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[54] DEVICE FOR BURNING THE UNBURNT RESIDUE IN THE EXHAUST GASES OF INTERNAL COMBUSTION ENGINES

[72] Inventors: **Louis Jules Bauger,** Vanves; **Roland Robert Charles Beyler,** Levallois-Perret; **Henri Le Guen,** Fontenay-Saux-Roses; **Jacques Eloi Pidebois; Michel Bernard Schenher,** both of Paris, all of France

[73] Assignee: **Societe National D'Etude et de Construction de moteurs D'Aviation,** Paris, France

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[51] **Int. Cl.** **F01n 3/14**

[58] **Field of Search** ..... 60/29 A, 30 R; 23/2 C, 277 C

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Primary Examiner—Douglas Hart

Attorney—Watson, Cole, Grindle & Watson

[57] **ABSTRACT**

A device for burning the unburnt constituents in the exhaust gases of a heat engine, for example a motor car engine, in which the exhaust gases, to which air may have been added, pass through an annular channel where sparks jump between an inner electrode and an outer electrode forming a wall of a combustion chamber. The annular channel is formed between the inner electrode and a conducting wall insulated electrically from the wall of the combustion chamber, the inner electrode being connected to the conducting wall by conducting vanes which impart a rotational movement to the gases in the annular channel, and the sparks jump in a restricted outlet of the annular channel located between the wall of the combustion chamber and a wider downstream part of the inner electrode.

