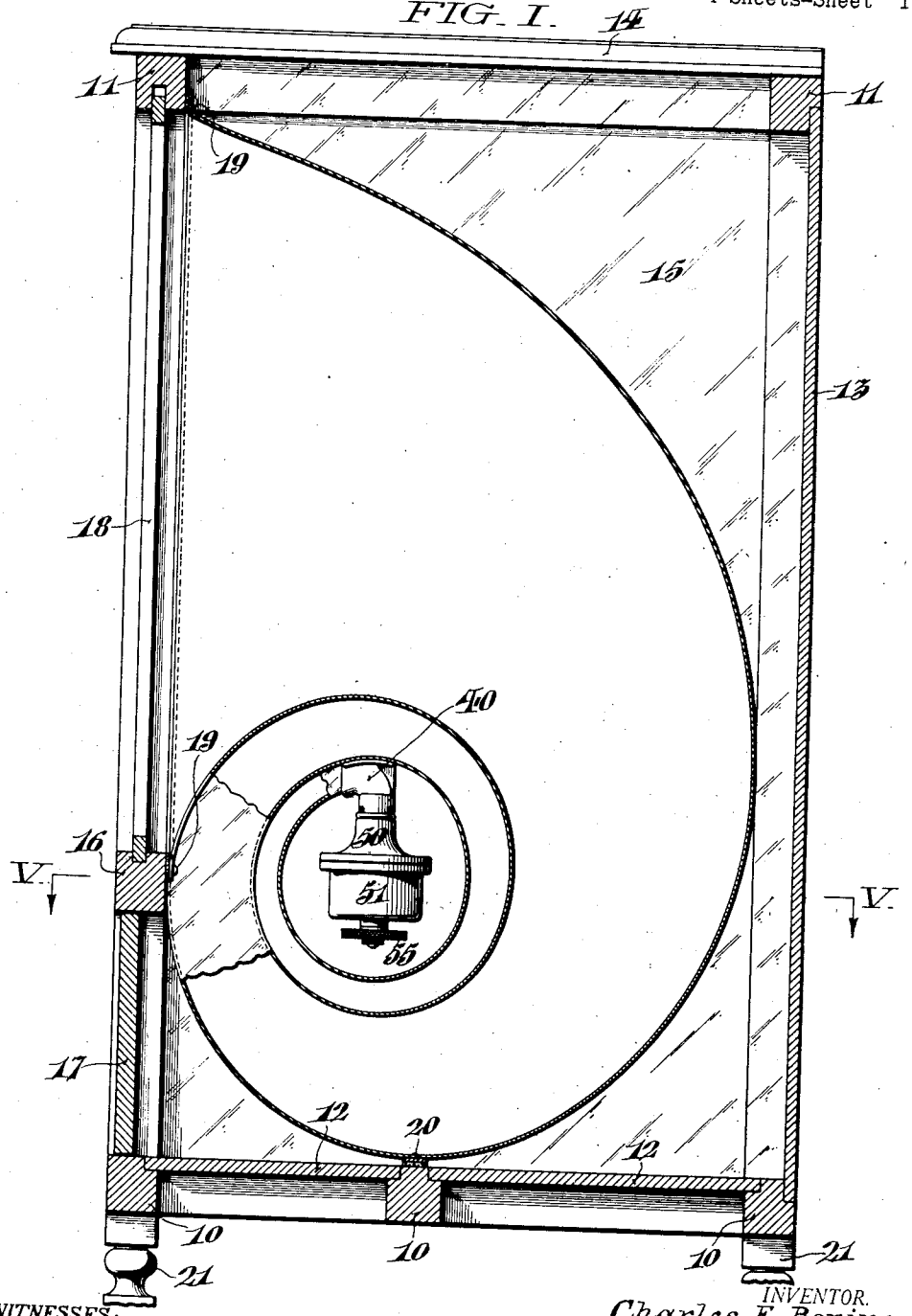
Dec. 15, 1931. C. E. BONINE 1,836,222

SOUND REPRODUCER

Filed Sept. 12, 1927 4 Sheets-Sheet 1

FIG. I.



