

[54] EXHAUST REACTOR

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[58] Field of Search..... 23/277 C, 288 F;
 55/DIG. 30; 60/282, 301, 302, 322, 323, 304

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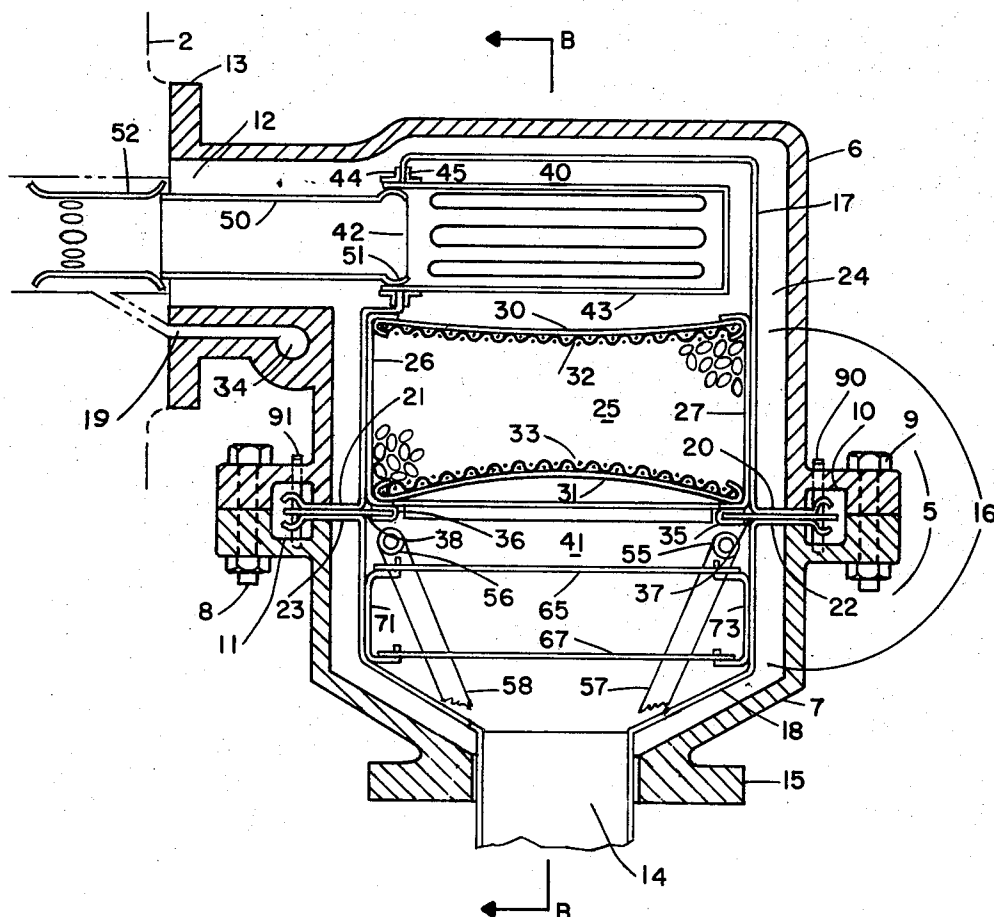
