

Sept. 18, 1973

MITSUMASA YAMADA ET AL
AFTER-BURNER FOR RE-COMBUSTION OF EXHAUST GASES
OF INTERNAL COMBUSTION ENGINES

3,759,668

Filed Oct. 14, 1971

2 Sheets-Sheet 1

FIG. 1

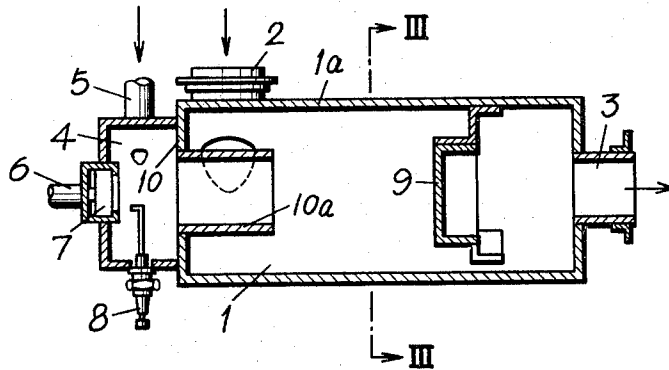


FIG. 2

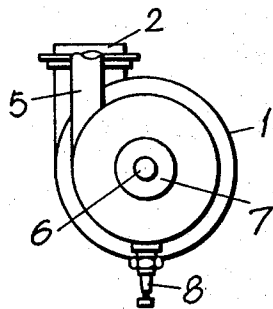
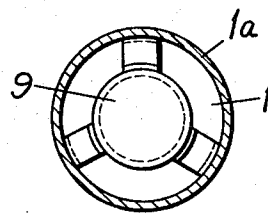


FIG. 3



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FIG. 4

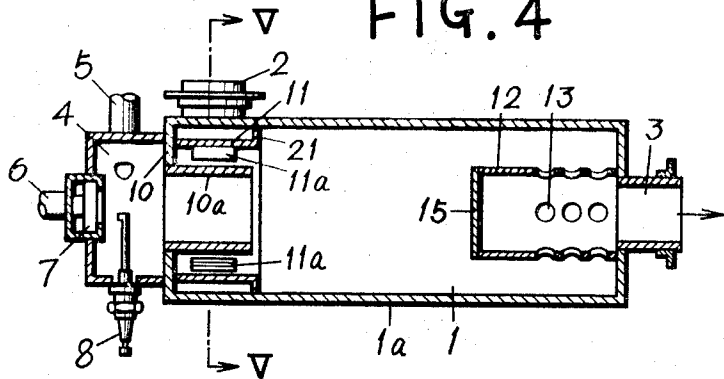


FIG. 5

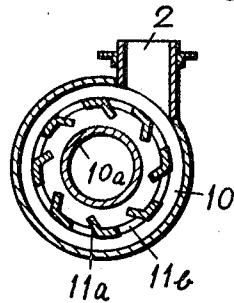


FIG. 6

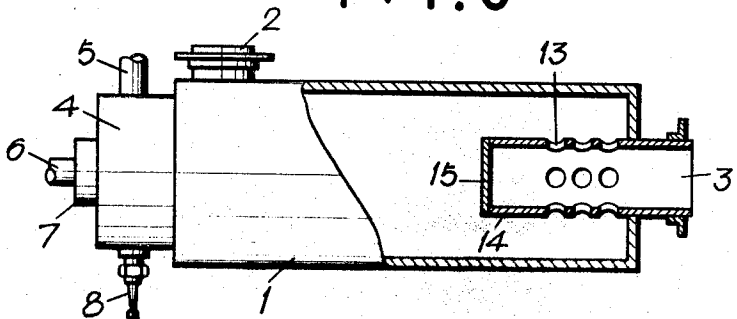


FIG. 7A

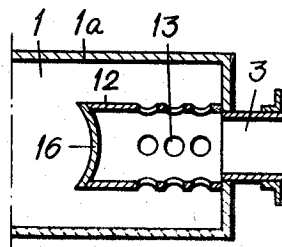


FIG. 7B

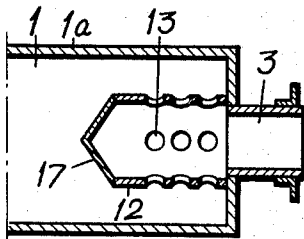
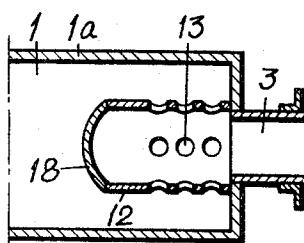


