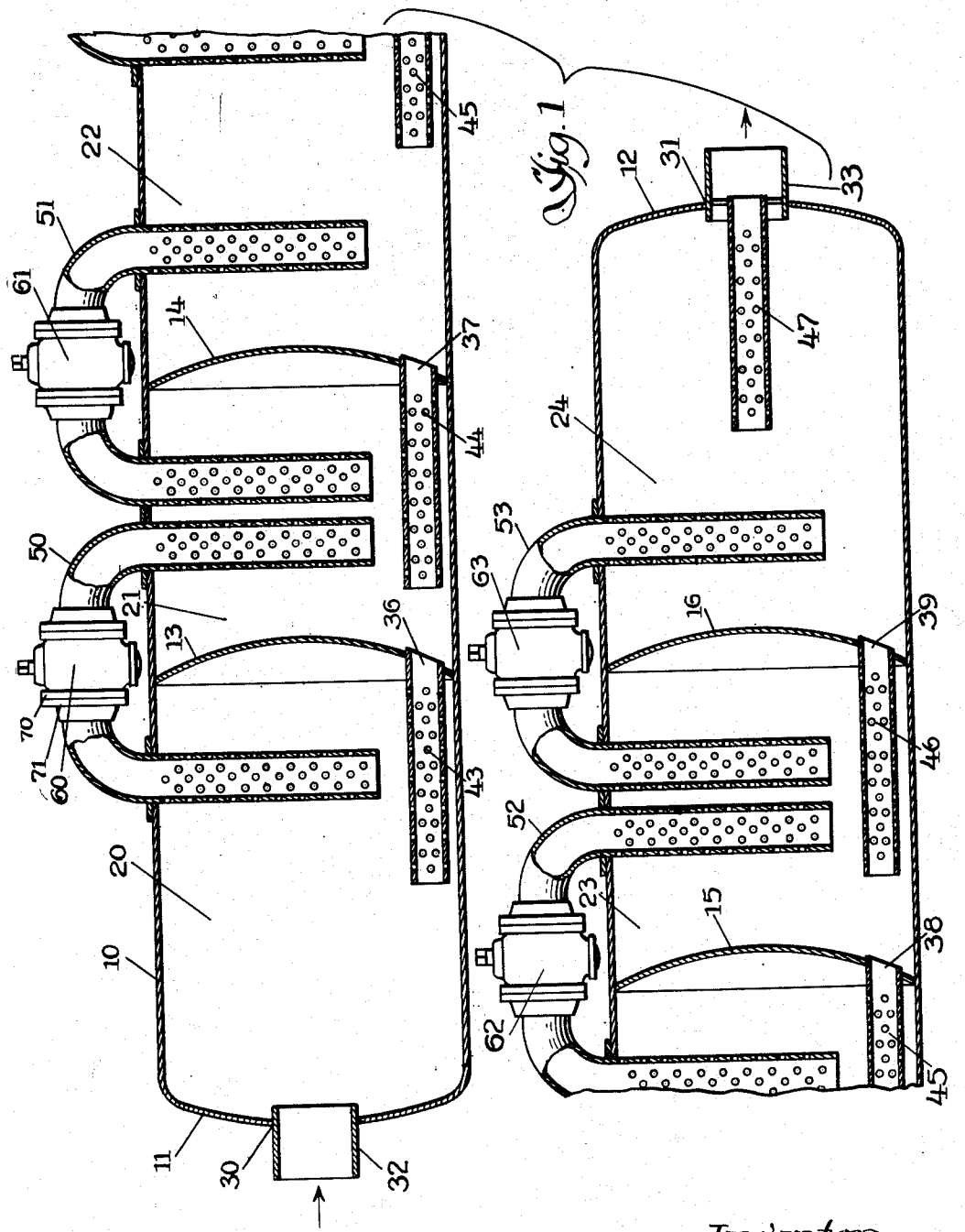
Dec. 17, 1963 A. P. GALLAGHER 3,114,430

PULSATION SNUBBER OR SILENCER

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Fig. 2

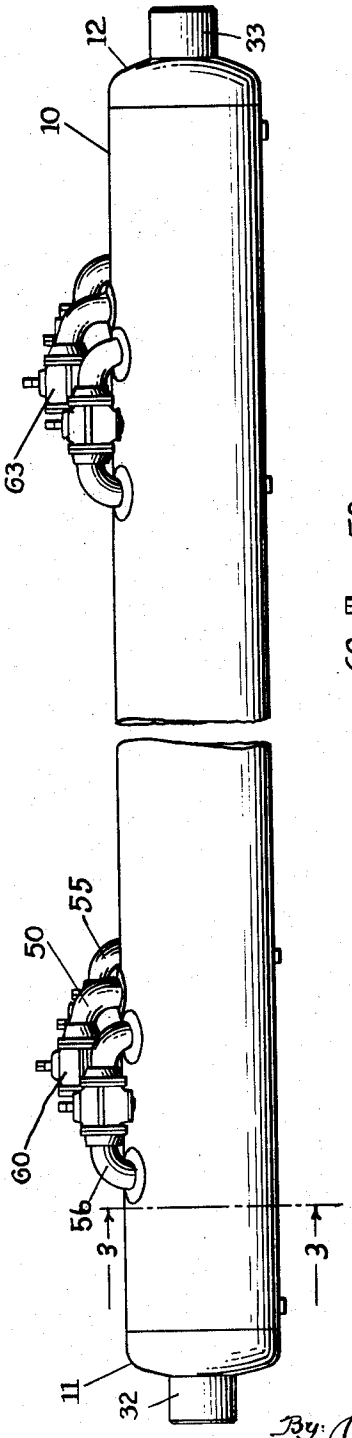
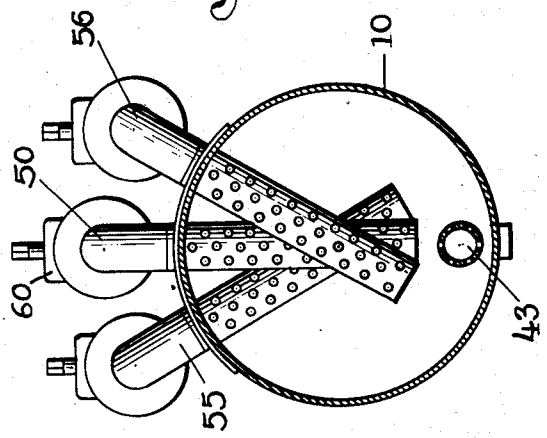


Fig. 3



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PULSATION SNUBBER OR SILENCER

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This invention relates to improvements in apparatus for snubbing or silencing pulsating flowing gases, and particularly to improvements in snubbers for smoothing the flow of pulsating gases such as the intakes and exhausts of internal combustion engines and the suction and discharge sides of gas compressors, blowers, and the like.

Pulsation snubbers heretofore known can be made to operate satisfactorily over a reasonable range of flow volumes, the greater range requiring some compromise in effectiveness in handling specific volumes of flow. It has been customary to design the apparatus for the most commonly encountered range of flow. The novel apparatus of this invention provides the means for the snubbing of pulsating gases over a relatively wide range of rates of flow in a highly effective manner, the need for compromise being eliminated by providing adjustability of flow rates encountered at any particular time.

Specifically, the silencing apparatus of this invention is the plural snubbing or surge chamber type in which each chamber has an inlet opening in one end wall and an outlet opening in the opposite end wall and a flow impedance means such as an open-ended, perforated conduit extending inwardly from the outlet opening toward and almost reaching the inlet opening end wall. In addition, each chamber contains one or more auxiliary flow impedance means, such as perforated conduits, each having a valve therein, the latter preferably being outside the chamber for better maintenance and operation. Each such valved auxiliary conduit is similarly constructed as an open-ended perforated conduit with the perforated walls extending inwardly into both chambers, so as to connect the chambers in series. With this combination of perforated conduits between each chamber and with perforated valved auxiliary conduit therebetween, an effective quieting action with a minimum restriction of flow is achieved. Furthermore, the range of gas flow being effectively silenced may uniquely be of several levels, thus providing a silencer which is adjustable and effective over a range of flows.