WITNESSES:

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George M. Muenkamp

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Charles E. Bonine,

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ATTORNEYS.

Dec. 15, 1931. C. E. BONINE 1,836,222

SOUND REPRODUCER

Filed Sept. 12, 1927 4 Sheets-Sheet 2

FIG. II.

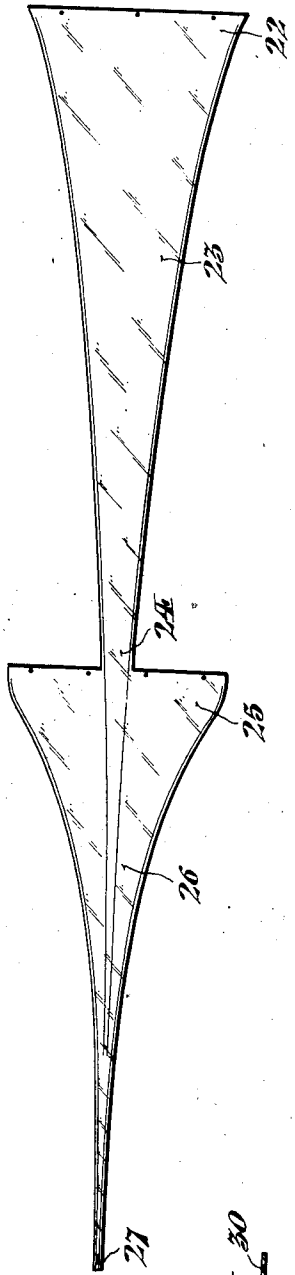


FIG. IV.

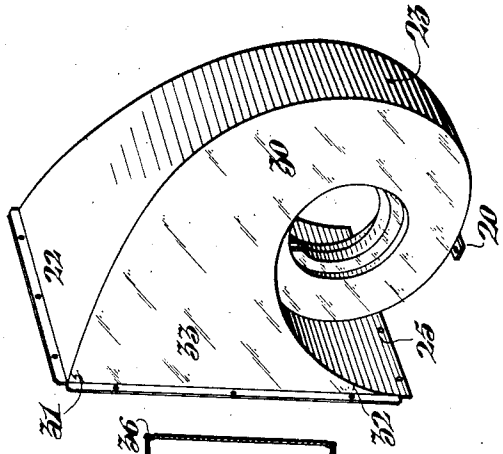


FIG. V.

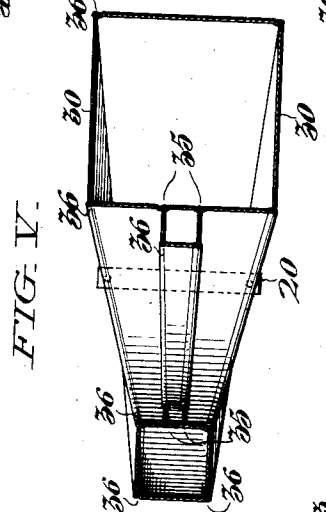


FIG. III.

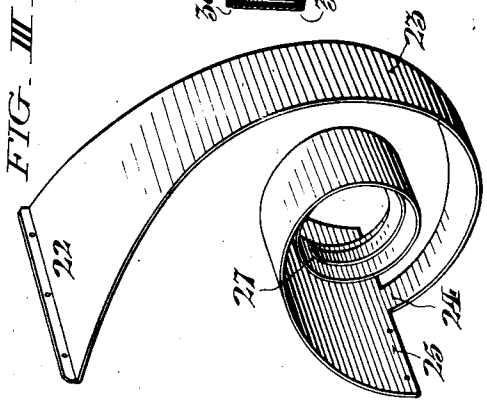
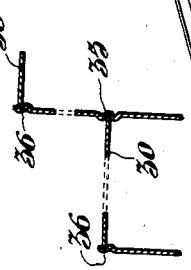


FIG. VI.



