Building a 36-Inch Cone Speaker

A Large Cone Capable of Reproducing Notes of Very Low Frequency

By WARREN T. MITHOFF

IT is with pleasure that we present to our readers this excellent constructional article on a three-foot cone loud speaker. There is no doubt that cone speakers of this size are among the leaders in reproduction of radio broadcast programs, and they are not as difficult to construct as might be thought. The parts for the one described below are inexpensive and easily obtained, and the results from this speaker should satisfy the most critical listener.—EDITOR.

THE broadcast-listener branch of the happy radio family is divided into two major classifications: first, those individuals who go to the store and order their receiving sets installed complete and who are content forever thereafter to pull the switch, turn the dials and listen, whether the resulting music is good, bad, or indifferent; and secondly, the vast group whose inquiring minds delve into all the seeming mysteries of grid leaks, space-wound solenoids, oscillation controls, and the thousand and one other fascinating items that comprise the modern receiving set.

It is safe to say without qualification that every man, woman, and child of this latter group has, at one time or another, stood gazing with fond desire at the smooth brown expanse of a 36-inch cone speaker as it stood in haughty solitude in a store window. Whether or not this fond desire was translated into action, and the cone carried in triumph to the gazer's cosy hearthside, depended solely upon the state of his bank balance.

The writer is one whose radio budget, having suffered ravages from a severe case of superheterodyne construction, would not permit of such gross extravagance just at the time the urge hit him. These 36-inch cones do cost real money, but they are worth every nickel of it, if we judge by results. The only alternative, then, was to build the much-coveted cone. Now there are on the market kits of parts for just this purpose; but the great ambition was to build out of such parts as the junk box afforded.

With this in mind work was started.

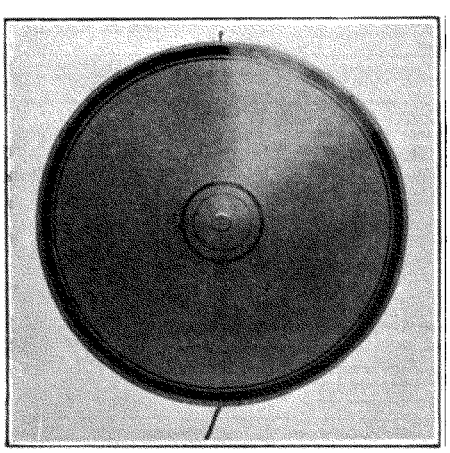
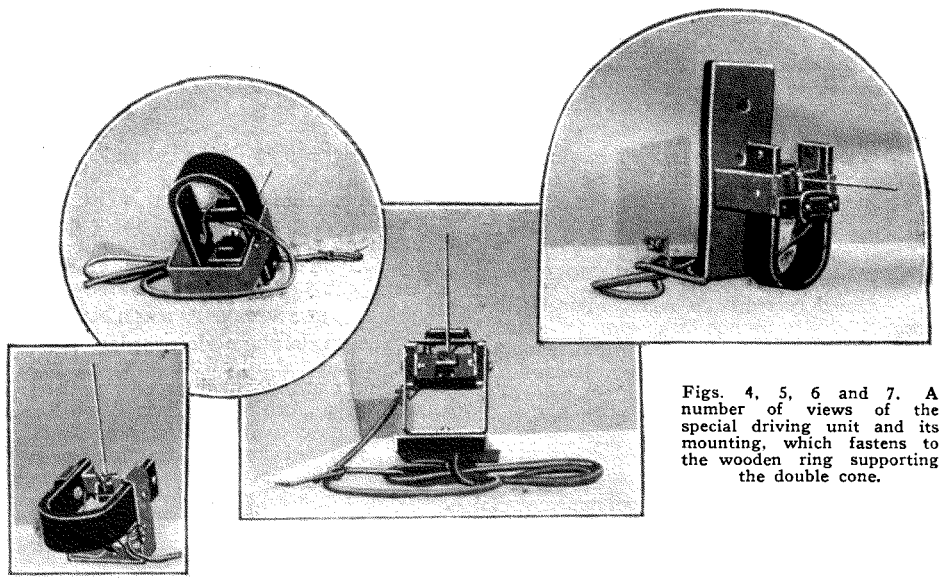


Fig. 1. From the front, the cone presents a very pleasing appearance; and if the constructor is handy with colors it can be made a thing of beauty.



