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APPARATUS FOR THE TREATMENT OF EXHAUST GASES

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2 Sheets-Sheet 1

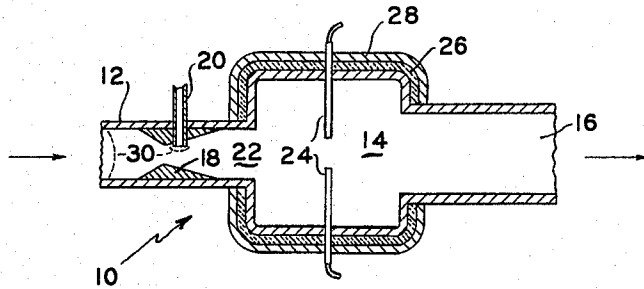


Fig. 1

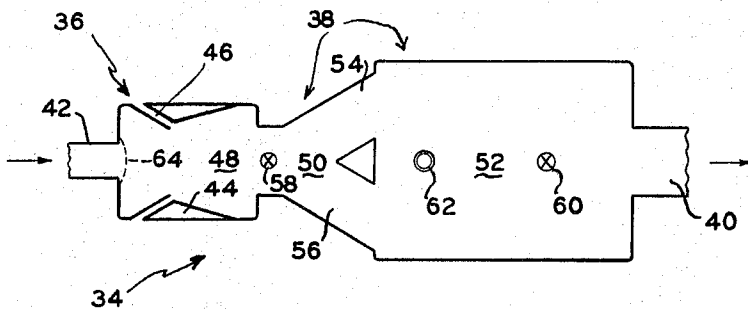


Fig. 2

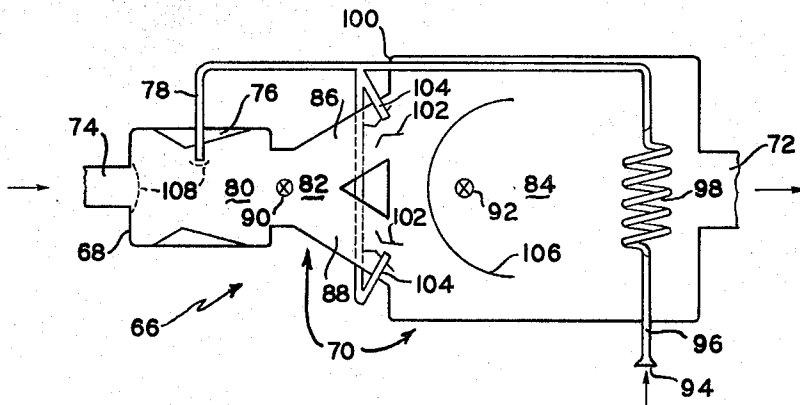


Fig. 3

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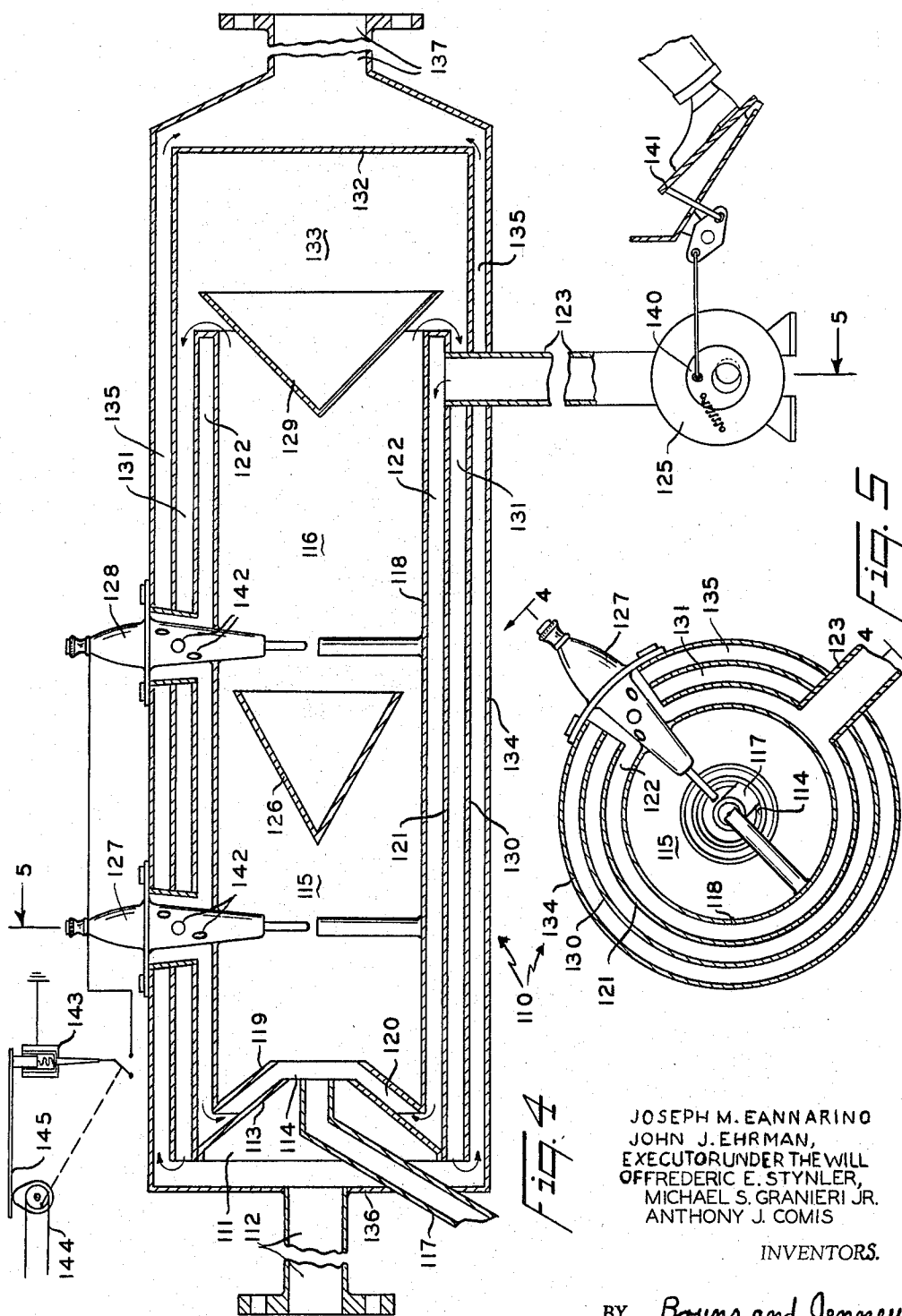
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2 Sheets-Sheet 2



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APPARATUS FOR THE TREATMENT OF EXHAUST GASES

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11 Claims. (Cl. 23-277)

This invention is a continuation-in-part of copending application Serial No. 154,573, filed November 24, 1961, by the same inventors and now abandoned. The invention relates generally to the treatment of combustion exhaust gases, and is particularly directed toward a novel method and apparatus for the oxidation of internal combustion engine exhaust gases by ignition induced direct flame afterburning.

For many years it has been known that exhaust gases from internal combustion engines contain air contaminants which consist primarily of carbon monoxide and various hydrocarbons present both as unburned fuel and as combustion products. Internal combustion engines have been suspected since at least as early as 1951 of being one of the contributors to air pollution in large cities. The contention, voiced as recently as 1956, that the automobile is only one of the principal sources is no longer tenable since it has now been established beyond any doubt that motor vehicles are the largest contributors to air pollution in cities having heavy traffic such as Los Angeles.

Studies by the Los Angeles County Air Pollution Control District indicate that automobile operation accounts for more than 80% of the total hydrocarbon emissions, the engine exhaust contributing approximately 50% and external venting from the crankcase contributing approximately 25%. The amount of carbon monoxide from internal combustion engine-exhaust gases ranges from as high as 10% under engine idling and deceleration conditions down to ½% when the engine is operated under load and/or high speeds. Hydrocarbons emitted through the exhaust manifold during deceleration constitute a major portion of the total exhaust.

Many approaches to reducing harmful exhaust emissions from automobiles have been suggested but few appear practical. Changing the nature of the fuel has been proposed, but this would have but an insignificant effect on reducing smog contributing emissions. Changing engine design to increase combustion efficiency has also been suggested, but for the degree of improvement required, engines would have to be changed drastically.

Since the highest concentration of unburned hydrocarbons is present in the exhaust gases during deceleration, a number of devices have been proposed to counteract their emission during this particular condition. Some of these proposed devices are deceleration fuel shut-offs, vacuum breakers and vacuum limiters. However, at best, these devices would suppress only 38% of the hydrocarbons.

