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2,853,367

CARTRIDGE TYPE CATALYTIC EXHAUST CLEANER

Filed Feb. 10, 1954

2 Sheets-Sheet 1

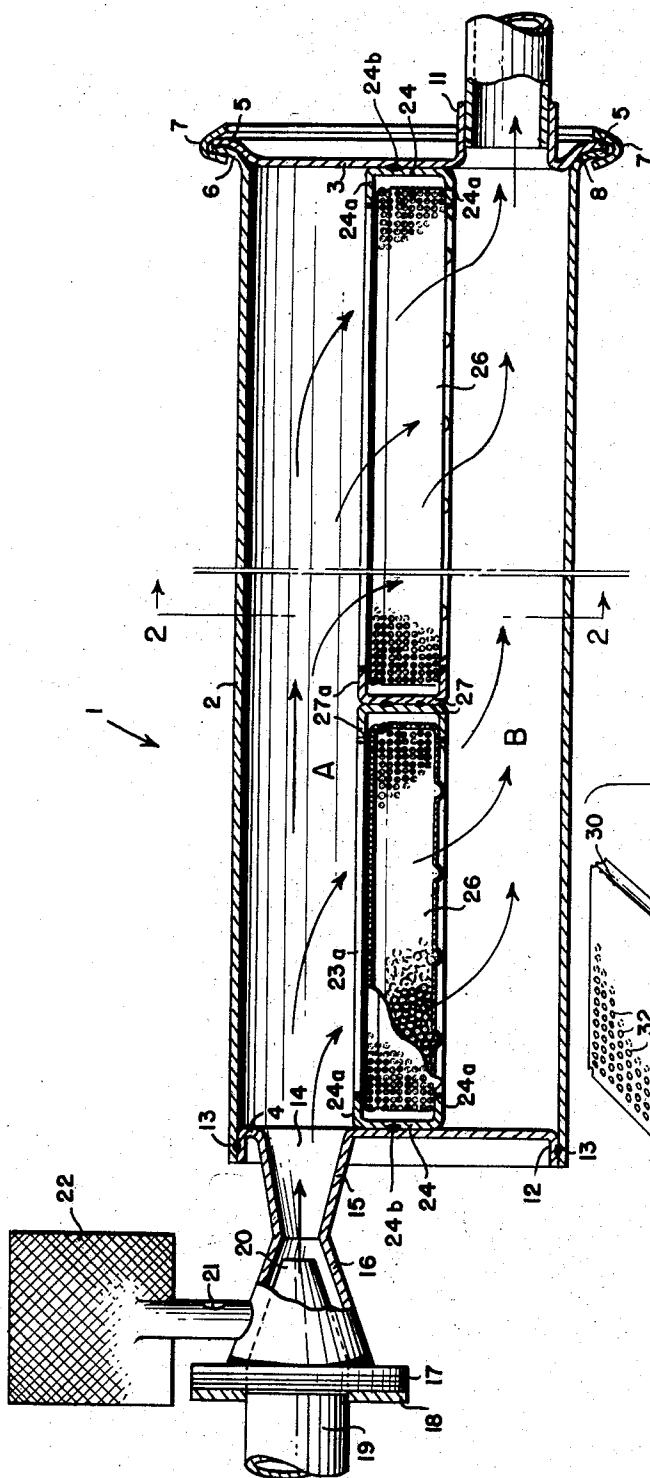


FIG. 1.

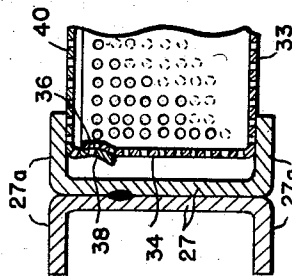


FIG. 6.

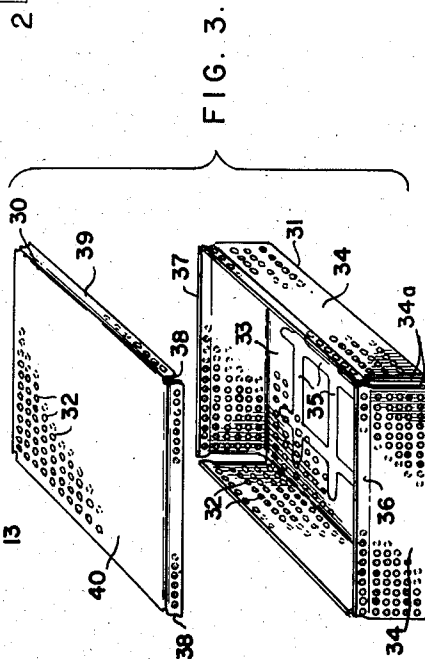


FIG. 3.

