March 4, 1952 C. B. HORSLEY ET AL 2,587,848

PISTON TYPE SOUND GENERATOR

Filed Sept. 2, 1949 2 SHEETS—SHEET 1

Fig. 1.

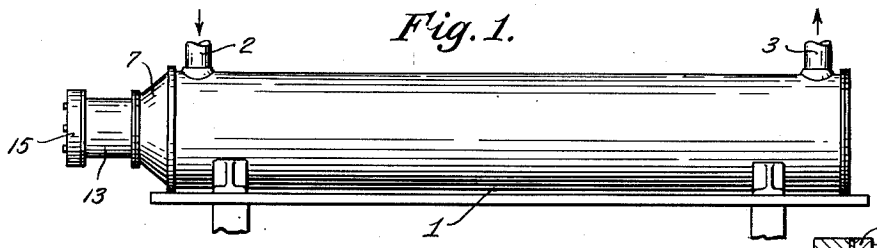


Fig. 2.

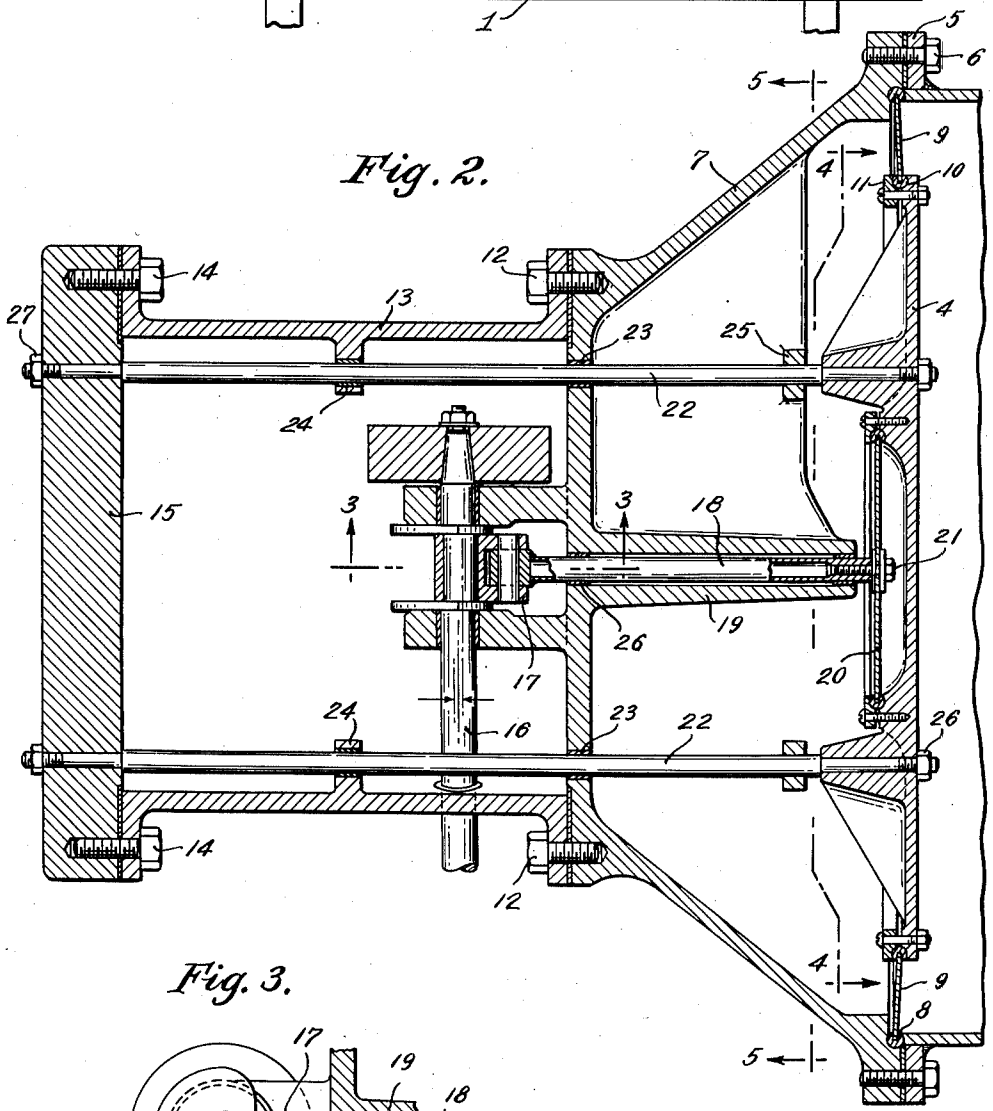
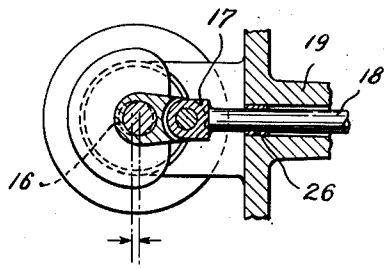


Fig. 3.



