

Aug. 15, 1939

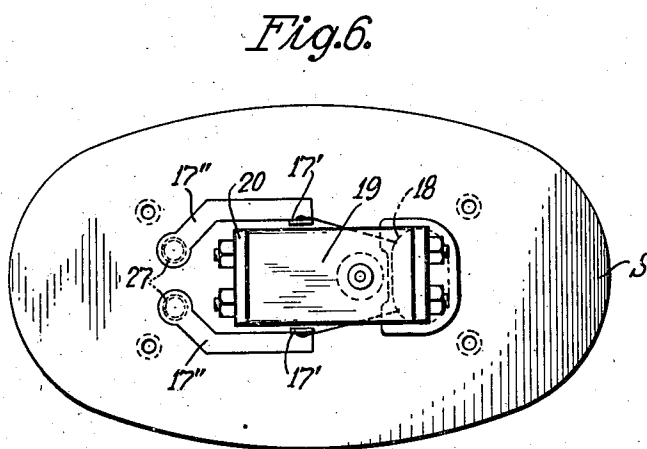
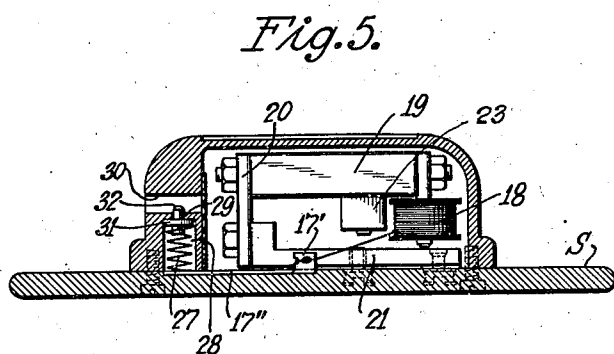
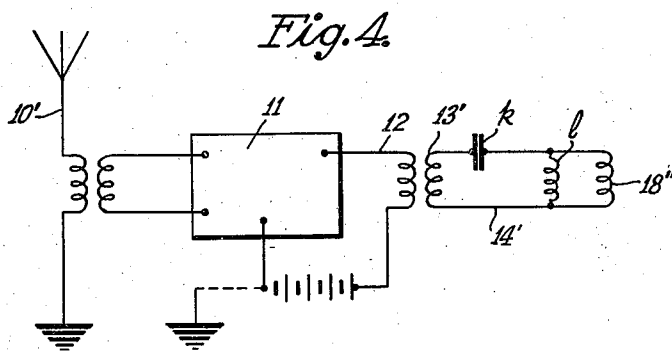
S. G. SEARS

2,169,744

SOUND REPRODUCING SYSTEM

Filed Dec. 7, 1936

2 Sheets-Sheet 2



INVENTOR.

Sterling G. Sears
 BY *Watson, Bristol, Johnson & Leavenworth*
 ATTORNEYS.

UNITED STATES PATENT OFFICE

2,169,744

SOUND-REPRODUCING SYSTEM

Sterling G. Sears, Garden City, N. Y., assignor to
Dictograph Products Company, Inc., New York,
N. Y., a corporation of Delaware

Application December 7, 1936, Serial No. 114,621

2 Claims. (Cl. 179-169)

This invention relates to sound reproducing systems, and more particularly to systems designed for the reproduction of sound with a volume and quality adapted for use in the field served by loudspeakers but may also be used by persons hard of hearing.

More particularly, the invention relates to devices for reproducing sound with high fidelity that are adapted for use in conjunction with ordinary sources of sound to be reproduced, such as phonographs, radio receivers, and the like, whereby persons using the devices may hear the sound with a desired effect.

The invention has for its object generally the provision of a system of the character indicated which is small and rugged and highly efficient and may be used to service persons of normal hearing and also persons hard of hearing under certain conditions.

Another object is to provide a device that is relatively small and light in weight and is of the inertia type for reactively driving the sound propagating diaphragm whereby the quality of the sound reproduced is unaffected by pressure on the diaphragm.