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2 Sheets-Sheet 2

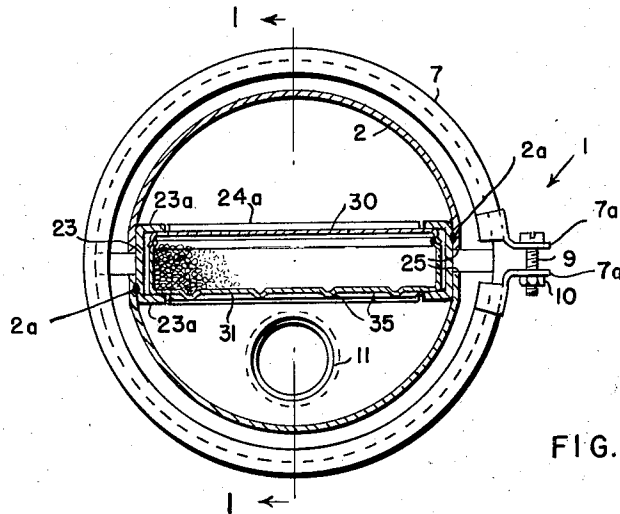


FIG. 2.

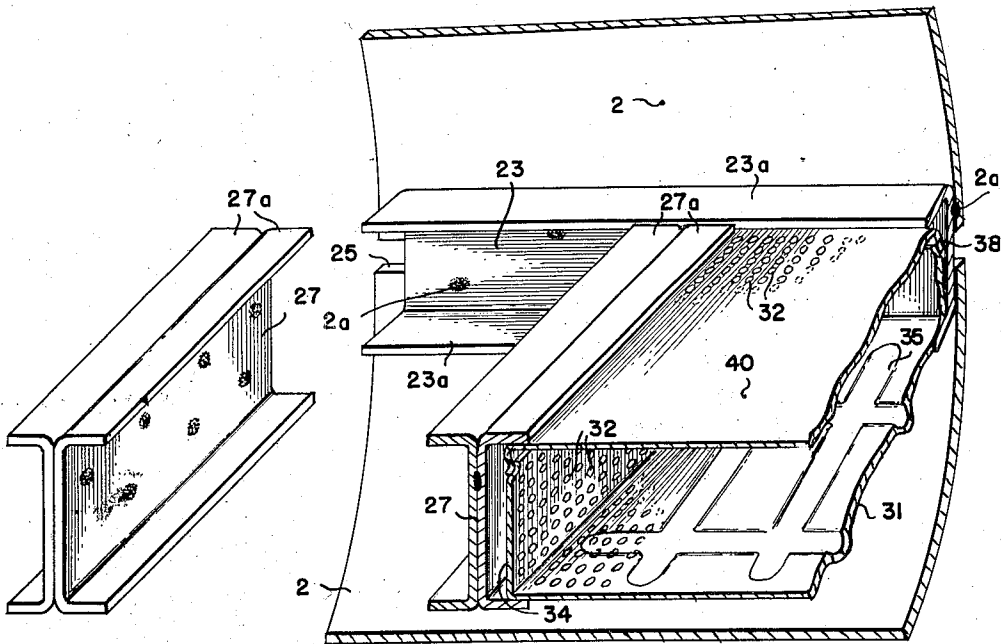


FIG. 4

FIG. 5.

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CARTRIDGE TYPE CATALYTIC EXHAUST CLEANER

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Application February 10, 1954, Serial No. 409,324

3 Claims. (Cl. 23—288)

Our invention relates to catalytic apparatus of the type suitable for attachment to the exhaust outlet of an internal combustion engine for oxidizing toxic and obnoxious components of the exhaust gases therefrom.

In devices of this type it has been found that obnoxious components of exhaust gases, such as hydrocarbons and carbon monoxide, can be oxidized by means of a catalytic muffler which contains a thin bed, or a plurality of thin beds, of catalyst particles through which the exhaust gases are forced to pass as they flow through the muffler. The copending application of Eugene J. Houdry Serial No. 318,382 filed November 3, 1952, for Catalytic Apparatus discloses the type of muffler to which the present invention relates. Our own copending application Serial Number 406,442 filed January 27, 1954, for Catalytic Device shows another muffler containing a thin bed of catalytic particles.

