April 28, 1970 YASUNORI MOCHIDA ET AL 3,509,290

FLAT-PLATE TYPE LOUDSPEAKER WITH FRAME MOUNTED DRIVERS

Filed Nov. 22, 1966 4 Sheets-Sheet 1

FIG. 1(A)

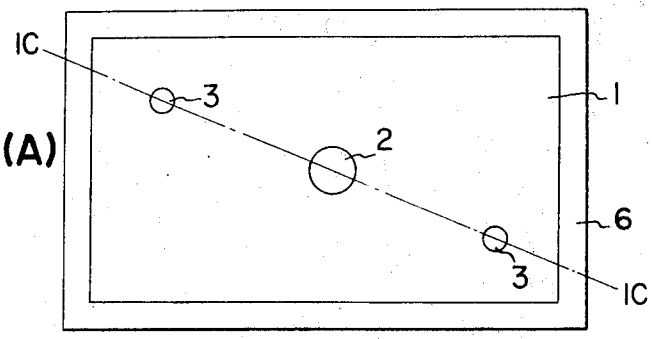


FIG. 1(B)

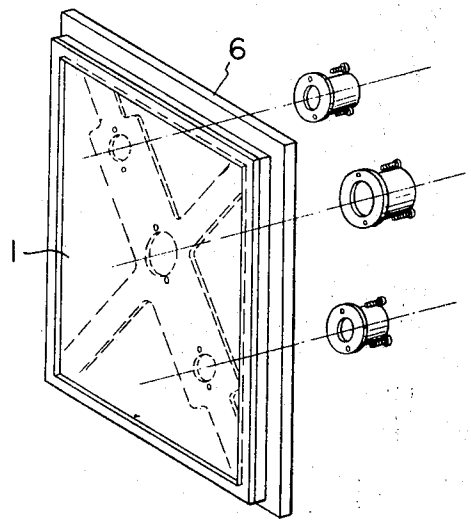


FIG. 1(C)

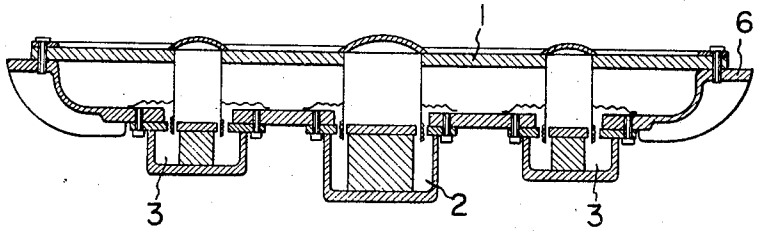


FIG. 2

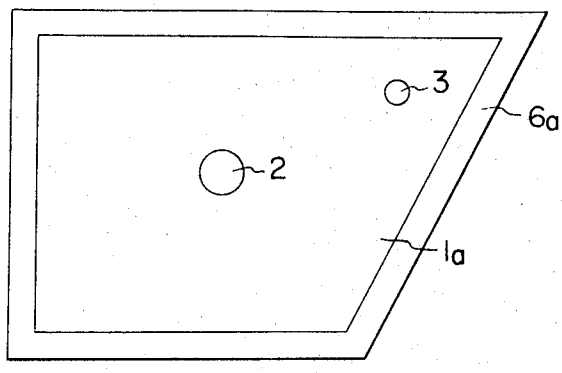
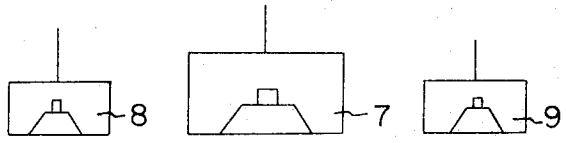


