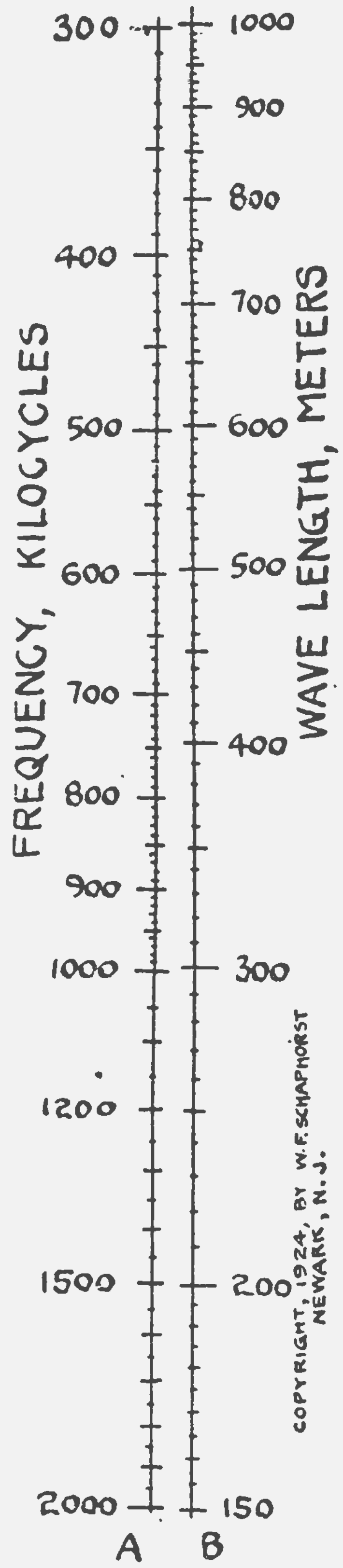

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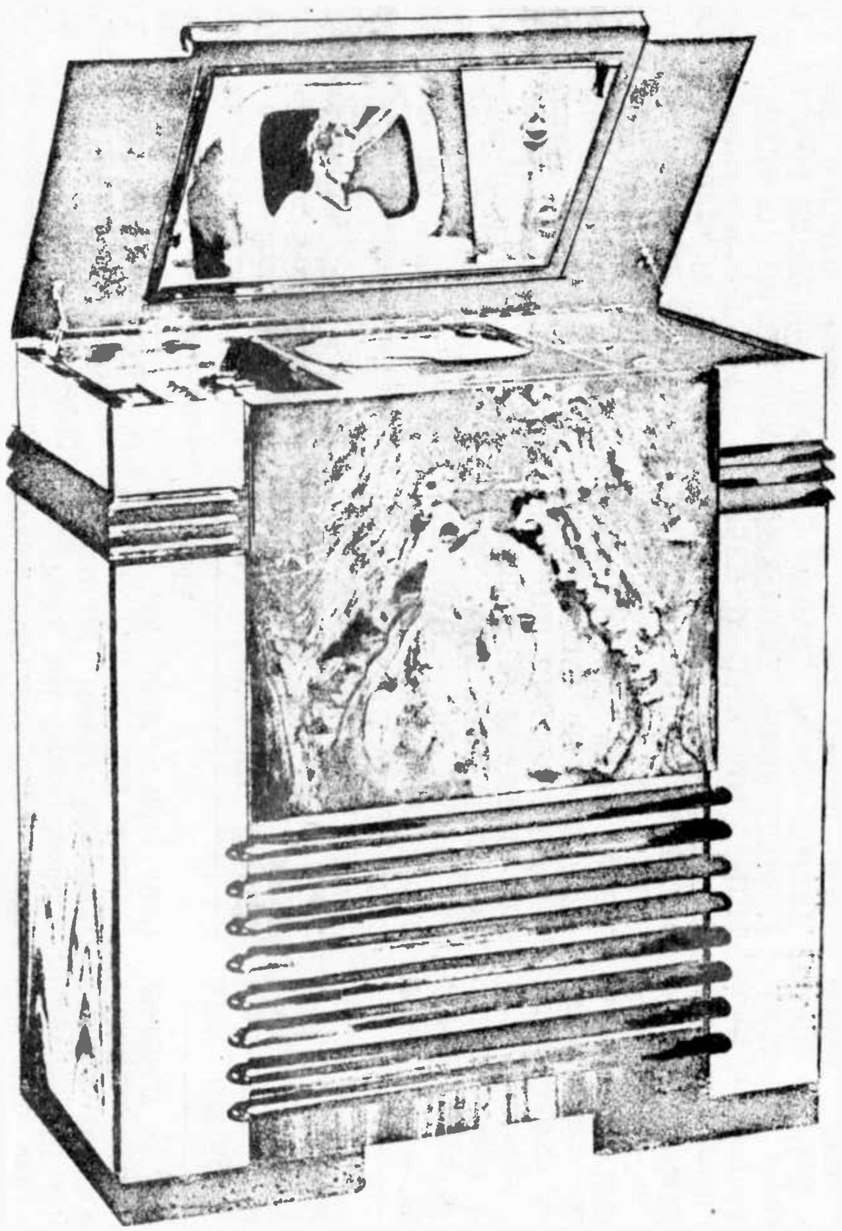

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