

June 2, 1953

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RETROVERTED PASSAGE TYPE MUFFLER WITH OUTER
CONDUIT FORMED OF SOUND ABSORBING MATERIAL

2,640,557

Filed Dec. 13, 1950

2 Sheets-Sheet 1

FIG. 1.

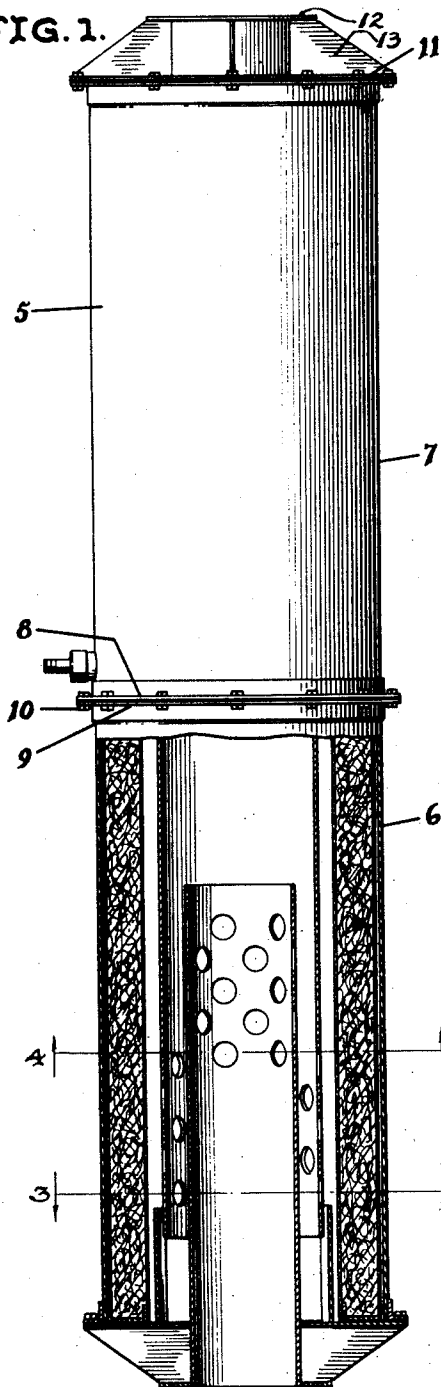
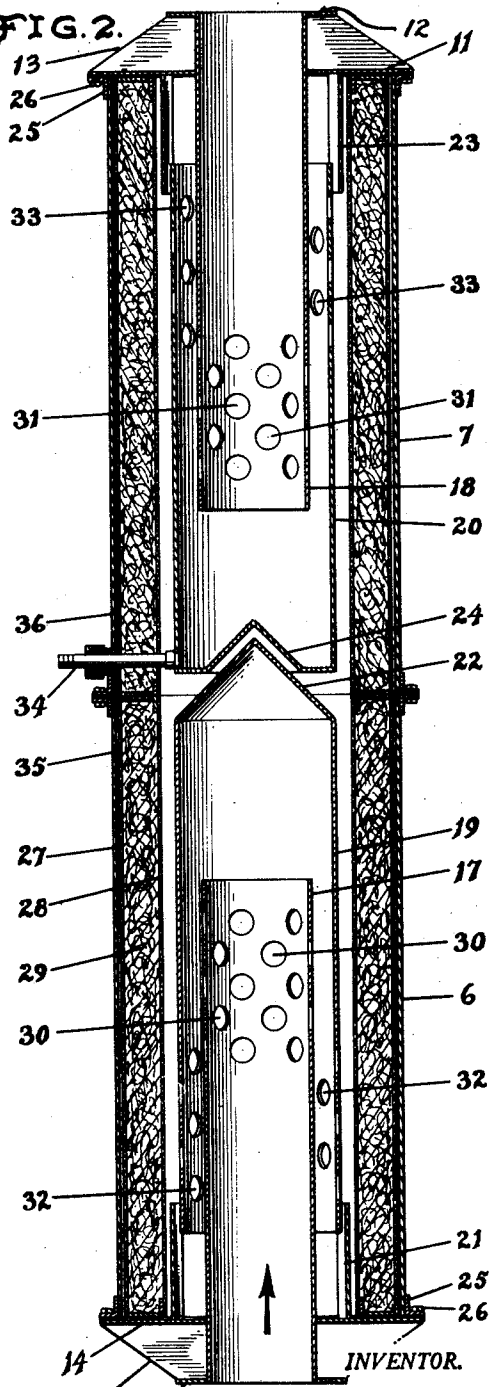


FIG. 2.



