April 27, 1937. J. A. DAY 2,078,754

SILENCER

Filed March 24, 1934 2 Sheets-Sheet 1

Fig. 1.

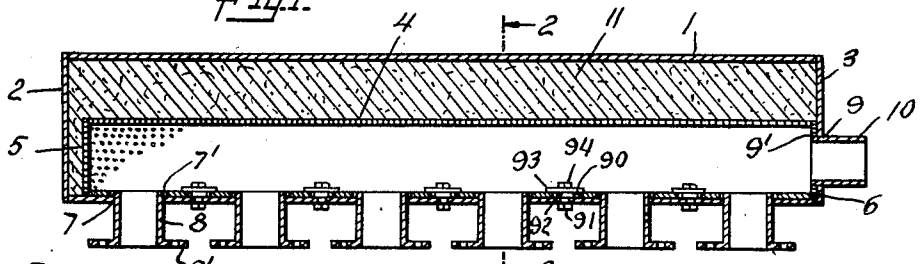


Fig. 2.

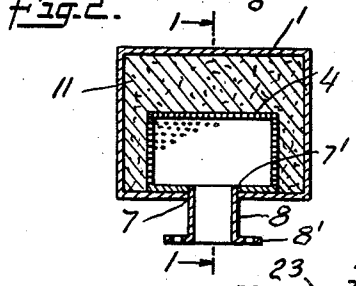


Fig. 3.

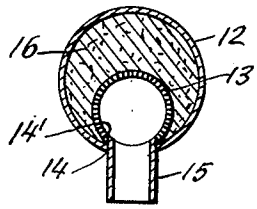


Fig. 5.

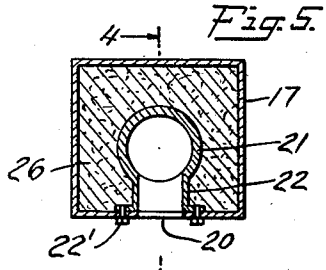


Fig. 4.

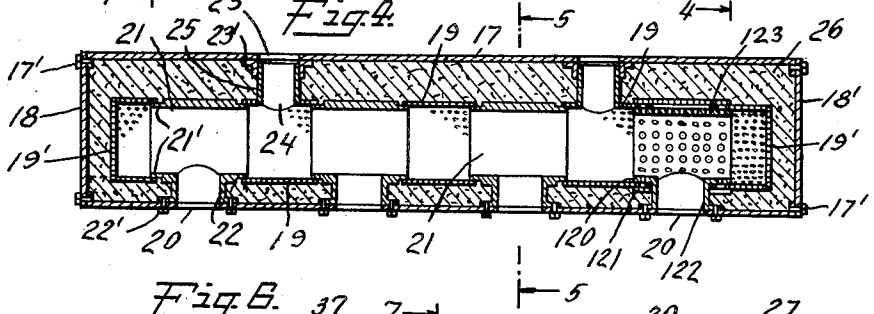


Fig. 6.

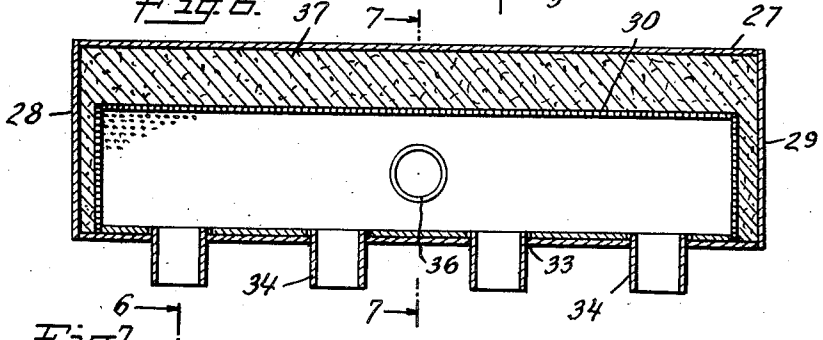
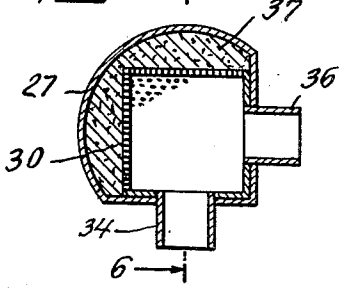


Fig. 7.