Figs. 4, 5, 6 and 7. A number of views of the special driving unit and its mounting, which fastens to the wooden ring supporting the double cone.

After several months of experimenting an arrangement was found which stood the test; yet the cost was under ten dollars, even with the full market price put upon the junk-box parts.

The only requisites for success along this line are the materials, a little patience and care—virtues possessed by every true experimenter—and a good audio amplifier. The amplifier, of course, is important, as a cone speaker will show up distortion entirely passed over by the usual type of horn.

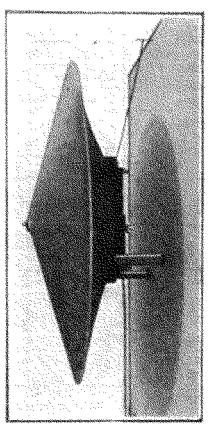


Fig. 2. This shows the manner in which the rear cone is joined to the wooden ring with sealing wax; also the manner of affixing legs, for use in hanging the cone on the wall.

SELECTION OF PARTS

To start with, certain materials and parts are needed, first in importance being the driving unit. A Baldwin "Type C" is first rate; either the phonograph attachment or one of a pair of earphones. One is being used by the writer with great success, and this article is being prepared with the Baldwin unit in mind. Dimensions and instruction are given accordingly; although the same general procedure can be followed with any unit which has the balanced-armature type of construction. Units which have the thin iron diaphragm supported above the coils will not do for this cone, as they are inclined to rattle, and do not have sufficient power.

A large permanent horseshoe magnet is also needed, and can usually be obtained from one of the firms which make a business of scrapping worn-out automobiles and trucks. The magnet required is the kind found on truck magnetos, 3⅜ inches across the legs, 6 inches long, and made of ⅜ x 1⅝-inch steel. These dimensions are used in this article and the accompanying drawings, and if a magnet of different size is obtained, allowance must be made accordingly. Most of these magnets are already provided with two drill holes on each leg, to pass ¼-inch machine screws.

The only other major item needed for the speaker is the paper from which to make the cone itself. The very best thing to use here is Alhambra "Low Frequency" paper; as its structure is such that it is not resonant to any particular frequency of its own, but reproduces all frequencies with good uniformity. Other papers can be used with greater or less success, depending on their nature. For example, lampshade parchment, which comes 36 inches wide, is highly satisfactory in actual practice, if not in theory; and it can be stained a rich brown with walnut-wood stain, and decorated with oil paints to suit the constructor's fancy. Some papers used for covers for catalogs and books can also be used, such as Castilian cover, heavy weight; a good printer can suggest something for the purpose. One trouble with the cover stocks is that gen-

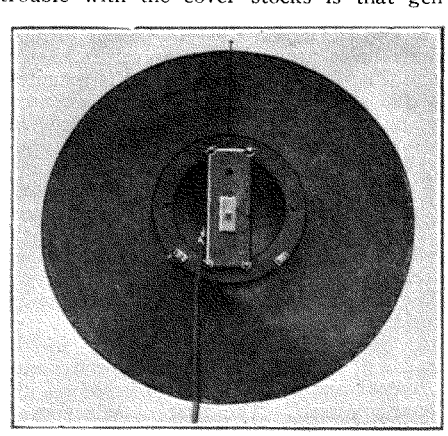


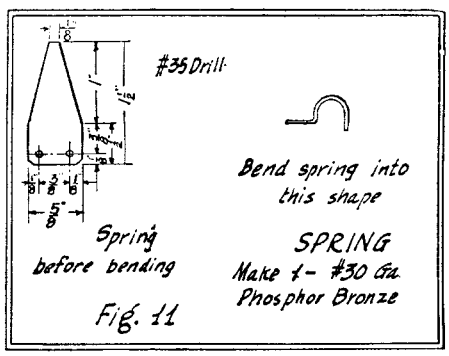
Fig. 3. Showing how the two cones are joined together with sealing wax or glue, and how the cross piece fits across the wooden ring.

erally the largest sheets obtainable are 23 x 33 inches, so they would have to be pieced out to make a 36-inch cone.

Some odds and ends are needed, of course, such as 6 inches of ⅛ x 1½-inch cold rolled steel; 12 inches of strip brass the same size; some No. 30 gauge sheet copper or brass, No. 30 gauge phosphor bronze, and ¼-inch, round brass rod. Machine screws in four sizes are used: ¼-inch, No. 6-32, 4-36, and 2-56. Taps should be on hand for the 6-32, 4-36, and 2-56 sizes.