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2 Sheets-Sheet 2

FIG. 3.

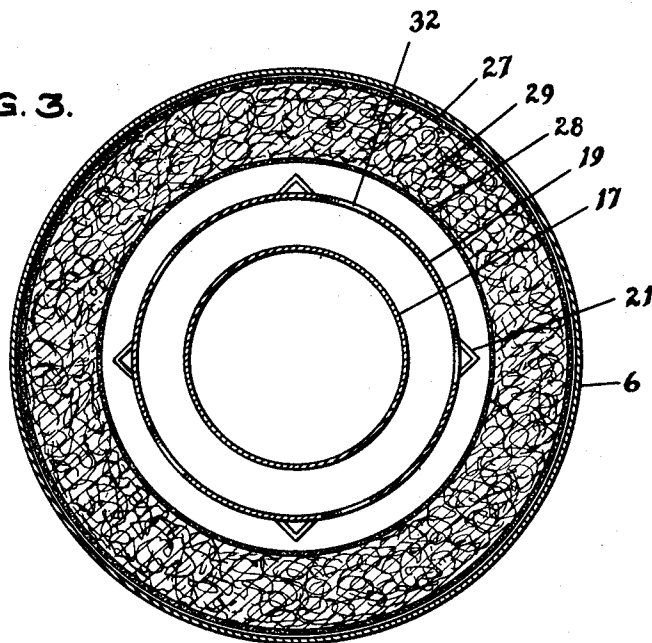
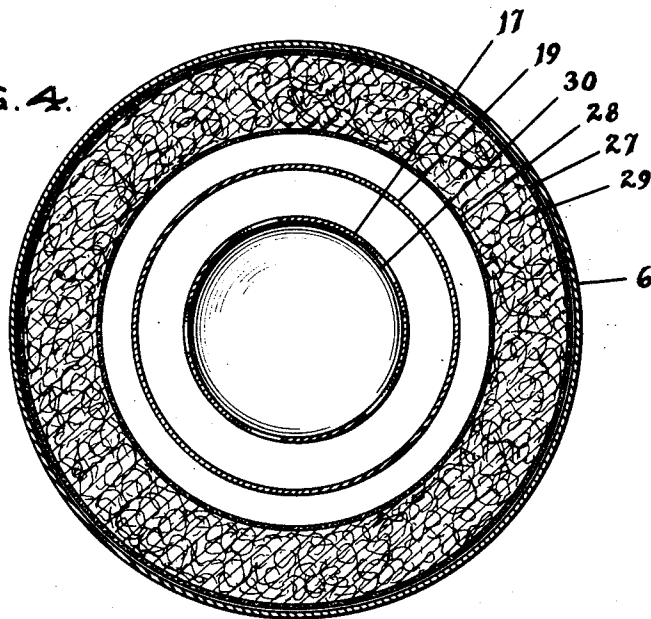


FIG. 4.



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RETROVERTED PASSAGE TYPE MUFFLER
WITH OUTER CONDUIT FORMED OF
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8 Claims. (Cl. 181—50)

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This invention relates to the silencing and attenuating of pulsations in a flowing gas stream such as that produced in the intake and exhaust of air pumps, internal combustion engines, and the like, and is particularly adaptable to exhaust silencers for positive pressure blowers.

It is especially concerned with the simple and effective means for silencing the exhaust noises of a pneumatic conveying system without substantially increasing the back pressure of the exhaust system. It is among the further purposes to provide a silencer that is equally effective in any position and that may be located at any point in the exhaust system with respect to the blower.

It is well known that the flowing gas stream in an exhaust system of a positive pressure blower comprises a series of separate gas slugs, or volumes of gas, at a relatively high pressure separated by volumes of gas at a relatively low pressure, and it is believed that the noise from such an exhaust system is produced by these high pressure slugs of gas hitting the surrounding air as the slugs are exhausted to atmosphere. To overcome a noise of this type the high pressure volumes and the low pressure volumes in the exhaust system must be smoothed out, or attenuated, to mean pressure to provide a constant pressure stream of gas flowing from the exhaust system to the atmosphere.

