Feb. 27, 1940. L. E. MULLER 2,191,620

RESONATOR SILENCER

Filed Sept. 26, 1936

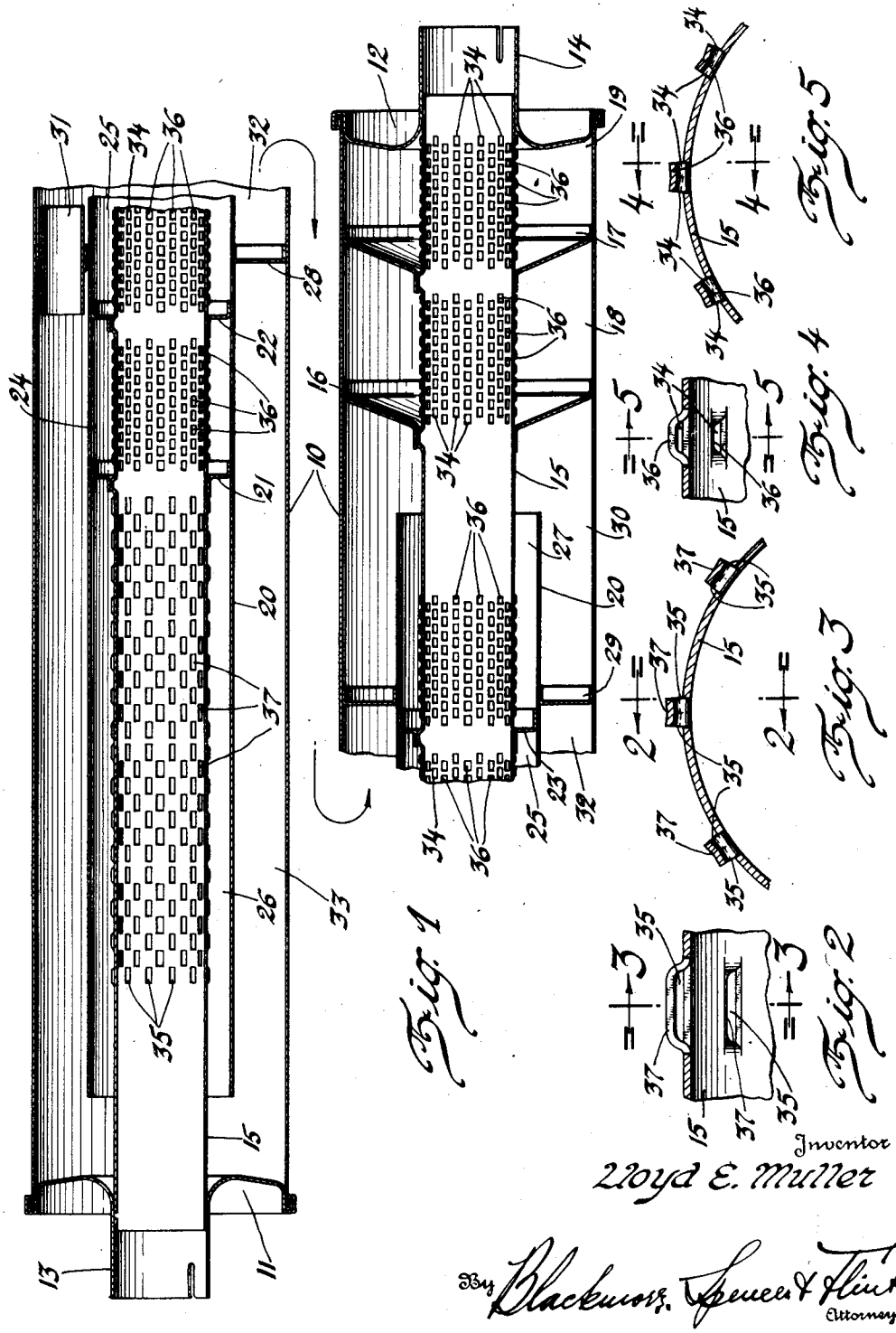


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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Patented Feb. 27, 1940 2,191,620

UNITED STATES PATENT OFFICE

2,191,620

RESONATOR SILENCER

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Application September 26, 1936, Serial No. 102,678

12 Claims. (Cl. 181—48)

This invention has to do with resonator silencers and is concerned with the connections of the resonance chambers thereof to the ducts through which the sound waves which are to be attenuated travel.

