United States Patent [19]

Goeckel

[11] **3,898,384**

[45] **Aug. 5, 1975**

[54] **LOUDSPEAKER CABINET**

[75] Inventor: **Helmut Goeckel,** Liebenau, Weser, Germany

[73] Assignee: **Neckermann Versand KGaA,** Frankfurt am Main, Germany

[22] Filed: **July 26, 1974**

[21] Appl. No.: **492,971**

[30] **Foreign Application Priority Data**

July 27, 1973 Germany 2338298

[52] **U.S. Cl.** .... **179/1 E;** 181/147; 181/152; 181/187; 181/193

[51] **Int. Cl.²** **H04R 1/30**

[58] **Field of Search** ...... 179/1 E, 115.5 H; 181/144, 181/147, 152, 159, 177, 187, 189, 192, 193, 198, 199

[56] **References Cited**

UNITED STATES PATENTS

2,754,926	7/1956	Rice	181/187
3,730,291	5/1973	Goeckel	181/193

FOREIGN PATENTS OR APPLICATIONS

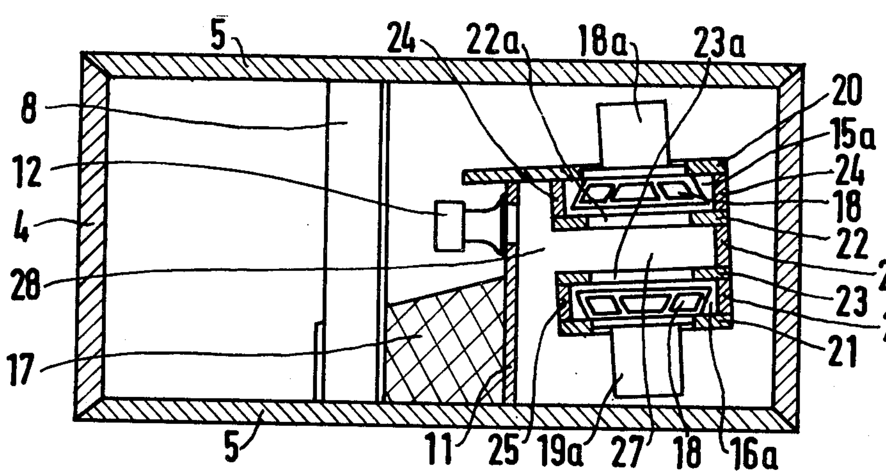
1,351,887	12/1963	France	181/31 B

Primary Examiner—Kathleen Claffy
Assistant Examiner—George G. Stellar
Attorney, Agent, or Firm—Waters, Schwartz & Nissen

[57] **ABSTRACT**

A loudspeaker cabinet incorporates two loudspeakers and an exponential acoustic horn for the two loudspeakers. The horn is provided by various walls of the cabinet and comprises a spirally extending first portion leading to a second portion terminating in a sound exit hole in the front wall of the cabinet. The loudspeakers are installed in such a manner that one side of their diaphragms radiates sound into the horn whilst the other side radiates sound directly through one or more further sound exit holes in the cabinet front wall. A tweeter is also incorporated in the cabinet and the loudspeakers and the tweeter are all installed in such a fashion that their bulk does not interfere with the exponential nature of the growth of the horn free space along the length of the horn.

