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Charlton

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[45] **Jan. 23, 1973**

[54] **EXHAUST POLLUTION CONTROL SYSTEM**

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[21] Appl. No.: **49,832**

[52] **U.S. Cl.** .....**55/100,** 23/284, 23/288 F, 55/126, 55/276, 55/233, 55/234, 55/512, 55/DIG. 30, 60/275, 60/297, 60/310

[51] **Int. Cl.** **B01d 50/00**

[58] **Field of Search** .....23/288 F; 181/55, 50; 60/287–324, 275; 55/DIG. 30, 100, 233, 315, 316, 234, 317–333

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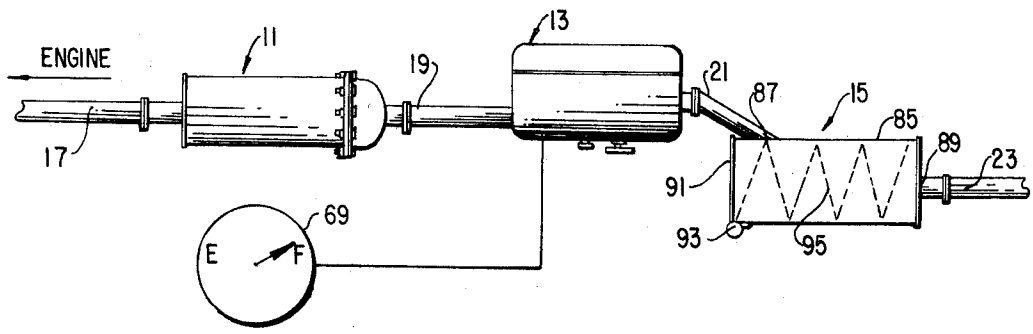
[57] **ABSTRACT**

An exhaust cleaning system which has three types of cleaning elements: a dry-scrubber cleaning element; a wet-scrubber cleaning element; and a filter cleaning element is disclosed. Cleaning members in each of the cleaning elements can be individually removed and replaced. The dry-scrubber cleaning element comprises insert tube cleaning members which can be removed from an outer housing for replacement. The dry-scrubber cleaning element further includes electrodes and magnets to attract magnetic pollutants. The wet-scrubber cleaning element comprises a tank, a liquid agent held in a sponge, and a copper surface plate. The filter cleaning element comprises a removable filter element mounted in a housing.

14 Claims, 9 Drawing Figures



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SHEET 1 OF 3

FIG. 1

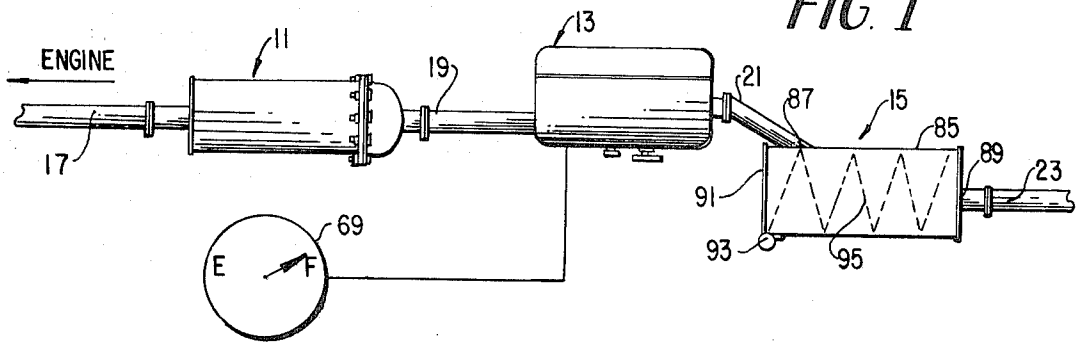
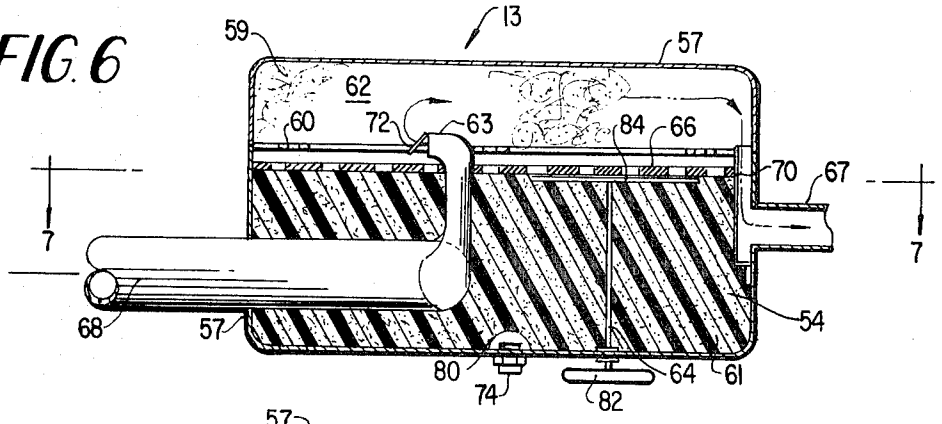