WITNESSES

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Dec. 15, 1931. C. E. BONINE 1,836,222

SOUND REPRODUCER

Filed Sept. 12, 1927 4 Sheets-Sheet 3

FIG. VII.

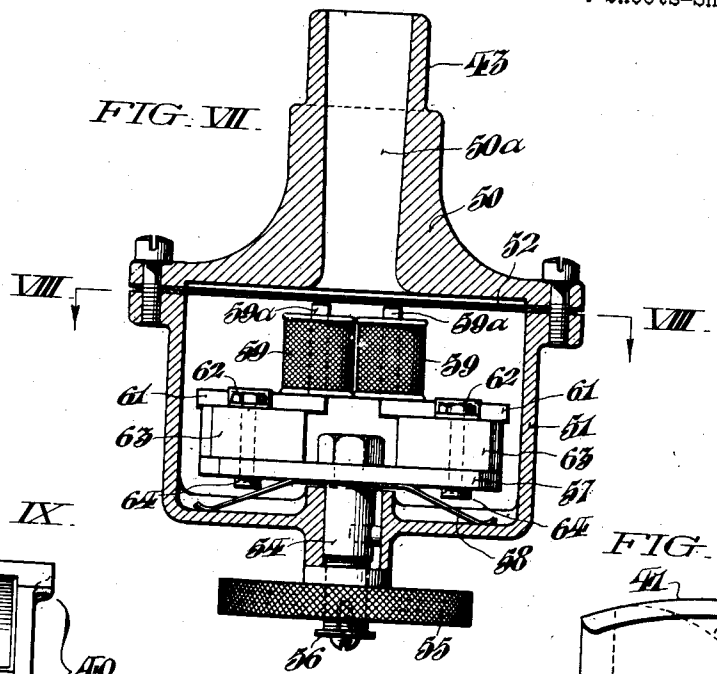


FIG. IX.

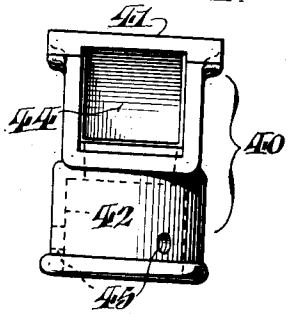


FIG. X.

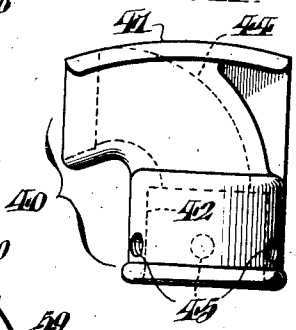


FIG. VIII.

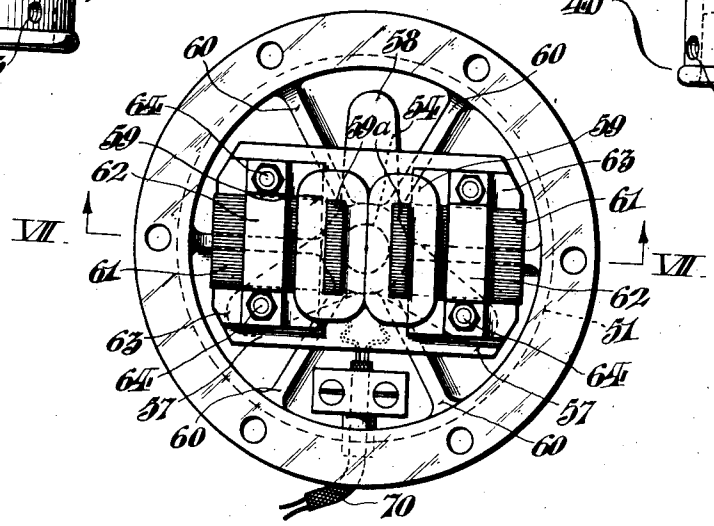
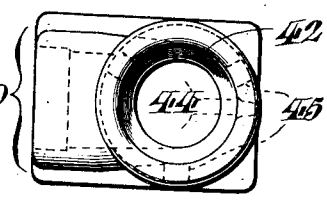


FIG. XI.