14 Claims, 5 Drawing Figures

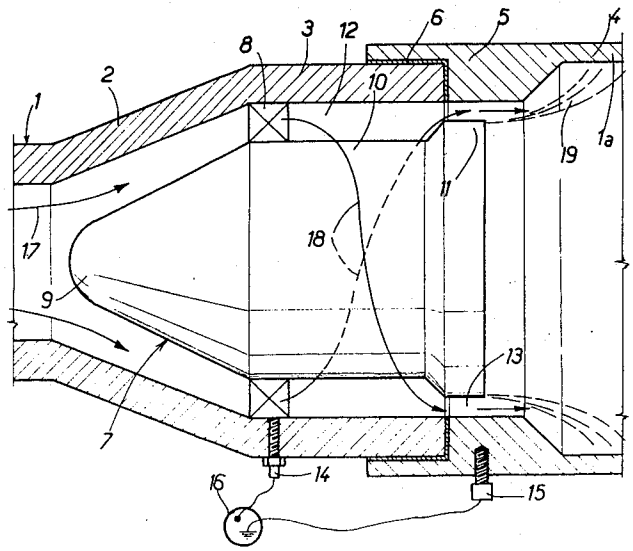

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FIG.: 1

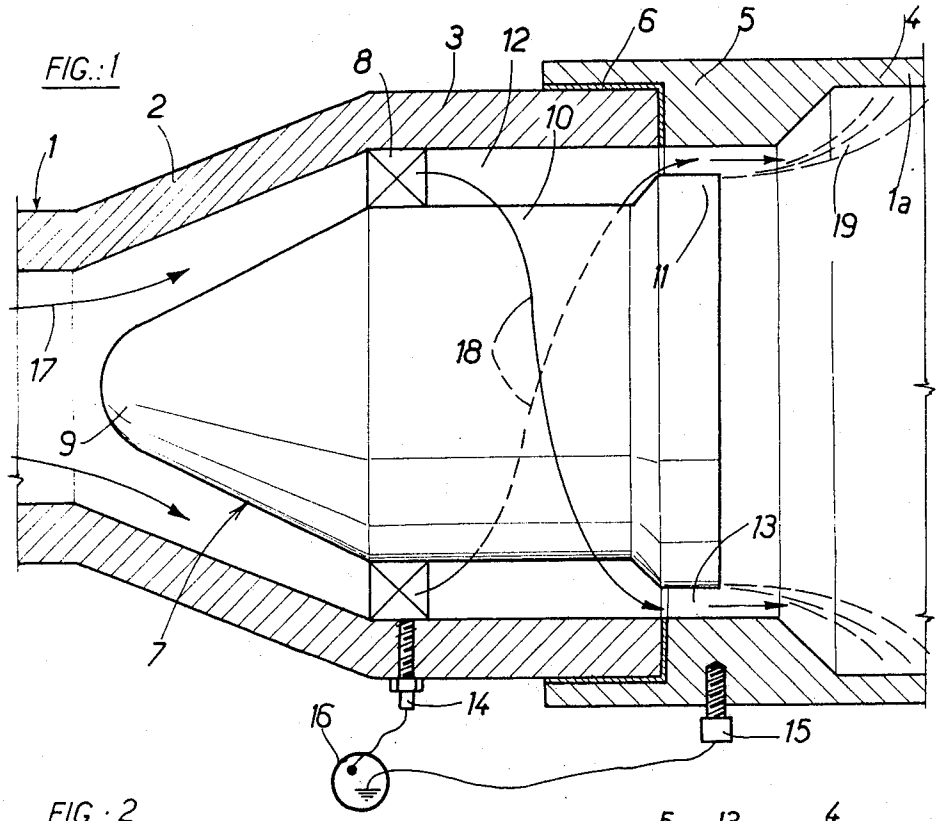
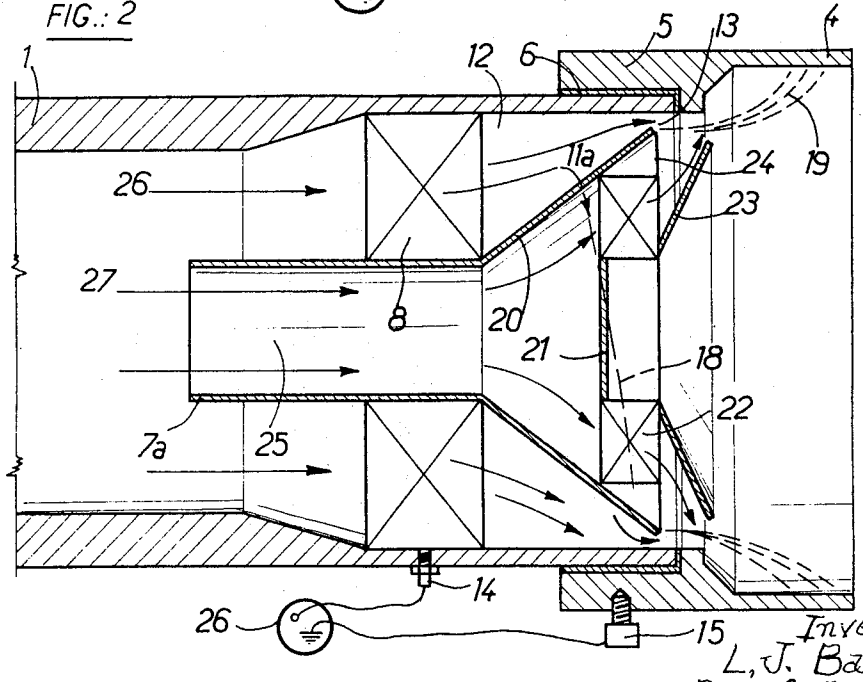


FIG.: 2



Inventors
L. J. Bauger
R. R. C. Beyler
H. Le Guen
J. E. Pidebois
M. B. Schenher
By
Watson, Cole, Grindle & Watson Attys.