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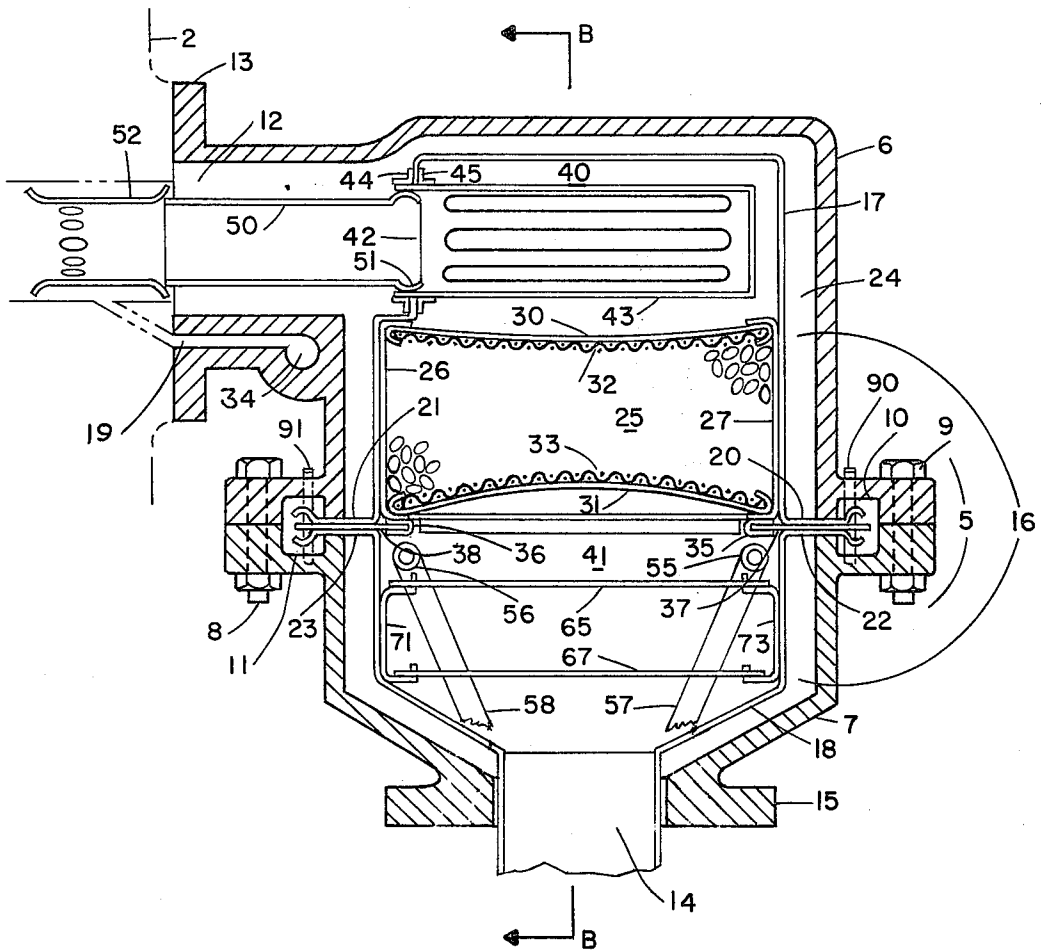
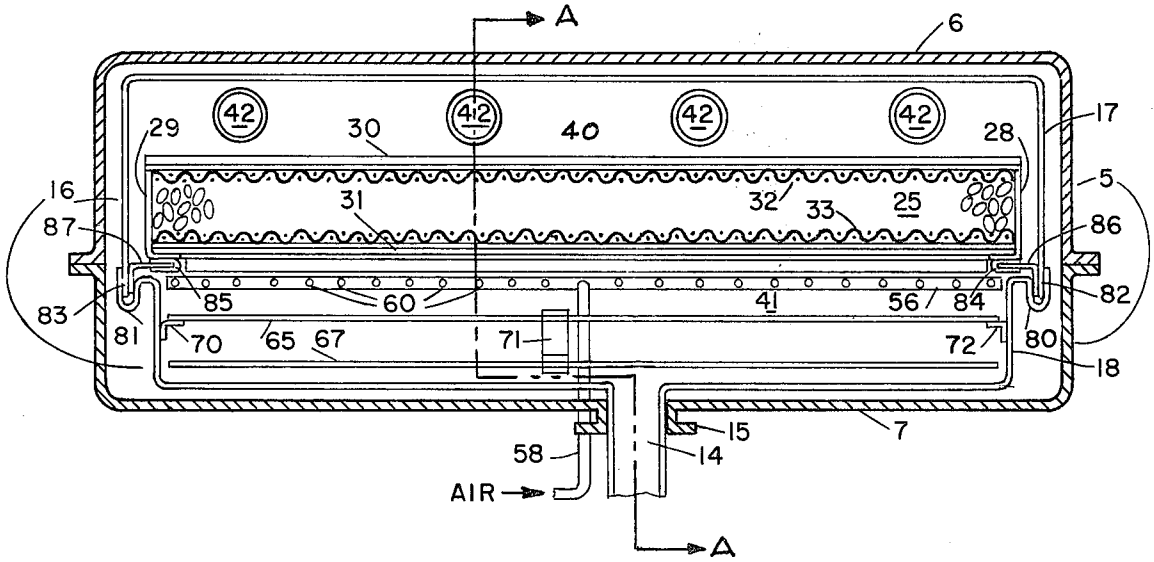
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[57] ABSTRACT