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SOUND REPRODUCER

Filed Sept. 12, 1927 4 Sheets-Sheet 4

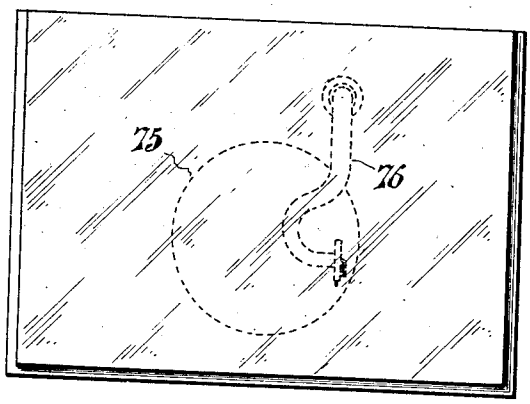


FIG. XII.

FIG. XIII.

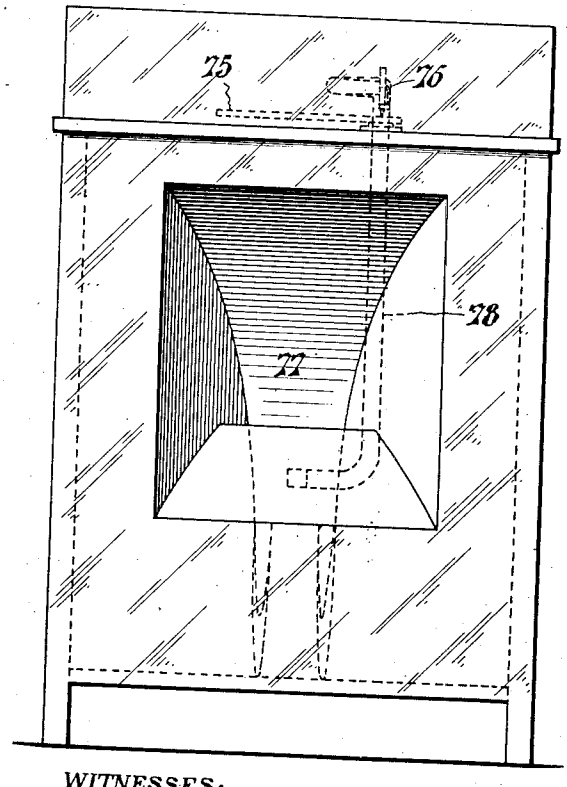
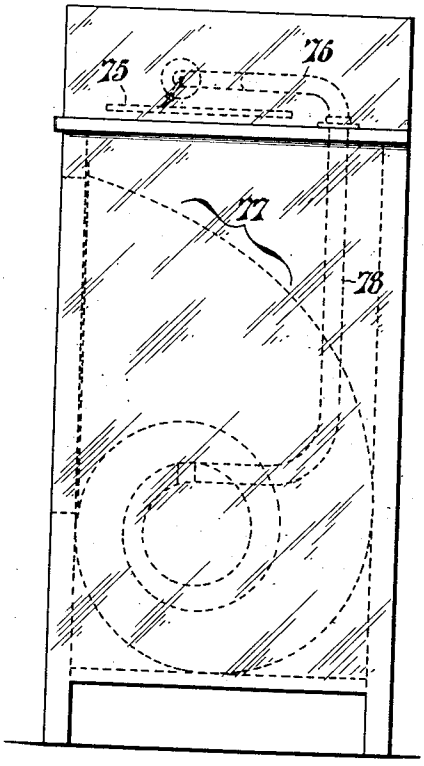


FIG. XIV.



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1,836,222

UNITED STATES PATENT OFFICE

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SOUND REPRODUCER

Application filed September 12, 1927. Serial No. 218,954.

