June 1, 1943. H. A. SMITH 2,320,668

MECHANICAL EXHAUST SILENCER

Filed Aug. 15, 1941 2 Sheets-Sheet 1

FIG.1.

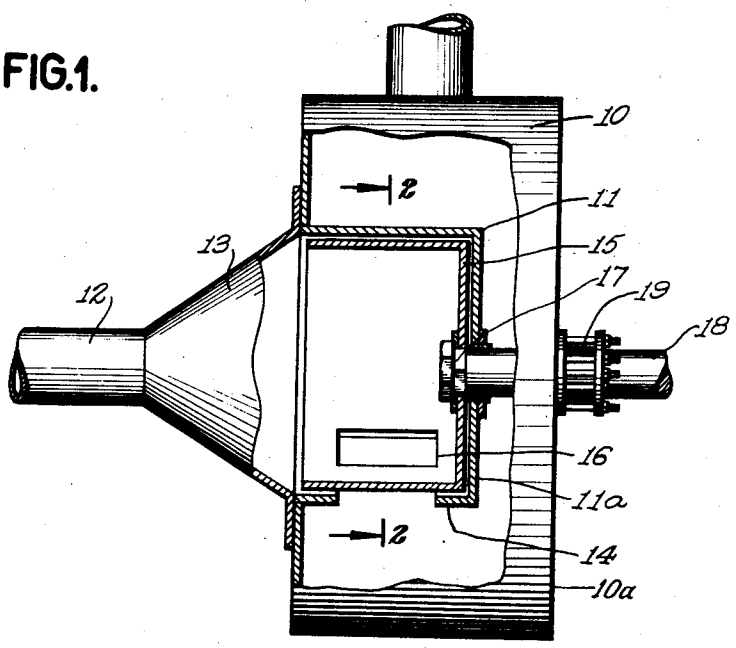
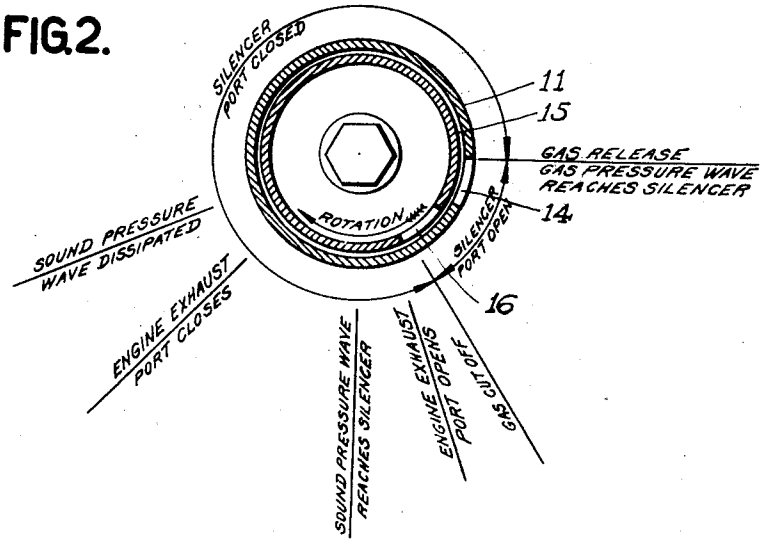


FIG.2.



INVENTOR
HARRY A. SMITH

BY Hoyt, Morsey & Campbell
his ATTORNEYS

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FIG.5.

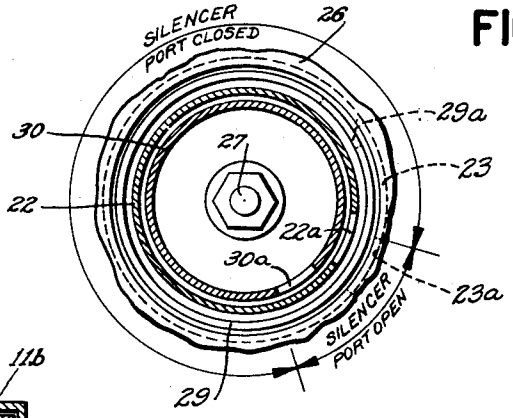
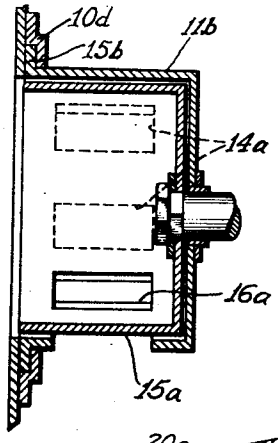


FIG.3.