It has been the practice to attenuate the variable pressures in an exhaust stream of gas by providing silencers having various obstructions and expansion chambers through which the gas must flow. The theory is that the obstructions to the flow will cause a damming up of the stream of gas and a resulting co-mingling of the separate volumes of gas to even out to a uniform pressure, while the expansion chambers will allow the high pressure volumes of gas to lose momentum and expand into the volumes of lower pressure gas. The objection to silencers of this type is the usual increase in back pressure of the gas stream incurred as the stream is forced to flow around the obstructions and into and out of the various expansion chambers through restricted openings. A further objection to silencers of this type is the lack of any provision for the absorption of sound waves produced by the vibrations set up from the flowing gas stream striking the various elements of the silencer.

The present invention is, accordingly, directed to an apparatus for silencing the noises in an exhaust system that are produced by the variations in pressure, or pulsations, in the gas stream. The

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apparatus includes novel means to receive and attenuate the pulsations to provide for a constant pressure in the gas stream flowing to the atmosphere, and to obtain a maximum efficiency in the attenuating of the pulsations without substantially increasing the back pressure in the exhaust system.

In general, the new silencer comprises a substantially cylindrical housing having an intake end and a discharge end. An open ended gas inlet conduit is positioned in the housing intake end, and is extended concentrically a substantial distance into the housing. In the same manner a gas outlet conduit of equal diameter is positioned in the housing discharge end and extended concentrically a substantial distance into the housing. An intermediate conduit, having one end closed and one end open, is positioned concentrically around the gas inlet conduit inside the cylindrical housing with the closed end opposite the inner open end of the gas inlet conduit and the open end positioned adjacent the intake end of the cylindrical housing. The diameter of the intermediate conduit is such that the annular, or effective area, of this conduit for the flow of gas is substantially equal to the area of the gas inlet conduit. In a like manner a second intermediate conduit of the same design is positioned concentrically around the gas outlet conduit and the effective area of this conduit is substantially equal to the area of the gas outlet conduit. An outer conduit, formed of a sound absorbing material, is positioned concentrically and externally of the two intermediate conduits and is extended substantially the length of the housing to serve as a means of communication between the open ends of the two intermediate conduits. The effective area of the outer conduit for the flow of gas is substantially equal to the effective area of either of the intermediate conduits, and it is seen that at all times the cross sectional areas of the gas stream through any part of the silencer is substantially equal.

The exhaust gas enters the silencer through the gas inlet conduit where it is discharged into the first intermediate conduit. Due to the closed end of the intermediate conduit being positioned opposite the inner opened end of the inlet conduit the flow of gas is forced to change direction as it is discharged from the inlet conduit and flow through the space defined by the inside of the intermediate conduit and the outside of the inlet conduit, which has the same area as the inlet conduit and therefore offers no obstruction to the flow of the gas. There is a co-mingling of

the volumes of gas of different pressures due to turbulence as the flow of gas is reversed in direction and a further co-mingling as the gas takes the form of an annular ring of the same area, but of thinner cross section, as it flows through the intermediate conduit. There is a further attenuating of the gas pressures as the direction of flow is changed from the intermediate conduit into the outer conduit. The gas now moves the length of the silencer and in doing so, the stream is in intimate contact with a relatively large surface of sound absorbing material. The gas stream is now quite thin in radial direction and is therefore less able to maintain any vibration in a radial direction, and any such vibration would be eliminated by the absorbing material. This outer conduit also prevents any sound waves set up inside the silencer from reaching the casing, thus avoiding any vibration and resulting noise from this source. The gas stream is discharged from the outer conduit into the second intermediate conduit, and from this conduit it passes into the outlet conduit through which it is discharged from the silencer in a smooth even pressure stream.

For a better understanding of the nature of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 is a plan view of the apparatus with sections broken away for the purpose of illustration;

Fig. 2 is a plan view in section along with center line of the apparatus;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 1;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 1.