21 Claims, 18 Drawing Figures



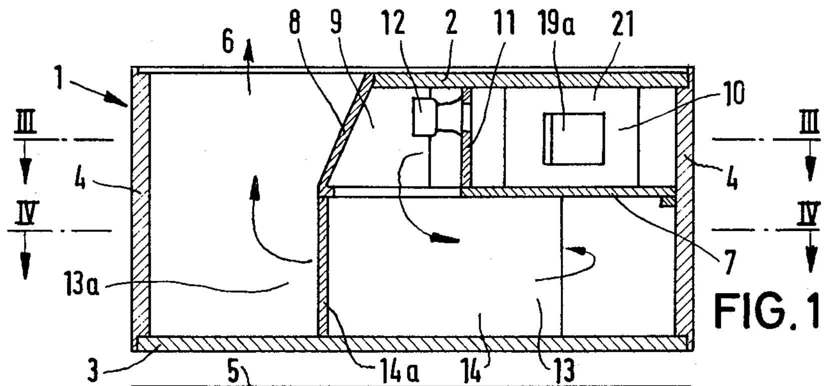


FIG. 1

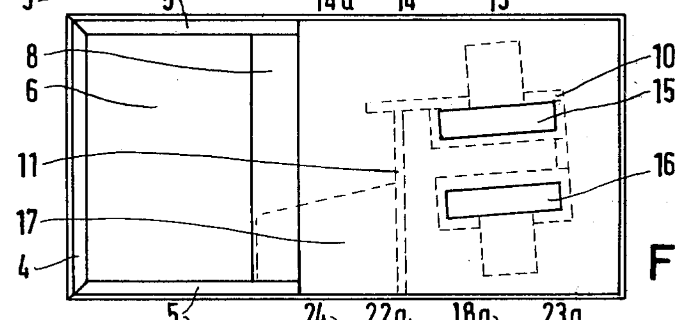


FIG. 2

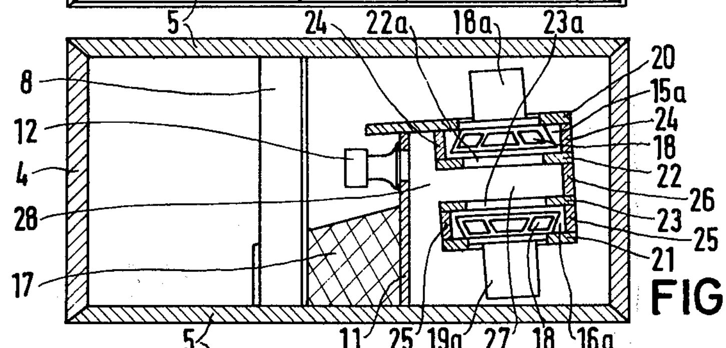


FIG. 3

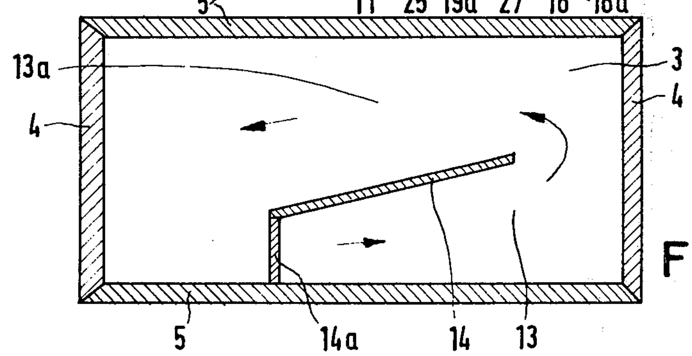


FIG. 4

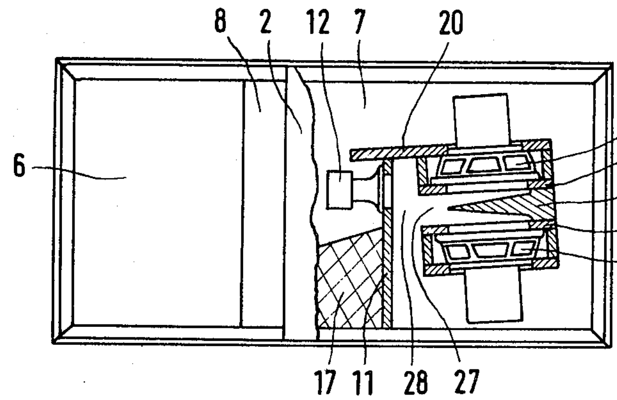


FIG. 5

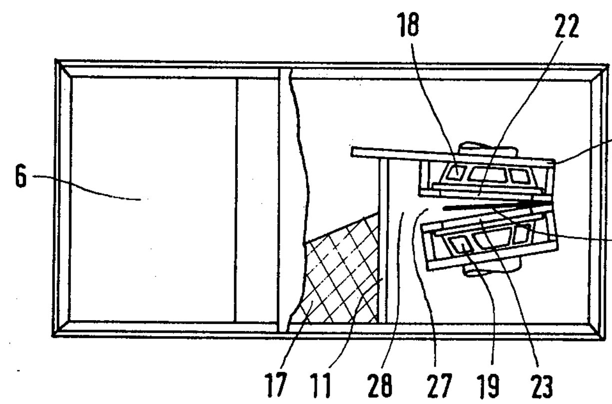


FIG. 6

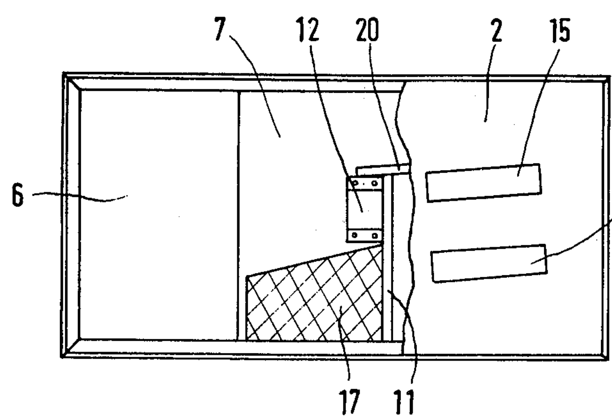


FIG. 7

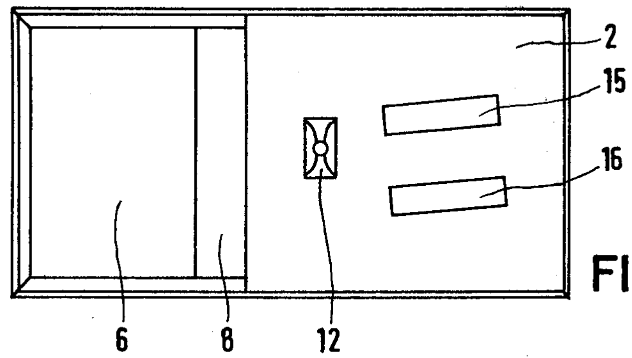


FIG.8

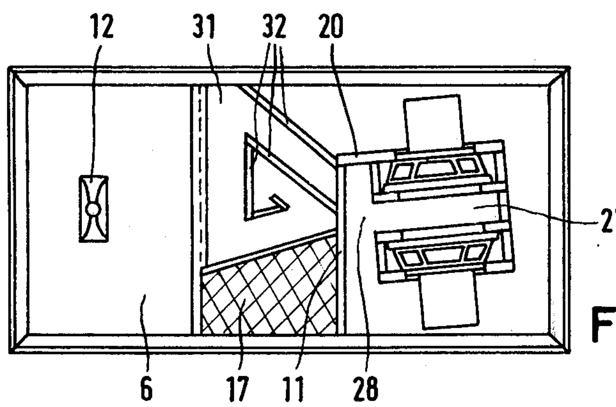


FIG.9

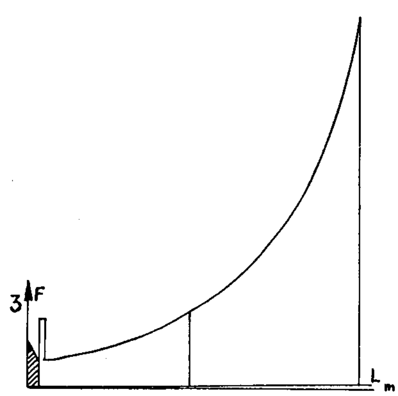


FIG.10