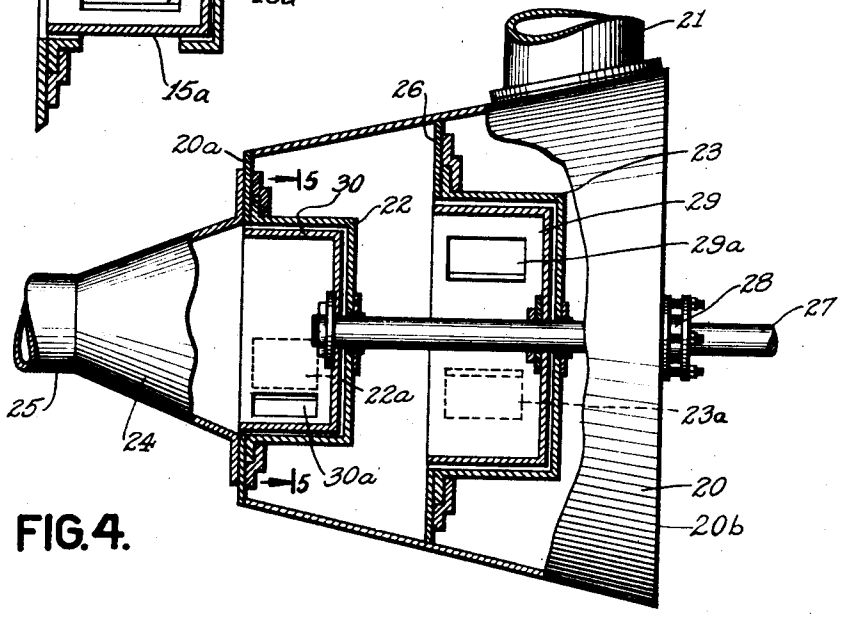


FIG.4.

INVENTOR
HARRY A. SMITH

BY Hoguet, Seaver & Campbell
his ATTORNEYS

Patented June 1, 1943

2,320,668

UNITED STATES PATENT OFFICE

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MECHANICAL EXHAUST SILENCER

Harry A. Smith, Garden City, N. Y.

Application August 15, 1941, Serial No. 406,960

11 Claims. (Cl. 181—64)

This invention relates to noise dissipating devices for combustion engines, and has particular reference to compact mechanical apparatus for dissipating the exhaust noises of internal combustion engines.

Mufflers of the fixed cell expansion type are too bulky for convenient installation in many types of vehicles or other devices powered by internal combustion engines.

In accordance with the present invention, I have provided mechanically-actuated sound dissipating devices which are compact and are capable of handling far greater volumes of exhaust gases than prior fixed cell mufflers of comparable size.

Devices of the type embodying the invention are designed to permit the ready flow of exhaust gases therethrough, but to block and dissipate the sound waves which precede the gas pressure waves because of their greater speed. More particularly, devices of the type embodying the present invention may include a chamber for receiving exhaust gases and sound waves and a valve mechanism which is actuated in time-phase relation to the exhaust valves of the engine to confine and dissipate the sound waves in the chamber but to permit the later-arriving exhaust gases to escape freely from the chamber.

For a better understanding of the present invention, reference may be had to the accompanying drawings in which:

Figure 1 is a view of a typical form of device embodying the invention, shown partly broken away and partly in section to disclose details thereof;

Figure 2 is a view in section taken on line 2—2 of Figure 1, disclosing also an example of the time-phase relationship between the operation of the device and an exhaust valve of a one-cylinder internal combustion engine.

Figure 3 is a view, partly broken away and partly in section, of a multiple-port sound dissipating device;

Figure 4 is a view in side elevation of a modified two-stage form of device embodying the invention, shown partly in section and partly broken away; and

Figure 5 is a view taken on line 5—5 of Figure 4 disclosing, in addition, the time-phase relationship between the second stage of the device and the first stage of the device.