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SILENCER

Filed March 24, 1934 2 Sheets-Sheet 2

Fig. 8.

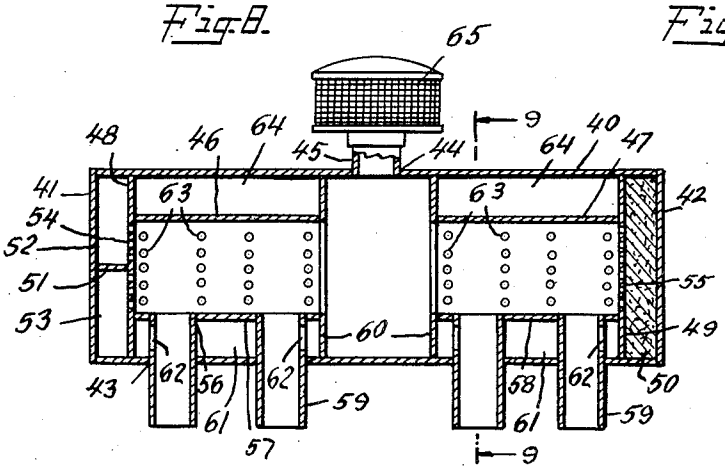


Fig. 9.

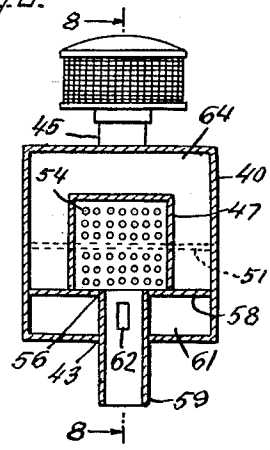


Fig. 10.

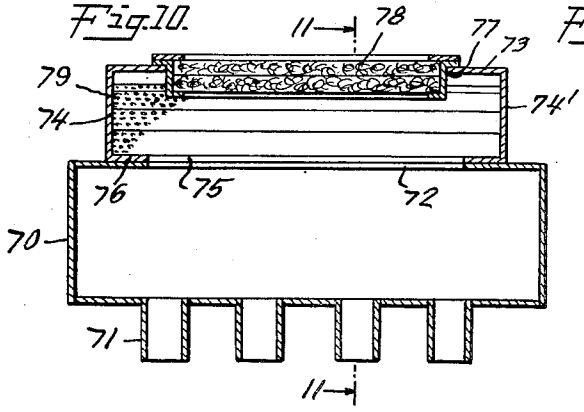


Fig. 11.

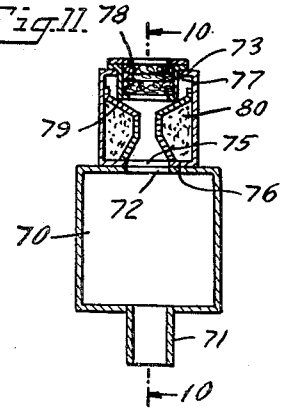


Fig. 12.

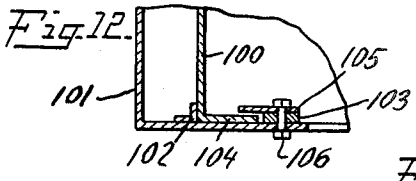


Fig. 13.

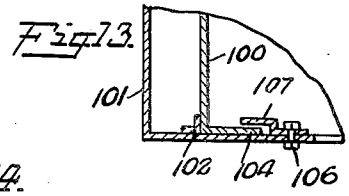
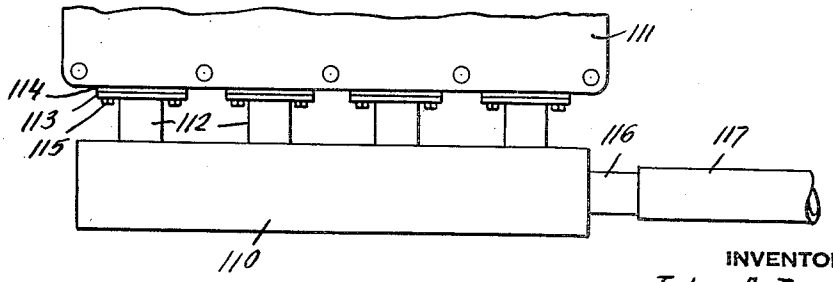


Fig. 14.



