March 21, 1961 D. M. CHAVE 2,975,852

LOUDSPEAKERS

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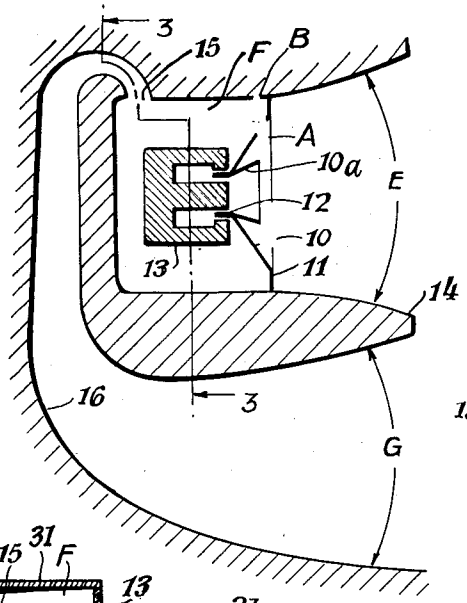


Fig. 1

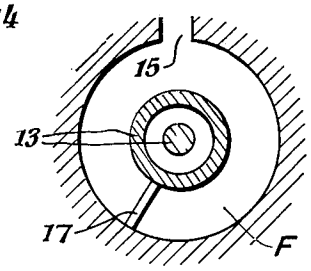


Fig. 3

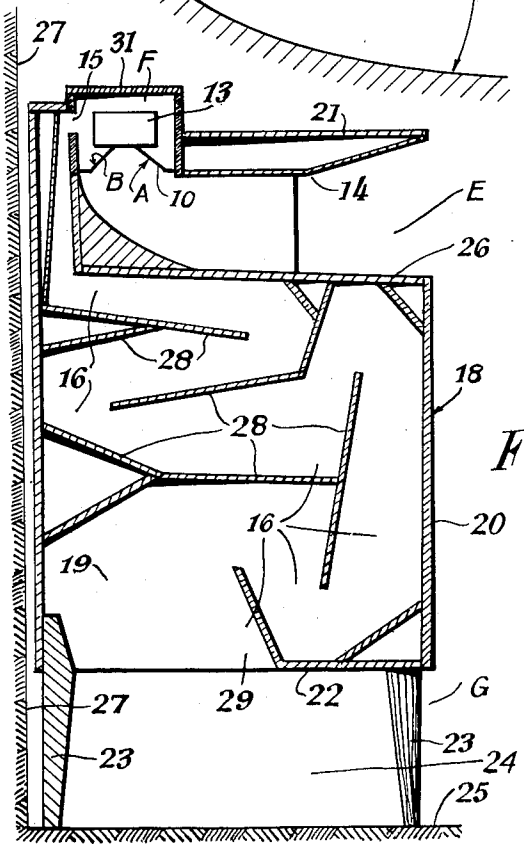


Fig. 2.

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LOUDSPEAKERS

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6 Claims. (Cl. 181—31)

This invention relates to loudspeakers and it has for an object to provide an improved loudspeaker unit which enables a loudspeaker to be built having extremely good working characteristics, more particularly as regards the high quality reproduction of music, speech and other sounds, say from the radio or from recordings.

It is a further object of the invention to produce a loudspeaker, the size of which, taken into consideration with the range of musical frequencies reproduced, is relatively small, while the transformation of energy from an electrical to an acoustical form is efficient, thereby enabling it to be operated from an electrical amplifier of moderate dimensions, with reduced electrical distortion.

According to the present invention, a loudspeaker is constructed to reproduce a wide range of frequencies, by comprising in it a thin electrically driven diaphragm, one face of which communicates with a first acoustical boundary so dimensioned as to enable that face of the diaphragm to radiate efficiently waves whose frequencies lie in an upper part of the said frequency range, while the other face is acoustically coupled to a second acoustical boundary so dimensioned as to enable the efficient radiation of waves whose frequencies lie in a lower part of the said range through the medium of an acoustical chamber having at least one input and one output orifice.