FIG. 3



PRIOR ART

FIG. 4

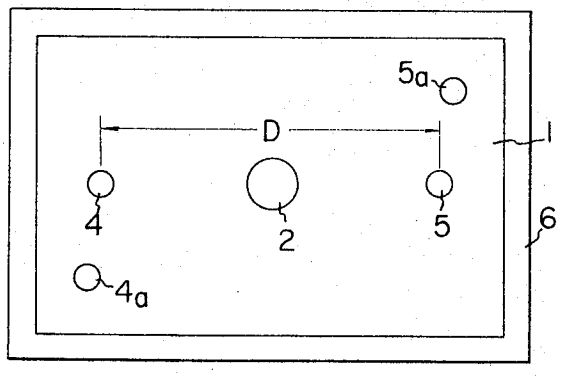


FIG. 5

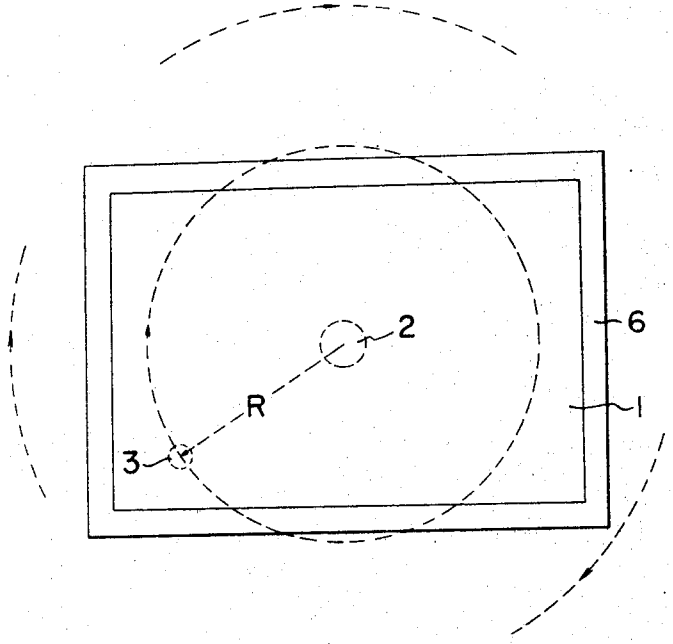
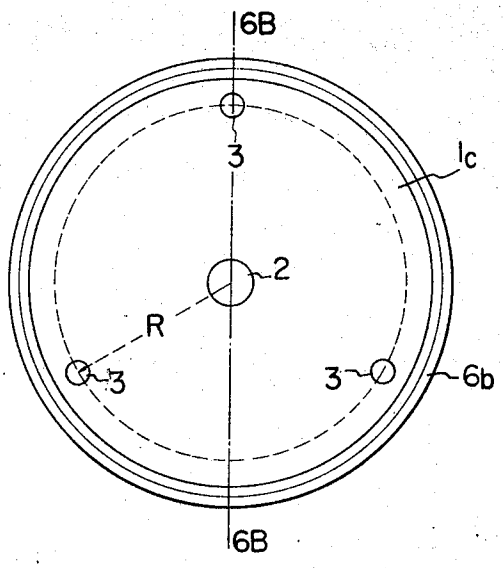


FIG. 6(A)

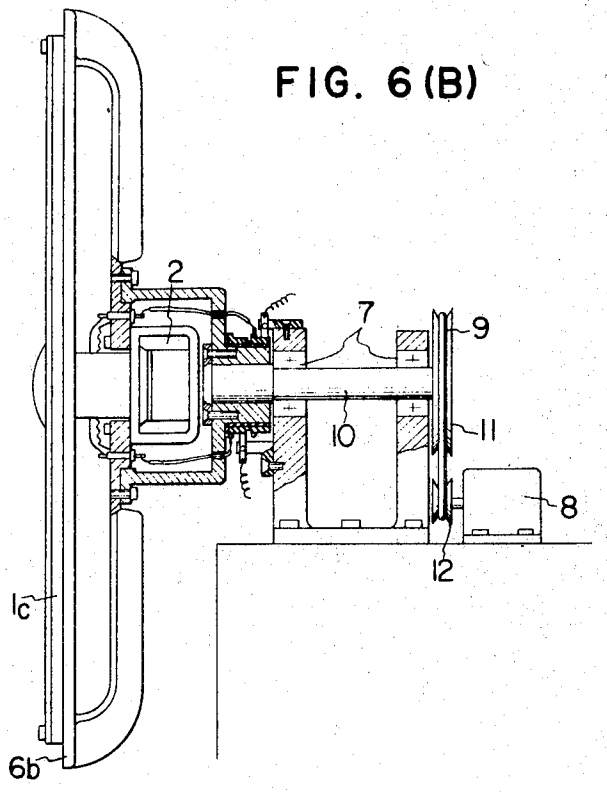


April 28, 1970 YASUNORI MOCHIDA ET AL 3,509,290

FLAT-PLATE TYPE LOUDSPEAKER WITH FRAME MOUNTED DRIVERS

Filed Nov. 22, 1966 4 Sheets-Sheet 4

FIG. 6(B)