FIG.:3

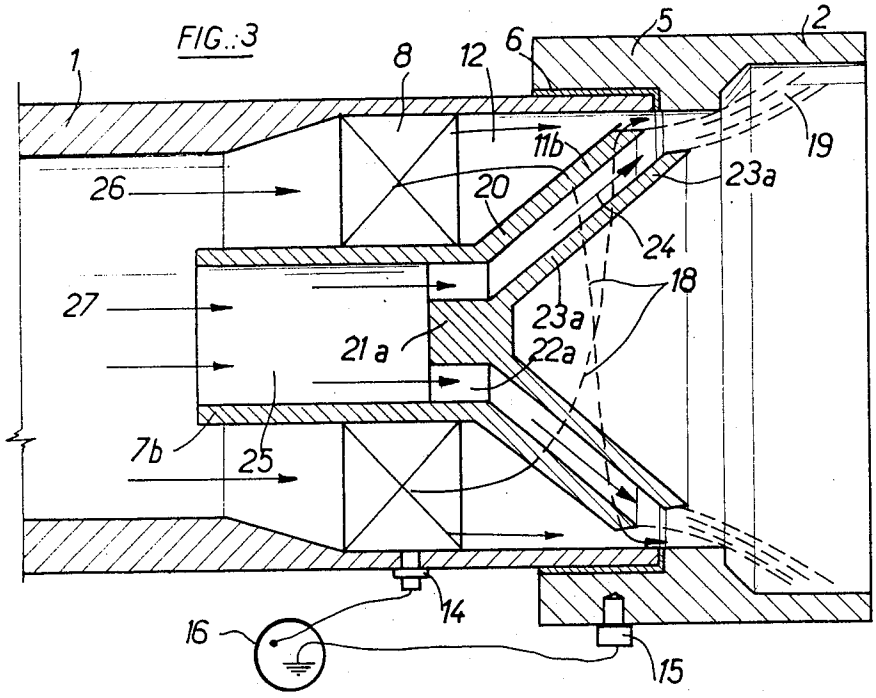
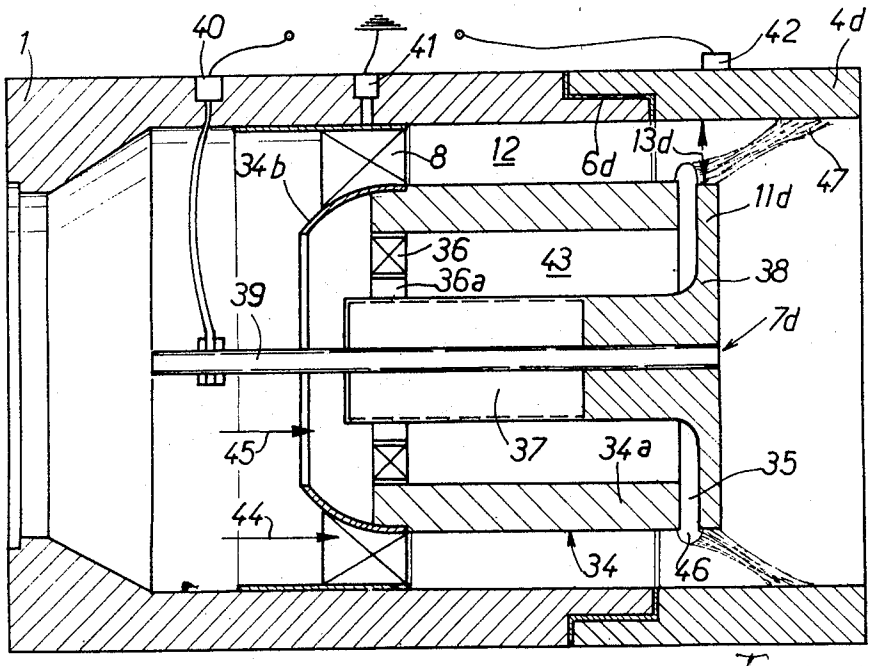


FIG.: 5



Inventors
L. J. Bauger
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H. Le Guen
J. E. Pide Bois
M. B. Schenher

By Watson Cole Grindle Watson Attys.

