Dec. 14, 1965 J. B. MAILLIE ETAL 3,223,491

MUFFLER CONSTRUCTION

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FIG. 1

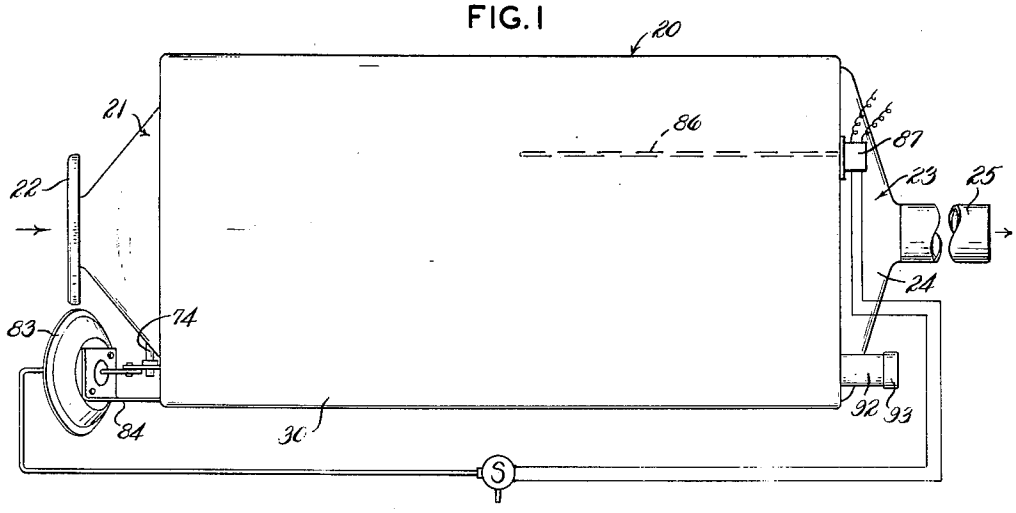


FIG. 2

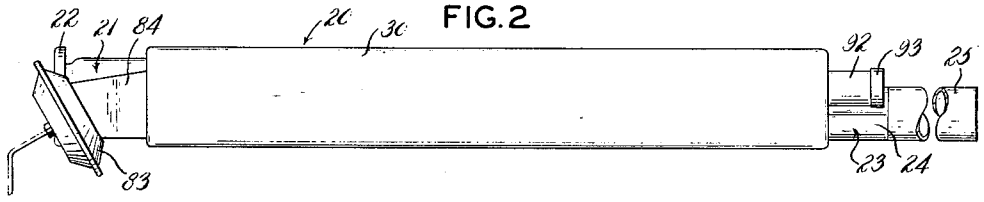


FIG. 3

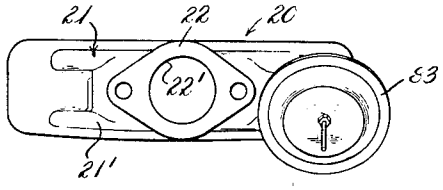
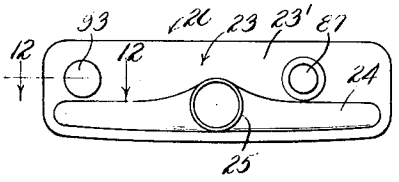