Still another object is to provide a device that may be used by persons hard of hearing in which the range may be varied to permit the user to select the sound perceived with a desired quality.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements and arrangement of parts, which will be exemplified in the construction hereinafter set forth and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a view, partly schematic and partly in section, showing a system embodying the invention;

Fig. 2 is a sectional view showing a modified form of sound reproducing device that may be used in the system of the present invention;

Fig. 3 is a diagrammatic chart showing the volume-frequency characteristic of a device constructed in accordance with the invention;

Fig. 4 is a schematic view showing a system in which the desired response characteristic is obtained electrically;

Fig. 5 is a sectional view showing still another

modification of a speaking device that may be used in the system of the present invention; and Fig. 6 is a plan view of the device shown in Fig. 5.

When the constants of a sound reproducing device are arranged to have relatively good efficiencies in both the high frequencies and the low frequencies, the perceived effect is said to be normal, a normal response characteristic being depicted in Fig. 3 by curve *z* in the drawings. Such response is approached in telephone receivers and loudspeakers, but has not been achieved with reactively driven sound reproducing devices, as shown, for example, in the U. S. patent to Reynolds, No. 1,630,028, dated May 24, 1927.

In accordance with the present invention, a response characteristic satisfactorily approaching normal may be attained with reactively driven sound reproducing devices, when driving relatively extended diaphragms and employed in free air. In such case, the driven member advantageously has a mass comparable with that of the driving part. The use of a reactively driven or inertia type vibrating mechanism permits the mechanical construction of the device and the housing for the vibrating mechanism to be provided in a relatively small space, which is advantageous. Also, the performance of the device is substantially unaltered by the application of pressure of external origin to the parts of the device, by reason of the constancy of the air gap employed in inertia type of vibrating mechanism. While the dimensions of the air gap are, of course, periodically altered by small displacements when the parts of the mechanism are vibrating, it is seen the average width of the air gap is substantially a fixed quantity and is the characteristic of the air gap of an inertia device. The performance of the device is hence substantially independent of external pressure. Such device may accordingly be used for the reproduction of sound with satisfactory perception characteristics in fields heretofore impossible of being serviced by sound reproducing devices, for example, for reproducing sound with a desired response in a sound absorbent medium.

Sound reproducing devices provided in accordance with the invention are found to be practical for reproducing sound in free air for those with faulty hearing. Such devices are also found to be practical as bone conduction hearing aid devices when the vibrated member is placed in direct contact with the bones of the head. Such devices when employing a diaphragm extended

as indicated to increase the baffle effect, may be used by persons hard of hearing by applying sufficient electrical energy to give a volume which overcomes the deficiency of the ear and to allow the user to adjust the tone characteristic or response range to suit the individual needs of the user, by proper placement over the ear.

A sound reproducing device, provided in accordance with the invention, may employ various constructions, for example, the size, shape, and electrical constants may be modified to accentuate the response of the device in certain regions, such as in the high frequencies, to compensate for the response imparted by baffling in order thereby to achieve a normal flat characteristic. Where a person of normal hearing is desirous of having sound reproduced with a flat characteristic under the unusual circumstances, for example, when the sound is transmitted through an absorbent medium, the constants are altered to provide a peaked response to compensate for the absorption. Hence, it is seen that a substantially normal characteristic may be attained under substantially any condition of use.

The source of the electric impulses for electromagnetically driving the vibrating mechanism may be any suitable source, for example, the output of a phonograph which employs a magnetic pick-up, or the output of a radio, telephone, or other convenient source.

Referring now to the drawings, and particularly to Fig. 1, 10 denotes a source of primary electric impulses here represented as had from a magnetic pick-up of a phonograph. The device 10 is connected to a suitable amplifier symbolically denoted 11, which supplies a coil 12 that may be the primary of a transformer having a secondary 13 for supplying current to a suitable electromagnetic driving means through conductors 14; the driving means being arranged to actuate a speaking device such as shown generally at R.

The speaking device R, according to the present invention, is preferably disconnectably connected with the source of actuating current. Accordingly, conductors 14 lead to a plug-in device 16; a control switch 15 being preferably inserted in the connections. From the plug 16 lead conductors 17 to a coil or winding 18 which comprises the driving or actuating means for the system which comprises the vibrating mechanism that vibrates diaphragm or member S of the device R. This mechanical system has articulated members 19, 20, and 21 arranged to form a tuning fork with the coil 18 disposed between the prongs. One prong, namely, member 21, is fixed to the diaphragm S so as to drive the same reactively; the system being disposed in a housing H that is secured to the diaphragm S. In this arrangement, the coil 18 is preferably mounted on a core member that is attached to the free prong 19, the core terminating short of the fixed prong 21 so that there is a relatively small air gap therebetween, as shown at 22.

