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APPARATUS FOR BURNING INTERNAL COMBUSTION ENGINE EXHAUST

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2 Sheets-Sheet 1

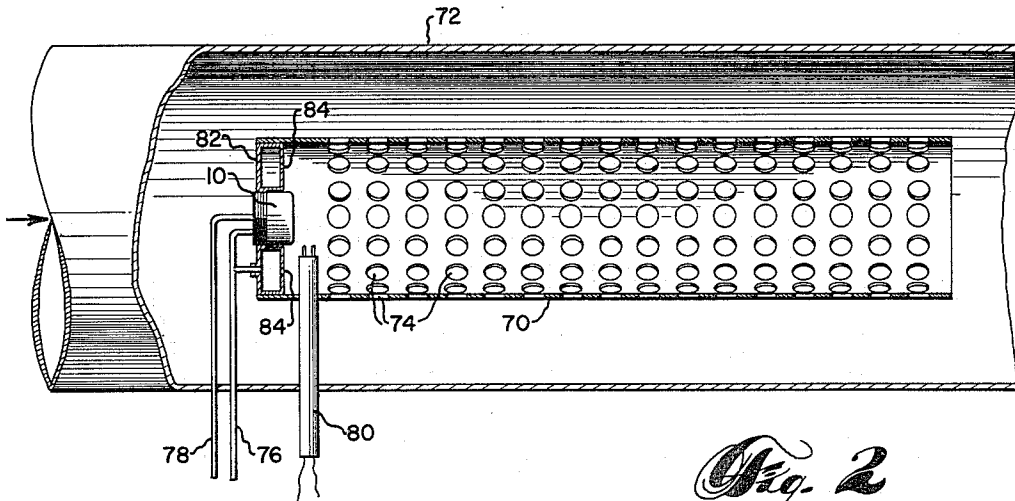


Fig. 2

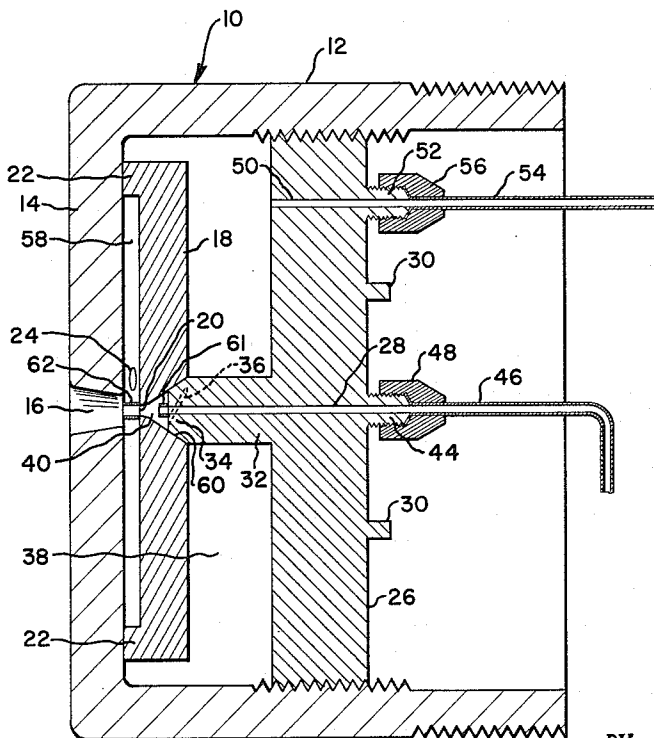


Fig. 1

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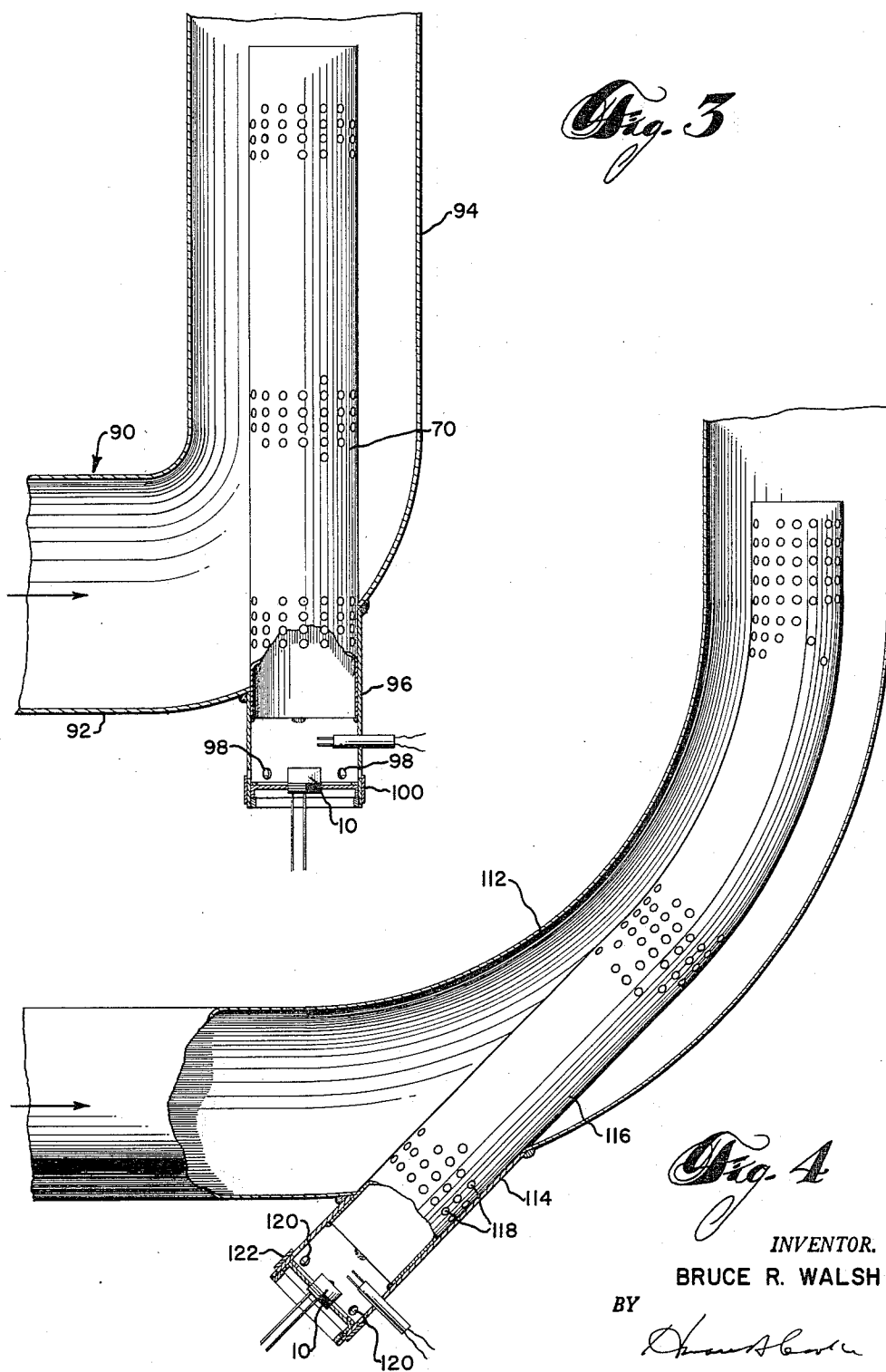
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APPARATUS FOR BURNING INTERNAL COMBUSTION ENGINE EXHAUST

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This invention relates to an apparatus for reducing smoke in a stream of incompletely burned gases such as the exhaust of an internal combustion engine.

Exhaust gases emitted from stationary or vehicular internal combustion engines which burn liquid hydrocarbon fuel such as gasoline or diesel oil are frequently heavily laden with smoke and soot. The apparatus of this invention is adapted to accomplish the substantially complete elimination of all such smoke and soot by burning the exhaust during its transit through the exhaust pipe so that upon discharge into the atmosphere it is clean and relatively smoke free, thereby reducing atmospheric pollution.

The apparatus of this invention comprises in combination with an exhaust pipe whose forward end is connected to a source of incompletely burned gases, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe intermediate the ends thereof, an aspirating nozzle having a discharge orifice disposed coaxially at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube, first conduit means extending from said nozzle to a source of aspirating gas, second conduit means extending from said nozzle to a fuel reservoir, and third conduit means extending from a source of oxygen containing gas and terminating in the forward region of said perforated tube.

