Nov. 5, 1963 G. SLAYTER ETAL 3,109,511

MUFFLER LINER

Filed June 7, 1960 2 Sheets-Sheet 1

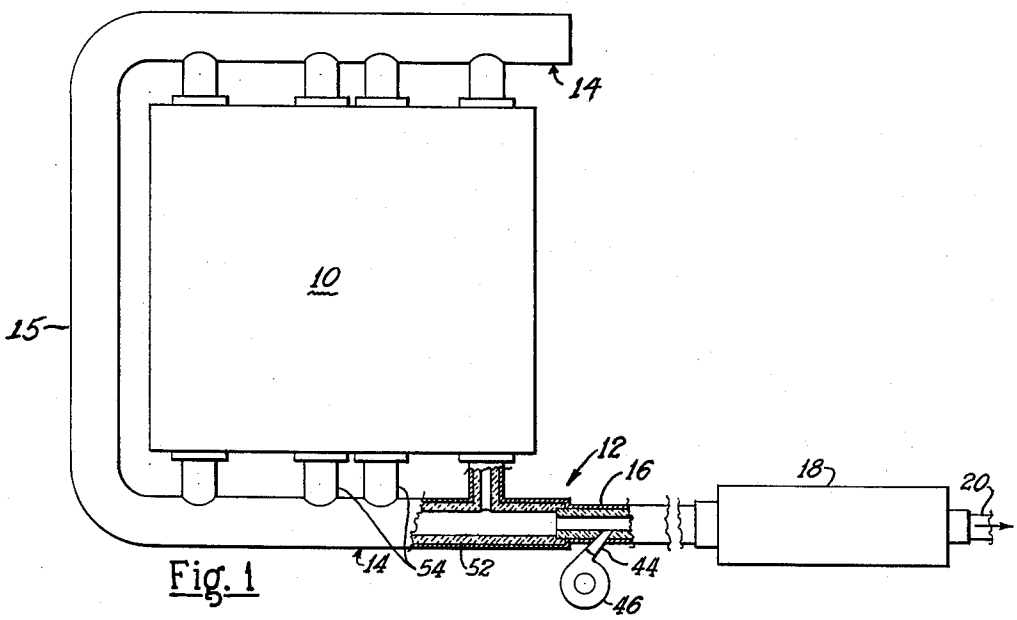


Fig. 1

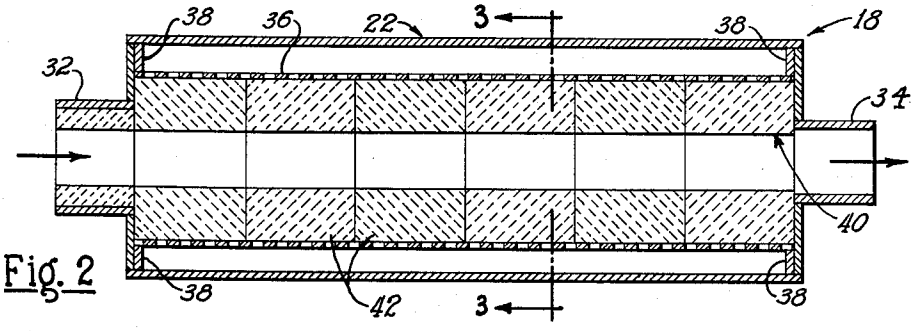


Fig. 2

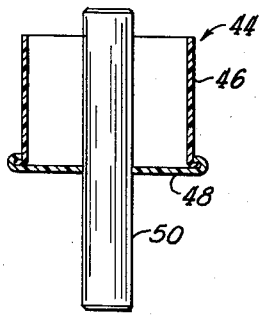


Fig. 5

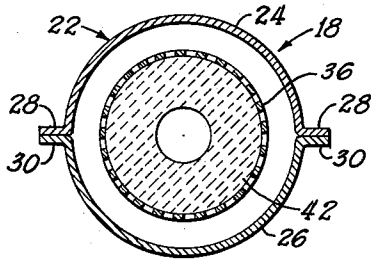


Fig. 3

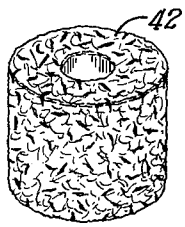


Fig. 4

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MUFFLER LINER

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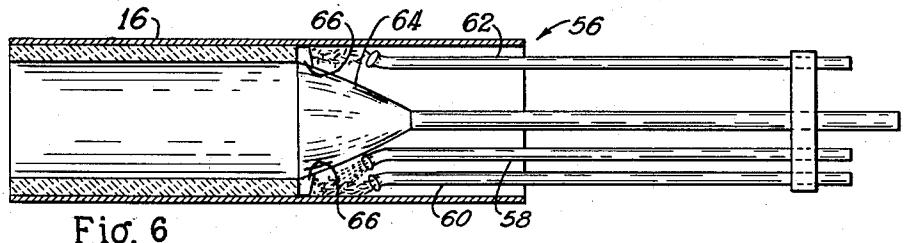


Fig. 6

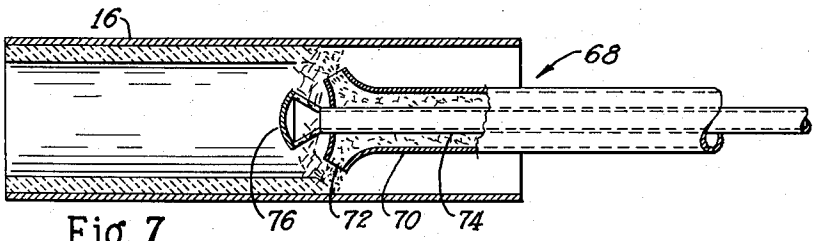


Fig. 7

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MUFFLER LINER

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2 Claims. (Cl. 181—61)

This invention relates to an improved muffling system and more particularly to a vehicle muffling system in which components are lined with highly refractory fibers.

Present mufflers include casings or walls of one or more wraps of steel which enclose a plurality of internal steel baffles to muffle the sound of the engine and exhaust gases. These mufflers are subjected to conditions which cause the casings to be attacked with the result that the mufflers are relatively short lived. For example, particularly in winter and on short trips, liquids of an acidic nature from the engine will deposit on and attack the interior surface of a muffler casing. On long trips the muffler casing also tends to become very hot, the gases within the casing often being over 1600° F. under normal operating conditions and may be substantially higher than this if a spark plug is not functioning with the result that a cylinder exhausts a mixture of air and raw fuel into the exhaust system where it burns partially. Oil expelled from the engine through the exhaust system, and deposited in the muffler, may also smolder and thereby further increase interior temperatures. Elevated muffler casing temperatures increase the rate at which the casing oxidizes or rusts.

There is also reason to believe that conventional mufflers may increase the amounts of certain deleterious contaminants in exhaust gases. Available evidence indicates that exhaust gases in contact with hot iron or steel undergo a reaction which increases the amounts of olefins in the gases. This reaction can occur in conventional muffling systems, wherever exhaust gases contact hot steel or oxidized cast iron components of an exhaust system.

In addition, the bare metal walls of conventional mufflers and muffling systems extract heat rapidly from the exhaust gases, thus causing the gases to cool rapidly. Such cooling prevents secondary combustion in the exhaust system that might otherwise consume at least part of the carbon monoxide and olefins in the exhaust gases. In present muffling systems, secondary combustion is very rare and may only occur at high operating speeds when raw fuel and air flow through the exhaust system.