FIG. 4



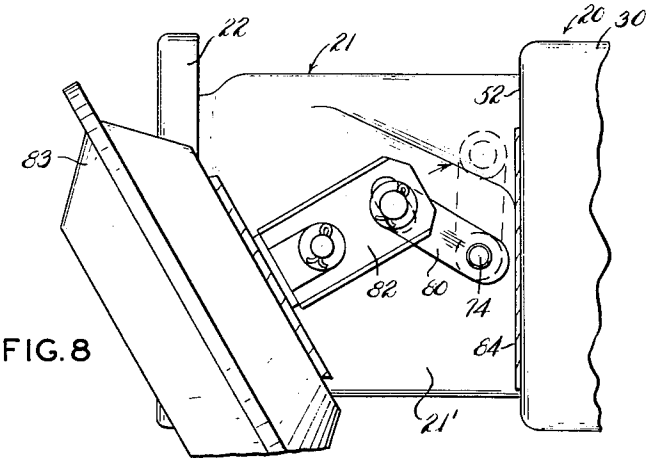


FIG. 8

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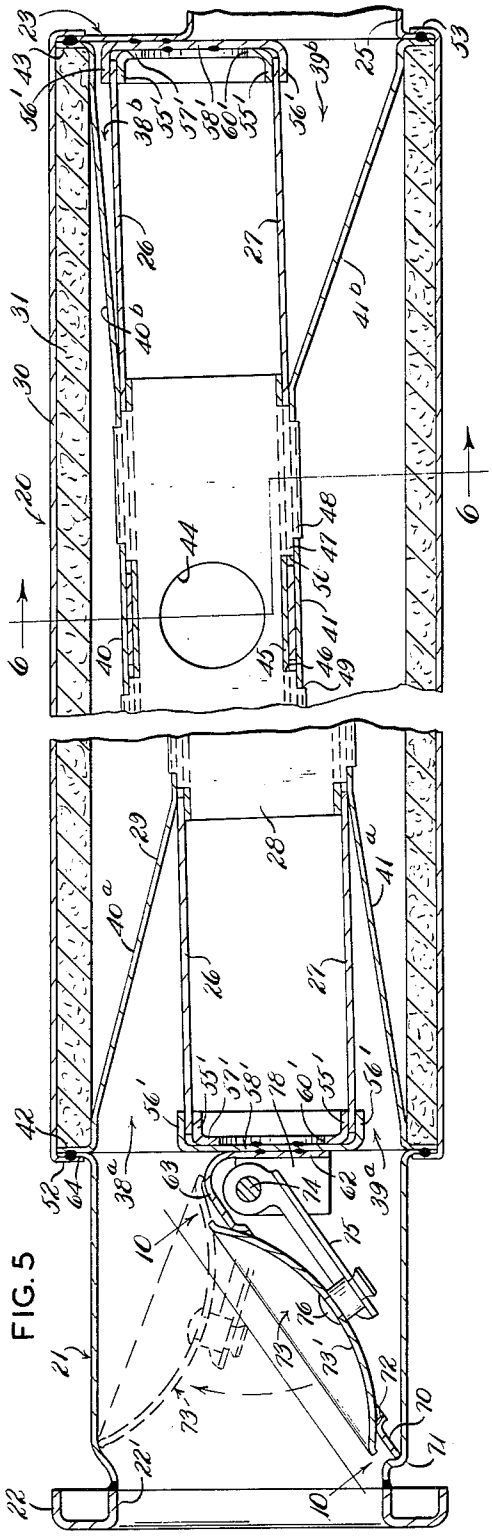