The nozzle employed is of the aspirating type wherein an aspirating gas, preferably air, under a small pressure passes through the nozzle in a manner which creates a suction thereby drawing liquid fuel into the nozzle which admixes with the air to form an atomized fuel-air mixture. Such a nozzle operates continuously on only about 0.1 gallon of fuel oil per hour. Advantageously, no special fuel reservoir is required since fuel can be drawn from the fuel tank of the vehicle on which the apparatus of this invention is employed and no pump is required to supply the fuel to the nozzle since the fuel is drawn into the nozzle by means of the air passing therethrough.

It is essential that the nozzle employed in the apparatus of this invention be of the aspirating type since this type of nozzle produces an air-fuel spray which upon ignition burns as a compact and elongated flame. The aspirating nozzle spray is sufficiently compact that its presence in the exhaust line does not constitute an obstruction for escaping exhaust gases. In contrast, the flame produced upon ignition of the spray from a non-aspirating nozzle to which liquid fuel is supplied under pressure tends to be widely dispersed to an extent that the entire transverse cross section of the exhaust duct in the region of the nozzle is obstructed by the flame. Still another disadvantage of the flame from a non-aspirating nozzle to which liquid fuel is pumped is that the flame is itself extremely smoky, thereby contributing to the problem it is desired to alleviate, while a substantially smoke-free flame is produced upon ignition of the air-fuel mixture from an aspirating nozzle.

The problems of wide flame dispersal and flame smokiness when employing a non-aspirating nozzle are due in part to the necessity of employing an excessively high oil flow rate through the nozzle and in part to the

absence of air in admixture with the fuel sprayed from the nozzle. An attempt to correct the problem when employing non-aspirating nozzles by reducing the rate of oil flow necessitates the construction of nozzles having such severely restricted oil passageways that nozzle plugging quickly occurs and renders the nozzle inoperative. On the other hand, relatively large oil passageways can be employed with an aspirating nozzle thereby obviating the danger of plugging even while employing extremely low oil flow rates.

The aspirating nozzle and perforated tube combination when employed in the interior of a duct exhausting the combustion products of an internal combustion engine accomplishes an advantage in engine operation in addition to its primarily intended purpose of smoke reduction. The flame from the aspirating nozzle travels through the perforated duct at a velocity sufficiently high and at a distance sufficiently close to the perforated tube wall to create an aspirating effect upon the exhaust gases traveling cocurrently on the outside of the perforated tube wall. This aspiration, by drawing the exhaust gases inwardly through the tube perforation, not only draws these gases into the flame thereby burning the carbon but also tends to hasten removal of the products of combustion from the engine, thereby increasing the efficiency of the engine. This hastening of removal of combustion products is seen to be a unique advantage of an aspirating nozzle since, as stated, a non-aspirating nozzle produces a flame which is so widely dispersed as to obstruct removal of exhaust gases rather than aid in their removal.

The aspirating nozzle and perforated tube combination of this invention is in still another respect uniquely adapted for operation as an afterburner in combination with an exhaust duct. The length of the flame from an aspirating nozzle directed into a perforated tube has been found to be capable of almost indefinite extension as long as combustible material is available outside of the perforated tube for inward aspiration. Any residual incompletely burned material not initially drawn into the perforated tube in the region of the nozzle can be drawn into the perforated tube any distance downstream from the nozzle to which the perforated tube extends. In the presence of combustible gases the flame length within the tube is only limited by the length of the perforated tube with which it is associated and therefore the perforated tube of this invention should be of sufficiently great length to accomplish substantially complete combustion of the flowing gaseous stream in which it is disposed.

This invention is more particularly illustrated by reference to the accompanying drawings in which FIGURE 1 shows a preferred aspirating type nozzle to be employed in the apparatus of this invention and in which FIGURES 2, 3 and 4 show various aspirating nozzle, perforated tube and exhaust duct combinations of this invention.

A preferred aspirating nozzle to be employed is of the type having a frusto-conical swirl stem possessing slanted peripheral grooves and disposed against a corresponding surface inside the nozzle body. The grooves constitute ducts leading into a swirl chamber whereby a swirling motion is imparted to the aspirating air passing therethrough en route to the swirl chamber. The swirl chamber has an axial discharge orifice restriction at the end opposite the swirl stem and an oil inlet duct extends axially into the swirl chamber a portion of the distance from the swirl stem to the discharge orifice. The aspirating air swirling through the swirl chamber draws oil into itself to form a mixture of fuel and air. The air-oil mixture from the swirl chamber is passed through the

discharge orifice of the nozzle and upon ignition burns as a compact, elongated flame.