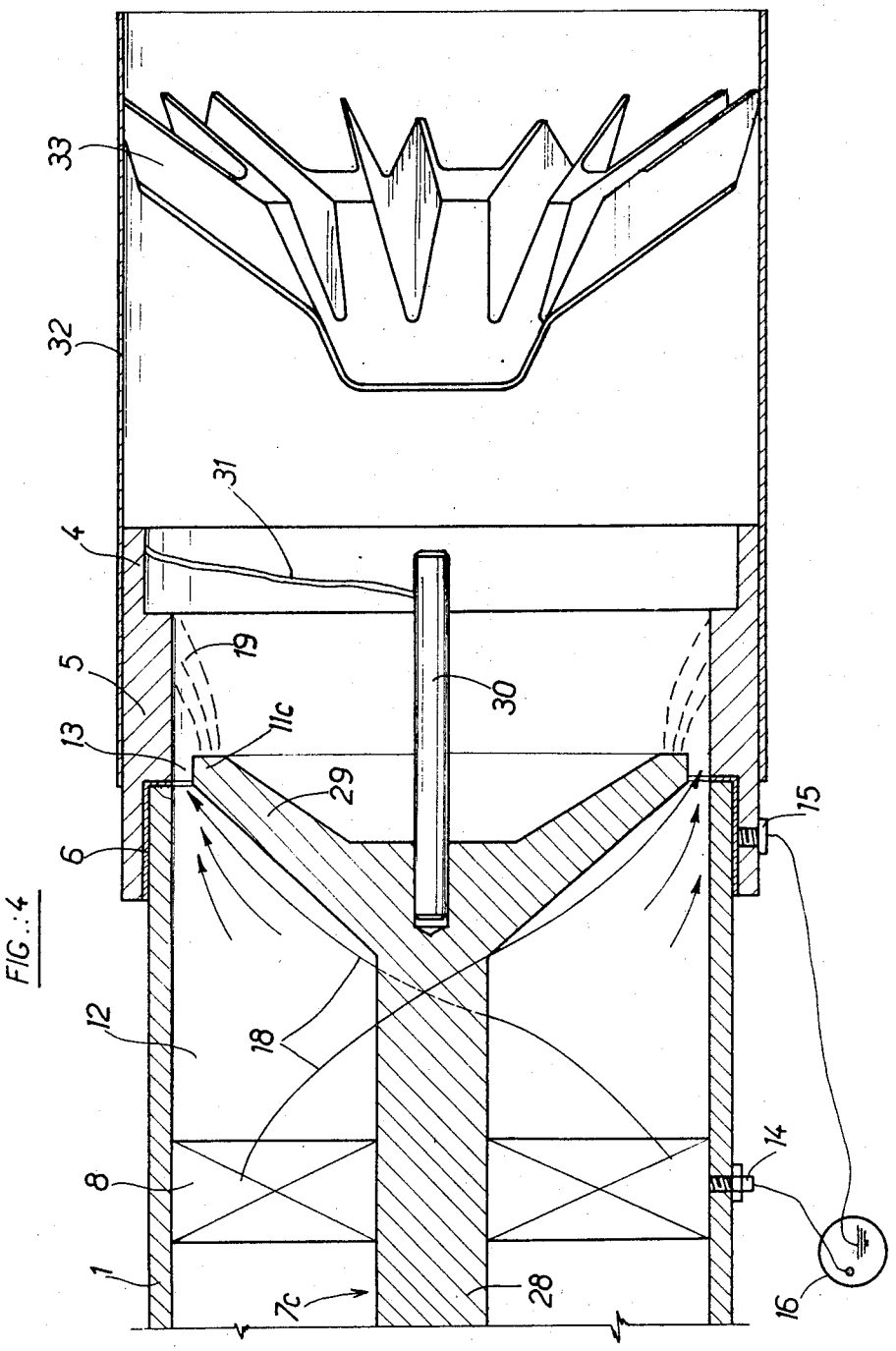

FIG. 4

Inventors
L. J. Bauget
R. R. C. Beyler
H. Le Guen
J. E. Pidebois
M. B. Schenher

By Watson Cole Grindle & Watson
Attys.

DEVICE FOR BURNING THE UNBURNT RESIDUE IN THE EXHAUST GASES OF INTERNAL COMBUSTION ENGINES

In order to make the atmosphere in towns less harmful, it is highly desirable that internal combustion engines and diesel engines of mechanically propelled vehicles should be equipped with devices which ensure the perfect combustion of the exhaust gases.

Because of changes in the running condition of engines of motor cars, particularly in towns, such as idling, accelerating, decelerating, and limited speed running, the percentage of carbon monoxide in the exhaust gases is generally between 3 and 5 percent for engines which are correctly adjusted, and this makes the atmosphere in towns with high traffic densities toxic for living organisms.