Referring to the drawings the silencer is disclosed in a vertical position and will be described in such a position for the purpose of orientation, but it is to be understood that although the apparatus is disclosed and usually installed in this position it will function equally efficient in any position. The silencer will be seen to comprise the casing 5 which is of generally cylindrical form, and which is formed by two chambers 6 and 7. Chambers 6 and 7 are fabricated as separate units to facilitate manufacture, but are formed into a single unit by means of flanges 8 and 9 secured together by bolts 10. Chamber 6 will be described as the intake section of the apparatus and chamber 7 will be described as the discharge section. The casing 5 is closed at the discharge end by an end plate 11 secured to the casing by means of a flange 25 and bolts 26. Positioned above the end plate 11 is a flange plate 12, of smaller diameter, and plates 11 and 12 are spaced apart and held in position by a series of spacer plates 13 positioned 90 degrees apart. In a like manner the intake end of casing 5 is closed by an end plate 14 secured to the casing by means of a flange 25 and bolts 26. Positioned below the plate 14 is a flange plate 15 of a smaller diameter than plate 14, and plates 14 and 15 are spaced apart and held in position by a series of spacer plates 16 positioned 90 degrees apart. Plates 12 and 15 are used as a means of attaching the silencer into an exhaust system.

Each end plate and flange plate is provided with aligned openings through which is mounted an open ended conduit, the conduit terminating at one end flush with the flange plate and passing through the opening in the end plate to extend concentrically a substantial distance into the casing 5. The gas inlet conduit 17, secured to

the end plate 14, is used as a means for conducting the gas stream into the casing 5; while the gas outlet conduit 18, secured to end plate 11, is used as a means for conducting the gas stream from the inside of casing 5. The conduit 17 is provided at its discharge end with a series of inlet ports 30 spaced around the circumference of conduit 17 and divided into equal distance center lines along a portion of the length of the conduit. The total combined area of the inlet ports is equal, or substantially equal, to the area of the conduit 17. In a like manner conduit 18 is provided with a series of inlet ports 31 at its discharge end positioned with the same spacing as is provided for conduit 17.

A first intermediate conduit 19 extends concentrically into the casing 5 externally of the gas inlet conduit 17, and is attached to the end plate 14 by means of bars 21. The intermediate conduit 19 is open at one end and closed at the other end by a conical plate 22 positioned opposite the inner open end of the gas inlet conduit 17. The annular, or effective cross-sectional area, of the first intermediate conduit is defined by the space between the outside of the gas inlet conduit 17 and the inside of the intermediate conduit 19, and this effective cross-sectional area is equal, or substantially equal, to the inside cross-sectional area of the gas inlet conduit 17.

In a like manner a second intermediate conduit 20 extends concentrically into the casing 5 externally of the gas outlet conduit 18 and has an effective cross-sectional area equal, or substantially equal, to the inside cross-sectional area of the gas outlet conduit. The second intermediate conduit 20, attached to the end plate 11 by means of bars 23, is open at one end and closed at the other end by a partially conical plate 24, the closed end being positioned opposite the inner open end of the gas outlet conduit 18. The conduit 19 is provided at its discharge end with a series of ports 32 spaced regularly around the circumference of the conduit and divided into equal distant center lines along a portion of the length of the conduit, the total combined cross-sectional area of the inlet ports are equal, or substantially equal, to the cross-sectional area of the conduit 19. In a like manner conduit 20 is provided at its discharge end with a series of inlet ports 33 positioned with the same spacing as is provided for conduit 19.

An acoustic outer conduit is formed by two porous walls 27 and 28 spaced apart by a blanket of sound absorbing material 29, such as fiber glass. This outer conduit extends the entire length of casing 5 and has an outer diameter slightly less than the inside diameter of the casing 5. The acoustic outer conduit is comprised of two units, outer conduit 35 positioned inside chamber 6 and outer conduit 36 positioned inside chamber 7. The inside diameter of conduit 35 is of such dimension that the effective area, that is the area defined by the space between the outside of conduit 19 and the inside walls 28 of the conduit 35, is equal, or substantially equal, to the effective area of the conduit 19. This dimension relationship also applies to the conduit 36 with respect to the conduit 20. As stated before, this apparatus is usually installed in a vertical position and may be outside of any weather shelter. In the event that there is an installation without any shelter, there is a probability that rain or other forms of moisture will enter the apparatus. To overcome this, a drain 34 has been provided at the bottom of conduit 20 to permit any accu-

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mulated moisture entering the conduit 18 to be removed.

