

April 24, 1928.

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R. D. FAY ET AL.

SOUND RADIATING DEVICE

Filed Nov. 20, 1925

2 Sheets-Sheet 1

Fig. 1.

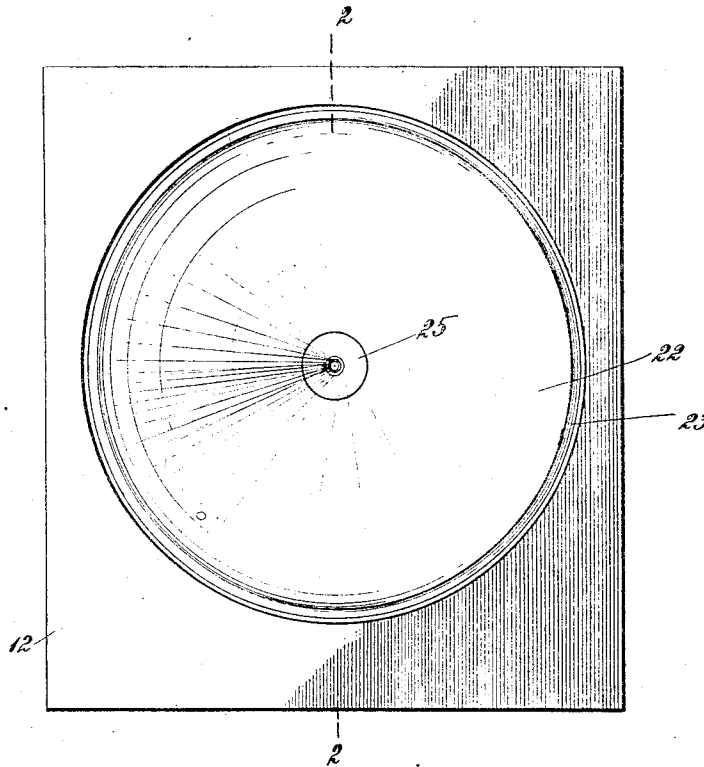
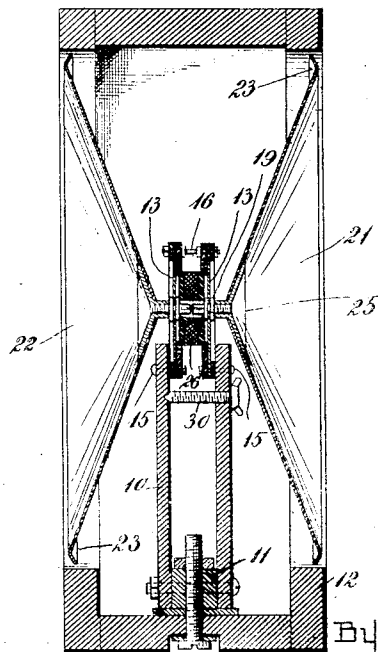


Fig. 2.



INVENTORS:
Richard D. Fay and
Robert E. Brecken
By Geo. K. Woodworth
ATTORNEY

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Fig. 3.

