July 7, 1942. E. F. CHANDLER 2,288,607

PNEUMATICALLY OPERATED LOUDSPEAKER

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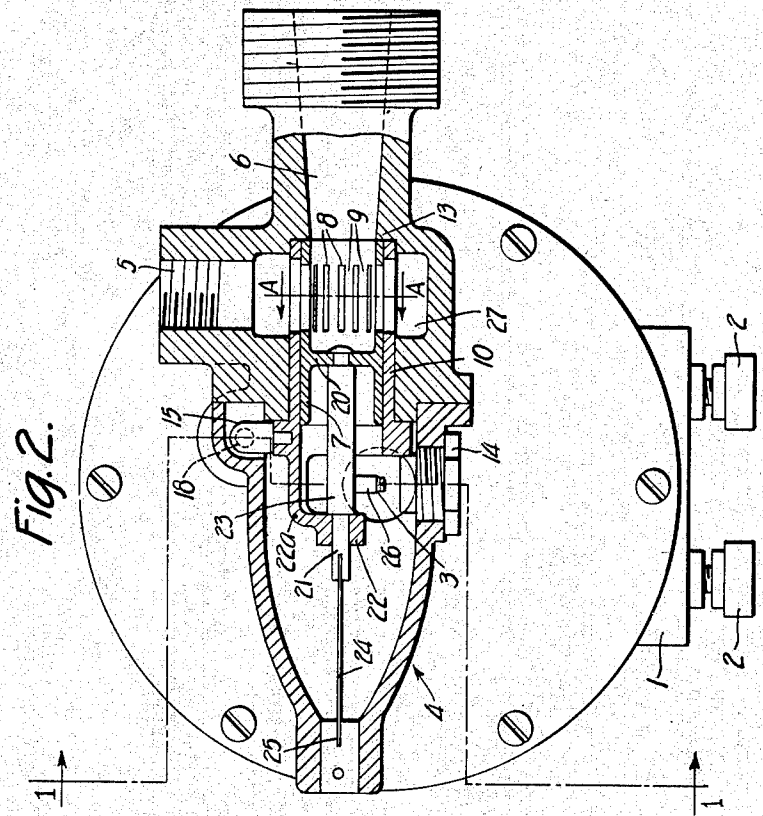


Fig. 2.

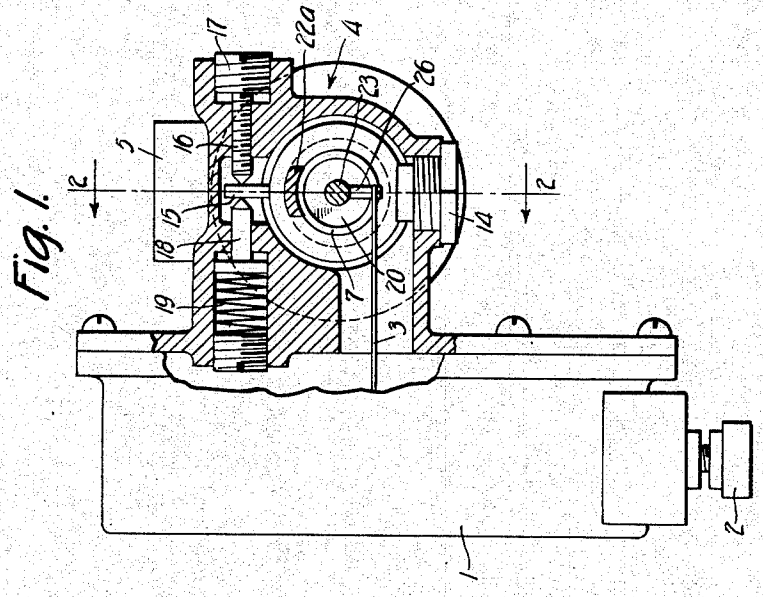


Fig. 1.

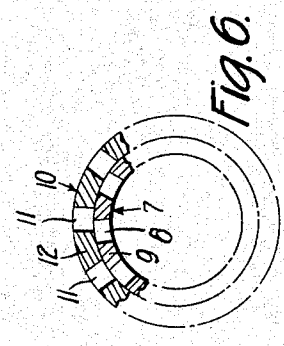


Fig. 6.