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Patented Apr. 27, 1937 2,078,754

UNITED STATES PATENT OFFICE

2,078,754

SILENCER

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Application March 24, 1934, Serial No. 717,197

15 Claims. (Cl. 181—40)

This invention relates to improvements in silencers, and particularly those used to silence the intakes and exhausts of internal combustion engines, compressors, pumps and the like. In particular it relates to improvements in the type of silencer disclosed and claimed in Schnell Patent No. 1,811,762.

It is an object of this invention to provide an improvement in the construction of a silencer of the type described whereby the effectiveness thereof is increased.

It is a further object of this invention to combine a silencer and manifold in such a manner that greatest possible effects are obtained from the silencing means used.

In an exhaust system, gas pulses at high pressure and sounds are both present. Since sound is an alteration in pressure, or a superposition of a number of pressure alterations, propagated in an elastic medium, a sound propagated in gas or air may be called a gaseous-pressure wave. Gas pulses may also be called gaseous-pressure waves. It is an object of this invention to provide an improved silencer which attenuates both of the mentioned kinds of gaseous-pressure waves. If the gas pulses are not attenuated or altered in form within the silencer, upon their emergence therefrom they expand into the atmosphere and create sounds. When the attenuation of sound is spoken of herein, it is meant to relate to the attenuation of gaseous-pressure waves which would otherwise result in objectionable sounds being heard.

I have found that it is possible to incorporate sound attenuating means, e. g., gaseous-pressure wave absorbing material and/or space-volumes, into a manifold, either intake or exhaust, and thereby eliminate the necessity of employing a silencer remote from the engine. This not only provides a single compact unit replacing two separate units, manifold and silencer, but affords greater silencing for the same size and amount of attenuating means used. In general, the silencing effect is increased if the attenuating means is moved closer to the source of the sounds. Placing the attenuating means adjacent the exhaust ports of the engine allows greater expansion of the exhaust gas at this point than would take place if the usual type of manifold is used. This is particularly advantageous in that the gases are at their highest temperature when they leave the cylinder of the engine and the expansion within the manifold silencer effects a greater cooling than is obtained with the usual type of manifold. When the manifold silencer is used as an intake silencer, the amount of attenuating means exposed to the incoming air is considerably greater than it is in the usual types of intake silencers, such as is disclosed in Hartsock United States Patent No. 1,934,463, because of the relatively greater size of the former.

In the drawings:

Fig. 1 is a longitudinal sectional view of one form of the silencer on line 1—1 of Fig. 2;

Fig. 2 is a transverse sectional view of the silencer on line 2—2 of Fig. 1;

Fig. 3 is a transverse sectional view of a modification of the silencer shown in Figs. 1 and 2;

Fig. 4 is a longitudinal sectional view of another form of silencer on line 4—4 of Fig. 5;

Fig. 5 is a transverse sectional view of the silencer on line 5—5 of Fig. 4;

Fig. 6 is a longitudinal sectional view of a further modification of the silencer on line 6—6 of Fig. 7;

Fig. 7 is a transverse sectional view of the silencer on line 7—7 of Fig. 6;

Fig. 8 is a longitudinal sectional view of another form of the silencer on line 8—8 of Fig. 9;

Fig. 9 is a transverse sectional view of the silencer on line 9—9 of Fig. 8;

Fig. 10 is a longitudinal sectional view of a further modification of the silencer on line 10—10 of Fig. 11;

Fig. 11 is a transverse sectional view of the silencer on line 11—11 of Fig. 10;

Figs. 12 and 13 are transverse detail views of a portion of the silencer shown in Figs. 1 and 2; and

Fig. 14 is a diagrammatical illustration showing the silencer mounted upon an engine block.