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FLAT-PLATE TYPE LOUDSPEAKER WITH FRAME MOUNTED DRIVERS

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Int. Cl. H04r 9/04
U.S. Cl. 179—115.5 1 Claim

ABSTRACT OF THE DISCLOSURE

A loudspeaker comprising a diaphragm plate made of foamed polystyrene in a substantially flat shape having substantial thickness throughout the plate, a supporting frame, a bass-tone driver and treble-tone drivers, periphery of the diaphragm being fixed to the supporting frame, the bass tone driver being supported by the supporting frame and connected to the diaphragm at its central portion, and the treble-tone drivers being supported by the supporting frame and connected to the diaphragm near peripheries thereof.

This invention relates to loudspeakers and more particularly to a new and improved flat-plate type loudspeaker in which a driving means for bass tones and at least one driving means for treble tones are disposed separately on a single diaphragm plate.

The term "driver" is herein used to designate a diaphragm driving means such as a voice coil, moving coil, or armature.

Heretofore, the diaphragm plate of a flat-plate type loudspeaker has, in general, been made of a substantially homogeneous material throughout its entire structure and has been driven at its central part. When a diaphragm plate is driven at its central part, optimum radiation efficiency is attained in the low-frequency region of approximately 300 cycles/second or lower, but for sounds in the medium- and high-frequency regions above 1,000 cycles per second, the effective mass is very great, whereby the radiation efficiency goes lower. Furthermore, when the bass tones and the treble tones are emitted simultaneously, the vibration of treble tone is superposed on the large amplitude of the bass tone, whereby intermodulation distortion occurs.

It is an object of the present invention to overcome the above described difficulties.

More specifically, it is an object of the invention to increase the radiation efficiency of a loudspeaker for treble tones.

Another object of the invention is to eliminate or greatly reduce intermodulation in loudspeakers.

Still another object of the invention is to provide a loudspeaker diaphragm plate which is driven at separate parts thereof respectively for base tones and treble tones.

A further object of the invention is to provide a loudspeaker having a single diaphragm plate whereby three-dimensional stereophonic sound reproduction can be accomplished.

A still further object of the invention is to provide a loudspeaker in which a rotational effect can be attained.

According to the present invention, briefly stated, there is provided a flat-plate type loudspeaker characterized by the combination of a diaphragm plate which is not of the free edge supported type, a frame holding the peripheral edge of the diaphragm plate, a driver for bass-tones coupled to the diaphragm plate at or in the vicinity of the centre of gravity thereof, and one or more drivers for treble tones each coupled to the diaphragm plate at a respective position near the peripheral edge thereof.

According to the present invention, in one specific aspect thereof, there is provided a loudspeaker of the above stated character in which the driver for bass tones and the driver for treble tones are respectively supplied with bass-tone signals and treble-tone signals derived from the signals of one and the same monochannel.

According to the present invention, in another specific aspect thereof, there is provided a flat-plate loudspeaker in which two drivers for treble tones are disposed apart respectively on left and right sides of the driver for bass tones and supplied respectively with the treble-tone signals of left and right channels of a stereophonic signal source, and the driver for bass tones is supplied with the bass-tone signals mixed from both said left and right channels.

According to the present invention, in a further aspect thereof, there is provided a flat-plate loudspeaker which is provided with a central bass-tone driver and one or more treble-tone drivers spaced apart from the bass-tone driver, and which is adapted to rotate about an axis passing through the centre of gravity thereof perpendicularly to the plane of the diaphragm plate.

The nature, principles, and details of the invention will be more clearly apparent from the following detailed description with respect, principally, to preferred embodiments of the invention when read in conjunction with the accompanying drawings in which like parts are designated by like reference numerals.