FIG. 5

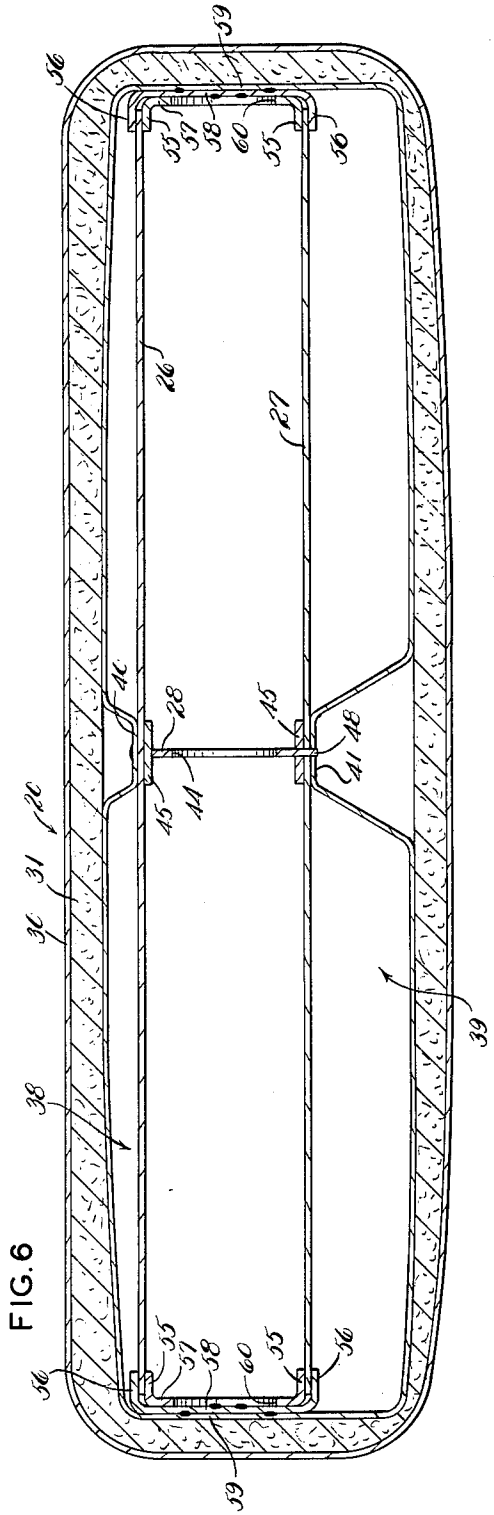


FIG. 6

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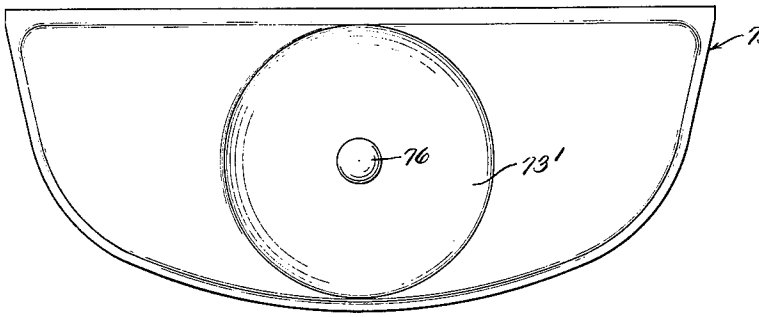


FIG. 10

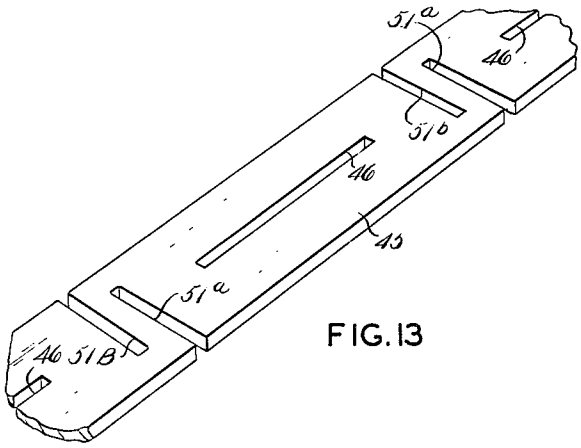


FIG. 13

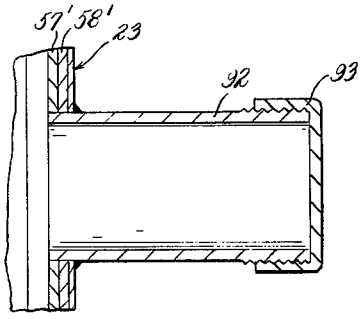


FIG. 12

FIG. 7

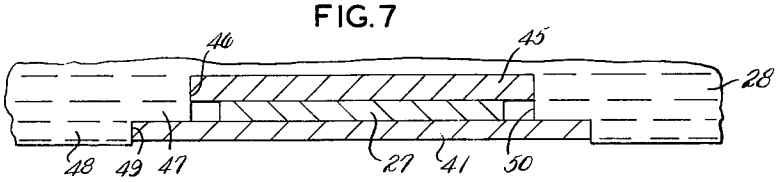
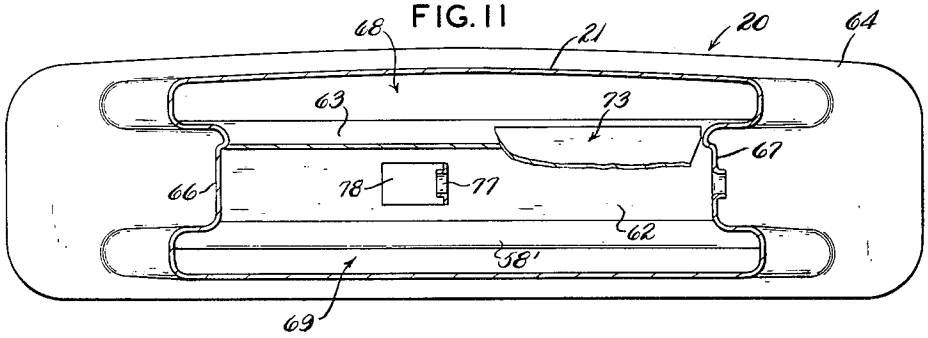