The silencer shown in Figs. 1 and 2 consists of an elongated imperforate outer casing 1, which may be rectangular in transverse section, as shown in Fig. 2. The casing is provided with end walls 2 and 3. One longitudinal wall of casing 1 is provided with a plurality of openings 7 in spaced relation. A single opening 9 is provided in end wall 3. An elongated perforate or foraminous shell 4, of smaller dimensions than casing 1, is disposed within casing 1. Shell 4 is provided with perforated end walls 5 and 6. One longitudinal wall of shell 4 is provided with a plurality of openings 7' in spaced relation. A single opening 9' is provided in end wall 6. Shell 4 is mounted within casing 1 in such a manner that openings 7' and 9' in shell 4 register with openings 7 and 9, respectively, in casing 1. The shell and casing are preferably in contact along one longitudinal wall and one end wall as shown in

Figs. 1 and 2, but may be in spaced relation. Openings 7 and 7' and 9 and 9' are adapted to receive conduits 8 and 10, respectively, which provide communication with the volume defined by shell 4. Gaseous-pressure wave absorbing material 11 is packed in the space between casing 1 and shell 4. The shell need not extend continuously but may be in two or more sections, as shown in Fig. 8.

For engine and compressor intakes, flammable absorbing materials such as cotton, wool, hairfelt, wood fiber and the like may be used, whereas for gas engine exhausts and other hot gases non-flammable absorbers should be used such as steel wool and other metallic wool, exfoliated vermiculite, asbestos fibers, rock wool, pumice, aggregate formed from heat expanded clay or other argillaceous material, and known under the trade-mark "Haydite" and other loose ceramic aggregates. The aggregates, however, may be bonded together in a manner so as to leave intercommunicating absorbing channels, as described in Jack United States Patent No. 1,921,468.

Openings 7 are spaced so as to allow conduits 8 to be fitted to the exhaust or inlet ports of an engine. Conduits 8 may be provided with integral flanges 8' which may be fastened directly to the engine block. Conduit 10 is adapted to connect with a tail pipe (not shown) when the device is used as an exhaust silencer. When the device is used as an intake silencer on a Diesel type engine, conduit 10 may be left open to the atmosphere, or, if desired, the conduit may be connected to a suitable air cleaning device (not shown). When the device is used as an intake silencer on an internal combustion engine having a carburetor, conduit 10 is connected to the carburetor.

When the device is used as an exhaust silencer, means should be provided to allow free expansion of the shell within the casing. Openings 7' in shell 4 are preferably larger than openings 7 in casing 1. Conduits 8 are rigidly secured to casing 1 and pass through openings 7'. Although conduits 8 are shown as extending inwardly a distance only equal to the thickness of the walls of shell 4, they may project into the volume defined by shell 4. Shell 4 is secured to casing 1 to permit independent movement thereof due to expansion or contraction. As shown, a plurality of openings 90 are provided in the longitudinal wall of shell 4. Bolts 91 pass through openings 90 and the adjacent portions of the wall of casing 1. Spacing washers 92, which are smaller in diameter than openings 90, are placed adjacent the inner surface of the wall of casing 1. Washers 93, which are considerably larger in diameter than openings 90, are placed between spacing washers 92 and nuts 94 on the ends of bolts 91 inside shell 4. The thickness of spacing washers 92 is greater than the thickness of the wall of shell 4, thereby allowing the shell to move freely as it expands or contracts. Spacing washer 92 and washer 93 may be replaced by a single member.

The high pressure exhaust slugs and other gaseous-pressure waves emerging from the engine and entering the silencer are reduced or attenuated by means of the gaseous-pressure wave absorbing material exposed by the walls of the perforated shell. The perforated shell is placed eccentrically within the outer casing, preferably in such a manner that one end wall and at least one longitudinal wall of the shell contacts with a corresponding end wall and longitudinal wall of the casing. This type of construction simplifies the fabrication of the silencer, but is not absolutely essential. The use of an eccentric shell within the casing provides certain advantages because of the different thicknesses of the walls of the gaseous-pressure wave absorbing material, as described and claimed in Spicer application, Ser. No. 506,361, filed January 3, 1931 (now Patent No. 2,046,193, granted June 30, 1936).

The use of a porous material within the manifold allows a greater expansion of the gases as they enter the manifold than is possible with the usual type of manifold. The highest temperatures of the exhaust gas in the exhaust system are encountered as the gases leave the cylinder and enter the manifold. By allowing a greater expansion at this point, a greater cooling effect is obtained which also aids in reducing the amplitude of the pressure slugs and pressure waves.