The above-identified applications disclose catalytic mufflers in which a thin bed of catalytic particles is contained between two opposed foraminous trays mounted within the muffler in face-to-face relationship. The space between these trays is filled with catalyst particles by charging loose material either through the open end of the muffler or through openings in the side of the muffler.

It is one of the objects of the present invention to provide a catalytic muffler in which the catalyst bed is contained within cartridge means which need only be inserted into the muffler when it becomes necessary to renew the catalyst particles.

It is a further object of our invention to mount a battery of cartridges within the muffler in such manner as to avoid by-pass of exhaust gases around the catalytic bed.

It is a further object of our invention to provide a catalytic muffler which is constructed in such manner that the various components will be capable of expanding and contracting relative to each other as the temperature of the apparatus fluctuates.

Further objects of our invention will be apparent from the following description of a preferred embodiment and from the accompanying drawings in which:

Fig. 1 is a cross-sectional longitudinal view of the preferred embodiment of our invention taken along the lines 1—1 of Fig. 2.

Fig. 2 shows a cross-section taken at right angles to Fig. 1 along the lines 2—2 of Fig. 1.

Fig. 3 is an exploded view of the cartridge casing of our invention.

Fig. 4 is a perspective view of a spacer member of a type used in the preferred embodiment of our invention.

Fig. 5 is a perspective fragmentary view showing the relationship of the cartridge casing, the spacer and the muffler shell of our invention to each other.

Fig. 6 is a fragmentary cross-sectional view showing the relationship between the cartridge casing and the spacer.

Referring to Figs. 1 and 2, the preferred embodiment of our invention consists of a housing generally indicated by the reference numeral 1 in which cartridge means 26

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containing catalytic material is mounted. The housing comprises a generally elongated cylindrical bipartite shell 2, the open ends of which are closed by end plates 3 and 4. A bipartite shell is provided only because of the convenience of manufacturing a shell in this form; it is, of course, within the scope of our invention to provide a unitary shell if economically feasible. End plate 3, shown on the right in Fig. 1 is provided with an offset peripheral flange 5 which abuts a complementary flange 6 on the end of shell 2. A split U-shaped clamping member 7 straddles the abutting flanges 5, 6 to removably secure end plate 3 to shell member 2 in substantially airtight relationship which may be facilitated by the interposition of gasketing 8. The ends of the split clamping member 7 are adjustably connected by a means such as a machine screw 9 and nut 10 which cooperate with perforate ears 7a on the ends of clamping member 7. An outlet 11 is provided on the lower portion of end plate 3, as viewed in Fig. 1, for the purpose of permitting the passage of oxidized exhaust gases to the atmosphere. End plate 4, shown on the left of Fig. 1, is provided with a reversed flange 12 which engages the internal surface of shell member 2 and is permanently secured thereto as by welding or riveting, spot welds 13 being disclosed in our preferred structure.

End plate 4 is provided with an inlet 14 which admits a mixture of raw (unoxidized) internal combustion engine exhaust gases and fresh air into the apparatus. The inlet comprises a diverging portion 15 and a converging portion 16 and terminates in a flange 17 which is bolted or otherwise secured to a mating flange 18 provided on the exhaust pipe 19. The exhaust pipe 19 extends through the mating flanges 17, 18 and terminates in a nozzle 20. An air inlet 21 and filter 22 conducts fresh air from the atmosphere into the chamber defined by the portions 15 and 16. The inlet 14, air inlet 21 and nozzle 20 constitute an inspirator functioning on the venturi principle, fresh air being drawn through inlet 21 by the momentum of the gases issuing from nozzle 20.

Shell member 2 and end plates 3 and 4 are provided with channel shaped cartridge supports 23 and 24 respectively which serve as a mounting means for catalyst-containing cartridges in a manner which will be explained below. As shown in Figs. 2 and 5 each channel member 23 is secured, as by welding at 2a, to each half of bipartite shell member 2. Channel members 23 run the full length of shell member 2 and effectively seal the space separating the opposed longitudinal edges 25 of the bipartite shell member 2. Channel members 24 are secured, as by welding at 24b, to the opposing faces of end plates 3 and 4 at the same level as channel members 23 so that the two sets of channel members 23, 24 form a continuous guideway extending endlessly around the interior of the housing.