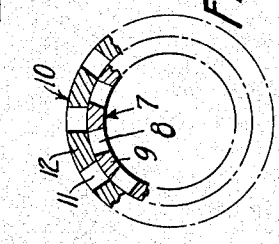


Fig. 5.

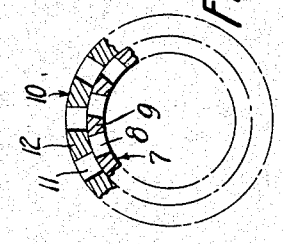


Fig. 4.

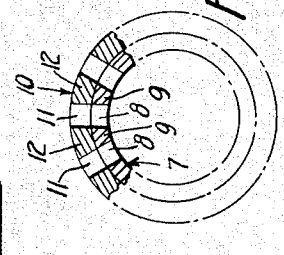


Fig. 3.

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PNEUMATICALLY OPERATED LOUDSPEAKER

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Fig. 7.

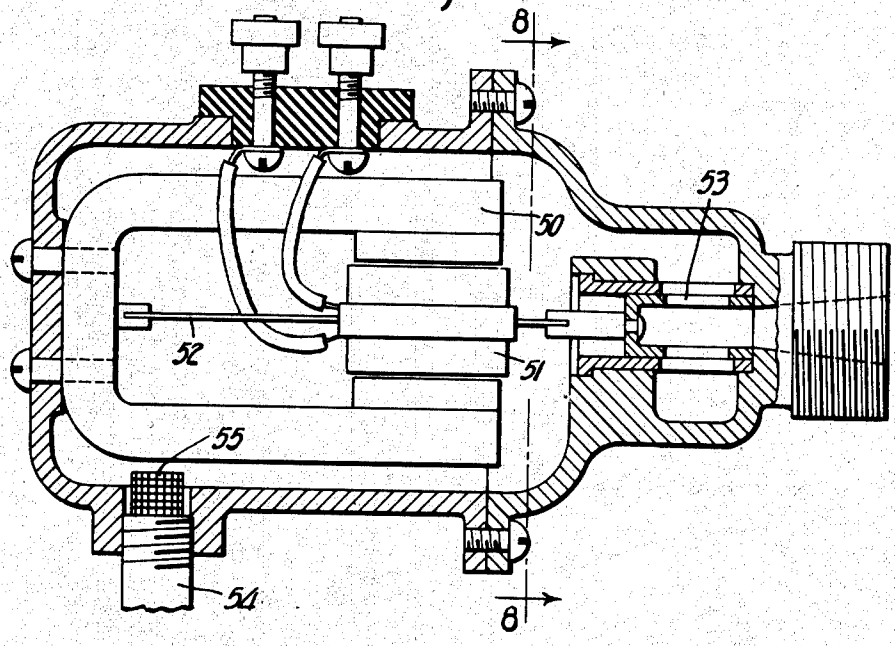
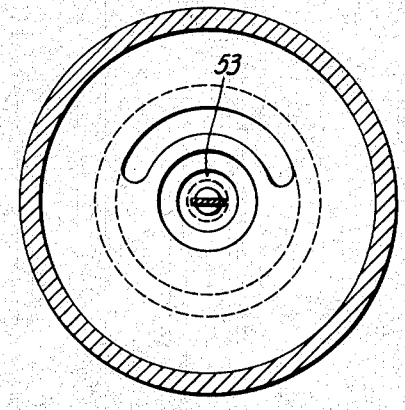


Fig. 8.



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PNEUMATICALLY OPERATED LOUD-SPEAKER

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Application December 21, 1939, Serial No. 310,361

10 Claims. (Cl. 179—108)

This invention relates to a pneumatically operated loud-speaker of the class in which compressed gas is caused to pass through a valve actuated in its openings and closings by sound which is to be amplified.