The silencer shown in Fig. 3 is similar in construction to the silencer shown in Figs. 1 and 2. Outer imperforate casing 12 and perforated shell 13 are circular in transverse section. Shell 13 is mounted within casing 12 in a manner such that one end wall and a longitudinal side of shell 13 is in contact with the corresponding elements of casing 12. Casing 12 and shell 13 are provided with a plurality of registering longitudinally spaced openings 14 and 14'. These openings are adapted to receive conduits 15. A conduit corresponding to conduit 10 of Fig. 1 is connected in similar fashion at one end of this silencer. Suitable means may be provided to allow free expansion of shell 13 within casing 12. The space between casing 12 and shell 13 is filled with a gaseous-pressure wave absorbing material 16.

Figs. 4 and 5 illustrate a silencer in which the foraminous shell is disposed concentrically within the casing. However, if desired, the shell may be disposed eccentrically therein. The silencer comprises an outer imperforate casing 17 having end walls 18 and 18'. The end walls may be removably secured to casing 17 by means of screws 17' to allow access to the interior of casing 17. Casing 17 is provided with a plurality of longitudinally spaced openings 20 along one longitudinal wall thereof. In place of the integral shell 4 of Figs. 1 and 2, I employ a plurality of foraminous tube sections 19 and cooperating solid or non-perforated T-shaped members 21. When the device is used as an exhaust silencer, the temperature of the exhaust gases may be sufficiently high to cause failure of a relatively thin perforated shell, such as shown in Figs. 1 to 3. To guard against such failure, the T-shaped members 21 are made of cast iron or equivalent material and are not perforated. The exhaust gases from the cylinders impinge against these cast iron sections. The latter are capable of withstanding the resulting high temperatures.

The closed end sections 19' are rigidly fastened to the adjacent ends 21' of T-shaped members 21, as by spot welding. The cylindrical leg portions 22 of the members 21 register with openings 20 and provide communication with the volume defined by members 21 and tube sections 19. Members 21 may be removably secured to casing 17 by means of screws 22' to allow the shell to be removed from casing 17 for cleaning or rebuilding. The ends of tube sections 19 are adapted to fit loosely over the adjacent ends of

T-shaped members 21 to provide slip-joints between them. Members 21 are provided with reduced end portions 21' for this purpose. Sufficient play is provided between the ends of tube sections 19 and the transverse shoulders upon the adjacent end portions of T-shaped members 21 to permit longitudinal expansion and contraction of these parts. One or more of the tube sections 19 are provided with openings 24 which are alined with openings 23 in casing 17. Branch pipe sections 25 are rigidly secured to tube sections 19 at openings 24 in the sides thereof and extend outwardly therefrom. The ends of pipe sections 25 fit slidingly within collars 23' which are secured to the interior of the side of casing 17 in registry with openings 23 in said side. This provides slip-joints, thereby allowing free lateral expansion and contraction of the shell with respect to casing 17. If desired, openings 23 and 24 and conduits 25 may be disposed on one of the adjacent walls of the silencer. The space between casing 17 and tube sections 19 and T-shaped members 21 is filled with gaseous-pressure wave absorbing material 26.

T-shaped members 21 may be replaced by concentric perforated tube sections 120 and 121 and conduit 122. Tube section 120 is preferably of greater thickness and has larger perforations than tube sections 19 and 121, and is capable of withstanding the temperatures resulting from the impingement of the hot exhaust gases from the cylinder. Conduit 122 registers with opening 20 and is rigidly fastened to casing 17 at one end and to tube section 120 at its inner end. The ends of tube sections 19 are adapted to fit loosely over the adjacent ends of tube sections 120 to provide slip-joints between them. Tube sections 120 and 121 may be held in spaced relation by means of spacers 123. When the concentric perforated tube sections are used in place of the solid T-shaped members, the area of the gaseous-pressure wave absorbing material exposed to the gases is greater than the area exposed when the solid T-shaped members are used.