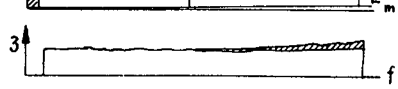


FIG.11

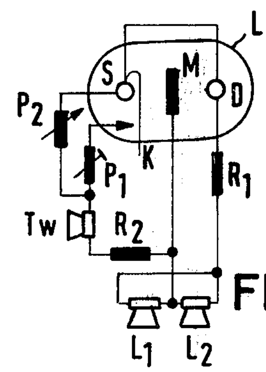


FIG.12

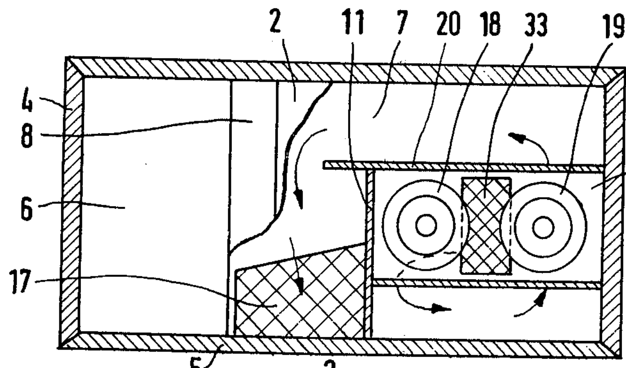


FIG. 13

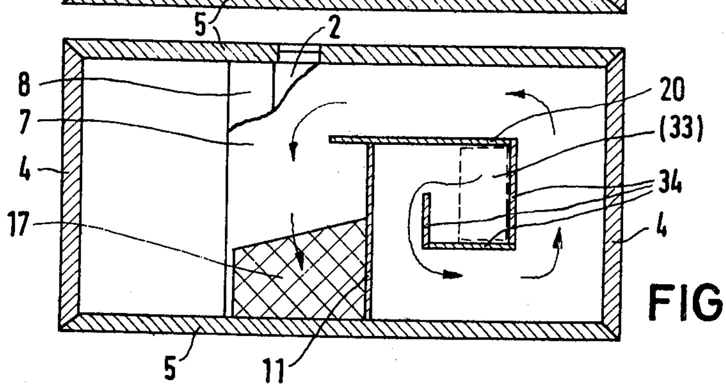


FIG. 14

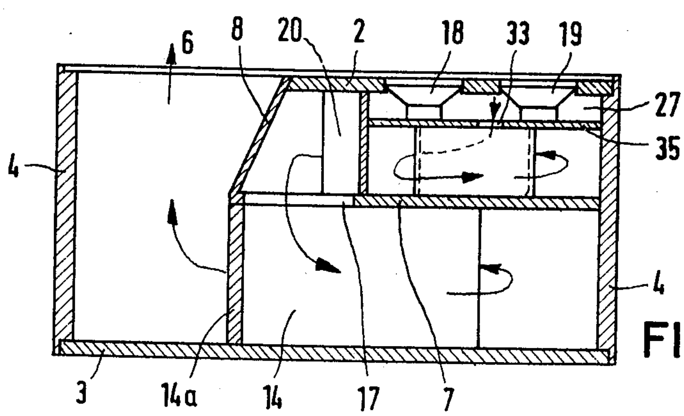


FIG. 15

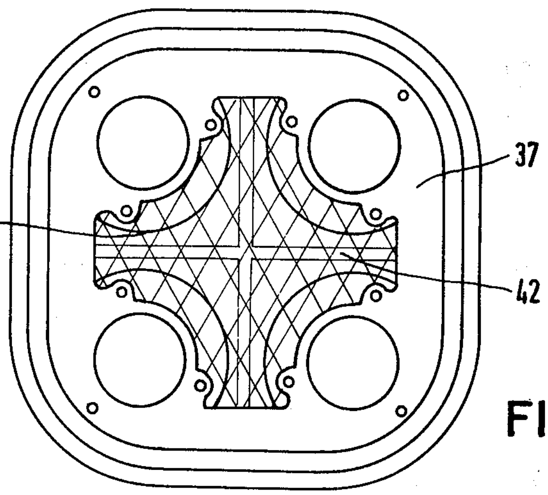


FIG. 17

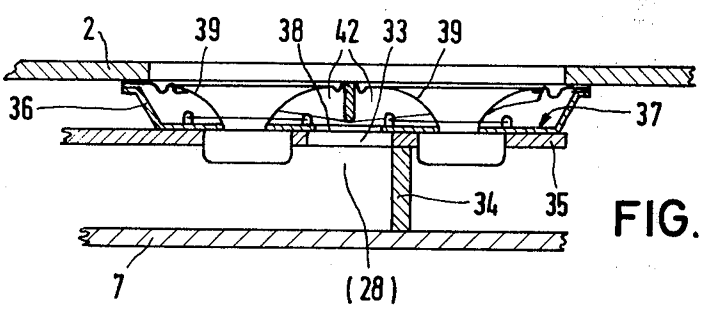


FIG. 16

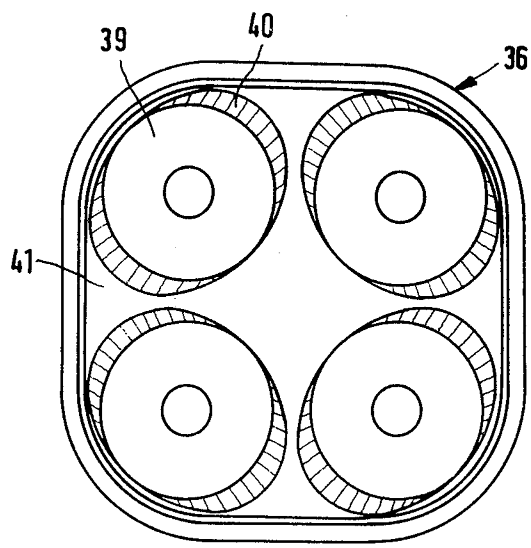


FIG. 18

LOUDSPEAKER CABINET

BACKGROUND OF THE INVENTION

This invention relates to a loudspeaker cabinet incorporating an exponential acoustic horn.