By an acoustical boundary I mean a rigid structure surrounding a volume of air, which volume is capable of propagating acoustical vibrations, the rigidity of the structure being sufficient to confine the propagation of vibrations substantially to the said volume of air. I shall describe methods of manufacture of acoustical boundaries sufficient for this definition.

The invention is illustrated by way of example in the accompanying diagrammatic drawings, in which

Figure 1 is a sectional view of an improved loudspeaker;

Figure 2 is a sectional elevation showing a convenient general arrangement of the loudspeaker.

Figure 3 is a fragmentray transverse section, taken on the line 3—3 of Figure 1.

The loudspeaker shown diagrammatically in Figure 1 has a diaphragm **10**, conveniently of frustoconical shape with a flexible rim member **11** and at its center a cylindrical coil **12** by which it is driven, the coil being freely movable in the annular gap of a magnet system **13**, and being fed with electrical signals in the well known manner so as to produce axial reciprocation of the coil and diaphragm. The front and rear faces of the diaphragm **10** are indicated at A and B respectively. Leading from the front of the diaphragm **10** is a treble horn-like passage **14** or other sound outlet, this constituting what will be herein referred to as the first acoustical boundary E, this being of course in communication with the hollow front surface A of the diaphragm **10**. An acoustical chamber F is arranged to communicate with, or be bounded by, the rear surface B of the diaphragm **10** and it also has an outlet **15** forming part of a second acoustical

boundary G, this in the example shown, being in the form of a tapered bass horn **16**.

The acoustical boundary E is so dimensioned as to enable face A to radiate efficiently waves whose frequencies lie in an upper part of the range to be reproduced, while face B is coupled to the acoustical boundary G, axially longer than E, through the medium of the acoustical chamber F.

I make the distinction between "acoustical boundaries," such as E and G, and an "acoustical chamber" such as F, in the following manner. The acoustical boundaries E and G are so shaped as to preserve or gradually vary the acoustic impedance seen along their axes, one end of which communicates with the free air. On the other hand the acoustical chamber F is so shaped as to present a defined acoustic reactance between its input and output orifices at any frequency within its working range.

The acoustical boundaries E and G are both made in the form of trumpets; that is to say, the cross-sectional area of each increases continuously along its axis. The boundary E is shorter axially, and the combination of boundary E with diaphragm face A radiates efficiently, as is well-known, frequencies in excess of a certain approximate frequency which will now be referred to as "the cross-over frequency." At the cross-over frequency, rear face B presents an acoustical impedance which is partly reactive due to the mass of the moving parts and the reactive loading of boundary E, partly resistive due to the residual resistive loading of boundary E, and is partly (though less significantly) affected by the mounting **11** and the electrical constants of coil **12** and the amplifier (not shown) feeding the loudspeaker. The reactive impedance or near face B has, in sum, the sign of a mass. Acoustical chamber F is then constructed to have a reactive impedance whose sign is that of a compliance of the same order of magnitude, and its output orifice **15** is made of such size that the loading of rear face B by the acoustical boundary G takes over with little change from the loading of front face A by acoustical boundary E as the frequency rises through the cross-over frequency; also that the sum of these loadings is adequate to damp the diaphragm. It is preferable to make acoustical chamber F with compliant reactance to all frequencies below the cross-over frequency; that is to say, to make its lowest natural frequency in the transverse mode higher than cross-over.

The effect of this arrangement is that the gamut of frequencies is reproduced with high and approximately equal efficiency from the highest frequency radiated by front face A and acoustical boundary E to the lowest frequency capable of being radiated by acoustical boundary G.

The radiation from front face A and acoustical boundary E is increased and made more uniform at the very highest frequencies by adding to it an open-ended cone **10***a* smaller and of less vertical angle than the main diaphragm, and rigidly secured to the junction of coil and diaphragm; it is preferably provided with a central stabilizing device as described in my co-pending application Serial No. 479,624 filed January 3, 1955, now Patent No. 2,808,895.