FIG. 6



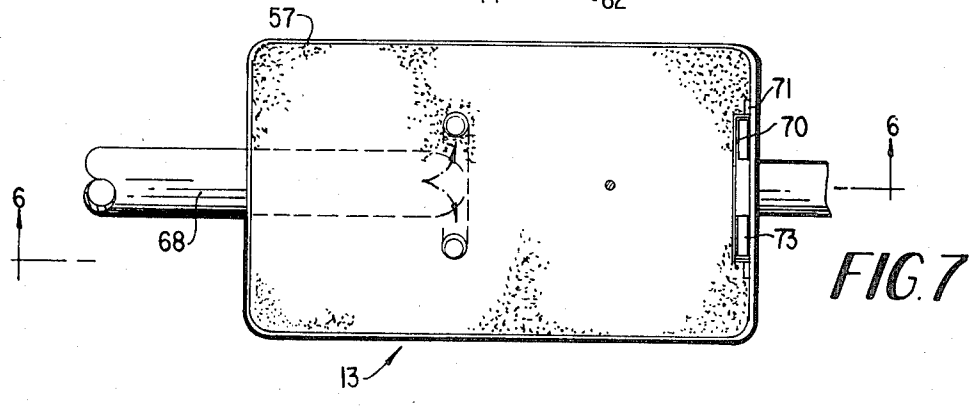


FIG. 7

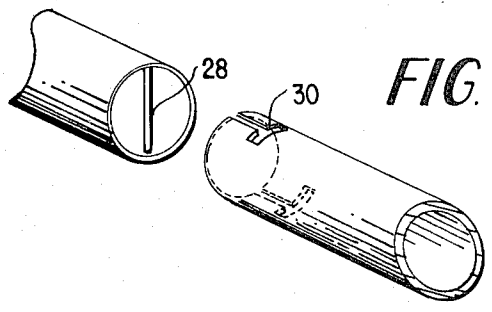


FIG. 5

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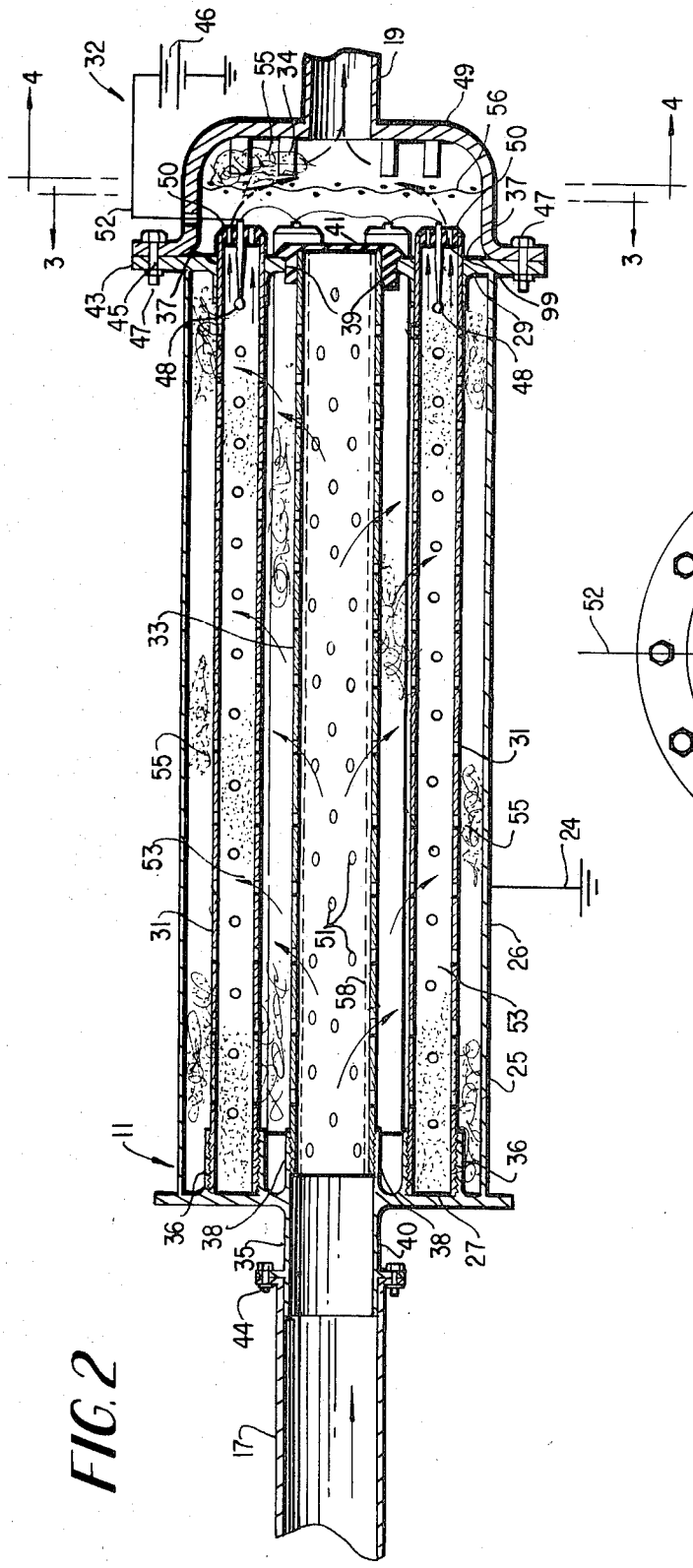