The advantage of an exponential acoustic horn when used in combination with a loudspeaker is the progressive nature of the radiation resistance of the horn, which yields high efficiency and virtually complete suppression of distortion factors and starting transient phenomena, as well as resonance formation. The column of air defined in the horn and the substantially reaction-free, delta-type, or spreading, sound radiation into the room or the like where the horn is used mean that the loudspeaker diaphragm has only small amplitude deflections to perform. These deflections increase in amplitude only to a small extent with increasing power, whilst the air acoustic acceptance increases. It is particularly important in this context that high frequencies too can be heard equally well throughout the room because of the spreading nature of the delta radiation. These high frequencies are propagated freely and omnidirectionally due to the exponential principle, unlike their behaviour with, for example, compact cabinets which compel the listener to sit directly in front of the cabinet for good reception.

Moreover the high, self-matching, radiation resistance of a loudspeaker employed in combination with an exponential horn causes the speech coil of the loudspeaker to remain in the uniform gap field of the operating magnet and produces the so-called sinusoidal quality in the acoustic reproduction. Even where the diaphragm area of the loudspeaker is relatively large, the smaller the amplitude of the diaphragm deflections the more faithfully is the sinusoidal function reproduced. Large diaphragms in conventional operation however, for example in compact cabinets, are hardly capable of faithful transmission of the entire frequency range because they tend to develop partial oscillations which result in distortions etc., thus impairing the clarity of reproduction. Even "undevelopable" diaphragms can only ameliorate these phenomena to some degree but not eradicate them.

One embodiment of a loudspeaker cabinet incorporating an exponential horn is described and claimed in German Pat. Specification No. 2,041,021.

SUMMARY OF THE DISCLOSURE

The object of the invention is to provide an exponential-horn loudspeaker cabinet incorporating at least two loudspeakers, which cabinet provides the advantages of an exponential horn and is also substantially smaller than some of the known, disproportionately large, exponential-horn loudspeaker cabinets. The last-mentioned requirement is not an easy one to satisfy because the objective of compactness on the one hand and efficiency and frequency response of the exponential system on the other are usually fundamentally mutually exclusive design aims.

The object is achieved by a construction based on the construction disclosed in the aforementioned German Pat. Specification No. 2,041,021.

According to the invention there is provided a loudspeaker cabinet comprising:

a front wall defining a first sound exit hole and at least one further sound exit hole;

a back wall;

an intermediate wall intermediate said front wall and said back wall;

a plurality of subsidiary walls between said front wall and said intermediate wall and arranged so as to provide a pressure chamber and a spirally extending first portion of a substantially exponential horn, said horn first portion extending from said pressure chamber to a sound passage defined between said intermediate wall and said back wall; one of said plurality of subsidiary walls being an inclined wall extending, at an angle, from said intermediate wall to said front wall and said substantially exponential horn having a second portion extending to said first sound exit hole and comprising said sound passage and a region partially defined by said inclined wall;

at least two loudspeakers each of which comprises a diaphragm and an operating means for the diaphragm and is arranged to radiate sound into said pressure chamber from one side of its said diaphragm and through the or one said further sound exit hole from the other side of its said diaphragm, each of said loudspeakers being arranged so that its said operating means occupies a volume of said loudspeaker cabinet which is substantially outside the substantially exponentially growing free space of said substantially exponential horn; and

a tweeter arranged to occupy another volume of said loudspeaker cabinet which is also substantially outside said substantially exponentially growing free space of said substantially exponential horn.

It is to be understood that a sound exit hole can be covered by fabric or by a rigid mesh yet still be understood as being a "hole."

The front sides of the diaphrams of the two loudspeakers can be arranged to face one another directly across the pressure chamber. The advantages are thus achieved that the loudspeaker diaphragm deflections are halved, the motion of the speech coils can thus remain in the uniform magnetic field, sinusoidal reproduction can be achieved and even the highest audible frequencies can be propagated uniformly throughout the whole room in which the cabinet is operating, thanks to the advantageous features of sound propagation associated with the exponential horn, without the listener having to sit at a specific location in the room.

In addition to the two loudspeakers the tweeter is arranged at a point which does not disturb the exponential nature of the horn geometry. The advantage of the exponential horn in terms of its progressive radiation resistance also helps the tweeter.

The tweeter may be arranged and connected in such a fashion that it is adjustable within a restricted range of operation. This enables the listener to match the sound brilliance and force, as well as the representation of characteristic frequencies which is required for high fidelity reproduction of an original musical event, to certain features such as partial hardness of hearing on the part of the listener or reproduction in rooms where there is particularly severe attenuation due to the presence of carpets, curtains, furniture or the like.

The tweeter may also be so installed that the frequencies radiated by it are superimposed upon the actual frequency response in the manner of a layer which increases in depth only to a negligible extent (see FIG. 11). To this end a three-terminal loudspeaker socket with switch may be provided. In one plug position the tweeter operates at optimum level and full volume whilst in the other a fixed or variable series resistor is included which is adjustable either by means of a screw driver or a nut.

The tweeter may be installed at the narrowest point of the initial part of the horn (i.e. throat of the horn) in a side-wall of the first spirally extending horn portion. The tweeter should be directed so that it radiates its sound into the horn throat at a slightly offset region in relation to the sound exit of the pressure chamber. Consequently the tweeter participates in the high progressive radiation impedance of the horn and in the propagation of the sound into the room. This increases the force, brilliance and clarity of the reproduction and can compensate for poor acoustic conditions in the room.