FIG. 7C



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AFTER-BURNER FOR RE-COMBUSTION OF EXHAUST GASES OF INTERNAL COMBUSTION ENGINES

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Filed Oct. 14, 1971, Ser. No. 189,172

Claims priority, application Japan, June 15, 1971 (utility model), 46/50,905

Int. Cl. F01n 3/14

U.S. Cl. 23—277 C

10 Claims

ABSTRACT OF THE DISCLOSURE

An after-burner for re-combustion of unburnt components of exhaust gases of an internal combustion engine, comprising: a burner including a mouth for producing and spouting from said mouth a jet flame swirling about a longitudinal center line of said jet flame; a chamber associated with the burner for receiving said jet flame, a longitudinal center line of said chamber being parallel to said jet flame longitudinal center line, the chamber having an end opposite to the burner; means mounted in the chamber for introducing the exhaust gases into the chamber and inducing the exhaust gases to rotate round the jet flame; a device mounted in the chamber and confronting the mouth for dispersing the jet flame radially with respect to the chamber and thereby mixing the jet flame with the rotating exhaust gases to make a mixture thereof; and an outlet pipe mounted on the opposite end. The unburnt components are burnt within the chamber to clear the exhaust gases of the unburnt components and then the cleared exhaust gases are discharged from the chamber through the outlet pipe.

This invention relates to an after-burner for recombustion of exhaust gases of internal combustion engines which is effective to purify exhaust gases by burning unburned components in the exhaust gases.

In conventional after-burners of the type described, an ignition plug has hitherto been used to ignite exhaust gases for burning unburned components in the exhaust gases. Difficulty has, however, been experienced in setting fire to unburned components in exhaust gases by means of an ignition plug. Besides, even if attempts at setting a fire by this means succeed, the flame produced is so unstable that it is blown out in no time, so that the process of setting a fire must be repeated again and again. It is thus difficult to burn completely unburned components in exhaust gases by using an ignition plug, and an increase in the efficiency of purifying exhaust gases cannot accordingly be expected.

This invention obviates the aforementioned disadvantage of conventional after-burners for burning unburned components in exhaust gases.

An object of this invention which is based on a known vortex burner is to provide an after-burner which provides for complete combustion of unburned elements in the exhaust gases of an internal combustion engine, no matter what operating condition the internal combustion engine is in.

Another object of the invention is to provide an after-burner which has, as a source for igniting exhaust gases, a strong and stable flame which causes continuous combustion of the exhaust gases to occur once it sets fire to the exhaust gases.

Another object of the invention is to provide an after-burner in which the flame produced by setting fire to exhaust gases is so stable that it never gets blown out irrespective of variations in the quantities of combustible

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components in the exhaust gases and the quantity of exhaust gases, and thus a special flame protective means which has been required with conventional exhaust after-burners can be eliminated.

Additional objects as well as features and advantages of this invention will become evident from the description set forth hereinafter when considered in conjunction with the accompanying drawings, in which:

FIG. 1 is a sectional view of an after-burner for burning exhaust gases comprising one embodiment of this invention;

FIG. 2 is a left side view of the after-burner in FIG. 1; FIG. 3 is a sectional view taken along the line III—III of FIG. 1;

FIG. 4 is a sectional view of an after-burner for burning exhaust gases comprising another embodiment of this invention;

FIG. 5 is a sectional view taken along the line V—V of FIG. 4;

FIG. 6 is a fragmentary sectional view showing the covered cylinder and exhaust gas discharge tube being formed integrally; and

FIGS. 7A, 7B and 7C are fragmentary sectional views showing other forms of the covered cylinder shown in FIG. 4.