Various devices have already been proposed for burning the carbon monoxide at the outlet of the exhaust systems of engines by means of spark plugs. In view of the fact that the exhaust gases do not generally contain sufficient oxygen to permit the total combustion of the unburnt residues, known devices usually include means for introducing fresh air into the exhaust gases. The main difficulty encountered in the design of these devices is to ensure a homogenous mixture and to achieve complete combustion.

The present invention relates to an improved device which makes it possible to burn completely the unburnt residues in exhaust gases of heat engines, and more particularly of internal combustion engines.

According to the invention the exhaust gases to which air may be added pass through a device comprising a combustion chamber, the wall of which forms an outer electrode, an inner structure forming with this wall an annular channel, and forming at the downstream end of this channel an inner electrode spaced by an annular gap from the outer electrode, means for generating sparks to jump between the electrodes at this annular gap, and means for producing a turbulence in the gases flowing through the annular channel.

In one embodiment of the invention, the whole of the exhaust gases, possibly with the addition of air, passes through the annular channel. In another embodiment, only a part of the gases passes through the annular channel and the rest passes through a passage in the inner structure where they can be agitated in the same direction as the gas passing through the annular channel or in the opposite direction, and are discharged into the combustion chamber in the neighborhood of the spark gap.

Owing to the speed of the gas flow passing through the spark gap at the end of the annular channel, the sparks jumping between the electrodes form a bundle of sparks distributed around the gap and extending and curving. Moreover, the flow of the eddying gas leaving the annular channel causes the bundle of sparks to perform a gyratory movement. The turbulence engendered in the exhaust gases or in the mixture of exhaust gases and air causes a mixing which homogenizes to some extent the contents of the waste gases of unburnt residue and oxygen, although in view of the relatively small residue content this homogeneity cannot be made perfect. The bundle of elongated and curving sparks distributed around the annular gap and entrained in the gyratory movement explores all sectors of the annular flow leaving the channel, and causes the combustion of the unburnt residue. This combustion forms a flame which, where only a part of the gas passes through the annular channel, ignites the unburnt particles in the remaining gas.

The following description, referring to the accompanying drawings given by way of non limiting example, will explain how the invention may be practised.

In the drawings:

FIG. 1 is a diagrammatical cross section of a device according to the invention in which the exhaust gases pass in their entirety through the annular channel;

FIG. 2 is a diagrammatical cross section of a device according to the invention, in which only a part of the exhaust gases pass through the annular channel;

FIG. 3 is a view similar to FIG. 2 and shows a modification thereof;

FIG. 4 is a view similar to FIG. 1 and shows a modification thereof; and

FIG. 5 is a view similar to the preceding figures showing another embodiment.

In the embodiment shown in FIG. 1 the downstream end of the rear section 1 of the exhaust pipe of a motor vehicle is widened by means of a conical section 2 connected to a cylindrical part 3. A metal collar 4, having at its upstream end an internal thicker portion 5, is fixed at the rear end of the cylindrical part 3 with the interposition of an electrically insulating joint 6. An internal structure 7 is centered and fixed in the section 1 by means of inclined vanes 8.

This structure 7 is made in one piece. It comprises a tapering and profiled upstream section 9 and a cylindrical center section 10 which are fitted, respectively, within the parts 2 and 3 of the exhaust system, and a flanged portion 11 located opposite the thicker portion 5 of the collar 4. The collar 4 surrounds a combustion chamber, upstream of which the structure 7 defines an annular channel 12 and at the downstream end of which there is an annular gap 13 located between the flanged part 11 of the structure 7 and the thicker portion 5 of the collar 4.

Two terminals 14 and 15, mounted respectively on the part 1 of the exhaust pipe and on the collar 4, are connected to an electrical power source 16 which applies to them a differential potential sufficient to cause sparks to jump across the annual gap 13 between the outer electrode formed by the collar 4 and the flanged portion 11 of the inner electrode formed by the element 7. The parts 1, 7 and 8 are of conducting metal, so that the current flows from the terminal 14 to the inner electrode through the vanes 8 and the structure 7, and it is apparent that if the terminal 15 is to be connected to earth, the section 1 may be insulated against earth, for example by means of an insulating joint located between an forward flange of this section 1 and a rear flange of the pipe element (not shOwn), to which it is connected.

