Dec. 27, 1938. W. C. EAVES 2,141,208

PNEUMATIC SOUND REPRODUCER

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Fig. 1.

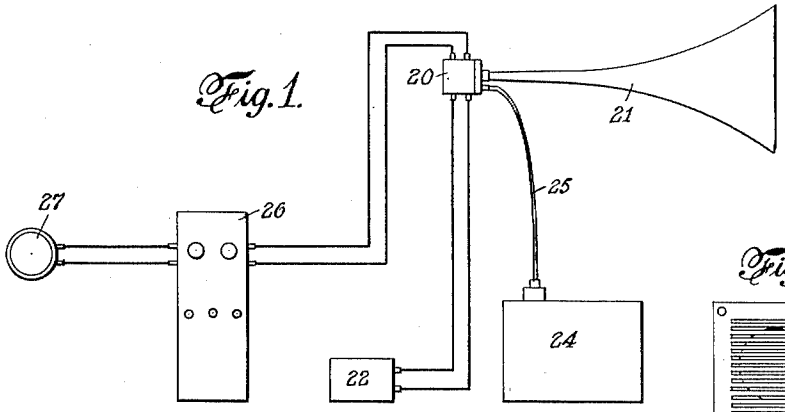


Fig. 3.

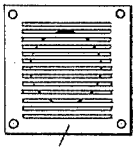
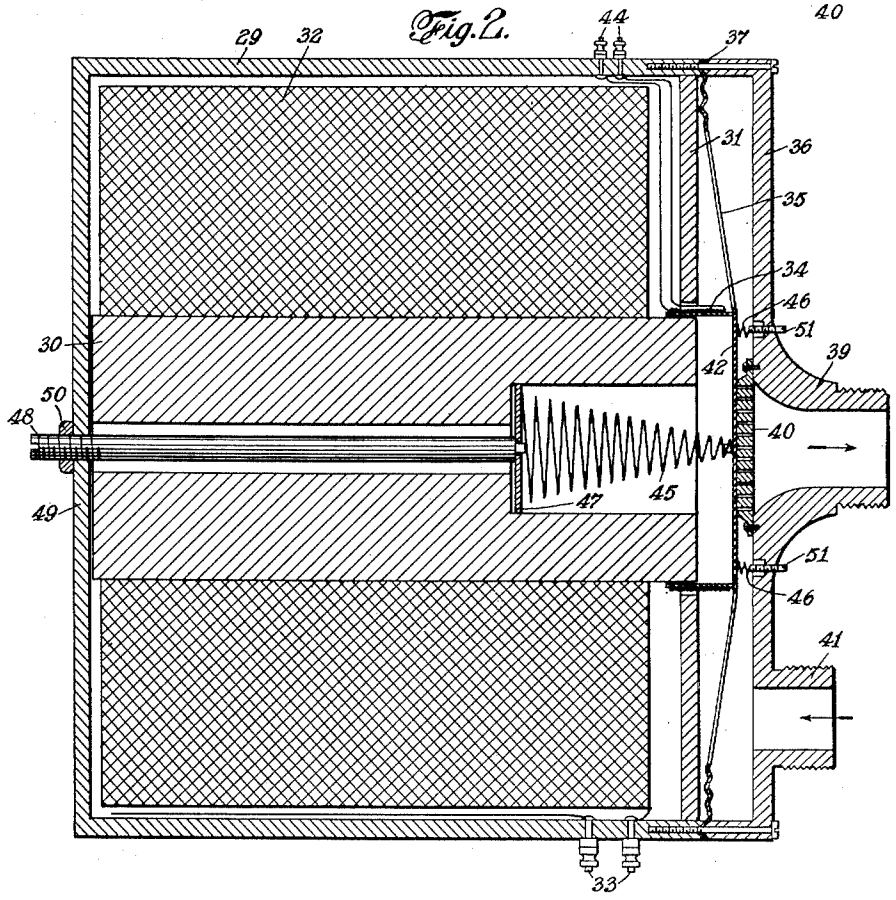


Fig. 2.



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Fig. 4.

