May 2, 1939. G. C. STARKWEATHER ET AL 2,157,029

MUFFLER

Filed Nov. 8, 1937

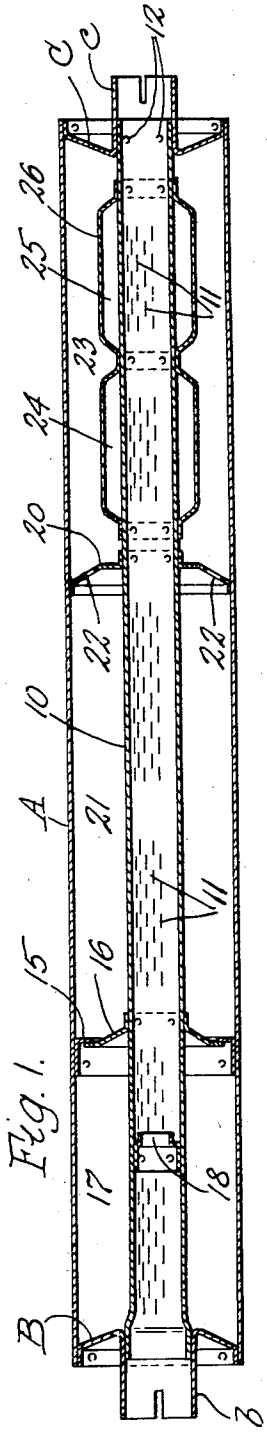

Fig. 1.

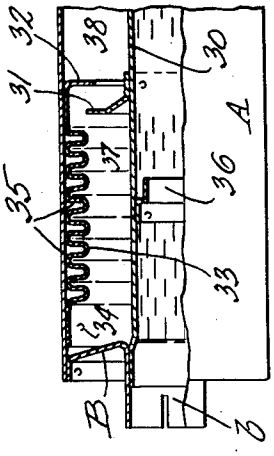

Fig. 4.

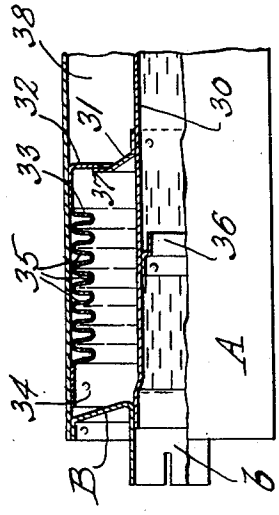

Fig. 3.

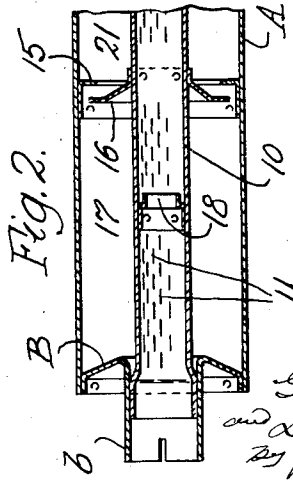

Fig. 2.

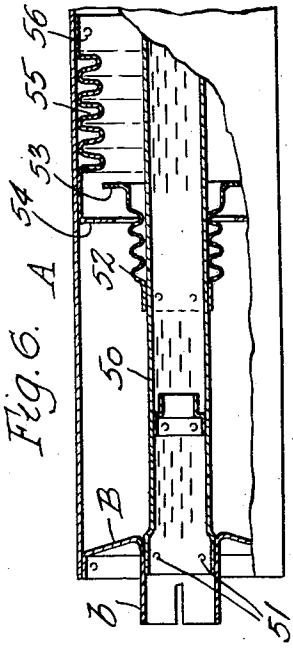

Fig. 6.

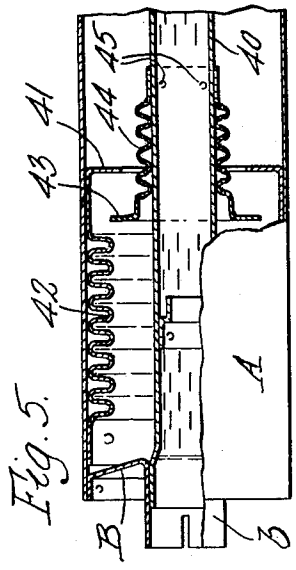

Fig. 5.

