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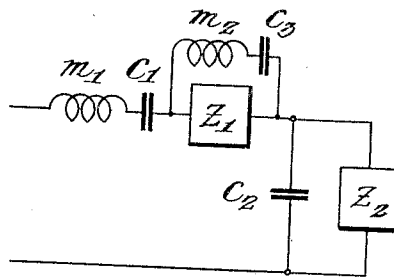
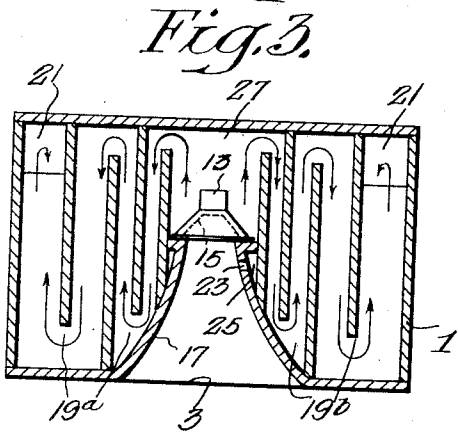
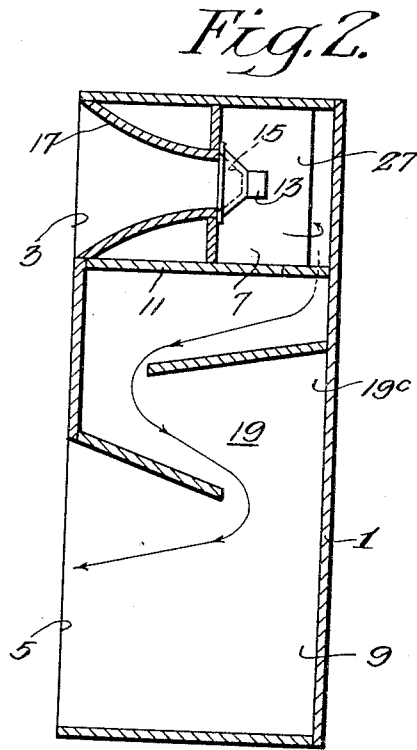
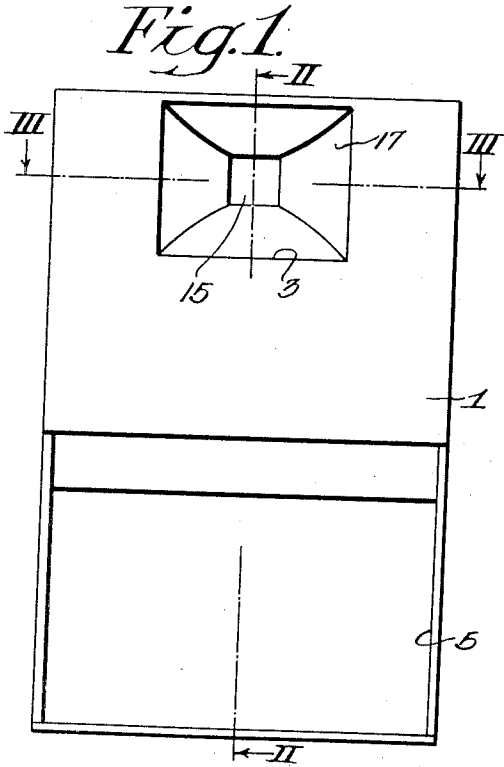
H. F. OLSON