The silencer shown in Figs. 6 and 7 consists of an outer imperforate casing 27 having end walls 28 and 29. Casing 27 is irregular in transverse section, as shown in Fig. 7, but may be of any desired shape. A perforated shell 30, of smaller dimensions than casing 27, is disposed within the casing and has two longitudinal walls fastened in contacting relation with two corresponding walls of casing 27. Shell 30 may be irregular in transverse section and may differ in transverse section from casing 27, but it is desirable to have the contacting walls of the casing and shell of the same shape so as to simplify the assembly operations. Lateral branch conduits 34 are connected to openings 33 in the side of casing 27 and pass through corresponding openings in the contiguous side of shell 30. In the same way lateral conduit 36 is connected to the adjacent side of casing 27 and passes through an opening in the contacting side of shell 30. Suitable means may be provided to allow free expansion of shell 30 within casing 27. The space between casing 27 and shell 30 is filled with gaseous-pressure wave absorbing material 37.

The silencer shown in Figs. 8 and 9 illustrates the use of space-volumes or resonating chambers to attenuate the gaseous-pressure waves. The silencer comprises an outer casing 40 which is provided with end walls 41 and 42. One longitudinal wall of casing 40 is provided with a plurality of longitudinally spaced openings 43. A single opening 44 is provided in the opposite longitudinal wall or in one of the adjacent longitudinal walls. Opening 44 is adapted to receive a conduit 45. Two shells 46 and 47 are secured within casing 40 in spaced relation to each other and to the casing. Transverse partitions 48 and 49 are secured to the outer ends of shells 46 and 47, respectively, to form end walls for said shells and also to provide closed space-volumes 50, 52 and 53 at the ends of casing 40. Transverse partitions 60 are secured to the inner ends of shells 46 and 47 and extend between the walls of the shells and the walls of the casing. One or more partitions 51 may be provided within space-volumes 50 to divide the volumes into a plurality of smaller space-volumes such as 52 and 53. Volume 50 may be filled with gaseous-pressure wave absorbing material which is exposed to the gaseous-pressure waves by means of perforations 55 in end wall 49. Communication between space-volumes 52 and 53 and the interior of shell 46 is provided by openings in end wall 48, such as perforations as shown at 54. The size and number of the space-volumes and of the openings in the end walls are in such proportion that these systems attenuate high frequency sound. A plurality of openings 56 are provided along longitudinal walls 57 and 58 of shells 46 and 47. Conduits 59 pass through openings 43 and terminate at openings 56 providing communication with the interior of the shells. Walls 57 and 58 of the shells extend laterally (see Fig. 9) to the longitudinal walls of casing 40 to provide closed space-volumes 61 and 64. Suitable openings 62 are provided in conduits 59 to provide communication with chambers 61. The size of openings 62 and space-volumes 61 are in such proportion that these systems attenuate low frequency sound. The remaining longitudinal walls of shells 46 and 47 are provided with a plurality of openings 63 to provide communication with space-volumes 64. The size and number of openings 63 and the size of volume 64 surrounding these longitudinal walls of shells 46 and 47 are in such proportion that these systems attenuate low frequency sounds. The total number and individual size of the various volumes may be changed to meet conditions encountered in different engines. Conduits 59 are connected to the ports of the engine and conduit 45 is connected to the exhaust pipe or carburetor, as the case may be. When the device is used as an intake silencer on a Diesel type engine, a suitable air cleaning unit 65 may be fitted to conduit 45. When the device is used as an intake silencer on an internal combustion engine having a carburetor, conduit 45 is connected to the carburetor. When the device is used as an exhaust silencer, suitable means may be provided as previously described, to allow free expansion of shells 46 and 67.

Figs. 10 and 11 illustrate a silencer which is particularly adapted for use as an intake silencer. The silencer is attached to a manifold 70 which is provided with the usual conduits 71 along a longitudinal wall of the manifold. An opening 72 is provided in one of the remaining longitudinal walls of the manifold. The silencer comprises an outer casing 73 having end walls 74 and 74'. Longitudinal wall 76 of casing 73, is provided with an opening 75 which registers with opening 72 in manifold 70. The opposite longitudinal wall of casing 73 is provided with

an opening 77 which is adapted to receive an air cleaning unit 78. Perforated partitions 79, shaped so as to allow sufficient space for air cleaning unit 78, are rigidly secured to the longitudinal walls of casing 73 and extend the length of the casing. The spaces between partitions 79 and casing 73 are filled with gaseous-pressure wave absorbing material 80.