In FIGURE 1 is illustrated an aspirating nozzle of this type having two swirl chambers instead of a single swirl chamber.

Referring to FIGURE 1, a longitudinal cross sectional view of a nozzle designated generally as 10 is shown having a tubular body portion 12 which is internally and externally threaded as shown. The forward end of body portion 12 terminates with a substantially flat integral enclosure 14 which is on a plane transverse to the axis of tubular body 12. Enclosure 14 has an axial tapered central orifice opening 16. Orifice plate 18 immediately inside of and adjacent to enclosure 14 has an over-all diameter less than the internal diameter of tubular body 12 and has an axial orifice 20. Orifice 20 is the apex of an axial conical bore 60 as shown. The diameter of orifice opening 16 is larger than the diameter of orifice opening 20 and a duct 62 extends from orifice 20 to partially obstruct the entrance to orifice 16. The forwardly protruding peripheral rim 22 of orifice plate 18 contains one or more borings 24 which open in a tangential manner into swirl chamber 58 which is formed by virtue of rim 22 setting apart the rearward surface of enclosure 14 and the forward surface of orifice plate 18.

A plug 26 having external threads and an axial bore 28 is equipped with two or more prongs 30 on its rear face so that it can be screwed into the interior of tubular body 12 and urge orifice plate 18 in sealing engagement against the inner surface of enclosure 14 so that orifice opening 20 is axially disposed. Plug 26 has a central forwardly projecting stud 32 terminating with a frusto-conical swirl stem 34 which holds orifice plate 18 in place by abutting firmly against the complementary internal surface of the base portion of conical bore 60 leaving unoccupied the apex of conical bore 60, the unoccupied apex of conical bore 60 constituting a swirl chamber 40. Swirl stem 34 is equipped with one or more peripheral slots 36 extending the length of the stem and providing passage between air chamber 38 and swirl chamber 40. Slots 36 are generally comparable in cross section and length with borings 24 so that the pressure drop through each is generally the same. In one example, slots .030 inch square are employed. Bore 28 which is coaxial with tubular body 12 constitutes a connecting passageway for the suction of oil from an oil reservoir on a lower level, not shown, into swirl chamber 40. Bore 28 is extended through a portion of the length of swirl chamber 40 by means of tube 61.

After the orifice plate 18 is secured in position by tightly screwing plug 26 into place as shown in FIGURE 1, the entire resulting nozzle assembly is secured into position for use as shown in FIGURES 2, 3 and 4. After the nozzle is assembled and secured into place, the vehicle fuel reservoir which is preferably on a level lower than the nozzle is connected to the nozzle at externally threaded boss 44 extending rearwardly from the center of plug 26 and coaxial with oil passageway 28. Suitable flared tubing 46 extends from below the level of oil in the reservoir and is attached in sealing connection to boss 44 by means of nut 48. Passage of compressed air to chamber 38 is provided by passageway 50 through plug 26 terminating with rearwardly extending externally threaded boss 52 to which flared tubing 54 is attached in sealing connection by means of internally threaded nut 56.

In operating the nozzle shown in FIGURE 1 air under a pressure between about 2 and 10 pounds per square inch gauge, pressures in the upper portion of this range being employed when it is desired to aspirate greater quantities of fuel oil than are aspirated at air pressures in the lower portion of this range, is charged to air chamber 38 from which it passes through groove 36 and enters swirl chamber 40 substantially tangentially and swirls in swirl chamber 40. The swirling air draws oil from a reservoir which is on a lower level than the nozzle by

suction through passageway 23 into swirl chamber 40 where a fuel-air mixture is formed which passes through orifice 20 and duct 62 to a second orifice 16. Tube 61 allows the air to assume an adequate swirling pattern prior to aspirating in oil and prevents air back pressure against the oil from the reservoir. Air from air chamber 38 also passes through tangential inlet ducts 24 to second swirl chamber 58 from which it swirls through orifice 16 where it increases in velocity and aspirates into itself the fuel-air mixture from duct 62 to form a new mixture in which the oil is more highly atomized and which is richer in air. The new mixture is discharged in a swirling pattern through orifice opening 16.