An exhaust converter for an internal combustion engine comprising an outer housing rigidly connected directly to the exhaust outlets of the engine and a light-weight flexibly constructed inner housing suspended inside the rigid outer housing. The inner housing contains a flexibly suspended catalyst container dividing it into an inlet plenum and a thermal non-catalytic reactor compartment. Air injection means are provided in the thermal reactor. The catalytic stage reduces NO_x and the thermal reactor oxidizes hydrocarbon and carbon monoxide. The light flexible construction of the inner housing allows it to expand and contract in response to thermal shock without destroying itself.

18 Claims, 5 Drawing Figures





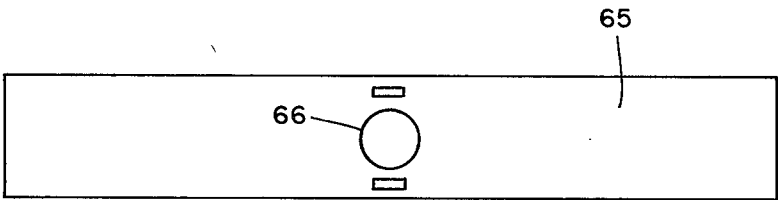


FIGURE 3

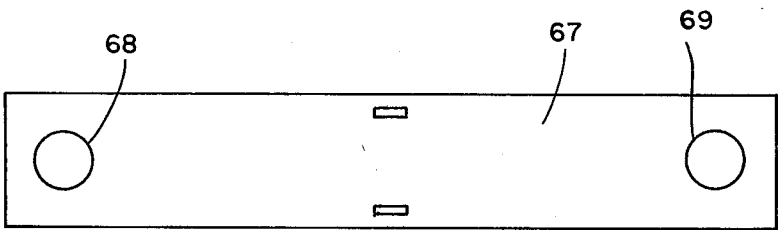


FIGURE 4

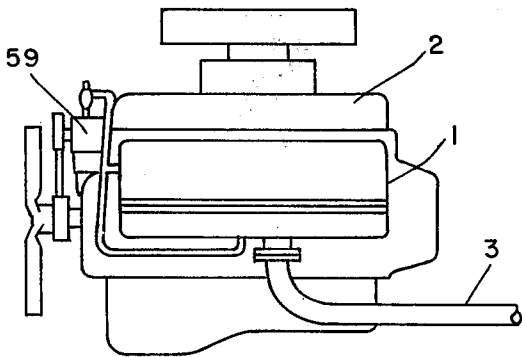


FIGURE 5

EXHAUST REACTOR

BACKGROUND

Exhaust gas from internal combustion engines contains components which contribute to air pollution. Components most frequently referred to are nitrogen oxides, hydrocarbons and carbon monoxide. Hydrocarbons and carbon monoxide can be lowered by such means as running the engine at higher air/fuel ratios (e.g., above 15) or by catalytic or thermal (i.e., non-catalytic) oxidation of these components in the exhaust system. Catalytic converters are described in U.S. Pat. Nos. 3,166,895 and 3,154,389. Placement of the catalyst in the exhaust manifold is described in U.S. Pat. No. 3,644,098. Non-catalytic converters are described in U.S. Pat. Nos. 3,247,666 and 3,633,368.

Nitrogen oxide emissions can be lowered by such means as exhaust gas recycle or by catalytic reduction of the nitrogen oxides. Attempts have been made to lower all three (i.e., nitrogen oxides, hydrocarbons and carbon monoxide) by catalytically reducing the nitrogen oxides in the exhaust by operating the engine rich and contacting the reducing exhaust with a catalyst and then injecting air into the exhaust and either catalytically or non-catalytically oxidizing the hydrocarbon and carbon monoxide constituents. Morris, U.S. Pat. NO. 3,581,490, describes such a method in which the exhaust is first conducted to a remote catalytic unit wherein the nitrogen oxide is reduced and then to a separate flame-type oxidation unit equipped with air and fuel injectors and a spark plug igniter. Tourtellotte, U.S. Pat. No. 3,699,683, describes a related system.