The most direct and promising approach to the problem of air contamination by internal combustion engines appears to be treatment of the exhaust gases with purifiers or afterburners. Purifiers for exhaust gases are in general impractical because they are too bulky, complicated and difficult to operate satisfactorily. Afterburners which perform effectively are of two basic types. These are (1) the catalytic type in which the harmful exhaust components are destroyed or substantially destroyed by the oxidizing action of a suitable catalyst, and (2) the direct flame type in which the exhaust gases are ignited and

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burn to carbon dioxide and water. Some of the known disadvantages of the catalytic type are that the catalyst can be poisoned by lead in the fuel thus destroying its effectiveness; catalytic burning may stop at engine idling because the temperature of the exhaust falls below the threshold activation temperature of the catalyst; and catalytic burning action may stop during prolonged downhill driving when relatively cool "raw" gasoline tends to be discharged into the exhaust manifold. Other disadvantages of the catalytic type afterburner are that there may be increased back pressure to the engine due to shifting and packing of the catalyst; gas composition is a problem because if the air-fuel ratio is abnormally low, or the engine is in poor mechanical condition, an abnormally high concentration of oxidizable material is exhausted from the engine resulting in fusion of lead compound on the catalyst surface; and to start catalytic action, most catalysts require preheating by passing an electric current through the catalyst mass.

Most direct flame afterburners are of two basic types. These are the direct flame type using air preheated to a fairly high temperature by an external auxiliary flame, and the direct flame type requiring auxiliary fuel to produce a flame used for secondary ignition of the exhaust gases. The direct flame afterburner of the present invention differs materially from both of these basic types in that electrical ignition is used and neither preheated air nor auxiliary fuel is necessary for successful operation.

In accordance with the invention, the exhaust gases are effectively burned by means of primary burning. As will be explained more fully hereinafter, this is accomplished by carefully channelling the gases and controlling the concentration thereof, and the process can be carried out in a properly designed air intake device which includes flow constricting means and means for admitting outside air containing the necessary amount of oxygen for primary burning. After thorough mixing in a chamber or chambers, the air-exhaust gas mixture is ignited by an electrical discharge.

When an apparatus of the type contemplated by the invention is connected to the exhaust manifold of an internal combustion engine, the carbon monoxide, hydrocarbons and other burnable gases will be burned effectively under a wide range of engine speeds. The primary electro-ignition process has several variations dependent upon the type of engine with which the apparatus is used. It can be a single or multiple primary ignition system. Both types are approximately equal in burning efficiency. With certain types of engines, multiple ignition is more efficient at higher speeds. In one variation of the invention, multiple ignition is employed in a step process, there being successive ignitions in progressively larger combustion chambers. The sizes, progressions and number of chambers can vary with the application. In all cases, the igniter is supplied with high voltage from any of a number of sources such as the automobile high voltage system, an auxiliary induction coil, a piezo-electric source, or the like.

With the foregoing and other considerations in view, it can be stated that the principal object of the present invention is to provide an electrical ignition direct flame type of afterburner and method wherein combustion exhaust gases can be effectively burned by means of primary burning, neither preheated air nor auxiliary fuel being necessary to initiate or maintain the burning process.

Another important object of the invention is to provide a direct flame type of afterburner and method which will effectively burn the exhaust gases of an internal combustion engine under all operating conditions of the engine including idling and deceleration.

A further important object of the invention is to provide a direct flame type of afterburner which is designed

so that it can be safely insulated against the transfer of dangerously high heat to adjacent structure.

Still another important object of the invention is to provide a direct flame type of afterburner which can be readily adapted to burn the exhaust gases of a number of different types of internal combustion engines.

A still further important object of the invention is to provide a direct flame type of afterburner having a sufficiently simple and economical construction as to render it practical for use on any type of motor vehicle.

Still another important object of the invention is to provide a direct flame type of afterburner which is relatively compact and light weight and will require minimum maintenance.

Other objects and advantages of the invention will become apparent from the following detailed description read in conjunction with the accompanying drawings which illustrate representative embodiments of the invention for the purpose of disclosure.

In the drawings:

FIGURE 1 is a semi-diagrammatic longitudinal section through one form of afterburner embodying the invention;

FIGURE 2 is a schematic illustration of another form of afterburner embodying the invention;

FIGURE 3 is a schematic illustration of a modified form of the afterburner of FIGURE 2;

FIGURE 4 is a semi-diagrammatic sectional view on the line 4—4 of FIGURE 5 of another form of afterburner embodying the invention; and

FIGURE 5 is a sectional view on the line 5—5 of FIGURE 4.