ADAPTING THE UNIT

The first step is the dismantling of the Baldwin unit. The top of the hard-rubber case is unscrewed; the entire mechanism may then be removed, and the double speaker cord disconnected and laid aside for future use. Before doing any more dismantling, it is well to examine what is found inside the Baldwin case. There is a small coil of very fine wire, oval in shape, with an oblong slot through the center of it. Through this slot there is a small, flat, iron armature, one side of which is joined to the diaphragm with a fine brass

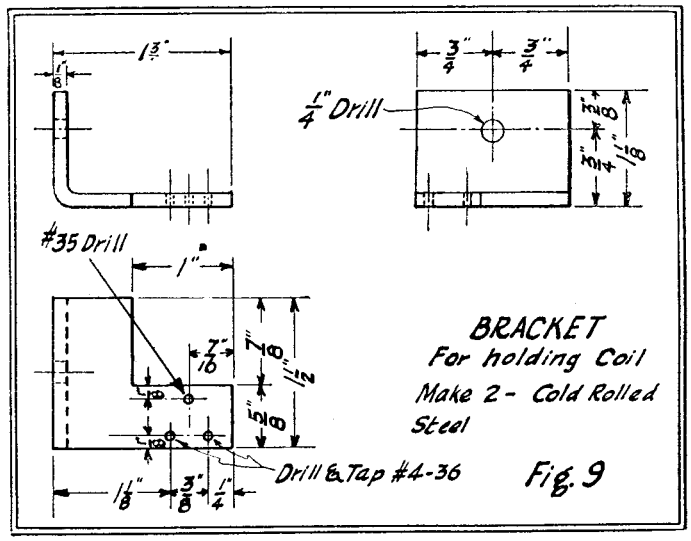


Details of the armature-balancing spring.

wire, and the other held in place with a bent wire spring. Around the coil are "U" shaped pieces of flat steel, and to them is fastened the permanent magnet with machine screws. It is an excellent idea to pay careful attention to the manufacturer's method of assembling this unit, with regard to coil and magnet polarity. In other words, when the unit is re-assembled, this should be done in the same manner as originally, the inner and outer ends of the winding going to the same respective binding posts, and these terminals placed with the same respect to the north and south poles of the magnet. By marking the coil before removing it, no trouble should be experienced in re-assembling.

The diaphragm used in this unit is of mica instead of metal; through the center of it projects the fine brass wire mentioned above, secured with a nut and a drop of solder. The mica should be cut or broken,

Details of the brackets, two of which are used for supporting the solenoid. These brackets form a part of the magnetic field.

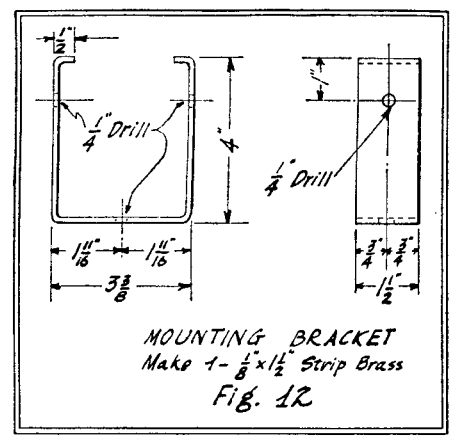


and the wire clipped and unhooked from the projecting end of the armature. The circular magnet is next removed from the coil by taking out the two small screws which hold it in place. Then the tiny wires leading from the coil to the binding posts are unsoldered, care being used that they are not broken. The binding posts may be removed also. The coil, together with the two "U" shaped pieces of steel, is held with three rivets to a metal disc, on which the mica diaphragm originally rested. These rivets must be cut or filed off to permit the coil to be removed; the disc is then thrown away. The small wire spring holding the armature is removed, and the armature is taken out and laid aside.

