United States Patent [19]

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[11] 3,836,338

[45] Sept. 17, 1974

[54] **ANTI-POLLUTION EXHAUST BURNER AND MUFFLER FOR INTERNAL COMBUSTION ENGINES**

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[22] Filed: **Feb. 11, 1972**

[21] Appl. No.: **225,408**

[52] **U.S. Cl.** ..... **23/277 C,** 23/288 F, 43/212, 60/286, 60/298, 60/303

[51] **Int. Cl.** **F23g 7/06,** F23c 9/04

[58] **Field of Search** ..... 23/277 C, 288 F; 423/212; 60/286, 298, 303

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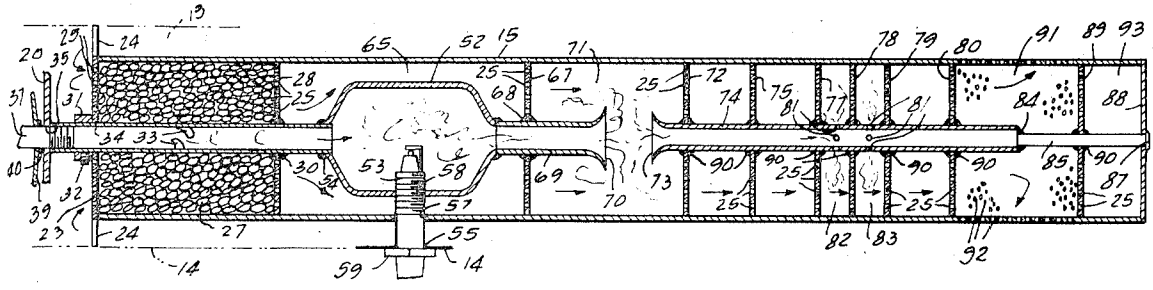
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[57] **ABSTRACT**

Anti-pollution control especially relevant to internal combustion engines involves producing intense consuming heat in a combustion tube, delivering engine exhaust gases into preheating relation to the outside of the tube wall, directing the preheated exhaust gases into the tube and therein subjecting the gases to the consuming heat and effecting complete combustion of combustible material entrained in the gases, and finally receiving the completely burned out exhaust gases from the tube in an expansion and muffle chamber and releasing them to atmosphere.

17 Claims, 6 Drawing Figures



ANTI-POLLUTION EXHAUST BURNER AND MUFFLER FOR INTERNAL COMBUSTION ENGINES

This invention relates to pollution control in general and is more particularly concerned with treatment of exhaust gases from internal combustion engines.

Internal combustion engines are notoriously inefficient in converting liquid fossil fuels into energy. The speeds at which such engines are required to operate and the rate at which the liquid fuel must be converted from liquid to combustible vapor by carburetion or fuel injection, leaves undesirable quantities of unburned hydrocarbons and carbon monoxide in the exhaust gases. Incompletely burned combustible constituents of the gases are especially prevalent during cold starting of the engines and in short run operation of the engines such as in common usage of automotive vehicles equipped with internal combustion engines. Due to the proliferation of automotive vehicles and the pollution problems inherent in such proliferation, stringent pollution control laws and regulations are being promulgated and enforced.

Another common problem in the operation of automotive vehicles equipped with internal combustion engines is that of condensate in especially the exhaust muffler system. Corrosion, deterioration and failure are common experience in automobile mufflers in particular from this cause.

An important object of the present invention is to overcome the foregoing and other disadvantages, defects, inefficiencies, shortcomings, and problems in the handling of internal combustion engine exhaust.

Another object of the invention is to provide new and improved means for completing the combustion of consumable constituents of internal combustion engine exhaust gases.

Still another object of the invention is to provide new and improved means for handling engine exhaust in automotive vehicles.

Yet another object of the invention is to provide a new and improved apparatus for eliminating combustible pollutants from internal combustion engine exhaust gases.

A further object of the invention is to provide new and improved combination afterburner and muffler apparatus for internal combustion engine exhaust systems.

A yet further object of the invention is to provide a new and improved anti-pollution system for internal engine exhaust which can be manufactured and sold economically, is simple, easy and economical to operate, functions efficiently and reliably, and provides long-lived, trouble-free service.