Cartridges 26 of catalytic material, described in detail below, extend within and are supported by the guideways formed by the channel members 23, 24 as shown in Figs. 1, 2 and 5. As is apparent from Figs. 2 and 5 two opposed edges of each cartridge extend within the guideway formed by the sides 23a of channel member 23. The cartridges do not extend to the base of the channel members 23 but merely overlap the sides 23a of the channels in order to permit thermal expansion of the cartridges independently of the channel members as will be explained more fully below. The cartridge members on the extreme right and left shown in Fig. 1 are additionally supported on one edge thereof by the channel members 24, the cartridges overlapping and extending between the sides 24a of these channels.

In the disclosed embodiment of our invention we provide a plurality of cartridges arranged in side-by-side relationship to form a catalytic bed which extends for

substantially the full length and width of the shell 2. However, a single cartridge may be provided rather than a plurality. Where a plurality of cartridges are provided, it is desirable to interpose spacers of the type shown in Fig. 4 between adjacent cartridges. These spacers can be formed by welding the bases of two channel sections together to form an I-shaped beam. An I-beam of appropriate size would, of course, suffice and welded channels are disclosed here only because of the fact that I-shaped beams are not commonly available in the size range required for our apparatus. The channels employed for the spacers 27 may be of the same size as the channels 23, 24 which are secured to the inside of the shell, and should be of a length slightly less than the distance between the edges of corresponding opposed sides 23a of the channel members 23. For example, it has been found that where the straight line distance between the edges of corresponding opposed sides 23a of the channels 23 is $6\frac{1}{4}$ ", a satisfactory length for the spacer members is $6\frac{3}{16}$ ". This difference provides a slight clearance, of the order of $\frac{1}{32}$ ", between the ends of the spacer 27 and the edges of sides 23a of flanges 23. As will be explained below this clearance is important to a successful muffler of the instant type.

The spacers are suspended by the cartridges which extend within and between the flanges 27a of the channels which form the spacers 27 in the same manner as is the case with the channels 23, 24. Figs. 5 and 6 clearly show that the top flanges 27a of the spacers rest on the cartridges, the cartridges as explained above and as shown in Fig. 5 being in turn supported by the channels 23 at their edges.

In the preferred embodiment of our invention the spacers 27 are formed from a stainless steel which is capable of withstanding the elevated temperatures reached while the device is functioning. The channel members 23, 24, the end plates 3, 4 and the bipartite casing 2 can be formed from ordinary cold rolled steel since these parts are not subjected to extremely high temperatures.

The cartridge usable with the preferred embodiment of our invention consists of a casing which is filled substantially but not entirely to limit of its capacity with catalytic particles. The casing, shown in Fig. 3, comprises a cap portion 30 and a body portion 31 both of which are formed from relatively thin gage, for example 22 U. S. gage, stainless steel or other high temperature alloy. The stock material from which the cartridges are formed is perforated over its entire area with small diameter holes 32, for example about 0.062" diameter, in rows with about 74 holes per square inch. These holes may be provided in staggered rather than straight rows in order to provide the maximum number of holes per unit of area. In the interest of clarity only a few of these holes are illustrated in the drawings. As will be explained below, these holes permit passage of the exhaust gases through the cartridge while the device is in operation. The body portion 31 of the cartridge casing comprises a base 33 having independent sidewalls 34 extending therefrom. The base 33 is provided with longitudinal and transverse stiffening ribs 35 which are pressed therein. The sidewalls 34 extend from the base independently of each other, and are not connected at their adjacent edges 34a as shown in Fig. 3. This type of construction permits each sidewall 34 to expand or contract under the influence of elevated temperatures independently of adjacent sidewalls. The edges of adjacent sidewalls are, of course, sufficiently close to each other to prevent the escape of catalyst pellets from the interior of the cartridge casing.

