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3,267,986

APPARATUS FOR PULSATING COMBUSTION

Filed June 4, 1965

2 Sheets-Sheet 1

FIG. 1

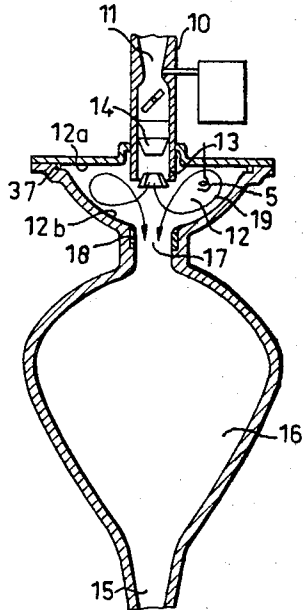


FIG. 5

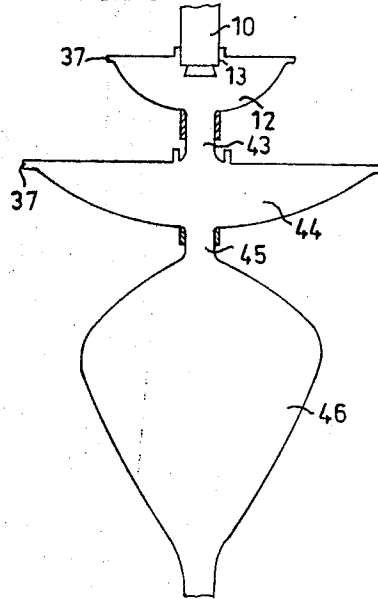


FIG. 2

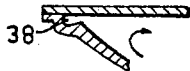


FIG. 3

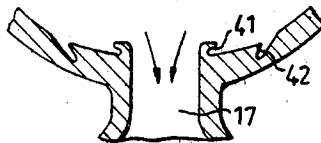


FIG. 4

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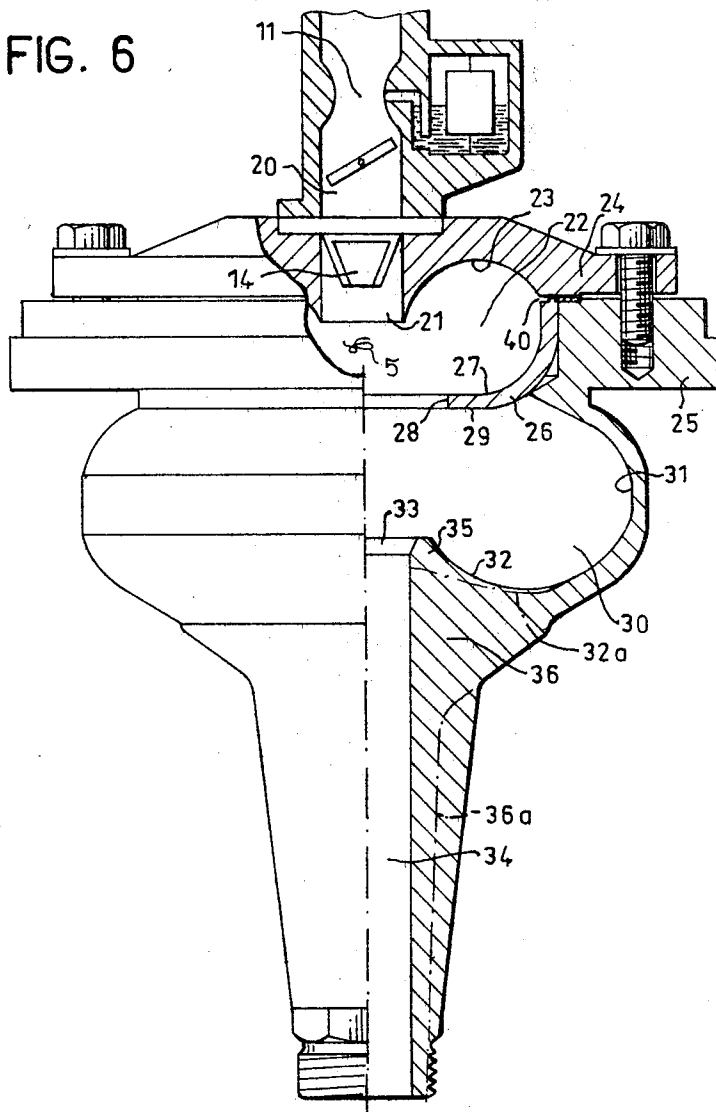
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2 Sheets-Sheet 2

FIG. 6



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1

3,267,986

APPARATUS FOR PULSATING COMBUSTION

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5,639/62

9 Claims. (Cl. 158—4)

This invention relates to apparatus for the pulsating combustion of a mixture of air and a gaseous liquid fuel, particularly fuel oil, and is of the general kind described in my copending application Serial No. 281,300, filed on May 17, 1963, and now abandoned, of which this application is a continuation-in-part.