The invention is based on the discovery that it is advantageous to employ relatively small orifices to connect chambers of resonators whose natural frequencies are relatively high and relatively large orifices to connect chambers of resonators whose natural frequencies are relatively low to the ducts through which the sound waves which are to be attenuated pass. It may be that orifices graduated in size in accordance with the natural frequencies of the resonators whose chambers they connect to the ducts would be most satisfactory but I have found that very satisfactory results can be obtained if only two different sizes of orifices are used.

For resonators whose natural frequencies are relatively high (i. e., higher than about 300 or 400 c. p. s.), I have found that orifices equivalent in area to circular orifices about $\frac{1}{16}$" (one-sixteenth of an inch) in diameter are most satisfactory. For resonators whose natural frequencies are relatively low (i. e., lower than about 300 or 400 c. p. s.), I have found that orifices equivalent in area to circular orifices between about ⅛ (one-eighth) and about ¼ (one-quarter), preferably between ⅛ (one-eighth) and $\frac{5}{32}$ (five thirty-seconds), of an inch in diameter are most satisfactory. The difference between the optimum sizes of the orifices for the two types of resonators may be explained upon the basis of the characteristics of the resonators which it is desirable to accentuate and the limitations on the accentuation of these characteristics.

In the case of resonators whose natural frequencies are relatively high, it is desirable to accentuate-broaden the range of response. This may be done by increasing the acoustical resistance of the orifices which connect the chambers of the resonators to the ducts through which the sound waves which are to be attenuated pass. Therefore, in the case of resonators whose natural frequencies are relatively high, relatively small orifices of which relatively high acoustical resistance is characteristic are employed. The limitation, beside the necessity of maintaining satisfactory communication between the chambers of the resonators and the ducts, is the size of the orifice that can be produced commercially in the material through which the orifice is to be made.

In the case of resonators whose natural frequencies are relatively low, the characteristic which it is desirable to accentuate is the efficiency of response at the natural frequency or frequencies of the resonators. This may be done by decreasing the acoustical resistance of the orifices which connect the chambers of the resonators to the ducts through which the sound waves which are to be attenuated pass. Therefore, in the case of resonators whose natural frequencies are relatively low, relatively large orifices of which relatively low acoustical resistance is characteristic are employed. There are two limitations on the accentuation of this characteristic. They are that the sizes of the orifices must not be so great that the gases which flow past them will interfere considerably with the natural movement of the gases within the chambers or as to reduce the acoustical inertance of the resonators to too low values.

For a better understanding of my invention, reference is made to the accompanying drawing and the following specification wherein there is shown and described a resonator silencer in which the invention is embodied.

In the accompanying drawing:

The two parts of Figure 1 constitute a longitudinal section through a resonator silencer in which my invention is embodied;

Figure 2 is an enlarged fragmentary longitudinal section, taken as indicated by the line 2—2 of Figure 3, through the relatively low frequency section of the center tube of the silencer shown in Figure 1;

Figure 3 is a fragmentary section taken as indicated by the line 3—3 of Figure 2;

Figure 4 is a fragmentary longitudinal section on approximately the same scale as Figures 2 and 3, taken as indicated by the line 4—4 of Figure 5, through one of the relatively high frequency sections of the center tube of the silencer shown in Figure 1;

Figure 5 is a fragmentary section taken as indicated by the line 5—5 of Figure 4.

The resonator silencer which is shown in the drawing includes an imperforate cylindrical shell 10 over whose ends there are secured heads 11 and 12. Through the heads 11 and 12 extend central orifices which are encircled by outwardly extending collars 13 and 14 and connected by a center tube 15 whose ends extend into the collars.