It has been found that ducts 61 and 62, which project axially a portion of the distance into each swirl chamber, are essential to operation of the nozzle and in the absence of either or both of these ducts the air was unable to aspirate sufficient oil into itself to create a mixture of oil and air capable of sustaining combustion.

FIGURE 2 is an elevational view illustrating the use of aspirating nozzle 10 and an associated perforated tube 70 in an exhaust duct 72. Although not shown, exhaust duct 72 is attached at its forward end to a source of incompletely burned gases such as the combustion products of an internal combustion engine. These gases travel through exhaust duct 72 from its forward end to its rearward end where they are discharged to the atmosphere.

Aspirating nozzle 10 is disposed coaxially with respect to exhaust duct 72 with its discharge orifice directed rearwardly in the duct. Aspirating nozzle 10 is disposed at the forward end of tube 70 which has a plurality of perforations 74 and which is of smaller diameter than exhaust duct 72. Perforated tube 70 is also coaxially disposed with respect to exhaust duct 72 and is of sufficient length so that substantially all unburned material contained in the exhaust gases traveling through exhaust duct 72 are drawn inwardly through perforations 74 by the aspirating effect of the flame produced upon ignition of the spray from nozzle 10. In this regard, tube 70 is of a sufficiently small diameter that perforations 74 are disposed close enough to the flame to permit an adequate aspirational effect to be exerted. As shown in FIGURE 2, the discharge end of perforated tube 70 opposite aspirating nozzle 10 is open and perforated tube 70 is axially unobstructed from aspirating nozzle 10 through its discharge end. As is also shown in FIGURE 2, except for perforated tube 70 and related burner apparatus the region of exhaust duct 72 shown is substantially unobstructed and the annular space between perforated tube 70 and exhaust duct 72 is also substantially unobstructed throughout and at its forward and rearward ends so that exhaust gases are not substantially forced into perforated tube 70 through perforations 74 but rather are drawn inwardly by the aspirating effect of the flame from nozzle 10.

A source of air at a pressure of about 2 pounds per square inch gauge is supplied to aspirating nozzle 10 through conduit 76 and this air causes the aspiration into the nozzle of fuel from the fuel reservoir supplying the internal combustion engine through conduit 78. A spray containing the mixture of aspirating air and fuel is emitted from nozzle 10 and is ignited by means of a sparking device 80 actuated by the ignition system of the internal combustion engine. The flame from the nozzle spray is confined within perforated tube 70 and in its transit past the perforations 74 creates an aspirating effect tending to draw inwardly through perforations 74 the exhaust gases passing on the outside of perforated tube 70 concurrently with the flame. In the event that the exhaust gases are devoid of material capable of supporting combustion such as incompletely burned material auxiliary air in a quantity sufficient to maintain combustion of the spray from the nozzle is supplied to the spray through a hollow circular tube 82 having a continuous circular slit-like opening 84 facing rearwardly into the tube. Hol-

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low circular tube 82 is supplied with air from air supply conduit 76. As is shown in FIGURE 2, hollow circular tube 82 provides enclosure means in the region of the forward end of perforated tube 70 for preventing the admission of engine exhaust gases through the forward end of perforated tube 70.

The quantity of auxiliary air supplied through opening 84 to support combustion of the spray from nozzle 10 should be large enough to prevent extinguishment of the flame. In this manner any incompletely burned material in the exhaust gases aspirated inwardly through perforations 74 of tube 70 will be burned. Tube 70 should be sufficiently long so that the flame will have opportunity to burn all carbon and soot contained in the exhaust. As long as combustible material is present in the exhaust gases the flame from nozzle 10 will naturally become elongated, its length within the tube only being limited by the length of perforated tube 70. Therefore, adequate perforated tubular length should be provided to obtain maximum advantage of the apparatus of this invention.

The exhaust gases issuing from some internal combustion engines are at temperatures so excessively high that the liquid fuel in the nozzle and in the portion of the fuel conduit extending through the exhaust duct becomes vaporized. This causes the system to become vapor locked and inoperative. FIGURES 3 and 4 each illustrate advantageous embodiments of this invention wherein the nozzle and fuel conduits are removed from the exhaust gas stream being treated and the problem of vapor locking is thereby avoided.