The apparatus of this invention is described in detail by specific reference to the accompanying drawings in which:

FIG. 1 is a longitudinal cross-sectional view of the silencing apparatus of this invention;

FIG. 2 is a side view on a reduced scale, of a modified form of the apparatus of FIG. 1, and

FIG. 3 is a transverse cross-sectional view of the apparatus of FIG. 2, on an enlarged scale taken along line 3—3 thereof.

Referring particularly to the drawings, the apparatus of this invention consists of a cylindrical shell **10** having end walls **11** and **12** and intermediate walls or partitions **13**, **14**, **15**, and **16** which separate the volume enclosed by the shell and end walls into separate compartments or chambers **20**, **21**, **22**, **23**, and **24**. The length of the shell **10**, as well as the number of compartments formed therein by the intermediate walls is discretionary with the use to which the apparatus will be put and is determined by well known design considerations. Also, the diameter, and even the configuration of the shell, may be varied to suit the needs of the particular use situation.

The intermediate walls or partitions **13** through **16** and the end walls **11** and **12**, are shown as being dished

to increase their strength, but they may be planar if desired. All of the parts are joined together in a suitable manner, such as by welding. Some of the parts may be made integral for added strength.

End wall **11** has an inlet opening **30**, while end wall **12** has an outlet opening **31**. Each opening is fitted with a short tube, **32** and **33**, for connection of the apparatus into the gas conduit.

Each partition **13** through **16**, has an outlet or escape opening **36**, **37**, **38**, and **39** respectively. These escape openings are shown arranged in alignment with each other for simplicity of illustration and may be staggered for effective pulsation dampening action without adverse effect upon gas flow. Flow impedance means, such as an apertured wall or perforated escape conduit **43**, **44**, **45** and **46** are mounted in each escape opening. In addition, a perforated escape conduit **47** is mounted in the outlet opening **31** in the end wall **12**. All of the escape conduits extend from their respective openings rearwardly into the chamber or in a direction counter to the normal flow of gas. If desired, although not necessary, they may also extend forwardly into the next succeeding chamber. The end of each escape conduit stops short of the opposite wall of its surrounding chamber. While the dimension of each conduit is not critical, it preferably should extend into its surrounding chamber a distance at least four times its diameter. The annular opening or gap between the end of each conduit and the adjacent wall or partition should preferably have an area twice the cross-sectional area of the conduit.

The chambers **20**, **21**, **22**, **23**, and **24** are also in communication with each other through an auxiliary gas escape flow impedance system. This gas escape system consists of a series of U-shaped conduits **50**, **51**, **52**, and **53**, the arms of which by-pass partition walls **13**, **14**, **15**, and **16** to connect the chambers on the opposite side of the by-passed partition. The forward arm of each U-shaped conduit; i.e. the arm extending into the chamber in the direction of gas flow may be omitted if desired. For brevity, however, the conduits will be described as U-shaped conduits. While in FIG. 1 only one U-shaped conduit is shown connecting each set of two succesive chambers, in actual practice a number of conduits, such as the three conduits **50**, **55** and **56** indicated in FIGS. 2 and 3 by way of example, may be used to still further extend the range of usefulness of the unit. Thus, adjacent compartments are in communication with each other by an inner and permanently open gas escape conduit and by one or more outer gas escape conduits, each of which is valved as will be explained. This arrangement imparts a relatively wide scope of adjustment to the silencer of this invention.

In each auxiliary gas escape conduit, preferably at the bight portion of its U-shape, are valves **60**, **61**, **62**, and **63**. For ease of maintenance and operation, it is preferred to mount the valve outside the shell of the snubber unit. It will be understood, however, that the auxiliary conduit system, including the valves, may be contained within the snubber shell with valve stems or other operating means extending outside the shell for controlling the valves.