Each sidewall is provided with an inturned curved portion 36 extending parallel to the base and along the top edge 37 thereof. These inturned portions cooperate with complementary inturned portions 38 of flanges 39 which depend from the top surface 40 of the cap 30 of the cartridge casing. The flanges 39, as shown in Fig. 3,

depend from the top surface 39 of cap 30 independently of each other which, as is the case with sidewalls 34, permits each flange to expand and contract independently of adjacent flanges. When the cap portion 30 and body portion 31 of the cartridge casing are assembled to each other, the flanges 39 and sidewalls 34 interengage with a snap fit, the curved portions 38 and 36 overlapping each other, as shown in Figs. 2 and 5. The sidewalls 34 are resiliently sprung inwardly when the cap 30 is assembled to the body portion 31 so that upon thermal expansion of the parts, the cap portion can be forced upwardly by the body portion without breaking the snap fit. Furthermore, by virtue of the resilient force of the sidewall 34, the cap 30 is forced upwardly when the cartridges are fitted within the flanges 27a of the spacers 27 and the flanges 23a, 24a of the channels 23, 24 respectively. As shown in Fig. 6 this results in a relatively snug fit between the flanges of the respective channels and spacers and the cartridges. As will be explained below, a relatively snug fit is essential in these parts in order to assure efficiency in the oxidation of the carbon monoxide and hydrocarbons in the engine exhausts.

In the preferred embodiment of our invention the cartridge casing is partially filled with catalytic particles. Any suitable oxidation catalyst may be employed, but one which has proved to be particularly satisfactory consists of pellets of activated alumina impregnated with about 0.4% platinum. The pellets may be of cylindrical shape of $\frac{1}{8}$ " to $\frac{1}{16}$ " in diameter and of the same length. We have found that the optimum charge of catalyst particles for each cartridge can be empirically determined by filling the cartridge casing to its capacity and thereafter removing about 5% by weight of the particles charged. One of the reasons for removing 5% of the capacity charge is that room must be provided for the particles to expand, when the device is in operation. Tightly packed particles would tend to be crushed by each other as the temperature of the device rises during operation.

The cartridges of catalytic material can be assembled to the muffler merely by removing the right end plate of Fig. 1 and sliding the requisite number of cartridges into the guideways while interposing a spacer between adjacent cartridges. This arrangement permits rapid replacement of the catalyst when necessary.

In the operation of our device exhaust gases from the internal combustion engine flow through exhaust pipe 19 and are emitted from nozzle 20. Fresh air from the atmosphere is drawn through air inlet 21 and intermixed with the exhaust gases as they pass into the upper chamber, designated by the letter A of the apparatus. From there, the mixture of raw exhaust gases and fresh air passes through the battery of cartridges 26 and into the lower chamber designated by the letter B of the apparatus from whence they are exhausted through outlet 11 to the atmosphere or (in the case of an engine mounted in a conventional automobile) to a tail-pipe of the automobile. In passing through the cartridges 26 the exhaust gases are oxidized, that is, the hydrocarbons are oxidized to yield carbon dioxide and water vapor, and the carbon monoxide is oxidized directly to carbon dioxide. The excess air inspired by the venturi inspirator assures substantial completeness of these oxidation reactions so that the gases liberated by an internal combustion engine to which our apparatus is attached consist of an innocuous mixture of carbon dioxide, water vapor, the usual inert atmospheric gases, and perhaps some free oxygen rather than the usual toxic and obnoxious mixture of hydrocarbons and carbon monoxide.

The oxidation reactions described above are exothermic, which means that heat will be liberated as these reactions proceed within the cartridges. The heat liberated will in part be dissipated as sensible heat in the gases exhausted through the outlet 11 and in part will raise the temperature of the structural components of

the apparatus. For example, it has been found that the temperature of the raw (unoxidized) gases entering the apparatus will vary from about 200° F. to 900° F., while the temperature of the gases passing through the catalyst bed will usually vary between 700° F. and 1300° F., although under extreme conditions of engine speed and load, the temperature of the gases here may reach a maximum of 1800° F. The oxidized gases leaving the outlet 11 will usually vary between limits of 650° F. and 950° F. Although these temperature ranges are only approximations, they clearly indicate the extremely rigorous conditions under which the structural components of our catalytic muffler must operate. The temperature of the base 33 of the body portion of the cartridge casings 26 will approach the temperature of the gases leaving the catalyst bed, namely 700° F. to 1300° F., or (under extreme conditions) 1800° F., while the temperature of the side walls 34 of these casings 26 will be somewhat lower. The operating temperature of the caps 30 of the cartridge casings will be still lower since these members are heated only by the incoming (unoxidized) gases and by conducted or radiated heat from the catalyst bed and the sidewalls 34. The operating temperatures of the channel members 23, 24 and the separators 27 will not be as high as that of the base of the cartridges 26, although these members 23, 24 and 27 will become hotter in their lower portions, as viewed in Fig. 1, where they are in constant contact with a stream of oxidized (heated) gases, than in their upper portions where they are in contact only with raw gases which as noted above are relatively cool.