The tweeter can alternatively be installed in the front wall of the cabinet and radiate directly into the room. Again, pivoted through 180°, it can be installed in the intermediate wall arranged between the front and back walls of the cabinet, the tweeter being directed towards the sound passage of the horn. Finally, it can be arranged in the neighbourhood of the first sound exit hole, at the interior of the back wall of the cabinet, so as to radiate in the same direction as does the terminal portion of the horn. Here again it will not substantially affect the horn geometry.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention and to show how the same may be carried into effect reference will now be made, by way of example, to the accompanying drawings in which:

FIG. 1 is an elevational section through a first embodiment of a loudspeaker cabinet according to the present invention;

FIG. 2 is a plan view of the loudspeaker cabinet of FIG. 1 with its front cover of fabric removed;

FIG. 3 shows a section taken through the plane III—III of FIG. 1;

FIG. 4 shows a section taken through the plane IV—IV of FIG. 1;

FIG. 5 shows a sectional view, taken along the same plane as is FIG. 3, of a second embodiment of loudspeaker cabinet according to the present invention;

FIG. 6 shows a sectional view, taken along the same plane as are FIGS. 3 and 5, of a third embodiment of loudspeaker cabinet according to the present invention;

FIG. 7 shows a partly sectional view of a loudspeaker cabinet basically the same as that shown in FIGS. 1 to 4 but with a variation in the installation of the tweeter;

FIG. 8 is a plan view of a loudspeaker cabinet basically the same as that shown in FIGS. 1 to 4 but with a second variation in the installation of the tweeter;

FIG. 9 is a section, similar to that of FIG. 3, of a fourth embodiment of loudspeaker cabinet according to the present invention;

FIG. 10 shows the horn exponential growth curve of the loudspeaker cabinet of FIG. 9;

FIG. 11 shows the impedance characteristic of the loudspeaker cabinet of FIG. 9;

FIG. 12 illustrates a socket circuit for the two loudspeakers and the tweeter in a loudspeaker cabinet according to the invention;

FIG. 13 is a plan view of a fifth embodiment of loudspeaker cabinet according to the present invention, with the cabinet front wall removed;

FIG. 14 is a view similar to that of FIG. 13 but with the front wall of the cabinet, the pressure chamber and the loudspeakers removed;

FIG. 15 is an elevational section through the whole of the loudspeaker cabinet shown in FIGS. 13 and 14;

FIG. 16 is an elevational sectional view of the pressure chamber of a sixth embodiment of loudspeaker cabinet according to the present invention;

FIG. 17 is a rear view of the pressure chamber of FIG. 16; and

FIG. 18 is a front view of the pressure chamber of FIGS. 16 and 17.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an elevational section through a loudspeaker cabinet indicated as a whole by **1** and comprising a front wall **2**, a back wall **3**, two short side walls **4** and two long side walls **5** (see FIG. 2). The front wall **2** is substantially shorter than the back wall **3** and determines the size of a first sound exit hole acting as the terminal orifice **6** of an exponential acoustic horn. Parallel to the front wall **2** there is provided an intermediate wall **7** which is somewhat longer than the front wall **2** and is connected to it by an inclined wall **8**. The walls **2, 4, 5, 7** and **8** define a front internal chamber **9** containing subsidiary walls which extend from the front wall **2** to the intermediate wall **7** and define a first exponential horn portion which extends spirally about an internal chamber **10** containing two loudspeakers to which reference will be made further on. Between the front wall **2** and the intermediate wall **7** a further subsidiary wall **11** is fixed which, as FIG. 2 shows, guides and limits the first horn portion. The side wall **11** has an acoustic orifice through which a tweeter speaker **12** can radiate sound into the start of the spiral first horn portion.

FIG. 2 is a plan view of the loudspeaker cabinet of FIG. 1 with the fabric removed. At the right-hand side, two further sound exit holes **15** and **16** in the front wall **2** of the cabinet can be seen, from which sound radiated by the rear sides of the diaphragms of the two loudspeakers leaves the cabinet. The positions of these loudspeakers in the internal chamber **10** and in relation to the subsidiary wall **11** have been indicated in broken line. The area defined in broken line and cross-hatched (see FIG. 3) between the subsidiary wall **11** and the inclined wall **8** is an acoustic transmission orifice **17** provided in the intermediate wall **7**. Sound emanating from the first horn portion enters the first half **13** of a sound passage through the orifice **17**. The sound passage first half **13** is followed by a second half **13***a* of the sound passage, wherefrom sound is directed to the horn terminal orifice **6** (see also FIG. 4). The sound passage **13**, 13*a* and that region between the sound passage **13***a* and horn terminal orifice **6** constitutes an exponentially growing second portion of the horn.

FIG. 3 shows a section III—III through the internal chamber **10** showing in detail two loudspeakers **18** and **19** facing directly opposite one another, two loudspeaker-diaphragm-containing chambers **15***a* and **16***a* and a pressure chamber **27**. All the walls shown edge-on in the front internal chamber **9** are subsidiary walls extending from the front wall **2** to the intermediate wall **7**.

The rear sides **18***a* and **19***a* of the two loudspeakers **18** and **19** are set against subsidiary walls **20** and **21**. The loudspeaker diaphragms face inwards to the pressure chamber 27 and the loudspeaker operating means (magnets 18*a* and 19*a*) point outwards into the first horn spiral section. However, it is to be noted that the sizes of those parts of first horn portion into which the magnets 18*a* and 19*a* project have been pre-arranged to be such that the presence in them of the loudspeaker magnets 18*a* and 19*a* merely reduces the free space in those horn parts to values consistent with an exponential growth of horn free space.

The loudspeaker diaphragms face two respective small baffles 22 and 23 which act as walls of the pressure chamber 27 and which contain acoustic holes 22*a* and 23*a*. Two respective narrow side walls 24 and 25 complete the chambers 15*a* and 16*a* located directly behind the sound exit holes 15 and 16, already referred to, in the front wall 2. The chambers 15*a* and 16*a* are disposed parallel to each other and are connected together by a subsidiary wall 26. They lie on opposite sides of a pressure chamber 27 having an acoustic exit 28.

The spirally extending first horn portion in the front chamber 9 has a height from the front wall 2 to the intermediate wall 7 and terminates in the acoustic transmission orifice 17 in the intermediate wall 7. The second horn portion starts with the first sound passage half 13 and terminates in the first sound exit 6, the second sound passage half 13*a* following the first half 13.

By virtue of the illustrated arrangement of the loudspeakers 18 and 19 a pressure chamber 27 with a particularly low air content is provided. The exit of the pressure chamber 27 to the commencement of the spirally extending first horn portion is the acoustic exit 28.