In the operation of the silencer, compressed gas, delivered by a blower into the exhaust system, enters the silencer through the inlet conduit 17 in the form of a gas stream comprised of a series of separate gas slugs, or volumes of gas, at a relatively high pressure separated by volumes of gas at a relatively low pressure. These separate slugs of gas move through the inlet conduit with an inertia sufficiently high to carry them rapidly past the ports 30 spaced around the circumference of the inner end of the conduit 17 and to discharge them into the closed end section of the first intermediate conduit 19. The gas stream, entering the closed end section of the first intermediate conduit, strikes a cushion of air pocketed in the conical plate 22. This cushion of air is maintained in the closed end section of the first intermediate conduit at all times because of the conical shape of plate 22, and acts as a sound absorber by preventing the separate slugs of gas from striking the plate 22 with full force.

The gas stream, after striking the air cushion, is reversed in direction and starts toward the open end of the first intermediate conduit 19, which by design has the same, or substantially the same, effective cross sectional area as that of the inlet conduit, and therefore offers no increased resistance to the flow of the gas stream. There is a turbulence in the gas stream as the direction of flow is reversed, and this turbulence will cause a partial equalization of pressures. This equalization is brought about by the comingling of the high pressure volumes with the low pressure volumes wherein the high pressures will be reduced by expanding into the lower pressures, and the low pressures will be increased. This means that equalization of pressures is prevalent throughout the silencer wherever the direction of flow of a gas stream is reversed. The turbulence of the gas stream is still present as the gas moves toward the open end of the first intermediate conduit and past the ports 30 of the inlet conduit. This turbulence will cause some of the high pressure volumes, as well as the low pressure volumes now at a higher pressure, to flow through the ports 30 and expand into the low pressure volumes flowing past in the inlet conduit.

The gas stream, now in the form of a series of annular slugs, continues through the first intermediate conduit to the open end of the conduit where its inertia carries it past the ports 32 into a chamber formed by the closed end of the outer conduit 35. The gas stream strikes a cushion of air contained in the closed end of the outer conduit and is again prevented from striking an element of the silencer with full momentum as its direction of flow is reversed. A second turbulence is created by the reverse flow of the gas stream into the outer conduit resulting in a further co-mingling of the separate volumes and an equalizing of pressures in addition to a further bypassing of the more equalized pressures through the ports 32 in the first intermediate conduit in the same manner as described for the ports 30. The gas stream, now in the form of a series of larger annular slugs, but having substantially the same area as the annular slugs of the first intermediate conduit, moves toward the discharge end of the outer conduit adjacent the open end of the second intermediate conduit 20. In flowing through the outer conduit the gas stream is in intimate contact with a relatively

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large surface of sound absorbing material. The stream is now quite thin radially and therefore less able to maintain any vibration in a radial direction, and any such vibration is eliminated by the absorbing material. This sound absorbing material is by design thick enough to absorb any additional sound waves that may exist due to the intermittent pulsating action of the blower impellers and by the vibrations set up by the turbulence created in reversing the direction of flow of the gas stream throughout the silencer. It also prevents any sound wave set up in the internal elements of the silencer from reaching the outer shell and thus avoid vibration of the shell and any resulting noise from this source.

As the gas stream is discharged from the outer conduit it is forced to change direction and enter the open end of the second intermediate conduit 20. Again there is a turbulence created with a further co-mingling of the separate volumes of gas making up the gas stream, and a bypassing of a portion of the gas stream from the second intermediate conduit through the ports 33 into the outer conduit, as described for other sections of the silencer. The gas stream flows through the conduit 20 where it strikes the partial conical plate 24, which by design offers a minimum resistance to the flow of the gas as it changes direction to flow into the outlet conduit 18. The convex shape of the conical plate 24 serves to facilitate the reversal of the annular flow at this point and the conversion of the annular ring of gas back into a single uniform cross sectional conduit. This is a desirable feature as the separate volumes of gas are now at a uniform pressure and have the characteristics of a constant pressure stream of gas and should be exhausted from the silencer through the outlet conduit 18 with a minimum amount of turbulence.