FIG. 11

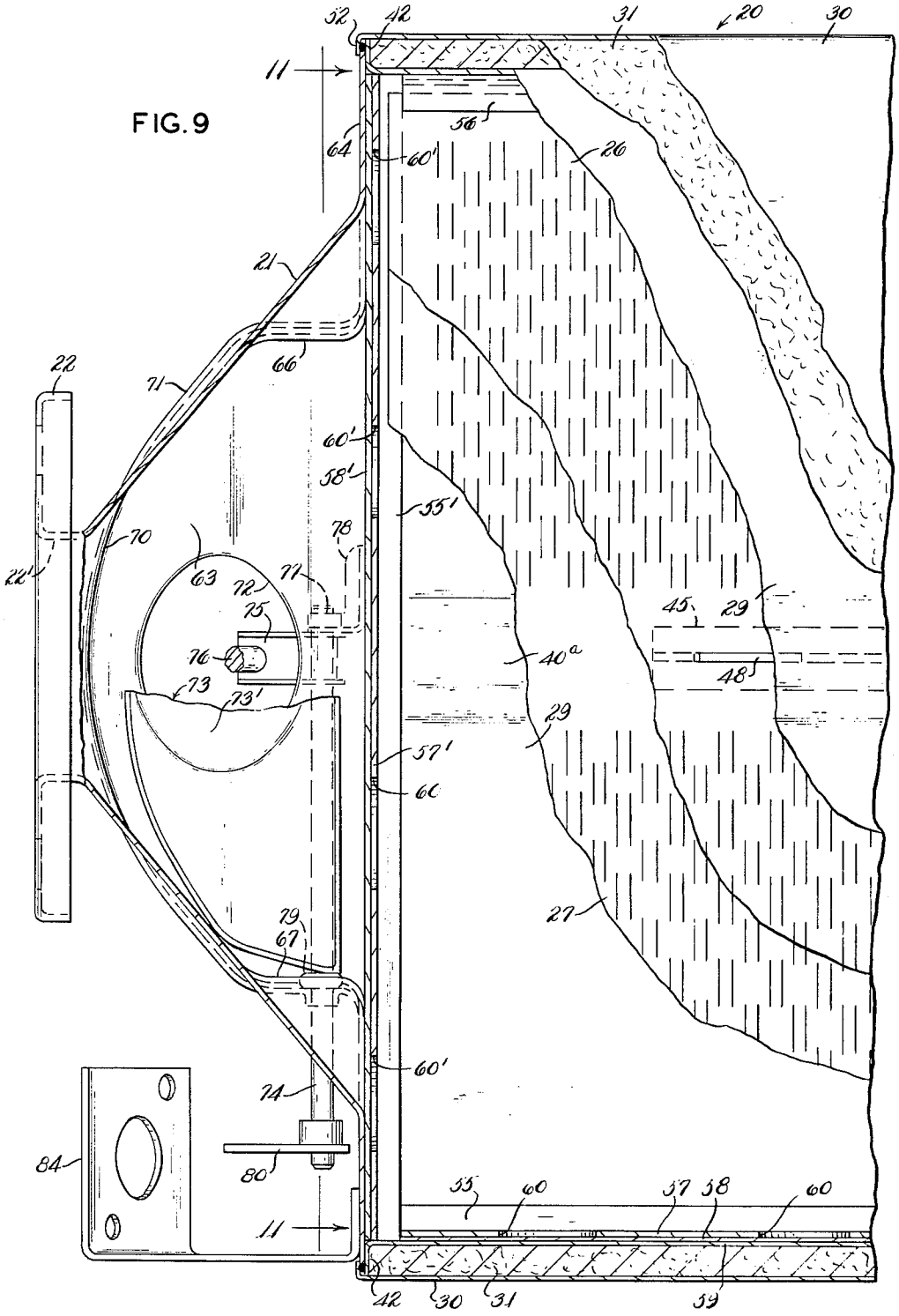


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MUFFLER CONSTRUCTION

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FIG. 9



United States Patent Office

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MUFFLER CONSTRUCTION

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Filed Sept. 27, 1962, Ser. No. 226,709
2 Claims. (Cl. 23—288)

The invention relates generally to catalytic apparatus for eliminating obnoxious vehicle exhaust emissions by oxidation, and more particularly to a catalytic apparatus adapted for connection to the exhaust pipe of an internal combustion engine to replace the conventional muffler, thus eliminating noise as well as fumes.

Catalytic mufflers have a number of requirements, which makes the construction of a practical, efficient and economical muffler for this purpose a difficult and complicated problem. The muffler shell must be of practical and reasonable dimensions, must not create excessive back pressure on the engine, must provide properly distributed contact between the exhaust gases and the catalytic material, must be rugged to withstand mechanical shocks in use and minimize distortion, and must provide for differential expansion between the outer parts and the inner parts where high temperatures are generated due to oxidation.

In addition, problems arise because the catalytic material is preferably in the form of granules or pellets, and must be supported in a relatively thin layer or bed, preferably in slightly tilted, substantially horizontal position, in such manner as to avoid excessive pressure drop and gas leakage in normal operation, while providing for positive by-passing of the bed by the gases in case of abnormal situations, such as fouled spark plugs, which would create excessive bed temperatures, damaging the catalyst as well as the muffler.