The smaller the air content of the pressure chamber 27, the clearer are the highest audible frequencies emanating from the loudspeaker cabinet, the more faithful is the reproduction of the original sound and the better is the efficiency of the cabinet.

FIG. 4 illustrates a sectional view IV—IV showing the back wall 3 of the loudspeaker cabinet 1. The aforementioned sound passage is provided by an acoustic guide consisting of wall sections 14 and 14*a* attached perpendicularly between the intermediate wall 7 and the rear wall 3. This guide extends in soundproof fashion up to the underside of the intermediate wall 7. It increases the length of the path taken by the sound coming from the acoustic transmission orifice 17, and therefore the length of the horn, as the arrows indicate. The top edges of the vertically disposed wall sections 14 and 14*a* abut in soundproof fashion against two sides of the acoustic transmission orifice 17, whilst its third side is delimited by the intermediate wall 11, as FIGS. 1 and 3 show. This means that the wall section 14 extends to a region beneath substantially the centre of the overlying pressure chamber 27, which gives the pressure chamber 27 a bracing effect which provides particularly good acoustic stiffness.

FIG. 5 illustrates how the pressure chamber 27 of FIG. 3 can be modified so that its air volume is rendered as small as possible. To this end, there is arranged in the pressure chamber 27 a wall 29 which tapers symmetrically, in wedge fashion, between the two baffles 22 and 23. As well as limiting the volume of the pressure chamber 27 the wall 29 at the same time directs the sound towards the acoustic exit 28 and prevents any eddying, reflection or the like.

The air volume in the pressure chamber 27 can, as FIG. 6 shows, alternatively be reduced by arranging that the two baffles 22 and 23 are in contact with one another and are arranged in wedge fashion to form a wedge-shaped pressure chamber 27. Here the loudspeakers no longer face directly opposite one another but face each other at a slight inclination. The wall 26 of FIG. 3 is omitted but the acoustic exit 28 is retained. Instead of the wedge-shaped wall 29 a thin central wall 30 is then introduced.

FIG. 7 shows a view of the partially cutaway front wall 2 of the cabinet with the two sound exits 15 and 16. The intermediate wall 7 having the acoustic transmission orifice 17 is also shown, as well as the subsidiary walls 11 and 20, both of which subsidiary walls belong to the spirally extending first portion of the exponential horn.

In the case of FIGS. 3 and 5 the tweeter 12 is attached to the subsidiary wall 11 and radiates through an opening provided therein, directly into the commencement of the spirally extending first horn portion, i.e. into a region slightly offset in relation to the acoustic exit 28. In the embodiment shown in FIG. 7, however, the tweeter 12 is arranged in the intermediate wall 7 and in the dead space defined by the external angle between the subsidiary walls 11 and 20, in such a way that the tweeter 12 is directed onto the back wall 3 of the cabinet in the region of the sound passage second half 13*a* (see FIG. 4). However, the tweeter 12 could also be directed forwards at the same position or could be installed in the front wall 2 of the cabinet to radiate directly from the front of the cabinet 1, in the manner shown in FIG. 8 where parts which correspond with those in the preceding Figures have been given the same references.

It should be pointed out that in the embodiments of FIGS. 1 to 7 the loudspeakers 18 and 19 could alternatively be installed in the reverse manner, i.e. the backs of their diaphragms could radiate into the pressure chamber 27 and the fronts of their diaphragms into the sound exit holes 15 and 16.

FIG. 9 illustrates a fourth embodiment of the invention in which a labyrinth horn 31 has been installed in the neighbourhood of the expansion of the first horn portion, just before the acoustic orifice. The labyrinth horn 31 is closed at one end and at the other end opens into the first portion of the horn beside the acoustic exit 28 of the pressure chamber 27, where it cancels out the cross-sectional surplus at that point and does not disturb or restrict the horn geometry. The labyrinth horn 31 comprises baffles 32, only a few centimetres high, which are attached to the intermediate wall 7 and are covered by a glued-on cover (not shown) to complete the labyrinth horn. If, for example, at the horn cross-section between the subsidiary walls 11 and 20 and the inclined wall 8 a theoretical cross-sectional area of 60 cm^2 is required but 100 cm^2 are available, then the labyrinth baffles 32 can be a total of 4 cm high. Between the cover completing the labyrinth horn and the underside of the front wall 2 of the cabinet there is then left adequate cross-sectional area for the sound emanating from the front chamber 9 through the acoustic transmission orifice 17 into the sound passage 13, 13*a*. The labyrinth horn is intended to compensate any disturbing resonance effects which might develop.

This labyrinth horn 31 fits into the said zone whatever the arrangement of the tweeter 12. With installation of the tweeter 12 in the intermediate wall 7 (see

FIG. 7) the labyrinth horn **31** is fitted beneath the front wall **2** of the cabinet.

The left-hand side of FIG. **9** shows the installation of the tweeter **12** on the interior of the back wall **3** in the neighbourhood of the front partial volume **13***a* (see FIG. **1**).

FIG. **10** illustrates schematically and in diagrammatic form the growth of the horn of FIG. **9** by means of a plot of the horn cross-section on the ordinate against the developed horn length on the abscissa. The small cross-hatched area at the left illustrates the pressure chamber volume defined by diaphragm area, chamber depth and sound hole size. The narrow prominence in the curve beside the pressure chamber sound exit hole indicates the volume of the labyrinth horn **31**. The perpendicular substantially half way along the graph indicates the position of the acoustic transmission orifice **17**.

FIG. **11** schematically illustrates the corresponding impedance characteristic of the loudspeaker horn. The narrow, wedge-shaped, cross-hatched area at the right indicates the additional sound input furnished by the tweeter, which is not really essential for transmission purposes but makes it possible to compensate for poor acoustics of the room or otherwise in which sound reproduction by the loudspeaker cabinet is to take place.