In FIG. 1 which shows one embodiment of this invention, 1 is a reactor proper for burning exhaust gases discharged from an internal combustion engine and containing unburned components. Connected to the reactor proper 1 are an exhaust gases inlet line 2 for introducing exhaust gases into the reactor proper 1 tangentially thereof, an exhaust gases outlet line 3 for discharging exhaust gases after being burned and purified, and vortex burner 4 for producing a flame and introducing the same into the reactor proper 1.

The vortex burner 4 is cylindrical in shape and has an air supply line 5 connected thereto tangentially thereof as shown in FIG. 2. A fuel evaporator 7 is attached to a side of the vortex burner 4 opposite to the side at which the burner 4 is connected to the reactor proper 1, and an ignition plug 8 for setting fire to the mixture of fuel and air is mounted radially of the burner 4. A fuel supply line 6 is connected to the fuel evaporator 7.

A discal baffle plate 9 for guiding the exhaust gases and expanding the flame is mounted in the reactor proper 1 in a position which is nearer to the side of the reactor proper 1 at which the exhaust gas outlet line 3 is connected to the reactor proper 1 than the side at which the vortex burner 4 is connected to the reactor proper 1. The vortex burner 4 and reactor proper 1 are separated from each other by a partition wall 10 which is provided with a cylinder 10a for ejecting into the reactor proper 1 a flame produced in the burner 4.

Operation of the after-burner constructed as aforementioned according to this invention will now be explained. Exhaust gases containing unburned components and discharged from the internal combustion engine are introduced through the exhaust gases inlet line 2 in to the reactor proper 1 tangentially thereof, so that the exhaust gases move in a swirling current in the reactor proper 1.

On the other hand, fuel supplied through the fuel supply line 6 into the vortex burner 4 is converted into a gaseous state by the fuel evaporator 7 and mixed with air introduced through the air supply line 5 into the burner 4 tangentially thereof. The air-fuel mixture is ignited by the ignition plug 8 and burns, so that the flame produced moves in vortical form or rotating columnar form as it is ejected through the cylinder 10a into the reactor proper 1.

The exhaust gases move in a swirling stream along the inner wall surface of the reactor proper 1, and the flame ejected through the cylinder 10a into the reactor proper 1 moves along the center axis of the reactor proper 1 in

a swirling stream toward the exhaust gases outlet line 3. Thus, the stream of exhaust gases moves in swirling motion around the stream of flame moving in swirling motion in the region of the reactor proper 1 near the flame ejection cylinder 10a, and the flame is very stable without being suppressed by the exhaust gases.

The swirling stream of flame ejected from the burner 4 and the swirling stream of exhaust gases reach the baffle plate still in two layers, although portions of the two layers gradually are mixed with each other. Upon impinging on the baffle plate 9, the stream of flame in vortical form or rotating columnar form ejected from the burner 4 is disturbed by the baffle plate 9 and expanded from the central axis of the reactor proper 1 into the peripheral region thereof. The expanded stream of flame is brought into contact and mixed with the swirling stream of exhaust gases moving along the inner wall surface of the reactor proper 1, so that carbon monoxide, unburned hydrocarbons and other noxious combustible components in the exhaust gases are burned in complete combustion. Burned and purified exhaust gases are vented through the exhaust gases outlet line 3.

Another embodiment of this invention will be explained with reference to FIG. 4. In FIGS. 1 and 4, like reference characters designate similar parts. In FIG. 4, a vortex burner 4 and reactor proper 1 are divided by a partition wall 10. A cylinder 10a for introducing a flame into the reactor proper 1 is provided in the central portion of the partition wall 10 to project into the reactor proper 1 and be disposed near an opening of an exhaust gases inlet line 2.

An exhaust gases guide cylinder 11 is mounted between the cylinder 10a and an inner wall surface 1a of the reactor proper 1. The cylinder 11 is provided with a number of blades 11a and formed with a number of apertures 11b for causing the exhaust gases introduced into the reactor proper 1 through the exhaust gases inlet line 2 to move in a swirling stream in the same direction as the swirling stream of flame in the region of the reactor proper 1 around the cylinder 10a. The cylinder 11 also has a flange 21 attached to the inner wall surface 1a of the reactor proper 1.