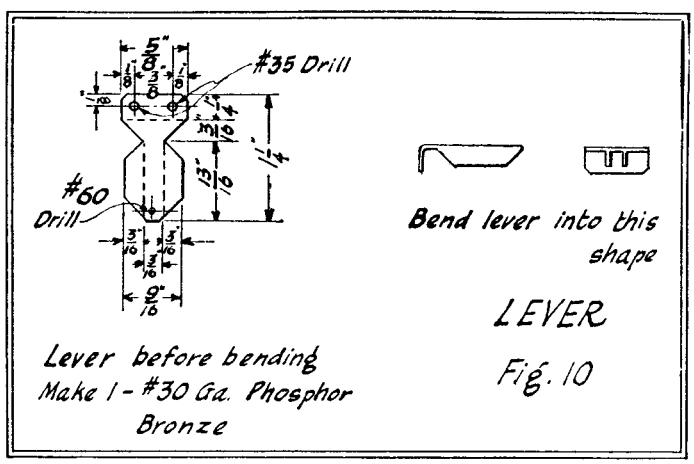
The coil is now to be mounted on the large horseshoe magnet; but, in order to do this, it is necessary to make two brackets of cold rolled steel, as shown in Fig. 9. These brackets are drilled and tapped as indicated, smoothed off with a file, and mounted with ¼-inch machine screws on the large magnet, so that there is an even separation between them. The coil, with the two "U" shaped pieces in place, is then put in position, and, if the holes are properly spaced, it can be fastened with two No. 4-36 machine screws, as shown in Fig. 8. It will be noted that the two "U" shaped pieces are already tapped for these screws.

The two brackets should hold the coil level, and the "U" shaped pieces should fit tight against the slot in the center of the coil, both top and bottom. The lever, Fig. 10, and the spring, Fig. 11, are next made. These two, which are of phosphor bronze, are drilled as shown to pass No. 4-36 screws. The lever will be mounted on one side of the coil by means of these screws, fitting the holes tapped in the steel brackets; but, before it is put in place, it should be noted that in the slot in the center of the coil are two small pins projecting from one side. The armature has drill holes provided for these pins and, when put in position through the slot, the pins fit through the drill holes. The lever should be mounted on the side of the coil which has these pins. The spring is then mounted on the opposite side.

The armature is put in place, and adjusted so that it will rock back and forth easily on the pins. A small hole is drilled in the end of the lever (Fig. 10) and a piece of No. 26 copper or brass wire run through this hole. A small hook is formed on the end of this wire, and caught through the hole in the part of the armature projecting from the slot. The spring on the other end of the armature is engaged, and the wire pulled up tight to balance the pressure exerted by



The brass bracket used for mounting the driving unit to the main support.



The lever to which is attached the drive rod. One end of the lever is fastened to the frame of the unit, and the other end is attached to the balanced armature.

the spring. The effect sought is so to balance the armature that it will remain stationary midway of the slot, so that any variations of current flowing through the coil will influence the armature magnetically and cause it to vibrate. After this has been achieved, the wire is secured to the lever with a drop of solder.

Binding posts should be provided for attaching the speaker cords, and it is best to use the one originally provided in the unit. These may be attached to suit the constructor's convenience, and the terminal wires soldered to them.

If the reader desires to test what he has done so far, he may at this point connect the unit alone to a set, with a good strong local station tuned in. If the unit is working properly, the armature will vibrate strongly with the signal received, giving a faint muffled sound of music or speech.

If the finger is placed on one of the projecting ends of the armature these vibrations will be plainly felt; in fact it will be difficult or impossible to hold the armature still in the center of the slot. This is exactly the effect desired, as considerable power is needed to drive a 36-inch cone.

After the test has been made, and the unit disconnected, a straight, stiff piece of bus bar, 1/16-inch in diameter, is soldered securely to the lever, about three-quarters or two-thirds of the way back toward the bend, or fulcrum. This bus bar should be about 7 inches long, and should extend out at right angles, as shown in Fig. 8, in the illustrations. The mounting bracket, Fig. 12, and the ring and cross piece, Fig. 13, should now be prepared. The bracket is made of ⅛ x 1½-inch brass, and requires a piece about 12 inches long, bent to shape and drilled as shown. The ring is cut with a jig saw, from ⅞-inch wood, either hard or soft, and has a diameter of 12 inches outside and 8 inches within. A piece of wood, 3 inches wide and 12 inches long, should also be cut, planed, and drilled as indicated, to be used as a support for the entire assembly, being secured to the ring with ¼-inch machine screws and wing nuts.