The combustion apparatus under consideration comprises an inlet duct, a first combustion chamber, a second combustion chamber, a discharge opening between said chambers and an outlet duct located coaxially after each other and being substantially rotationally symmetrically with respect to the central axis of the apparatus.

The fuel mixture is admitted intermittently to the first chamber in response to the negative pressure occurring in the first chamber at the frequency of explosions therein.

The general object of the invention is to provide a combustion apparatus referred to in which pulsating combustion of the fuel mixture occurs efficiently in the first and second combustion chambers, particularly for heating purposes.

Other objects of the invention are, among others, to provide a combustion apparatus of the kind under consideration having a small size relative to its heating capacity and which is reliable in operation; has a variable capacity within a wide range; is relatively noiseless in operation; may be driven with a small fuel consumption when desired; and which is flame proof.

These and other objects will appear more in detail from the following disclosure of some embodiments of the apparatus according to the invention shown by way of example in the accompanying drawings.

FIG. 1 is a central longitudinal section of an embodiment of the apparatus, FIGS. 2 to 4 illustrate various forms of pockets provided in the wall of the first combustion chamber to improve ignition of fuel mixture in the first chamber, FIG. 5 diagrammatically illustrates an alternative embodiment having an intermediate combustion chamber located between the first and second combustion chambers and FIG. 6 is an elevation of another embodiment, half of which being shown in section.

As will be seen from the drawings the apparatus is symmetrical with respect to a central axis, and each combustion chamber is in accordance with the invention formed to establish a vortex flow as will appear hereinafter.

As will be seen from FIG. 1, the inlet duct 10 is associated with a fuel supply means for admitting fuel such as fuel oil to a nozzle section 11, through which inlet air passes and is mixed with the fuel before entering into the first chamber 12 at the outlet end or mouth 13 of the duct 11. The outlet end of duct 13 projects into the first chamber so that the mouth 13 will be axially offset inwardly with respect to the rear end wall 12a of the first chamber.

The inlet duct 11 is preferably provided with a non-return valve 14 of the flap valve type having resilient tongues opening in response to negative pressure downstream the valve and closing for positive pressure, that is when explosions occur in the first chamber. When the apparatus is at rest, the tongues of the valves are preferably slightly open to permit dropping of starting fuel into the first chamber.

The outlet duct 15 from the second combustion chamber 16 is preferably connected to an exhaust pipe (not

2

shown) which in a known manner per se may be constructed as a resonator tube so that a non-return valve in the outlet duct may be omitted.

The medium to be heated, such as water or air, surrounds the second chamber and said exhaust pipe. The apparatus may be applied to boilers as well as to devices for space heating.

A spark plug or an electrically heated glow wire 15 is disposed within the first chamber and is heated for igniting starting fuel dropped into the first chamber to initiate the pulsating combustion. The electrical glow wire is then shut off since the entering charges of fuel mixture will thereupon be ignited by burning gases in the first chamber.

The first chamber 12 communicates with the second chamber 16 through a centrally located discharge opening 17 forming a restricted passage between the two chambers. The walls of the discharge opening may include ceramic material 18 to form a hot point for igniting any fuel not ignited by the burning gases in the first chamber.

It is a basic feature of the invention that the first chamber is relatively short and wide. The axial extensions of the first chamber between the rearmost wall portions of the rear end wall of the first chamber around the inlet mouth 13 to the discharge opening should preferably be less than the radial distance from the central axis of the apparatus to the outermost peripheral portions of the first chamber. Further, the front end wall 12b of the first chamber is generally concave to form a concave annular wall portion around the restricted discharge opening 17. The above features in combination with the location of the mouth 13 ahead of the axially rearmost portion of the rear end wall 12a contributes to effect the specific vortex flow indicated by the arrows 19 in the first chamber.