This invention relates to improvements in sound reproducers useful either with loud speakers of the type employed with radio apparatus, or with phonographs.

It has heretofore been proposed to employ sound reproducers of many designs, both with phonographs and with radio apparatus. It is essential in such reproducers that the sound waves be delivered with uniform frequency response over a range of at least 100 cycles per second to around ten thousand cycles per second.

Radio receiving apparatus as now constructed is capable of giving excellent amplification to both vocal and instrumental music frequencies throughout the above range as a consequence of attention given to designing the several elements of the sets with a view toward obviating distortion. The loud speakers at present on the market are mainly of two types: the short horn type and the cone or disk variety. In practice neither of these types is capable of delivering undistorted sound to the listener even though it is supplied with properly amplified and undistorted tone frequencies by a good receiver. The deficiencies of the short horn speaker are fully recognized owing to its failure to deliver the low notes of the scale, as well as its inability to deliver more than a small amount of sound energy. These difficulties arise from the shortness of the acoustic chamber which prevents response to low frequencies. In a horn of twenty-four inches length from diaphragm to mouth, frequencies below five hundred cycles are absent. Sixty per cent of the energy of the voice lies in the range below five hundred cycles, so that if the device does not deliver below this frequency, then not only will this percentage of the total energy be lost, but the resulting sound will be weak and thin for lack of the low notes. Attempts to increase the output of such a speaker by increasing the electrical input still maintain the resulting sound weak and thin and true reproduction is impossible.

On the other hand, the cone or disk type of speaker delivers the low frequencies more readily than the high frequencies with the result that the delivered sound is "throaty." Although they reproduce the major portion of the energy as set forth above, the reproduction is nevertheless faulty since the quality or timber of the music and voice reside in the higher frequencies of overtones. Accordingly, when the speaker fails to reproduce these higher overtone frequencies, the imperfections in the sound are readily noticeable. The reason for the selective absorption of the higher frequencies by the cone or disk type speaker is that the vibrating sounding member is of a fibrous material such as paper or wood having low relative elasticity. Since the energy of the high frequency notes is relatively low, the energy is not sufficient to cause the cone or disk to vibrate sufficiently at the given high frequency to reproduce a note in its proper proportion of sound with respect to the lower tones, which difficulty is further increased with a greater energy required for the higher velocity changes in the direction of movement of the material for the higher tones. It is found that articulation falls off quickly with reduction of the higher frequencies: the elimination of frequencies above fifteen hundred cycles reduces the articulation thirty-five per cent, elimination of above twenty-five hundred cycles seventeen per cent, and elimination above thirty-five hundred cycles reduces the articulation fifteen per cent, etc., resulting in a more or less "throaty" sound from the speaker.

Therefore, if a faithful reproduction of the sound represented by the electrical waves as amplified and delivered by a good receiver is to be obtained, the entire range of frequencies must be had, so that the maximum energy is delivered, and perfect articulation maintained: or in other words, the response of all frequencies must be uniform.

Further, it is necessary to employ an electro-magnetically actuated unit in conjunction with the acoustic chamber itself, which is capable of delivering to the chamber the vibrations which can be properly amplified and conducted therein.

Moreover, it is commercially necessary that such acoustical chambers may be cheaply and esaily constructed.

It is therefore the purpose of the present invention to set forth improvements in such acoustical chambers and associated electro-magnetic response devices as to provide for uniform response substantially throughout the audible scale, and for simple construction.

In the accompanying drawings:

Fig. I is a vertical section through a cabinet embodying a sound reproducer for use in connection with radio receiving apparatus according to the present invention.

Fig. II is a development view showing the shape of the blank for the spiral acoustic chamber or horn.

Fig. III is a perspective view showing the blank when coiled.

Fig. IV is a similar view showing the spiralized blank with the side plates in position.

Fig. V is a section on a smaller scale on substantially line V—V of Fig. I.

Fig. VI is a detail section showing the relationship of the spiral and side plates.

