May 19, 1936. A. L. THURAS 2,041,157

ACOUSTIC DEVICE

Filed July 13, 1932 2 Sheets-Sheet 1

FIG. 1

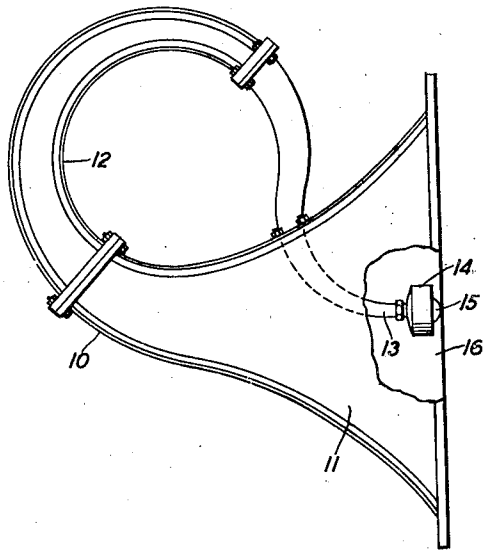


FIG. 2

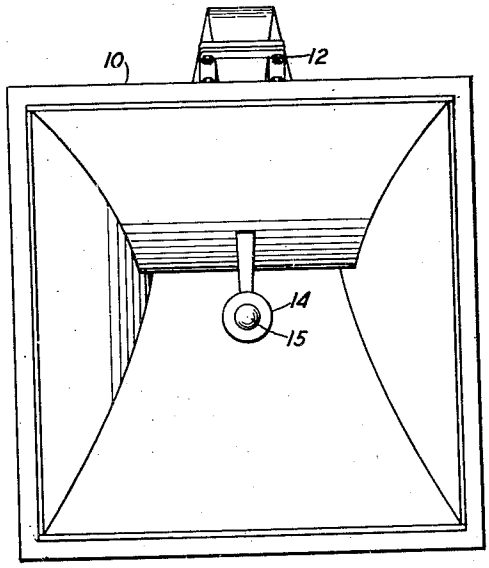


FIG. 3

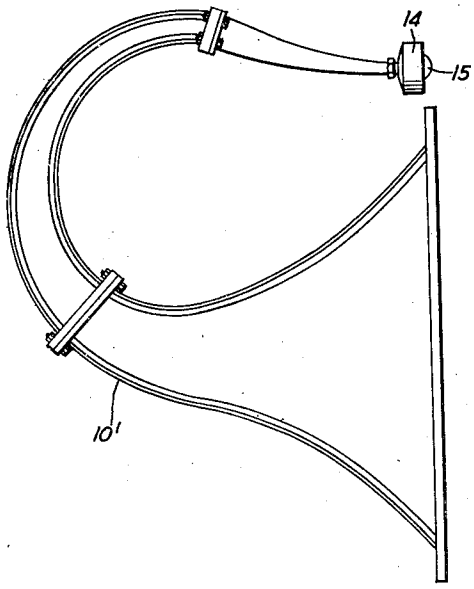
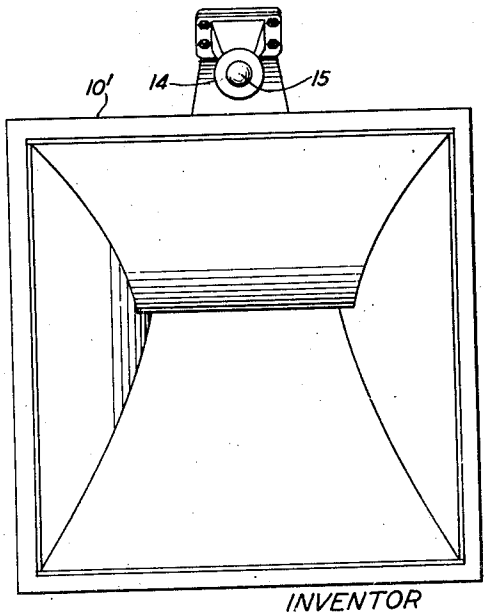