Other objects, features and advantages of the invention will be readily apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawing, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts embodied in the disclosure, and in which:

FIG. 1 is a plan view, partially schematic, of apparatus embodying features of the invention;

FIG. 2 is an enlarged plan view, partially in section, showing details of the fuel mixing chamber structure for the exhaust gas burner of the device;

FIG. 3 is an enlarged sectional elevational detail view taken substantially along the line III—III of FIG. 1;

FIG. 4 is a longitudinal sectional detail view taken substantially along the line IV—IV of FIG. 3;

FIG. 5 is an enlarged sectional detail view taken substantially along the line V—V of FIG. 1; and

FIG. 6 is a fragmentary end elevational view taken substantially on the plane of line VI—VI of FIG. 5.

According to the present invention, incompletely burned combustible material in the exhaust gases of an internal combustion engine are eliminated by burning the same before emission to atmosphere. In accomplishing this condensate accumulation in the system is avoided. To attainment of these ends, the exhaust gases are conducted through a preheating zone, an intense combustion zone, and a muffling zone before emission to atmosphere. All of this is accomplished in respect to automobile engine exhaust treatment in a unit **10** (FIG. 1) which can be accommodated in a space on the order of that customarily occupied by the usual exhaust muffler. To this end, the unit **10** comprises a distributor **11** within which exhaust gases are received from an exhaust pipe **12** and distributed to a preheating chamber **13** within a tubular casing **14** within which is mounted a combustion tube **15** leading to an expansion and muffling chamber **17** on a downstream enlarged end portion **18** of the casing **14** and from which the completely burned out exhaust gases are released to atmosphere.

In a desirable construction, the distributor **11** provides an initial muffle stage and comprises a blind end tube which may be of about 2½ inches outside diameter and from which lead a plurality of lateral distributor ports **19** which may be in the form of tubular elongations on the order of 1 5/16 inches outside diameter tubing located about 2 inches on center and directing the exhaust gases from the distributor chamber into the preheating chamber **13** at a plurality of places therealong spaced a substantial distance from the upstream end of the casing **14** and the combustion tube **15** so that the exhaust gases subdivided into a plurality of streams from the distributor will flow towards and about the combustion tube **15** in an efficient preheating relation.

In a preferred construction, the housing or casing tube **14** is of normally open ended form having the major smaller diameter portion thereof about 3 3/4 inches outside diameter and a length of about 12 inches, with the larger diameter portion **18** adding another approximately 6 3/4 inches for a total of 17 inches to 18 inches. With a total width of the device inclusive of the manifold tube **11** and the housing tube **14** of about 8½inches maintains the basic outside dimensions of the device reasonably within space occupancy relation to better grade automobile mufflers. It will be understood, of course, that specific dimensions are not intended as limiting but only as illustrative and to demonstrate that practical realities have been considered in devising the device. At its upstream end, the housing tube **14** is closed for operation by means comprising a removable closure plate **20** secured as by means of screws **21** to an annular radially outwardly extending integral attachment flange **22** on the housing tube.

Construction and relationship of the combustion tube **15** to the housing tube **14** within which it is operatively mounted, is such that not only is efficient preheating of the exhaust gases from the distributor **11**

provided for, but successive muffling is accomplished as well as the important complete combustion of unburned constituents of the gases. For this purpose, the combustion tube **15** is of a diameter as large as practicable for burning treatment of the exhaust gases therewithin, but of sufficiently smaller differential diameter than the inside diameter of the housing tube **14** to provide an efficient capacity annular space for the chamber **13.** For this purpose, the outside diameter of the tube **15** may be about 2½inches where the inside diameter of the tube **14** is about 3 5/8 inches. Assembly of the tube **15** within the tube **14** is facilitated by constructing the combustion tube and conformance of the device carried thereby as a cartridge adapted to be installed, or removed, from either or both ends of the housing tube **14.** In length, the tube **15** is such as to be fully contained within the tube **14** and the expansion chamber enlargement **18** and is desirably slightly shorter so that at its upstream, inlet end, the tube **15** can be adequately spaced from the enclosure **20** for reception thereinto of exhaust gases from the chamber **13,** as generally indicated by the directional arrows in FIGS. **1** and **4.** Lateral, substantially concentric spacing of the tube **15** within the tube **14** is effected at the upstream end of the assembly by means such as a spider **23** in the form of a disk plate carried by the upstream end of the tube **15** and having an equally circumferentially spaced plurality, herein four, radial spacer arms **24** which engage the inner wall defining the tube **14,** with the principal diameter of the plate **23** substantially the same as the outside diameter of the tube **15.** In this instance, the plate **23** provides a separable, perforated dispersion of spreader screen to assure reasonably uniform entry of the exhaust gases to be treated into the tube **15.** Within the general parameters of the illustrative device, the body of the plate **23** may efficiently be provided with two hundred 1/8 inch diameter screen perforation holes **25** therethrough. In addition to its spreader screen function, the plate **23** serves as a retainer for a mass of coarsely particulate flow stabilizing and preheating material **27** filled into the tube **15** between the plate **23** and an inwardly spaced dispersion or spreader screen plate **28** which is also provided with the perforation holes **25,** desirably of the same size and number as in the plate **23.** The material **27** may be of any suitable stable variety for the purpose, hard coral, seashell and stainless steel shavings of about 1/4 inch particle size having been found satisfactory, by way of example. The cartridge space between the plates **23** and **28** accommodating the material **27** may be about 3 inches or less in length.