The present invention relates to a muffling system having a lined component and to an insulating liner which overcomes the above-discussed disadvantages of existing muffling systems. The liner is preferably made of highly refractory fibers held together by a suitable binder, the liner being located near the inner surface of the component, between it and the exhaust gases. There is a much smaller tendency for condensation to occur with the new exhaust system because the exhaust gases are kept out of contact with the cold walls of the system, and because the liner remains hot longer after the engine is stopped. Any such liquid that does condense, as in winter when the engine is not operated for a long enough period to heat the liner sufficiently, will eventually evaporate in the exhaust gases and thereby be carried out of the exhaust system without doing any damage. The insulating liner also maintains the outer metal walls of the exhaust system components at much lower temperatures by comparison with conventional systems, the walls being approximately 300° F. or less when the exhaust gases are 1600° F. when a liner only one-half inch thick is used. The relatively cool walls thus tend to oxidize,

rust, and warp to a much smaller degree than formerly and no special steels are required for the muffler components as might otherwise be necessary. In addition, the new liner prevents contact between the exhaust gases and the steel or cast iron walls of the lined exhaust system component and thus prevents an increase in the amount of olefins which otherwise occurs. Reduction in heat loss from the manifold under the hood also reduces driver discomfort in the summer when the manifold is lined in accordance with the invention. Because the insulating liner prevents rapid extraction of heat from the exhaust gases to the muffler walls, the exhaust gases remain at much higher temperatures and can undergo secondary combustion in the system. The liner also provides an effective surface in contact with which combustion of the gases can proceed. To aid in secondary combustion, air can be added to the exhaust gases at a point upstream of the muffler to provide additional oxygen for combustion of the remaining fuel in the exhaust gases.

It is, therefore, a principal object of the invention to provide an improved muffling system including an interior, insulating liner.

Another object of the invention is to provide an exhaust system where fewer deleterious substances are present in the exhausted gases.

Still another object of the invention is to provide a muffler having a longer life than those presently known in the art.

Yet another object of the invention is to provide a muffling system in which the exhaust gases are maintained at higher temperatures so that additional, secondary combustion can occur therein.

Other objects and advantages of the invention will be apparent from the following detailed description of a preferred embodiment thereof, reference being made to the accompanying drawings, in which:

FIG. 1 is a somewhat schematic view, with parts broken away and parts in cross section, of an engine and a muffling system embodying the principles of the invention;

FIG. 2 is a greatly enlarged view in cross section of a muffler of the system shown in FIG. 1;

FIG. 3 is a view in transverse cross section taken along the line 3—3 of FIG. 2;

FIG. 4 is a view in perspective of a liner segment used in the muffling system and the muffler of FIGS. 1–3;

FIG. 5 is a view in vertical cross section of a mold for making the segment shown in FIG. 4;

FIG. 6 is a somewhat schematic view in cross section of modified apparatus for lining muffling systems; and

FIG. 7 is a view in cross section of further modified apparatus for lining muffling systems.

Referring to FIG. 1, an eight cylinder engine is indicated at **10**, the cylinders of which are connected to a muffling system indicated generally at **12**, although the two banks of cylinders can alternately be connected to separate muffling systems. The system **12** includes lined manifolds **14**, a lined connecting pipe **15**, a lined exhaust pipe **16**, a lined muffler **18**, and a tailpipe **20** which can be lined or not.

The muffler **18** (FIGS. 2 and 3) includes a casing **22** comprising two half sections **24** and **26** which can be bolted together at flanges **28** and **30** (FIG. 3) extending longitudinally thereof. Suitable connecting pipes **32** and **34** (FIG. 2) are affixed to end walls of the casing **22** for connection with the exhaust pipe **16** and the tailpipe **20**, in a manner well known in the art. Within the casing **22** is a perforate metal tube **36**, which is spaced from the casing **22** by suitable spacers **38**, reinforced cement rings being suitable for this purpose. Within the perforate tube **36** is a cylindrical liner **40** made of a plurality of

circular or ring segments **42** which are placed in coaxial, end-to-end relationship and preferably cemented together by a ceramic band. The outer diameter of the segments **42** is large enough to enable them to be held tightly within the tube **36** and the inner diameter of the segments **42** is sufficient to form a passage for exhaust gases from the engine **10**. The walls of the segments **42** are at least ¼" thick to provide reasonable strength and have been made in thicknesses up to approximately 1½" of either porous or non-porous ceramic of the type described below.