Between portions of the shell 10 and center tube 15 near the head 12 extend imperforate annular partitions 16 and 17. The partitions 16 and 17 are separated from each other lengthwise of the shell and the center tube and with the

latter and the head 12 define the chambers 18 and 19 of two simple resonators with relatively high natural frequencies.

The portion of the center tube 15 between the head 11 and the partition 16 is encircled by an imperforate tubular shell 20. The shell 20 is of larger diameter than the center tube and of smaller diameter than the cylindrical shell 10 and is coaxial with both and terminates short of the head 11 and the partition 16. Between portions of the tubular shell 20 and the center tube 15 about midway between the ends of the silencer extend three imperforate annular partitions 21, 22 and 23. The partitions 21, 22 and 23 are separated from each other lengthwise of the tubular shell and the center tube and with the latter define the chambers 24 and 25 of two simple resonators with relatively high natural frequencies and two open-ended annular apertures 26 and 27.

Between portions of the cylindrical shell 10 and the tubular shell 20 somewhat farther from the head 11 than from the head 12 extend annular partitions 28 and 29 which are separated from each other lengthwise of the cylindrical and tubular shells. The partition 29 is imperforate and with the partition 16 and the cylindrical and tubular shells defines the chamber 30 of a resonator with a relatively high natural frequency. The partition 28, through which extend one or more orifices in each of which there is secured a tube 31, defines with the partition 29 and the cylindrical and tubular shells the secondary chamber 32 and with the head 11 and the cylindrical and tubular shells the primary chamber 33 of a compound resonator with relatively low natural frequencies.

The portions of the center tube 15 which are encircled by the chambers 18, 19, 24 and 25 are riddled with orifices 34 about 0.003 (three thousandths) of a square inch in area which connect the chambers to the center tube. The portion of the center tube between the partitions 16 and 23 is imperforate from the partition 16 to a point about midway between the ends of the annular aperture 27 but the remainder of it is riddled with orifices 34 of the same size as the orifices 34 mentioned above. The aperture between the end of the tubular shell 20 and the partition 16, the annular aperture 27 and these orifices connect the chamber 30 to the center tube.

The portion of the center tube 15 between the head 11 and the partition 21 is imperforate from the head to a point well within the annular aperture 26 but the remainder of it is riddled with orifices 35 about 0.015 (fifteen-thousandths) of a square inch in area. The aperture between the end of the tubular shell 20 and the head 11, the annular aperture 26 and the orifices 35 connect the chamber 33 to the center tube.

As the drawing indicates, the orifices 34 may be formed in pairs by making in the material of which the center tube is to be formed pairs of short slits which extend lengthwise and are separated circumferentially of the tube and pressing the material between each pair of slits out of the plane of the material without breaking it away therefrom at the ends of the slits so as to form shields 36 which bridge the space between the slits from end to end and are elevated above the plane of the material. As the drawing also indicates, the orifices 35 may be similarly formed but to make them larger than the orifices 34 the slits are made longer and the shields 37 pressed farther out of the plane of the material from which the center tube is to be made.

The silencer shown in the drawing was designed for installation in the exhaust system of an internal combustion engine with the collar 13 connected to the exhaust pipe and the collar 14 to the tail pipe of the engine so that the exhaust gases of the engine pass through its center tube 15 in the course of their passage to the atmosphere. The resonator 32—31—33—26—35 and the resonators 24—34, 25—34, 30—27—34, 18—34 and 17—34 are, of course, so tuned in the manner set forth in the Wilson application Serial No. 470,700, filed July 25, 1930, and the corresponding foreign patents, viz., Canadian Patent No. 348,037, British Patent No. 391,180, French Patent No. 720,611 and Italian Patent No. 300,037, that they respond to and attenuate by resonance, respectively, sound waves of relatively low frequencies and sound waves of relatively high frequencies which occur in the exhaust gases of the engine.