For maintaining the plates **23** and **28** in place, they are mounted on an axial rod **29** extending through the plates, the plate **23** being relatively axially slidably assembled with the rod and the plate **28** being desirably fixedly secured thereto as by means of welding **30.** At its outer perimeter, the plate **28** engages slidably with the inside wall surface of the tube **15.** This enables the plate **28** to be mounted with the rod **29** serving as a stem by introducing the same into the tube **15** from the upstream or entry end of the tube. After the plate **28** has been inserted to the desired distance within the tube **15,** the material **27** can be filled into the cartridge chamber therefor, whereafter the plate **23** is assembled onto an axially outward extension of the stem rod **29** and against the end of the tube **15,** with means such as a releasable collar **31** then secured on and about the outer end portion of the stem rod **29** and against the plate **23** and fastened as by means of a set screw **32.**

In addition to its supporting function, the stem rod **29** serves as part of combustion heat producing means within the tube **15.** To this end, the stem rod **29** is in the form of a fuel mixing turbine tube throughout its length and provided intermediately therein with a plurality of fixed turbine blades **33** such as three about 1/4 inch long within a 7/16 inch diameter tubular passage **34.** At its outer end, the tube **29** is adapted to engage against the closure plate **20** which has a coaxially aligned aperture **35** through which extends a nipple **37** threadedly engaged into the adjacent end of the tube **29** and thereby supporting on the closure plate **20** an air and fuel vapor mixing chamber **38** having an outwardly convex base wall **39** through which the nipple extends and is fixedly secured as by welding **40.** Securing of the nipple **37** to the tube **29,** thereby not only draws the end of the tube **29** releasably against the plate **20,** but also draws the base wall **39** toward and into bottomed engagement with the plate **20.**

Air and fuel are supplied to the chamber **38** through its end opposite to the base wall **39** through an inlet nipple **41** having secured thereto by suitable coupling **42** the delivery end of a venturi tube **43** to the receiving end of which is connected a compressed air supply duct **44** to which air under pressure is supplied from a suitable compressor or pump **45.** Fuel is aspirated into the side of the tube **43** by venturi structure **47** therein from a fuel tank **48** which may be the fuel tank of the associated vehicle connected to the venturi tube **43** through a duct **49.** Fuel and air are thus driven into the mixing chamber **38** and thence passes into the nipple **37** through an inlet orifice **50** which is desirably slightly smaller in diameter than the funnel of the venturi **47** to provide a desirable pressure drop and velocity within the turbine tube passage **34** for optimum vaporization and gasification of the fuel diffused in the air and delivered from the inner end of the turbine tube into a combustion chamber **52** within which the air-fuel mixture is ignited as by means of a spark plug **53.** By having the chamber **52** secured as by means of welding **54** to the turbine tube **29,** direct heat transfer, as well as radiant heat transfer, is effective to heat the tube, as well as the plate **28** and the material **27** not only to preheat and improve the efficiency of the air fuel mixture but also to improve the preheating of the exhaust gases as they advance into and through the combustion tube **15,** first through the body of material **27** and then in heat transfer relation to the wall defining the combustion chamber **52** from which heat is radiated to and heats the wall of the tube **15** along which the combustion gases are caused to travel toward the entry end of the combustion tube.