2,224,919

LOUD-SPEAKER

Filed March 31, 1937

2 Sheets-Sheet 1



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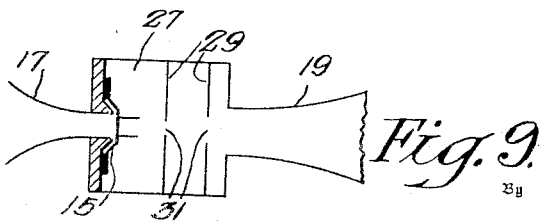
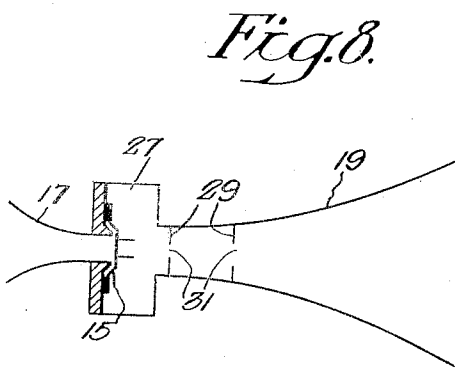
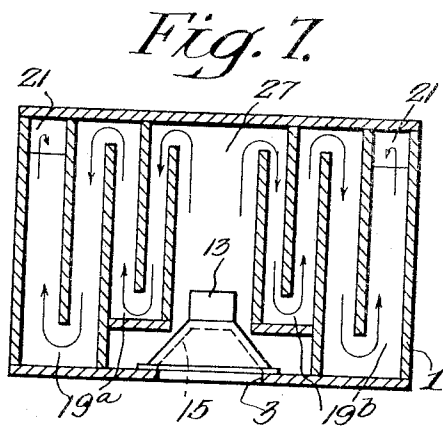
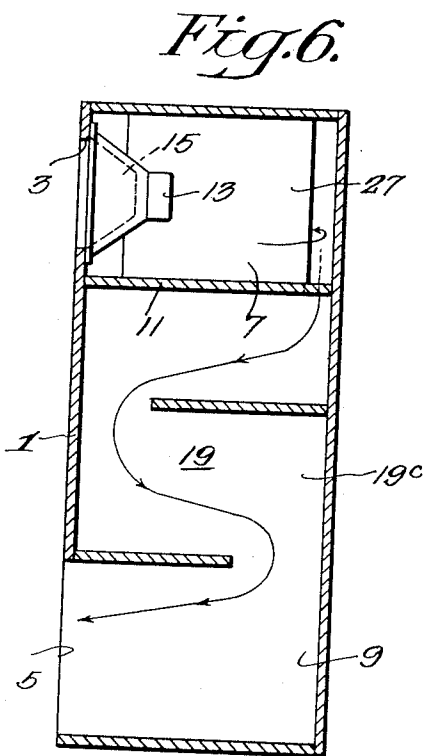
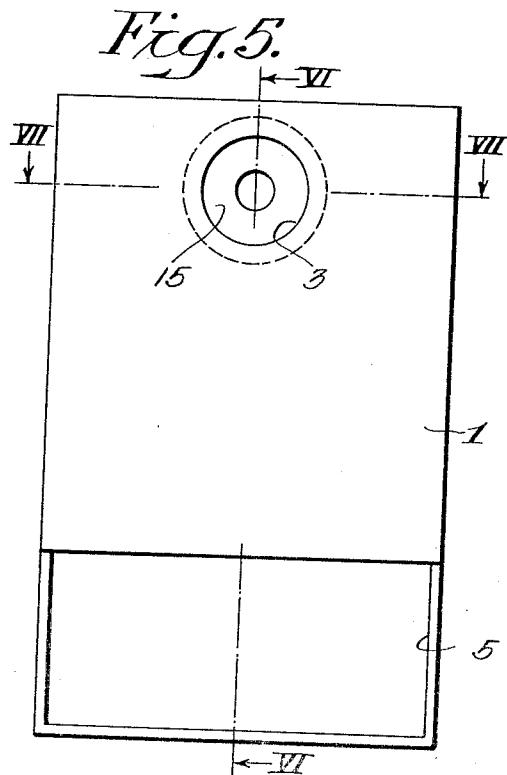
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LOUD-SPEAKER

Filed March 31, 1937

2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

2,224,919

## LOUD-SPEAKER

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Application March 31, 1937, Serial No. 134,100

17 Claims. (Cl. 181—31)

This invention relates to loud-speakers, and more particularly to loud-speakers of the compound type.