The segments **42** are integral, porous bodies containing highly refractory, titania fibers, and are self-sustaining within the tube **36**, requiring no internal wall or support within the bodies. The liner **40** prevents attack of the muffler casing by keeping any corrosive liquids in the exhaust gases out of contact therewith. The titania ceramic is also resistant to acids, to high temperature steam, and to the various corrosive contaminants within the exhaust gases. The liner **40** also acts as an extremely good insulator with the result that the temperature of the casing **22** seldom exceeds 300° F., even when the exhaust gases are at 1600° F. or higher. In addition, the exhaust gases are kept out of contact with the casing **22** to prevent an increase in the amount of olefins which might otherwise result. Finally, the exhaust gases are kept at a higher temperature within the exhaust system due to the insulating effect of the liner **40** that additional combustion of these gases can take place in order to reduce the amount of deleterious contaminants therein. For this purpose, additional air can be added to the exhaust system through an air pipe **44** (FIG. 1), which is connected to the exhaust pipe **16**. The air can be supplied by a small blower **46** or, during movement of the vehicle, by an air scoop.

The segments **42**, a single one of which is shown in perspective in FIG. 4, have been made from a mixture of 87 grams crystalline titania fibers from ¼" to ½" long, 20 grams of wood sawdust, 25 grams of montmorillonite and 13 grams of powdered soda-lime glass. This mixture was combined with sufficient water to make a mortar or paste of fibrous pellets which were then pressed into a mold the size and shape of the segment **42** and fired at 2500° F. to cause the soda-lime glass and montmorillonite to form a binder for the titania fibers and to cause the sawdust to burn out and leave a porous body. The resulting body consisted essentially of 70% titania, 20% montmorillonite, and 10% soda-lime glass. By volume, the body contained approximately 70% air, 20% titania fibers, and 10% binder (montmorillonite and soda-lime glass), with an apparent density of approximately 70 pounds per cubic foot. Segments 1" thick show only slight resistance when air is blown through them.

While the segments **42** have been made in a metal mold having an annular, tapered cavity, it has been found that the material is difficult to remove therefrom preparatory to firing. For this reason, the segments **42** are preferably made in a mold **44** shown in FIG. 5. The mold **44** includes an outer cylindrical wall **46** and an end wall **48** of paper, cardboard, or other organic material which will burn away at a temperature below the firing temperature of the segment material. A metal rod **50** which is concentric of the mold **44** extends through the end wall **48** to form an annular cavity with the end wall **48** and the cylindrical wall **46**, the cavity having a shape and size similar to those of the segment **42**. After the liner material is placed in the cavity and tamped therein, the metal rod **50** is removed to leave the green liner and the walls **46** and **48** which are fired as a unit, the walls **46** and **48** burning away, with only the fired, hardened segment **42** then remaining. With this arrangement, the liner material need not be removed from the mold prior to firing.

The porous liner **40** not only provides the advantages outlined above, but also constitutes an effective acoustic material to absorb sound and muffle the noise of the exhaust gases and engine. The perforate tube **36** further enhances the acoustical absorption properties of the muffler **18**, particularly for sound of lower frequency. However, the liner **40** can be made with a larger diameter and placed immediately adjacent the casing **22**, with the porous tube **36** eliminated, to provide substantially as good sound absorption. It is desirable that the muffler have a volume about ten times the volumetric displacement of the engine cylinders from an acoustical standpoint.

In accordance with the principles of the invention, it also has been discovered that the liner material can be employed in the manifold **14** and the exhaust pipe **16** to maintain the temperature of the exhaust gases several hundred degrees higher than otherwise and also to keep the exhaust gases separate from the steel or iron of which the manifold **14** and the exhaust pipe **16** are made to prevent reaction on the surface thereof. The manifold **14** and the exhaust pipe **16** are also maintained at cooler temperatures by being insulated from the exhaust gases, and temperatures under the hood are decreased. Because the temperatures of the lined exhaust system components are much lower than in conventional exhaust systems, the manifold **14** can be made of welded or fabricated sheet steel, the manifold **14** in this case comprising a cylindrical metal tube **52** and shorter connecting tubes **54** of welded sheet steel. Previously, it was necessary in most instances to cast the manifold **14** which, because of its high temperature, had considerable tendency to warp, making the use of fabricated steel impractical.