Fig. 12 illustrates another method of mounting the foraminous shell within the outer casing to allow the shell to freely expand relative to the casing when the device is to be used as an exhaust silencer. This construction may be used in place of that shown in Fig. 1. Shell 100 differs from the shells shown in previous illustrations in that one longitudinal wall is not completely closed, thus providing a flange 104. Angle 102 is rigidly fastened to casing 101 adjacent the longitudinal wall of shell 100 and extends substantially the length of shell 100. Spacing members 103 are disposed on casing 101 in spaced relation to the edge of flanges 104 of shell 100 and extend substantially the length of shell 100. The thickness of spacing members 103 is slightly greater than the thickness of flanges 104. Cover plates 105 are disposed on spacing members 103 and extend longitudinally substantially the length of shell 100 and extend laterally over a portion of flanges 104. Spacing members 103 and cover plates 105 are rigidly fastened to casing 101 by means such as bolt 106. Spacing members 103 and cover plates 105 may be replaced by a Z-shaped member 107, as shown in Fig. 13.

Fig. 14 illustrates a manifold silencer 110 mounted upon an engine block 111 by means of flanges 113 on conduits 112. Flanges 113 are fastened to engine block 111 at ports 114 by suitable means such as bolts 115. When the device is used as an exhaust silencer, conduit 116 may be connected to tail pipe 117. When the device is used as an intake silencer on a Diesel type engine, conduit 116 may be left open to the atmosphere or may be connected to a suitable air cleaning unit such as shown at 65 in Figs. 8 and 9. When the device is used as an intake silencer on an internal combustion engine having a carburetor, conduit 116 is connected to the carburetor (not shown).

Other changes in design may be made. The number of conduits communicating with the manifold depends upon the number of cylinders in the engine for which the silencer is to be used. A combination of gaseous-pressure wave absorbing material and space-volumes may be used in a single silencer. The number and size of the space-volumes and the number, size and type of openings to the space-volumes may be varied to attenuate sounds of any particular range of frequencies.

I claim:

1. A manifold for internal combustion engines comprising a substantially imperforate casing, a shell within said casing, the walls of said casing and said shell defining spaces therebetween, said spaces comprising gaseous-pressure wave attenuating means and being acoustically connected to the interior of said shell, said shell having a plurality of openings in the walls thereof, at least one of said openings being connected to the atmosphere, at least some of the remainder of said openings being adapted to be connected to the ports of the engine and providing communication between said ports and the interior of said shell.

2. The manifold of claim 1 in which the walls of said shell are foraminous and the spaces between said casing and said shell contain gaseous-pressure wave absorbing material.

3. The manifold of claim 1 in which a portion of the walls of said shell is foraminous and gaseous-pressure wave absorbing material is exposed in the walls of said foraminous portion of said shell.

4. An exhaust manifold for internal combustion engines comprising a substantially imperforate casing, a shell within said casing, the walls of said shell and said casing defining spaces therebetween, said spaces containing gaseous-pressure wave absorbing material, a wall of said shell having openings therein, conduits passing through said casing and adapted to connect said openings with the exhaust ports of the engine and providing communication between said exhaust ports and the interior of said shell, the portions of the wall of said shell opposite said openings being imperforate, at least a portion of the remainder of the walls of said shell being foraminous.

5. A manifold for internal combustion engines comprising a substantially imperforate casing, a foraminous shell within said casing and defining spaces therebetween, means for mounting said shell within said casing in relatively movable relation to said casing whereby said shell may expand freely with respect to said casing, gaseous-pressure wave absorbing material in said spaces, and a plurality of conduits communicating with the inner volume defined by said shell, some of said conduits being adapted to be connected to the ports of the engine.

6. A manifold for internal combustion engines comprising a substantially imperforate casing, a perforated shell within said casing and spaced from at least two longitudinal walls thereof and defining spaces therebetween, means for mounting said shell within said casing in relatively movable relation to said casing whereby said shell may expand freely with respect to said casing, gaseous-pressure wave absorbing material in said spaces, and a plurality of conduits communicating with the interior of said shell, some of said conduits being adapted to be connected to the ports of the engine.