Valves **60**, **61**, **62**, and **63** are preferably of the quarter-turn full-open plug type. Such a valve is preferred because of its ease of operation and maintenance, as well as its suitability for series mechanical connection with the other valves to effect simultaneous operation of a complete bank of auxiliary gas escape conduits. As with the other valves shown in the drawing, but not specifically numbered, valve **60** is connected into the auxiliary escape conduit by its flanges **70** which are joined to flanges **71** of the conduit **50**.

The arms of each conduit **50**, **51**, **52**, and **53** consist of

open-ended perforated flow impedance tubes, such as shown in FIG. 1. Their extension into each chamber and their size are governed by the specifications discussed below.

Where automatic operation of a complete bank of valves is desired, the handle of each valve is coupled to a control bar which may be moved manually, or pneumatically, or through a pneumatic or electrical mechanism controlled by the volumetric rate of flow of gases flowing into the apparatus.

The silencer of this invention may be connected to the intake or the exhaust conduits of internal combustion engines, blowers, air compressors, or the like. When attached to the exhaust conduit, inlet 32 is coupled to the exhaust pipe, while outlet 33 is coupled to a tail pipe which directs the exhaust gases to some particular desired area. When attached to the intake as a silencer of pulsation absorber, outlet 33 normally is connected to the intake conduit of the apparatus being silenced. However, in certain instances, such as when in close proximity to an air compressor on the intake side, the unit is connected with end 11 closest to the compressor.

During use, the gases from the exhaust of the engine or compressor enter the chamber 20 through inlet 32 in the form of a succession of high pressure surges or slugs. The intervening voids are frequently much lower than atmospheric pressure. The surges or slugs consist of masses of gas under high pressure traveling at a high velocity. As each slug emerges into chamber 20, it immediately expands and spreads throughout the chamber. The velocity, pressure and kinetic energy of each slug is thereby greatly reduced and dissipated. The apertured or perforated wall of conduit 43 acts as a flow impedance means to exert a moderate restraining action upon the gases. Such impedance, properly related to volumetric rate of flow, causes the pressure in chamber 20 to be dissipated relatively gradually in known manner, and an effective checking or snubbing of the high velocity high pressure slug takes place. This expansion and checking or flow proceeds with each succeeding slug, and in each succeeding chamber, the net result being a relatively smoothly flowing, quiet exit of gases through outlet pipe 33.

The auxiliary gas escape conduit system serves to supplement the permanently open impedance escape means of each chamber. It is utilized when the flow of pulsating gases is beyond the capacity of the regular escape conduit system. Since several banks of auxiliary gas conduits may be employed, and recognizing that the flow-smoothing treatment of the gases is most effective when influenced by flow impedances of magnitudes properly related to flow rate, the silencer is thereby made adjustable to accommodate a number of flow rates. When used, each bank of the auxiliary gas escape conduit system must be opened at one time; i.e., when increased flow requires reduction of impedance by opening the valve in an auxiliary escape conduit, this must be done throughout the length of the unit. This provides for smoothing the flow without the formation of a bottleneck in some intermediate portion of the silencer apparatus.

The passage of the gases out of each chamber and into the next succeeding chamber should be moderately restrained and distributed over a relatively large area. To realize this mode of operation, each escape conduit or gas flow impedance means should extend into the snubbing chamber a substantial distance, equal to at least twice the diameter of said escape conduit. Also, the apertures in the wall of each escape conduit should be distributed, preferably uniformly, over the area of said wall and should preferably have an aggregate area from 1 to 5 times the cross-sectional area of the escape conduit. These limits are not closely critical.

As has been indicated throughout this discussion, the apparatus of the invention produces good silencing results and reduces the magnitude of pulsations to very low levels, the latter being the most important feature of this invention. Because the device is adjustable over a range of flow rates and is very effective in minimizing pulsations, it has important application in the metering of gases, being used in conjunction with orifice measuring devices, for example, to increase the accuracy of such measurements.