It has long been recognized that the efficient transformation of electrical variations into corresponding acoustical vibrations over a wide frequency range is, in general, restricted by practical limitations. Experience has shown that most efficient reproduction over a wide frequency range may be obtained by an arrangement wherein a cone or other suitable diaphragm is employed to drive both a short horn for reproduction of high frequencies and a long horn for reproduction of low frequencies, and various arrangements of this sort have been proposed heretofore.

It is also well known that high frequency waves are highly directional and are easily absorbed and affected by reflection. With compound horn type loud-speakers of the prior art, little attention has been given to minimizing attenuation of the higher frequencies in inexpensive horn loud-speakers, and as a result, the efficiency of distribution of high frequency sounds where such loud-speakers have been used has suffered.

The primary object of my present invention is to provide an improved compound horn loud-speaker of the type referred to above which is particularly suitable for reproduction over a wide range.

More particularly, it is an object of my present invention to provide an improved loud-speaker as aforesaid which will reproduce the high frequencies in a manner not to cause them to suffer serious attenuation or reflection.

Another object of my present invention is to provide improved acoustic filters for discriminating between the range of frequencies supplied by the respective high and low frequency systems of the loud-speaker.

A further object of my present invention is to provide an improved loud-speaker of the type set forth which is very simple in construction, yet highly efficient in use, and which is relatively inexpensive of manufacture.

In accordance with my present invention, I provide a cabinet having upper and lower openings in one of its walls and divide the cabinet into two chambers or compartments. A small, straight axis horn adapted to particularly transmit high frequencies is placed in the upper compartment and fits into the upper openings, while a long, folded, low frequency horn is disposed partly in the upper and partly in the lower com-

partment and terminates at the lower opening, a single driver feeding both horns. The small horn is arranged at substantially the level of the listeners' ears, whereby very little loss of high frequencies is obtained as a result of absorption and reflection. If desired, the small horn may be omitted and the cone or diaphragm of the single driver arranged to feed directly into the atmosphere as a direct radiator. In either case, the low frequency horn is preferably provided with an acoustic filter which efficiently passes only the low frequencies, and the high frequency horn, in the first modification referred to above, may be provided with an acoustic filter which efficiently permits transmission of only the high frequencies.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of several embodiments thereof, when read in connection with the accompanying drawings in which

Figure 1 is a front elevation of one form of my invention,

Figure 2 is a sectional view taken on the line II—II of Fig. 1,

Figure 3 is a sectional view taken on the line III—III of Fig. 1,

Figure 4 is a circuit diagram of the electric equivalent of the acoustic arrangement of this modification of my invention,

Figure 5 is a front elevation of another form of my invention,

Figure 6 is a sectional view taken on the line VI—VI of Fig. 5,

Figure 7 is a sectional view taken on the line VII—VII of Fig. 5,

Figure 8 is a diagrammatic illustration of a horn embodying a low pass filter and acoustic capacitance according to my present invention, and

Figure 9 is a diagrammatic illustration of a modified form of combined low pass filter and acoustic capacitance according to my invention.

Referring more particularly to the drawings, wherein similar reference characters designate corresponding parts, there is shown, in Figs. 1, 2 and 3, a cabinet 1, the front wall of which is provided with a relatively small opening 3 at the top and a relatively large opening 5 at the bottom, and the cabinet being divided into upper

and lower compartments 7 and 9, respectively, by a partition 11. Mounted in the upper compartment is a suitable electro-acoustical driver 13, such as an electro-dynamic loud-speaker which includes a cone or diaphragm 15 and which is preferably adapted to reproduce acoustic signals over a wide range. A short, straight-axis horn 17, which preferably is of the exponentially expanding type, is also located in the compartment 7 and loads one side (for example, the front) of the diaphragm 15, and, by terminating at the small opening 3, serves to establish communication between front side of the diaphragm 15 and the opening 3 as well as the atmosphere. Also mounted in the upper compartment 7 are the two divided sections 19a and 19b of a long, folded horn 19 which loads the rear side of the diaphragm 15. The sections 19a and 19b are disposed symmetrically with respect to the diaphragm 15 and each communicates, through openings 21 in the partition 11, with the single section 19c of the horn 19 located in the lower compartment 9. The horn 19, preferably also of the exponentially expanding type, terminates at the large opening 5 and thus serves to establish communication between the rear side of the diaphragm 15 and the opening 5 as well as the atmosphere.