FIGURE 3 is an elevational view of the aspirating nozzle and perforated tube combination of this invention at a right angle elbow in an exhaust tube 90. Exhaust tube 90 has a forward portion 92 and a rearward portion 94. The region of rearward portion 94 shown in FIGURE 3 is substantially unobstructed except for perforated tube 70. A coaxial tubular extension 96 protrudes outwardly from an opening on the periphery of the exhaust pipe which is coaxial with rearward duct portion 94. Perforated tube 70 is of smaller diameter than the exhaust pipe and is disposed coaxially with respect to exhaust duct portion 94 extending from extension 96 at least a portion of the distance toward the rearward end of exhaust duct portion 94. As is shown in FIGURE 3, extension 96 prevents the admission of engine exhaust gases through the forward end of perforated tube 70. Extension 96 is provided with openings 98 for the admission of atmospheric air into the exhaust system by means of any suction created by the flame from nozzle 10. The quantity of air passing through openings 98 is adjusted by means of a slip ring 100 which is longitudinally movable on extension 96 so as to adjust the size of openings 98. Although a pressurized auxiliary air supply can be employed, this configuration can obviate the necessity of such a pressurized auxiliary air source.

FIGURE 4 is an elevational view showing the combination of an aspirating nozzle and a curved perforated tubular duct at a curved exhaust duct section 112. Curved exhaust duct section 112 has an extension 114 protruding from an opening on the forward region of its periphery so that the axis of extension 114 is tangential to the axis of curved section 112. The curved section 112 shown in FIGURE 4 is substantially unobstructed except for perforated tube 116. Perforated tube 116 having a plurality of perforations 118 and of a diameter smaller than the diameter of exhaust duct section 112 extends coaxially with respect to extension 114 from extension 114 up to its point of tangency with the axis of curved section 112 whence it extends coaxially with respect to exhaust duct 112. Extension 114 is provided with air openings 120 having adjustable closure means provided by slip ring 122. Either atmospheric air or pressurized air can be admitted through air openings 120. Unlike the unmanageable flame issuing from a non-aspirating type nozzle

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to which liquid fuel is pumped under pressure, the flame from an aspirating nozzle is facily confined within a perforated tube even having a curved axis.

Various changes and modifications can be made without departing from the spirit of this invention or the scope thereof as defined in the following claims. For example, the apparatus of this invention can be incorporated as part of an exhaust muffler.

I claim:

1. In an engine exhaust system, an apparatus comprising an exhaust pipe having a substantially unobstructed region therein, the forward end of said pipe connected to a source of incompletely burned exhaust gases, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means having a discharge orifice coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized gas aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, air admitting means for admitting air to said perforated tube, enclosure means in the region of the forward end of said perforated tube for preventing admission of engine exhaust through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the engine exhaust flowing concurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine.

2. An apparatus for use in an engine exhaust system comprising an exhaust pipe having a substantially unobstructed region therein, the forward end of said pipe adapted to be connected to the exhaust of an internal combustion engine and the rearward end of said pipe adapted for discharge of exhaust to the atmosphere, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized gas aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, air admitting means for admitting air to said perforated tube, enclosure means in the region of the forward end of said perforated tube for preventing admission of engine exhaust through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the engine exhaust flowing concurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine.

3. An apparatus comprising an exhaust pipe having a substantially unobstructed region therein, the forward end of said pipe adapted to be connected to a source of in-

completely burned gases, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means having a discharge orifice coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized gas aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, enclosure means in the region of the forward end of said perforated tube for preventing admission of said incompletely burned gases through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, means for supplying pressurized air to said nozzle, means for supplying liquid fuel to said nozzle, and means for supplying air to said perforated tube, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal.

4. In the combination of an internal combustion engine and an exhaust pipe having a substantially unobstructed region therein with the forward end of said exhaust pipe attached to said internal combustion engine, the improvement comprising an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means having a discharge orifice coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized gas aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, air admitting means for admitting air to said perforated tube, enclosure means in the region of the forward end of said perforated tube for preventing admission of engine exhaust through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the engine exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine.