Mounting of the spark plug **53** is effected through an opening **55** in the wall of the housing tube **14** aligned with an opening **57** in the combustion tube **15** and an opening **58** in the wall of the combustion chamber **52** into which the firing end portion of the spark plug is threadedly engaged. Desirably a packing gland **59** is secured about the spark plug to seal the housing tube opening **55.** This arrangement also has the advantage of maintaining the tube **15** and the assembly including the combustion chamber **52** in proper relative axial position relative to one another and to the housing tube **14** by virtue of the spark plug **53** serving as a connector.

Sparking potential for the spark plug 53 is provided by connecting into the ignition system of the associated vehicle. To this end, a coil 60 is connected into line 61 between ignition coil 62 and distributor 63 and is connected by a lead line 64 to the spark plug 53. By having not only the spark plug 53 but also the pump 45 activated by starting of the vehicle engine, prompt operation of the burner system is attained. Experience has shown that ignition of the flame in the burner system can be accomplished is about five seconds after the engine is started, and then will continue operating as long as the vehicle engine operates. Any moisture or condensate in the exhaust is promptly vaporized because the combination muffler and burner device rapidly heats up in the path which the exhaust gases must travel within the chamber 13 and then within the combustion tube 15.

As will be observed in FIG. 4, after the exhaust gases pass downstream from the spreader plate 28, they must pass the casing which provides the combustion chamber 52 and which although it is of smaller outside diameter than the inside diameter of the tube 15 provides a baffle bulge in the path of the on-flowing exhaust gases stream causing the stream to travel a reduced cross sectional area annular subpassage 65 between the tube 15 and the chamber 52 attaining improved heat transfer preheating of the exhaust stream flowing past the combustion chamber. Beyond the combustion chamber, the exhaust gases stream passes through a dispersion or spreader plate screen 67 which is provided with holes 25 similar in size and number to the holes in the upstream spreader screen plates. The plate 67 is in sliding fit at its outer perimeter with the tube 15 and is secured as by means of welding 68 to and about an elongated flame nozzle 69 leading from the combustion chamber 52 and having a flaring mouth 70 opening into a flame subchamber 71 between the plate 67 and a similar dispersion spreader screen plate 72 spaced a sufficient distance downstream from the nozzle mouth 70 to accommodate a receiving mouth 73 of a flame runner tube 74 concentric with the nozzle 69 but of slightly smaller diameter and with the flaring mouths 70 and 73 spaced apart sufficiently to enable flame to spread from the nozzle mouth 70 into fairly uniform, burning relation to the exhaust gases stream passing through the subchamber 71. A central core of the flame discharging from the nozzle mouth 70 enters the flame runner tube 74 and travels downstream therethrough. In the exemplified device, a gap of about 3/4 inch between the flaring mouths 70 and 73 has been found effective. A desirable size differential between the nozzle tube 69 and the flame runner tube 74 may be 9/16 inch inside diameter for the nozzle and 9/64 inch inside diameter for the flame runner tube.

After leaving the subchamber 71 through perforations 25 in the spreader screen plate 72, the flame treated exhaust gases are passed through a series of additional perforated dispersion spreader screen disk plates 75, 77, 78, 79 and 80 successively spaced downstream from one another and having the tube 74 extending therethrough. Each of the spreader screen disk plates has the same pattern of similarly dimensioned holes 25 therethrough as in the screen disk plates upstream therefrom so that there is highly efficient dispersion and spreading of the exhaust gases accompanied by efficient muffling. Between certain of the screen disks along the flame runner tube 74 sufficiently downstream from the subchamber 71 to provide for efficient booster burning of the exhaust gases, flame from the runner tube is released therefrom into the exhaust gases stream to complete burning of any possible incompletely burned constituents that may have escaped therewith from the primary burning subchamber 71. To this end, the flame runner tube 74 is provided with a set of flame ports 81 desirably in two groups equally disposed about the perimeter thereof in two contiguous sections of the tube and opening into respective relatively short subchambers 82 and 83 between respectively the screen disks 77 and 78 and 78 and 79. In a practical arrangement four of the ports 81 open into the subchamber 82 and four of the ports 81 open into the subchamber 83. At its downstream end a substantial distance beyond the ports 81, the tube 74 is blindended, as for example by securing to such end as by means of welding 84, the inner end of an attachment rod 85 which has its outer end secured as by means of riveting 87 to an end closure plate 88 of the same diameter as the tube 15 and extending across its downstream terminal end. Spaced inwardly from the imperforate closure plate 88 is desirably a final perforated spreader screen plate 89. All of the screen plates along the tube 74 and the rod 85 are secured to the tube and rod as a unit, as by means of welding 90, and have their outer diameters in sliding fit with the inside diameter of the tube 15 so that they can be inserted into the tube as a unit with the flame runner tube and rod and the end closure plate 88.