If the exhaust gas of the engine, containing carbon monoxide, does not contain sufficient oxygen to permit its complete combustion, fresh air is introduced by means not shown, for example a fan or a pump drawing in air from the outside. The bases, with the possible addition gases, air, pass through the section 1 of the exhaust system and flow in the direction of the arrows 17 towards the annular channel 12, along the profiled portion 9 of the structure, which acts as a deflector. At the inlet of the annular channel, the gases pass through the ring of inclined vanes 8 which impart thereto a gyratory movement within the channel, as indicated by arrows 18. The differential potential applied to the terminals 14 and 15 causes sparks to jump the annular spark gap 13 between the flanged portion 11 constituting the inner electrode and the thicker portion 5 of the outer electrode 4. The flow of gas arriving at the spark gap 13 from the channel 12 extends the sparks, so that these sparks jump at 19 between the rear section of the flanged portion 11 of the inner electrode and the thinner portion of the outer electrode 4. At the Same time, the rotation of the gas flow causes the sparks to carry out a rotational movement so that these sparks occupy the entire annular space of the section of the gas flow and ignite thereby the unburnt particles in all sections of the flow. The unburnt particles are, therefore, completely burned in the presence of the oxygen contained in the exhaust gases to which air may have been added.

In the embodiment shown in FIG. 2, the inner structure 7*a*, centered and fixed by inclined vanes 8 in the section 1 of the exhaust pipe and forming therewith a funnel, the expanding portion 20 of which is directed downstream, so that its annular end forms the flanged part 11*a* of the inner electrode. A disc 21 is centered and fixed in this wider portion by means of a rim of vanes 22 which may be inclined in the same sense as the vanes 8, or in the opposite sense. A deflector 23 in the shape of a truncated cone is mounted at the base of the vanes 22, and defines with the expanding portion 20 an annular passage

24, the inlet of which communicates with the center cavity 25 of the structure as a channel 7a, and the outlet of which is directed towards the outer electrode 4.

The center cavity is open in the upstream direction, so that the flow of the exhaust gases, possibly with the addition of air, coming from pipe section 1 is divided into a peripheral flow 26 and a center flow 27. The peripheral flow 26 is given a gyratory movement by the vanes 8, passes through the annular channel 12 in the direction of the arrows 18, as in the embodiment of FIG. 1, and leaves through the spark gap 13, whilst extending and turning the sparks 19. The center flow 27 is given a gyratory movement by the vanes 22 and passes in rotation through the annual passage 24 which discharges into the ring of flames produced by the combustion of the unburnt particles in the flow 26 under the action of the sparks 19. This ring of flames causes in turn the combustion of the unburnt particles in the flow 27 which are completely burned.

FIG. 3 shows a modification in which the structure 7b also forms a funnel in which the end represents the flanged part 11b of the inner electrode, but the annular passage 24 is defined inside the hallow portion 20 by means of a conical deflector 23a, whose core 21a is retained in the center of the funnel by vanes 22a, which are inclined in the same manner as the vanes 22 in FIG. 2. The operation of this modification is exactly the same as that of the embodiment shown in FIG. 2.

FIG. 4 shows a modification of the embodiment of FIG. 1, particularly suitable where the flow of exhaust gases is large. In this modification, the structure 7c has the shape of a mushroom, the plain stem 28 of which is centered and retained in the exhaust pipe section 1 by vanes 8, and the wider portion of which faces downstream. The downstream edge of this wider portion 29 forms the active part of the inner electrode 11c and defines with the thicker portion 5 the annular spark gap 13 at the end of the annular channel 12. At the end of this wider portion 29, there is provided a rod 30 which serves as relay electrode. As in the case of the embodiment shown in FIG. 1, the whole of the exhaust gases, possibly with the addition of air, flows in a gyratory movement through the annular chamber 12 and extends and curves the spark path 19. The sparks 19 ionize the gas, thereby making it possible for other sparks 31 to jump between the relay electrode 30 and the thinner part of the collar which forms the outer electrode. The unburnt particles contained in the gases are ignited by the sparks 19 and 31 and burn in the zone formed within the shoulder opposite the wider portion 29. Moreover, the collar 4 is extended by a sleeve 32 which contains a star-shaped flame stabilizer 33. This arrangement increases in the case of a substantial exhaust gas flow substantially the front surface of the exhaust gas exposed to the sparks 31, and the flame iS stabilized behind the star-shaped flame stabilizer 33.