5. In an exhaust pipe having a substantially unobstructed region therein, the forward end of said exhaust pipe adapted for attachment to the exhaust of an internal combustion engine, the improvement comprising an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means having a discharge orifice coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized gas aspirates liquid fuel therethrough for producing a spray which

upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, air admitting means for admitting air to said perforated tube, enclosure means in the region of the forward end of said perforated tube for preventing admission of engine exhaust through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the engine exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine.

6. In an exhaust pipe having a substantially unobstructed region therein, the forward end of said exhaust pipe adapted for attachment to the exhaust of an internal combustion engine, the improvement comprising an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe intermediate the ends thereof and in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means having a discharge orifice coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized gas aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, air admitting means for admitting air to said perforated tube, enclosure means in the region of the forward end of said perforated tube for preventing admission of engine exhaust through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the engine exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine.

7. An exhaust pipe having a substantially unobstructed region therein, the forward end of said pipe adapted for attachment to the exhaust of an internal combustion engine, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe disposed coaxially within said exhaust pipe intermediate the ends thereof and in said substantially unobstructed region thereof to provide an annular space between said perforated tube and said exhaust pipe, aspirating nozzle means having a discharge orifice coaxially disposed at the forward end of said perforated tube with said discharge orifice directed toward the rearward end of said perforated tube adapted so that pressurized air aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, air admitting means for admitting air to said perforated tube, enclosure means in the region of the forward end of said perforated tube for preventing admission of engine exhaust through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, said annular space being longitudinally unobstructed throughout and at its forward and rearward ends

so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the engine exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine, said perforated tube being of sufficient length to accomplish substantially complete combustion of exhaust gases.

8. An apparatus comprising an exhaust pipe having a forward portion and a rearward portion, each of said portions having a forward end and a rearward end, the forward end of said forward portion connected to a source of incompletely burned gases, the longitudinal axis of said rearward portion being bent with respect to the longitudinal axis of said forward portion, the forward end of said rearward portion having a substantially unobstructed region and having a coaxial tubular extension protruding outwardly from an opening on the periphery of the exhaust pipe, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe to provide an annular space therebetween disposed coaxially with respect to said rearward portion within said substantially unobstructed region and extending from said extension at least a portion of the distance to the rearward end of said rearward portion, aspirating nozzle means having a discharge orifice coaxially disposed with respect to said tubular extension with said discharge orifice directed into said perforated tube adapted so that pressurized air aspirates liquid fuel therethrough for producing a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, said tubular extension preventing admission of said incompletely burned gases through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, the rearward end of said annular space being open and said annular space being longitudinally unobstructed so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine, and opening means in said tubular extension for providing passage for the atmosphere into said apparatus.

9. Claim 8 wherein said forward portion and said rearward portion are bent with respect to each other so that their respective longitudinal axes form a right angle.

10. An apparatus comprising an exhaust pipe having a substantially unobstructed curved section, said curved section having a curved longitudinal axis, the forward end of said exhaust pipe leading to a source of incompletely burned gases, said curved section having a tubular extension protruding from an opening on the forward region of its periphery so that the axis of said extension is substantially tangential to said curved axis, an elongated perforated tube having a diameter less than the diameter of said exhaust pipe to provide an annular space therebetween extending from said extension and coaxial with respect to said extension up to the point of tangency with said curved axis whence it extends coaxially with respect to said curved axis, aspirating nozzle means having a discharge orifice coaxially disposed with respect to said tubular extension with said discharge orifice directed into said perforated tube adapted so that pressurized air aspirates liquid fuel therethrough to produce a spray which upon ignition burns as a compact, elongated flame within said perforated tube, igniter means for igniting said spray, said tubular extension preventing admission of said incompletely burned gases through the forward end of said perforated tube, the rearward end of said perforated tube being open and said perforated tube being axially unobstructed from said aspirating nozzle through its rearward end, the rearward end of said annular space being open and said annular space being longitudinally unobstructed so that exhaust is not substantially forced into said perforated tube but so that the flame from said aspirating nozzle creates an aspirating effect upon the exhaust flowing cocurrently on the outside of said perforated tube drawing said exhaust inwardly through the tube perforations to both burn said exhaust and hasten its removal from the engine, and opening means in said tubular extension for providing passage for the atmosphere into said perforated tube.

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