FIG. 4



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ACOUSTIC DEVICE

Filed July 13, 1932 2 Sheets-Sheet 2

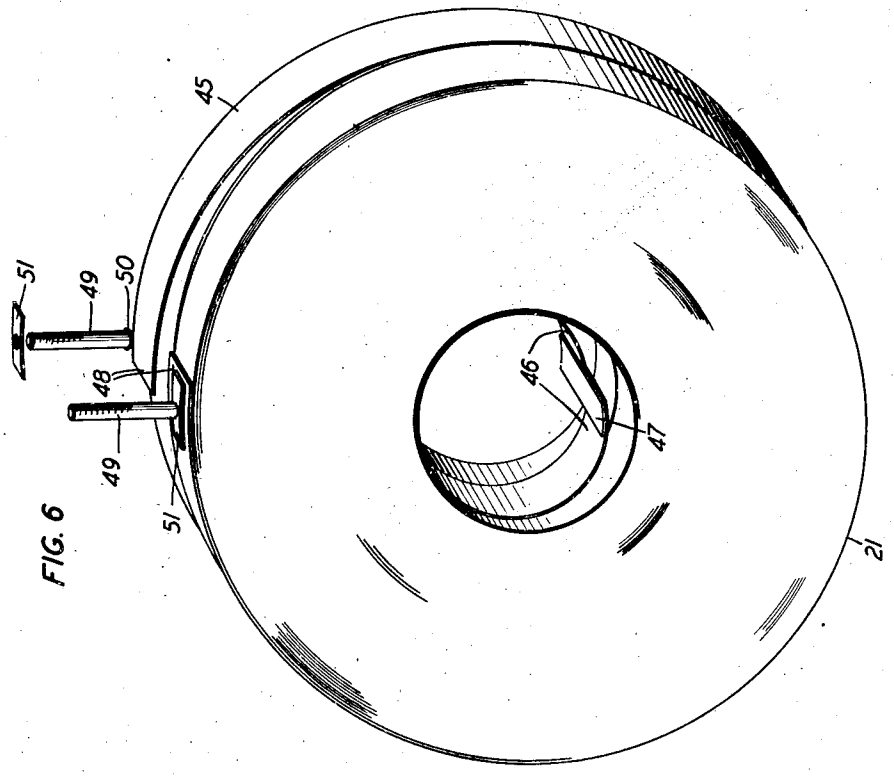

FIG. 6

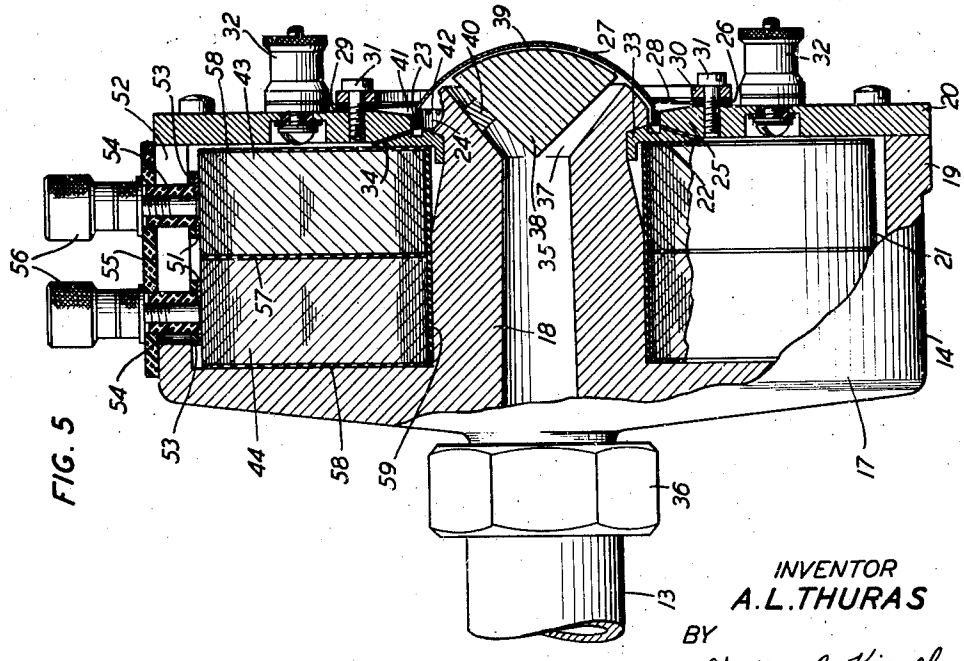

FIG. 5

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UNITED STATES PATENT OFFICE

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ACOUSTIC DEVICE

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Application July 13, 1932, Serial No. 622,191

4 Claims. (Cl. 179—120)

This invention relates to acoustic devices and more particularly to loud speaking telephones.

An object of this invention is to improve the response of a loud speaking telephone over substantially the entire frequency range of speech and music.

A feature of this invention comprises loading a diaphragm on one side with a horn and freely exposing the other side of the diaphragm, the exposed side of the diaphragm facing in the direction in which sound waves emanate from the horn.

Another feature of this invention comprises a diaphragm loaded by a horn on one side and freely exposed on the other side, the diaphragm being positioned adjacent the mouth portion of the horn and its exposed side radiating little sound in the transmitting range of the horn but radiating frequencies above the upper cut-off frequency of the horn, sound waves radiated from each side of the diaphragm being propagated in the same direction.

A further feature of this invention relates to a magnet structure energized by a magnetizing coil comprising a ribbon conductor.

This invention is embodied, preferably, in a loud speaker comprising a horn, a diaphragm, and means for actuating the diaphragm. The diaphragm is positioned so that one side thereof is loaded by the horn and so that its other side is freely exposed to the atmosphere such that it radiates sound waves in the same direction as the horn. Preferably, the horn comprises a bell or mouth portion and a long curved tapering tube portion terminating in a throat portion secured to a structure supporting the diaphragm adjacent the mouth portion of the horn.