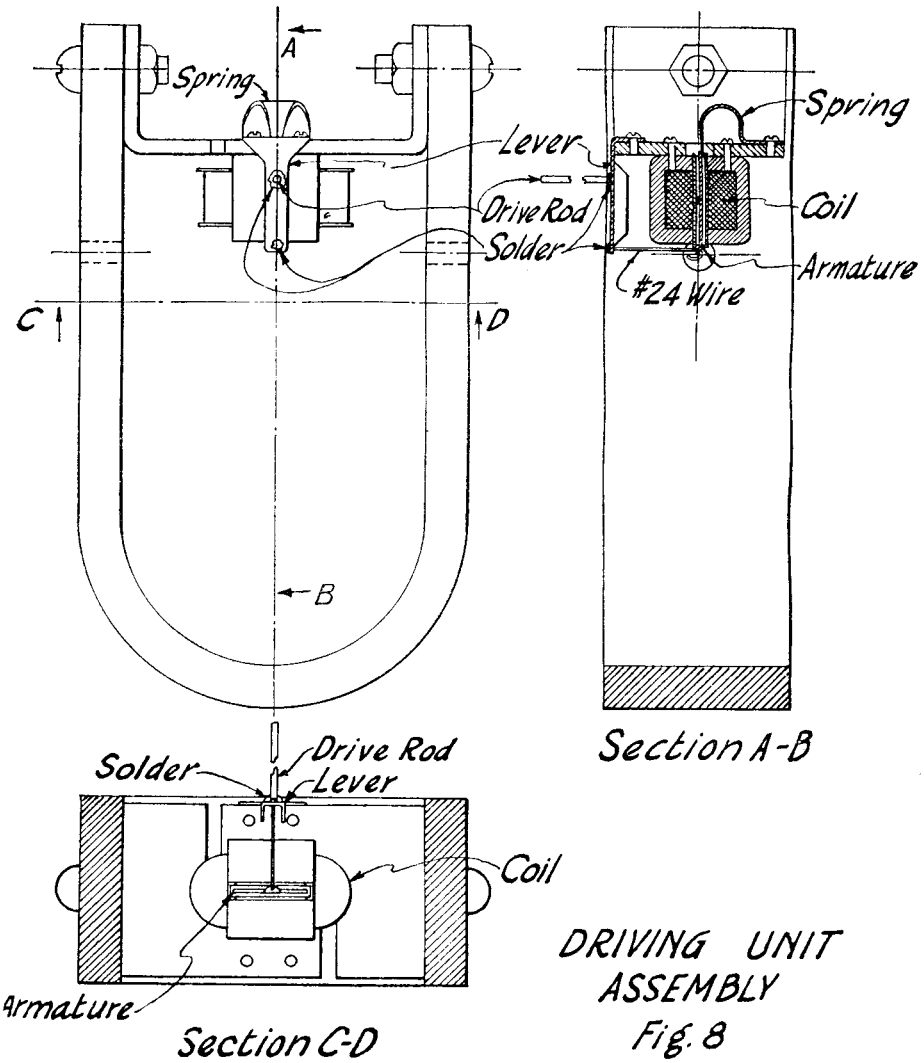
CONSTRUCTING THE DIAPHRAGM

The next logical step is the making of the cone itself. Assuming that Alhambra paper is to be used, two sheets will be needed, 38 inches square. If the constructor has artistic tendencies, the cone may be decorated to suit his fancy with water colors, mixed and applied rather thick. It is best to do this decorating before making the cone. For the actual construction of the cone, one sheet of paper is laid flat on a table, rough side up; and, around a thumb tack in the exact center of the sheet, a circle is drawn as large as possible, by means of a string and a soft pencil. This circle, allowing for any bent or torn edges on the paper, will be close to 38 inches in diameter when flat, but the shaping of the cone will reduce it to about 36 inches.

When the paper is bought, there will be found a note on the wrapper indicating which way the grain runs; and the sector cut out, to form the cone, must be cut with the grain, not against it. The sector to be removed comprises about 15 to 20 degrees, or from 5 to 6 inches along the outer circumference of the circle. After marking these lines, the circle may be cut out, and the sector also cut; the latter operation being performed with a sharp-pointed knife and a straight edge, to insure a perfectly straight cut.

Next a strip about 1½ inches wide and 19 inches long is cut, not necessarily from the same paper. The two edges of the segment are brought together, with the smooth surface of the paper on the inside, or concave side of the cone, and the strip is glued to both edges so that it holds them firmly together. The glue which works best is one made by dissolving celluloid in amyl acetate, as this mixture is waterproof. Many fans are familiar with it, having used it in the construction of self-supporting coils. It will be well to try out the glue on some small pieces of paper before using it, to make sure that it will hold properly. A good celluloid-base glue can be obtained from the same source as the Alhambra paper, and is strongly recommended by the makers for this work. Regular glue should not be used, as it may cause the paper to buckle or warp, and may loosen in damp weather.