Fig. VII is a vertical section through the electro-magnetic reproducing unit, substantially on line VII—VII of Fig. VIII.

Fig. VIII is a horizontal section through the reproducing unit substantially on line VIII—VIII of Fig. VII.

Figs. IX, X, and XI are views of the adapter employed to connect the electro-magnetic unit with the horn proper.

Figs. XII, XIII, and XIV are diagrammatic views showing the adaptation of my invention to phonographs.

The present structure comprises a spiral acoustical chamber or horn leading from the magnetic unit to an outwardly directed mouth. The shaping of this horn is determined mathematically with respect to its length along the spiral. In particular, this horn increases in area along its length by a logarithmic formula:

$$\text{Area} = A_0 x^a$$

where x is the distance along the axis measured from the origin, and a is a constant, while A_0 is the area of the horn at a given starting point. In the present instance the shape of the acoustic channel has been worked with the constant a equal to 50, and the length of the channel made approximately seventy-two inches so that the response comes just under one hundred cycles per second. Sheet steel has been employed in making the speaker owing to its high modulus of elasticity which especially adapts it for sound reflection. The cross section of the tube has been made square throughout in order to simplify its construction. The blank for the chamber has been rolled upon itself in such manner that the smaller portion of the tube reinforces the larger tube to which it is attached: whereby the over-all dimensions and the amount of metal are reduced to the minimum. In this way one thickness of metal serves as a boundary between two successive convolutions of the horn sound passage. It is preferred to employ terne plate in order to enable ready soldering of the joints between side plates and the spiral plate to render the acoustic chamber airtight.

In the drawings, Fig. I shows a cabinet comprising lower frame members 10 and upper frame members 11 supporting respectively lower plates 12, the rear wall 13 and the top wall 14. The side walls 15 completely enclose the horn within the structure, except for the front which has an auxiliary frame member 16 supporting a front wall panel 17 below the horizontal plane through the axis of the spiral, and a permeable panel 18 thereabove. As shown in Fig. I, the spiral plates constituting the horn are fastened by screws 19 to the members 11 and 16: while the lower part of the horn rests by a support 20 on one of the lower frame members 10. The whole device may be supported on legs 21 in a manner common to console cabinets.

The main spiral plate for the horn is formed as shown in Fig. II with a broad end 22 having apertures therein to receive the screws 19 securing the horn to the frame member 11. The sides of the blank of Fig. II first curve inward slightly and then converge symmetrically, through a body portion 23, to a narrow neck 24 at which the blank has shoulders providing a second wide portion 25 with apertures along the shoulders to receive the screws 19 which connect the assembled horn to the frame member 16. It will be noted that when the assembly is completed (Fig. IV), these screw holes are all accessible from the exterior of the horn, and that the screw heads do not project into the chamber to impede or distort the sounding surfaces. From the broad portion 25 the blank again curves and converges to provide a portion 26 ending in a narrow portion 27. The cross section of the horn is square at all points, and hence the width of the blank starting from the end 27 may be calculated easily from the formula hereinbefore given until the broad portion 25 is reached. However, it is possible to calculate mathematically the length along the spiral from the neck 24 to the corresponding width of the body 26, when the device has been curled as shown in Fig. III. Since the acoustic chamber is to be square in section throughout, it is obvious that these two widths must be equal (see Fig. IV); and likewise it is mathematically possible to calculate the successive widths of the body portion 23 to produce a broad end 22 of the same width as the broad portion 25.

The blank of Fig. II may then be curled into the form shown in Fig. III in which it will be noted that the distance between two

successive convolutions is equal to the width of the blank at the inner convolution.

The side plates 30 are similarly prepared, and it will be noted that these plates are each formed from a single sheet of material cut along converging spiral lines starting at the corners 31 and 32 of the broad portion 33 and extending inward about the axis of the curled blank (Fig. III). These spirals blend into each other in the original blank, and represent the adjacent edges of the cut sheet. The width of the blank for each of the side plates at a given point is equal to the width of the inner convolution of the spiral plate of Fig. III at the corresponding point, in order that the acoustic chamber shall be square throughout its length.