I have found that not only the desired axial mode of vibration can be excited in the acoustical chamber, but also an undesirable circular mode or modes. These occur even when, as is convenient, the structure is given apparent circular symmetry, and I believe they are excited by reason of small asymmetries in the diaphragm or its rim member. Such modes are typically lightly coupled and of low decrement; and at least one such resonance may occur in the operating range of rear face B, acoustical chamber F and acoustical boundary G, causing an abrupt change in radiation efficiency in

the neighborhood of its frequency. I have found that this can be prevented, however, by including in cylindrical acoustical chamber F of a plate-like baffle **17** (see Figure 2) placed so as to lie in a radial plane of the voice coil **12** in contact with the side of the chamber F as to damp or prevent the occurrence of circular modes within the operating range. Preferably the baffle plate **17** is asymmetrically placed with respect to the output orifice **15** as seen in Figure 3. More than one baffle may be used if desired.

Figure 2 shows diagrammatically in sectional view a practical form of the invention. A cabinet **18**, conveniently arranged to fit into the corner of a room or hall, has two side walls at right angles to one another (one being shown at **19**), a front wall **20**, a top **21** and a bottom **22**, the cabinet being supported on legs **23** so as to provide a clear space **24** between the bottom **22** and the floor **25**. A horizontal partition **26** extends nearly to the back corner and forms the base of a "treble" horn **14** constituting the acoustical boundary E. Although this horn appears to have only a small degree of divergence as seen in elevation, it will be appreciated that its side walls have a wide spread and merge into the surfaces of the room walls as they dierge from the corner, indicated at **27**. Adjacent the corner **27** the horn **14** is turned upwards, and it is energized by the front face A of the diaphragm **10**, which faces downwards, the magnet system **13** being mounted with its axis vertical. A stout metal box **31** to form the acoustical chamber F is built into the top **21** of the cabinet so as to be bounded at its bottom by the rear face B of the diaphragm **10**. The chamber F has an outlet **15** forming the entry of a long folded horn indicated generally at **16** and disposed in the lower part of the cabinet **18**, the horn being defined by an array of partitions and walls **28**. The horn passage **16** extends through an opening **29** at the rear of the bottom **22**, so that the space **24** underneath the bottom **22** (defined by the walls of the room as they diverge from the corner **27**) constitutes the mouth of the horn and may be regarded as communicating with the "bass" acoustical boundary G.

In one example the axial length of the "trebel" horn **14** is about 22 inches and the "bass" horn about 104 inches, measured to the plane of the bottom **22**.

The lateral dimensions of the various parts of the horn are conveniently arranged to suit the desired exponential expansion of the cross sectional area along the axis of the horn; it has been found, however, that it is unnecessary, for good reproduction, to maintain strictly

exponential expansion over short lengths, thereby enabling plane partitions to be used without appreciably detracting from the performance. Furthermore, I have found that the sharp bends at the ends of the said sections have little or no deleterious effect, provided they occur at relatively short distances along the axis. In contrast to these findings, it is desirable to make the expansion of the "treble" horn **14** relatively uniform, and therefore the side walls of this horn are curved almost throughout their length.

I claim:

1. A loudspeaker horn having an acoustic chamber, a loudspeaker in said chamber, said loudspeaker having a substantially cylindrical voice coil, a plate-like baffle in said chamber having contact with the side of said chamber and lying in a radial plane of said voice coil.

2. The combination of claim 1 wherein said chamber has a main opening and said loudspeaker includes a diaphragm across the inlet end of the horn completely closing off the main opening of said chamber.

3. The combination of claim 2, including a second horn, said chamber having an orifice defined in the wall thereof communicating with the inlet end of said second horn.

4. The combination of claim 3, wherein said diaphragm has a concave face and a convex face with the convex face facing into said chamber.

5. The combination of claim 1, including a second horn, said chamber having an orifice defined in the wall thereof communicating with the inlet end of said second horn.

6. The combination of claim 2 wherein the plane of said baffle passes outside said orifice.

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