Having specific reference now to the drawings, and with particular reference to FIGURE 1, 10 generally indicates an afterburner apparatus which is particularly adapted for use with small or relatively low horsepower internal combustion engines.

Afterburner 10 is essentially comprised of an inlet conduit or passage 12, an enclosed combustion area or chamber 14 and an outlet conduit or passage 16. The inlet conduit 12 is adapted to be suitably connected to the exhaust manifold of the engine so as to receive the exhaust gas stream therefrom.

In accordance with the invention, the inlet conduit 12 is provided with flow constricting means 18 which may be in form of a venturi as shown whereby a low pressure point or area is created in the exhaust gas stream directly adjacent the downstream side of the venturi throat. Means such as a smaller conduit 20 communicate with the intake conduit at this low pressure point for introducing outside air into the gas stream, the reduced pressure causing air entering into the conduit or inspirator tube 20 from an outside source to be sucked into the intake conduit 12 and added to the exhaust gas stream passing therethrough.

The outside air and exhaust gases are mixed in a mixing area 22 forming a part of the intake conduit downstream from the flow constricting means 18, and then expand into the combustion chamber 14 where further mixing takes place. The air-exhaust gas mixture is ignited in the combustion chamber by a high voltage, low-amperage electrical discharge, the discharge being provided by electrodes 24 as shown, or by any other suitable means which can be connected to the high voltage ignition system of the engine, to an auxiliary induction coil or to a piezo-electric source. It is also contemplated that the electrical energy for the ignition means be derived from a plurality of thermocouples located in the combustion chamber or chambers, whereby normally wasted heat is utilized to provide a self-contained electrical system. The burning process converts the engine exhaust gases to carbon dioxide and other non-objectionable compounds which leave the combustion chamber through the outlet conduit 16. Conduit 16 can be con-

nected to an exhaust muffler and/or exhaust pipe, or to an expansion chamber and exhaust pipe.

Since high temperatures are developed in combustion chamber 14, the chamber is preferably constructed of a heat resistant material such as stainless steel or a ceramic, and the chamber is completely enclosed by a layer of insulation 26 which is held in place by a jacket 28 of a suitable light gauge metal. Insulation may also be provided as necessary for the outlet conduit 16 although not illustrated in the drawings. As a safety precaution, the burning gases are prevented from propagating back towards the engine or into the inspirator tube 20 by means of a Davis or similar type fine wire mesh 30 as indicated in the drawings.

Burning of the air-exhaust gas mixture takes place in the afterburner described above, without adding auxiliary fuel or preheating the air, because of the manner in which the gases are channelled and their concentration controlled. This may be accomplished by the proper proportioning of the device and by the location of the flow constricting means 18 and the ignition means 24. Thus the flow constricting means or venturi 18 changes the concentration of the exhaust gases by modifying the rate of flow and this causes the outside air to be added through the tube 20. Thereafter, these gases expand and mix in the mixing area and then further expand and mix in the combustion chamber 14 where they are ignited by the ignition means. The location of the latter is therefore governed by both the air intake and by the mixing action of the gases, the ignition means preferably being located at a point close to the air intake where thorough mixing of the gases has occurred.

It should also be noted that successful ignition and burning is aided by the use of an electrical discharge for the ignition means. It is a well known fact that an electrical discharge in air creates a small amount of ozone which provides heat energy that is very conducive to burning. Thus as stated by E. Briner of the University of Geneva, Switzerland: "On replacing oxygen by ozone in the oxidation one obtains for the activation energy of the autoxidation reaction a supplementary energy—namely, the oxidation energy liberated when ozone transforms into oxygen, 34 kcal. per gram-mole of ozone. Expressed differently, the reaction chains induced by ozone would then be of an energy type The more completely the ozone molecule is surrounded by the oxygen molecules—i.e., the higher the concentration of oxygen molecules with respect to ozone molecules the better the supplementary energy is utilized." From "Ozone Chemistry and Technology," published March 1959 by the American Chemical Society, page 193.