A further consideration with reference to the temperature variations and fluctuations within our apparatus is that changes in the speed of the internal combustion engine will cause an abrupt change in the volume of exhaust gases produced, abrupt changes in the amount of carbon monoxide and hydrocarbon in the exhaust gases, and hence abrupt changes in the amount of heat produced in the oxidation of these gases. Such abrupt changes in engine speed will therefore produce equally abrupt dimensional changes in the structural components by virtue of the thermal expansion caused. This is particularly true where relatively light gage metal is used (such as the 22 U. S. gage stainless steel used for the cartridges in our invention) since the heat capacity of such thin sections is comparatively low.

The present invention provides a structure capable of withstanding the extremes of temperature variations and fluctuations of catalytic mufflers. Referring first to Fig. 3, it is apparent that the cartridge casing is capable of thermal expansion without the development of detrimental thermal stresses. The four sidewalls 34 can expand independently of each other since the corners 34a are not connected as would they be in a conventional casing. The base portion 33 can expand along either of its dimensions without imposing or being restricted by the forces which might develop at such connected corners. The cap portion 30 can, of itself, likewise react to temperature changes and the interengaging curved portions 36, 38 of the sidewalls 34 and flanges 39 permit independent thermal expansion of these two members while maintaining the integrity of the snap fit which connects the two.

With reference to Figs. 1 and 5, it can be seen that the cartridges are supported in such manner that they may expand and contract as individuals without the development of thermal stresses in the supporting means. The relationship between the channels 23 and the cartridges 26, with the cartridges extending within and between the sides 23a of the channels, permits expansion of the cartridges in a direction transverse to the longitudinal axis of the shell 2 while the relationship between the spacers 27 and the edges of the cartridges 26 received therein permits similar independent thermal behavior. As noted above, the spacers themselves do not contact the

side channels 23 which again permits these spacers to independently respond to abrupt temperature variations. The end plate channels 24 bear a relationship to cartridges 26 similar to that of side channels 23.

In the operation of catalytic devices of the instant type, it is of paramount importance that substantially all of the exhaust gases pass through the bed of catalyst particles and that no opportunity is presented for gases to by-pass the bed as by channelling through crevices separating the catalyst bed from the muffler housing. Crevices or gaps between the catalyst bed and the muffler housing would be particularly detrimental in lowering the efficiency of any catalytic muffler in view of the fact that the pressure drop across such crevices would be considerably lower than the pressure drop across the catalyst bed, since such crevices would present an unobstructed path for gases to flow through while gases flowing through the catalyst bed would be forced to follow a circuitous path. It follows that an inordinately high percentage of the gases would follow the relatively unobstructed path through a crevice rather than the relatively difficult path through the catalyst bed. Gases which by-pass the bed are, of course, not oxidized and would be released into the atmosphere with their hydrocarbons and carbon monoxide unaltered.

With our apparatus by-passing of the catalyst bed is obviated and all gases from the engine are forced through the catalyst bed. Raw gases in the upper chamber A can flow to the lower chamber B only by passing through the battery of cartridges mounted, as shown in Fig. 1, between these two chambers. As shown in Figs. 1 and 2, the gases cannot pass between the channel 23, 24 and the shell 2 and end plates 3, 4 since the channels are firmly secured to the shell and end plate as by welding. The gases cannot flow through gaps between adjacent cartridges because these gaps are effectively sealed by the spacers 27 which overlap the tops and bottoms of the cartridges as shown in Figs. 1, 5 and 6. As explained above, and as shown in Fig. 6, the cartridges fit snugly within the flanges 27a of the spacers. Finally, the gases cannot avoid the cartridges by passing between the edges of the cartridges and the channel members 23, 24 because the cartridges extend snugly within these channels.

