June 18, 1963 W. B. INNES ETAL 3,094,394

CATALYTIC MUFFLER

Filed July 22, 1960

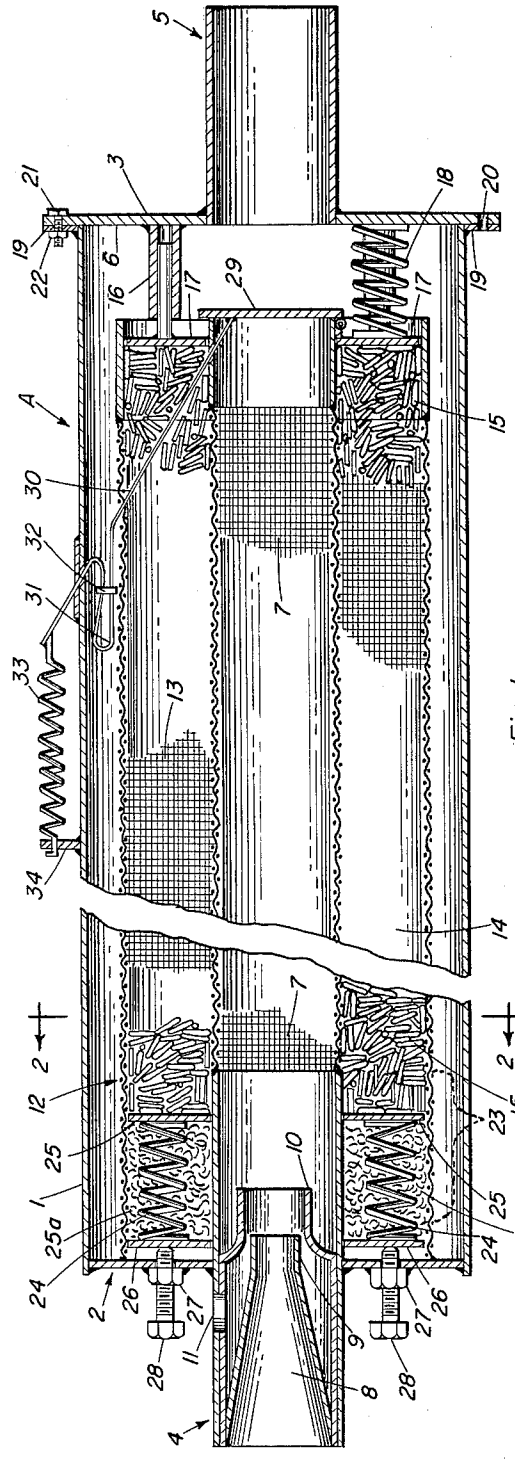

Fig. 1

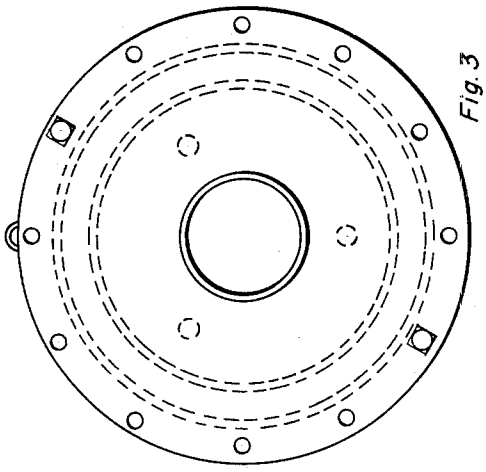

Fig. 3

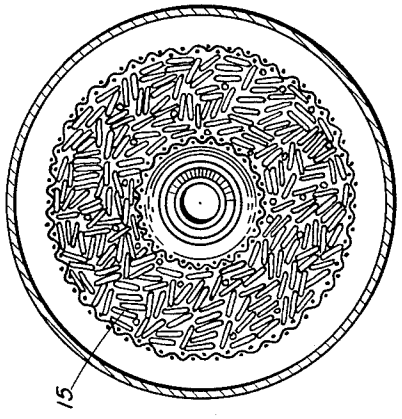

Fig. 2

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CATALYTIC MUFFLER

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This invention relates to catalytic apparatus of the type employable with an internal combustion engine for oxidizing the toxic and obnoxious components of hydrocarbon combustion exhaust gases.