The above specific features of the first chamber are illustrated in FIGS. 1, 5 and 6. Accordingly, when a fuel mixture charge has been ignited and the combustion gases generated thereby are leaving through the discharge opening 17a negative pressure will arise so that a charge of fresh fuel will be sucked into the first chamber. When entering the first chamber the gas column of fuel mixture will meet a negative pressure of such a degree that the fuel mixture is rapidly expanded radially outwardly to all sides and sweeps along the concave front end wall 12b which due to its shape guides the flow rearwardly to form the annular vortex, as indicated, having portions sweeping radially inwardly along the rear end wall of the first chamber to meet again at the centre and flow axially out through the discharge opening. An annular core of hot and burning gases will probably be maintained in the center of the vortex.

This new and improved general configuration of the first chamber is preferably formed in detail as illustrated in FIG. 6, wherein numeral 20 denotes the inlet duct, 21 the mouth of the inlet duct, 22 the first combustion chamber defined by a concave annular groove 23 in the lid 24 secured to the casing 25 of the apparatus and an inner concave ring member 26 forming an extension of the groove 23 and secured to the lid by welding in the example shown. This ring member 26 forms the front end wall 27 of the first chamber as well as the outer periphery of the first chamber. The central opening of the ring member 26 defines the discharge opening 28. The portion of the ring member adjacent the opening 28 is located in a substantially radial plane.

It is characteristic of the embodiment shown in FIG. 6 that marginal portion or front end wall portion 27 of ring member 26 forms part of the rear end wall 29 of the second combustion chamber 30. Alternatively, ring member 27 may be integral with the casing 25 which is

then formed with an annular flange separating the two combustion chambers and defining the discharge opening 28.

In FIG. 6 the second combustion chamber has generally the same axially short and radially wide configuration as the first chamber 22. Both chambers have a kidney shaped cross-section as will appear from FIG. 6. The rear end wall 29, the circumferential side portion 31 and the forward end wall 32 of the second chamber 30 form an annular chamber with smooth curvature in cross-section. This annular chamber has its radially inner side open and communicates at one end thereof with the discharge opening 28 and at the other end with the outlet opening 33 forming the entrance to the outlet duct 34 connected to an exhaust pipe not shown.

It is characteristic of the second chamber in FIG. 6 that the annular front end wall portion 32 tapers towards an annular end portion 35 surrounding the outlet 33, and that this end portion is located axially offset rearwardly relative to the foremost portion of the front end wall 32.

As will be seen from FIG. 6 there is formed a relatively thick metal portion 36 around the outlet 33 and the adjacent outlet duct portion so that the portion 36 will be heated to a temperature of the order of 800° C.

The apparatus shown in FIG. 6 has been tested for heating water surrounding the first and second chambers as well as the exhaust pipe connected to the outlet duct 34. The apparatus has also been tested for space heating, and the apparatus has then been placed in the flow of air to be heated. In this case the shape of the second chamber is somewhat modified as indicated by dotted lines 32a and 36a to obtain a smaller portion 36 of material around the outlet 36 in order to avoid overheating.

In order to obtain a more efficient ignition of the fresh fuel mixture entering the first chamber small pockets, preferably in the form of annular grooves at the periphery of the first chamber may be provided as indicated at 37 in FIGS. 1 and 5, at 38 in FIG. 2, at 39 in FIG. 3 and at 40 in FIG. 6. As shown in FIG. 4, similar annular pocket grooves 41, 42 may be provided adjacent the outlet opening 17.

These pocket grooves have preferably a larger depth than width as seen in the figures. The size of the pocket groove is relatively small and is selected with respect to the fuel employed, the frequency of pulses and the operating gas pressure. The pocket grooves at the periphery of the first chamber are shaped to take part in the following functions.

Assuming that fresh fuel mixture enters into the first chamber, there has previously occurred a combustion or explosion in the first chamber. On the pressure rise at this last mentioned explosion and burning of the gases, ignited but only partially burned gas has been forced into the pocket groove to be blocked therein by the high pressure gas outside the groove. The pocket groove is then shaped to provide a delay combustion of the gas enclosed in the pocket groove. This delayed combustion shall thereafter result in a directed burning gas flow with high velocity. To this end the pocket groove has a relative small volume, that is it does not form any side chamber for the actual combustion in the first chamber. The width of the groove is kept small in relation to its depth in order to obtain the delayed combustion desired.