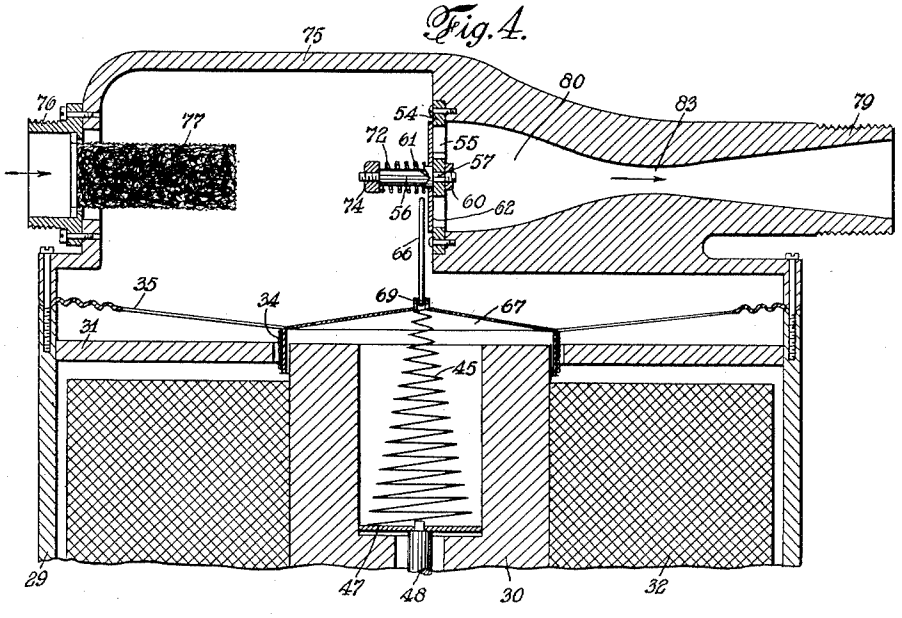


Fig. 5.

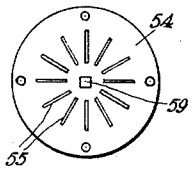


Fig. 6.

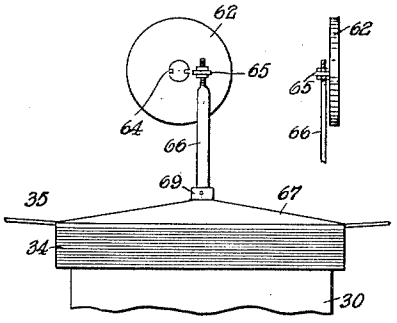


Fig. 7.

Fig. 9.

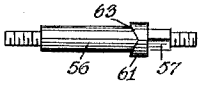


Fig. 8.

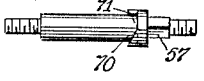


Fig. 14.

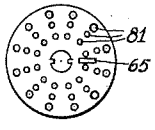


Fig. 10.

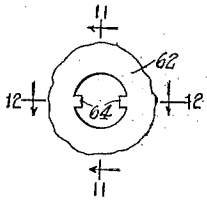


Fig. 11.



Fig. 13.

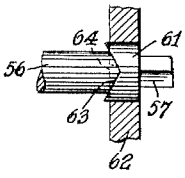


Fig. 15.

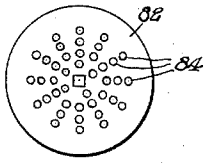
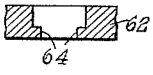


Fig. 12.



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Fig. 16.

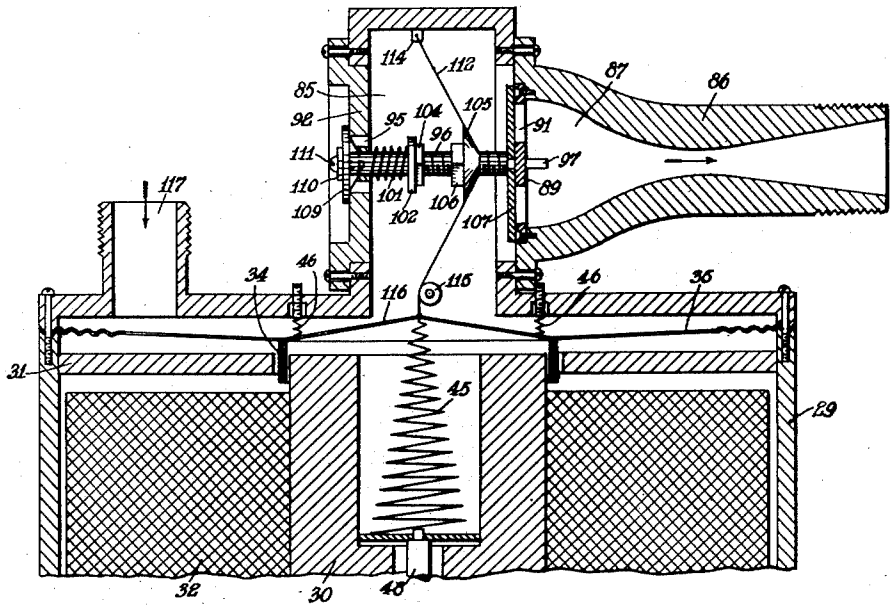


Fig. 17.