Example

An afterburner of the configuration shown in FIGURE 1 was constructed and tested. In this afterburner the cross sectional area of the combustion chamber was approximately three times the cross sectional area of the inlet conduit and approximately twice the cross sectional area of the outlet conduit. The ignition means was located at the approximate longitudinal mid-point of the combustion chamber, at a point close to the air intake where thorough gas mixing occurs. Tests were conducted using a Clinton 3¼ H.P. 4-cycle lawnmower type engine. The inlet conduit was connected directly to the exhaust manifold of the engine and the outlet conduit was connected to a suitable exhaust muffler. The ignition means received its high voltage from the engine's high voltage source in one series of tests, and from an external high voltage source in other tests. Burning of the exhaust gases was present and observed in the combustion chamber under conditions of idling, acceleration, deceleration and constant speed. All of these tests and observations were made with the engine under load and no load conditions.

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Reference is now made to FIGURE 2 wherein a multiple chamber afterburner of the above mentioned type is schematically illustrated, the afterburner shown being particularly adapted for use with a conventional automobile engine. The afterburner, generally indicated at 34, is once again essentially comprised of an intake conduit or passage 36, a combustion area 38 and an outlet conduit 40. The inlet portion 36 of the afterburner is adapted to be suitably connected as by a conduit 42 to the exhaust manifold of the engine so as to receive the exhaust gas stream therefrom.

The inlet conduit or portion 36 acts as an expansion chamber and is provided with flow constricting means 44 and an outside air intake or inspirator 46 which operate in the manner previously described. Downstream from the flow constricting means, the inlet portion includes a primary mixing area 48. In this form of the invention, the combustion area 38 comprises two chambers 50, 52 connected by branch ducts 54, 56 which may diverge in the downstream direction as shown. Ignition means such as spark plugs 58, 60 are provided in the chambers 50, 52 respectively.

With this arrangement, the exhaust gases from the engine manifold enter the inlet portion 36 through the conduit 42. They expand upon entering and are mixed with outside air admitted through the air intake 46. Mixing of the gases occurs in the area 48 and as the gases leave this area they are ignited by the ignition means 58. The gases burn in the chamber 50 and in the branch ducts 54, 56. During idling, low speed cruising and deceleration, the burning process takes place in and is predominantly confined to the chamber 50 and ducts 54, 56. At higher speeds, the volume of the exhaust gases from the engine increases rapidly and the gases travel at a much higher velocity. The burning process is then no longer completely restricted to areas 50, 54 and 56, but some amount advances to chamber 52. There the mixture of partially burned exhaust gases, unburned exhaust gases, and air from air intake 46 receive additional outside air through an air intake 62 which can be arranged to coact with flow constricting means (not shown) or can be introduced into the chamber under pressure. Another electrical discharge is provided by means of spark plug 60 in the chamber 52, and the gas mixture containing burned gases, unburned gases, nitrogen and oxygen from the air intake surrounds the electrical discharge. As described above, the oxygen molecules surround the few ozone molecules created by the electrical discharge and are activated to higher energy levels in the autoxidation process. This assures the complete burning of the remaining unburned gases. The stream of gas leaving chamber 52 through the outlet conduit 40 is now composed of nitrogen, carbon dioxide and under some conditions, unused reconstituted oxygen. This gas mixture may enter into the ambient air directly through conduit 40 or, in the case of an automobile system, through the muffler and tailpipe.

While not shown in the schematic illustration of FIGURE 2, the combustion area 38 including chambers 50 and 52 and ducts 54, 56 will be provided with suitable insulation against heat transfer as shown and described in connection with the embodiment of FIGURE 1. Likewise, the outlet conduit 40 may be insulated as necessary. The embodiment illustrated in FIGURE 2 will also be provided with fine wire mesh 64 at the intake conduit and air intake 46 to prevent upstream propagation of the burning gases.

FIGURE 3 schematically illustrates a variation of the afterburner of FIGURE 2. Here again, the afterburner which is generally indicated at 66 is essentially comprised of an inlet conduit or passage 68, a combustion area 70 and an outlet conduit 72. The inlet conduit is adapted to be suitably connected by a conduit 74 to the exhaust manifold of the engine and is provided with flow constrict-

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ing means 76 and an outside air intake or inspirator tube 78, all as previously described.

The inlet conduit or portion 68 acts as an expansion chamber and includes a mixing area 80 downstream from the flow constricting means 76. The combustion area 70 comprises the chambers 82 and 84 connected by branch ducts 86, 88 and ignition means such as spark plugs 90, 92 are provided for the chambers.

In this variation of the invention, the outside air may be preheated by heat from the combustion chamber 84, the intake tube 78 forming a part of a tube 94 which enters the chamber at 96, is formed into a coil or the like at 98 and leaves the chamber at 100. The preheated air, of course, provides additional energy to enhance the burning process although no external or auxiliary means are used for preheating.