In the design of this silencer all cross sectional areas of flow are kept equal, or substantially equal, which results in the velocity of the gas stream remaining constant and the only change taking place being that of pressure equalization of the separate volumes of gas within the gas stream. This design of the silencer also furnishes a means for creating a concentric flow of gas through the apparatus which progressively becomes thinner in radial cross section, and therefore more responsive to pressure equalization, until it reaches its thinnest cross sectional area where it has its greatest area exposed to and in intimate contact with, a sound absorbing material.

I claim:

1. A silencer comprising a substantially cylindrical housing having an intake end and a discharge end, an open ended gas inlet conduit positioned in the housing intake end and extending concentrically a substantial distance therein, the inlet conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length of its inner end, an open ended gas outlet conduit positioned in the housing discharge end and extending concentrically a substantial distance therein, the outlet conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its inner end, a first intermediate conduit having one end opened and one end closed positioned concentrically and externally along a substantial portion of the inlet conduit, the closed end of the first intermediate conduit being positioned inwardly from the inner end of the inlet conduit, the open end of the first intermediate conduit

being positioned inwardly from the intake end of the housing, the first intermediate conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its open end, a second intermediate conduit having one end open and one end closed positioned concentrically and externally along a substantial portion of the outlet conduit, the closed end of the second intermediate conduit being positioned inwardly from the inner end of the outlet conduit, the opened end of the second intermediate conduit being positioned inwardly from the discharge end of the housing, the second intermediate conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its open end, and an outer conduit formed of sound absorbing material positioned concentrically about and spaced from the two intermediate conduits and extending substantially the length of the housing, the outer conduit forming an annular space about the two intermediate conduits which provides a means of communication between the open ends of the two intermediate conduits.

2. A silencer comprising a substantially cylindrical housing having an intake end and a discharge end, an open ended gas inlet conduit positioned in the housing intake end and extending concentrically a substantial distance therein, an open ended gas outlet conduit positioned in the housing discharge end and extending concentrically a substantial distance therein, the cross-sectional area of the gas inlet conduit being substantially equal to the cross-sectional area of the gas outlet conduit, a first intermediate conduit having one end open and one end closed positioned concentrically and externally along a substantial portion of the inlet conduit, the effective cross-sectional area of the first intermediate conduit where it extends along the inlet conduit being substantially the same as the cross-sectional area of the inlet conduit, the closed end of the first intermediate conduit being positioned inwardly from the inner end of the inlet conduit, a second intermediate conduit having one end open and one end closed positioned concentrically and externally along a substantial portion of the outlet conduit, the effective cross-sectional area of the second intermediate conduit where it extends along the outlet conduit being substantially the same as the cross-sectional area of the outlet conduit, the closed end of the second intermediate conduit being positioned inwardly from the inner end of the outlet conduit, and an outer conduit positioned concentrically about and spaced from the two intermediate conduits and extending substantially the length of the housing, the effective cross-sectional area of the outer conduit where it extends along the intermediate conduits being substantially the same as the effective cross-sectional area of either of the two intermediate conduits, the outer conduit forming an annular space about the two intermediate conduits which provides a means of communication between the open ends of the two intermediate conduits.

3. A silencer comprising a substantially cylindrical housing having an intake end and a discharge end, an open ended gas inlet conduit positioned in the housing intake end and extending concentrically a substantial distance therein, the inlet conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length thereof from its inner

end, the combined cross-sectional areas of the series of ports being substantially equal to the cross-sectional area of the gas inlet conduit, an open ended gas outlet conduit positioned in the housing discharge end and extending concentrically a substantial distance therein, the outlet conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length thereof from its inner end, the combined cross-sectional areas of the series of ports of the outlet conduits being substantially equal to the cross-sectional area of the gas outlet conduit, a first intermediate conduit having one end open and one end closed positioned concentrically and externally along a substantial portion of the inlet conduit, the closed end of the first intermediate conduit being positioned inwardly from the inner end of the inlet conduit, the open end of the first intermediate conduit being positioned inwardly from the intake end of the housing, the first intermediate conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its open end, the combined cross-sectional areas of the series of ports of the first intermediate conduit being substantially equal to the effective cross-sectional area of the first intermediate conduit where it extends along the inlet conduit, a second intermediate conduit having one end open and one end closed positioned concentrically and externally along a substantial portion of the outlet conduit, the closed end of the second intermediate conduit being positioned inwardly from the inner end of the outlet conduit, the open end of the second intermediate conduit being positioned inwardly from the discharge end of the housing, the second intermediate conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its open end, the combined cross-sectional areas of the series of ports of the second intermediate conduit being substantially equal to the effective cross-sectional area of the second intermediate conduit where it extends along the outlet conduit, and an outer conduit formed of sound absorbing material positioned concentrically about and spaced from the two intermediate conduits and extending substantially the length of the housing, the outer conduit forming an annular space about the two intermediate conduits which provides a means of communication between the open ends of the two intermediate conduits.