A more complete understanding of this invention will be obtained from the description which follows considered with reference to the appended drawings, wherein:

Fig. 1 is a side view of one embodiment of the invention;

Fig. 2 is a front view of the device of Fig. 1;

Fig. 3 is a side view of another embodiment of the invention;

Fig. 4 is a front view of the device of Fig. 3;

Fig. 5 shows a receiver unit partially broken away and in section embodying features of the invention; and

Fig. 6 shows a perspective view of the magnetizing coil of the receiver of Fig. 5.

There is shown in Figs. 1 and 2 an acoustic device comprising a horn 10, having a bell or mouth portion 11 and a long tapering tube portion 12 terminating in a throat portion 13 adjacent and within the mouth portion of the horn. The throat portion is attached to the receiver unit 14 which is positioned in the mouth of the horn preferably centrally thereof. The receiver unit is shown more clearly and in greater detail in Figs. 5 and 6. The diaphragm 15 of the receiver is supported substantially in the plane of the mouth 16 of the horn and is loaded on one side by the horn 10. It is freely exposed to the atmosphere on its other side, the exposed side of the diaphragm facing in the same direction as that in which sound waves are emitted from the mouth of the horn. A protective screen (not shown) of suitable material which will not interfere with the sound waves emanating from the exposed surface of the diaphragm may be employed if desired to protect the diaphragm from mechanical injury. The horn 10 is preferably of the exponential type and may be constructed in accordance with the teachings of D. G. Scrantom Patent 1,852,793, granted April 5, 1932. The arrangement shown in Figs. 3 and 4 differs from that of Figs. 1 and 2 in that the receiver unit 14 and consequently the diaphragm is positioned outside of but adjacent to the bell portion and mouth of the horn 10'.