A major problem with previous exhaust converters is their tendency to buckle and crack when exposed to the severe thermal shock of typical automobile use. In order to be effective, the units must be able to heat up rapidly. Generally, the units heat to about 1200°F. in a matter of 2-3 minutes. During rapid acceleration, and in the case of engine misfire, abrupt temperature excursions in excess of 1800°F. can be expected. The various parts of most units are rigidly connected and when they expand and contract due to temperature change they tend to buckle and crack, leading to self-destruction.

SUMMARY OF THE INVENTION

According to the present invention, an exhaust converter is provided which, due to its flexible construction, can endure thermal expansion and contraction and still maintain its integrity. The converter construction may be adapted to form a catalytic reactor, a non-catalytic (i.e., thermal) reactor, or a combination of a catalytic and non-catalytic reactor. In general, the structure comprises a converter housing constructed of parts which fit together by flanges slidably fit in channels such that the individual parts can independently expand and contract without distorting or cracking other connected parts.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-section taken generally at BB of the converter including both a catalytic stage and a thermal stage.

FIG. 2 is a transverse cross-section taken generally at AA.

FIG. 3 is a plan view of the top baffle in the thermal stage.

FIG. 4 is a plan view of the second baffle in the thermal stage.

FIG. 5 shows an engine with the converter mounted directly to the exhaust outlets.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 5, exhaust converter 1 connects directly to the exhaust ports of engine 2 such that it receives exhaust gas, lowers the content of nitrogen oxide, hydrocarbon and carbon monoxide and, finally, exhausts the treated gas through pipe 3.

Construction of the converter is shown in detail in FIGS. 1 and 2. It comprises an elongated outer converter housing indicated generally by 5 constructed of an upper casing 6 and a lower casing 7. Outer housing 5 is made of cast metal such as cast iron. Casings 6 and 7 are open on one side and the open sides joined by bolts 8 and 9. Internal T-shaped recesses 10 and 11 are provided along their longitudinal line of joinder. Upper casing 6 has an exhaust inlet 12 adapted by flange 13 to rigidly connect directly to the exhaust outlet of engine 2. Lower casing 7 has an exhaust outlet 14 adapted by flange 15 to connect to exhaust pipe 3.

Longitudinal passage 34 is provided in upper casing 6 which is connected by lateral spurs 19 to air injection inlets in engine 2.

Inner converter housing, indicated generally by 16, is flexibly suspended inside outer housing 5. It is made of sheet metal construction, preferably sheet stainless steel. It is formed by elongated upper shell 17 and lower shell 18, both of which are open on one side and join along the edges of their open side to form inner housing 16. The manner in which they are joined is an important feature of this invention since it provides a flexible connection which allows the upper and lower shells to expand and contract individually according to their temperature without placing undue strain on the rest of the housing.

Both upper shell 17 and lower shell 18 have longitudinal outwardly extending flanges 20, 21, 22 and 23 along the longitudinal edges of their open sides. These flanges are slidably fit into recesses 10 and 11. The width of recesses 10 and 11 is such that it allows the members fit therein to move in response to thermal expansion and contraction, but is snug enough that very little exhaust gas can escape inner converter housing 16 between flanges 20 and 22 and flanges 21 and 23. This results in a flexible suspension of inner converter housing 16 inside outer converter housing 5. Outer housing 5 acts as a cradle to hold the flexible inner structure. The outer edges of flanges 20, 21, 22 and 23 are crimped to prevent them from slipping out of recesses 10 and 11.

The edges of the ends of lower open-sided shell 18 are bent in a goose-neck form to provide upward opening channel members 80 and 81. The edges of the ends of upper open-sided shell 17 have extensions 82 and 83 which slidably fit into channels 80 and 81, thus sealing inner housing 16.

Anchor pins 90 and 91 are inserted in openings in upper casing 6 and extend part-way through the flange of lower casing 7. Pins 90 and 91 are longitudinally centrally located and pass through openings in flanges 20, 21, 22 and 23 and in catalyst container retainers 37 and 38 and serve to anchor these elements to outer converter housing 5 at a central location. This insures

that inner housing 16 will expand and contract uniformly in both directions inside outer housing 5.