In such loud-speakers it is customary to control the valve by either a voice coil or an electromagnetic unit of the magnetic or dynamic type. It is customary, also, in such loud-speakers to assemble a grid member as the air valve and a coacting plate, so that relative movement between the grid member and the plate serves to open and close the valve, in accordance with the characteristics of the sound being amplified.

The valves are ordinarily of the poppet or sliding valve types. The former are subject to high leakage of gas, causing a hissing sound in the speaker and requiring an unnecessarily large consumption of gas. The latter are not adapted for satisfactory operation at any one setting over a wide range of frequencies.

There is a tendency of the valve assembly to chatter or vibrate with the production of undesired noise and a metallic quality in the sound. The parts of the conventional assembly require careful and extensive initial machining and the assembly is difficult to keep in proper adjustment.

It is an object of the present invention to provide a loud-speaker in which these disadvantages are eliminated or minimized and which is relatively inexpensive to make, rugged and durable. Other objects and advantages will appear from the detailed description that follows.

The invention, in brief, comprises a speaker including a tubular air valve provided with ports, a tubular cover or seat fitting over the valve and provided with ports adapted to register with the ports in the valve, means for holding the valve normally in the position of non-communication between the ports in the valve and cover, means energized by sound, through either a voice coil or an electromagnetic unit, for rocking the valve on its longitudinal axis, so as to place the ports in the valve and cover in communication, means for supplying a gas under pressure to the outside of the valve cover, so that air passes as puffs or blasts through the valve assembly when the ports are placed in communication, and means for returning the valve to its normal position when the energizing effect ceases. Preferably the speaker includes an exponential horn so placed as to receive directly the air which passes thus through the air valve.

The invention will be illustrated by description in greater detail in connection with the attached drawing, to which reference is made.

Fig. 1 is an end view, partly in section, on line 1—1 of Fig. 2;

Fig. 2 is a plan view, partly in section, on line 2—2 of Fig. 1;

Figs. 3, 4, 5 and 6 are sectional views of the air valve assembly, on line A—A of Fig. 2, showing different relative positions of the inner and outer parts of the assembly;

Fig. 7 is a longitudinal section of a modified form of embodiment; and

Fig. 8 is a view showing a sectional view of Fig. 7 taken on the lines 8—8.

There are shown a base member 1 including electrical binding posts 2. Extending from the base is the link 3 constituting the sound energized driving member.

Disposed within the base, but not shown, is any suitable conventional means for imparting to the driving member 3 vibrations characteristic of sound waves. Thus, the base may contain a unit of the magnetic or of the dynamic type such as used in common loud-speakers, the unit receiving its impulses through the electric current supplied to the binding posts 2 and being initially generated by the sound which is to be amplified, as by means of a microphone or like circuit.

The speaker includes a casing indicated generally at 4, an inlet 5 for compressed gas and a sound and air outlet 6. The outlet is connected to a usual type of speaking horn (not shown). The casing is suitably made in two parts, one to the left and one to the right in Fig. 2, held together by conventional bolts or clamps (not shown) acting upon flanges or lugs of usual type projecting from the two parts.

Extending between the air inlet and the outlet 6 is an air valve assembly including a tubular valve 7 provided with spaced ports 8 and intervening imperforate areas or lands 9. Disposed around the valve and fitting snugly thereagainst is a tubular valve cover or seat 10 provided with ports 11 and intervening lands 12, the ports in the two concentric tubular members being spaced angularly the same, that is, equally spaced at their centers around the circumference of the tubular members, so that all the ports in one member may be placed at one time in communication, in full registration if desired, with ports in the other of the members. The relative position of the ports at registration is shown in Fig. 3. Figs. 4 and 6 show the ports in communication but not in registration.

The lands 12 of the tubular cover are at least

as large in all dimensions as and preferably are somewhat wider than the ports 8 in the valve, as shown in Figs. 5 and 6, so that the ports 8 may be closed completely by the lands 12.

The tubular cover fits tightly within the casing 4 of the speaker and is prevented from slipping in the direction of the sound outlet by the shoulder 13 of the casing. At the other end, the cover is prevented from moving lengthwise by the nut 14 which closes the hand hole and terminates at the inner end of the said cover.