Horn type loud speakers are ordinarily operated with the diaphragm of the receiver unit loaded on one side by a horn and enclosed on its other side. It has been suggested that complete enclosure of one side of the diaphragm places undesirable restraints upon the freedom of motion of the diaphragm and hence interferes with the loud speaker response and that one side of the diaphragm may be exposed to avoid this condition. It has not been proposed, however, to utilize each side of the diaphragm as an effective source of sound waves, to load the diaphragm on one side by means of a horn and freely expose the other side to the atmosphere, the radiations from the exposed side of the diaphragm adding little to the output in the frequency range of the horn but adding materially to the output of sound wave frequencies above the upper cut-off frequency of the horn. The diaphragm must be positioned, however, so that its exposed surface is facing in the same direction as that in which sound waves are emitted from the horn mouth, and preferably substantially in the plane of the horn mouth. The frequency range capable of being reproduced by the acoustic device is so broadened, therefore, that more natural and faithful translation of audible frequencies is possible.

The receiver 14 comprises a casing 17 of magnetic material having a central pole 18, an outer cylindrical pole 19, and an annular plate pole 20 defining a cavity or chamber in which the magnetizing coil or winding 21 is positioned. The poles 18 and 19 define an air gap 22, preferably annular, in which is disposed an annular coil 23 mounted on the coil form or frame 24 which is attached to the diaphragm 15. The innermost portion 25 of the pole piece 20 is tapered preferably as shown. The diaphragm comprises an outer peripheral portion 26, an inner central stiffened, dished or dome portion 27, and an intermediate flexible portion 28, the coil form being secured to the diaphragm at the junction of the flexible and dome portions thereof. The diaphragm is secured to and supported by the pole piece 20, the peripheral portion of the diaphragm being positioned between washers 29 of insulating material and held against the pole piece 20 by the ring member 30 and the fastening members 31. The ends (not shown) of the coil may be brought out in any suitable manner to the binding posts or terminals 32 carried by the pole piece 20. Encircling the center pole immediately under the air gap 22 and extending between the center pole and the plate pole is a closure or ring member 33 of non-magnetic material, such as brass, which prevents air flow into or out of the magnetizing coil cavity. A sealing washer or washers or gasket 34 is positioned between the closure member and the plate pole. The center pole contains a sound wave passage 35, preferably tapering exponentially, which expands into the throat 13 of the horn 10. The horn may be appropriately coupled to the receiver by the coupling member 36. The narrow end of the passage 35 expands into a sound chamber 37, frusto-conically shaped, in which is positioned a conical plug member 38 forming with the diaphragm and sound chamber converging passages leading to the passage 35. The surface 39 of the plug member conforms to the curvature of the dome portion of the diaphragm and is closely adjacent thereto. A plurality of thin flat spacer members 40 (one only being shown) maintain the plug member in proper position. A short path between the space 41, under the flexible portion of the diaphragm, and the sound chamber 37, is provided by the perforations 42 in the coil form.

The magnetizing coil or winding 21 comprises coaxial coil portions 43 and 44 of ribbon conductor 45 coated with an insulating varnish, such as bakelite varnish, one of the coil portions being wound counter-clockwise with reference to the other. The inner ends or terminations 46 of the coils are electrically connected by a conductive strip 47 welded, soldered or otherwise suitably attached thereto. To each of the outer ends or terminations 48 of the coil portions is secured a rigid metal stud or terminal 49 surrounding which and against whose flanged end 50 is a plate member 51 which is welded, soldered or otherwise suitably secured to the ribbon conductors on its flat surface. When the magnetizing current is disconnected at the terminals substantially no sparking occurs with the coil arrangement described. The casing 17 has a slot 52 through which extend the terminals 49, insulated from the casing by the washers 53, sleeves 54, and plate 55, all of insulating material. The threaded ends of the studs 49 are provided with knurled wire clamping members 56. The coil portions are separated from each other by a washer or gasket 57 of insulating material and from the magnet casing by the washers 58 and tube 59 each of insulating material.