The temperatures required for catalytic oxidation of vehicle emissions are upwards of 1000° F., necessitating the use of stainless steel parts, at least in and adjacent to the catalytic bed, but even such high-temperature alloys require substantial intermediate support to prevent sagging and distortion, and there is the ever-present problem of compensating for differential expansion without excessive use of costly metal.

Certain prior catalytic mufflers have been proposed which meet a substantial number of the foregoing requirements, but said prior constructions have been difficult and expensive to fabricate, involving laborious hand operations, uneconomic use of stainless steel, and an excessive number of parts. They have also inhibited the free spread of catalytic action and created turbulence in the flow of exhaust gases therethrough.

A general object of the present invention is to provide a novel and improved catalytic muffler construction which will meet the foregoing requirements, which will be more efficient in operation, and which can be simply and economically fabricated with a minimum of material and labor.

Specifically, an object of the present invention is to provide a catalytic muffler construction which utilizes a minimum number of parts and lends itself to fabrication by automatic welding operations.

Another object is to provide an improved construction for solidly supporting the catalytic bed while minimizing distortion and compensating for differential expansion of the parts thereof relative to the muffler shell.

A further object is to provide an improved light-weight central beam construction for preventing sagging while permitting free spread of catalytic action throughout the bed.

Another object is to provide an improved deflector valve arrangement for selectively by-passing flow of exhaust gases around the bed.

A further object is to provide an improved muffler construction for facilitating easy replacement of the catalytic material in the bed.

A still further object is to provide an improved muffler construction which promotes smooth, non-turbulent flow of exhaust gases to and from the catalytic bed.

These and other objects are accomplished by the parts, constructions and combinations comprising the present invention, a preferred embodiment of which is shown in the drawings and described herein as an example of the best known mode of carrying out the invention. Various modifications and changes in details of construction are embraced within the scope of the appended claims.

The improved catalytic muffler comprising the present invention consists of a flattened tubular one-piece body shell surrounding a rectangular construction of channels and perforate grids containing a bed of catalytic material, the bed structure being spaced from the top and bottom of the body shell to form gas inlet and discharge ducts. Central longitudinal embossments formed inwardly top and bottom in the body shell are welded to an open, non-warpable, bed-supporting beam in the bed structure in such manner as to permit differential expansion between the shell, the beam and the bed structure. The perforate grids of the bed structure are slidably supported both peripherally and along the longitudinal beam. Inlet and outlet end shells, attached to the body shell by welded mating peripheral flanges, provide smooth, non-turbulent gas flow to and from the bed. The mated flanges provide positive location for a wrap-around thermal insulation blanket and means for attaching its protective cover. A simplified deflector valve is mounted in the inlet end shell for selectively by-passing flow of exhaust gases around the bed.

Referring to the drawings:

FIG. 1 is a plan view of a catalytic muffler embodying the present invention.

FIG. 2 is a side elevation thereof.

FIG. 3 is a front end elevation thereof.

FIG. 4 is a rear end elevation thereof.

FIG. 5 is an enlarged longitudinal sectional view, parts being broken away.

FIG. 6 is a cross sectional view on line 6—6 of FIG. 5.

FIG. 7 is a further enlarged view of a portion of FIG. 5.

FIG. 8 is an enlarged view of a portion of FIG. 2 partly broken away and in section.

FIG. 9 is a fragmentary enlarged plan sectional view of the inlet portion of the muffler, with parts broken away.

FIG. 10 is an elevation on line 10—10 of FIG. 5, of the by-pass deflector valve removed from the muffler.

FIG. 11 is a transverse sectional view on line 11—11 of FIG. 9, with parts removed.

FIG. 12 is a fragmentary sectional view of the filler tube in the rear end.

FIG. 13 is a detached fragmentary perspective view of the expansible bearing strip between the grids and the central beam.

Referring first to FIGS. 1–4, the improved catalytic muffler comprises a flattened elongated body 20, substantially rectangular in all elevations and having tapered end shells 21 and 23 attached to its inlet and outlet ends, respectively. Inlet end shell 21 preferably has a usual attaching flange 22 for bolting to a similar flange on the exhaust pipe (not shown) of an internal combustion engine. Outlet end shell 23 is attached to the other end of the body 20 and preferably terminates in a cylindrical exhaust pipe 25.

As shown in FIGS. 5 and 6, the body **20** comprises an inner bed structure including spaced-apart upper and lower grids **26** and **27** with a central longitudinal beam or web **28** extending vertically between the grids, a body shell **29** surrounding said bed in vertically spaced relation to said grids, and a metal cover **30** enclosing a blanket **31** of thermal insulation material wrapped around the body shell **29**.

The upper and lower grids are foraminous plates; that is, they have a multiplicity of openings or perforations formed in the plates in any suitable manner. The openings are large enough to permit through flow of gases but small enough to prevent escape of the catalyst granules.