We have found that the use of a battery of cartridges presents, in itself, several advantages over the other types of structures. A cartridge can be manufactured and filled with catalytic particles with relative ease by mass production methods. As noted above, in bed-type catalytic apparatus, the catalytic bed must not occupy the entire volume of space within its confines, in order to permit expansion of the catalyst particles without crushing under extreme variations in temperature. A cartridge can be expeditiously filled to the requisite degree by conventional filling techniques in a factory so that renewal of the catalyst in a muffler merely requires placement of an exhausted set of cartridges with new cartridges. Furthermore, factory filled cartridges relieve the mechanic of the tedious and burdensome duty of weighing out the required amount of catalyst and inserting, piece by piece, into the muffler. In the preferred embodiment of our invention the removable end plate 3 facilitates replacement of the cartridges.

Finally, a cartridge type muffler presents an advantage in that the catalytic bed (of a battery of juxtaposed cartridges) is effectively divided into a plurality of discrete compartments, the side walls 34, of the cartridge acting as dividers for the bed. Where a bed-type catalytic muffler is provided with one continuous bed of loosely packed catalytic particles, the particles will have a tendency to fall toward one end of the device if the muffler is tilted from a horizontal position. Such tilting could readily occur in a catalytic apparatus incorporated in an automotive vehicle as the vehicle ascends or descends a hill. When packing of this type occurs, it is obvious that channelling of the exhaust gases through the bed will

result with attendant incomplete oxidation of the gases. This matter is explained more fully in the copending application of Eugene J. Houdry, Serial Number 438,423 filed June 22, 1954 for Catalytic Exhaust Purifier.

While we have disclosed the preferred embodiment of our invention, we contemplate that various modifications and changes falling within its scope might be effected by those skilled in the art.

We claim:

1. Catalytic apparatus suitable for attachment to the exhaust outlet of an internal combustion engine for oxidizing toxic and obnoxious components of the exhaust gases therefrom comprising a housing including a shell having at least one removable end plate, guideways located on the internal lateral walls of said shell for receiving a plurality of perforated cartridges containing catalytic material, said cartridges being insertable into and removable from said shell upon removal of said end plate, said guideways comprising U-shaped channels disposed opposite one another, said channels being adapted to receive slidably the lateral edges of said cartridges, said lateral edges extending into said channels but sufficient space being provided between the base of said channels and said lateral edges that said cartridges are free to expand and contract independently of said channels, said cartridges being supported in side-by-side relationship in said channels to provide a catalyst bed extending substantially the length and width of said shell, and sealing means provided between the adjacent edges of said side-by-side cartridges.

2. Catalytic apparatus suitable for attachment to the exhaust outlet of an internal combustion engine for oxidizing toxic and obnoxious components of the exhaust gases therefrom comprising a housing including a shell having at least one removable end plate, guideways located on the internal lateral walls of said shell for receiving a plurality of perforated cartridges containing catalytic material, said cartridges being insertable into and removable from said shell upon removal of said end plate, said guideways comprising U-shaped channels disposed opposite one another, said channels being adapted to receive slidably the lateral edges of said cartridges, said lateral edges extending into said channels but sufficient space being provided between the base of said channels and said lateral edges that said cartridges are free to expand and contract independently of said chan-

nels, said cartridges being supported in side-by-side relationship in said channels to provide a catalyst bed extending substantially the length and width of said shell, and sealing means provided between the adjacent edges of said side-by-side cartridges, said sealing means comprising I-shaped members providing a pair of channels facing in opposite directions, said pair of oppositely facing channels being adapted to receive the adjacent edges of a pair of side-by-side cartridges whereby exhaust gases flow through and not between said cartridges.

3. Catalytic apparatus suitable for attachment to the exhaust outlet of an internal combustion engine for oxidizing toxic and obnoxious components of the exhaust gases therefrom comprising a housing including a shell having at least one removable end plate, guideways located on the internal lateral walls of said shell for receiving a plurality of perforated cartridges containing catalytic material, said cartridges being shaped rectangularly and being relatively shallow in depth and being insertable into and removable from said shell upon removal of said end plate, said guideways comprising U-shaped channels disposed opposite one another, said channels being adapted to receive slidably the lateral edges of said cartridges, said lateral edges extending into said channels but sufficient space being provided between the base of said channels and said lateral edges that said cartridges are free to expand and contract independently of said channels, said relatively shallow cartridges being supported in side-by-side relationship in said channels to provide a relatively shallow catalyst bed extending substantially the length and width of said shell, and sealing means provided between the adjacent edges of said side-by-side cartridges.

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