As in the afterburner of FIGURE 2, the air and exhaust gases are mixed in mixing area 80, ignited by ignition means 90 and burned in chamber 82 and ducts 86, 88. As previously described, a complete burning process is initiated during idling of the engine, low cruising speeds and deceleration, in the case of an automobile. At acceleration and high speeds the volume and velocity of the exhaust gases increases and some of the burning advances to the secondary combustion chamber 84.

In FIGURE 3 arrangement, the ducts 86, 88 are provided with flow constricting means 102 adjacent the downstream ends of the ducts and inspirator tubes 104 are provided to introduce preheated air at the low pressure points created by the constricting means 102. As shown, the tubes 104 are connected to the tube 94 which passes through the combustion chamber 84. Depending upon the type of engine used, thorough mixing can be attained by the use of a baffle 106 in the chamber 84, the ignition means 92 being located at the optimum point relative to the baffle.

As an example of an operable embodiment of the afterburner arrangement illustrated in FIGURES 2 and 3, an apparatus with the following approximate proportions has been developed for a 115 horsepower automobile motor. In this afterburner, the cross sectional area of the primary combustion chamber 82 is approximately equal to that of each of the ducts 86 and 88; the cross sectional area of the secondary combustion chamber 84 is approximately three and one-half times the cross sectional area of the ducts 86 and 88; the length of the secondary combustion chamber 84 is approximately one and one-third times its diameter or width; and the cross sectional area of the secondary combustion chamber 84 is approximately three times that of the outlet conduit 72.

FIGURES 4 and 5 schematically illustrate another variation of the afterburner of FIGURE 2 in which preheating of the outside air taken into the combustion chamber is provided for. The afterburner generally indicated at 110, has an inlet portion 111 which is adapted to be connected by a conduit 112 to the exhaust manifold of the engine. A funnel-shaped flow-constricting means 113 is provided at the downstream end of the portion 111 and a central constricted passage 114 leads to successive combustion areas 115 and 116 of the combustion chamber.

A "blow-by" tube 117 is provided leading to the engine "breather" device, not shown, for conducting air and crankcase fumes to the afterburner, the exhaust end of tube 117 being centered in the passage 114.

The sidewalls of 118 of the combustion areas 115 and 116 are formed of a heat-resistant and heat conductive material such as stainless steel and the intake end of area 115 is provided with a funnel-shaped end wall 119 parallel to the constricting means 113 forming an annular air inlet passage 120 opening into passage 114. A second stainless steel sidewall 121, connected at its upstream end to the constricting means 113 and to the sidewall 118 at the other end, forms, with sidewall 118, an air supply passage 122 completely around the combustion areas 115

and 116. An air supply tube 123 at the downstream end of the afterburner leads from a source of air under pressure 125 to the passage 122.

A first baffle 126 supported by means not shown, from the sidewall, 118 flares outwardly for mixing air and exhaust gases and for directing the hot gases outwardly toward the sidewall 118. Baffle 126 separates the combustion areas 115 and 116, and an igniter 127 is provided, having its electrodes at the center of chamber 115.

A second igniter 128 is provided in area 116, and has its electrodes at the center of but downstream from, the baffle 126, and is nearer to this baffle than the second outwardly flaring baffle 129 at the downstream end of the area 116.

Outward of the sidewall 121, the afterburner 110 is provided with a double-walled, heat-exchanger arrangement, the inner sidewall 130 of which surrounds and is spaced from the sidewall 121, forming an exhaust passage 131 therewith. A closure 132, at the downstream end of sidewall 130, forms an exhaust pressure chamber 133 downstream of baffle 129 for forcing the exhaust gases counter to the flow through the combustion areas back through the exhaust passage 131, as indicated by arrows in FIGURE 4.

The outer sidewall 134 of the heat-exchanger arrangement forms the outer layer of the afterburner, and surrounds and is spaced from the sidewall 130 to form the second exhaust passage 135. The upstream end of the sidewall is closed at 136, but spaced from sidewall 130, so that passage 131 communicates with the passage 135 at this end. The other end of the outer wall 134 is closed, so as to form a connection with an outlet conduit 137 in communication with the exhaust passage 135.

Sidewall 118 is preferably insulated, to contain the thermal energy released by the combustion process. The wall 121, between the air passage 122 and exhaust passage 131, is heat-conductive for maximum heating of incoming air, and outer walls 130 and 134 are preferably insulated to prevent high temperature radiation.