I claim:

1. In a silencer, a tube which is riddled throughout a portion of its length with orifices equivalent in area to circular orifices about one-sixteenth of an inch in diameter and throughout another portion of its length with orifices equivalent in area to circular orifices between about one-eighth and about five thirty-seconds of an inch in diameter, a shell which encircles and is radially spaced from the riddled portion of the tube, heads which with the tube and the shell define a compartment which encircles the riddled portion of the tube, and a partition which subdivides the compartment into chambers of resonators with natural frequencies above and below about 300 or 400 cycles per second which are connected to the tube by the smaller orifices and the larger orifices, respectively.

2. In a silencer, a tube which is riddled throughout a portion of its length with orifices equivalent in area to circular orifices between about one-eighth and about one-quarter of an inch in diameter and throughout another portion of its length with smaller orifices, a shell which encircles and is radially spaced from the riddled portion of the tube, heads which with the tube and the shell define a compartment which encircles the riddled portion of the tube, and a partition which subdivides the compartment into chambers of resonators of relatively low frequency and relatively high frequency which are connected to the tube by the larger orifices and the smaller orifices, respectively.

3. In a silencer, a tube which is riddled throughout a portion of its length with orifices of relatively small size and throughout another portion of its length with orifices of relatively large size, a shell which encircles and is radially spaced from the riddled portion of the tube, heads which with the tube and the shell define a compartment which encircles the riddled portion of the tube, and a partition which subdivides the compartment into chambers of resonators of relatively high frequency and relatively low frequency which are connected to the tube by the smaller orifices and the larger orifices, respectively.

4. In a silencer, a tube which is riddled throughout a portion of its length with orifices with relatively high acoustical resistance and throughout another portion of its length with orifices with relatively low acoustical resistance, a shell which encircles and is radially spaced from the riddled portion of the tube, heads which with the tube and the shell define a compartment which

encircles the riddled portion of the tube, and a partition which subdivides the compartment into chambers of resonators of relatively high frequency and relatively low frequency which are connected to the tube by the orifices of relatively high acoustical resistance and the orifices of relatively low acoustical resistance, respectively.

5. In a silencer, a tube which is riddled throughout a portion of its length with relatively small orifices and throughout another portion of its length with relatively large orifices, a shell which encircles and is radially spaced from the riddled portion of the tube, heads which with the tube and the shell define a compartment which encircles the riddled portion of the tube, and a partition which subdivides the compartment into chambers of relatively small and relatively large size which are connected to the tube by the smaller orifices and the larger orifices, respectively.

6. In a silencer, a duct, and means which defines chambers of resonators with natural frequencies above and below about 300 or 400 cycles per second connected to the duct by orifices equivalent in size to circular orifices about one-sixteenth of an inch and between about one-eighth and about five thirty-seconds of an inch in diameter, respectively.

7. In a silencer, a duct, and means which defines chambers of resonators of relatively low frequency and relatively high frequency connected to the duct by orifices equivalent in size to a circular orifice between about one-eighth and about one-quarter of an inch in diameter and a smaller orifice, respectively.

8. In a silencer, a duct, and means which defines chambers of resonators of relatively high frequency and relatively low frequency connected to the duct by orifices with relatively high acoustical resistance and relatively low acoustical resistance, respectively.

9. In a silencer, a duct, and means which defines chambers of resonators of relatively high frequency and relatively low frequency connected to the duct by orifices of relatively small and relatively large size, respectively.

10. In a silencer, a duct, and means which defines chambers of relatively small and relatively large size connected to the duct by orifices of relatively small and relatively large size, respectively.

11. In a silencer, a duct, and means which defines chambers of relatively small and relatively large size connected to the duct by orifices with relatively high acoustical resistance and relatively low acoustical resistance, respectively.

12. In a silencer, a tube which is riddled throughout a portion of its length with orifices with relatively high acoustical resistance and throughout another portion of its length with orifices with relatively low acoustical resistance, a shell which encircles and is radially spaced from the riddled portion of the tube, heads which with the tube and the shell define a compartment which encircles the riddled portion of the tube, and a partition which subdivides the compartment into chambers of relatively small and relatively large size which are connected to the tube by the orifices of relatively high acoustical resistance and the orifices of relatively low acoustical resistance, respectively.

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