More particularly, the present invention relates to a catalytic converter and more preferably, a catalytic converter which is capable of being readily inserted into the exhaust system of an internal combustion engine as, for example, in lieu of a muffler therein. Suitable converters may be inserted before or after the exhaust manifold or other convenient locations.

The exhaust gases from the combustion of hydrocarbon fuels such as gasoline, diesel fuel and the like in internal combustion engines, contain mixtures of carbon monoxide and various hydrocarbons, both saturated and unsaturated, nitrogen and other constituents. These mixtures are both poisonous and obnoxious.

In addition to the known hazards resulting from the inhalation of combustion exhaust gases of hydrocarbon fuels, such gases have, of comparatively recent times, been identified with smog formation and, to a lesser extent, with various forms of cancer.

Thus, it is known that exhaust gases from automobiles, particularly olefin and nitrogen oxide components, have been demonstrated to be a primary cause of "photochemical smog" in heavily populated metropolitan centers of this country, such as Los Angeles, California. Smog, as the term is generally employed, is broadly understood to refer to a variety of phenomena which are related to the interaction of nitrogen oxides, hydrocarbons and sunlight. These include a fog-like haze, high oxidant concentration in the atmosphere (mostly ozone), eye irritation, plant damage and the like. In general, smog is defined more fully in an article by W. L. Faith, entitled "Nature of Smog," in Chemical Engineering Progress, 53, 406 (1957).

The hazards and nuisance created by hydrocarbon combustion exhaust gases from internal combustion engines have, over the years, resulted in a number of processes, catalysts and apparatus whereby the reduction or the elimination of the harmful components of these gases has been the primary object.

A relatively common device employed for this purpose has been what is sometimes referred to as a "catalytic muffler" which normally refers to a device which is to be substituted into the exhaust line of an internal combustion engine in lieu of a muffler. This has been a particularly preferred area of activity in view of the fact that the cost of such a device is reduced by the cost of a conventional muffler normally employed, and by other obvious advantages. Such devices are inserted into the exhaust line of an internal combustion engine and by the action of catalysts contained therein, oxidize the exhaust gases so that the exit gases from the muffler contain reduced amounts of the harmful and obnoxious constituents of the exhaust gases.

To our knowledge, none of these devices have in the past proved successful, probably because of a number of practical considerations. Among these might be included the development of significant back pressures, the size, weight and cost of such devices, the comparative short activity life of catalysts employed and the difficulty of recharging the device with fresh catalysts, the inability of

many of these devices to withstand the elevated temperatures obtained in the catalytic oxidation of exhaust gases, the difficulty in achieving uniform conditions in such devices under operating conditions and the difficulty in maintaining the catalyst bed under a constant pressure so as to prevent the formation of voids therein whereby the catalyst is rapidly and prematurely attrited and whereby catalyst is prematurely deactivated through the development of hot spots in the catalyst bed.

The present invention has for its principal object the providing of a catalytic converter and, more preferably, a catalytic muffler whereby uniform conditions are maintained both in the operation of the internal combustion engine and in the muffler itself by virtue of its novel design.

It is a particular object of the present invention to provide such a catalytic muffler which is of simple construction, is easily adaptable to be positioned in the exhaust line of an internal combustion engine and may be readily recharged after deactivation of the catalyst contained therein.

It is a further and particular object of the present invention to provide a catalytic muffler so constructed that losses in catalysts due to attrition are readily and automatically compensated for and whereby the presence of voids otherwise formed in a catalyst bed are automatically eliminated, thus avoiding excessive attrition and deactivation.

It is a further and particular object of this invention to provide a catalytic muffler which, in the event that excessively high temperatures are achieved during its normal operation, automatic means for permitting the ready exit of the unoxidized exhaust gases is provided.

Further objects include providing a catalytic muffler which substantially eliminates pressure drop or results in a low pressure drop due to minimum back pressure, and to provide a muffler device which effects good noise elimination.

These and other objects, advantages and features of the present invention will become more apparent from the detailed description thereof set forth, which description is particularly in reference to the accompanying drawing of which:

FIGURE 1 is a longitudinal cross-sectional view of the catalytic converter contemplated by this invention;

FIGURE 2 is a sectional view along the line 2—2 of FIGURE 1; and

FIGURE 3 is an end view of the converter of FIGURE 1.