While but a single modification has been described and illustrated, there are many ways in which the apparatus may be altered without departing from the principles of the invention. For example, while the openings and the permanently open escape conduits are all arranged off center, with respect to the unit, they may be arranged centrally. They may have an aligned relationship or may be staggered in zig-zag fashion along the length of the silencer. The auxiliary escape conduits may be staggered, aligned or arranged in any desired fashion. In addition, the conduits may be of other than the cylindrical shape shown; for example, angular, oval or irregular, such as star-shaped, in transverse section. The outer shell may also be of other than cylindrical shape, such as angular or oval. The apertures in the walls of the escape conduits are shown as being circular, and they, also, may be of other shape, and may be in the form of elongated slots. It should also be understood that the chambers may be of different relative sizes than has been described and illustrated in the foregoing.

Invention is claimed as follows:

1. Apparatus for smoothing the flow of pulsating gases comprising means forming a plurality of chambers, each said chamber having an inlet opening and an outlet opening, flow impedance means at each said outlet opening, said plurality of chambers being arranged in series with the outlet opening of each in communication with the inlet opening of the next adjacent chamber, and at least one optionally open or closed auxiliary valved flow impedance means connecting each two successively connected chambers, said auxiliary flow impedance means being arranged optionally to provide a path of flow additional to that through said first-mentioned flow impedance means whereby to render said apparatus operative to handle an additional range of volumetric rate of flow of gases therethrough.

2. Apparatus for smoothing the flow of pulsating gases comprising means forming a plurality of chambers, each chamber having an inlet opening and an outlet opening and an open-ended perforated conduit extending inwardly from said outlet opening into said chamber, said plurality of chambers being arranged in series with the outlet opening of each in communication with the inlet opening of the next adjacent chamber, and at least one auxiliary valved gas escape open-ended conduit between each two successively connected chambers, each said valved conduit including a perforated terminal portion extending into one of said chambers and serving to make said apparatus adjustable to accommodate an additional range of gas flow for each said auxiliary conduit.

3. Apparatus for smoothing the flow of pulsating gases comprising means forming a plurality of chambers, each of said chambers having a forward wall and a rearward wall arranged oppositely with respect to each other, said forward wall having an inlet opening therein and said rearward wall having an outlet opening therein, an open-ended, perforated conduit extending inwardly into the chamber from each rearward wall in connection with the outlet opening therein whereby said chambers are connected in series in the path of the gases, and at least one auxiliary valved gas escape open-ended conduit connecting each two successive chambers, said valved conduits including a perforated terminal portion extending into one of said chambers and serving to make the apparatus adjustable to accommodate several levels of flow of gases.

4. Apparatus for smoothing the flow of pulsating gases

comprising means forming a plurality of chambers, each chamber having an inlet opening and an outlet opening and an open-ended perforated conduit extending inwardly from said outlet opening into said chamber, said plurality of chambers being arranged in series with the outlet opening of each in communication with the inlet opening of the next adjacent chamber, and at least one auxiliary valved gas escape U-shaped open-ended conduit arranged to connect each pair of consecutive chambers and having its bight portion outside of the apparatus and containing the valve, at least one arm of said U-shaped conduit extending into a chamber and having the portion thereof within the chamber perforated, said valved conduits serving to make said apparatus adjustable to accommodate several levels of flow of gases.

5. In apparatus for smoothing the flow of pulsating gases including a cylindrical shell having an inlet opening and as outlet opening at the respective ends thereof, spaced transverse partitions within said shell forming a series of chambers, each said partition having an opening therein and an open-ended perforated conduit connecting with said opening and extending into a chamber toward the end of said shell having the outlet opening therein; the improvement which comprises means for extending

the range of rates of gas flow for which the apparatus is effective to smooth the flow of pulsating gases, said means comprising a U-shaped auxiliary conduit for each pair of consecutive chambers mounted upon the shell and arranged to connect the associated pair of consecutive chambers as a path for gas flow additional to that provided by the opening in each partition, at least one arm of each said U-shaped conduit extending into a chamber and having the portion within the chamber perforated, the bight portion of said U-shaped conduit being outside of the shell, and a valve in each said U-shaped conduit in the bight portion thereof whereby the additional path of flow of gases through said apparatus may be opened or closed.

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