7. An exhaust manifold for internal combustion engines comprising a substantially imperforate casing, a shell within said casing, the walls of said shell and said casing defining spaces therebetween and having a plurality of corresponding openings therein, gaseous-pressure wave absorbing material between said shell and said casing, conduits connecting corresponding openings in the walls of said shell and said casing and communicating with the interior of said shell, at least one of said conduits communicating with the atmosphere and at least some of the remaining conduits being adapted to communicate with the exhaust ports of the engine, said shell comprising a plurality of tube sections having their ends fitting loosely together to permit relative longitudinal movement therebetween, said tube sections which have openings adapted to communicate with said exhaust ports being imperforate and of relatively increased heat resistance, the remainder of said tube sections being foraminous.

8. A silencer comprising an elongated casing, an elongated perforated shell disposed therein, said casing and said shell each having a plurality of corresponding openings spaced along one

longitudinal wall and at least one corresponding opening in one of the remaining walls, said shell and said casing being fastened together along said longitudinal walls, conduits passing through said openings and providing communication between the exterior of said casing and the interior of said shell, and gaseous-pressure wave absorbing material filling the space between said casing and said shell.

9. In a device of the class described, a substantially imperforate casing having a plurality of openings therein, a shell within said casing and in spaced relation thereto, said shell comprising a plurality of sections fitted together in non-adherent, end-to-end relation, some of said sections being cylindrical, the remainder of said sections being T-shaped and having cylindrical cross and leg elements, said leg elements being fastened to the interior surface of said casing and forming the means for spacing said shell from said casing, the interior of said leg elements registering with said openings, and gaseous-pressure wave attenuating means in the space between said shell and said casing and acoustically connected to the interior of said shell.

10. In a device of the class described, the combination of an outer substantially imperforate casing, an inner shell within said casing and spaced from said casing, said shell and casing having corresponding openings in corresponding walls thereof, a plurality of conduits disposed in spaced relation along one longitudinal wall of said casing and at least one conduit on one of the remaining walls of said casing, said conduits connecting said corresponding openings and providing communication between the exterior of said casing and the interior of said shell, and sound attenuating means acoustically connected to the interior of said shell.

11. A silencer comprising an outer imperforate casing, end walls for said casing, a shell having end walls within said casing and spaced from at least two longitudinal walls of said casing, said shell and casing having corresponding openings in corresponding walls thereof, a plurality of conduits spaced along a longitudinal wall of said casing, at least one conduit disposed on one of the remaining walls of said casing, said conduits connecting said corresponding openings and providing communication between the exterior of said casing and the interior of said shell, and sound attenuating means between said casing and said shell and acoustically connected to the interior of said shell.

12. A silencer comprising an imperforate casing, a shell having smaller dimensions than said casing disposed therein, said casing and shell each having a plurality of corresponding openings in one corresponding wall thereof, a plurality of conduits connecting said corresponding openings and providing communication between the exterior of said casing and the interior of said shell, and a plurality of space volumes between said casing and said shell, some of said space volumes being acoustically connected to said ducts and some being acoustically connected to the interior of said shell, said casing having an additional opening in the wall thereof and communicating with the interior of said shell.

13. A silencer comprising an imperforate casing, a shell disposed therein, said casing and shell each having a plurality of corresponding openings in one corresponding wall thereof, a plurality of conduits connecting said corresponding openings and providing communication between the exterior of said casing and the interior of said shell, and a plurality of space volumes between said casing and said shell, said space volumes being acoustically connected to the interior of said shell, said casing having an additional opening in the wall thereof and communicating with the interior of said shell.

14. A manifold for an internal combustion engine comprising an imperforate casing, a shell disposed in said casing, said shell and said casing having a plurality of corresponding openings in one corresponding wall, and having at least one corresponding opening in another corresponding wall, some of the walls of said casing and said shell being spaced from each other, and sound attenuating means arranged in said spaces and communicating with the interior of said shell.

15. A device in accordance with claim 14 wherein said shell is mounted in said casing to permit expansion and contraction of said shell in said casing.

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