The horn 17 is employed to transmit high audible frequencies with great efficiency and the horn 19 to transmit low frequencies within the audible range with great efficiency. For this purpose, I provide one or more openings 23 in the horn 17 in proximity to its throat and place about the throat end of the horn 17 a partition or casing which provides a closed chamber 25 in parallel relation to the horn 17, the chamber 25 having communication with the horn 17 only through the opening or openings 23, as the case may be. The opening 23 and the chamber 25 form a series resonant circuit and they are so designed as to resonate at the lower cut-off frequency of the horn 17. Thus, only substantially those vibrations above the resonant, or predetermined cut-off, frequency of the resonant circuit will be transmitted by the horn 17, and in order to minimize the loss of the transmitted high frequencies, the cabinet 1 and the partition 11 are so arranged that the horn 17 is substantially at the level of the listeners' ears. In this way, the loss of the high frequencies by absorption and reflection is very greatly reduced.

As stated previously, the horn sections 19a and 19b are disposed symmetrically with respect to the driver 13, one on each side thereof. By separating these two sections which, in effect, constitute but a single horn portion with each section of half the cross sectional area of the combined horn portion in the compartment 7, a chamber 27 is formed immediately behind the diaphragm 15. The chamber 27 has a cross sectional area which is appreciably greater than the total throat area of the combined sections 19a and 19b and provides an acoustic capacitance which is comparable to the impedance of the horn 19 at the high frequency cut-off frequency of the horn 19, and this is preferably in the vicinity of the low frequency cut-off frequency of the horn 17. To further insure against transmission of high frequencies by the horn 19, it may be provided with one or more axially spaced baffles 29 (Fig. 8) each provided with an opening 31 therein of an area smaller, of course, than the cross sectional areas of the horn 19 at the points where the baffles 29 are located and each opening

31 preferably of progressively larger diameter as the cross sectional area of the horn 19 increases. The effect of the baffles 29 is to cut down radiation of high frequency vibrations by reflection thereof back toward the chamber 27 and by attenuation due to the constrictions at the openings 31. In the modification of my invention illustrated in Figs. 1 to 3, the baffles 29 are constituted by those portions of the partition 11 which border on the openings 21 and the openings 21 correspond to the openings 31 of Fig. 8, being of an area appreciably smaller than the cross sectional areas of the horn sections 19a and 19b at the points where the openings 21 are provided. The combined effect of the chamber 27 and the openings 21 is to keep the response of the horn 19 down below its intended, or predetermined, high-frequency cut-off frequency. Thus, the horn 19 will transmit only the lower frequencies and the horn 17 only the higher frequencies, and each with great efficiency.

The equivalent electrical circuit of the modification of my invention just described is shown in Fig. 4. If  $m_1$  represents the combined mass of the diaphragm 15, its voice coil support and the voice coil,  $m_2$  the mass of air in the opening 23,  $C_1$  the capacitance of the suspension of the cone 15,  $C_2$  the acoustic capacitance of the chamber 27,  $C_3$  the acoustic capacitance of the chamber 25,  $Z_1$  the impedance of the horn 17 and  $Z_2$  the impedance of the horn 19, the electrical analogues will be arranged as shown. It will be noted that the inductance  $m_2$  and the capacitance  $C_3$  form a series resonant circuit in shunt with the impedance  $Z_1$  and that the capacitance  $C_2$  is shunted across the impedance  $Z_2$ . This arrangement is essential to provide efficient cut-offs for the two horns.