At the downstream end portion of the tube 15, the now fully burned out exhaust gases are permitted to expand and are then discharged to atmosphere. To this end, in an area or subchamber 91 between the last two screen disks 80 and 89 in the series, the clean exhaust gases are permitted to leave the combustion tube 15 through a perforated longitudinal area of the tube which, in the illustrated instance, may be on the order of 2 inches long. Such area of the tube is uniformly perforated to provide an exhaust screen wherein perforations 92 may be on the order of 1/16 inch in diameter. There may, for example, be on the order of eleven hundred of the perforations 92, enabling fairly rapid expansion of the gases outwardly throughout the radial extent of the subchamber 91. To enhance the expansibility of the gases entering the subchamber 91, a blind end muffler chamber 93 is desirably provided between the closure plate 88 and the screen disk 89, accommodating any surges of the gas and assuring smooth, quiet emission from the exhaust end of the combustion tube system.

Combustion efficiency attainable with the present system is demonstrated by the fact that temperature sensing tests in the subchamber 91 have revealed an average of about 800°F. under normal operating conditions. To reduce the emission temperature, expansion and cooling of the exhaust gases leaving the subchamber 91 are provided for. To this end, the expansion chamber 17 within the housing tube enlargement 18 is of generous annular volume capacity and preferably has heat transfer means therein cooperating with the metal shell of the expanded housing tube portion 18 to dissipate heat by direct heat transfer and radiation to the ambient atmosphere and more particularly the customary air stream passing thereby in the forward movement of the associated vehicle by virtue of the free exposure of the device in the customary muffler-

mounting place under the rear portion of the associated vehicle body. Of course, where the device is employed on some other type of vehicle than an automobile or truck, such as on a diesel locomotive, the device may be mounted in any suitable air stream location such as on the locomotive roof. Where used in association with a stationary internal combustion engine, the device may be located at a suitable outdoor location in a blower exhaust duct.

On leaving the exhaust chamber **91**, the expanding exhaust gases are desirably conducted in a circuitous expanding path not only for cooling heat transfer but also for final muffling before release to atmosphere. For this purpose, means comprising an exhaust reversal cone **94** (FIGS. **1** and **5**) is mounted concentrically about the tube chamber **91** within the expansion chamber **17** and provides an imperforate annular wall which flares in spaced relation upstream relative to the tube **15** and is of a length somewhat greater than the length of the perforated area of the tube **15** about the chamber **91** so that the exhaust gases leaving the combustion tube through the perforations **92** will be expansively guided upstream for further expansion in the chamber **17.** In a desirable construction, the reversal cone **94** extends inwardly to a radial closure ring **95** secured to the housing tube **14** at juncture with an annular frustoconical offset **97** with the expansion chamber enlargement **18** and having its inner edge in sliding engagement with the tube **15** to provide a barrier between the preheating chamber **13** and the exhaust expansion chamber **17.** For free expansion of the exhaust gases from the inner end portion of the reversal cone, the wall of such inner end portion is provided with a plurality, such as four large equidistantly circumferentially spaced expansion openings **98** through which the expanding exhaust gases can freely move in substantially equalized lateral expansion into the expansion chamber **17.**

From the inner end portion of the expansion chamber **17,** the exhaust gases are conducted outwardly in an expanding annular flow path about the reversal cone **94** within the expansion chamber enlargement **18.** For primarily heat exchange, but also for muffling, a fill of coarse particulate material **99** is desirably contained in the exhaust flow path in the outermost portion of the chamber **17.** Such material may be similar to the material **27** at the preheating end of the combustion tube **15,** namely, hard coral, seashell, stainless steel shavings, and the like, coarse enough to be retained between a pair of axially spaced radially extending ring-shaped perforated screen disks **100** and **101** which are secured by means such as welding **102** to the outer perimeter of the reversal cone **94.** At their perimeters, the disks **100** and **101** are desirably dimensioned to have sliding engagement with the inner surface of the housing enlargement **18.** While the material **99** may be filled in between the disks **100** and **101** and the cone **94** and the shell of the housing portion **18,** the preferred construction comprises enclosing the material in cartridge form enabling insertion or removal of the cone **94** and the cartridge as a unit, and for this purpose a retaining ring sleeve **103** is preferably secured to and between the outer margins of the disks **100** and **101.** Through this arrangement, all of the exhaust gases must, in order to leave the expansion chamber **17,** pass through the bed of material **99.**