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MUFFLER

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22 Claims. (Cl. 181—45)

This invention relates to improvements in mufflers or silencers of the kind which are used in connection with the silencing of the exhaust of internal combustion engines.

When a vehicle propelled by an internal combustion engine is operated at low speeds, for example, in city driving, the back pressure in the muffler is also low and has very little effect upon the operation of the engine. When, however, the engine is operating near its maximum capacity, as at high speeds, much larger volumes of gas are passed through the muffler with resulting increase in back pressure. It is also a fact that as a general rule mufflers which are constructed for the maximum silencing effect also build up the largest back pressures.

One of the objects of this invention is to provide a muffler in which ample muffling capacity is provided when the engine is starting or operating at low speeds, and in which greater freedom for the flow of gases through the muffler is provided when the engine operates at higher speeds. It is also an object of this invention to provide a muffler, which when relatively cool, provides its maximum silencing effect and which when heated provides for a more ready flow of gases through the same. Another object is to produce a muffler which has heat responsive means for providing for an increased passage of gases through the muffler when the same becomes hot. It is also an object of this invention to provide a muffler which is so constructed that the heat of the gases passing through the muffler, when reaching the desired temperature, actuates means for reducing the back pressure of the muffler. Another object of this invention is to provide a muffler with means for resisting to a certain extent the flow of gases through the muffler, which means are actuated by thermo-responsive means to become inoperative when the temperature within the muffler is materially increased. It is also an object of this invention to provide a muffler with a plurality of passages through the same, one of which has valve means which are moved into opening position by thermo-responsive means provided in the muffler, when the temperature within the muffler increases to a predetermined extent.

A further object of this invention is to provide a muffler with thermo-responsive means which depend on their operation upon differences in temperature in the interior and exterior of the muffler and which operate suitable valve means to provide for a decreased resistance to flow of gases through the muffler when the muffler becomes hot. Another object is to provide a muffler with a plurality of silencing chambers which are connected to form a passage for gases when the muffler becomes heated. Other objects of the invention will appear from the following description and claims.

In the accompanying drawing:

Fig. 1 is a longitudinal central sectional elevation of a muffler provided with means embodying this invention for decreasing the resistance to the flow of gases through the muffler when the muffler becomes heated.

Fig. 2 is a central sectional view of a part of the muffler shown in Fig. 1, but showing the parts in the positions which they occupy when the muffler is hot.

Fig. 3 is a fragmentary longitudinal sectional view, partly in elevation, of a muffler of modified construction.

Fig. 4 is a view similar to that shown in Fig. 3, but showing the parts in positions which they occupy when the muffler is hot.

Figs. 5 and 6 are fragmentary longitudinal central sectional views of mufflers of modified construction, partly in elevation.

We have shown in the accompanying drawing several different embodiments of our invention, and have shown them aplied to mufflers of relatively simple construction, for the purpose of illustrating this invention, but it will be understood that it is not intended to limit the invention to the particular embodiments herein shown nor to the particular muffler constructions, since it will be obvious that this invention may be employed in connection with mufflers of many different types. In all of the mufflers shown, a housing or casing is illustrated which includes an outer shell A to one end of which is applied a head B, a portion of which is formed to provide an inlet duct *b* and to which an exhaust pipe (not shown) from an engine may be secured. The other end of the housing may be formed by means of a discharge head C secured at its peripheral portion to the shell A and having a discharge duct *c* from which the exhaust gases may be discharged from the muffler and to which a tail pipe (not shown) may be secured, if desired.

The particular muffler shown in Figs. 1 and 2 is of the straight through type and has an inner shell or conduit 10 which may be provided with suitable openings or perforations 11, through which gases may pass into the space between the shells 10 and A. If desired, the openings may be in the form of perforations arranged in groups spaced at intervals lengthwise of the inner shell

or conduit 10 and these perforations may be of any suitable or desired form.

In accordance with this invention we may vary the resistance to the flow of gases through the muffler by employing any suitable heat responsive means. For example, in Figs. 1 and 2, we have shown how this can be accomplished by employing only the shells of the muffler as heat responsive means because of differences in temperature between the inner and outer shells. In Figs. 3 to 5, we have illustrated how added heat responsive means may be used to supplement the relative expansion and contraction of the shells of the muffler, and in Fig. 6, we show how the desired result can be accomplished by heat responsive members without utilizing the relative contraction and expansion of the shells. In Figs. 3 to 6 the thermo-responsive means shown may be used without relying upon the differential expansion of two different muffler shells.