FIG. 2

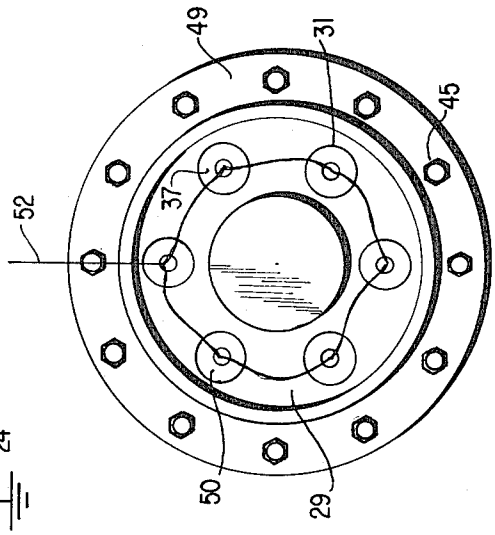

FIG. 3

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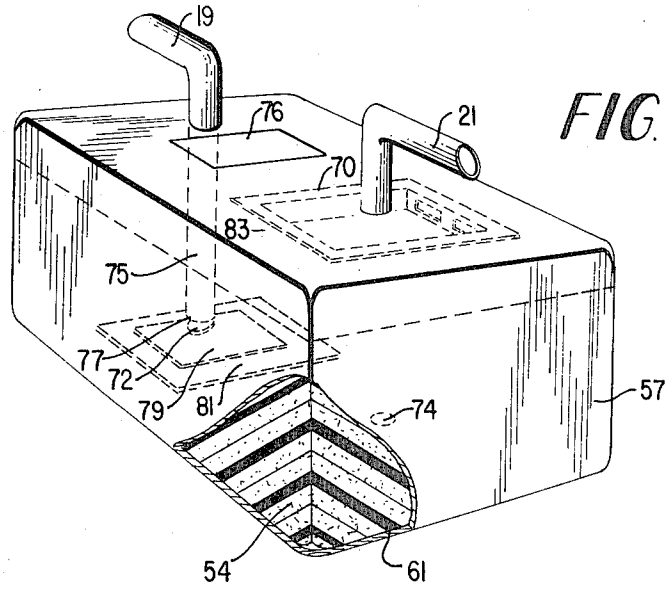

FIG. 9

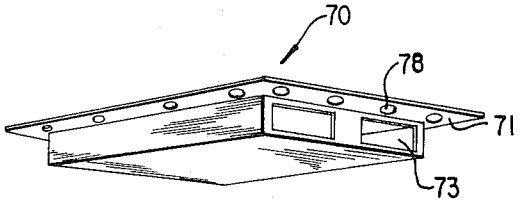

FIG. 8

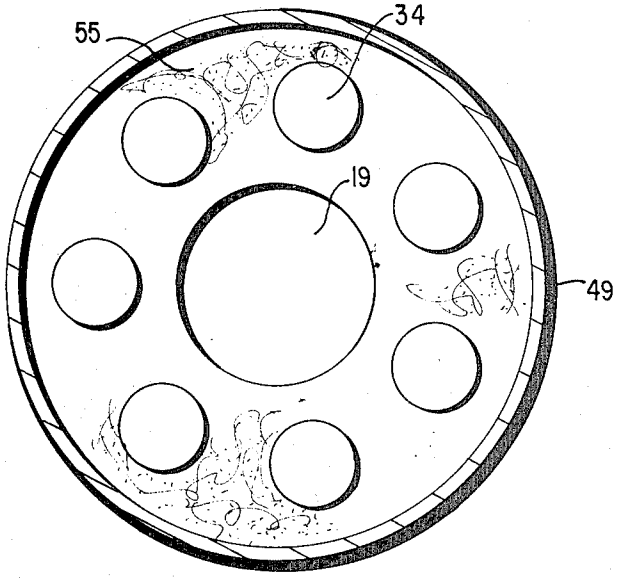

FIG. 4

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EXHAUST POLLUTION CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This invention relates generally to the art of pollution control devices. More particularly, it relates to the art of engine exhaust cleaning systems.

Air pollution has come to be regarded in recent years as a severe problem and internal combustion engines, which are used in vehicles and other machinery, are generally recognized to be major contributors to air pollution. For this reason, a great deal of air pollution research is directed toward finding a suitable system for cleaning air pollutants from exhaust gases of internal combustion engines.

A significant problem in finding a practical exhaust cleaning system is finding one that is inexpensive but yet effective. An exhaust cleaning system for a car, for example, should not be so expensive initially that it unduly affects the price of a new vehicle. Similarly, a car exhaust cleaning system should be inexpensive to maintain.

Generally, there are three major types of exhaust cleaning elements used in exhaust cleaning systems: (1) dry-scrubber cleaning elements; (2) wet-scrubber cleaning elements; and, (3) filter cleaning elements. A dry-scrubber cleaning element, as used in this specification, comprises a housing containing generally loose reacting materials which absorb, adsorb and chemically react with pollutants, thereby removing them from exhaust gasses passing through the housing. A wet-scrubber cleaning element, as used here, comprises a fluid, gas or liquid, into which exhaust gases are blown. The fluid traps and suspends pollutants, thus, removing them from exhaust gases. A filter cleaning element, as used here, generally comprises a filter which has small pores through which exhaust gases pass but which are sufficiently small to prevent some pollutants from passing. Each of these three types of exhaust cleaning elements clean some of the same pollutants from an exhaust stream as the other types of elements clean, however, each of the types of elements is generally more effective for certain pollutants than for others. Many prior art exhaust cleaning systems do not take full advantage of the three types of cleaning elements and, therefore, are not as effective as they could be. It is, therefore, an object of this invention to provide an exhaust cleaning system which employs all three types of cleaning elements.