The side plates 30 are then warped out of plane as shown in Figs. IV and V, and then assembled with respect to the spiral of Fig. III so that the side plates join points on the edges of the respective inner convolution with opposite intermediate points of the width of the outer convolution (Figs. V and VI) and the elements of the side walls are at right angles to the convolution walls to provide a sound chamber of rectangular section. To facilitate assembling it is preferred to form the spiral plate along opposite edges with grooves 35, 36 as shown in Figs. V and VI, to receive and return the inner convolutions of the side plates 30. The large portions 22 and 25 of the spiral plate and the ends 33 of the side plates are thus held in proper relative position while their edges are soldered together to seal the acoustic chamber against air leakage along the corners. This soldering is continued around the edges presented by the spirals leading from the top corners 31 of the side plates to the broad portion 25 of the spiral plate itself: and also along the inner convolutions of the spiral where the respective plates are held in proper relative position by the grooves 35, 36.

It is preferred to solder the supporting strip 20 to the outer body portion 23 of the spiral plate at the line representing the lowest part of the acoustic chamber, so that this strip 20 may later be securely screwed to the frame member 10 at the bottom of the housing cabinet.

An adapter 40 is secured to the smaller or inner end of the acoustic chamber as shown in Fig. I. This adapter has a curved upper wall 41 which fits the inner convolution of the spiral plate and may be soldered or welded thereto to securely support the adapter in position. The adapter has an inwardly projecting cylindric connection 42 to receive the coupling neck 43 of the electro-magnetic unit. The adapter is preferably made of a single piece of material and has a sound passage 44 therethrough leading from the outlet of the electro-magnetic unit to the smaller square end of the acoustical chamber by a smooth curve which at the arc of greater diameter blends smoothly with the curve of the upper surface of the wall 41. As shown in Figs. IX and XI, this passage 44 merges smoothly from the circular section of Fig. XI into the square section of Fig. IX and constitutes the transition from the circular section of the passage 50*a* in the casting 50 of the electro-magnetic unit to the smaller square end of the acoustic chamber itself.

The electro-magnetic unit comprises the connection casting 50 having the neck 43 extending upward therefrom and adapted to be received within the connection 42 wherein it is held by screws which may be passed through apertures 45. It will be noted that the axis of the sound passage through the connection 42 and the casting 50 extends radially with respect to the spiral of the acoustic chamber, passing substantially through the axis of this acoustic chamber, and lying in the central plane of the horn assembly within the inner turn of the spiral. The magnetic sound producing unit is thus protected against accidental injury, and at the same time firmly and rigidly supported by the stiff walls of the horn.

The lower casing 51 of the electro-magnetic unit is bolted fixedly to the casting 50 with the diaphragm 52 clamped therebetween. A threaded spindle 54 passes through an aperture in the bottom of the casing 51 and is provided on its exterior with an adjusting nut 55 and a stop washer 56. The inner end of the spindle 54 is surmounted by a frame 57 which is normally forced to its uppermost position by a spring 58. The frame 57 carries a pair of electro-magnets 59 which are supported with their cores 59*a* closely adjacent the diaphragm 52. The distance between the magnet cores and the diaphragm may be adjusted by rotation of the nut 55, which by its movement in one direction draws the frame 57 with the electro-magnets downward in opposition to the spring 58: and by its movement in the other direction releases the spindle 54 so that the frame may be moved upward by the spring 58.

As shown in Fig. VIII, the bottom of the casing 51 is stiffened by radial ribs 60: and the spring 58 is formed as a three-armed spider having a central aperture for passage of the spindle 54: and a substantially closed electro-magnetic circuit is provided for the magnets 59 by making the cores 59*a* of laminated steel with outwardly projecting legs 61 which are clamped together by saddles 62 and thus held to the blocks 63 resting upon the frame 57 which itself constitutes a permanent magnet for maintaining the normal magnetic flux through the cores 59*a*. It will be noted that the bolts 64 pass through the ends of the saddle 62 through

the block 63 and through apertures of the permanently magnetic frame 57.