In Figs. 1 and 2, the inner shell or conduit is rigidly secured at one end thereof to the discharge head C of the muffler, for example, by arranging the end of the conduit 10 within the discharge duct *c* and spot welding the end of the conduit 10 to the duct as indicated at 12. The other end of the inner shell or conduit 10 is telescopically arranged in the duct *b* and is not secured to the muffler, the conduit being left free to expand and contract due to changes in temperature to which the conduit may be subjected. Since the outer shell or housing A of the muffler is not exposed directly to the hot gases passing through the muffler to the same extent to which the inner shell or conduit is exposed to the same, and since furthermore, the outer shell A has its outer surface exposed to the atmosphere and cooled thereby, it is obvious that the inner shell or conduit 10 will become heated to a materially higher temperature than the outer shell A by the gases passing through the muffler. Consequently, when the muffler is heated by gases from an engine, the inner shell or conduit will expand to a greater extent than the outer shell and this difference in expansion is utilized in order to provide an increased passage for the gas when the muffler becomes heated. In the construction shown in Figs. 1 and 2, this is accomplished by providing a valve of suitable form in the space between the inner and outer shells and such valve may, for example, be formed by providing an annular inwardly extending flange or projection 15 on the inner surface of the outer shell A and by providing on the conduit 10 an outwardly extending flange or web 16, the outer edge portion of which abuts against the inwardly extending edge or flange 15 when the muffler is cold. Consequently, the parts 15 and 16 form a transverse baffle or partition within the space between the inner and outer shells and when these two baffle parts are in engagement, a resonator chamber 17 is formed between the head B and this baffle. The parts 15 and 16 also form with a transverse baffle 20 a second chamber 21. The baffle 20, in the construction shown, is provided with apertures 22 communicating with a third chamber 23. If desired, high frequency resonator chambers 24 and 25 may be formed in the muffler by means of an intermediate shell 26 of any suitable or desired form which encloses perforate portions of the inner shell or conduit 10. It will, of course, be obvious that other forms of silencing chambers may be provided in the muffler. In order to render the chamber 17 more effective in connection with the silencing of sound waves, a restriction 18 may be provided in the conduit 10 to produce a greater flow of gases and sound waves through the perforations in the conduit 10 into the chamber 17.

When the muffler is cold or only heated to such extent as would be the case when the vehicle is operated at moderate speeds, the parts of the muffler will be in the positions shown in Fig. 1, and the gases entering the inner conduit 10 are then first exposed to the silencing effect of the resonator chamber 17, and then to the further silencing effect of the chambers 21 and 23. Finally before the gases pass out of the muffler, the high frequency chambers 24 and 25 result in further cancellation of sound waves. If, however, the muffler becomes heated due to the flow of a greater volume of hot gases through the same, it will be obvious that the inner shell or conduit 10 will attain a higher temperature than the outer chamber A, and consequently, the inner shell or conduit will increase in length by thermal expansion, so that the outwardly extending flange or disk 16 will move out of contact with the inwardly extending flange 15, thus forming an opening between the chambers 17 and 21 as is clearly shown in Fig. 2. This connection between the two chambers converts the chambers into a flow passage arranged in parallel with the passage through the conduit 10. While this reduces the silencing effect of these chambers, it has the advantage of providing a relatively large passage for the flow of gases about the inner conduit 10, in addition to the passage through the inner shell or conduit 10. This provision of two passages for the gases materially reduces the back pressure of the muffler, and thus enables the engine to attain a higher speed or to deliver more power. The fact that the muffler will under these conditions have a decreased amount of silencing effect on the exhaust will not be objectionable, for the reason that when travelling at high speeds, some additional noise from the exhaust is not noticed. It is evident, however, that when starting the engine while cold, or when driving the vehicle slowly or on short trips, the muffler will be either cold or will not be heated sufficiently to open the valve formed by the disk 16 and flange 15 so that the noise of the exhaust will be suppressed. When a vehicle is being used in this manner, the back pressure in the muffler is very low, since the volume of gas flowing through the same is small.