Ambient air is introduced into the afterburner 110 at the passage 114, as described above, through the projecting tube 123 from a blower, venturi, or pump 125 as shown in FIGURE 4, driven by the internal combustion engine. Metering means is preferably provided for the air supply. Coarse metering is accomplished by a pump drive that varies with the speed of the internal combustion engine. Fine metering can be accomplished by a vari-coupler or an air control valve connected to the engine control means and air from the fine metering means may be introduced either through tube 117 or through tube 123. The latter is preferred, however, so that all the air may be preheated.

A fine metering device is diagrammatically shown in FIGURE 4 comprising an air control valve 140 connected to the accelerator mechanism 141 of an automobile. Fine metering can be further enhanced for idling speeds by electrical or other control means operated by temperature sensing means, not shown, provided in the afterburner 110.

Igniters 127 and 128 may be of the spark plug type, or, as shown in FIGURES 4 and 5, have separate grounded electrodes. It will be noted that the igniters are secured in wells and cooled by the stream of incoming air in passage 122. Ports 142 may be provided in the ceramic portion of the electrodes so that the air coolant may come in contact with the electrodes themselves.

The source of electrical current for the igniters 127 and 128 is preferably of a type delivering high voltage capable of capacitive discharge, such as the piezo-electric source 143 shown diagrammatically in FIGURE 4. Driven from the fan belt 144 or other rotating part of the engine, so as to periodically move the actuating arm 145, it imposes no load on the automotive battery, and provides quick ignition when the engine is cold. Because of its

capacitive discharge capability, it allows an igniter to fire even if the igniter is damp, wet or contaminated. The actuating arm 145 may be manually lifted from engagement with the rotating part to extend the life cycle of the piezo-electric source, when desired, or the disengagement may be mechanically accomplished automatically under control of temperature sensors in the afterburner 110, when optimum temperature is achieved.

Exhaust gases from the exhaust manifold and crank-case vent are mixed with air from passage 120 in, and downstream of, the constricted passage 114 and during idling, low speed cruising and deceleration; the burning process, initiated by igniter 127 takes place in, and is predominantly confined to, the combustion area 115 between igniter 127 and baffle 126. At higher speeds, the volume of the exhaust gases from the engine increases and the gases travel at a higher velocity.

Baffle 126 serves as a shock absorber and mixer for the secondary combustion area 116 and prevents back pressure on the area 115. At higher speeds, the burning process is no longer completely restricted to combustion area 115, and gases, advancing to the combustion area 116, are reignited by igniter 128 and burn in the area 116.

Baffle 129 extends outwardly to the exhaust passage 131 and deflects toward that passage, the gas mixture now comprising nitrogen, carbon dioxide and, under some conditions, unused reconstituted oxygen, as described above in connection with the afterburner shown in FIGURE 2. Baffle 129 also serves to prevent back pressure on the area 116 and to maintain thermal energy within the combustion chamber. Both baffles act to prevent flame-out at higher speeds. As described above, oxygen molecules surround the few ozone molecules created by the electrical discharge at igniter 128 and the molecules are activated to higher energy levels in the autoxidation process. This assures the complete burning of the unburned gases. At excessively higher speeds, the flame front moves upstream from baffle 129 thus allowing the flame to impinge on a larger surface area of walls 121 and 130 resulting in the thermal energy remaining relatively constant despite the lower dwell time of the exhaust gases.

The hot, now-burned gas mixture is now forced by pressure in the chamber 133, through the exhaust passages 131 and 135, and out the conduit 137, directly into the ambient air or, in the case of an automobile system, through the muffler and tailpipe. The hot gases while passing through the exhaust passage 131 transfer their heat to the wall 121 which heats the air entering the air intake passage 122 so as to preheat the air entering the afterburner at the constricted passage 114. The concurrent cooling of the exhaust gases prevents excessive heating of the afterburner while passing through the exhaust passage 135.

From the foregoing description it will be apparent that the invention provides a practical and highly versatile direct flame type of afterburner capable of burning combustion exhaust gases by primary burning. As will be understood by those familiar with the art, the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed are therefore to be considered in all respects as illustrative rather than restrictive, the scope of the invention being indicated by the appended claims.