FIG. **12** illustrates a circuit arrangement for the selective switching in and control of the tweeter **12**. A direct socket D, an earth socket M, a switching socket S and a connection contact K, matching resistors R_1 and R_2, an input level control P_1 and a manual control P_2 (with an off position for the tweeter) and all connected to a loudspeaker switching socket L. The tweeter Tw, whose volume level is basically optimally adjusted at the factory, can be disconnected altogether or can have its volume increased in continuously variable fashion to achieve special sound reproduction effects. For example, it is well known that marches played by military bands in the open air have a dull and thumping sound when reproduced by means of a microphone and loudspeaker in a room, because at the time of recording the air acts as a kind of "filter curtain" and there is no reverberation. Thus, all the high frequencies are lacking despite attempts to compensate this by the introduction of such instruments as a bell lyra, a glockenspiel and a double piccolo section. Brillance and clarity are lost by this effect and strong sound is only attainable in the immediate neighbourhood of the microphone. It is in such a situation that the installation of a tweeter fulfils a novel function of compensating for these kinds of transmission losses. The tweeter speaker is thus not a correcting device for the exponential horn; the latter reproduces faithfully everything fed into it. In this situation, by virtue of various possibilities of the application of high frequencies as a kind of overlay in the relatively straight frequency response of the exponential horn, relatively good concert reproduction can be achieved even under poor reproduction conditions.

FIG. **13** illustrates a fifth embodiment of the invention in which the two parallel-connected loudspeakers **18** and **19** have the front sides of their diaphragms arranged close together and so as to radiate directly into the room or the like through sound exit holes in the front wall of the cabinet **1**. The rear sides of their diaphragms operate into the pressure chamber **27**, which is shallow and therefore has its own back partition **35** with a rectangular central opening **33** shown in cross-hatched fashion, in order for the sound to leave the pressure chamber **27**. A top left-hand corner piece of the front wall **2** of the cabinet has been indicated and this wall **2** covers the pressure chamber **27** and contains suitable acoustic orifices for the loudspeakers, these being fitted in sound-proof fashion to the front wall of the cabinet.

Because of the shallow depth of the pressure chamber **27** between its back partition **35** and the intermediate wall **7** there is adequate space to introduce, in the manner shown in FIG. **14**, a substantially P-shaped acoustic guide formed by subsidiary walls **34** which are fitted in sound-proof fashion between the back partition **35** and the intermediate wall **7**. The P-shaped acoustic guide provides the spirally extending first horn portion and directs sound, emanating from the rectangular opening **33**, in the direction indicated by the arrows to the acoustic transmission orifice **17**, from where it enters the first sound passage half **13** (see FIG. **4**). The further path taken by the sound is indicated by arrows in FIGS. **4** and **1**.

As many loudspeakers as there are chamber side walls available can operate into the pressure chamber **27**, in each case those sides of the diaphragms operating towards the exterior of the pressure chamber having access to the air of the room or the like in which the cabinet is disposed. The more loudspeakers are arranged, close together, in the pressure chamber **27**, all operating in the same direction, the more the overall radiation resistance and frequency range of the cabinet is improved.

FIGS. **16** and **18** show a sixth embodiment in which four loudspeakers are housed in the cabinet and are located in one plane to radiate forwardly of the cabinet through an appropriate acoustic aperture in the front wall **2**. These four loudspeakers are arranged to radiate in the same direction and have a single common diaphragm **41** installed in a common support dish **36** which is specially adapted to the exponential installation, is extremely shallow and is laterally closed, i.e. has no lateral orifices. The support dish **36** is equipped with a flat, dished, back wall **37** which supports the four loudspeaker magnets and centering spiders. The wall **37** also has a central acoustic exit **38** so that the dish **36** itself acts as a pressure chamber. The dimensions of the hole 33 (see FIG. **16**), which is in tight abutment against the exit **38** of the support dish **36**, produces the requisite velocity transformation by blanking-off some of the exit window **38**.

In order to distribute the action of the pressure chamber and the radiation resistance (bearing in mind the special nature of the exponential principle) over the large, flat, single common diaphragm **41** it is provided between its four loudspeaker cones **39** with creases or folds and with an on-edge cross **42** the arms of which, in accordance with the principles governing simple supported uniformly loaded beams, taper towards the external ends in order to reduce weight. These arms are made up of very light hard foam (styropor or the like) and improve the transmission of the four individual drive amplitudes to the diaphragm as a whole because of the transition from the four, stiff, circular cones **39** associated with the loudspeaker speech coils, through elliptical cone extensions **40** (see FIG. **18**) into the overall diaphragm, and because of the maximum distribution of drive to the particular frame which is consequently achieved.

The lines of intersection between the cones **39**, the ellipses **40**, and the plane of the diaphragm **41** are in the form of miniature folds or creases which are mechanically damped using elastic resin, in order at the same time to allow the four cones to act preferentially as tweeters.

The distance of the four speech coil axes from the central axis of the overall diaphragm **41** is determined by the distribution of the radiation resistance at both sides, thus: each overall diaphragm frame has an imaginary point of application of the resultant radiation resistance gradient, beneath which the speech coil section must lie. In this way, the relevant diaphragm portion is uniformly loaded and tilting of the speech coil and the associated frame, and of the single common diaphragm **41** as a whole, is prevented.

Despite the use of four loudspeakers, by these described measures an optimally restricted pressure chamber, plus adequate space for the first part of the first horn portion, is provided and a particularly small cabinet design made possible.