From the other sheet of paper, another circle is cut, with a diameter ¼-inch less than the first one. An inner circle, 11½ inches in diameter, is also cut out, as well as the same angular sector as on the first sheet. This cone may also be glued, with a 1½-inch strip holding the edges together. After the glue has set, this cone should be mounted on the wood ring as shown in Fig. 2. The 11½-inch circle cut from the paper should be centered exactly on the 12-inch ring, leaving about ¼-inch all around. The paper is fastened temporarily with three or four tacks near the inner edge. The most satisfactory method of making the permanent joint here is to use sealing wax. The stick of wax is heated in a flame, and the wax spread evenly along the inside of the cone, making a tight joint between the paper and the wood.



Details of the complete driving unit, as it is when assembled.

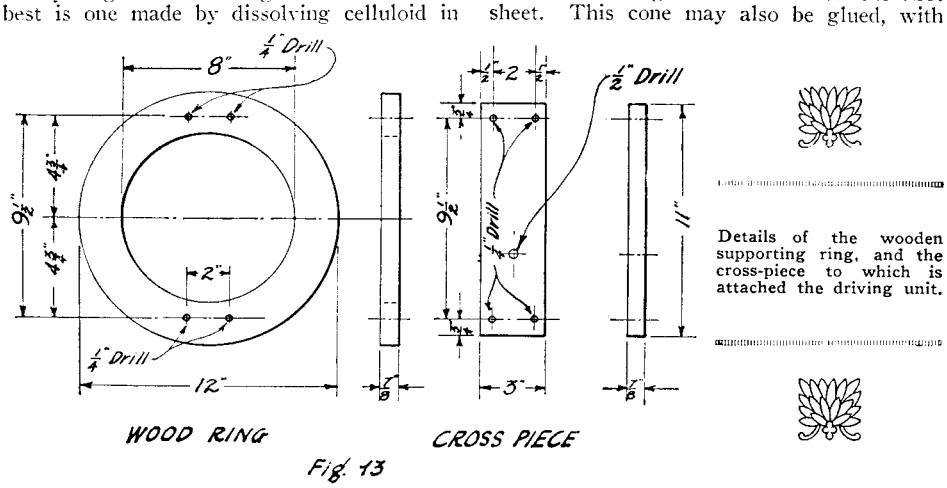


Fig. 13

Details of the wooden supporting ring, and the cross-piece to which is attached the driving unit.

MOUNTING THE CONE

The front cone is now set, with the apex down, into a dish pan or other large round pan to hold it in position. The other cone, with the wood ring affixed, is placed, ring uppermost, on the first one. If the circles have been accurately cut, the front cone, which is lying in the dish pan, should extend about ⅛-inch beyond the other one, all around. It is on this ⅛-inch extension that the glueing is done. There are two methods available for fastening these two cones together. One is to use sealing wax, applying it carefully and sparingly, so that it does not run over on the front of the cone; and the other is to use the celluloid-base glue mentioned previously. If the glue is used, it must be applied quite liberally, to fill the crack or seam between the two edges. The sealing wax is a little easier to work with, as it hardens more quickly, and it seems to make no difference in the operation of the speaker. In using the wax, it must be applied very hot, so it

will flow evenly, and in just sufficient amount to cover thoroughly every inch of the circumference, as seen in Fig. 3.

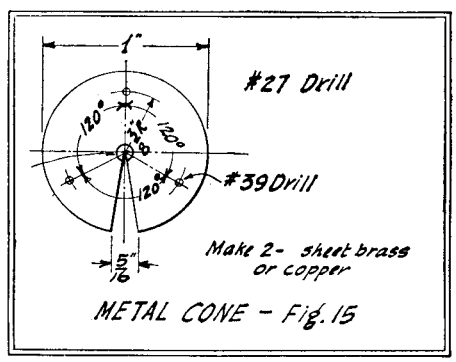
It is necessary now to provide some means of joining the actuating unit to the cone proper. This is done by means of the tip illustrated in Figs. 15, 16 and 17. The two small circles, Fig. 15, are cut out of thin sheet brass or copper, drilled as shown, and formed into the shape of a cone, being held in shape by means of solder sparingly applied to the seam. Excess solder must be removed with a file. Then the tip is made from ¼-inch brass rod, drilled through the center, or axially, with a No. 50 drill, slightly countersunk on one end, and drilled and tapped for a No. 2-56 machine screw through the side, as indicated. This tapped hole is for the set screw that holds the driving rod. This tip is then carefully soldered to the apex of one of the small metal cones, so that it fits in place straight, and so that the drill holes do not fill with solder.