The efficiencies of must exhaust cleaning systems decrease as a function of time. The main reason for this is that cleaning members in exhaust cleaning systems normally become saturated with air pollutants after a period of time and cannot thereafter function properly. To solve this problem, many prior art exhaust cleaning systems include access openings so that members can be periodically replaced. However, prior art replaceable cleaning members are generally impractical for various reasons. Some of them require undue labor to install and consequently are seldom replaced. Others are unduly expensive because they each serve one, two or three types of cleaning elements. For example, individual replaceable cleaning members which serve combinations of filter dry-scrubber type cleaning elements are normally more expensive than replaceable cleaning members which serve either filter type cleaning elements or dry-scrubber type cleaning elements alone. Further, replaceable filter cleaning members must normally be cleaned or replaced more often than replaceable dry-scrubber cleaning members. Also, replaceable dry-scrubber cleaning members are often large and cumbersome and, therefore, difficult to replace, whereas replaceable filter cleaning members are generally smaller and less difficult to replace. It follows that an exhaust cleaning system which has separate replaceable cleaning members for each type of cleaning element is less expensive to maintain than a system which has replaceable cleaning members serving combinations of diverse cleaning elements. Further, to replace some prior art single element replaceable cleaning members, it is necessary to replace an entire element, including an element housing, which is clearly unduly expensive. It is, therefore, another object of this invention to provide an exhaust cleaning system in which different types of cleaning elements are separable, and each is served by replaceable cleaning members.

Many prior art dry-scrubber cleaning elements are arranged so that exhaust gases must travel only short distances through their loose reacting materials. For example, in U.S. Pat. No. 3,147,097 to Aguas, a perforate exhaust pipe surrounded by a thin dry-scrubber element (filled with washed gravel and coconut charcoal) extends into a hollow muffler housing; so that exhaust gases which come out of pores in the perforate pipe pass through the thin packed element into an open space in the housing. In essence, exhaust gases pass through a relatively thin dry-scrubber element and, therefore, maintain contact with reacting material in the dry-scrubber element for a relatively short time. It is desirable that exhaust gases maintain contact with a dry-scrubber element's reacting materials for a relatively long period of time so that there is sufficient time for absorption, adsorption and chemical reactions to take place. It is, therefore, yet another object of this invention to provide a dry-scrubber element which is arranged to channel a flow of exhaust gasses through its reacting materials for a relatively long distance so that it maintains contact with the reacting materials for a relatively long period of time.

To be practical, dry-scrubber type exhaust cleaning elements should contain reacting materials which are relatively inexpensive; however, such reacting materials should be effective and should be properly arranged so that they clean exhaust gases which are channeled through them. Although some prior art dry-scrubber cleaning elements are effective enough, they often are not practical because they employ expensive reacting materials. It is, therefore, yet another object of this invention to provide a dry-scrubber type cleaning element which is effective but yet employs inexpensive reacting materials.

Most internal combustion engines emit magnetic by-product pollutants. Few prior art exhaust cleaning devices take advantage of the "magnetic" characteristics of such pollutants to clean them from exhaust gases. It is, therefore, an object of this invention to provide an exhaust cleaning system which takes advantage of "magnetic" characteristics of some exhaust pollutants to clean such pollutants from an exhaust stream.

Many prior art exhaust wet-scrubber cleaning elements are arranged so that an exhaust stream blows

directly into a liquid. Such an arrangement is often unsatisfactory because it tends to back up an exhaust stream and, thereby, stalls an engine in the same manner as a car engine is stalled when the car is driven through a deep mud puddle. It is, therefore, another object of this invention to provide a wet-scrubber cleaning element which is not arranged so that an exhaust stream blows directly into a liquid but is nevertheless effective.

SUMMARY OF THE INVENTION

According to the principles of this invention, an exhaust cleaning system has three types of cleaning elements — a dry-scrubber cleaning element, a wet-scrubber cleaning element and a filter cleaning element — connected in series, each element being separate from the others. Cleaning members in each of the cleaning elements can be easily removed and replaced individually.

The dry-scrubber exhaust cleaning element comprises a plurality of elongated exhaust cleaning insert tubes and an insert pipe located in a muffler housing. The insert tubes and the insert pipe are attached at their front ends to a front muffler housing end plate by means of threaded sockets. The insert tubes and the insert pipe are supported at their rear ends by the sides of smooth bores in a rear muffler housing end plate. The elongated insert tubes and the insert pipe can be removed by unscrewing them from the threaded sockets and pulling them out of the muffler housing through the smooth bores in the rear end plate. The insert tubes and the insert pipe are perforate and contain inexpensive reacting materials. Electrodes and magnets are positioned in the muffler housing to help trap magnetic by-products of an exhaust stream.

The wet-scrubber cleaning element includes a liquid mixture of water and glycerol-glycol which is held in a sponge and which is in contact with a copper surface plate. A tank in which the liquid mixture is contained has a draining means for draining stale liquid from the tank and an access opening for refilling the tank. A squeezing device is mounted in the tank for squeezing the sponge when the tank is flushed. Exhaust gases are circulated above the copper surface plate.

The filter cleaning element comprises an impregnated perforate paper filter member contained in a filter housing. The filter housing has an access means through which the filter member is replaced.

DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the preferred embodiments of the invention, as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead is placed upon illustrating the principles of the invention in a clear manner.