Referring now to Figure 1 of the drawings, a typical form of the invention may include a generally cylindrical housing 10 in which is mounted a cylindrical cup-shaped element or stator 11 which forms a chamber for receiving exhaust gases from an engine exhaust pipe 12. The exhaust pipe 12 may be connected to a receiving chamber 13 of generally conical or funnel shape having its larger end disposed substantially in alignment with the open face of the stator 11. The stator 11 is provided with a gas escape port 14 of rectangular or any other desired shape which cooperates with a rotary valve member or rotor 15 to establish communication with the interior of the housing 10 when the valve port 16 in the rotor 15 is in alignment therewith. Suitable clearances are provided between the rotor and the stator for gas pressure bleeding. The rotor 15 is fixed on the squared end 17 of a rotatable shaft 18 which passes through a sidewall 10a of the housing 10 and the base 11a of the chamber-forming member 11. The shaft 18 is supported in a stuffing box 19 fixed to the wall 10a of the housing 10 and may be driven either by the internal combustion engine (not shown) or by other means.

The stuffing box 19 may, if desired, be water-cooled so as to avoid damage by the heat of the exhaust gases.

With this construction the exhaust gases delivered through the exhaust pipe 12 will be received in the chamber 13 and in the stator 11, and can escape through the port 14 when the port 16 of the rotor 15 is in alignment therewith.

The theory of operation of sound dissipating devices of the type described is as follows:

It is recognized that both sound waves and gas pressure waves are generated by the operation of an internal combustion engine. The sound waves, under the conditions of pressure and temperature usually encountered in the manifolds and exhaust pipes of such engines, have a velocity of about 1400 feet per second, whereas the flow of exhaust gas through the manifold and the exhaust pipe is considerably slower. Therefore, the sound waves precede the exhaust gas pressure waves along the exhaust pipe.

The present device takes advantage of the difference in speed of flow of the exhaust gases and the rate of propagation of the sound waves and by means of the stator 11 and the rotor 15, described above, efficiently traps and dissipates the sound waves while permitting the escape of later-arriving exhaust gases to the atmosphere without creation of substantial back-pressure.

Referring now to Figure 2, as illustrative of the time-phase relationship between the operation of the exhaust port of a one-cylinder internal combustion engine and the operation of my sound dissipator, it will be seen that the stator 11 and the rotor 15 may be disposed so that the valve ports 14 and 16 therein are out of alignment when the engine exhaust port opens. The sound waves which travel faster than the exhaust gas pressure waves reach the rotor 15 and the

stator 11 while the ports 14 and 16 are out of communication. The engine exhaust port then closes and the sound waves are confined and dissipated before the ports 14 and 16 begin to come into alignment. As the slower travelling gas pressure wave reaches the stator 11, the port 16 begins to come into alignment with the port 14 as gas may flow into the housing 10 and thence to atmosphere. The ports 14 and 16 remain in partial or complete alignment for a sufficient length of time to permit the exhaust gases to escape and to keep the flow resistance at a minimum. It will be understood, of course, that the rotor 15 moves continuously in the cycle just described.

It should be understood that the above-described cycle may vary considerably depending upon a number of factors and that the number of gas escape ports in the sound dissipator, in most instances, may be more than one. As shown in Figure 3, the stator 11*b* may be provided with a plurality of ports 14*a* which cooperate with the single port 16*a* in the rotor 15*a*. It will be understood that the stator 11*b* may have a single port, while the rotor 15*a* may have a plurality of ports 16*a* or both the rotor and stator may have a plurality of ports.

With a multi-cylinder engine, the operation of the exhaust valve will cause a plurality of exhaust gas surges to travel successively along the exhaust pipe, each of these surges being preceded at a continuously increasing distance by its corresponding sound waves.

Under these conditions, it will be clear that a sound wave from one cylinder arriving at the noise dissipator may be followed and preceded closely by gas pressure waves from other cylinders. Therefore, the port or ports in the sound dissipator must open and close at very short intervals of time so that passage of the sound waves is blocked while permitting passage of the exhaust gases.

Obviously, the timing and phasing of my sound dissipator cannot be the same for all internal combustion engines. After installation of a sound dissipator of the type described above, it may be adjusted for best results. The adjustment of the stator 11*a* with relation to the rotor 15*a* may be accomplished by adjusting the rotated position of the shaft 18 relatively to the cam shaft of the engine or by adjusting the position of the stator 11*b*. As shown in Figure 3, the stator 11*b* may be supported for rotary adjustment in the housing 10 by means of overlapping flanges 15*b* and 10*d* on the stator and housing, respectively. Likewise, the speed of rotation of the rotor 15 or 15*a* may be varied until optimum sound dissipating effect is obtained.