Means are provided on the cone **94** for receiving and supporting the adjacent end of the combustion tube **15** and for securing the cone in place in the expansion chamber enlargement **18.** To this end, the outer end portion of the cone **94** carries either as an integral stamped sheet metal portion thereof, or, as shown, as a separately formed and attached member, a generally cup-shaped outer end closure and combustion tube receiving socket **104.** The member **104** may be secured to the end of the cone as by means of welding **102.** By having the socket provided by the number **104** properly dimensioned, the adjacent end of the tube **15** is received slidably therein. Releasable attachment of the cone unit against outward displacement from the expansion chamber **17** is effected by means, comprising in this instance a plurality, such as four equally circumferentially spaced attachment angles **105** secured as by means of welding to the marginal flange of the end closure socket member **104** and dimensioned to engage slidably within the outer end margin of the housing portion **18** to which the attachment angles are releasably secured as by means of screws **107.** Through this arrangement, not only is the cone member **94** retained in place, but the tube **15** is retained against outward displacement and the closure disk **88** is maintained in closing relation to the contiguous end of the tube **15** against any tendency toward displacement of the disk and flame runner assembly from the tube **15.** In addition, the assembly of parts is maintained neatly within the outer end of the housing portion **18.** By having the attachment angles **105** widely spaced, such as quadrantly, there is minimum interference with free exhaust of gases to atmosphere through the endmost perforated disk **101.**

All components of the unit **10** which lend themselves to sheet metal fabrication are desirably made from suitable heat-resistant material, for example sheet metal on the order of 1/16 inch thickness. Although the expansion chamber portion **18** of the housing is desirably exposed to atmosphere to enhance heat transfer and cooling of the expanded exhausting gases, it may be desirable to insulate the housing tube **14** upstream from the portion **18** against heat loss so as to gain every possible advantage of the preheating and combustion of the exhaust gases within the unit. Accordingly, the tube **14** inboard relative to the portion **18** may be covered with heat insulation **108.** Such insulation may, if desired, also be applied to the initial stage muffler and distributor **11** and the distributor ducts **19.**

It will be understood that variations and modifications may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. A device for eliminating incompletely burned combustible material in the exhaust gases from an internal combustion engine, comprising:

means defining a combustion zone;

means for delivering the engine exhaust gases into preheating relation to said combustion zone;

means for directing the preheated exhaust gases into the combustion zone;

means in said combustion zone for subjecting the exhaust gases to multiple flame treatment by successive stages to attain complete combustion of the combustible materials in the gases; and

means providing an expansion zone for the completely burned exhaust gases and discharging to atmosphere.

2. A device according to claim 1, wherein said means defining a combustion zone comprises an elongated combustion tube, said multiple flame treatment means comprising a flame generator having a nozzle discharging into the exhaust gases flowing through the combustion tube, and a flame runner tube mounted within said combustion tube and having a receiving mouth spaced downstream relative to said nozzle to receive flame from the nozzle, and flame discharge ports in said flame runner tube for directing flame from the flame runner tube into the exhaust gases in the combustion tube downstream from the flame nozzle.

3. A device according to claim 1, wherein the multiple flame treatment means comprise a flame generator having a nozzle discharging into the combustion zone, and a flame runner tube mounted within said combustion zone and having a receiving mouth spaced downstream relative to said nozzle to receive flame from the nozzle, and flame discharge ports in said flame runner tube for directing flame from the flame runner tube into the exhaust gases in the combustion zone downstream from the flame nozzle.

4. A device according to claim 3, wherein said runner tube has the ports at spaced intervals therealong, and further including exhaust gas dispersion disks mounted on and external to said flame runner tube and mounted between said ports and through which disks the exhaust gases are directed.