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Fig. 4.

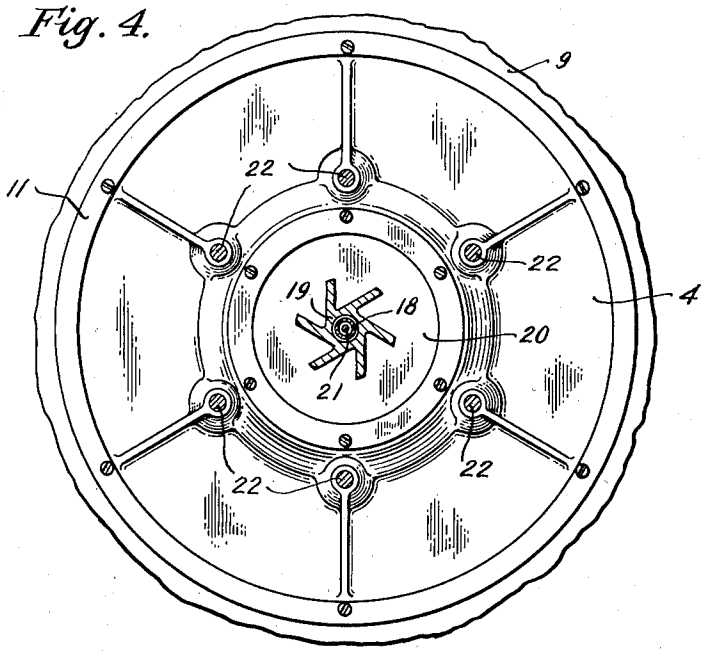
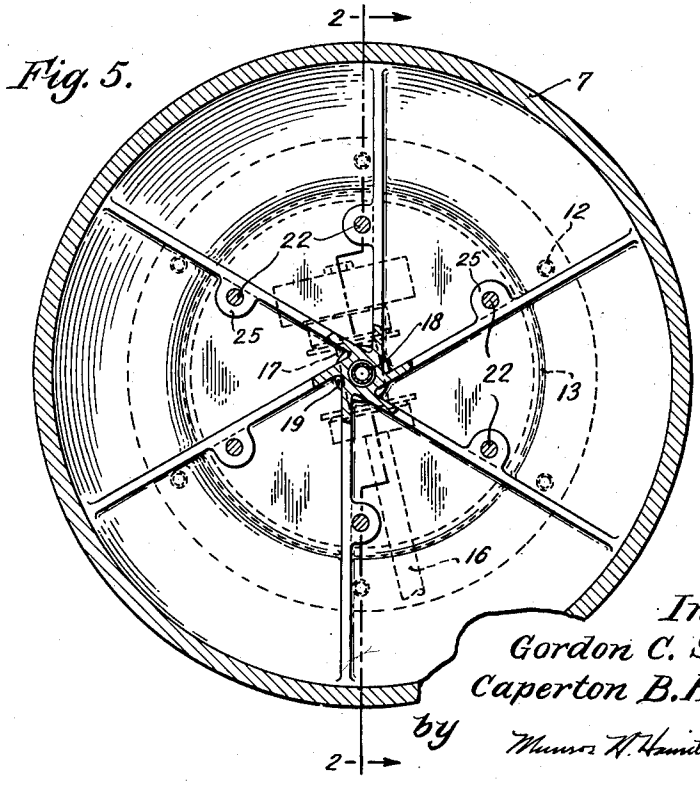


Fig. 5.



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PISTON TYPE SOUND GENERATOR

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6 Claims. (Cl. 116—137)

1

This invention relates to a sonic apparatus of the type in which sound is produced by a surface of a periodically oscillating body which is mechanically driven. In one preferred embodiment the invention is exemplified by a sonic apparatus for treating gases and for agglomerating or flocculating particles or droplets suspended in a gaseous medium.

In producing sound by mechanically oscillating a body, an immediate problem is the development of high bearing loads in the equipment which is employed to actuate the oscillating body and thus to produce sound when operating at intensities which are suitable for commercial applications.

Means have been proposed for reducing bearing loads in connection with sonic treatment of liquids where it is possible to take advantage of the inertial and elastic effects inherent in a liquid body which is being treated. A similar advantage cannot of course be realized to any appreciable extent when dealing with a gaseous type body.