FIG. 5 shows an embodiment in which an auxiliary spark gap permits sparks to jump in an annular spark gap with large radial extension. Also here, a collar 4d is mounted behind a pipe section 1 and electrically insulated against the same by a joint 16, but the structure 17, forming the inner electrode whose wider portion 11d defines the annular spark gap 13d, comprises in addition, an element 34 which comprises a ring or collar 34a forming an auxiliary electrode which defines, with this wider portion 11d, the relay spark gap 35.

The element 34 is centered and mounted in the pipe section 1 by inclined conducting means 8. It comprises a ring or collar 34a which forms on the one hand the auxiliary electrode, and defines on the other hand the auxiliary channel 12 with the section 1, and an annular deflector 34b directed in the upstream direction. The ring 34a supports, by means of inclined vanes 36 and an insulating ring 36a, a cylindrical part 37 provided at its downstream end with a flange 38, the periphery of which forms the active part of the inner electrode 7d. The cylindrical element 37 carries a rod 39 which extends beyond the deflector 34b and is connected to an electrical terminal 40. The vanes 8 are connected to a second terminal 41 and the collar 4d is connected to a third terminal 42.

The cylindrical element 37 is centered by means of vanes 36 in the ring 34a and defines thereby inside this ring an annular passage 43 leading transversely and downstream into the relay spark gap 35 and communicating upstream with the exhaust pipe section 1 across the vanes 36 and the center opening of the deflector 34b. Vanes 36 may be inclined in the same direction as the vanes 8, or in the opposite direction. The exhaust gases, possibly with the addition of air, coming from the exhaust pipe section 1, are divided into a peripheral flow 44 which is given a gyratory movement by the vanes 8 and passes through the annular channel 12, and a center flow 45 which is given a gyratory movement by the vanes 36 and passes through the annular passage 43.

As may be seen from the drawing, the relay spark gap 35 has a comparatively small width and the main spark gap 13 a comparatively large width. The terminal 41 is earthed and the terminal 40 is subjected to a high voltage, so that the sparks jumping in the relay spark gap 35 between the wider portion 11d of the inner electrode and the upstream end of the sleeve 34a of the auxiliary electrode. The gases of the center flow 45, leaving in a gyratory movement through the relay spark gap 35, extend and curve the sparks at 46 and cause them to eddy in a manner similar to that explained above. The sparks 46 ionize the gas in the main spark gap 13d, so that, when a high voltage differential is applied between the terminals 41 and 42 (for example, by applying to the terminal 42 the same voltage as to the terminal 40), a second bundle of sparks jumps between the sparks 46 and the outer electrode 4. This second bundle of sparks is extended at 47 and caused to curve by the flow of gas 44 coming from the annular channel 12, as in the embodiments shown in the preceding figures, and ignites the unburnt constituents of the exhaust gases.

It should be noted that, since the spark gap 13d is clearly too narrow to permit sparks to jump between the electrodes 4d and 11d subjected to the differential voltages used, the relay spark gap 35 permits, in combination with the center flow 45, the jumping of sparks between the same and the outer electrode, owing to the sparks 46 which ionize the gas and approach in their curved path the outer electrode 4d.

Obviously, the embodiments described hereinbefore are merely examples, and can be modified, particularly by substituting equivalent means, without thereby departing from the principle of the invention as defined in the appended claims. More particularly, in the embodiments shown in FIGS. 2 and 3, comprising a gas flow which passes through a passage in the inner structure and is discharged in the vicinity of the annular spark gap, it is possible for this gas flow not to be given a gyratory movement.