The diaphragm S is preferably extended beyond the housing H to an extent which accomplishes the desired air coupling; for example, the diaphragm may be in the neighborhood of 2 inches in diameter. The driving system, in consequence, is relatively small and may be enclosed in a housing in the neighborhood of 1½ inches in length and ½ inch in both width and height.

The volume-frequency response of the air coupled device shown in Fig. 1 is depicted in Fig. 3, which illustrates curves drawn so that the ordinates represent volume, while the abscissa represent frequencies.

The flat perception characteristic desired for persons of normal hearing is represented by the curve *u*. Where a diaphragm of extended surface is employed in a bone conduction device in accordance with the present invention, improved response is produced for the low frequencies by the action of the extended surface covering the external auditory canal. Persons of normal hearing using such an extended diaphragm would, in consequence, receive a pleasant and natural type of reproduction, in accordance with the curve *u* shown in Fig. 3.

This type of response will result from an instrument peaked in the neighborhood of 4000 cycles per second, as depicted in the curve *w*, which represents the response in free air when used as described. However, if the device is not held in intimate contact with the external auditory canal, a response characteristic intermediate to the curves *u* and *w* is had, and is depicted in curve *v*. Satisfactory results, however, can be obtained with response characteristics with peaks located in the region of from 2000 to 6000 cycles per second. Response characteristic curves having such properties are shown in the drawings at *w'* and *w''*. It is important when accentuating frequencies in this region that so-called high frequency noise be reduced, such as record scratch and the like. The reduction of these noise frequencies, however, should be only to the extent which gives an agreeable tone value and not to an extent which affects the quality of the music or speech.

To introduce the desired response characteristics mechanically into the system shown in Fig. 1, the resonance characteristics thereof are so proportioned as to peak the response in accordance with the curve *w*. This may be accomplished, for example, by stiffening the yoke or reed member 20. The ratio of high frequency to low frequency may be increased by increasing the stiffness in any suitable manner, for example, by altering the cross-section of the reed or yoke 20 to increase its thickness. Stiffness being also dependent on the material employed, the desired increase may also be achieved by using harder material, or by the combined use of a harder material and an altered cross-sectional dimension. Also it will be readily understood that the area and stiffness of the diaphragm S may be altered to impart additional modification to the response characteristics. For example, the surface of the diaphragm S may be increased to increase the ratio of low frequency to high frequency energy in the sound response.

In the modification shown in Fig. 2, the vibrating surface of the diaphragm is not made plane but has a conical configuration. In this form of device, the relatively light but stiff surface is indicated at T. This may be made of any suitable material, such as a molded cellulose product with acetate base. The mechanical system which drives the diaphragm is shown as comprising articulated members 19', 20', and 21', which form a tuning fork that is electromagnetically driven by a winding 18' supplied with actuating current through conductors 17 as in Fig. 1. The fixed prong member 21' is rigidly secured to the diaphragm near the apex by means of studs as indicated at 24. The free prong member has a support 25 thereon which supports the connections to which the terminals of the winding 18' are led and secured. Here, the members comprising the driving mechanism are not only stiffened to a

desired extent but the mass is increased by adding a projecting weight 26 thereto. It will be perceived that by positioning the weight 26 to project at the end of the member 19', the center of percussion of the system is changed and brought toward the winding 18', so that it is substantially over the apex of the cone. In this manner, a particularly advantageous driving action is achieved. The back of the diaphragm T is closed by a layer of non-resonating material t, such as a sheet of cloth, that is secured about the periphery of the conical diaphragm in any convenient manner.

In this form of device, the operation is substantially the same as that shown in Fig. 1, the response characteristic being such as to give sound perceived with the desired flat characteristic in consequence of the modification imparted by increasing the mass of the driving system, thereby making the response quite uniform throughout the audible region.