An object of the invention therefore is to deal with the problems indicated and to devise an improved sound generating apparatus in which practical and efficient means are incorporated for overcoming to a very large extent the forces that would otherwise cause excessive bearing loads, especially with reference to treatment of gaseous bodies.

These and other objects and novel features of the invention will appear from the following description of a preferred embodiment of the invention, selected for purposes of illustration and shown in the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of the sonic apparatus employed in the invention, including a sound generator and a chamber;

Fig. 2 is a central cross section taken on the line 2—2 of Fig. 5 illustrating the sound generating apparatus of the invention with a section of the chamber being illustrated fragmentarily at one side thereof;

Fig. 3 is a cross section taken on the line 3—3 of Fig. 2;

Fig. 4 is a view taken on the line 4—4 of Fig. 2; and

Fig. 5 is a view taken on the line 5—5 of Fig. 2 to more clearly indicate the position of the crank mechanism.

The general plan of the sound generating apparatus of the invention includes a spring mechanism useful in reducing bearing loads, combined with a piston which is arranged to oscillate in a closed chamber. In the combination the chamber represents an enclosure having a length substantially equal to a multiple of half of the wavelength of sound in the gaseous medium to be treated at the operating frequency. The piston is located at one end of the chamber and spring means are operatively connected to the piston so that the natural frequency of oscillation of the piston is substantially the same as the operating frequency. The driving mechanism is connected to the piston through one spring member which is substantialy weaker than the spring means which determine the natural frequency of oscillation of the piston.

2

Considering in greater detail the embodiment of this combination as shown in the accompanying drawings, 1 denotes the sound chamber which may be mounted on any conventional type of base such as the supports shown and which is provided with an inlet 2 and an outlet 3 by means of which a gaseous medium such as for example an aerosol may be introduced into the chamber 1 and discharged after having been processed.

One end of the chamber is closed as shown in Fig. 1, while a piston 4 is mounted for reciprocation at the opposite end, as shown in Fig. 2. The piston end of the chamber is formed with a flange section 5 to which is secured by fastenings 6 a housing 7 extending rearwardly of the chamber. A ring 8 is received and held between the housing and the flange 5, and in turn supports in a groove therein a flexible annular sealing member 9. The inner circular edge of the sealing member 9 engages with the piston and is fitted into a second ring 10 carried in piston 4. The ring 10 is held in place by an annular retaining member 11. It is not intended that the invention be limited to sealing means such as those just described, but may include arrangements wherein the actuating means are isolated from the gaseous medium to be treated.

The housing 7 has attached to it by fastenings 12 and extension 13 which is in turn fastened by bolts 14 to a solid end wall 15. A shaft 16 located through the extension 13 is driven by some conventional means as an electrical motor not shown in the drawings. Shaft 16 actuates a crank mechanism 17 of conventional design, which in turn oscillates a shaft 18 received through a guide bearing 26 in a tubular section 19 of the housing 7. The right-hand end of shaft 18, as viewed in Fig. 2, is spring-connected to the piston 4 by means of an annular driving spring member 20. The outer peripheral edge of driving spring 20 is secured in a boss formed on one side of piston 4,

while the inner peripheral edge of spring 20 is fastened to the shaft 18 by a fastening 21.

The resonating spring means which determines the natural frequency of oscillation of the piston is comprised by a series of rods 22. These rods or resonating springs have their extremities attached to the piston 4 in some convenient manner as by fastenings 26 along a region lying between the point of attachment to the piston of flexible sealing member 9 and the point of attachment of driving spring 20. A series of six of the resonating springs may for example be employed and are spaced away from the center of the piston 4 the same radial distance in every instance, as shown in Fig. 4. The resonating spring elements 22 pass through guide bearings 23, 24 and 25 to prevent bending or lateral vibration and are attached to massive wall member 15 by fastenings 27.

In operation, as the crank of the driving mechanism starts to rotate and thus oscillate shaft 18 back and forth, almost all of this movement of shaft 18 is taken up by bending of driving spring 20 since this spring is substantially weaker than the spring system composed of the resonating springs 22. However, when the frequency of the driving mechanism has been so increased that it nearly equals the natural frequency of oscillation of the spring mass system composed of piston 4 and resonating springs 22, the amplitude of oscillation of piston 4 will increase so that it is an appreciable fraction of the amplitude of oscillation of shaft 18.