Accordingly, when the first chamber is filled with above mentioned fresh fuel charge of relative low temperature, there is obtained a strong pressure drop due the expansion and concurrent cooling thereby which further contributes to decrease the pressure which is still more lowered by the cooling effect from the low temperature of the entering fuel mixture. Accordingly, the pressure outside the pocket groove will be extremely low and this results in that the gas enclosed in the pocket groove, which will now have burned to a still further extent, will be violently launched straight out into the first chamber

to meet the fuel mixture on its way towards the periphery of the first chamber so that the fuel mixture is effectively ignited by the hot gas flow from the pocket. The fuel mixture, however, has already been partially ignited by burning residual gases from the combustion of the preceding charge of fuel mixture.

It should be noted that the apparatus may function without the aid of said pocket grooves but that the operation features are considerably improved by the pocket groove which enable the apparatus to operate within a wider range of pulse frequencies and facilitates the starting of the apparatus.

As to FIG. 2 the pocket groove 38 widens slightly inwardly towards its bottom which may be preferred for relatively slowly burning fuels such as heavy fuel oils, whereas in FIG. 3 the pocket groove 39 widens slightly towards its mouth which may be preferred for relatively rapidly burning fuels such as gasoline.

FIGS. 1, 5 and 6 show the intermediate profile of the pocket grooves 37, 40 having parallel side walls.

The modified form of the apparatus shown in FIG. 5 comprises a first combustion chamber 12, a first discharge opening 43 connecting the first chamber with an intermediate combustion chamber 44 and a second discharge opening 45 connecting the intermediate chamber with a second combustion chamber 46. The apparatus in FIG. 5 has its combustion chambers and discharge openings constructed similar to the apparatus in FIG. 1, but it should be noted that in the preferred form of the general arrangement indicated in FIG. 5, the combustion chambers and discharge openings have substantially the same general configuration as indicated in FIG. 6.

Starting of the apparatus in FIG. 5 is effected in the same way as described in connection with the apparatus in FIG. 1. The combustion gases generated in the first chamber 12 pass practically directly from the opening 43 to the opening 45 and down into the second chamber 46 when the apparatus is fed with fuel for normal heat producing capacity, for instance when used in a water boiler for small houses. However, when an instant and considerable increase of the capacity is desired, the fuel supply is increased so that the fuel mixture is momentarily over-riched which results in that the walls around first opening 43 are cooled and the combustion intensity is thus reduced. The greater part of the fuel mixture will accordingly not be ignited until it enters into the intermediate chamber 44 where the ignition now takes place. The intermediate chamber 44 has a larger diameter and a greater volume than the first chamber 12, and thus the suction effected in the intermediate chamber will be greater than is possible to obtain in the first chamber. The gases will thus continue to pass the first chamber and enter into the intermediate chamber. This switching on to combustion in the intermediate chamber is effected rapidly and thereafter the supply of fuel is adjusted to obtain a normal mixture for driving with the intermediate chamber and effecting the greater heating capacity. By increasing the air portion in the inflow mixture, it is easy to step down again to drive on the first chamber. Thereafter, the fuel mixture is again adjusted to normal composition.

As to the relative dimensions of the first and second chambers it is preferred that the second chamber has a greater diameter and greater volume than the first chamber. Further it should be pointed out, that the second chamber 30 as shown in FIG. 6, similar to the first chamber, preferably has an axial extension which is less than its maximum inner radius.

The apparatus according to the invention forms a very small device in relation to its heat producing capacity. The flame surface of the apparatus is formed by the inner walls of the combustion chambers and the outlet duct including the exhaust pipe surrounded by the medium to be heated. This flame surface may be only 5% of the corresponding surface for a conventional water boiler for the

same heating capacity and the same exhaust gas temperature. The apparatus also has very satisfactory combustion characteristics such as a high CO₂-content. Soot deposits are avoided in the combustion chambers due to the vortex flow therein. Further, the apparatus need not be connected to a chimney since it is sufficient to discharge the exhaust gases to the atmosphere through a pipe having about the same small inner diameter as the outlet duct. The temperature of the exhaust gases will be so low that no flame danger will arise. When the apparatus is used for water heating the exhaust gas temperature may be kept at about 105° C. when the water has a normal temperature of about 80° C. For conventional boilers the exhaust gas temperature is considerably higher, about 200° C. Accordingly, the low exhaust gas temperature at the apparatus according to the invention results in a better heat exchange, which is still more increased due to the fact that the apparatus operates with a pulsating combustion which as known per se gives a more effective heat exchange than in apparatus with continuous combustion.