5. A device for eliminating incompletely burned combustible material in the exhaust gases from an internal combustion engine, comprising:

means for producing intense comsuming heat in a combustion zone;

means for delivering the engine exhaust gases into preheating relation to said combustion zone;

means for directing the preheated exhaust gases into the combustion zone for subjecting the gases to the consuming heat therein for complete combustion of the combustible materials in the gases;

means providing an expansion zone chamber for the completely burned exhaust gases and having a discharge to atmosphere and including heat transfer cooling means in said expansion chamber;

said combustion zone including a combustion tube extending into said expansion zone chamber;

said tube having a perforated area for escape of burned out exhaust gases from the combustion tube; and

an exhaust reversal cone spaced in coaxial relation about said perforated section of the combustion tube and providing a tortuous path with said expansion chamber means.

6. A device according to claim 5, wherein said means providing the expansion zone chamber comprise a tubular enlargement about said perforated area of the combustion tube, said enlargement having the heat transfer cooling means therein.

7. A device according to claim 5, wherein said heat transfer cooling means comprise an annular cartridge about said exhaust reversal cone, said cartridge being filled with a coarse particulate material.

8. A device according to claim 5, including muffling means about said reversal cone in said expansion zone chamber.

9. A device for treating exhaust from an internal combustion engine, comprising:

means defining a muffle chamber and distributor receptive of the exhaust;

an elongated tubular housing;

a plurality of passages effecting communication between said means and an area intermediate the length of said housing;

a tube extending longitudinally in spaced relation within said housing;

a combustion flame system within said tube and means for generating flame in the system;

a barrier within the housing between said tube and the housing compelling exhaust flow from said passages to travel toward one end of said tube;

said end of the tube being receptive of the exhaust to travel through the tube toward its opposite end portion and thereby subjected to the flame of said system;

dispersion means located at several longitudinally spaced intervals along the interior of the tube past which the exhaust must travel;

means carried by the housing at the opposite side of said barrier from said passages providing an expansion chamber and escape to atmosphere for exhaust leaving said opposite end portion of the tube;

said dispersion means comprising a series of axially spaced perforated spreader screen disks having their edges in sliding fit within said tube; and

elongated stem means connecting the screen disks and enabling unitary insertion and removal of the screen disks relative to the tube.

10. A device according to claim 9 wherein said stem means comprise a tubular element of said combustion flame system.

11. A device according to claim 9, wherein said stem means have an imperforate disk thereon beyond said screen disks, said imperforate disk providing an end closure for said tube, said tube having lateral exhaust ports therefrom ahead of said closure disk.

12. A device for eliminating incompletely burned combustible material in the exhaust gases from an internal combustion engine, comprising:

an elongated combustion tube of substantial diameter;

a housing tube enclosing said combustion tube in spaced relation thereto;

a closure means across one end of said housing tube in spaced relation to one end of said combustion tube;

means for delivering engine exhaust gases into preheating relation to said combustion tube within the space between the tubes and means located adjacent said one end of said combustion tube directing the preheated exhaust gases into said combustion tube;

a fuel delivery tube of smaller diameter than said combustion chamber tube extending through said closure means into said one end of said combustion tube and delivering into a combustion chamber located within said combustion tube at a position downstream from said preheated exhaust gas directing means and having a diameter larger than said delivery tube but of smaller diameter than said combustion tube and about which the preheated exhaust travel in further preheating relation;

means in said combustion chamber for igniting the fuel;

said combustion chamber having a discharge orifice directed downstream within the combustion tube;

a plurality of longitudinally spaced dispersion disks located downstream from said orifice within said combustion tube and through which the burning combustion gases must pass toward the opposite end of said combustion tube;

means closing said opposite end of the combustion tube and the combustion tube having laterally opening perforations therefrom upstream of said closing means; and

means defining an expansion and exhaust chamber about said combustion tube to receive the exhaust gases from said perforations.

13. A device according to claim **12,** wherein said means for delivering exhaust gases comprise a tubular manifold having a plurality of lateral distributor ports therealong communicating through said housing tube with said space between the combustion and housing tubes and directed toward said combustion tube substantially downstream from said one end of the combustion tube so that combustion gases entering into said space must travel in preheating relation a substantial distance along the combustion tube to said one end.

14. A device according to claim **12,** including a body of particulate flow dispersion and preheating material filling the space between said delivery tube and the combustion tube between said one end of the combustion tube and said combustion chamber.

15. A device according to claim **12,** said fuel delivery tube having turbine blades therein.

16. A device according to claim **15,** including means for supplying air and fuel mixture under pressure to said fuel delivery tube including a pressure drop inlet orifice opening into the fuel delivery tube.

17. A device according to claim **16,** including a mixing chamber from which the orifice receives the fuel-air mixture.

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