The tubular valve 7 is rotatable to the extent that it may be rocked back and forth through a small angle, within the valve cover 10. In this manner, ports within the two members may be made alternately to communicate and not to communicate.

An element such as the lug 15 extends from the outside of the tubular valve cover, substantially in the direction of an extended radius thereof, that is, transversely with respect to the longitudinal axis of the cover. A set screw 16, with lock nut 17, acts upon one side of the said element, whereas the stop 18 is forced by spring 19 against the other side of the element. By changing the position of the set screws 16, the element 15 and attached tubular cover 10 are rotated slightly. At all times the element 15 is held in firm, non-rattling manner between the end of the set screw and the spring-pressed stop.

The inner of the concentric tubes constituting the air valve 7 is attached, as by a web member 20 to a bolt or shaft member 21. The latter passes through a guide member 22, which is continuous with a hook-like extension 22*a* of the tubular valve cover 10.

The sleeve or enlargement 23 around the bolt 21 rests at one end against the web member 20 and at the other end against the guide 22, as illustrated, and prevents lengthwise movement of the valve member 7 towards the said guide. Lengthwise movement of the valve 7 in the other direction is prevented by abutment against the shoulder 13 of the casing.

A torsion spring 24, advantageously of flat spring steel, is secured at one end 25 to the casing, as by extending into a slit in a plug seated non-rotatably in the casing. At the other end, the spring is held in a slit in the end of shaft 21. The right hand end of the shaft 21, in turn, is fixed to the web member 20, as by being welded thereto, so that the spring is held in established relation at one end to the air valve 7 and at the other to the casing of the speaker.

An element 26 extends from the enlargement 23 around the shaft 21, generally transversely with respect to the axis of the shaft and of the valve member 7. Means such as a small screw attach the driving member 3 to the end of this element 26 that is remote from the said shaft.

The casing defines a chamber 27 that extends completely around the part of the valve cover provided with the ports and that is continuous with the gas inlet 5.

The operation of the loud speaker will be in part evident from the description of it that has been given. More specifically, it is as follows.

At the outset, the tubular cover member 10 is set angularly, by turning the set screw 16, so that the ports 8 and 11 are non-communicating. Gas under pressure, ordinarily air, is then admitted through the inlet 5, so that the air is supplied to one side, the outside of the valve assembly. Because the ports in the two concentric tubes 7 and 10 are non-communicating, there is substantially no important passage of air into the outlet 6.

Whatever small leakage may occur between the members 7 and 10 does not cause chattering, since the air chamber 27 extends completely around the grid portion of the tubular cover 10 and the pressure of the air is exerted equally in all directions upon the outside of the cover and of the tubular valve member 7. Because the conforming portions of the valve 7 and cover member 10 are relatively short between the said ports and the ends of valve and cover members adjacent to the sound outlet and relatively long at the other end, whatever leakage of air does occur is largely in the direction of the outlet 6, because of the lesser resistance to leakage at that end of the assembly.

With gas under pressure in the chamber 27 and the tubular cover 10 set so that the ports therein are not in communication with the ports in the air valve (Fig. 5), the speaker is ready for operation. When sound energized impulses are transmitted through the driving member 3, the air valve 7 is caused to rock slightly upon its longitudinal axis or center line, say, to the position shown in Fig. 4 or Fig. 6, at a frequency characteristic of the sound which energizes the member 3. Also, the extent of the rocking and the nearness of complete registration of ports in valve 7 with the ports in the cover 10 are determined by the characteristics of the sound being amplified, especially by the intensity thereof.

As the valve 7 is rocked, the torsion spring 24 is twisted, so that it comes to exert a force tending to return the valve 7 to its original position. As soon as the energizing force transmitted through member 3 causes to act, this restoration is made by the spring.

This operation, of course, is repeated in rapid succession, so that air is caused to pass through the valve assembly in a series of short puffs or blasts which generate sound of great intensity.

In fact, the apparatus is adapted to amplify the human voice so that it may be heard under favorable outdoor condition for a distance of approximately four miles.