An important feature of this construction is that inner housing 16 has very little contact with outer housing 5 and thus heat conduction is minimized. This allows inner housing 16 to heat up rapidly because of its low mass and resultant low heat capacity while outer housing 5 remains relatively cool. This feature is improved by providing insulation 24 such as asbestos wool in the space between inner housing 16 and outer housing 5.

Positioned within upper shell 17 of inner housing 5 is catalyst container 25 formed by side walls 26 and 27, end walls 28 and 29, perforate inlet wall 30 and perforate outlet wall 31. Screen catalyst retainers 32 and 33 are positioned adjacent the perforate walls to prevent the escape of catalyst. Catalyst container 25 is loosely fit in upper shell 17 such that when it extends and contracts it does not distort inner housing 16. Even if container 25 presses against the side walls of upper shell 17, it can be seen that these walls are supported by flanges 20 and 21, which can flex in recesses 10 and 11 to accommodate such pressure without breaking.

Attached longitudinally along both side edges of perforate outlet wall 31 are channel members 35 and 36. Catalyst container support members 37 and 38 are slidably fit into channels 35 and 36 and in-between flanges 20 and 22 and flanges 21 and 23. This flexible suspension permits catalyst container 25 to independently expand and contract within inner housing 16 without distorting it or causing it to rupture.

Attached transversely at both ends of catalyst container 25 are channel members 84 and 85. Angle members 86 and 87 are slidably fit — one into channels 80 and 84 and the other into channels 81 and 85 — thus substantially sealing inlet plenum 40 from outlet plenum 41 except for the flow path through perforate inlet wall 30 and perforate outlet wall 31 of catalyst container 25.

Catalyst container 25 divides inner housing 16 into inlet plenum 40 and outlet plenum 41. The embodiment shown in FIGS. 1 and 2 includes both a catalytic reactor section and a thermal reactor section. In this arrangement, outlet plenum 41 functions as the thermal non-catalytic reactor in a manner which will be explained later.

Inlets 42 of inlet plenum 40 are fitted with tubular slotted baffles 43 which are flexibly retained in inlets 42 by flanges 44 and 45. Inlet tube 50 extends inside exhaust inlet 12 and has embossed end 51 slip-fit into tubular baffle 43. When outer housing 5 is rigidly connected to engine 2, flexible tube 50 engages exhaust port-liner 52, forming an exhaust flow path from the exhaust port directly into inlet plenum 40. The flexibility of tube 50 is another important feature of the invention because the engine remains much cooler than the inner converter housing and thus the engine and inner housing expand at much different rates. Flexible tube 50 allows each element to expand and contract at its own rate without placing strain upon the other element which could lead to rupture.

Air injection conduits 55 and 56 are positioned longitudinally in outlet plenum 41 and are centrally connected by air tubes 57 and 58 through lower shell 18 and lower casing 7 to an air pressure source such as air pump 59 on engine 2. A series of small openings 60 are

provided along air conduits 55 and 56 for injecting air into plenum 41.

Located in plenum 41 below air conduits 55 and 56 is first baffle 65, shown also in FIG. 3. Baffle 65 has a central opening 66 through which the exhaust gas/air mixture passes. Located below baffle 65 is second baffle 67, shown also in FIG. 4. Baffle 67 is provided with openings 68 and 69 near its ends. Alternatively, baffle 67 can merely be made shorter to provide an opening between its ends and the end wall of lower shell 18. Baffles 65 and 67 are flexibly suspended by brackets 70, 71, 72 and 73 such that they can expand and contract at their own rate without placing a strain on inner housing 16.

In the embodiment shown, the converter contains both a catalytic reduction zone and a thermal oxidation zone. It is preferred that the engine be operated rich in order to insure a reducing gas in the catalytic zone. This is done by adjusting the air/fuel ratio to achieve about 1–4 percent CO in the exhaust gas. This generally requires an air/fuel ratio of about 12.5–14.5/1. The engine is started, and during the first minutes of operation air is injected into the engine exhaust ports through passage 14 to provide an oxidizing gas (i.e., oxygen in stoichiometric excess over hydrocarbon and carbon monoxide). This gas passes through conduit 50 into inlet plenum 40 and then through perforate wall 30 and screen 32 into the catalyst container. At this stage the catalyst functions as an oxidation catalyst, which is a very exothermic reaction and rapidly heats up the catalyst and inner housing 16. After the first few minutes of operation, air injection into the exhaust ports is stopped and the exhaust gas immediately becomes reducing. The catalyst then functions to catalyze the chemical reduction of the nitrogen oxides in the exhaust.