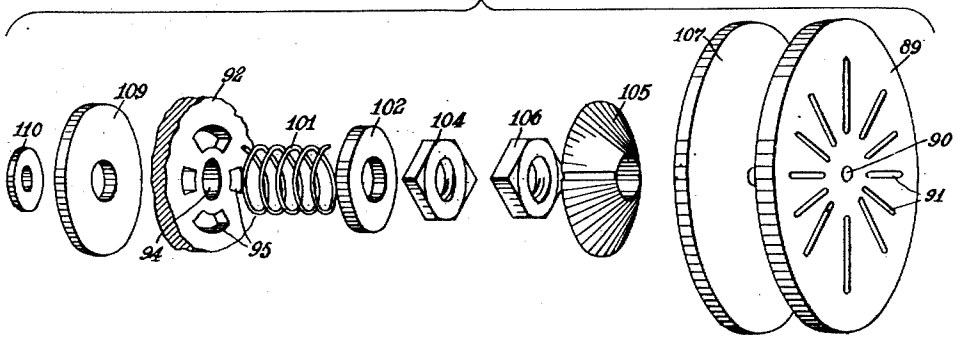
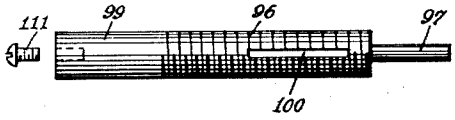


Fig. 18.



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Patented Dec. 27, 1938 2,141,208

UNITED STATES PATENT OFFICE

2,141,208

PNEUMATIC SOUND REPRODUCER

William C. Eaves, New York, N. Y., assignor of one-third to Carl H. Fowler, New York, N. Y.

Application March 31, 1934, Serial No. 718,326

6 Claims. (Cl. 179—108)

This invention relates to pneumatic sound reproducers of the type in which an elastic fluid medium, such as air under pressure, is released through a vibrating valve in such manner as to generate sound waves.

The principal object of the invention is to provide improved mechanism whereby more satisfactory reproduction of sound may be accomplished.

Further objects are to provide apparatus which will produce greater amplification of the sound for a given unit of input power than has heretofore been accomplished, giving reproduced sound of increased intensity or loudness; to provide means for more fully utilizing the vibratory impulses produced by electromagnetic loud speaker motors; and to provide valve mechanism and operating means therefore which is less critical in adjustment and therefore less liable to fail in operation.

Other objects will more fully appear from the following description, which, taken in conjunction with the several drawings, illustrate various embodiments of the invention.

In the drawings Fig. 1 shows diagrammatically a complete sound reproducing system utilizing the present invention; Fig. 2 is a sectional view of one type of sound reproducing unit; Fig. 3 shows a type of grid suitable for use in the unit shown in Fig. 2.

Fig. 4 is a section through a part of another type of embodiment; Fig. 5 is a plan view of a form of grid for use in a reproducer such as shown in Fig. 4; Figs. 6 and 7 are detail views of the valve shown in Fig. 4 at right angles to one another; Figs. 8 and 9 are detail views of the valve arbor showing two different types of valve cam; Fig. 10 shows a broken plan view of the center of the valve of Fig. 6 showing in detail the cam following lugs; Fig. 11 is a section taken on the line 11—11 of Fig. 10 and Fig. 12 is a section taken on the line 12—12 of Fig. 10; Fig. 13 is a broken view partly in section showing parts of the valve, the valve arbor and the cam; Fig. 14 shows a modified form of valve having apertures for the passage of fluid; Fig. 15 shows a modified form of grid.

Fig. 16 is a sectional view of part of another embodiment; Fig. 17 is an exploded view showing the grid and the parts of the valve mechanism which are assembled on the arbor which is shown in plan view in Fig. 18.