This is rather a particular operation, and several attempts may be necessary before a good job is obtained. With reasonable care, however, it can be done successfully. This tip, with its metal cone, is mounted on the apex of the large paper cone, and the other metal cone placed inside. Before putting these in place, it is a good idea to spread a little rubber cement (or the celluloid-base glue may be used) both inside and outside, to join the tip securely to the paper. Further strength is obtained by passing No. 2-56 machine screws through the holes in the metal cones and through the paper, and tightening up the nuts on the inside. This makes a neat and serviceable job.

The bracket, Fig. 12, which was made out of strip brass, is used to hold the magnet and unit in place. The bracket is mounted on the magnet with ¼-inch machine screws, and the whole assembly laid in position on the cross piece (the wood strip which is fastened to the back of the wood ring), in such a way that the driving rod is exactly in line with the center point of the cross piece. This is of great importance, and care will be needed to see that there is no appreciable variation from the center. When this has been determined, a ½-inch hole is drilled in the cross piece, to line up with the ¼-inch hole in the back of the bracket. A ¼-inch machine screw is passed through these two holes, and a 1-inch washer slipped over the end of the screw. A suitable square washer can be made from the strip brass used on the bracket. A wing nut is used on the machine screw, as it can be loosened for adjustment without a wrench. It will be noted that the hole drilled in the wood crosspiece is ½-inch in size, while the bolt passing through it is only ¼-inch. This is to permit the entire driving mechanism assembly to be shifted slightly after the cone is put in place, in order to line up the driving rod exactly with the apex of the cone.

The crosspiece, with mechanism attached, is now fastened to the wood ring with ¼-inch machine screws, also using wing nuts to permit easy access. At this stage the writer found it very convenient to construct a rough stand, to hold the cone proper while mounting and adjusting the mechanism. It is very difficult to hold a 36-inch cone with one hand and work with the other, tightening nuts, and fitting the driving rod into the tip of the cone. This stand consisted simply of a board, 3 feet long and 10 inches wide, laid flat on the floor, and two 3-foot uprights nailed on the edges at the center. Another strip was used to brace each upright. The cone was fastened to the uprights with wood screws, and was thereby held firmly in position, leaving both hands free for other work. It is strongly recommended that every constructor build such a stand for use during the early experimental stages.

The reader is cautioned at this point not to allow the driving rod to puncture the paper of the cone while trying to fit the unit into the cone; also to make sure that it fits easily into place. If it does not, then some miscalculation has been made in laying out the various parts, and trying to force it into place may injure the mechanism. It is well to proceed slowly, even though a favorite broadcasting station may be clamoring for a chance to get at that cone.

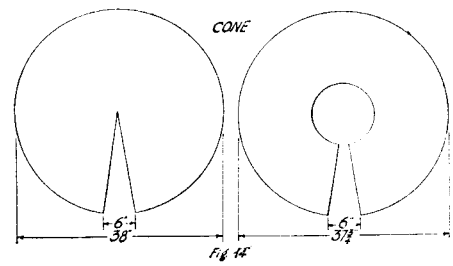


The small metal cone or apex. Two of these are used, at the point where the drive-rod is attached to the cone.

ADJUSTMENT AND OPERATION

If everything fits properly, and all the nuts are tightened, the speaker may be connected to the set. It is best, first to tune in a powerful station clear and loud on the present speaker, and then connect the cone. The first sounds may be disappointing; if so, it is because the set screw on the tip of the cone has not been tightened. A No. 2-56 machine screw should be inserted here and tightened, thereby holding the driving rod securely in place. If the mechanism is properly adjusted, and exactly centered, a surprise will follow—a flood of golden melody such as seldom is heard from a receiving set. After making sure that everything is right, the surplus length of driving rod protruding from the tip is cut off, and the cone may be hung on the wall with picture wire; or perhaps the constructor who is ambitious with carpenter's tools will wish to build a permanent stand, of the three-legged variety, so that the speaker may stand on the floor near the set, or as far distant from it as he may choose. Before hanging the cone from the wall, two wooden strips are screwed to the edge of the wood ring near the bottom, and tipped with sponge rubber. The strips hold the cone away from the wall, while the rubber prevents vibrations being transmitted to it.