The manifold **14** and the exhaust pipe **16** have been lined with segments similar to the segments **42**, but of smaller diameter. However, where the manifold **14** or the exhaust pipe **16** is of relatively complicated shape, the liner can be applied to these components in the form of a thick coating on the interior walls thereof. Because sound absorption is not a consideration in the manifold **14** and the exhaust pipe **16**, the liner in this case need not be porous, and the sawdust or other material forming voids in the final product need not be employed or can be employed to a lesser degree. The refractory fibers in the liner material preferably are shorter than those used in the liner **40** to enable the liner material to be more easily applied to the interior of the components. After the liner material is applied, it can be fired in the muffling system components by passing highly heated gases therethrough to provide the proper firing temperatures therein without excessively heating the outer walls of the components.

A thick layer of the coating material can be applied to the inner surfaces of the manifold **14** and the exhaust pipe **16** with the apparatus shown in FIG. 6. In this instance, the binder materials and the titania fibers can be supplied separately, and titania powder can be added to increase the strength of the liner. The apparatus, indicated generally at **56**, moves from left to right in FIG. 6 through the exhaust pipe **16**, for example, which preferably is concommitantly rotated. Titania powder can first be supplied to the interior of the pipe **16** through a supply line **58** and the binder material then supplied through a second supply line **60**, with the titania fibers then being supplied to the surface of the binder material through a third supply tube **62**. The binder and titania also can be supplied through a single supply line as a premixed aqueous paste by means of air pressure. The liner material which is now deposited on the interior of the tube **16** is subsequently spread evenly by means of a spreader **64** which is in the form of a flexible cone or a plurality of flexible arms. In either case the spreader **64** is spaced from the inner surface of the pipe **16** by means of spacers **66** which determine the thickness of the liner.

A modified liner applicator **68** is shown in FIG. 7 and includes an outer passage **70** through which the binder or coating material is sprayed through an annular nozzle **72** which also can be a plurality of individual nozzles. The titania fibers are subsequently sprayed onto the wet

coating material by means of an inner passage **74** through which the titania fibers are blown, being deflected to the wall of the pipe **16** by a deflector **76**. Again the titania fibers and the binder material can be supplied through a single spray passage.

Other binders and other highly refractory fibers, such as zircon and zirconia fibers, have been found to be suitable for use in a lined muffling system according to the invention. The fibers employed must be of a highly refractory nature, capable of withstanding temperatures of 1800° F. and preferably 2600° F. because the internal temperature of the exhaust system may be as high as 2600° F., or possibly higher, if a spark plug is inoperative and a mixture of air and raw gas is expelled into the exhaust system. However, the titania fibers, whether oxidized or oxygen deficient, have properties which render them particularly suitable for a muffling system, these fibers apparently having a catalytic effect on the exhaust gases. Titania, zirconia, and zircon fibers over an inch in length and in single crystalline form have been produced in quantities according to a process set forth in a copending application of Russell, Morgan, and Scheffler filed on or about May 26, 1960.

We claim:

1. A lined muffling system component comprising a casing forming an elongate chamber having an inlet opening and an outlet opening, and an integral, self-sustaining liner within said chamber forming a passage for exhaust gases between said inlet opening and said outlet opening, said liner being interposed between said passage and said casing with the inner surface of said liner being substantially unobstructed for contact with exhaust gases flowing through said component, said liner comprising highly refractory, inorganic, crystalline fibers selected from the group consisting of titania, zirconia, and zircon, and an inorganic binder.

2. A lined muffling system component comprising a casing forming an elongate chamber having an inlet opening and an outlet opening, and an integral, self-sustaining, porous liner within said chamber forming a passage for exhaust gases between said inlet opening and said outlet opening, said porous liner being interposed between said passage and said casing with the inner surface of said liner being substantially unobstructed for contact with exhaust gases flowing through said component, said porous liner comprising highly refractory, inorganic, titania fibers, and an inorganic binder holding said fibers together and forming a multiplicity of voids in said liner.

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