In accordance with the present invention, a catalytic converter is provided comprising a cylindrical housing having an inlet end and an outlet end, and having centrally positioned therein a longitudinally extending cylindrical tube, which is perforated intermediate its ends. A longitudinally extending perforated cylindrical sleeve having a cross-section greater than that of the aforesaid cylindrical tube but less than that of said housing is positioned intermediate the inlet and outlet ends of the cylindrical housing and the area between the said cylindrical sleeve and tube define the bed for hydrocarbon combustion exhaust catalyst. The area between the outside surface of said sleeve and said inside surface of said housing define a space for catalytically oxidized exhaust gases to be carried to the outlet end of the housing. The catalytic muffler of this invention is of a symmetrical design whereby uniform operating conditions are maintained for both the internal combustion exhaust engine and in the catalytic muffler itself.

While catalytic mufflers of this invention are described as being cylindrical and as being of symmetrical design, it should be noted that the term cylindrical as employed herein also contemplates catalytic converters having elip-

tical configurations. In all of the converters of this invention the construction may further be described as being radial in that the catalyst bed extends outwardly from the center of the device where the exhaust gases enter. It is essentially this radial arrangement from which uniform operation conditions, faster warm up times, and maximum flexibility of construction are accomplished that comprise the essential elements of this invention.

At the inlet end of the catalytic muffler, means are provided for the addition of air to the combustion exhaust gases entering the catalytic muffler. This may be accomplished by the construction of a venturi at the inlet end thereby avoiding the need for pumps and other complicated and expensive devices readily subject to mechanical failure.

Further, at the inlet end of the device, inside the cylindrical housing and surrounding the centrally disposed cylindrical tube through which the exhaust gases enter the catalytic chamber, a catalyst reservoir is provided which may contain, for example, between 2 and 10 percent or more of the total volume of catalysts in the activity zone. Means are provided for maintaining a uniform and steady pressure on this catalyst reservoir as, for example, a spring which means preferably have an external or exposed element whereby pressure on the reservoir may be periodically increased as the catalyst attrits. This aspect of the present invention is particularly desirable in that it permits, a user, by comparatively simple adjustment, to maintain the catalyst bed in this catalytic muffler of uniform density and thereby prevents excessive attrition and premature deactivation of the catalyst.

At the exit end of the catalytic muffler, means are provided for closing the catalyst bed as for example, a suitable plate-like member disposed about the central tube. In order to recharge the muffler, this plate-like member must be removed and so it may be connected to the outside end plate that this may be accomplished readily. Alternatively, such a plate-like member may be placed under pressure as for example by means of springs.

A further important aspect of this invention involves the employment of relief means whereby when the catalyst bed reaches a predetermined and undesirable intense heat, which if allowed to continue would result in the ready deactivation and possible destruction of the catalyst contained therein as well as the container; a cap or other closing means positioned at the exit end of the centrally positioned cylindrical tube is released, permitting the combustion exhaust gases to flow directly through the device without benefit of contact and oxidation by the catalyst bed. Such a means could involve a heat sensitive cap subject to melting at a predetermined temperature or, and preferably, a capping means maintained in the closed position by a heat fusible element which when a predetermined heat is reached becomes molten enabling the capping means to be opened merely by the force of unoxidized exhaust gases contacting the same.

Referring to the drawing, in which a specific illustrative embodiment of this invention will be described, it will be seen that a catalytic muffler A of a cylindrical configuration and a symmetrical design is shown comprising a cylindrical housing **1**, preferably of a high grade heat resistant steel, though in general steels or metals, and preferably light weight metals able to resist temperatures of up to 750° C. may be employed. Said cylindrical housing **1** has an inlet end plate **2** and an outlet end plate **3** and having extending at right angles from end plates **2** and **3** centrally positioned inlet and outlet tubes **4** and **5** respectively. Tubes **4** and **5**, in general, provide a convenient means for adapting the catalytic muffler of this invention into an exhaust system of an internal combustion engine and for purposes of this description are of substantially the same diameter. With respect to tube **4**, it will be noted that this tube extends into the housing **1** in a centrally disposed longitudinal plane terminating a short distance from the inside surface **6** of exit end **3**

and in the same plane as exit tube **5**. This portion of tube **4** is comprised of a major perforated segment **7** which segment may be said to comprise a major and central portion of the internal segment of tube **4**.