When employing the construction described, it is also possible to make the restriction 18 in the inner shell or conduit somewhat greater than has been considered practical heretofore, for the reason that if greater back pressure is built up because of the greater restriction, this increased back pressure would help to suppress noises at low speeds and in starting. When driving the vehicle at higher speeds, high back pressures are avoided, since the heat from the exhaust would then be great enough to open the valve formed by the members 15 and 16 so that the gases can readily by-pass the restriction 18.

In Figs. 3 and 4 is shown a construction whereby the opening movement of the valve resulting from the expansion of the inner shell or conduit 10 is amplified. In this muffler, the inner shell 30 has a sliding connection in the head B as described in connection with Figs. 1 and 2, and this shell also has an outwardly extending flange or disk 31 which forms a part of the valve. The other part of the valve is formed by an inwardly extending flange 32, which in this construction is formed on or secured to a thermo-responsive

member which moves the flange or ring 32 away from the disk 31 when the member is heated. In the particular construction shown, the flange 32 is formed on one end of an expansible member 33, the other end of which is secured to a fixed part of the muffler, for example, to the outer shell A by spot welds 34. The portion of the member 33 intermediate of its ends are preferably provided with corrugations 35 so that this member becomes elongated when its temperature is raised. The flange 32 and the disk 31 together form a baffle or transverse partition between the two adjacent shells of the muffler when the muffler is cold or not raised to a high temperature, and in Fig. 3, the parts are shown in this position. If, however, the muffler is subjected to high temperatures due to increased speed or power developed by the engine, the corrugated portion 35 expands so that the inwardly extending flange 32 is moved toward the rear of the muffler. The outwardly extending flange 31 on the other hand moves toward the opposite end of the muffler, so that the movement of both of these valve parts in opposite directions results in an increased opening of the valve. 36 represents a restriction in the inner shell which may be used, if desired. The other parts of the muffler which are not shown may be of any suitable or usual construction, and it will be obvious that when the valve is open the gases are free to flow from the chamber 37 arranged in front of the valve to a chamber 38 arranged in rear of the valve. This construction, therefore, provides for two parallel paths or passages for the gases when the muffler is hot.

In Fig. 5 is shown a construction whereby a still further amplification of the opening of the valve may be provided, if desired. In this construction, an inner shell or conduit 40 is provided which is similarly arranged with reference to other parts of the muffler as in the constructions shown in Figs. 1 to 4, and this muffler is also provided with a flange 41 extending inwardly from the shell A to form a part of the valve, this flange being actuated by means of a thermo-responsive member 42, which may be similar to the one described in Figs. 3 and 4. In this construction, the other part of the valve is formed by a flange or disk 43 extending outwardly from the inner shell 40. In this construction, this valve member 43 is moved away from the flange 41 when the muffler becomes heated, by suitable thermo-responsive means. For example, member 43 may be formed at one end of an expansible member, the other end of which is secured to the inner shell or conduit, for example, by spot welds 45, this member, in the construction shown, also having a corrugated portion 44 intermediate of its ends. In this construction, the expansion due to heat of the inner shell 40 is supplemented by the expansion of the corrugated expansible member 44, so that the outwardly extending flange 43 moves toward the front of the muffler to a greater extent than would result from the expansion of the inner shell 40 only. The opening of the valve is further supplemented by movement of the valve part or flange 41 by the expansible member 42.

In Fig. 6 is shown another modification of this invention in which an inner shell 50 is provided having the front end thereof secured to the head B, for example, by means of spot welds 51. In this construction, the expansion of the inner shell relatively to the outer shell is not relied upon to effect opening of a by-pass valve. Consequently, a thermo-responsive member 52 is secured at one end to the inner shell or conduit and is provided with an outwardly extending flange or valve member 53 at the other end thereof. This member is similar to the member 44 described in connection with Fig. 5, but is arranged in the reverse direction from that shown in Fig. 5.