Any of a large number of heat-resistant exhaust gas catalysts can be used. Preferred catalysts are those containing a Group V-B, VI-B, VII-B, VIII or I-B metal or metal oxide on a suitable support such as alumina, silica-alumina, silica-magnesia-alumina, cordierite, mullite, and the like. The catalyst may be an unsupported metal such as copper screen, copper wire, nickel turnings, copper-nickel alloy (Monel) turnings, and the like. Examples of useful catalysts are copper oxide, copper oxide-vanadia, vanadia, copper oxide-chromia, nickel oxide, manganese oxide, copper oxide-nickel oxide, copper-nickel-iron oxides, and the like, on an alumina support. Useful catalysts are described in U.S. Pat. No. 3,545,917; 3,483,138; 3,552,913; 3,540,838; 3,524,721; 3,447,893; 3,433,581; 3,374,183; 3,271,324; 3,226,340 and Fr. 2,109,662.

The treated exhaust gas leaves catalyst container 25 by passing through screen 33 and perforate outlet wall 31 and enters outlet plenum 41. Air is injected into the exhaust gas through air conduits 55 and 56 in an amount sufficient to render the exhaust gas oxidizing but not an amount which would cool the gas and prevent oxidation. As soon as the exhaust gas/air mixture forms, oxidation initiates spontaneously causing a lowering in the hydrocarbon and carbon monoxide content of the gas. The oxidizing gas mixture passes through central opening 66 in baffle 65 and impinges against baffle 67. It then passes through openings 68 and 69 in baffle 67 and, finally, leaves the inlet plenum through exhaust outlet 14 and is conducted to the atmosphere through exhaust pipe 3.

The embodiment described includes both a catalytic reduction stage and a thermal oxidation stage. In other embodiments, either of these stages can be omitted. In other words, catalyst container 25 in FIGS. 1 and 2 can be omitted to obtain a thermal (non-catalytic) reactor which has improved durability due to its method of construction. Likewise, catalyst container 25 can be retained and air conduits 55 and 56 and baffles 65 and 67 omitted to obtain a catalytic reactor of improved durability. The resultant catalytic reactor can be used to reduce nitrogen oxides, as in the present embodiment, or, by operating the engine leaner (above 15/1 air/fuel ratio) and/or by continuously injecting air into the exhaust ports, it can be used as a catalytic oxidation reactor. All of these embodiments will have improved durability and faster heat-up compared to a conventional unit because of the manner of construction heretofore described at which the following claims are directed.

We claim:

1. A thermal exhaust converter adapted to connect directly to the exhaust outlets of an internal combustion engine, said converter comprising an elongated outer converter housing and an elongated inner converter housing, said outer housing comprising an upper open-sided casing and a lower open-sided casing, the open sides of which join to form said outer housing, said inner housing comprising an upper open-sided shell and a lower open-sided shell, the open sides of which flexibly join to form said inner housing, longitudinal recesses inside said outer housing along the line of joinder of said upper casing to said lower casing, longitudinal outwardly extending flanges along the longitudinal edge of said upper shell and said lower shell, said flanges being slidably fit into said longitudinal recesses to flexibly suspend said inner housing inside said outer housing, exhaust inlet means adapted to connect directly to the exhaust outlets of an internal combustion engine and conduct exhaust gas into said inner housing, exhaust outlet means adapted to conduct treated exhaust gas from said inner housing out through said outer housing and means for injecting air into said exhaust gas such that said air mixes with said exhaust gas in said inner housing thereby thermally oxidizing the combustibles in said exhaust gas.

2. An exhaust converter of claim 1 having a baffle flexibly suspended longitudinally within said inner housing after said means for injecting air, said baffle increasing mixing of said air and exhaust gas.