A covered cylinder 12 provided with a cover 15 for expanding the flame ejected from the burner 4 into the peripheral portion of the reactor proper 1 and a number of small apertures 13 for permitting gases to pass therethrough is provided on a side of the reactor proper 1 which is opposite to the side at which the burner 4 is connected through the partition wall to the reactor proper 1. The covered cylinder 12 is disposed concentrically with the reactor proper 1 and adjacent an opening of an exhaust gases outlet line 3.

Operation of the second embodiment of this invention constructed as aforementioned will now be described. Exhaust gases discharged from the internal combustion engine are introduced through the exhaust gases inlet line 2 into the reactor proper 1 tangentially thereof. The flow of exhaust gases is adjusted by the blades 11a of exhaust gases guide cylinder 11 and moves toward the exhaust gases outlet line 3 while moving in a swirling stream between the cylinder 10a and inner wall surface 1a of the reactor proper 1.

On the other hand, a flame moving in vortical form or rotating columnar form is produced in the burner 4 in the same manner as described with reference to the first embodiment shown in FIG. 1. The flame is ejected through the cylinder 10a into the reactor proper 1.

The flame ejected into the reactor proper 1 in this way moves toward the exhaust gases outlet line 3 in a swirling stream which is separated, near the opening of the cylinder 10a, from the swirling stream of exhaust gases moving in a swirling stream along the inner wall surface 1a of the reactor proper 1. Since the covered cylinder 12 is provided in the front of the exhaust gases outlet line 3, the swirling stream of flame moving on the inner side

of the swirling stream of exhaust gases containing unburned components impinges on a cover 15 and the cylindrical portion of the covered cylinder 12 contiguous with the cover 15, so that the stream of flame in vortical form or rotating columnar form is disturbed and expanded toward the peripheral region of the reactor proper 1.

The swirling stream of exhaust gases moving along the inner wall surface 1a of the reactor proper 1 is brought into contact with the expanded swirling stream of flame and mixed therewith, so that the noxious combustible components contained in the mixture of flame and exhaust gases are burned while moving between the inner wall surface 1a of the reactor proper 1 and the covered cylinder 12.

It has been ascertained experimentarily that, if the outer diameter of the covered cylinder 12 is greater than the inner diameter of the cylinder 10a through which the flame is ejected, then the swirling stream of flame ejected through the cylinder 10a is not suppressed by the swirling stream of exhaust gases moving on the outside of the swirling current of flame. The flame in the reactor proper 1 is stable, and the swirling streams of flame and exhaust gases can be thoroughly mixed with each other by the covered cylinder 12.

The exhaust gases which have been mixed with the flame and have had the unburned components therein burned by the flame are introduced into the interior of the cylinder 12 through a number of small apertures 13 formed in the cylindrical portion of the covered cylinder 12. At this time, the exhaust gases are at elevated temperature because they are mixed with the flame and the unburned components therein are burned by the flame. As the exhaust gases at elevated temperature pass through the small apertures 13, a number of swirling streams are produced in the exhaust gas at elevated temperature, with a result that the exhaust gases are thoroughly mixed and the unburned components therein are burned in complete combustion. The exhaust gases burned in complete combustion are led to the exhaust gases outlet line 3 and discharged therethrough out of the reactor proper 1.

FIG. 6 shows a modification of the second embodiment in which a covered cylinder 14 and exhaust gases outlet line 3 are formed integrally and mounted on the reactor proper 1. This construction provides an after-burner which is easy to manufacture and low in cost.

FIGS. 7A to 7C illustrate other forms of the covered cylinder. The cylinder of FIG. 7A is provided with a concave cover 16; the cylinder of FIG. 7B is provided with a conical cover 17; and the cylinder of FIG. 7C is provided with a convex cover 18. It is to be understood that results similar to those achieved by the covered cylinder of the first and second embodiments can be achieved by the modifications of the covered cylinders shown in FIGS. 7A to 7C. The cover of the covered cylinder need not be planar in surface at all times.