Referring to the drawings, Fig. 1 shows a pneumatic sound reproducer 20 of the so-called "dynamic" or floating coil type and embodying the present invention which is equipped with a horn 21, preferably of the exponential type, and supplied with current for the field coil from any suitable source 22. Compressed air is supplied to the sound reproducer from any suitable source 24 through a pipe 25. Modulated current is supplied to the voice coil of the sound reproducer from an amplifier 26 which has a current input generally represented at 27, which may be a microphone, an electromagnetic pick-up for recorded sound, a photo-electric cell or any other suitable source.

Referring to Fig. 2, a sound reproducer illustrating one embodiment of the invention will now be described in detail. The usual elements of the dynamic type of loud speaker are shown including a container having magnetic walls 29 to which are secured the center pole piece 30 and the outer pole 31 which is in the form of a disc, between which a strong magnetic field is created by the flow of current through the field coil 32 in known manner. Terminals 33 are provided for attaching the field coil current supply. In this magnetic field a voice coil 34 is suspended by means of a flexible spider 35. The spider 35 is clamped between the walls 29 and the cap 36 which are provided with V edges 37. The spider 35 is corrugated or crimped around its outer edges so as to permit axial movement of the voice coil 34 and is provided with large apertures to permit free flow of fluid around it.

The cap 36, which is of non-magnetic material, has a neck 39 provided with means for attaching a horn through which is a passageway communicating with the inside of the unit. Across this passageway a grid 40 is secured in such manner that all air leaving the unit must pass therethrough. The cap is further provided with an air coupling 41 having a passage communicating with the inside of the unit through which compressed air or other fluid may be supplied. It will thus be seen that air introduced at 41 must find its exit through the grid 40 into the horn attached to the neck 39. In order to set up vibrations or sound waves in this outwardly moving air, a valve is provided across the face of the grid 40. In the embodiment shown, this valve is in the form of a smooth solid plate 42 secured to the voice coil 34.

When a modulated current is supplied to the voice coil, through the terminals 44, it will vibrate in known manner, along its axis, and will generate corresponding vibrations or sound waves in the air flowing through the grid 40 into the horn, thus generating audible sound having modulations corresponding to the modulations of the voice coil current.

Resilient means are provided for positioning the voice coil and the valve carried thereby relative to the grid. These means include the conical spring 45, mounted in a well in the pole piece 30, and the springs 46. These springs are adjustable, the spring 45 being mounted on a plate 47 secured to the end of an adjusting screw 48 which is threaded in the bottom wall 49 and

provided with a lock-nut 50. The springs 46 are mounted on the ends of screws 51 threaded into the cap 36. It will be understood that there are at least three springs such as 46 to provide proper balance for the voice coil. These springs position the voice coil so as to normally close the grid and also function to dampen the movement of the voice coil and the valve carried by it as may be desired. For the springs 45 and 46 any other suitable resilient material, such as rubber blocks, may be substituted. It will be noted that the fluid pressure of the compressed air is shown as applied on the same side of the grid on which the valve is located. This arrangement is preferred because it has been found that it effects substantial increase in the intensity of the sound emitted as compared with the usual practice of the prior art to apply fluid pressure on one side of the grid having the valve located on the opposite side. This increase in intensity is believed to be due to the full utilization of the latent energy of the pressure of the fluid medium as it is permitted to escape through the grid in accordance with the vibration of the valve.

Referring now to Figs. 4 through 15, in Fig. 4 the same general construction of loud speaker is illustrated for supplying the motive power which operates the valve. The construction and operation of the valve are as follows: A grid 54 having radial slots 55 is placed across the air outlet of the unit. The stud 56 is provided with a square end 57 which fits in a square hole 59 in grid 54 and is secured therein by a nut 60. On the stud 56 is a circular collar 61 on which is rotatably mounted a valve plate 62. The face of the collar 61 away from the grid is cut at an angle to form a cam as shown at 63 (Fig. 9). Lugs 64 (Fig. 10) are provided on the valve plate 62 to bear against the cam 63 in such manner that when the valve plate 62 is rotated it will move away from the grid 54, thus permitting the escape of fluid therethrough.

Referring to Fig. 9, it will be noted that the cam is cut with two angular faces so that the valve plate will be moved away from the grid as it is rotated in either direction from its center position. In Fig. 8 a modified cam is shown which will cause the valve to move away from the grid when it is rotated in one direction but not when it is rotated in the other. This cam has on each side an angular face 70 and a face 71 in a plane perpendicular to the axis of the arbor. It will be seen that if the valve is positioned upon the arbor so that its lugs are at the junctions of the faces 70 and 71, the valve will move away from the grid if turned clockwise (viewed as in Fig. 6), but if turned counterclockwise it will remain in the same plane and therefore in contact with the grid. In order to oscillate the valve 62 in accordance with the movement of the voice coil 34, the valve is provided with a pivoted lug 65 to which a link 66 is secured. The voice coil is provided with a rigid conical top 67 carrying a bracket 69 to which the lower end of the link 66 is pivoted. To hold the valve normally in closed position against the grid the coil spring 72 is placed around the stud so as to press against the valve and held in place by an adjusting nut 74.