The modification of my invention shown in Figs. 5, 6 and 7 is practically identical with that previously described insofar as the low frequency horn 19 is concerned. However, in this modification, the high frequency horn 17 is omitted and the diaphragm 15 is mounted immediately behind the small opening 3 to have direct communication therewith and with the atmosphere, whereby it acts as a direct radiator. Such a construction is preferable to that previously described in certain cases, as in radio receiver loud-speakers, monitoring loud-speakers, with centralized radio systems, and the like, since a direct radiator is usually sufficiently efficient in the mid- and high-frequency ranges. Also, since the intensity level of reproduction in small rooms is considerably less than the intensity level of the original sound, some accentuation of low-frequency response may be required. Coupling the horn 19 to one side of the diaphragm 15 provides a good system of low-frequency efficiency and, since the diaphragm 15 is a direct radiator in the arrangement shown in Figs. 5 to 7 and covers a wide angle of distribution, it is possible to use a small and light vibrating system for the efficient reproduction and distribution of the mid- and high-frequency ranges from the open side of the cone 15.

While I have shown and described but two modifications of my invention, I am fully aware that many other modifications thereof and changes therein may be made within the spirit of my invention. For example, in place of a single driver, two separate drivers may be employed, as may also a driver having a single field supply for two separate cones and voice coils of the type disclosed and claimed, for example, in

the copending application of Frank Massa, Serial No. 113,475, assigned to the Radio Corporation of America. It will also be obvious that the horns 17 and 19 may be of any desired shape in cross section instead of square as shown, and that these horns may be made to expand in any desired way. Also, if desired, the baffles 29 may be placed in the chamber 27 instead of in the horn 19, as shown in Fig. 9. Many other changes will, no doubt, readily suggest themselves to those skilled in the art. I, therefore, desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. Signal translating apparatus comprising, in combination, a hollow cabinet, a partition therein dividing said cabinet into a pair of compartments, said cabinet including a wall provided with a pair of openings one of which establishes communication between the atmosphere and one of said compartments and the other of which establishes communication between the atmosphere and the other of said compartments, an electro-acoustical driver in one of said compartments, said driver having a diaphragm one side of which is in communication with the opening associated with one of said compartments, and a horn coupled to the other side of said diaphragm, said horn extending through said partition and having its terminal at the other of said openings.

2. Signal translating apparatus comprising, in combination, a hollow cabinet, a partition therein dividing said cabinet into upper and lower compartments, said cabinet including a wall provided with a relatively small opening which establishes communication between the atmosphere and said upper compartment and with a relatively large opening which establishes communication between the atmosphere and said lower compartment, an electro-acoustical driver in said upper compartment, said driver including a diaphragm one side of which is in communication with said small opening, and a horn coupled to the other side of said diaphragm, said horn extending through said partition and having its terminal at said large opening.

3. The invention set forth in claim 2 characterized in that the first named side of said diaphragm has direct communication with the atmosphere through said small opening.

4. The invention set forth in claim 2 characterized by the addition of a second horn which is coupled to said first named diaphragm side and which terminates at said small opening.

5. The invention set forth in claim 2 characterized in that said horn is of the folded type and is relatively long, said horn being particularly adapted to transmit low frequency vibrations, and characterized further by the addition of a relatively short, straight-axis horn particularly adapted to transmit high frequency vibrations, said second horn being coupled to said first named side of said diaphragm and terminating at said small opening.

6. The invention set forth in claim 2 characterized in that said horn is provided with one or more perforated baffles therein constituting an acoustic filter adapted to pass only vibrations below a substantially predetermined frequency.

7. The invention set forth in claim 2 characterized in that said horn is provided with a chamber behind said other side of said dia-

phragm constituting an acoustic capacitance adjacent said diaphragm.