Increased efficiency with small magnetizing power has been obtained by the use of a ribbon conductor instead of the cotton covered round wire hitherto used in telephone receivers. The size of the magnet structure for a given number of ampere turns and the same magnetizing power may be greatly reduced by the use of a ribbon wound coil in place of a coil of round wire. This is brought out clearly in the following:

The length (l) of the nth turn of a disc layer of the coil is

$$l=2\pi\left[r+\left(n-\frac{1}{2}\right)d\right]$$

and the total length (L) of turns in one disc layer is

$$L=2\pi N\left(r+\frac{Nd}{2}\right)$$

N=total number of turns in one layer
d=overall diameter or thickness of the conductor
r=the inner radius of the coil.

Case 1.—Let the height of the coil remain constant and let the cross-section of the ribbon wire be equal to the cross-section of the round wire. For equal number of turns the resistance (R) of each coil will be proportional to

$$2\pi N\left(r+\frac{Nd}{2}\right)$$

for the wire coil and

$$2\pi N\left(r+\frac{Nd}{4}\right)$$

for the ribbon coil. Assuming

$$r=1'',\ Nd=2\frac{7}{32}''$$

the resistance of the wire coil is K 2.1 and that of the ribbon coil is K 1.55.

The resistance of the ribbon conductor coil is therefore 74% of the resistance of the round wire coil. If the resistance of the ribbon coil is made equal to the resistance of the round wire coil then the copper cross-section of the ribbon wire can be reduced 26%. This reduction decreases the space occupied by the ribbon coil by 20%, assuming no decrease in the insulation on the ribbon wire. The space occupied by the ribbon coil for the same ampere turns and the same resistance, therefore, would be 40% of the space occupied by the round wire coil. This reduction in coil space decreases the size of the magnet. The ribbon wound magnet requires less than 60% of the iron used in a magnet wound with round wire.

Case 2.—Let the height of the coil and the diameter of the coil decrease in the same proportions; the shape of the magnet remaining the same; the cross-section of the wire and the ampere turns the same as in Case 1. The resistance of the ribbon coil in this case will be 85% of the resistance of the round wire coil. Decreasing the size of the ribbon coil so that the resistances of the two coils are equal further reduces the space occupied by the ribbon coil 14%. In Case 2, therefore, the space occupied by a ribbon magnetizing coil is 43% of the space occupied by a round wire magnetizing coil for the same ampere turns and resistances.

Although this invention has been described with particular reference to preferred embodiments thereof, it is to be understood that it is

susceptible of various modifications without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. An acoustic device comprising a diaphragm having an outer peripheral portion, a central stiffened portion, and an intermediate flexible portion, means between which the peripheral portion of the diaphragm is secured, one side of the flexible and stiffened portions of the diaphragm being exposed directly to the air, and means including a magnet for said device forming on the other side of the diaphragm a sound wave passage having an annular open end adjacent a portion of the diaphragm intermediate the central and outermost portions of the stiffened portion.

2. An acoustic device comprising a diaphragm, a hollow coil attached to said diaphragm, means defining a magnetic air-gap for said coil and containing a sound wave passage connecting with a sound chamber adjacent the diaphragm, and a plug member in said chamber spaced from the defining surface thereof and from the diaphragm to form a substantially annular sound path that converges from a portion of the diaphragm within said coil to said sound passage.

3. An acoustic device comprising a diaphragm having a central stiffened portion and a surrounding flexible portion, a hollow coil attached to said diaphragm at the junction of said portions, means defining a magnetic air-gap for said coil and containing a sound wave passage connecting with a sound chamber adjacent the diaphragm, and a plug member in said chamber spaced from the defining surface thereof and from the diaphragm to form a substantially annular sound path that converges from a portion of the diaphragm within said coil to said sound passage.

4. A loud-speaker receiver comprising a diaphragm having a central stiffened portion and a flexible portion joined thereto, a coil attached to said diaphragm at the junction of said diaphragm portions, a magnet having an air-gap in which said coil is disposed, and a sound chamber adjacent the central portion of one side of said diaphragm and defined by a surface converging toward the small end of a tapered sound wave passage in said magnet, and a member in said sound chamber and spaced from its defining surface to form a substantially annular space therewith.

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