From the foregoing description and the showing in the drawings, it will be appreciated that the after-burner according to this invention uses, as a source of ignition of exhaust gases of an internal combustion engine, a flame ejected from a vortex burner which is a source of a strong and stable flame. The flame used as a source of ignition of exhaust gases is stabilized by the novel arrangement of blowing the exhaust gases of the internal combustion engine into the reactor proper or by using a flame introducing cylinder of the vortex burner and exhaust gases guide cylinder. Thorough mixing of the exhaust gases of the internal combustion engine with the flame serving as an exhaust gases igniting source can be attained by using a baffle plate or covered cylinder. Thus, the exhaust gases can be burned in complete combustion.

This invention obviates the disadvantages of incomplete combustion of exhaust gases or interruption of combustion of exhaust gases which are inherent in conventional after-burners for internal combustion engines. This invention

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permits the burning of exhaust gases in complete combustion regardless of the state of operation of the internal combustion engine as well as an increase in the efficiency of the after-burner for internal combustion engines in burning exhaust gases in complete combustion.

The after-burner according to this invention has been described as using a baffle plate and a covered cylinder formed with small apertures as a flame expanding means. It is to be understood that this invention is not limited to the specific forms of the flame expanding means shown and described herein, and that many changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An after-burner for re-combustion of unburnt components of exhaust gases of an internal combustion engine, comprising: a burner including a mouth for producing and spouting from said mouth a jet flame swirling about a longitudinal center line of said jet flame; a chamber associated with said burner for receiving said jet flame, a longitudinal center line of said chamber being parallel to said jet flame longitudinal center line, said chamber having an end opposite to said burner; means mounted in said chamber for introducing said exhaust gases into said chamber and inducing said exhaust gases to rotate round said jet flame, said exhaust gases and said jet flame being substantially separated as they traverse said chamber a predetermined distance; means mounted in said chamber and confronting said mouth for dispersing said jet flame radially with respect to said chamber and thereby mixing said jet flame with said rotating exhaust gases to make a mixture thereof; and an outlet pipe mounted on said opposite end, whereby said unburnt components are burnt within said chamber to clear said exhaust gases of said unburnt components and then said cleared exhaust gases are discharged from said chamber through said outlet pipe.

2. An after-burner as defined in claim 1, wherein said dispersing means comprises: a baffle plate spaced apart with respect to said chamber; and a plurality of supports, each of said supports having an end connected to said baffle plate and the other end connected to said chamber, each of said supports being spacedly disposed with respect to other.

3. An after-burner as defined in claim 1, wherein said dispersing means comprises a cylinder with a plurality of first apertures therein, said cylinder having a closed end and an open end, said cylinder being mounted on said

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opposite end at said open end, said open end communicating with said outlet pipe, said closed end confronting said mouth, whereby mixing of said jet flame with said rotating exhaust gases is consummately made when said mixture goes through said first apertures.

4. An after-burner as defined in claim 3, wherein said closed end is flat.

5. An after-burner as defined in claim 3, wherein said closed end is concave when said closed end is viewed from said mouth.

6. An after-burner as defined in claim 3, wherein said closed end is convex when said closed end is viewed from said mouth.

7. An after-burner as defined in claim 3, wherein said closed end is conical.

8. An after-burner as defined in claim 3, wherein said closed end is integrated with said outlet pipe at said open end.

9. An after-burner as defined in claim 1, wherein said introducing means comprises an intake pipe disposed on said chamber tangentially with respect thereto and communicating therewith, an imaginary straight longitudinal extension of said intake pipe being outside a path of said jet flame.

10. An after-burner as defined in claim 1, wherein said introducing means comprises: an intake pipe disposed on said chamber obliquely with respect thereto; and an annular enclosure integrated with an inner wall of said chamber for defining an annular space therein, said intake pipe communicating with said space, said annular enclosure having a plurality of apertures and guide vanes, said guide vanes extending inwardly, radially and obliquely from said annular enclosure, a flow direction vector of said exhaust gases forming an acute angle with said guide vanes.

References Cited

UNITED STATES PATENTS

3,311,456	3/1967	Denny	23—277 C
3,360,927	1/1968	Cornelius	60—286
3,408,167	10/1968	Burden	23—277 C
3,473,323	10/1969	Briggs	60—303
3,637,343	1/1972	Hirt	23—277 C

DOUGLAS HART, Primary Examiner

U.S. Cl. X.R.

60—303