FIG. 1 is a schematic representation of an exhaust cleaning system employing the principles of this invention;

FIG. 2 is a cutaway view as seen along a longitudinally bisecting plane of a combination muffler-dry-scrubber cleaning element employing the principles of this invention;

FIG. 3 is a cross-sectional view taken along line 3—3 in FIG. 2;

FIG. 4 is a cross-sectional view taken along line 4—4 in FIG. 2;

FIG. 5 is an isometric view of an alternative tube and pipe fastening means;

FIG. 6 is a cutaway view as seen along a longitudinally bisecting plane of a wet-scrubber cleaning element employing the principles of this invention;

FIG. 7 is a top cutaway view taken along line 7—7 in FIG. 6;

FIG. 8 is an enlarged isometric view of the outlet baffle which is designated in FIGS. 6 and 7 by numeral 70; and

FIG. 9 is another embodiment of a wet-scrubber cleaning element of this invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to FIG. 1 wherein an exhaust cleaning system employing the principles of this invention is shown, the exhaust cleaning system essentially comprises: a muffler-dry-scrubber cleaning element 11; a wet-scrubber cleaning element 13; and a filter cleaning element 15.

Exhaust gases are fed from an internal combustion engine (not shown) through a manifold pipe 17 to the muffler-dry-scrubber cleaning element 11. From there the gases flow through a muffler pipe 19 to the wet-scrubber cleaning element 13. From the cleaning element 13 the gases flow through a wet-scrubber element pipe 21 to the filter cleaning element 15. The exhaust gases are then released from the filter cleaning element 15 into surrounding atmosphere through an exhaust pipe 23.

Each of the exhaust cleaning elements 11, 13, and 15 functions in a different way to clean exhaust gases. Generally, the muffler-dry-scrubber cleaning element 11 is the main cleaning element and is backed up by the wet-scrubber cleaning element 13 and the filter cleaning element 15.

The muffler-dry-scrubber cleaning element 11 serves both to suppress engine noise and to absorb and to adsorb pollutants in exhaust gases. Its structure can best be understood by reference to FIG. 2 wherein is shown a side cutaway view of the muffler-dry-scrubber cleaning element 11 shown in FIG. 1. The muffler-dry-scrubber cleaning element shown in FIG. 2 comprises: a muffler housing 25 which includes a tubular portion 26, a front end plate 27, and a rear end plate 29; perforate insert tubes 31; a perforate center insert pipe 33; various reacting materials which will be described later; a collector pipe 49; an electric field circuit 32; and magnets 34.

The muffler housing 25 includes a tubular portion 26 which has a shape similar to that of a normal muffler, that is generally tubular, and is constructed of sheet stainless steel. The muffler housing 25 is closed at its front end by a machined stainless steel front end plate 27 which is welded or otherwise attached to the tubular portion 26. An entrance pipe 35 is an integral part of the front end plate 27 and forms an opening therethrough. An inner portion 38 of the entrance pipe 35 extends into the muffler housing 25 and is internally threaded for receiving a front end of the perforate center insert pipe 33. An outer portion 40 of the entrance pipe 35 extends away from the muffler housing

25 and is used to attach the muffler-dry-scrubber cleaning element 11 to the manifold pipe 17 with manifold pipe bolts 44. Six internally threaded sockets 36 (only two are shown in FIG. 2) are welded or otherwise attached to the inside of the front end plate 27 for receiving front ends of the perforate insert tubes 31. The sockets 36 are arranged in a circle, one every 60°.

The muffler housing 25 is closed at its rear end by a machined, stainless steel rear end plate 29 which is welded or otherwise attached to the tubular portion 26. The rear end plate 29 has six smooth-bore, flanged insert tube openings 37 arranged in a circle, one every 60° for receiving the perforate insert tubes 31 (See FIG. 3), and one smooth-bore center insert pipe opening 39 (FIG. 2) for receiving the perforate center insert or inlet pipe 33 and an associated center pipe plug 41. The insert tube openings 37 are arranged to line up with the sockets 36 and the center insert pipe opening 39 is arranged to line up with the internally threaded inner portion 38 of the entrance pipe 35. A rim 43 of the rear end plate 29 extends beyond the tubular portion 26 and has bolt holes 45 for receiving collector pipe bolts 47. A collector pipe 49 is attached to the rear end plate's rim 43 by the collector pipe bolts 47. The collector pipe 49 collects all of the exhaust gases passing through the muffler-dry-scrubber cleaning element 11 and channels them to the muffler pipe 19.

The perforate insert or outlet tubes 31 are mounted between the front and rear end plates 27 and 29. That is, front ends of the perforate insert tubes 31 have male threads which respectively engage the threaded sockets 36 and rear ends which are slidably supported in the smooth-bore flanged insert tube openings 37.

The perforated center insert pipe 33 is also mounted between the front and rear end plates. A front end of the perforate center insert pipe 33 has external threads which are engaged with the internally threaded inner portion 38 of the entrance pipe 35 and the rear end also has external threads which are engaged with the internally threaded center pipe plug 41. The center pipe plug 41 impinges on an outside surface of the rear end plate 29 and is tightly screwed onto the perforate center insert pipe 33 so that the perforate center insert pipe 33 is held firmly in the smooth center insert pipe opening 39.

FIG. 5 shows an alternate fastening means for fastening the insert tubes 31 and the center insert pipe 33 to the front end plate 27. The alternate fastening means comprises fastening pins 28, which are fixedly attached across the mouths of the sockets 36 and the inner portion 38, and T-shaped slots 30, which are cut in the front ends of the insert tubes 31 and the insert pipe 33. The alternate fastening means is engaged by manipulating an insert tube so that a fastening pin 28 is inserted into an upper crossed portion of the T-shaped slot.