In case, however, that flood of melody does not come, there are several minor adjustments to be made that may coax it along. First, it would be well to loosen the set screw on the cone tip, and carefully pull out or push in on the driving rod. If that brings out the volume and richness of tone, then all is well, and the screw may be tightened. If not, the screw is loosened again, and the wing nut in the center of the cross-piece in the rear is unscrewed a little, and the entire mechanism shifted slightly, up, down, or sideways.



Details of the front and rear cones.

If this is unsuccessful, the unit should be removed from the cone, and examined for evidence of damage that may have occurred while fastening it in place. A bent drive rod, or a lever sprung out of place, will cause trouble. The armature should be examined to make sure that it is centered in the slot and able to move freely. A slight adjustment of the spring will usually take care of this.

Another thing that may help is to put a .005-mf. fixed condenser across the speaker terminals. It was found desirable, on the writer's speaker, and was mounted inside the cone. Reversing the speaker cords may induce a change for the better in the tone quality. As a last resort, if results are disappointing (and it is extremely unlikely that they will be, if directions have been followed carefully) the set itself should be looked to. There must be no distortion here, as a cone speaker will reproduce the distortion faithfully where a horn might pass it over. This is not theory but fact. If a milliammeter is available, it should be connected in the "B—" lead to make sure that the proper grid bias is being used on the audio tubes, and that regeneration, if any, is not being pushed too far. This is not the place for a discussion of this subject, which has been covered before in RADIO NEWS; suffice it to say that there should be only the most minute variation of the milliammeter needle with the received signals. Anything more than that indicates distortion, which must be cured before the cone can do its best.

One further word about audio amplifiers. A 36-inch cone deserves the very best amplifier that the pocketbook will permit. Careful tests have been made with several different amplifiers, all of which gave fine results. One test was made with a well-known manufactured receiver, using 201-A tubes throughout, and 90 volts of "B" battery, properly biased. Volume and quality were splendid, on both

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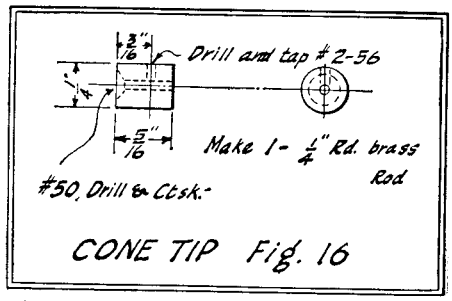
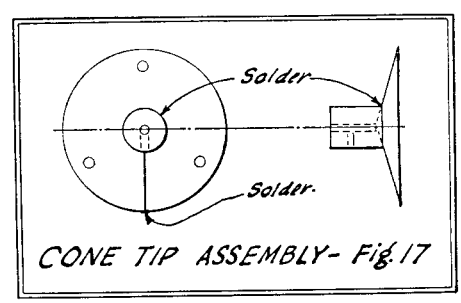


The cone tip, where adjustments of the drive rod are made, is soldered to one of the apexes, as shown in Fig. 17.



Showing how the cone tip is soldered to one of the apexes.

Building A 36-Inch Cone Speaker

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local and distant stations. Further tests included a different set, with transformer-coupled audio, using the 112 type of tube in the last stage, with 135 volts on the plate, and 9 volts negative grid bias. With this arrangement, greater volume was obtained, together with somewhat better quality, especially when full volume was used. A straight resistance-coupled amplifier was also used, with high-mu tubes in the first two stages, and the 112 type in the output stage. This amplifier also worked beautifully. Of course, if the larger power tubes, such as the 171 or 210, are available, they should be used, for they will operate the cone more satisfactorily, just as they will any speaker.

One thing is certain: A home-made cone, carefully built and adjusted according to instructions, will work, and work right, provided, of course, that the amplifier is doing its share. And when a 36-inch cone works right, the music has a richness and timbre not even remotely approached by that from the smaller cones and horns; especially on the bass notes, which pour forth with a fine resonant quality that is delightful to hear. The higher frequencies are not by any means slighted, however, and the soft voice of a violin, for instance, is reproduced with marvelous sweetness and purity.