At a combustion pulse frequency between 40–50 the noise level will be below that for conventional oil burners.

From the above it will be evident that the apparatus according to the invention has been constructed specifically for operating with pulsating combustion and that the apparatus is taken advantage of the specific operating conditions relating thereto.

What I claim is:

1. Apparatus for the pulsating combustion of a combustible mixture of air and fluid fuel, including, in series an inlet duct for a current of such mixture said duct including a non-return valve and having a discharge mouth;
 - a first chamber into which said inlet duct discharges, said first chamber having a rear end wall in which said inlet duct is located and an opposite forward end wall at least a portion of which is generally concave; a restricted connecting passageway communicating with said first chamber at said forward end wall;
 - a second chamber communicating with said first chamber by means of said connecting passageway; and a discharge outlet in said second chamber opposite to said connecting passageway;
 - each of said inlet ducts, first chamber, connecting passageway, second chamber and discharge outlet being rotationally symmetrical about one common main axis and serially providing a straight flow-through direction and symmetrical and stable flow for such mixture;
 - said first chamber being characterized in that its main axial dimension from the rearmost portion of its rear end wall to said restricted passageway is shorter than is its maximum inner radius resulting in a relatively flat configuration and in that the rearmost portion of its rear end wall is axially offset rearwardly in relation to the mouth of said inlet duct and in that said at least partially concave forward end wall forms a substantially concave annular wall portion extending radially outwardly to the inner periphery of the first chamber, whereby whirling vortical flow of air-fuel mixture in said first chamber is ensured.
2. An apparatus as defined in claim 1, in which said annular front end wall portion is located in a substantially radial plane in its area adjacent said connecting passageway.
3. An apparatus as defined in claim 1, in which the maximum inner radius of said second chamber is greater than the maximum inner radius of said first chamber.
4. An apparatus as defined in claim 1, in which a circumferential groove is provided at the periphery of the

inner wall of said first chamber, said groove having a greater depth than its relatively small width to provide a pocket for trapping a small portion of the fuel mixture sucked into said first chamber and to obtain a delayed combustion thereof in said groove so that the trapped gases will be launched into the first chamber for ignition purposes when next charge of fuel mixture is admitted into said first chamber.

5. An apparatus as defined in claim 1, in which an intermediate rotationally symmetrical combustion chamber is located between said first and said second combustion chambers and connected therewith through connecting passageways, said intermediate combustion chamber having substantially the same configuration as said first chamber.

6. An apparatus as defined in claim 1, in which said connecting passageway is defined by a centrally disposed aperture of an annular flangelike member forming a partition wall which on one side forms part of the forward end wall of said first chamber and on the opposite side forms part of the rearward end wall of said second chamber.

7. An apparatus as defined in claim 6, in which said annular member is a separate ring having an outer marginal portion forming the inner circumference of said first chamber and secured to a lid formed with an annular groove defining the rearward end wall of said first chamber.

8. An apparatus as defined in claim 7, in which the forward end wall of said second chamber is formed as an annular recess axially offset forwardly relative to said outlet opening.

9. An apparatus for the pulsating combustion of an air-fuel mixture, said apparatus having one central axis and comprising a first and a second combustion chamber each chamber having a configuration which is rotationally symmetrical with respect to the central axis of the apparatus, an axial inlet duct for admitting fuel mixture to said first chamber, and having its forward end projecting into said first chamber, a restricted discharge opening in the forward end wall of said first chamber for discharging combustion gases into said second chamber for continued combustion therein, said discharge opening having a diameter which is less than the inner diameter of said first chamber, a central outlet opening located in the front end wall of said second chamber and connected with an outlet duct for exhaust gases, each of said first and second chambers having an axial extension between its rearmost rearward end wall portion and its foremost forward end wall portion which is less than the maximum inner radius of the respective chamber, said forward end wall of said first chamber forming a substantially concave annular wall portion extending radially outwardly to the inner periphery of said first chamber and extended into said rearward end wall thereby providing a concave annular portion around and axially rearwardly offset from said projecting end of said inlet duct whereby to ensure whirling vortical flow of said mixture in said first chamber, said inlet duct, first chamber, discharge opening, second chamber, central outlet opening and outlet duct being serially arranged and rotationally symmetrical about one common main axis thereby providing straight-through flow for such air-fuel mixture.

References Cited by the Examiner

UNITED STATES PATENTS

1,828,784	10/1931	Perrin	158—4
2,543,758	3/1951	Bodine	158—4

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