The various reactive materials are located in the muffler-dry-scrubber cleaning element 11 as follows: the perforate center insert pipe 33 is filled with charcoal silica brick 51; the perforate insert tubes 31 are filled with a mixture 53 of ground glass, aluminum shavings, magnesium shavings, and stainless steel shavings; and the space between the perforate insert tubes 31 and the perforate center insert pipe 33 is filled with spun fiberglass 55 which contains hexachlorophene, a bacterial decontaminant and dust inhibitor. A wire basket 58 is mounted in the center insert pipe 33 to hold the charcoal silica brick and prevent it from being blown through the pores of the center insert pipe 33 by an exhaust stream.

The electric field circuit 32 comprises a grounded voltage source 46; six 3-inch electrodes 48 each of which are inserted into the back ends of separate perforate insert tubes 31 and held in that position by perforate insulating mounting means 50; and an insulated wire 52 which connects the voltage source 46 with each of the electrodes 48 (See FIG. 3).

The electric field circuit 32 establishes an electromagnetic field about the electrodes 48 which attracts and thereby retains magnetic by-products from exhaust streams. A conductive grounding tape 24 hangs from the muffler housing 25 to ground to drain off any electricity which is short-circuited from an electrode 48 to the muffler housing 25.

Magnets 34 are embedded in spun fiberglass 55 which is held in the collector pipe 49 by a perforate retainer screen 56. These magnets establish a magnetic field in the collector pipe 49 which attracts and retains magnetic by-products which the electric field allows to pass. A cross-sectional view of the magnets 34 is shown in FIG. 4.

Flow of exhaust gases through the muffler-dry-scrubber cleaning element 11 is shown in FIG. 2 by arrows as follows: exhaust gases flow from the manifold pipe 17 through the entrance pipe 35 into the perforate center insert pipe 33 which contains charcoal silica brick 51. The exhaust gases then flow along the perforate center insert pipe 33 until finding pores in the outer surface of the perforate center insert pipe 33; at which point the exhaust gases flow out of the pores into a space between the perforate insert tubes 31 and the perforate center insert pipe 33, which space contains fiberglass. The exhaust gases then find pores in the outer surfaces of the perforate insert tubes 31 and flow through these pores into the perforate insert tubes 31, wherein the mixture 53 (described above) is contained. Exhaust gases flow along the perforate insert tubes 31 to the right, as seen in FIG. 2, until they flow out of the rear ends of the tubes through slots 99 into the collector pipe 49. It can be understood from this that most of the exhaust gases maintain contact with the charcoal silica brick 51 in the perforate center insert pipe 33 over a relatively long distance of travel and also maintain contact with the mixture 55 of ground glass, aluminum shavings, magnesium shavings, and stainless steel shavings in the perforate insert tubes 31 over a relatively long distance of travel.

The charcoal silica brick 51 in the perforate center insert pipe 33 and the mixture 53 in the perforate insert tubes 31 normally become saturated after a period of use and, therefore, must be replaced. These members are replaced by first removing the collector pipe 49 by unfastening the collector pipe bolts 47. The rear ends of the perforate insert tubes 31 extend outside the rear end plate 29 and can, therefore, be gripped and rotated so that the front threaded ends of the perforate insert tubes are disengaged from the threaded sockets 36. Once the perforate insert tubes 31 are disengaged from the threaded sockets 36, they can be slid to the rear out through the smooth-bore flanged insert tube openings 37. This procedure is reversed to mount new perforate

insert tubes 31 in the muffler housing 25. The perforate center insert pipe 33 is similarly removed by first unscrewing the center pipe plug 41 and then unscrewing the perforate center insert pipe 33 from the inner portion 38 of entrance pipe 35. The perforate center insert pipe 33 can then be pulled out through the smooth-bore center insert pipe opening 39.

It will be understood by those skilled in the art that the above described muffler-dry-scrubber cleaning element 11 is relatively inexpensive to construct and relatively economical to service. Further, it is effective both as a noise supressor and as a pollutant cleaner.

The wet-scrubber cleaning element 13 (FIG. 1) serves to trap pollutants which are not cleaned out of exhaust gases by the muffler-dry-scrubber cleaning element 11. Its structure can best be understood by reference to FIGS. 6 and 7.

The fluid cleaning element 13 is made up of: a tank 57 having an access cover 59 which is mounted on hinges 60; sponges 61 which are saturated with a liquid agent 54; two inlet nozzles 63 (only one can be seen in FIG. 5); spun fiberglass packing 62 which is mounted in the access cover 59; a sponge squeezer 64 which is slidably mounted in the bottom of the tank 57; and a perforate copper plate 66 which is in contact with the top surface of the saturated sponges 61.

In one embodiment, the tank 57 is made of water-proof exterior plyboard covered with a layer of fiberglass, however, in another embodiment, it is constructed of molded plastic.

The sponges 61 prevent the liquid agent 54 from splashing. In the preferred embodiment, the liquid agent 54 is water mixed with one-fourth volume of glycerol-glycol, which prevents freezing.

In the illustrated embodiment, exhaust gases flow into a copper inlet pipe 68 which is embedded in the sponges 61 saturated with a liquid agent 54. The copper inlet pipe 68 channels exhaust gases to the two nozzles 63 which blow the exhaust gases into a gaseous area of the tank 57 which is located above the saturated sponges 61. The two nozzles 63 are covered by all-weather valves 72 which prevent moisture from being sucked into the nozzles 63 but yet allow exhaust gases to be blown out of the nozzles 63 into the tank 57. The gaseous area includes the area defined by the access cover 59, which is filled with spun fiberglass packing 62, and a small open area located between the perforate copper plate 66 and the spun fiberglass packing 62.