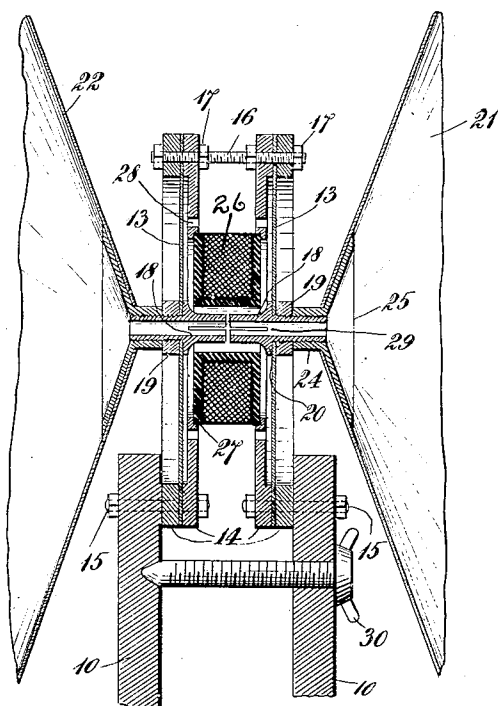
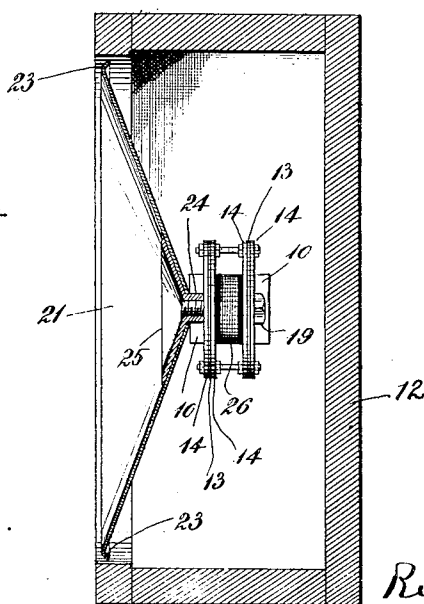


Fig. 4.



By

INVENTORS:
Richard D. Fay and
Robert E. Brewer
George Goodworth
ATTORNEY:

UNITED STATES PATENT OFFICE.

RICHARD D. FAY, OF CAMBRIDGE, AND ROBERT E. BREWER, OF BOSTON, MASSACHUSETTS.

SOUND-RADIATING DEVICE.

Original application filed April 17, 1925, Serial No. 23,917. Divided and this application filed November 20, 1925. Serial No. 70,399.

Our invention relates to an apparatus for radiating sound waves, and is adapted particularly for use with radiophone receiving systems, although capable of more general application and not limited to such use.

It is well known that electromagnetically-operated sound-radiating devices commonly known as "loud speakers" that employ diaphragms, sound chambers and horns are subject to certain limitations chief of which is their inability to reproduce the sounds initiated at the transmitting station without change of pitch and timbre or quality, the main cause of such distortion being the impossibility of eliminating the natural period of the diaphragm and the stationary parts associated therewith. Another limitation to which such devices are subject is the absorption of energy by the stationary parts associated with the diaphragm or other vibrating member and the resulting creation of mechanical vibrations in such parts with the result that, for a given amount of received energy, the amplitude of the sound waves emitted is reduced.

While loud speakers employing sound-radiating members such as plates and cones constructed and arranged to propagate relatively-intense sound waves through the air are in certain respects more satisfactory than those of the diaphragm and horn type and reproduce sounds more faithfully over a somewhat wider range of frequencies, they do not, so far as we are advised, overcome such objections as the undue amplification of sound waves having a pitch approximately equal to the natural period of the vibrating system, the wasting of energy by the creation of vibrations in parts intended to be stationary, and the inability to reproduce notes of the lower frequencies unless the area of the radiating member is prohibitively large.

The principal object of our invention, generically speaking, is to provide an apparatus for the radiation of sound waves of a wider range of frequencies than has heretofore been found possible without unduly increasing the linear dimensions of the sound-radiating member or members, the greatest linear dimension of our device being only about one-thirty-seventh of the wave length in air of the lowest tone to be reproduced, and for the more faithful and efficient reproduction of the quality and pitch of the original sounds than can be effected by the prior methods and apparatus.

Another object of our invention is to provide a sound-radiating device by means of which the sound waves produced by the two surfaces of a sound-radiating member constructed and arranged for the propagation of relatively intense sound waves through the air will be prevented from interfering; or a sound-radiating device having two such sound-radiating members disposed oppositely by means of which the sound waves produced by the inner surfaces of said members are prevented from interfering with those produced by the outer surfaces thereof.