Air under pressure is admitted into the inside of the cap 75, which is made of non-magnetic material, though the collar 76 which is provided with an air filter 77. The cap is also provided with a connection 79 for a horn through which is the air passageway from the grid. This passage is given an internal configuration similar to that of a mouth piece for a musical instrument of the horn type to promote the production of sound waves. Adjacent the grid is a chamber 80 gradually decreasing in cross-section to the throat 83, at which point the exponential curve of the horn commences.

Instead of using a solid valve like that shown in Figs. 6 and 7 it may be desirable to use a valve having apertures therein which will provide a shorter path for the air in seeking an outlet through the grid. Such a valve is shown in Fig. 14 in which there are graduated holes 81. This valve is so positioned over the grid 54 that each row of holes falls midway between two of the slots 55, shown in Fig. 5. As the valve is oscillated by the reciprocation of the voice coil 34, communicated to it through the link 66, it separates slightly from the grid by the action of the lugs 64 on the cam 61 and the air under pressure within the cap 75 intermittently escapes through the openings 81, between the valve and the grid and through the openings in the grid. By reason of the rapid vibration of the valve, sound waves will be set up in the passage 80 having characteristics corresponding to the fluctuations of the current impressed upon the voice coil. It will be noted that in this construction with the valve on the same side of the grid from which the fluid under pressure is supplied all of the fluid passing through the grid must be subjected to the action of the valve and therefore modulated to produce sound waves. This gives a marked increase in efficiency over constructions in which the valve is on the side of the grid opposite to that from which the fluid is supplied under pressure, in which case much of the fluid passing through the grid escapes around the valve and is not modulated.

The use of a valve without any openings through it has an advantage, however, in that an added cushioning effect is secured, eliminating slap between the valve and the grid. The air between the grid and the valve, in the case of a solid valve, can escape from the pressure chamber only through the apertures in the grid and the total area of the valve being greater than the area of the apertures in the grid, the rapid movement of the valve toward the grid will be impeded by the resistance which the grid presents to the flow of air. Obviously this cushioning effect will be somewhat decreased if the air can also escape from between the grid and valve through apertures in the valve.

Fig. 15 shows an alternate form of grid 82 having rows of holes 84 for the same purpose and in place of the radial slots 55 in the grid 54.

A third embodiment of the invention, utilizing a somewhat different means of operating the valve and providing for a partially balanced valve assembly, is illustrated in Figs. 16, 17 and 18. In Fig. 16 will be seen the same general arrangement of a dynamic type of loud speaker described in Figs. 2 and 4, including the magnetic walls 29, pole pieces 30 and 31, field coil 32 and voice coil 34 supported by a spider 35 and balanced between the springs 45 and 46. The structural parts above the pole piece 31 are principally of non-magnetic material. Above the voice coil a suitable chamber 85 is provided to house the valve operating mechanism. On one side thereof is the connection 86 for the horn in which is a passageway 87 closed at the inner end by the grid 89. In the center of the grid is a circular hole 90 around which are disposed ra-

dial slots 91. In the wall 92 opposite the grid is a circular hole 94 around which are outlet ports 95. The combined area of the ports 95 is preferably approximately equal to the combined area of the apertures 91 in the grid, to provide the proper balancing effect. The valve arbor 96, shown in detail in Fig. 18, has a reduced end portion 97 machined to slide freely in the hole 90 in grid 89. The hole 94 is of such size as to permit the smooth end portion 99 of the arbor 96 to slide in it and the rest of the arbor is provided with a fine thread. A longitudinal slot 100 is provided in the arbor for a purpose which will presently appear.