The amplified sound shows only a minimum of metallic quality and is substantially free from noises created by vibration of the valve or cover.

The speaker, once adjusted, holds the adjustment very well. The torsion spring damps the rocking of the valve and gives a sharp air cut off without hammering.

Because my valve is balanced and housed so that weight is not much of a factor, thicker walls and hence deeper slots may be employed. Such deep slots afford viscous air-flow resistance, in distinction to the predominantly turbulent air-flow which is set up in other types of valves. The modulation of air-flow, by the variation of such a viscous resistance, produces a better tone quality than that obtained by variations of a turbulent resistance; in the latter case, the tendency toward non-linear distortion and toward a reduction of the per cent modulation at larger initial valve clearances is greater.

For similar reasons, the load carrying capacity of my improved valve is large.

The valve, being balanced about the axis upon which it turns and being under fluid pressure that is equally distributed over its entire active surface, requires only limited clearance between the valve and its tubular cover or seat, thereby reducing leakage and "hiss."

The valve in the casing or housing is protected

and practically immune to damage during use. Chatter due to occasional over-loading is eliminated or minimized.

Reed effect is reduced by the design of the valve, as are distortion and howling due to self-oscillation.

Maximum acoustic efficiency may be obtained, because it is easy to provide a conduit (horn) of exponentially increasing cross-section from the throttling area to the mouth of the conduit.

It is not necessary to the invention, however, that any one loud-speaker must possess all of these advantages.

In constructing the apparatus, the casing may be cast of aluminum, brass, iron, or other suitable metal. The amount of machining necessary is small. For best results the chamber which holds the tubular cover 10 is machined as are the exterior and interior faces of the cover 10 and the exterior face of the tubular valve member 7.

The ports that are at this time preferred are substantially rectangular slots extending lengthwise of the concentric tubular members 7 and 10. The ports in valve 7 may be of equal dimensions at the inside and the outside of the tube. That is, they are non-flaring. The imperforate areas or lands 9 and 12 intervening between non-flaring slots, on the other hand, flare necessarily and become wider towards the outside.

In the preferred embodiment the ports in the cover 10 are somewhat longer than those in the valve 7, to facilitate lengthwise adjustment of parts 7 and 10. The tubular members 7 and 10 are suitably constructed of metal, brass, aluminum, stainless steel, or the like, and have relatively thick walls. The valve cover is made of such size as to fit snugly over the selected valve. The base of the casing, in turn, is made to fit in substantially air-tight manner around the valve cover 10.

In the modified form of construction illustrated in Figures 7 and 8, the voice coil motor is of the nature of a d'Arsonval galvanometer having a stationary magnet element 50 and a movable coil element 51, the last-named element being mounted for rocking on a flat steel spring 52 about the longitudinal axis thereof. The rocking movements of element 51 are transmitted to a valve 53, which is similar to the valve 7 of the previous modification. The straight line coupling of the actuating motor and valve reduces the opportunity for the introduction of self-imposed frequencies and thus reduces undesired noises. This arrangement also permits a reduction in the weight of moving parts. The fluid medium is delivered to the unit through a pipe 54 and freed from dust by means of a filter 55. The air and gas which enter through pipe 54 are caused to flow over the actuating motor on its way to the valve thereby cooling the motor.

It will be understood that the details given are for the purpose of illustration, not restriction, and that variations within the spirit of the invention are intended to be included within the scope of the appended claims.

I claim:

1. A pneumatically operated loud-speaker comprising a casing, two concentric snugly fitting tubular members provided with ports angularly spaced around the circumference of the said members and constituting an outer valve cover and an inner air valve, respectively, means for mounting the valve cover in fixed position within the casing, means supporting the air valve rotatively within the cover, means for establishing the normal angular position of the air valve, so that the ports in the cover and valve are non-communicating, means energized by the sound to be amplified for rocking the air valve on its longitudinal axis so as to place the ports therein in communication with the ports in the cover; means for supplying air under pressure to the communicating ports so that it passes therethrough, and a torsion spring having one end secured to the air valve and its other end secured in fixed relation to the casing, said spring being arranged to restore the air valve to the position of non-communication of the ports therein with the ports in the cover when the energizing action ceases.