4. A silencer comprising a substantially cylindrical housing having an inlet end and a discharge end, an open ended gas inlet conduit positioned in the housing intake end and extending concentrically a substantial distance therein, the inlet conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length of its inner end, the combined cross-sectional areas of the series of ports being substantially equal to the cross-sectional area of the gas inlet conduit, an open ended gas outlet conduit positioned in the housing discharge end and extending concentrically a substantial distance therein, the outlet conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its inner end, the combined cross-sectional areas of the series of ports of the gas outlet conduit being substantially equal to the cross-sectional area of the gas outlet conduit, the cross-sectional area of the gas inlet conduit being substantially equal to the cross-sectional area of the gas outlet conduit, a first intermediate

conduit having one end open and one end closed positioned concentrically and externally about a substantial portion of the inlet conduit, the closed end of the first intermediate conduit being positioned inwardly from the inner end of the inlet conduit, the open end of the first intermediate conduit being positioned inwardly from the intake end of the housing, the first intermediate conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its open end, the combined cross-sectional areas of the series of ports of the first intermediate conduit being substantially equal to the effective cross-sectional area of the first intermediate conduit, the effective cross-sectional area of the first intermediate conduit where it extends along the inlet conduit being substantially the same as the cross-sectional area of the inlet conduit, a second intermediate conduit having one end open and one end closed positioned concentrically and externally about a substantial portion of the outlet conduit, the closed end of the second intermediate conduit being positioned inwardly from the inner end of the outlet conduit, the open end of the second intermediate conduit being positioned inwardly from the discharge end of the housing, the second intermediate conduit having a series of gas ports positioned around its circumference and spaced along a portion of the length from its open end, the combined cross-sectional areas of the series of ports of the second intermediate conduit being substantially equal to the effective cross-sectional area of the second intermediate conduit, the effective cross-sectional area of the second intermediate conduit where it extends along the outlet conduit being substantially the same as the cross-sectional area of the outlet conduit, and an outer conduit formed of sound absorbing material positioned concentrically about and spaced from the two intermediate conduits and extending substantially the length of the housing, the effective area of the outer conduit where it extends along the intermediate conduits being substantially the same as the effective area of either of the two intermediate conduits

where they extend along the inlet and outlet conduits, the outer conduit forming an annular space about the two intermediate conduits which provides a means of communication between the open ends of the two intermediate conduits.

5. The silencer defined in claim 4 wherein the closed end of the first intermediate conduit is a plate having a concave shape with respect to the inner end of the inlet conduit, and the closed end of the second intermediate conduit is a plate of convex shape with respect to the inner end of the outlet conduit.

6. The silencer defined in claim 4 wherein the closed end of the first intermediate conduit is a plate having a concave conical shape with respect to the inner end of the inlet conduit, and the closed end of the second intermediate conduit is a plate having a convex partially conical shape with respect to the inner end of the outlet conduit.

7. The silencer defined in claim 6 wherein the second intermediate conduit is provided with means for removing accumulated condensate.

8. The silencer defined in claim 1 in which the gas ports in the intermediate conduits are positioned axially outwardly substantially from the inner end of the series of gas ports in the inlet and outlet conduits, respectively.

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References Cited in the file of this patent UNITED STATES PATENTS

Number	Name	Date
1,051,130	Lattime	Jan. 21, 1913
1,057,485	Knollmann	Apr. 1, 1913
1,115,873	Spencer	Nov. 3, 1914
1,553,264	Reasonover	Sept. 8, 1925
1,772,589	Beamer	Aug. 12, 1930
1,966,620	Flour	July 17, 1934
2,455,965	Wohlberg	Dec. 14, 1948

FOREIGN PATENTS

Number	Country	Date
461,065	Great Britain	Feb. 9, 1937
593,282	Great Britain	Oct. 13, 1947