While devices having only one-stage, like those described above, are satisfactory under many conditions, it may be desirable to provide two or more sound dissipating stages in the device when it is not possible to suitably phase one stage. For example, occasionally it may be impossible to prevent a sound wave and a gas pressure wave from arriving at the stator simultaneously while the ports of the rotor and stator are aligned and, therefore, the sound wave is not dissipated in the device. In order to overcome this deficiency of a single stage device, a second stage or even more stages may be added with the ports thereof arranged so that they will attenuate and finally block the passage of the sound wave, without preventing the escape of the more slowly moving gas pressure waves.

As shown in Figure 4, a typical form of device having two sound dissipating stages may include an enlarged frusto-conical housing 20 having an outlet 21 and two axially aligned generally cylindrical chamber-forming members or stators 22 and 23 disposed therein. The stator 22 may be supported on the front wall 20*a* of the chamber and is in communication with the receiving member 24 and the exhaust pipe 25. The second chamber or stator 23 may be supported on a diaphragm or partition 26 about midway of the housing 20 which together with the stator 23 divides the housing into two compartments.

A driveshaft 27 supported in a water-cooled bearing 28 in the end wall 20*b* of the housing 20 carries a rotor 29 and a rotor 30 which cooperate with the stators 23 and 22, respectively.

As illustrated, the stator 22 is provided with an exhaust port 22*a* and the cooperating rotor 30 is provided with a single exhaust port 30*a*. Similarly, the stator 23 and the rotor 29 may be provided with the ports 23*a* and 29*a*, respectively.

The first stage of the device including the rotor 30 and the stator 22 is operated in time relationship to the exhaust valve of the motor in the manner described above.

The second stage of the device including the stator 23 and the rotor 29 is operated in accordance with the timing shown in Figure 5. In the second stage, the port 29*a* may be staggered in such a manner that it will not be in communication with port 23*a* at the same time that ports 22*a* and 30*a* of stage one are in communication so as to dissipate the sound pressure waves that may pass through the first stage while the port 22*a* is in communication with the port 30*a*. The staggered relationship must be such, however, that the exhaust gases may pass through both of the stages without substantial back-pressure.

It will be understood that additional stages may be included which cause further attenuation of the sound waves without blocking the passage of the exhaust gas and that additional ports 22*a* and/or 30*a*, and 23*a* and/or 29*a* may be provided as shown in Fig. 3.

While I have disclosed the invention as including rotary elements for opening and closing the ports in the sound dissipating chambers of the various stages, it will be understood that other types of valves may be used, if desired. For example, one or more poppet or slide valves may be used. These valves may be actuated by a cam shaft in timed relationship to the actuation of the exhaust valves of the associated internal combustion engine in the time-phase relation described above. Accordingly, it will be understood that the invention is susceptible to considerable modification in its details without departing from the invention and that the form of the invention disclosed herein should be considered as illustrative only and not as limiting the scope of the following claims.

I claim:

1. In a sound-dissipating device for an internal combustion engine having an exhaust duct, the combination of a member having walls forming a chamber communicating freely with said exhaust duct for receiving exhaust gases and sound pressure waves from said engine, a gas escape port in a wall of said chamber, valve means for opening and closing said port, and means for actuating said valve in timed relation to the operation of said engine to open said port to permit gases to escape from said chamber only when said exhaust gases are being delivered to

said chamber and to close said port to trap sound pressure waves in said chamber.

2. In a sound-dissipating device for an internal combustion engine having an exhaust duct, the combination of a member having walls forming an unobstructed chamber for receiving exhaust gases from said duct, said member having a gas escape port in a wall thereof, valve means for opening and closing said port, and means for actuating said valve means for opening said port during the flow of exhaust gases into said chamber, only, to permit exhaust gases to escape from said chamber, and for closing said port to trap and dissipate sound pressure waves in said chamber.