I claim:

1. A loudspeaker cabinet comprising:

a front wall defining a first sound exit hole and at least one further sound exit hole;

a back wall;

an intermediate wall intermediate said front wall and said back wall;

a plurality of subsidiary walls between said front wall and said intermediate wall and arranged so as to provide a pressure chamber and a spirally extending first portion of a substantially exponential horn, said horn first portion extending from said pressure chamber to a sound passage defined between said intermediate wall and said back wall; one of said plurality of subsidiary walls being an inclined wall extending, at an angle, from said intermediate wall to said front wall and said substantially exponential horn having a second portion extending to said first sound exit hole and comprising said sound passage and a region partially defined by said inclined wall;

at least two loudspeakers each of which comprises a diaphragm and an operating means for the diaphragm and is arranged to radiate sound into said pressure chamber from one side of its said diaphragm and through the or one said further sound exit hole from the outer side of its said diaphragm, each of said loudspeakers being arranged so that its said operating means occupies a volume of said loudspeaker cabinet which is substantially outside the substantially exponentially growing free space of said substantially exponential horn; and

a tweeter arranged to occupy another volume of said loudspeaker cabinet which is also substantially outside said substantially exponentially growing free space of said substantially exponential horn.

2. A loudspeaker cabinet as claimed in claim **1**, wherein the two or two of the said loudspeakers are arranged spaced apart and facing one another or back-to-back, said pressure chamber being provided between said two loudspeakers.

3. A loudspeaker cabinet as claimed in claim **2**, wherein said diaphragms of said two loudspeakers are contained in respective ones of two diaphragm-containing chambers extending from said intermediate wall to said front wall and comprising two respective ones of said further sound exit holes and also respective sound entry holes into said pressure chamber from said diaphragm-containing chambers.

4. A loudspeaker cabinet as claimed in claim **3**, wherein said loudspeakers face one another or are back-to-back in directly opposite directions and said pressure chamber contains a wedge-shaped, symmetrically tapering, one of said plurality of subsidiary walls, said wedge-shaped wall extending symmetrically between said chambers so that its narrower edge is directed centrally towards an exit of said pressure chamber leading to said horn first portion and said wedge-shaped wall extending substantially completely across the extent of said sound entry holes of said diaphragm-containing chambers.

5. A loudspeaker cabinet as claimed in claim **3**, wherein said two loudspeakers face one another or are back-to-back in an inclined manner so that said pressure chamber is wedge-shaped and diverges towards a sound exit of said pressure chamber leading to said horn first portion, there being edges of respective ones of said diaphragm-containing chambers which are connected together in airtight manner to form the thin edge of said wedge-shaped pressure chamber, whilst remote edges of respective ones of said diaphragm-containing chambers partially define a sound exit of said pressure chamber leading to said horn first portion.

6. A loudspeaker cabinet as claimed in claim **5**, wherein a relatively thin wall of said plurality of subsidiary walls extends from said thin edge of said wedge-shaped pressure chamber and substantially completely across the extent of said sound entry holes of said diaphragm-containing chambers.

7. A loudspeaker cabinet as claimed in claim **3**, wherein said spirally extending first horn portion extends about said pressure chamber.

8. A loudspeaker cabinet as claimed in claim **1**, wherein said at least two loudspeakers are arranged to radiate sound into said pressure chamber from the rear sides of their said diaphragms, and directly through said at least one further sound exit hole from the front sides of their said diaphragms.

9. A loudspeaker cabinet as claimed in claim **8**, wherein said pressure chamber extends from said front wall only as far as a partition extending intermediate said front wall and said intermediate wall, said partition defining a sound exit of said pressure chamber leading to said horn first position and said spirally extending horn first portion being partially defined by walls of said plurality of subsidiary walls which extend from said partition to said intermediate wall.

10. A loudspeaker cabinet as claimed in claim **9**, wherein said at least two loudspeakers comprise four loudspeakers arranged substantially in a square and having their diaphragms constituted by a single common diaphragm comprising four cone portions for the four loudspeakers, said single common diaphragm having corners with a large radius and being stiffened by creases and/or a cross piece.

11. A loudspeaker cabinet as claimed in claim **10**, wherein said single common diaphragm is mounted in a support dish arranged to act with said single common diaphragm as said pressure chamber, said support dish also supports said operating means of said four loudspeakers and said pressure chamber comprises a single sound exit leading to said first spirally extending horn portion and comprising a hole in the bottom of said support dish.

12. A loudspeaker cabinet as claimed in claim **11**, wherein said partition is in tight abutment against said support dish bottom and defines a partition hole limiting the size of said single sound exit by blanking-off some of said hole in said bottom of said support dish.

13. A loudspeaker cabinet as claimed in claim **1**, and comprising a closed spirally extending labyrinth horn portion extending off said spirally extending first horn portion from a region adjacent a sound exit from said pressure chamber into said spirally extending first horn portion.

14. A loudspeaker cabinet as claimed in claim **1**, wherein said tweeter is attached to one of said subsidiary walls defining an initial part of said spirally extending first horn portion, said tweeter being arranged to radiate sound into a region which is off-set in relation to an exit of said pressure chamber leading to said spirally extending first horn portion.

15. A loudspeaker cabinet as claimed in claim **1**, wherein said tweeter is attached to said intermediate wall and arranged to radiate sound into said sound passage.

16. A loudspeaker cabinet as claimed in claim **1**, wherein said tweeter is attached to said back wall and arranged to radiate sound directly to said first sound exit hole.

17. A loudspeaker cabinet as claimed in claim **1**, wherein said volume occupied by said tweeter is substantially outside said substantially exponentially growing free space of said substantially exponential horn by virtue of its being located on one of said subsidiary walls behind a projecting portion of another of said subsidiary walls, said projecting portion providing a baffle blocking said volume from the path of sound travelling through said horn.

18. A loudspeaker cabinet as claimed in claim **1**, and comprising a tweeter controller operable to control the volume of said tweeter relative to the volume of said at least two loudspeakers.

19. A loudspeaker cabinet as claimed in claim **1**, wherein said sound passage is partially defined by an acoustic guide extending perpendicularly from said intermediate wall to said back wall and in such a direction as to provide said sound passage with its substantially exponential form.

20. A loudspeaker cabinet as claimed in claim **1**, wherein said front wall and said intermediate wall are parallel to one another and said subsidiary walls, except said inclined wall, are vertical to said front wall and to said intermediate wall.

21. A loudspeaker cabinet as claimed in claim **1**, wherein said back wall is parallel to said front wall.

* * * * *