The body shell **29** is preferably a single piece of sheet metal, which is formed into a flat tubular shape and seam-welded at any convenient location (not shown). The body shell is vertically spaced above grid **26** and below grid **27** to form gas inlet and outlet ducts **38** and **39**, respectively. Preferably, the grids **26** and **27** are inclined slightly with respect to the top and bottom portions of the shell, so that the duct **38** is relatively deep at its inlet end **38A** and relatively shallow at its opposite end **38B**, while duct **39** is relatively shallow at the inlet end **39A** and relatively deep at the opposite or outlet end **39B**. Exhaust gases normally enter inlet end **38A**, and due to the inclination of the bed are more effectively and uniformly directed into and through the bed.

The upper portion of body shell **29** has a central longitudinal embossment or channel **40** formed inwardly thereof, and the lower portion of body shell **29** has a central longitudinal embossment or channel **41** formed inwardly thereof. The inward faces of embossments **40** and **41** intermediate their ends rest against the upper and lower grids **26** and **27**, respectively, and the end portions **40A**, **40B** and **41A**, **41B** of the embossments taper outwardly and terminate at the peripheral flanges **42** and **43** which extend continuously around the inlet and outlet ends, respectively, of the body shell **29**. The intermediate portions of embossments **40** and **41** vary in depth to accommodate the inclination of the grids **26** and **27** with respect to the body shell **29**.

The novel one-piece body shell with outwardly flanged ends eliminates peripheral trim waste and gas port punch-out waste inherent in prior constructions using deep drawn half shells, and eliminates expensive welding entirely around the outer periphery of the muffler by requiring welding only one longitudinal seam. Moreover, the improved one-piece shell provides for positive attachment of the insulation cover locating the insulation blanket, and for cam-programmed automatic welding of the shell to the end shells.

The central beam or web **28** is preferably substantially co-extensive with the intermediate portions of embossments **40** and **41** and terminates adjacent to the start of the tapered end portions, so that longitudinal expansion and contraction of the beam is minimized while providing adequate support for the grids **26** and **27**. Large openings **44** are provided through the beam at longitudinal intervals between welds attaching the beam to the body shell **29**. These openings serve to provide communication between both sides of the bed to permit spread of catalytic action throughout the bed, as well as to facilitate rapid filling and removing of catalytic material. Further, the openings **44** weaken the web between weldments and provide for incremental take-up of the web's longitudinal expansion by slight lateral bending of the weakened portions. The beam **28** being fore-shortened at both ends substantially reduces the amount of stainless steel required for central support in previous designs.

Longitudinally expansible bearing strips **45** are preferably interposed between the edges of perforated center beam **28** and the inner surfaces of grids **26** and **27**, for the purpose of providing continuous support to same. As shown in FIGS. 5, 6, 7 and 13, these strips have longitudinal slots **46** at longitudinal intervals through which

projections **47** on the beam **28** extend. The projections **47** continue into further stepped projections **48** which extend through accommodating longitudinal slots **49** in the intermediate bottom portions of embossments **40** and **41** and are attached thereto. The projections **47** also project through the grids **26** and **27** (FIG. 7), via longitudinal slots which are long enough to permit differential expansion movement between the beam and the grids. The shoulders formed between projections **47** and stepped projections **48** locate and support the body shell embossments **40** and **41** during assembly.

Between the slots **46** the bearing strips **45** are provided with staggered transverse edge-opening slots **51A** and **51B**, which take up the strips' longitudinal expansion movements incrementally between beam projections **47**. The bearing strips **45** widen the continuous bearing area between the beam edges and the grids to prevent sagging, and also prevent catalyst granules from working their way into the ends of grid slots **50** where they would be subject to crushing due to differential expansion. Thus, the grids are free to move longitudinally and the differential longitudinal expansion between the cool body shell and the hot beam-and-bearing-strip structure is divided into a plurality of small harmless increments.

The insulation cover **30** is preferably an aluminum sheet wrapped around the body shell **29** in spaced relation to enclose the thermal insulating blanket **31** engirdling the body shell **29**. The cover **30** is preferably lock-seamed at any convenient location (not shown), and its ends are formed into inward peripheral flanges **52** and **53** for locking engagement with the shell flanges. The cover **30** thus secures the insulation blanket **31** on the muffler and seals its ends against road splash.