The entrance end of tube **4** is designed in the form of a venturi whereby the combustion exhaust gases are readily mixed with air or other oxidizing gas to insure their complete oxidation. The venturi is composed of a centrally disposed tapered cone **8**, the narrowed inner end **9** of which is positioned between but spaced from the inside walls of a collar-like member **10**, the end of which extends inward from narrowed end **9** but is spaced from the perforation **7** in the central portion of tube **4**. An opening **11** in the upper surface of the external portion of tube **4** is the entrance for air which is drawn in by the raw combustion exhaust gases entering the external end of tube **4** from the exhaust line of the internal combustion engine.

Positioned about the longitudinally extending cylindrical tube **4** is a longitudinally extending perforated heat resistant metal sleeve **12** having a cross-section greater than that of said cylindrical tube **4** but less than that of the inside diameter of housing **1**. In general, the diameter of sleeve **12** will be from about 1.5 to about 3 times the diameter of tube **4**. In this illustrative embodiment it is about 2.5 times. The cylindrical sleeve **12** has perforations **13** and is of a length substantially equal to the length of the internally disposed portion tube **4**. Sleeve **12** may be welded to the inside surface of inlet entrance plate **2** or otherwise supported therein by suitably positioned lugs or the like. Positioned between the outer surface of longitudinally extending tube **4** and longitudinally extending sleeve **12** is the catalyst bed **14** containing a suitable oxidizing catalyst **15**. Such catalysts may be any of a number suitable for use for this purpose as, for example, an iron oxide-chromium oxide catalyst prepared from 85 to 97 percent of Fe_2O_3 and 0.5 to about 15 percent of Cr_2O_3 which is described in copending application Serial No. 786,973, filed January 15, 1959. Alternatively, such catalysts may be of the type described in U.S. Patent 2,912,300.

Exit pipe is preferably joined to end plate **3** as by a weld or other suitable means. Extending perpendicular from the inside surface **6** of plate **3** are arms **16** which in turn are connected to a circular plate **17** having a centrally disposed opening therein for receiving the exit end of longitudinally positioned tube **4**. When assembled, as will be seen in FIGURE 1, plate **17**, positioned on arms **16**, functions as a retaining member for the catalyst **15** in catalyst bed **14**. Alternatively, springs **18** (only one of which is shown only on a lower arm **16**) may be positioned over the arms **16**, as a means of maintaining a force at the exit end of the muffler to maintain the density of the catalyst bed. In such an arrangement it will be apparent that plate **17** is free for longitudinal movement.

The exit end plate **3** is mechanically joined to the cylindrical housing **1** in that the exit end of said housing contains an annular flange **19**, said annular flange **19** and exit plate **3** having correspondingly positioned holes **20** in their peripheral edges for receiving a suitable number of bolts **21** which are secured in position by nuts **22**. It will be seen that such an arrangement provides an easy method for removing deactivated catalyst from catalyst bed **14** and permits the ready and rapid refilling of said catalyst bed.

At the inlet end of the illustrative exhaust muffler, the catalyst bed is provided with a reservoir area **23** which may, depending upon the particular device, contain from between about 2 and about 10 percent or more of the total catalyst charged to a given catalyst bed. In effect, this reservoir area **23**, which area can be varied by the amount of compression placed on springs **24** normally does not include catalyst particles extending over the perforated portion of tube **4**. Reservoir area **23** has posi-

tioned at its outside end a ring-like plate 25 which has a centrally disposed opening for receiving tube 4. Plate 25 is movably positioned between the outside surface of tube 4 and the inside surface of sleeve 12. Positioned between outside surface of plate 25 and the inside surface of the entrance end plate 2 is a second cylindrical plate 26 having a centrally disposed opening which also is free for longitudinal movement and positioned between said plate 26 and said plate 25 are a plurality of coil springs 24. Preferably, springs 24 are made of a highly heat resistant steel alloy and is preferably positioned in a refractory wool or other stabilized heat resisting media 25a.

Extending through thread retaining nuts 27 positioned in contact with inlet end plate 2 are a plurality of screws 28. The inside end of screws 28 are in contact with the outside surface of plate 26 and as will be apparent by turning the screw in the appropriate direction, the pressure of springs 24 can be brought to bear on plate 25 and consequently the catalyst reservoir in the reservoir area. Such an arrangement enables the user to maintain a uniform density in the catalyst bed simply by tightening screw 28. In this connection it will be noted that a fully packed uniform density is important if excessive losses due to attrition is to be avoided. In addition, the action of the springs alone will compensate for some loss in bed density due to attrition.