To facilitate assembly of the unit the rear wall 92 is made removable. The valve arbor 96 is mounted in the chamber 85 so as to have free axial movement, through a limited distance, perpendicular to the grid 89. Carried by the arbor is a spring 101, a retaining washer 102 and its adjusting nut 104, which cause the arbor to be normally moved toward the grid. Sliding on the threaded portion of the arbor is a conical bearing member 105 and its adjusting nut 106. The valve plate 107, which may be of any suitable type, is secured at the base of the reduced portion 97 of the arbor 96 so that it will move with the arbor. On the outer end of the arbor 96 which protrudes through the opening 94 is a valve plate 109 held in place by the washer 110 and screw 111. The size of the parts is such that when the valve 107 is flush with the grid 89 the valve 109 will be flush with the wall 92 closing the ports 95 so that the air pressure in chamber 85, by acting upon the plate 109, will balance, to some extent, the air pressure on the valve plate 107.

In order to cause the valve 107 to vibrate in accordance with the vibrations of the voice coil 34 a flexible member 112, in the form of a flat strip of metal, a wire or other suitable material is anchored at 114 to the top of the chamber 85, passing angularly downward over the face of the bearing member 105, through the slot 100, over the bearing pulley 115 and thence to the center point of the conical top 116 of voice coil 34. It will thus be seen that movement of the voice coil 34 in a downward direction will tend to straighten out the flexible member 112 and will lift the valve 107 away from the grid 89, permitting the intermittent escape of air in accordance with the movement of the voice coil and setting up vibrations in the air, whereby sound waves will be generated in the passage 87. Air under pressure will be supplied to the unit from any suitable source through the inlet port 117. The air pressure used should be constant and may be from 3 to 25 pounds pressure per square inch.

Several embodiments of the invention have been described in the foregoing specification. It will be understood that various modifications may be made in the constructions shown and particularly described within the purview of invention as defined in the following claims.

I claim:

1. In a pneumatic sound reproducer having an apertured grid, means for controlling the passage of fluid through said grid so as to produce sound comprising a valve plate secured to an arbor, bearings for said arbor permitting axial movement thereof perpendicular to said grid, means for urging said arbor toward said grid, a flexible member operatively connected to said arbor at an angle and arranged to move said arbor axially in accordance with variations of tension applied at one end of said member, and electro-magnetic means for varying the tension on said member.

2. In a pneumatic sound reproducer having a horn and an apertured grid, and a chamber for elastic fluid under pressure, means for controlling the passage of fluid from said chamber, through said grid and into the horn so as to produce sound comprising an arbor mounted for axial movement vertical to the plane of said grid, a pair of valves on said arbor against which pressure in the chamber is exerted, one controlling the flow of fluid through said grid and into the horn and the other permitting escape of fluid from the chamber elsewhere than through the horn, and means for vibrating said arbor axially.

3. In a pneumatic sound reproducer having a grid and a relatively reciprocating valve which valve is mounted on an arbor, means for causing said reciprocation comprising an oscillating voice coil, a flexible member anchored at one end and attached to the voice coil at the other end and operatively connected to said arbor at an angle, whereby movement of the voice coil is communicated to the valve through said flexible member.

4. In a pneumatic sound reproducer having a horn and an apertured grid through which all of the fluid entering the horn must pass, and a chamber for elastic fluid under pressure, means for controlling the passage of fluid through said grid so as to produce sound comprising a valve and a member carrying said valve and moving with it, and means also associated with said member upon which the fluid pressure in the chamber is exerted in a direction opposite to the pressure on the valve to counteract the tendency of the pressure to close the valve, any escape of fluid from the chamber permitted by the last-mentioned means being elsewhere than through the horn.

5. In a pneumatic sound reproducer having a horn and an apertured grid through which all of the fluid entering the horn must pass, and a chamber for elastic fluid under pressure, means for controlling the passage of fluid through said grid so as to produce sound comprising a valve and a member carrying said valve and moving with it, and an auxiliary valve also carried by said member and subject to the pressure of the fluid in the chamber and tending, under that pressure, to move said member in a direction opposite to that in which the pressure on the first mentioned valve tends to move it, the escape of fluid from the chamber about the auxiliary valve being elsewhere than through the horn.

6. A pneumatic sound reproducer having a horn and an apertured grid, a chamber for elastic fluid under pressure having an opening communicating with the horn across which said grid is disposed, a valve mounted for vibratory movement relative to said grid to control the passage of fluid therethrough and into the horn, means operatively connected with said valve and moving with it and in communication with atmospheric pressure elsewhere than through the horn upon which means the pressure in said chamber is exerted so as to tend to move the valve in a direction opposite to the direction in which the pressure on the valve tends to move it whereby the pressure on the valve is counterbalanced by the pressure on said means, and means for vibrating said valve relative to said grid.

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