Conductor leads 70 pass through a suitable opening in the casing 51 and have their terminals connected to the windings of the electro-magnets 59.

With reference now to Figs. XII–XIV wherein I have shown my invention embodied in a phonograph, the turn table of the latter is indicated at 75 and the associated tone arm at 76. The horn generally designated by the numeral 77 is constructed in exactly the same manner as described in connection with the loud speaker embodiment, i. e., it is of square cross section throughout varying in area in accordance with the formula hereinbefore given. As shown, the smaller inner end of the horn is connected to the tone arm 76 of the phonograph by a tube 78 which may be square in cross section and rounded only at the point of juncture with the tone arm.

It is obvious that the invention is not limited to the specific form of embodiment shown but that it may be modified in many ways within the scope of the appended claims.

Having thus described my invention, I claim:

1. A blank for forming a sound reproducer, having a spiral acoustic chamber, comprising an integral sheet of material having one end substantially of the dimension of the large end of the spiral horn and the other end substantially of the dimension of the small end of the spiral horn, said sheet having a wide portion intermediate its ends likewise substantially of the width of the large end of the spiral, adjacent which intermediate wide portion is a narrow neck, the sheet tapering from said wide portions to said narrow portions.

2. In a sound reproducer, a spiral horn comprising a spiral wall embodying progressively-mergent successive sections and two side walls, the said walls defining a spiral acoustic chamber, and said spiral wall sections forming continuous convolute faces for the acoustic chamber at successive convolutions thereof.

3. In a sound reproducer, a spiral horn providing a sound chamber and formed from three members, one of said members being a spirally wound sheet which progressively decreases in width from the large end of the chamber to an intermediate point of the chamber: and then is widened to the width of the wide portion of the chamber, and again decreases in width to the end of the chamber, so that the single spiral wall sheet forms the spiral walls of the chamber, and two side plates closing the sides of the chamber and joined to said spiral plate so that any radial section through said chamber is rectangular.

4. In a sound reproducer, a spiral acoustic chamber, a reproducing unit located at the axis of the spiral with its sound chamber radial with respect to the spiral, and an adapter member secured to the wall of said chamber and having an angularly turned sound passage therethrough to transmit sound vibrations from the radial chamber of said unit to the spiral sound chamber, said member supporting said unit.

5. In a sound reproducer, a horn providing a spiral acoustic chamber and comprising a spiral wall sheet having grooves thereon, and side plates to define therewith the spiral chamber, said side plates being received in and held in position by the grooves of said spiral plate.

6. In a sound reproducer, a horn providing a spiral acoustic chamber and comprising a spirally wound sheet, and side plates closing the sides of the acoustic chamber, the width of the side plates at any radial section of the spiral chamber being substantially equal to the width of the inner convolution of the spiral at such section.

7. In a sound reproducer, a horn providing a spiral acoustic chamber and comprising a single thickness wall between successive convolutions, and a pair of side walls of successively spirally increasing width extending between successive convolutions of said wall and warped out of plane so that its elements are at right angles to the parts of said convolution walls contacting therewith.

8. In a sound reproducer, a horn providing a tapering spiral acoustic chamber formed from sheet metal, the convolute walls whereof comprise aligned complemental sections which jointly form a continuous single thickness wall between the successive convolutions.

9. In a sound reproducer, a horn providing a tapered spiral acoustic chamber of rectangular cross section throughout formed from sheet metal, the convolute walls whereof comprise progressively-mergent aligned sections which jointly form a continuous single thickness wall between the successive convolutions.

In testimony whereof, I have hereunto signed my name at Philadelphia, Pennsylvania, this 8th day of September, 1927.

CHARLES E. BONINE.