The outlet or exit end of centrally disposed tube 4 has thereon a cap 29 which is connected to a wire 30 extending through the upper surface of tube 4 through the catalyst bed 14 and is looped 31 between the internal surface of cylindrical housing 1 and the outer surface of sleeve 12. Positioned about the loop 31 is a heat sensitive metallic ring 32. Wire 30 then extends through the upper surface of cylindrical housing 1 where it is coiled 33 and the end thereof affixed to a mounting stud 34. This simple device insures that the catalyst bed will not be prematurely deactivated and the device overheated as, for example, as a result of the misfiring of a cylinder in an internal combustion engine, in that as the temperature of the oxidized combustion exhaust gases exceed a predetermined temperature as, for example, 800° C., loop 31 flows permitting the coiled 33 and loop 31 portion of the wire to be stretched under the force of the combustion exhaust gases against the inside surface of cap 29. This permits the direct exit of the raw exhaust gases through outlet pipe 5, whereby little or no oxidation is effected.

As will be apparent in the operation of the instant device, the hydrocarbon combustion exaust gases enter inlet pipe 4 and the force of their movement results in air entering the venturi arrangement at the entrance end through opening 11. This mixture then enters the central perforated portion of tube 4 from where it is distributed readily to the catalyst bed 12 through perforations 7 where it is oxidized and enters into the conduit or channel-like area between the inside surface of housing 1 and the outside surface of sleeve 12 through perforations 13. The natural direction of flow is then to the outlet end of the device and the ultimate emission of the oxidizing gases through outlet pipe 5 directly into the atmosphere or into suitable conduit for emission into the atmosphere

The employment of a device of the type illustrated in FIGURES 1–3 whereby the inlet gas enters at the center of the cylindrical muffler device in addition to being capable of simple adaptation to the above described and illustrative combinations (means for maintaining catalyst bed density etc.) its construction lessens warm-up time significantly in that the maximum amount of exhaust gas

contacts the maximum amount of catalyst in the briefest time period. Thus mufflers of the type of this invention are in general characterized by more rapid warm-up than units with a centrally positioned catalyst bed, such as is described in U.S. Patent 2,909,415.

It will be evident from the present description that the catalytic muffler device of this invention results in low catalytic attrition and fast warm-up in addition to being of easy and simple assembly and manufacture. It will be apparent that other numerous modifications and advantages of this invention will be obvious and, therefore, no limitations should be set thereon except insofar as they are set forth in the appended claims.

We claim:

1. A catalytic muffler for oxidizing hydrocarbon combustion exhaust gases comprising a cylindrical housing having an inlet end and an outlet end, a longitudinally extending cylindrical tube centrally positioned within said housing between said inlet end and said outlet end and extending from said inlet end, that portion of said tube within said housing being perforated, a capping element for said tube adjacent said outlet end, a longitudinally extending perforated cylindrical sleeve within said housing and surrounding said tube, said sleeve having a cross-section greater than that of said tube but less than that of said housing, catalyst particles for oxidizing said hydrocarbon combustion exhaust gases disposed within the zone defined by said tube and said sleeve, a plate like retaining member transversely situated between said tube and said sleeve adjacent to said outlet end of said housing, the area between the outer surface of said sleeve and the inner surface of said housing defining a zone for catalytically oxidized exhaust gases to be carried to the outlet end of said housing, a moveable disk positioned within said housing and adjacent to the inlet end of said housing said disk being slideably fitted for longitudinal movement over said tube, the inner surface of said disk disposed to be in contact with catalyst particles in said catalyst zone and yieldable means contacting said slideably mounted disk whereby a force is created by said means against said catalyst particles so as to maintain said zone free of voids.

2. A catalytic muffler according to claim 1 in which a venturi is positioned within said tube and adjacent said inlet end, that portion of said tube extending from said inlet end of said housing having an orifice for admitting air under the influence of the moving hydrocarbon combustion exhaust gases to be oxidized.

3. A catalytic muffler according to claim 1 having means for retaining said capping element in a normally closed position and a heat sensitive element secured to said retaining means whereby when said heat sensitive element reaches a predetermined temperature, said retaining means is released thus permitting said capping element to open from a normally closed position thereby allowing hydrocarbon combustion exhaust gases to pass from said outlet end of said housing without significant oxidation.

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