Another object of our invention is to provide a sound-radiating device in which the sound-radiating member is actuated by one of two oppositely-directed armatures each carried by a flexible supporting member together with means for preventing interference between the sound waves produced by the two surfaces of said member; or a sound-radiating device in which two oppositely-disposed sound-radiating members are employed, each actuated by one of said armatures, together with means for preventing interference between the sound waves produced by the inner and outer surfaces of said radiating members.

Various other objects of our invention will hereinafter appear in the detailed description of the several illustrative embodiments of our invention.

Our invention contemplates the use of two oppositely-disposed armatures supported, respectively, by substantially-parallel flexible members, such as relatively-stiff discs, means for magnetizing said armatures by variable electric currents and a sound-radiating member constructed and arranged for the propagation of relatively intense sound waves through the air, as distinguished from a telephone diaphragm or the like, such sound-radiating member, which may be plane, conical or of any suitable configuration, being supported at its center or at its apex, as the case may be, on one of said armatures, together with means for preventing interference between the sound waves produced by the inner and outer surfaces of said ra-

diating member. It contemplates also such use of two oppositely-disposed sound-radiating members of any appropriate shape, conical or otherwise, each supported at its center on one of the armatures aforesaid, and in the case of conical radiating members, each cone preferably flares outwardly from its point of support. In either case we prefer to support the sound-radiating member solely by its actuating armatures.

Our invention comprises means whereby the sound waves produced by the two surfaces of a sound-radiating member constructed and arranged for the propagation of relatively intense sound waves through the air will be prevented from interfering, or means whereby the sound waves produced by the inner surfaces of two such sound-radiating members oppositely disposed are prevented from interfering with the sound waves produced by the outer surfaces thereof, such means consisting in general of an enclosure screening the space between the two surfaces of a single sound-radiating member or the space between the two sets of surfaces where two oppositely-disposed members are employed.

Our invention comprises also a sound-radiating device having two oppositely disposed sound-radiating members constructed and arranged for the propagation through the air of relatively intense sound waves of like pressure phase together with means of any suitable character for preventing interference between the waves produced by the inner and outer surfaces of said members whereby we obtain a reinforcing effect and a hemispherical, rather than spherical, sound wave distribution resulting in the doubling of the radiation resistance for each side which permits the halving of the area of each radiating member without reducing the radiation resistance.

Our invention comprises various parts and combinations of parts hereinafter more fully described and set forth in the appended claims.

In the drawings which accompany and form a part of this specification we have shown in detail various embodiments of our invention which have given good results in practice and also several modifications thereof; but these constructions are to be considered as illustrative rather than restrictive, because the principle underlying our invention may be embodied in a variety of apparatus.

In the drawings—

Figure 1 is a front elevation of a sound-radiating device embodying our invention;

Fig. 2 is a vertical transverse section taken on the line 2—2 of Fig. 1;

Fig. 3 is a section on an enlarged scale corresponding to Fig. 2;

Fig. 4 is a horizontal section of a sound-

radiating device in which only one radiating member is employed.

In the particular drawings selected for more fully disclosing the principle of our invention 10 represents a permanent magnet having two oppositely-disposed, substantially-rigid arms shown in the present instance as bolted to a block 11 of magnetic material which in turn is bolted to the base of the casing 12, although it will be understood of course that we may employ a one-piece permanent magnet of the U or horseshoe shape, or of any other suitable shape. Secured to the inner sides of said arms near the upper ends thereof are two oppositely-disposed and substantially-parallel flexible permeable armature-supporting members 13, 13 which are shown in the present instance as relatively stiff, flexible discs, each clamped between a pair of permeable rings 14, 14 arranged on the opposite faces of each disc near the periphery thereof, by screws or bolts (not shown). In the present instance the discs are secured to the permanent magnet by bolts 15 which assist in clamping the discs between their respective supporting rings.

The bolt 16 of non-permeable metal and the nuts 17 threaded thereon, serve not only to clamp the discs between the rings 14, 14, but also to hold said discs rigidly spaced apart at their circumferences farthest away from their points of attachment to the permanent magnet.