In the drawings:

FIG. 1A is a planar schematic view showing an example of a loudspeaker embodying the invention;

FIG. 1B is a perspective view of the loudspeaker of FIG. 1;

FIG. 1C is a sectional detailed view along the line 1C—1C of FIG. 1A;

FIG. 2 is a planar view showing another embodiment of the invention;

FIG. 3 is a simplifier side view showing a conventional arrangement of loudspeakers for three-dimensional stereophonic sound reproduction;

FIG. 4 is a planar view showing an example of a loudspeaker according to the invention for three-dimensional sterephonic sound reproduction;

FIG. 5 is a schematic planar view showing one example of a rotary loudspeager according to the invention;

FIG. 6A is a schematic planar view showing another example of a rotary loudspeaker according to the invention; and

FIG. 6B is a detailed side view, partly in section, along the line 6B—6B in FIG. 6A and showing an actual embodiment corresponding to the example of FIG. 6 in which the treble-tone driver being omitted.

Referring first to FIGS. 1A, 1B and 1C illustrating the first embodiment of the invention, the loudspeaker shown has a rectangular diaphragm plate **1** provided with a driver **2** for bass tones (approximately below 1,000 c./s.) disposed in the vicinity of the central part of the diaphragm plate **1** and drivers **3** for treble tones (approximately above 1,000 c./s.) disposed apart from the central part of the diaphragm plate **1** in corner parts thereof near the peripheral edge thereof.

The entire peripheral or outer edge of the diaphragm plate **1** is held by a frame **6** whereby the outer edge is not a free edge. For this diaphragm plate **1** which is a substantially flat plate, a foamed polystyrene or some other foamed synthetic resin is suitable. In the example shown in FIGS. 1A, 1B and 1C, two drivers **3** for treble tones are used.

In the second embodiment of the invention as illustrated in FIG. 2, the loudspeaker is provided with a diaphragm plate **1***a* of trapezoidal planar shape. A driver **2** for bass tones (below 1,000 c./s.) is disposed at the centre of gravity of the diaphragm plate **1***a*, and a driver **3** for treble tones (about 1,000 c./s.) is disposed near the corner thereof formed by the most acute one of the four angles.

In the embodiments of the invention illustrated in FIGS. 1A, 1B, 1C and 2, the disposition of the drivers **3** for treble tones in the vicinity of the edge of the diaphragm plate **1** causes the effective mass imposed on these drivers **3** (that is, the mass to be driven thereby) to be small, whereby the radiation efficiency for treble tones is high. This radiation efficiency can be increased even further by increasing the rigidity of the diaphragm plate in the neighborhood of the parts driven for treble tones, for example, by stiffening these parts with thermosetting resin such as phenol resin and epoxy resin applied thereon by lamination or impregnation.

Since the diaphragm plate **1** is driven in the vicinity of its central part for bass tones, its amplitude for bass tones is the greatest in the vicinity of the central part and is small in the vicinity of the edge. Since the diaphragm plate **1** is driven for treble tones in the part near the edge where the amplitude for bass tones is small, the influence of the large amplitude of bass tones on each driver for treble tones is small. Accordingly, intermodulation distortion is low.

From the above description, it will be apparent that the loudspeaker according to the invention can be used as an improved type for the so-called two-way system wherein the diaphragm plate is driven by transmitting monochannel bass-tone signals to the driver for bass tones coupled to the diaphragm plate in the vicinity of the central part thereof and transmitting monochannel treble-tone signals to the drivers for treble tones coupled to the diaphragm plate near the edge thereof.

Furthermore, the loudspeaker according to the invention can be used also as a three-dimensional stereophonic loudspeaker. For this purpose, signals containing a mixture of bass tones from two channels (left and right) are transmitted to the bass-tone driver in the central part of the diaphragm plate, and the treble-tone signals respectively of the two channels, distinguished as left and right channels, are transmitted respectively to the bass-tone drivers disposed apart on the left and right.

In a conventional three-dimensional loudspeaker system, a bass-tone loudspeaker **7** is installed in the centre, and treble-tone loudspeakers **8** and **9** respectively for the left channel and for the right channel are respectively installed on the left and right of the bass-tone loudspeaker **7** as shown in FIG. 3. Accordingly, at least three loudspeakers are required.

In contrast, the present invention affords, through the use of a single loudspeaker, a loudspeaker system for three-dimensional stereophonic sound reproduction which has high performance and is economical. That is, bass tones are emitted not only from the central part but from the entire diaphragm plate. Accordingly, the disadvantageous feature of conventional three-dimensional systems of only bass tones being audible from the centre is overcome, and bass tones having a wide expanse are produced, whereby the feeling of presence is increased.