2. A loud-speaker as described in claim 1, the means for rocking the air valve including a coil mounted coaxially with the air valve, and means for supporting said coil for oscillation about the longitudinal axis of the air valve.

3. A loud-speaker as described in claim 1, the tubular valve cover fitting tightly within the said casing in angularly adjustable manner and having a member extending outwardly therefrom, and opposed adjustable screw and spring means carried by the casing and pressing against the opposite sides of said extending member.

4. A loud-speaker as described in claim 1, comprising an element extending transversely from the side of the tubular valve cover, portions of the said casing fitting tightly around the cover, a set screw extending through a part of the casing and acting upon one side of the transversely extending element, and a spring-pressed stop contacting the other side of the said element, so that the angular setting of the element and attached valve cover may be adjusted and the element held firmly between the said screw and stop.

5. A pneumatically operated loud-speaker comprising a speaking horn, a casing member provided with an inlet for air under pressure and an outlet to the horn, an air valve assembly disposed between the said inlet and outlet and including snugly fitting concentric tubes provided each with air ports spaced similarly in the two tubes, a part of the casing defining a chamber around the portion of the concentric tubes provided with ports, means for fixing the angular position of the outer of the tubes with respect to the casing, means energized by the sound to be amplified for rocking the inner of the tubes on its longitudinal axis, a torsion spring, and means holding the torsion spring at one end in fixed relation to the casing and at the other in fixed relation to the inner of the tubes, the inlet for air being continuous with the said chamber, the inner tube being in free communication with the horn, and the means for rocking the inner tube including an element extending generally transversely with respect to the longitudinal axis of the inner tube, a driving member energized by the vibrations of a sound-actuated diaphragm, the driving member extending at approximately right angles to the said axis and to the direction of extension of the said element, and means connecting the driving member to the said element at a position remote from the said axis.

6. A pneumatically operated loud-speaker comprising a hollow valve member provided with a series of rectangular shaped, axially extending ports about its periphery, an actuating motor for rocking said valve member about its axis, said motor being of the d'Arsonval galvanometer type, and means for establishing the flow of air over said motor and through said valve member.

7. A pneumatically operated loud-speaker comprising a speaking horn, a casing member provided with an inlet for air under pressure and an outlet to the horn, an air valve assembly disposed between the said inlet and outlet and including snugly fitting concentric tubes provided each with air ports spaced similarly in the two tubes, a part of the casing defining a chamber around the portion of the concentric tubes provided with ports, means for adjusting the angular position of the outer of the tubes with reference to the casing and means energized by the sound to be amplified for rocking the inner of the tubes about its longitudinal axis, said means comprising a voice coil element mounted for oscillation about the longitudinal axis of the tubes.

8. A loud-speaker as set forth in claim 7 in which one end of the voice coil element is provided with a horizontally extending supporting spring.

9. A pneumatically operated loud-speaker comprising a speaking horn, a casing member provided with an inlet for air under pressure and an outlet to the horn, an air valve assembly disposed between the said inlet and outlet and including a pair of snugly fitting concentric tubes provided each with airports spaced similarly in the two tubes, a part of the casing defining a chamber around the portion of the concentric tubes provided with ports, means cooperating with the casing for adjusting the angular position of one of the tubes with respect to the casing, means energized by the sound to be amplified for rocking the other of the tubes on its longitudinal axis, a torsion spring, and means holding the torsion spring at one end in fixed relation to the casing and at the other end in fixed relation to said other tube, the inlet for air being continuous with the said chamber, the inner tube being in free communication with the horn, and the means for rocking said other tube including an element extending therefrom generally transversely with respect to the longitudinal axis of the tubes, a driving member controlled by the sound vibrations and extending at approximately right angles to the said axis and means connecting the driving member to the said element at a position remote from the said axis.

10. A loud-speaker as described in claim 9 in which the airports consist of rectangular shaped non-flaring slots disposed at uniform intervals around the entire circumferences of the tubes, said slots extending longitudinally in a direction parallel to the axis of the tubes.

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