The valve shown in Fig. 6 is completed by means of an inwardly extending flange or part 54 formed at one end of a thermo-responsive member 55, one end of which is secured to the outer shell A, for example, by welding, as indicated at 56. When the muffler becomes heated, it will be obvious that the two thermo-responsive members 52 and 55 will expand in such a manner that the portions thereof which form the valve move in opposite directions so as to form an opening through which gases pass. It will, of course, be understood in connection with Figs. 5 and 6 that when the muffler is cold or not raised to a high temperature, the valve members will be in contact as shown in Figs. 1 and 3 to form a baffle or transverse partition.

The expansible members shown in Figs. 3 to 6 inclusive which include corrugated portions may be constructed of a single metal sheet and are comparatively inexpensive to produce. It will be understood, however, that if desired, bimetallic expansible members may be employed to produce the movement to effect opening of the valve. In the foregoing description, the shell A of all of these mufflers has been referred to as an outer shell, but it will be understood that this is intended to indicate that the shell A is arranged about the inner shell or conduit and that additional shells may be arranged within or about the outer shell A, if desired. In other words, it is not intended hereby to limit this invention to use in connection with the mufflers having only two shells.

In the several constructions shown, the parts of the by-pass valve may be initially placed under tension when the muffler is cold so that considerable heating of the muffler may be necessary before the by-pass valve opens.

It will be noted that in the several constructions shown, there are provided more openings or perforations in the inner shell in front of the restriction 18 than immediately in rear thereof. This enables gases to discharge freely from the inner shell in advance of the restriction, so that when the muffler becomes hot and a by-pass valve is opened, there will be ample openings in advance of the restriction to permit gases to flow freely out of the inner shell and through the valve.

We claim as our invention:

1. A muffler having a plurality of shells arranged one within another and forming a plurality of passages for gases, valve means located in one of said passages for controlling the flow of gases through the same, and means for moving said valve means toward opening position when the interior of said muffler becomes heated by said gases.

2. A muffler having a plurality of shells arranged one within another and forming a plurality of passages for gases, valve means located in one of said passages for controlling the flow of gases through the same, and means responsive to differences in temperature in said passages to move said valve in a direction to open the passage in which said valve is located.

3. A muffler comprising a casing, dividing walls

in said casing forming a plurality of passages therein and connected in parallel with each other, a valve device controlling the flow of gases through one of said passages, and heat-responsive means within said casing and operable upon a sustained increase in temperature within said casing for opening said valve.

4. A muffler having an inner shell forming a passage for gases, a shell arranged about said inner shell, and spaced therefrom, a partition dividing the space between said shells into separated chambers and including a part which is movable into a position to form an opening in said partition, said inner shell having openings communicating with said chambers, and means responsive to increases in temperature in said muffler to move said part into opening position to permit gases to pass through said partition to convert said chambers into a passage paralleling the passage through said inner shell.

5. A muffler having an inner shell forming a passage for gases, a shell arranged about said inner shell and spaced therefrom, a partition arranged in the space between said shells and formed of relatively movable parts which when in one position divide said space into two separated chambers, an inner shell having openings communicating with both of said chambers, and means responsive to increases in temperature in said muffler to produce relative movement of said parts of said partition to permit gases to pass between said parts to convert said chambers into a passage for gases parallel the passage through said inner shell.

6. A muffler having an inner shell forming a passage for gases, a shell arranged about said inner shell and spaced therefrom, a partition arranged in the space between said shells and including a part extending inwardly from the outer of said two shells and a part extending outwardly from the inner of said two shells and cooperating with said first part to divide said space into separated chambers when the muffler is cold, and means responsive to increases in temperature in said muffler to move a part of said partition out of engagement with the other part to permit gases to pass through said partition to convert said chambers into a passage paralleling the passage through said inner shell.

7. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, and a valve in said space connected with both of said shells and which is moved into open position by greater expansion of said inner shell than said other shell, said valve when closed dividing said space into separate chambers.

8. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, and a valve in said space dividing said space into separate chambers, said valve including a movable member which is connected with said inner shell and moved thereby into valve opening position when said inner shell expands to a greater extent than the other shell.

9. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a flange extending outwardly from said inner shell, a flange extending inwardly from the other shell, said flanges when the muffler is cold being in engagement with each other and forming a partition extending transversely of said space and dividing the same into separate chambers, the flange of said inner shell being moved by said inner shell out of engagement with the other flange when said inner shell expands due to heat to a greater extent than said other shell.

10. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a flange extending outwardly from said inner shell, a flange extending inwardly from the other shell, said flanges when the muffler is cold being in engagement with each other and forming a partition extending transversely of said space and dividing the same into separate chambers, and thermo-responsive means connected with one of said flanges for moving the same into and out of engagement with the other flange when said muffler becomes heated.

11. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two parts, and means acting when said muffler becomes heated for separating said parts to permit gases to bypass a portion of said inner shell.

12. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two parts, one of said parts being mounted on said inner shell and movable by said inner shell away from said other part when said inner shell expands due to heat, to a greater extent than the other shell.

13. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two parts, and thermo-responsive means acting on one of said parts for moving the same away from said other part when said muffler becomes heated.

14. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two parts, and thermo-responsive means connected with each of said parts for moving said parts away from each other to form a passage through said partition when the muffler becomes heated.

15. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two parts, one of said parts being mounted on said inner shell and movable away from said other part when said inner shell becomes heated to a greater extent than the outer shell, and thermo-responsive means acting on said other part for moving the same in a direction opposite to said first part when said muffler becomes heated.

16. A muffler including an inner shell forming a passage for gases, a shell surrounding said inner shell and forming therewith a space into which

gases may enter from said inner shell, a thermo-responsive element arranged in said space, a partition extending transversely of the space between said shells and formed of two parts, one of said parts being connected with and moved by said thermo-responsive element, said element having a portion thereof provided with annular corrugations which expand in the direction of the axis of said muffler when heated to move said part of said partition connected with said element out of engagement with the other part of said partition.

17. A muffler including an inner shell having perforate portions, a second shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two engaging parts and forming the space between said shells into two chambers arranged one in advance of the other, both of said chembers being in communication with said inner shell through perforations in said inner shell, a restriction in said inner shell arranged between two perforate portions communicating with the first of said chambers to cause some of the gases in said inner shell to by-pass said restriction by flowing through said first chamber, and thermo-responsive means for separating said parts of said partition when the muffler becomes heated to permit gases to flow from said first chamber into the other chamber.

18. A muffler according to claim 17, characterized in that the perforate portion in advance of said restriction has greater gas conducting capacity than the perforate portion in rear of said restriction communicating with said first chamber.

19. A muffler including an inner shell having perforate portions, a second shell surrounding said inner shell and forming therewith a space into which gases may enter from said inner shell, a partition extending transversely of the space between said shells and formed of two engaging parts and forming the space between said shells into two chambers arranged one in advance of the other, both of said chambers being in communication with said inner shell through perforations in said inner shell, a restriction in said inner shell arranged between two perforate portions communicating with the first of said chambers to cause some of the gases in said inner shell to by-pass said restriction by flowing through said first chamber, one of said parts of said partition being secured to said inner shell and the other part of said partition being secured to said other shell, the portion of said inner shell to which a part of said partition is secured being slidably mounted relatively to said other shell, whereby said inner shell, when expanded by the heat of gases flowing through said muffler, moves the part of the partition carried thereby out of engagement with the other part of said partition to permit gases to flow through said partition from one chamber to the other.

20. Means for muffling the exhaust of an internal combustion engine, including means forming a main gas passage, means forming a branch passage terminating at its ends in said main passage, means responsive to changes in temperature of said muffling means to restrict the flow of gases through said branch passage when said muffling means are relatively cool and for opening said branch passage when said muffling means become heated.

21. Means for muffling the exhaust of an internal combustion engine, including means forming a main gas passage, and having a plurality of openings therein, means forming a plurality of sound reducing chambers connected with said openings in said passage, means for establishing communication between said chambers to permit gas to flow from one chamber to another, and heat responsive means operatively connected with said means for establishing communication, to permit gas to flow from one chamber to another when the temperature in said muffling means becomes high.

22. Means for muffling the exhaust of an internal combustion engine, including means forming a pair of gas passages terminating in a common passage, sound deadening means associated with said common passage and acting on the exhaust while passing through said common passage, valve means for controlling the flow of exhaust through one of said passages, and heat responsive means operatively connected with said valve means for restricting the flow of exhaust through one of said passages when the temperature of said muffling means is relatively low and for opening said passage when the temperature is relatively high.

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