The side edges of grids **26** and **27** are slidably received in longitudinal slots formed between the legs **55** and **56** of nested channels **57** and **58** extending longitudinally along the side wall portions **59** of body shell **29**. The inner channels **57** are welded at longitudinal intervals to the outer channels **58** and the webs of the inner channels are provided with openings **60** between weldments, so that the nested channel assemblies can be attached to the side wall portions **59** by spot welding the outer channels to the shell through the openings **60**. This avoids the difficulties of welding through three thicknesses of metal.

The end edges of grids **26** and **27** are similarly received in transversely extending slots formed between the legs **55'** and **56'** of nested channels **57'** and **58'** extending transversely of the ends of the grids and closed at their ends against the ends of side channels **57** and **58**. The webs of inner channels **57'** are provided with welding openings **60'** through which the outer channels **58'** can be spot welded to the end shells **21** and **23**, respectively. As seen in FIG. 5, the channel **58'** at the outlet end is welded to the upper flat portion of outlet end shell **23**; and the channel **58'** at the inlet end is welded in its laterally central portion to the vertical flange **62** of inclined partition **63** in the inlet end shell **21**, and welded near its ends to inward projections of flange **64** of inlet end shell **21**, as seen in FIG. 11.

The inlet end shell **21** tapers outwardly from the circular opening **22'** in its attaching flange **22** to flat substantially rectangular shapes top and bottom, as shown in FIG. 11, and it terminates in a peripheral flange **64** mating with peripheral flange **42** on body shell **29**. Preferably, flanges **42** and **64** are welded together by an automatic welding operation.

As seen in FIGS. 9 and 11, the flat outward tapers of inlet shell **21** form lateral transition chambers which communicate with upper and lower gas ducts **68** and **69**, and they are separated by a central chamber formed substantially by vertical side walls **66** and **67**. The transition chambers are smoothly tapered to avoid the turbulence created in many prior designs, with resultant increase in back pressure. Moreover, less material and labor and a minimum of welding (all automatic) is required. The

inclined partition 63 extends laterally between the walls 66 and 67, and its laterally curved lower edge 70 conforms to and is through-welded against a curved inset 71 formed jaw-fashion in the lower portion of inlet shell 21. The upper portion of partition 63 is bent rearwardly downward to form the transverse attaching flange 62, thus completing the sealed separation of flow chambers communicating with upper and lower gas ducts 68 and 69.

The partition 63 has a preferably circular valve port 72 formed centrally therein, and a substantially semi-circular deflector valve 73 is provided with a spherically shaped embossment 73' which normally seats in valve port 72, as shown in FIG. 5, closing off the entrance of gas flow to the lower transition chamber and the lower gas duct 39A. The deflector valve 73 is pivotally mounted from its underside on a shaft 74 by means of an arm 75 attached to a center post 76 in the spherically embossed portion of the valve, for swinging to the dotted line position. The shaft 74 is journaled at its inner end in a bearing 77 formed in a bracket 78 attached to flange 62, and the shaft extends through a gas-tight bearing 79 in side wall 66.

The outer end of shaft 74 has a lever arm 80 thereon which is pivoted at its outer end by a pin and slot connection 81 (FIG. 8) to the operating arm 82 connected to the diaphragm of a conventional vacuum booster 83 mounted on a bracket 84 attached to the flange 64 of inlet end shell 21. The arm 82 normally holds the lever 80 in the full line position of FIGS. 5 and 8 to hold deflector valve 73 closed, and it swings to the dotted line position to direct the gas flow on a by-pass course around the catalyst when necessary to prevent over-heating.

The improved one-piece deflector valve utilizes a minimum of material, and the location of its pivotal mounting on the underside eliminates any obstacles to normal gas flow. The interior bearing 77 reduces the number of exterior wall gas-tight bearings to one instead of two, as in many prior constructions.

The by-pass system is preferably controlled by the temperature of the catalytic material in the bed between the grids 26 and 27. As shown in FIG. 1, a thermocouple probe 86 may be inserted through the upper flat portion of outlet end shell 23, extending into the central portion of the catalytic bed. The thermocouple 86 is calibrated to actuate a thermal switch 87 at a predetermined maximum temperature above which the bed structure or the catalytic material or both would be damaged. The switch 87 is electrically connected to activate the vacuum booster during normal operation of the muffler. When high temperatures threaten, the switch shuts off the vacuum and permits the usual diaphragm-opposing spring in the booster to open the by-pass valve.

The flat portion 23' of the outlet end shell is readily adapted to accommodate a filling tube 92 extending through rear channels 57' and 58' and opening directly into the space between grids 26 and 27 for filling or replacing catalytic material forming the bed. A suitable cap 93 normally closes the tube. Thus, the filler opening, as well as the thermocouple opening, is directly accessible to the catalytic bed rather than through the thermal insulation blanket and cover which are required when inserted from the side of the muffler.