3. In a sound-dissipating device for internal combustion engines, the combination of a housing, means having walls forming a substantially unobstructed chamber in said housing for receiving exhaust gas and sound pressure waves from said engine, said chamber forming means having a port in a wall thereof connecting the interior of said chamber with the interior of said housing, valve means for opening and closing said port, and means for actuating said valve means to open said port to permit exhaust gases to flow from said chamber into said housing during flow of exhaust gas into said chamber and closing said port to trap and dissipate the sound pressure waves received from said engine.

4. In a sound-dissipating device for an internal combustion engine having an intermittently actuated exhaust valve and an exhaust port, the combination of a member having walls forming a chamber communicating with said exhaust port for receiving exhaust gas and sound pressure waves therefrom, means forming a port in a wall of said member to permit escape of gases from said chamber, valve means for opening and closing said port, and means for actuating said valve means in time-phase relation to the intermittent actuation of said exhaust valve, to open said port to permit exhaust gas to escape through said port from said chamber and to substantially close said valve means to trap and dissipate said sound pressure waves in said chamber.

5. In a sound-dissipating device for internal combustion engines having an intermittently actuated exhaust valve and an exhaust port, the combination of a chamber communicating with said exhaust port for receiving exhaust gas and sound pressure waves therefrom, valve means communicating with said chamber, means for opening and closing said valve means in time-phase relation to the intermittent actuation of said exhaust valve, to open said valve means to permit exhaust gas to escape from said port and chamber and to substantially close said valve means to trap and dissipate said sound pressure waves in said chamber, and means for adjusting the time-phase relation between said exhaust valve and said valve means.

6. In a sound-dissipating device for internal combustion engines, the combination of a chamber for receiving exhaust gas and sound pressure waves freely from said engine, said chamber having a port therein for allowing escape of exhaust gases from said chamber, a valve for closing and opening said port, and means for actuating said valve to open said port to permit the exhaust gases received therein to escape and for closing said port to trap and dissipate sound waves received therein.

7. In a sound-dissipating device for an internal combustion engine, the combination of a chamber for receiving exhaust gases and sound pressure waves from an internal combustion engine, said chamber having at least one gas escape port therein, rotary valve means for opening and closing said port, and means for rotating said valve means in time-phase relation to said engine to close said port intermittently to trap and dissipate sound pressure waves in said chamber and open said port intermittently to allow escape of exhaust gases.

8. In a sound-dissipating device for an internal combustion engine, the combination of a chamber for receiving exhaust gases and sound pressure waves from an internal combustion engine, said chamber having at least one gas escape port therein, rotary valve means for opening and closing said port, means for rotating said valve means in time-phase relation to said engine to close said port intermittently to trap and dissipate sound pressure waves in said chamber and open said port intermittently to allow escape of exhaust gases, and means for adjusting said chamber and said rotary valve means relatively to each other to vary the phase relationship between said valve and said engine.

9. In a sound-dissipating device for internal combustion engines, the combination of a housing, means forming a chamber having at least one gas escape port communicating with said housing, a rotor in said chamber having at least one port therein adapted to move into and out of alignment with the port in said chamber, and means for rotating said rotor to move the rotor port out of alignment with said chamber port to trap sound pressure waves from said engine and to move said rotor port into alignment with said chamber port when exhaust gases arrive at said chamber.

10. In a sound-dissipating device for internal combustion engines, the combination of a housing, means forming a chamber having at least one gas escape port communicating with said housing, a rotor in said chamber having at least one port therein adapted to move into and out of alignment with the port in said chamber, means for rotating said rotor to move the rotor port out of alignment with said chamber port to trap sound pressure waves from said engine and to move said rotor port into alignment with said chamber port when exhaust gases arrive at said chamber, and means for adjusting the angular relationship between said rotor and chamber ports to vary the phasing of said ports with relation to the operation of said engine.

11. In a sound-dissipating device for internal combustion engines, the combination of a housing, a plurality of chamber forming means in and dividing said housing into a plurality of compartments, at least one gas escape port in each of said chamber forming means to permit exhaust gases to flow from one chamber into a compartment and to another chamber, and from said another chamber into another compartment, rotary valve means in each of said chambers having ports for opening and closing the ports in said chambers, and means for rotating said valve means to open the ports in said chambers successively to let said gas escape from one chamber to another, and to close said ports to trap and dissipate sound pressure waves in said chambers.

HARRY A. SMITH.