Two oppositely-directed armatures 18 herein shown as tubular, are supported on said discs, respectively, at the centers thereof, and in the present instance each armature is shown as having a threaded end projecting through its supporting disc, on which ends nuts 19 are threaded to clamp the disc between said nut and a shoulder 20 on the armature.

It will be understood of course that any suitable means may be employed for securing said armatures to the discs.

Supported by the armatures in any suitable manner are oppositely-disposed sound-radiating members 21, 22, which may be of parchment, fibre, or any other suitable relatively-thin, stiff, homogeneous material, and preferably the said sound-radiating members, if conical as shown herein, have their peripheral portions slightly bent back, as shown at 23 to slightly stiffen the same near their peripheral edges and thereby prevent substantial deformation thereof by giving said members relatively greater rigidity near their peripheries than at their central portions, whereby the periphery of each member is substantially free to vibrate with the same amplitude as any other portion. As indicated in Fig. 2 every element of the bent portion 23 forms with the plane of the base of the tympanum the same angle as every element of said tympanum.

It will be understood of course that said sound-radiating members, each of which is supported at its center on one of said armatures, are not necessarily conical. In the present instance each conical tympanum or sound-radiating member is supported solely at its apex on its actuating armature by means of a sleeve 24 which passes through the apex and is threaded to the outwardly projecting end of the armature, said sleeve being formed integral with a conical portion 25 to which the tympanum may be attached by gluing or otherwise. When so supported, each sound-radiating member is free to vibrate substantially as a whole. The said sleeve and conical member 25 or whatever other device is employed for coupling the tympanum to the armature, should be of wood, aluminum or other light material.

A magnetizing coil 26 is arranged in the space between the discs and is concentric with the armatures, said coil being wound on an insulating spool 27 supported in the present instance in the rabbeted inner peripheries of the adjacent rings 14. In order to avoid the possible detrimental effects of air compression in the space between the spool and the discs, the inner rings 14 may be provided with a series of holes 28. The juxtaposed faces of the armatures which are separated by a relatively short gap are plane and are normal to the common axis of the two armatures so that they are in absolute parallelism, and in our preferred construction, the said armatures are slotted longitudinally to eliminate eddy current losses, as shown at 29.

When the magnetizing coil 26 is energized by current modified in accordance with sound waves initiated at another point as for example the variable uni-directional currents in the plate circuit of a radiophone receiving system to which said coil is electrically connected, or by variable electric currents of any nature, the constant magnetic flux in the air gap between the armatures created by the permanent magnet will be modified and hence the magnetic pull on the armatures will be changed, and as the same force acts on each armature in opposite directions, the motions of said armatures will be equal and opposite, thereby causing the outer surfaces of the cones to produce sound waves of like pressure phase and the inner surfaces thereof to produce sound waves of like pressure phase opposite to that of the phase of the sounds produced by said outer surfaces. It will be noted that a force acting on any element of the system is balanced by an equal and opposite force on the counterpart of such element so that the tendency of the moving elements to create mechanical vibrations in their associated stationary parts is eliminated and practically all of the energy of motion is converted into sound waves.

This saving of energy is especially important in the reproduction of the lower frequencies and we have succeeded by our invention in reproducing the lowest audible notes with substantially the same facility as those of the upper register by using sound-radiating cones whose diameter is about twelve inches or approximately one thirty-seventh of the wave length in air of the sound made by the lower notes of a piano, say, about thirty cycles per second.

In order to reproduce sounds of low pitch the radiating member must have a comparatively large area because the radiation depends on the square of the area or on the fourth power of the radius if the tympanum is circular, when the radius of the surface is small with respect to the wave length of the sound, provided however that the sound waves produced by the opposite surfaces of the sound-radiating member are prevented from interfering with each other. In the absence of such means for preventing interference practically no radiation can be effected unless the radius is approximately a quarter wave length of the sound, and in the present instance our sound-radiating members would have to be about 220" in diameter in order to radiate waves having a frequency of thirty per second unless such interference was prevented.