3. An exhaust converter of claim 1 wherein said exhaust inlet means comprises extensions in said outer housing adapted to connect rigidly to said exhaust outlets of said engine and a flexibly connected inlet tube within each of said extensions adapted to form a conduit from each of said exhaust outlets of said engine into said inner housing.

4. An exhaust converter of claim 3 having a baffle flexibly suspended longitudinally within said inner housing after said means for injecting air, said baffle increasing mixing of said air and exhaust gas.

5. An exhaust converter adapted to connect directly to the exhaust outlets of an internal combustion engine, said converter comprising an outer converter housing and an inner converter housing flexibly suspended within said outer converter housing, said outer converter housing comprising an upper open-sided casing and a lower open-sided casing, the open sides of which

join to form said outer converter housing, said inner converter housing comprising an upper open-sided shell and a lower open-sided shell, the open sides of which flexibly join to form said inner converter housing, longitudinal recesses inside said outer converter housing along the line of joinder of said upper casing to said lower casing, longitudinal outwardly extending flanges along the longitudinal edges of said upper shell and said lower shell, said flanges being slidably fit into said longitudinal recesses to flexibly suspend said inner housing inside said outer housing, said inner converter housing having a catalyst container therein partitioning said inner housing into an inlet plenum above said catalyst container and an outlet plenum below said catalyst container, said upper casing having exhaust inlets adapted to connect directly to the exhaust outlets of said engine, inlet means adapted to deliver exhaust gas from said exhaust inlets into said inlet plenum, outlet means to permit treated exhaust gas to escape said outlet plenum, said catalyst container being formed by an upper perforate inlet wall and a lower perforate outlet wall joined by enclosing side walls, channel members attached longitudinally to said catalyst container, longitudinal catalyst container support members slidably fit between said flanges in said recesses such that a longitudinal edge of said support members extends inwardly into said inner housing and slidably fits into said channel members on said catalyst container to flexibly suspend said catalyst container inside said inner housing.

6. An exhaust converter of claim 5 including flexibly connected inlet tubes within said exhaust inlets of said outer converter housing adapted to form conduits from said exhaust outlets of said engine into said inlet plenum.

7. An exhaust converter of claim 6 having insulation between said inner converter housing and said outer converter housing.

8. An exhaust converter of claim 5 further characterized by including means for injecting air into said outlet plenum such that said outlet plenum functions as a thermal oxidative reactor compartment.

9. An exhaust converter of claim 8 having upward opening channel members along edges of the ends of said lower open-sided shell and extensions of the edges of the ends of said upper open-sided shell, said extensions being slidably fit into said upward opening channel members to substantially sealably connect the edges surrounding the open sides of said upper and lower shells in a flexible manner.

10. An exhaust converter of claim 9 having transverse channels at the ends of said catalyst container and transverse angle members slidably fit into said transverse channels and into said upward opening channel members to substantially seal said inlet plenum from said thermal reactor compartment except for the path through said perforate inlet and outlet walls of said catalyst container.

11. An exhaust converter of claim 10 having a longitudinal first baffle flexibly suspended inside said thermal reactor compartment between said catalyst container and said outlet means, said air injection means being provided in the space between said first baffle and said catalyst container.

12. An exhaust converter of claim 11 having a second baffle flexibly suspended between said first baffle and said outlet means.

13. An exhaust converter of claim 12 wherein said first baffle has an opening proximate to its longitudinal center and said second baffle has openings proximate to both ends providing an elongated exhaust flow path.

14. An exhaust converter of claim 8 including means for anchoring said longitudinal outwardly extending flange of said upper and lower open-sided shells at a central location in said longitudinal recesses such that said upper and lower open-sided shells expand and contract substantially equally in both directions inside said outer converter housing.

15. An exhaust converter of claim 8 having a longitudinal first baffle inside said thermal reactor compartment between said catalyst container and said outlet

means, said air injection means being provided in the space between said first baffle and said catalyst container.

16. An exhaust converter of claim 15 wherein said first baffle is flexibly suspended.

17. An exhaust converter of claim 16 having a second baffle flexibly suspended between said first baffle and said outlet means.

18. An exhaust converter of claim 17 wherein said first baffle has an opening proximate to its longitudinal center and said second baffle has openings proximate to both ends providing an elongated exhaust gas flow path.

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