The gaseous area normally contains gaseous moisture which has evaporated from the liquid agent. The gaseous moisture is in a continuous state of evaporation-condensation balance. That is, as moisture evaporates from the liquid agent, an almost equal amount of moisture is condensed back into water.

When exhaust gases mix with the above-mentioned gaseous moisture in the gaseous area, the gaseous moisture tends to trap some pollutants in the exhaust gases. In this regard, when moisture which has trapped pollutants is condensed back with the liquid agent in the sponges 61, the thusly trapped pollutants are also carried into the liquid agent and are held there.

The exhaust stream flows out of the gaseous area through an outlet 67. An outlet baffle 70 which is located in front of the outlet 67, prevents liquid agent from flowing through the outlet 67 but allows exhaust gases to flow out of the outlet, as is shown by an arrow in FIG. 6.

The outlet baffle 70 can be seen in more detail in FIG. 8 wherein is shown an isometric view of an enlarged outlet baffle 70. The outlet baffle 70 has a flanged outer edge 71, which is secured to the inner surface of the tank 57 by rivets 78, and baffle outlet openings 73, through which exhaust gases flow when they are discharged from the tank 57.

If gaseous moisture flows out of the outlet 67, this has a cooling effect on the fluid cleaning element and thereby causes more condensation of gaseous moisture. In this respect, in another embodiment, cool air is channeled from a car air conditioning unit into the tanks in order to enhance cooling of the exhaust gases.

It should be noted that some exhaust gases which are circulating in the gaseous area come into direct contact with the liquid agent in the sponges 61 and thereby transfer pollutants directly to the liquid agent.

A dashboard mounted indicator 69 (FIG. 1) provides information as to whether or not more liquid agent 54 must be added to the sponges 61. Fresh liquid agent may be added through an access covered by the access cover 59. Stale liquid agent is removed from the tank 57 by removing a plug 74 from a drain. A wire sieve 80 prevents sponges 61 from clogging the drain. Stale liquid agent 54 is flushed out of the sponges 61 by pulling downwardly on a squeezer handle 82 which, in turn, forces a squeezer head 84 downwardly against sponges 61; the sponges 61 are thereby squeezed and discharged stale liquid agent 54.

An alternate embodiment of the wet-scrubber cleaning element is shown in FIG. 9. In the alternate embodiment, an inlet pipe 75 blows through a nozzle 77 directly into liquid agent saturated sponges 61. The nozzle 77 has an all-weather valve 72 mounted on it. The stream of exhaust gases discharged from the nozzle 77 is directed toward a sheet of asbestos 79 which covers a layer of copper 81, which, in turn, is mounted on the inner surface of the tank 57. An outlet baffle 70, which is shown in greater detail in FIG. 8 and which is described above, covers an outlet opening 83 and thereby prevents liquid from splashing through the outlet opening 83. Stale liquid agent is removed using a plug 74 and fresh liquid agent may be added through an access door 76.

The filter cleaning element 15 serves to catch solid particles remaining in the exhaust gases after they have passed through the muffler-dry-scrubber cleaning element 11 and the wet-scrubber cleaning element 13.

Referring to FIG. 1, the filter cleaning element 15 comprises: a hollow filter housing 85 having a filter inlet 87; a filter outlet 89; an access door 91 hinged on a piano type hinge 93; and a removable filter 95 (shown by dashed lines) which is positioned in said hollow filter housing 85 so that all exhaust gases entering the hollow filter housing 85 through the filter inlet 87 must go through the removable filter 95 before leaving the hollow filter housing 85 through the filter outlet 89. In the preferred embodiment, the hollow filter housing 85 is fabricated of carbon steel and has generally a block shape. The removable filter 95 is a multiple-fold, heavy, impregnated, perforate, paper filter in the illustrated embodiment; however, in another embodiment, the removable filter comprises spun fiberglass.

The removable filter **95** can easily be replaced by opening the access door **91**, taking out an old filter **95** and replacing it with a new filter **95**.

It can be seen in FIG. **1** that exhaust gases pass firstly through the muffler-dry-scrubber cleaning element **11**, secondly through the wet-scrubber cleaning element **13**, and thirdly, through the filter cleaning element **15**. Employing principles based on absorbtion and adsorbtion, the muffler-dry-scrubber cleaning element **11** cleans exhaust gases of fumes, magnetic by-products, carbon-monoxide and other gases and solid wastes formed by engines, especially it cleans out complexes formed by incomplete burning of many additives in gasoline. The wet-scrubber cleaning element **13** traps and suspends pollutants remaining in exhaust gases after they have been through the muffler-dry-scrubber cleaning element **11**. The filter cleaning element **15** picks up particles remaining in exhaust gases after they have been through the wet-scrubber cleaning element **13**. The three cleaning elements **11–15** compliment one another because each functions differently and, therefore, cleans out somewhat different pollutants from the exhaust gases.

The cleaning members of each of the cleaning elements can be individually, relatively easily, replaced, therefore making the system both practical and economical.

The advantage of the exhaust cleaning system herein disclosed is economical, in both labor and money, to install and maintain.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail can be made without departing from the spirit and scope of the invention. For example, the order in which the various cleaning elements are connected in series may be varied from the order disclosed above. Also, in another embodiment of the muffler-dry-scrubber, the insert tubes and the insert pipe are removable through smooth bore openings which are located in the front of the muffler housing.