We therefore provide means for preventing interference between the inner and outer surfaces of the cones 21, 22, or in the case where a single cone or sound-radiating member of other shape is employed as illustrated in Fig. 4, means for preventing interference between the sound waves produced by the inner and outer surfaces of the single sound-radiating member. Such prevention of interference may be accomplished in a variety of ways, and in the present instance we have illustrated the arrangement which we prefer to use for this purpose, viz., a casing 12 which sufficiently encloses and screens the space between the inner surfaces of said members, or the inner surface of the member 21 in Fig. 4, to prevent the sound waves produced by said inner surfaces (or surface) from interfering with the sound waves produced by the outer surfaces (or surface) thereof, the said casing surrounding at least a portion of the convex side of the sound-radiating member and substantially preventing interference between the sound waves emanating from the convex side and the concave side of said member or members.

Inasmuch as the outer surfaces of the cones create sound waves of like pressure phase and interference between said waves and those produced by the inner surfaces is prevented, we obtain substantially the same reinforcing effect as if a rigid medial plane through which sound waves could not pass were placed between the cones normal to the

axis of the armatures, and also a hemispherical, rather than a spherical, sound-wave distribution which results in the doubling of the radiation resistance for each side,—in other words, the area of each surface may be halved without reducing the radiation resistance.

The length of the gap between the armatures may be adjusted by means of the screw 30 threaded into one of the arms of the magnet 10 and having its end bearing against the other.

Fig. 4 shows a sound-radiating device embodying our invention that is particularly designed for incorporation in the cabinet of a radio receiving set. In this construction the free armature is found to react on the armature which supports the sound-radiating member 21 and to reinforce its action. The nut 19 whereby the free armature is clamped to one of the discs 13 may be slightly larger than the corresponding nut shown in Fig. 3 for securing the other armature to the other disc, if the latter nut be employed, or, as shown in Fig. 4, the threaded sleeve 24 may serve to clamp the non-supporting armature to its disc. In either case the weight of said nut on the free armature will serve in a certain degree to compensate for the reduction of weight resulting from the omission of the cone 21. There is evidently a magnetic coupling between the armatures which tends to balance the two sides of the vibrating system.

Without limiting ourselves to any specific type of cone, or in fact to a sound-radiating member of any particular shape, we prefer to employ conical sound-radiating members capable of producing sound waves having wave fronts which are initially curvilinear as claimed in our application Ser. No. 69,368,

filed Nov. 16, 1925 as a division of our application, Ser. No. 23,917, filed Apr. 17, 1925.

This application is a division of our application Ser. No. 23,917, filed Apr. 17, 1925.

Having thus described illustrative embodiments of our invention without however limiting ourselves thereto, what we claim and desire to secure by Letters Patent are:—

1. In a sound-radiating device, two oppositely-disposed sound-radiating members constructed and arranged for the propagation through the air of relatively intense sound waves of like pressure phase, and means for preventing interference between the sound waves produced by the inner and outer surfaces of said sound-radiating members.

2. In a sound-radiating device, two oppositely-disposed sound-radiating members constructed and arranged for the propagation through the air of relatively-intense sound waves of like pressure phase, and means sufficiently enclosing and screening the space between the inner surfaces of said members to prevent interference between the sound waves produced by the inner and outer surfaces thereof.

3. In a sound-radiating device, a free-edge conical tympanum of relatively-thin, stiff, material having its peripheral portion reversely bent to increase the peripheral rigidity thereof, every element of the bent portion of said tympanum forming with the plane of the base of said tympanum the same angle as every element of said tympanum.

In testimony whereof, we have hereunto subscribed our names November, 1925.

RICHARD D. FAY.
ROBERT E. BREWER.