8. The invention set forth in claim 2 characterized in that said horn is so constructed and arranged within said cabinet that it cooperates with said cabinet to provide a chamber behind said other side of the diaphragm constituting an acoustic capacitance immediately behind said diaphragm.

9. The invention set forth in claim 2 characterized in that said horn is provided with one or more perforated baffles therein constituting an acoustic filter adapted to pass only vibrations below a substantially predetermined frequency, and characterized further in that said horn is provided with a chamber behind said diaphragm constituting an acoustic capacitance, the capacitance of said chamber being comparable to the impedance of said horn at substantially said predetermined frequency.

10. Signal translating apparatus comprising, in combination, a hollow cabinet, a partition therein dividing said cabinet into upper and lower compartments, an electro-acoustical driver in said upper compartment, said driver including a diaphragm, a relatively short, straight-axis horn in said upper compartment coupling one side of said diaphragm with the atmosphere, and a relatively long, folded horn coupling the other side of said diaphragm with the atmosphere, said last named horn extending through said partition and having a portion located in said upper compartment and a portion located in said lower compartment and communicating with the atmosphere from said lower compartment.

11. The invention set forth in claim 10 characterized in that the portion of said long horn which is located in said upper compartment is divided into two sections symmetrically disposed with respect to said diaphragm, said sections each terminating into the portion located in said lower compartment.

12. The invention set forth in claim 10 characterized in that said small horn is provided with at least one opening in the wall thereof adjacent its throat and characterized further by the addition of means providing a chamber in parallel relation to said small horn, said chamber communicating with said small horn through said opening.

13. The invention set forth in claim 10 characterized in that said small horn is provided with at least one opening in the wall thereof adjacent its throat, and characterized further by the addition of means providing a chamber having communication with said horn through said opening, said chamber constituting an acoustic capacitance and the mass of air in said opening constituting an acoustic inductance in series with said capacitance, and said chamber being so arranged with respect to said horn that said series connected capacitance and inductance form a resonant circuit in shunt with the impedance of said horn, said resonant circuit being such as to resonate at the low frequency cut-off frequency of said small horn.

14. Signal translating apparatus comprising, in combination, a cabinet including a side wall, a partition in said cabinet dividing it into upper and lower compartments, said lower compartment having an opening in said wall whereby communication is established between the atmosphere and said lower compartment, an electro-acoustical driver in said upper compartment, and

- a horn coupled to said driver and terminating at said opening, one portion of said horn being located in said upper compartment and another portion thereof being located in said lower compartment, said partition constituting a wall common to all of said horn portions, and said partition having at least one opening therein for establishing communication between said horn portions.
- 10 15. The invention set forth in claim 14 characterized in that said horn increases uniformly in cross-section along its length and characterized further in that the opening in said partition is of smaller area than the cross-sectional area of the horn at the same point, the area of said opening being so related to the cross-sectional area of the horn at said point as to constitute an acoustic filter adapted to pass only vibrations below substantially a predetermined frequency.
- 15 16. The invention set forth in claim 14 characterized by the addition of means in said upper compartment providing a chamber interposed between said driver and the throat of said horn, the cross-sectional area of said chamber being appreciably greater than the cross-sectional area of said throat whereby said chamber constitutes an acoustic capacitance, and characterized further by the addition of an acoustic filter in said horn adapted to pass only vibrations below substantially a predetermined frequency, said acoustic capacitance being comparable to said horn impedance at substantially said predetermined frequency.
- 10 17. Signal translating apparatus comprising, in combination, an electro-acoustical driver, a horn loading one side of said driver, said horn having a small opening therein in proximity to said driver, and means providing a chamber about the throat end of said horn having communication with said horn through said opening, said chamber constituting an acoustic capacitance and the mass of air in said opening constituting an acoustic inductance, said chamber and said opening being so related to said horn as to form a series resonant circuit in shunt with the impedance of said horn, and said resonant circuit being such as to resonate at a predetermined frequency.
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