In still another embodiment of the invention as illustrated in FIG. 4, the loudspeaker has a rectangular diaphragm plate **1** driven at its central part by a bass-tone driver **2** and held at its edge by a frame **6**. The diaphragm plate **1** is further provided with treble-tone drivers **4** and **5** respectively for left and right channels and disposed near the right and left sides of the diaphragm plate **1**.

The distance D between the centres of the treble-tone drivers **4** and **5** is selected to be appropriate for stereophonic reproduction, a suitable value thereof being, for example, approximately 60 cm. for 90 cm. x 60 cm. diaphragm plate. In the case where it is desired to increase this spacing distance D, it is possible also to couple the drivers in positions **4***a* and **5***a* on a diagonal line.

Another advantageous feature of the loudspeaker of the invention is that, by driving the loudspeaker in rotation by means of a suitable motor, a rotational effect can be obtained.

In one embodiment of the invention utilizing this feature as indicated in FIG. 5, the bass-tone driver **2** is coupled to the diaphragm plate **1** near its centre of gravity, and a treble-tone driver **3** is provided near the edge thereof at a point spaced apart by distance R from said centre of gravity. As described before, the edge of the diaphragm plate **1** is held by a frame **6**. This loudspeaker is rotated by a motor (not shown) about an axis which passes through the centre of gravity of the diaphragm plate **1** perpendicularly to the plane of the plate **1**.

FIG. 6A illustrates an example of a flat-plate loudspeaker having a diaphragm plate **1***c* of a circular planar shape and a frame **6***b* supporting said diaphragm plate **1***c*. This loudspeaker differs from that shown in FIG. 5 only in the planar shape of the diaphragm plate and, in actual operational effect, is the same as that shown in FIG. 5. The rotating means may be of any suitable one such as indicated in FIG. 6B, in which a rotary shaft **10** supporting the diaphragm plate **1***c* is rotatively supported by bearings **7** so as to be rotated by means of an electric motor **8** through a belt **9** and pulleys **11** and **12**.

While the operational results improve with increase in the distance R of the treble-tone driver **3** from the centre of gravity, fully satisfactory results can be obtained with a distance R of approximately 40 cm. Furthermore, while the effects attained differ with the rotational speed, a chorus effect is attainable at a speed of from 30 to 150 r.p.m., and a tremolo effect can be obtained at a speed of from 300 to 450 r.p.m on account of frequency modulation due to the Doppler effect.

In this rotary loudspeaker, since the bass tones are radiated from the entire surface of the diaphragm plate, the rotational effect is small, yet there is some rotational effect. This is convenient since a pronounced rotational effect is not desirable for bass tones. Furthermore, since the treble-tone driver is disposed at the peripheral part of the diaphragm plate, its radiation efficiency is excellent, and, at the same time, it describes a locus with a radius equal to the aforementioned distance R during rotation, whereby a pronounced rotational effect (i.e., a chorus or tremolo effect) can be obtained.

From the foregoing disclosure, it is to be observed that the present invention affords a loudspeaker of high efficiency and low intermodulation by use of a single diaphragm plate of flat-plate type which is held around its edges and is provided near its central part or centre of gravity with a bass-tone driver and near its edge with at least one treble-tone driver.

The loudspeaker according to the invention, furthermore, can be widely applied as a loudspeaker for two-way sound reproduction, a loudspeaker for three-dimensional stereophonic sound reproduction and as a rotary loudspeaker.

It should be understood, of course, that the foregoing disclosure relates to only preferred embodiments of the invention and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the invention as set forth in the appended claims.

What we claim is:

1. A flat-plate type loudspeaker comprising a diaphragm plate, a frame secured to and holding the peripheral edge of said diaphragm plate, a driver for bass tones having a voice coil and coupled through its voice coil to the diaphragm plate in the vicinity of the center thereof, at least one driver for treble tones having a

voice coil and coupled to the diaphragm plate at a respective position near the peripheral edge thereof, means mounting said drivers on said frame, the planar shape of the diaphragm plate being a circle, means for rotating said frame to provide rotation of said diaphragm plate about an axis through the center of gravity thereof perpendicular to the plane of the diaphragm plate, and at least three drivers for treble tones disposed at equal intervals on the circumference of a common circle with its center coincident with said axis of rotation.

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WILLIAM C. COOPER, Primary Examiner

U.S. Cl. X.R.

179—181; 181—31