The embodiments of the invention in which an exclusive property or privilege is claimed as defined as follows:

1. A dry-scrubber element for cleaning pollutants from the exhaust gases of an engine comprising: an elongated outer housing closed at opposite ends and defining a long axis; an elongated inlet tube carried by and substantially centrally disposed within said housing and extending in a direction generally parallel to said long axis, said housing and said inlet tube defining a chamber therebetween; said inlet tube having a plurality of apertures spaced axially therealong and having an inlet at an end thereof adjacent one end of said housing for receiving the gases exhausting from the engine for flow through said inlet tube and through said apertures into said chamber, said inlet tube being closed but for said apertures and said inlet; a plurality of outlet tubes carried by said housing and disposed in said chamber, said outlet tubes being circumferentially spaced one from the other about said inlet tube and extending in a direction generally parallel to said long axis, said inlet tube and said outlet tubes being substantially coextensive in length with said housing and extending between the opposite ends thereof, said outlet tubes having a plurality of apertures spaced axially therealong for transmitting exhaust gases from said chamber into said outlet tubes, each of said outlet tubes having an opening at one end thereof adjacent the opposite end of said housing and defining an outlet for exhausting the gases therefrom whereby the stream of exhaust gases flows through said inlet, at least part of said inlet tube, said chamber, at least part of one of said outlet tubes, and the outlet of said one tube during its passage from the one end of said housing to its opposite end, each of said inlet tube, said chamber, and said outlet tubes containing material for cleaning pollutants from the exhaust gas stream as the latter flows through said housing.

2. An element according to claim **1** including an electrode in each of said outlet tubes, and means for applying an electrical potential to said electrodes thereby establishing an electrical field about the electrodes and through which field the stream of gases flows.

3. An element according to claim **1** including a magnet carried by said housing, said magnet being located to establish a magnetic field through which the stream of gases flows as it passes through said housing.

4. An element according to claim **1** wherein one of said inlet tube and said outlet tubes contains charcoal silica brick, the other of said inlet tube and said outlet tubes containing a mixture of ground glass, aluminum shavings, magnesium shavings, and stainless steel shavings.

5. An element according to claim **4** including a fiberglass material in said chamber between said inlet tube and said outlet tubes.

6. An element according to claim **1** wherein said inlet tube contains charcoal silica brick; said outlet tubes containing a mixture of ground glass, aluminum shavings, magnesium shavings, and stainless steel shavings; a fiberglass material in said chamber between said inlet tube and said outlet tubes, an electrode in each of said outlet tubes adjacent the ends thereof which exhaust the gases from said housing, means for applying electrical potential to said electrodes thereby establishing an electrical field about the electrodes and through which field the stream of gases flow, means for collecting the gases exhausting from said outlet tubes, a magnet carried by said collecting means for establishing a magnetic field through which the stream of gases flow.

7. An element according to claim **6** in combination with a wet scrubber for cleaning pollutants from the exhaust gases discharged from said dry scrubber element, means carried by said housing for collecting the gases exhausting from said dry scrubber element and channelling the same into said wet scrubber.

8. A dry scrubber element according to claim **1** in combination with a wet scrubber element comprised of a tank having an inlet for receiving the exhaust gases discharged from said outlet tubes and an outlet for discharging exhaust gases from said wet scrubber; a liquid agent occupying a portion of said tank and having an upper surface; means connecting said dry scrubber element and said wet scrubber element such that the exhaust gases are discharged into said wet scrubber element at a level above the upper surface of said liquid agent in said tank; and a splash inhibiting means in said liquid agent for preventing the liquid agent from splashing.

9. The apparatus according to claim 8 including a separate porous filter element having pores for collecting solid particles remaining in the exhaust gases after passage through the dry and wet scrubbing elements, and means coupling the filter element and said wet scrubber element for communicating the gases from said wet scrubber element into said filter element.

10. An element according to claim 1 wherein said housing has opposite end walls, a plurality of openings in one of said end walls for slidably receiving said inlet tube and said outlet tubes, and means cooperable with the other housing end wall and with like ends of said inlet tube and said outlet tubes for releasably retaining the latter within said housing whereby said tubes are selectively removable from said housing through the openings in said one housing wall.

11. An element according to claim 10 wherein said retaining means comprise rotationally responsive means for releasably retaining said inlet tube and said outlet tubes in said housing in response to rotation of said inlet tube and said outlet tubes.

12. An element according to claim 11 wherein said rotationally responsive means comprise threads on the ends of said inlet tube and said outlet tubes.

13. An element according to claim 11 wherein said rotationally responsive means comprise pins which match with slots in said tubes.

14. An exhaust cleaning system of the type used for cleaning pollutants from the exhaust gases of an engine comprising:

a separate dry scrubber element for adsorbing and absorbing air pollutants; said dry scrubber element means including means for flowing the exhaust gases through a plurality of serially arranged zones of pollutant cleaning materials, one zone of materials comprising charcoal silica brick, another zone including ground glass and shavings of magnesium, aluminum and stainless steel, and an intermediate zone including a fiberglass material;

a separate wet scrubber element means for trapping air pollutants in a fluid;

a separate porous filter element means having pores of such size as to allow passage of some gases but to prevent passage of some particles;

means connecting between said dry scrubber element means, said wet scrubber element means and said filler element means for serially channelling the exhaust gases of said engine through said separate dry scrubber element means, said separate wet scrubber element means, and said separate filter element means.

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