We claim:

1. A device adapted to be connected to the exhaust system of a heat engine for burning the unburnt constituents in the exhaust gases of the engine, to which air may have been added, comprising an outer wall of an electrically conducting material defining a passage for the exhaust gases and having an upstream portion and a downstream portion electrically insulated from the upstream portion and surrounding a combustion chamber; an inner electrode defining an annular channel inside the said upstream wall portion and having a wider downstream wall portion which projects into the combustion chamber and forms an outlet restriction for the annular channel between the said wider downstream portion and the downstream portion of the outer wall; vanes of an electrically conducting material connecting the upstream portion of the outer wall with the inner electrode for fixing and centering the latter within the said upstream portion of the outer wall, wherein the said vanes are inclined to impart a rotational movement to the exhaust gases within the annular channel; and means producing an electrical potential between the outer wall portions upstream and downstream to cause sparks to jump between the wider portion of the inner electrode and the downstream portion of the outer wall.

2. A device according to claim 1, wherein the restriction of the annular outlet channel is formed between the wider

downstream portion of the inner electrode and an internally thicker downstream portion of the outer wall followed by an internal widening, wherein the said internally thicker portion extends in the downstream direction over a sufficiently short distance that the sparks formed in the restriction and carried by the exhaust gases in the downstream direction are struck between the wider downstream portion of the inner electrode and the internal widening of the downstream portion of the outer wall.

3. A device according to claim 1, comprising a rod of an electrically conducting material, mounted axially and extending the inner electrode in a downstream direction beyond the wider portion and electrically connected to the inner electrode.

4. A device according to claim 1, comprising a flame stabilizer in the combustion chamber, downstream of the inner electrode.

5. A device according to claim 1, comprising in addition a passage within the inner electrode, adapted to receive a part of the exhaust gases upstream of the annular channel and discharging into the combustion chamber near the outlet restriction of the said annular channel.

6. A device according to claim 5, comprising meanS for imparting a rotational movement to the gases leaving the said passage.

7. A device according to claim 5, comprising means for imparting to the gases leaving the said passage a rotational movement in the opposite sense to the rotational movement imparted to the gases flowing through the annular channel.

8. A device according to claim 5, wherein the said passage leads into the combustion chamber at the outlet of the restriction formed at the outlet of the annular channel.

9. A device according to claim 8, wherein the inner electrode comprises a structure having the general form of a funnel with its expanding portion pointing in the downward direction and forming the wider portion of the inner electrode, wherein a deflecting element is located downstream of the said wider portion so as to define an annular outlet from the passage, and arms connecting the wider portion with the deflecting element to fix and center the same within the said structure.

10. A device according to claim 9 in which the said arms are vanes adapted to impart a rotational movement to the gases in the annular outlet of the passage.

11. A device according to claim 9, wherein the said arms are vanes adapted to impart to the gases within the annular outlet of the passage a rotational movement in the opposite sense to the rotational movement of the gases within the annular channel.

12. A device for mounting on the exhaust system of a heat engine for burning the unburnt constituents in the exhaust gases of the engine which may contain additional air, comprising an outer wall of an electrically conducting material defining a conduit for the exhaust gases, and having an upstream portion and a downstream portion electrically insulated from the upstream portion and surrounding a combustion chamber; an auxiliary electrode in the general form of a sleeve or collar defining an annular channel inside the upstream portion of the wall; vanes of an electrically conducting material and forming part of the auxiliary electrode to fix and center the same within the upstream portion of the wall, wherein the vanes are inclined to impart a rotational movement to the exhaust gases in the annular channel; an internal electrode having an upstream portion which defines an annular passage inside the auxiliary electrode and a wider downstream portion which defines with a downstream end of the auxiliary electrode a restricted annular outlet for the passage, leading radially into the outlet of the annular channel; connecting elements for fixing and centering the inner electrode in the auxiliary electrode and for insulating these electrically against each other; means producing an electrical differential voltage between the vanes and the auxiliary electrode to form sparks between the downstream end of the auxiliary electrode and the wider downstream end of the inner electrode; and means for applying to the downstream part of the wall a potential adapted to produce sparking between the said downstream wall part and the said electrodes.

13. A device according to claim 12, comprising means for imparting a rotational movement to the gases within the said annular passage.

14. A device according to claim 12, comprising means for imparting to the gases in the annular passage a rotational movement in the opposite direction to the rotational movement imparted to the gases in the annular channel.

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