The circuit of the electromagnetic driving means is seen to comprise the windings 13 and 13' which are connected by the conductors 17. This circuit in order to operate with a maximum efficiency preferably has matched impedances at 13 and 13'. Where it is desired to impart the response characteristics electrically to the translating device of the present invention, this driving circuit is modified to shift the resonance characteristic to a point corresponding to the peak in the curve w. This is accomplished by introducing suitable elements of inductance and capacitance in the driving circuit as illustrated in Fig. 4. Here, primary electric impulses corresponding to the sound to be reproduced are the modulations of a radio carrier that is collected by an antenna 18' coupled to the amplifier 11 that supplies a winding 12. This winding may be the primary of a transformer whose secondary 13' feeds its output through conductors 14' into the electromagnetic driving means comprising a winding 13'' of the speaking device (not shown in the interests of clearness of illustration in the drawings). The circuit comprising windings 13' and 13'' and conductors 14' is modified by the introduction of the elements of impedance which may be accomplished in any one of several ways, for example, by introducing an element of inductance l in shunt with the winding 13'' and an element of capacitance k in series therewith, the values being chosen so that the response characteristic of the diaphragm approaches that of the curve w.

In the modification of Figs. 5 and 6, an arrangement for a speaking device similar to that of Fig. 1, but providing the plug-in connections in the housing H of the device, is shown. Here, the diaphragm S is driven by means of the mechanical system comprising members 19, 23, and 21, the member 19 having a weight 23 attached. The coil 18 has its terminals conductively secured to terminal lugs 17' struck up from flat conductors 17'' that are embedded or molded in suitable grooves formed in the inner side of the diaphragm S. These grooves are preferably so located as not to extend beyond the edges of the housing H and are, therefore, closed and protected by it. The conductors 17'' terminate in enlarged portions so as readily to make contact with the spring-like conductors 27 that engage therewith and are housed in cylindrical bores 28 formed in the end of the housing H and having their axes lying substantially in a plane perpendicular to the longitudinal axis of the housing. The interior ends of the bores 28 have reduced bores 29

centrally placed and penetrating further into the housing. This penetration is sufficient to establish communication with the bores 30 that are parallel to the longitudinal axis of the housing and enter from the outside. The diameter of each of the bores 30 is sufficient to accommodate the terminals of the conductors, such as those shown at 14, which supply the electric impulses representing the sound to be reproduced. In each of the bores 28 is disposed a plunger member 31 which is placed on the spring-like conductor 27 in the bore and pressed against the end of the bore, each plunger having a reduced portion 32 that is arranged to extend through the reduced bore 29 that communicates with the bore 30. The extension of the portion 32 is such as to penetrate only partially into the bore 30, in order thereby to make yielding but frictional contact with the terminal member that may be inserted therein.

In each of the forms described, it is seen that an air gap of substantially constant dimensions is employed. In consequence, the performance of the device is substantially unaffected by the application of pressure to the diaphragm or extended vibrated member. Such devices may hence be described as resistant to volume or tone change. By reason of this fact also it is practical to use such devices as variable range hearing aid devices for the hard of hearing. No matter how gripped or held, the mechanical performance of such devices is substantially the same. By a suitable selection, however, of the range at which such device is used, the person using the same may achieve the effect of varying the effective air coupling, as pointed out above, and hence vary the quality of the sound perceived so as to obtain a desired effect.

It is seen, in consequence, that such devices are particularly adapted for use with group hearing aids, as, for example, in theaters and motion-picture houses, where it is desired to have sound supplied from suitable outlets distributed around the theater or moving-picture house.

Since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, for example, by proportioning the magnetic circuit so that when used on a hearing aid of the battery operated type, battery current flowing through the actuating winding would not alter the constants from the desirable, but would make an efficient substitute for the heavier and bulkier bi-polar ear-piece, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a loudspeaker, the combination of a portable enclosed casing, at least one side of which forms an extended member adapted to be electrically vibrated for the propagation of sound at audible volume and at voice frequencies, a vibrating mechanism in the casing comprising members arranged in the form of a tuning fork, one of the prongs thereof being secured to the said extended member for reactively imparting vibrations thereto, electro-magnetic driving means disposed between the prong members of the said mechanism at the open end thereof, and means for imparting mechanical mass and stiffness to the said vibrating mech-

anism to alter the frequency response of the system.

5 2. In a loudspeaker, the combination of a portable enclosing casing adapted to be bodily vibrated for the propagation of sound at audible volume and at voice frequencies through an elastic medium, at least one side of said casing being of extended area, and a vibrating mechanism in said casing comprising a massive element, means connecting one portion of said

element to the said side with the other portion of the element extending free of said side and substantially parallel thereto, and electrical means for causing vibration of said freely extending portion of said element, said connecting means providing vibration of said side and the remainder of the casing by reaction in response to the vibration of the freely extending portion of said element.

STERLING G. SEARS. 10