The location of the thermal switch and filler tube at the rear end of the muffler above the transition chamber 24 of the outlet end shell protects them from road damage from flying stones and the like, and it also simplifies packaging or palletizing the mufflers for shipment.

The transition chambers 21 and 24 of the inlet and outlet end shells provide smooth, gradual transition of gas flow from the exhaust pipe opening 22' into the upper gas duct 38 (or via 21' into the lower gas duct 39 during by-pass), and from the lower gas duct 39 to the tail pipe 25, without requiring punched out gas flow openings in the body shell, the ragged edges of which tend to create turbulence in the gas flow.

In the operation of the improved catalytic muffler, the exhaust gases entering the inlet end shell 21 flow through port 22' and are deflected upwardly by the deflector valve 73 in its normal closed position into the entrance end 38A of upper gas duct 38. The hot gases flow uniformly over the entire upper surface of inclined upper grid 26 and pass through the openings 35 therein into and through the bed of catalytic material contained between grids 26 and 27. The catalytic material causes oxidation of noxious exhaust emissions, resulting in temperatures of the order of 1000°–1400° F. The gaseous products of combustion flow through lower grid 27 into the lower gas duct 39, and thence out through the transition chamber 24 of outlet end shell 23 and exhaust pipe 25.

The construction of the improved catalytic muffler is such as to reduce or muffle the sound of the exhaust from the engine, so that it performs the dual function of reducing noise and eliminating fumes.

If the temperature of the bed is unduly elevated by excess hydrocarbons in the exhaust gases, e.g., caused by a fouled spark plug or carburetor malfunction, the thermocouple will actuate the switch 87 to cut off the vacuum and permit the diaphragm-opposing spring (not shown) to move deflector valve 73 to its upper position, closing the upper transition chamber to gas duct 38 and opening the lower transition chamber to gas duct 39 to the direct flow of exhaust gases, thus by-passing the catalytic bed. As soon as the bed temperature returns to normal, the thermocouple actuates switch 87 to reinstate the vacuum and the vacuum booster diaphragm movement returns the deflector valve to normal position, deflecting flow into upper gas duct 38.

The improved catalytic muffler is simple and inexpensive to fabricate and service, embodies a minimum number of parts and a minimum quantity of material, and it minimizes distortion and sagging due to high operating temperatures. It also provides smooth flow transitions and minimizes back pressures due to turbulence. Moreover, it effectively removes noxious exhaust emissions and eliminates engine exhaust noise, while providing compact and rugged construction highly resistant to shocks and impact.

What is claimed is:

1. Catalytic muffler construction for exhaust gases comprising, upper and lower foraminous grids having spaced longitudinal slots and forming an elongated flattened bed structure for enclosing catalyst material, a one-piece body shell surrounding said upper and lower grids and having peripheral flanges at either end, longitudinal inward embossments formed in said body shell exteriorly of said grids, a longitudinal perforated center beam between said grids extending a portion of the length thereof, spaced projections on the edges of said longitudinal perforate beam extending through said spaced slots in said grids and attached to said longitudinal inward embossments of said body shell, bearing strips interposed between said longitudinal center beam and the inner surfaces of said grids, whereby said grids are movably supported and the catalytic material is restricted from escaping into the slots of said grids, end shells having peripheral flanges mating with and attached to the peripheral flanges on said body shell and providing tapered flow transitions, and means on the interior of said body shell and end shells sealing the periphery of said grids against the escape of catalyst material.

2. Catalytic muffler construction in accordance with claim 1 wherein said means on the interior of said body shell and end shells sealing the periphery of said grids against the escape of catalyst material comprises nested channels which matingly engage the peripheral edges of said upper and lower grids.

(References on following page)

References Cited by the Examiner

UNITED STATES PATENTS

1,595,711	8/1926	Cornelier	23—288
2,488,563	11/1949	Sills.	
2,776,875	1/1957	Houdry	23—288
2,807,930	10/1957	Bratton.	
2,834,657	5/1958	Houdry	23—288
2,853,367	9/1958	Karol et al.	23—288
2,898,202	8/1959	Houdry et al.	23—288
2,909,415	10/1959	Houdry	23—288
2,991,160	7/1961	Claussen	23—288

3,024,593	3/1962	Houdry.	
3,050,935	8/1962	Eastwood.	
3,083,084	3/1963	Raymond	23—288
3,086,839	4/1963	Bloch	23—288 XR
3,090,677	5/1963	Scheitlin et al.	23—288
3,094,394	6/1963	Innes et al.	23—288
3,097,074	7/1963	Johnson	23—288

FOREIGN PATENTS

448,850	6/1936	Great Britain.

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