What is claimed is:

1. Apparatus for the treatment of combustion exhaust gases comprising an intake conduit for receiving the exhaust gas stream of a previous combustion in an internal combustion engine, flow constricting means in said intake conduit to provide a low pressure area therein, an opening communicating with said intake conduit at said low pressure area for introducing preheated outside air into the exhaust gas stream, means forming a first enclosed insulated combustion area connected to said intake

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conduit at the downstream side thereof, said combustion area including baffle means, electric ignition means adjacent the upstream side of said combustion area for igniting the mixture of air and exhaust gases entering the area, means surrounding said combustion area forming means and forming therewith a heat exchanger passage for preheating the air introduced at said opening, said passage communicating with said opening, means for supplying air under pressure to said passage, means forming a second combustion area communicating with the downstream side of said first combustion area, electric ignition means in said second combustion area, and an outlet conduit communicating with the downstream side of said second combustion area for permitting escape of the combustion gases therefrom.

2. Apparatus as defined in claim 1 including an external pump for providing metered air to effect optimum burning in said combustion areas at all rates of flow.

3. Apparatus as defined in claim 1 including an external piezo-electric current generator for providing high voltage electric current to said electric ignition means.

4. Apparatus as defined in claim 1 including a thermal sensor to activate and deactivate said air supply means to maintain said combustion areas in a desired heat range.

5. Apparatus as defined in claim 1 including an air supply tube having its exit end opening at said low pressure area and having its entrance end adapted to be connected to the breather opening of the internal combustion engine whereby fumes from the engine are mixed with the exhaust gas stream and burned.

6. Apparatus for oxidizing the oxidizable components of the exhaust gases from an internal combustion engine comprising means forming an intake passage arranged to be connected on its upstream side to the exhaust manifold of the engine, said intake passage receiving the exhaust gas stream from the manifold and having flow constricting means to provide a low pressure point therein, said intake passage including a mixing area for the air and exhaust gases downstream from said flow constricting means, means forming a primary combustion area in communication with said mixing area on the downstream side thereof, said primary combustion area including a pair of branch ducts each having a cross sectional area approximately equal to that of said mixing area, high voltage electric ignition means adjacent the upstream side of said primary combustion area for igniting the air-exhaust gas mixture entering the area, means forming a secondary combustion area communicating with the downstream sides of the ducts of said primary combustion area, said secondary combustion area having cross sectional area approximately three and a half times that of one of said ducts, high voltage electric ignition means in said secondary combustion area, and means forming an outlet passage in communication with the downstream side of said secondary combustion area for permitting escape of the combustion gases therefrom, said outlet passage having a cross sectional area that is approximately one-third the cross sectional area of said secondary combustion area.

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7. Apparatus as defined in claim 6 together with baffle means in said secondary combustion area to aid in the mixture of air and exhaust gases entering the chamber.

8. Apparatus as defined in claim 6 including flow constricting means in each of said branch ducts to form low pressure points therein, and means to admit outside air into said ducts at said low pressure points.

9. Apparatus as defined in claim 8 together with means for pre-heating the outside air admitted into said intake passage and branch ducts.

10. Apparatus for the treatment of combustion exhaust gases comprising an intake conduit for receiving the exhaust gas stream of a previous combustion, means forming an enclosed combustion area connected to said intake conduit at the downstream side thereof, a conduit heat-exchanger located in said combustion chamber and communicating with said intake conduit for preheating outside air and introducing the preheated air into the exhaust gas stream, means for supplying metered outside air under pressure to the inlet of said conduit heat-exchanger, said combustion area including baffle means, ignition means adjacent the upstream side of said combustion area for igniting the mixture of air and exhaust gases entering the area, and an outlet conduit communicating with said combustion area for permitting escape of the combustion gases therefrom.

11. Apparatus for the treatment of combustion exhaust gases comprising an intake conduit for receiving the exhaust gas stream of a previous combustion in an internal combustion engine, flow constricting means in said intake conduit to provide a low pressure area therein, an opening communicating with said intake conduit at said low pressure area for introducing automatically metered, pressurized and preheated outside air into the exhaust gas stream, means forming an enclosed insulated combustion area connected to said intake conduit at the downstream side thereof, said combustion area including baffle means, electric ignition means adjacent the upstream side of said combustion area for igniting the mixture of air and exhaust gases entering the area, means surrounding said combustion area forming means and forming therewith a heat-exchange passage for preheating the air introduced at said opening, said passage communicating with said opening, means for supplying outside air under pressure to said passage, and an outlet conduit communicating with said combustion area for permitting escape of the combustion gases therefrom.

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