It will be apparent that for any specific frequency the amplitude of oscillation of piston 4 which it is feasible to obtain will be limited by considerations such as the stresses in resonating springs 22 and piston 4, the elastic hysteresis losses in spring elements 22 and the like.

In order to obtain the maximum sound intensity in the chamber for any fixed frequency and amplitude of oscillation of piston 4, the length of this chamber is chosen as a multiple of a half wavelength of sound in the gaseous medium to be contained in or passed through this chamber, at the frequency at which piston 4 is to be operated. Thus piston 4 is located at or near a velocity minimum, pressure maximum, position in the standing sound wave pattern in the chamber at which position the desired sound intensity may be maintained in the chamber with the minimum piston displacement, thus reducing the required stresses and hysteresis losses in the resonating spring elements. At this position the maximum amount of power is radiated into the chamber for the specific amplitude and frequency of oscillation of the piston.

As an example of the minimum piston displacement at the velocity node, as referred to above, there may be cited the use of a device constructed in accordance with the invention in which this minimum displacement is plus or minus .027" from rest position, that is, a total piston throw of .054", where it is desired to maintain sound intensities of 173 db above .0002 dynes/cm.^{2} (RMS) in the sound chamber, at 400 cycles per second. This may be contrasted with the displacement of plus or minus .480", or a total piston throw of .960", which would be required if the piston were located at the velocity antinode of the standing wave pattern providing the same sound intensity in the chamber.

From the above it will be seen that in obtaining a certain desired sound intensity at a certain desired frequency in the chamber, the stresses and losses in elements of the sound operating apparatus are reduced by locating the piston at a velocity node (pressure antinode). Then the inertia load of the piston is removed from the bearings of the drive mechanism by the use of a spring system to carry this load at the operating frequency and a weaker spring member to prevent excessive loads during the intervals of starting and stopping.

The application of the invention to the treatment of gases is thus seen to be made possible by the resonating spring means above described. This is in contrast to prior art devices for treatment of liquids in resonating chambers which depend for their effectiveness on the fact that the liquid body, by reason of its physical characteristics, may be utilized as the equivalent of a resonating spring, and is therefore an essential part of the treating means.

Having thus disclosed our invention and described in detail illustrative embodiments thereof, we claim as new and desire to secure by Letters Patent:

1. A piston type sound generator comprising a reciprocable piston, a relatively stationary support for said piston, resonating spring mountings fastening said piston to said support and elastically holding it stationary against motion in either direction, the resiliency of said mountings and the mass of said piston being so chosen that together they constitute a spring-mass system having a predetermined natural frequency of vibration, whereby when said system is vibrating at such frequency the inertia load of said piston will be sustained by said mountings, a driving mechanism for reciprocating said piston at said frequency, and a resilient driving connection between said mechanism and said piston to take up relative motion therebetween during starting and stopping, said resilient connection being substantially weaker than said spring mountings.

2. Apparatus according to claim 1 in which said spring mountings comprise at least one resilient rod connected at one end to said support and at the other end to said piston.

3. Apparatus according to claim 1 in which said mountings comprise a series of resilient rods symmetrically arranged with respect to the axis of said piston, and each connected at one end to said support and at the other end to said piston.

4. Apparatus according to claim 1 in which said driving mechanism includes a crank shaft and a crank thereon, and said connection comprises a connecting rod on said crank and a spring connecting said rod to said piston.

5. A piston type sound generator for producing a standing wave pattern in a treating chamber, which comprises a reciprocable piston the face of which is adapted to be positioned at one end of said chamber, a relatively stationary support for said piston, resonating spring mountings fastening said piston to said support and elastically holding it stationary against motion in either direction, the resiliency of said mountings and the mass of said piston being so chosen that together they constitute a spring-mass system having a predetermined natural frequency of vibration corresponding to a resonant frequency of said chamber, whereby when said system is vibrating at such frequency the inertia load of said piston will be sustained by said mountings, a driving mechanism for reciprocating said piston at said frequency, and a resilient driving connection between said mechanism and said piston to take up relative motion therebetween during starting

and stopping, said resilient connection being substantially weaker than said spring mountings.

6. A piston type sound generator comprising a reciprocable piston, a relatively stationary support for said piston, resonating resilient mountings fastening said piston to said support and elastically holding it stationary against motion in either direction, the resiliency of said mountings and the mass of said piston being so chosen that together they constitute a spring-mass system having a predetermined natural frequency of vibration, whereby when said system is vibrating at such frequency the inertia load of said piston will be sustained by said mountings, driving means for reciprocating said piston at said frequency, and yielding means connecting said driving means to said piston for taking up relative

motion therebetween during starting and stopping.

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