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RESONANT COMBUSTION APPARATUS

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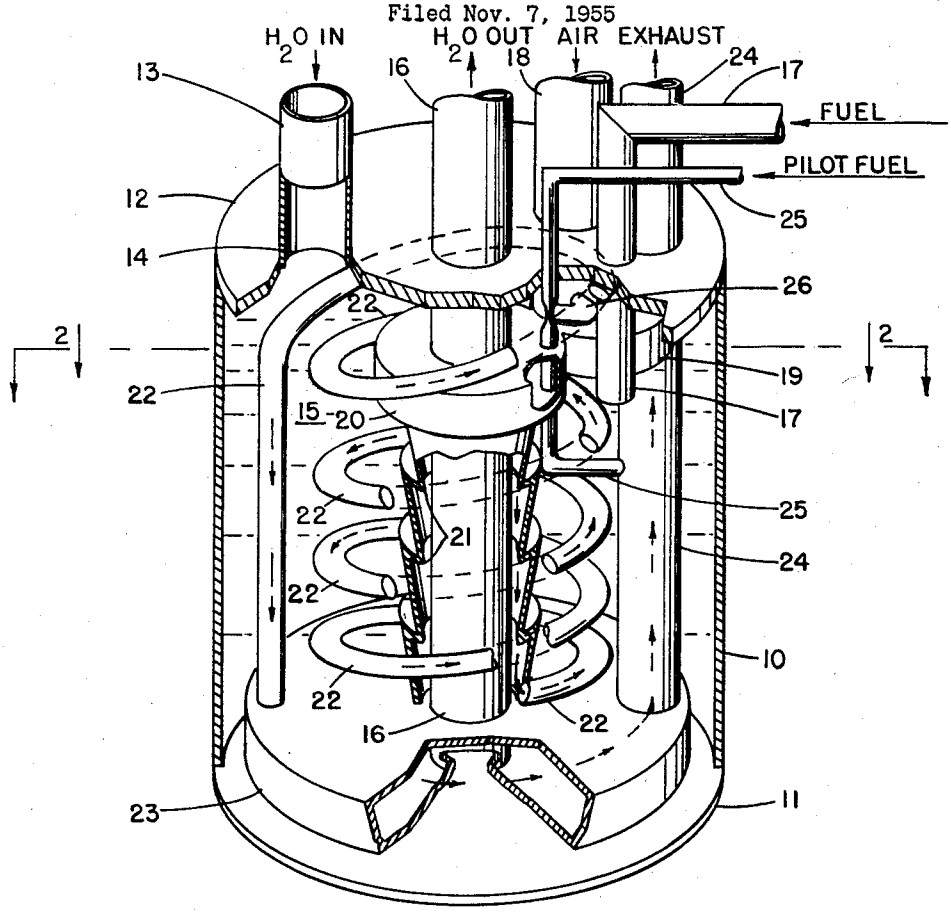


FIG. 1

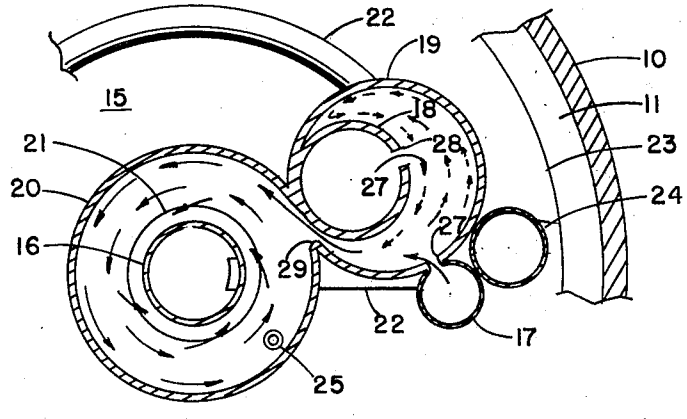


FIG. 2

INVENTOR.
EMERSON L. KUMM
BY Ralph B. Pastoriza
ATTORNEY

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RESONANT COMBUSTION APPARATUS

Emerson L. Kumm, Pacific Palisades, Calif., assignor, by mesne assignments, to Curtiss-Wright Corporation, a corporation of Delaware

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This invention relates generally to combustion apparatus, and more particularly to a novel pulsating resonant combustion system for burning an air-fuel mixture. While numerous uses for the present invention will occur to those skilled in the art, a preferred embodiment thereof will be described as incorporated in a hot water heater.

A primary object of this invention is to provide a combustion apparatus or burner operating under pulsating flow conditions for maximum heat transfer characteristics, in which no moving mechanical parts, such as valves, fans, blowers and the like, are incorporated or necessary.

Another object is to provide an improved hot water heater incorporating combustion apparatus of the above type, employing an independent ignition system for initiating and maintaining combustion, whereby more reliable operation than has characterized heaters heretofore is assured.

Another object is to provide a pulsating resonant type combustion apparatus embodied in a hot water heater, in which any noises generated are substantially suppressed.

A more general object of the invention is to provide a combustion apparatus which is extremely rugged and reliable in operation, and in which more heat is available than in prior art heaters of comparable size.

These and other objects and advantages of the present invention are attained by providing a combustion apparatus comprising the following basic components: an entrance resonant chamber, a combustion chamber, a unidirectional flow means, and an exit resonant chamber. A communicating means is provided between the entrance resonant chamber and the combustion chamber for passing a fuel-air mixture into the combustion chamber in such a manner as to establish given desired flow characteristics within the combustion chamber. Hot combustion gases pass from the combustion chamber through the unidirectional flow nozzles and ultimately to the exit resonant chamber and a suitable exhaust pipe. The dimensioning of the basic components relative to each other is such that a pulsating combustion takes place generating pressure pulsations within the combustion chamber and within the entrance resonant chamber. The combustion chamber pressure pulsations are substantially 180° out of phase with the entrance resonant chamber pressure variations. Similarly, pressure variations in the exit resonant chamber are substantially 180° out of phase with the pressure pulsations in the combustion chamber.

In the preferred form of the apparatus as embodied in a hot water heater, the entire unit is submerged within a tank filled with water, suitable fuel-air inlet means and combustion gas exhaust means passing from the unit to the exterior of the tank. To realize maximum heat transfer characteristics, water supplied through the upper portion of the tank is passed out of the tank through a water pipe extending upwardly from adjacent the lower portion of the tank axially through the exit resonant chamber, uni-directional flow means, and combustion chamber. A helical conduit is provided between the end portion of the uni-directional flow means and the entrance portion

of the exit resonant chamber for passing hot combustion gases between these components. This helical conduit is arranged to spiral throughout the interior of the container so that a relatively large contact area between the walls of the conduit and water within the container is realized. This feature, together with the fact that the hot gas flow is pulsating in nature insures maximum heat transfer conditions.

In accordance with a further feature of the invention, ignition of fuel-air mixtures within the combustion chamber is accomplished by an independent ignition apparatus. Preferably this apparatus comprises a tube member passing through a portion of the combustion chamber, together with means for passing hot gases through the tube to maintain the exterior tube wall within the combustion chamber portion, sufficiently hot to initiate and maintain combustion. Inasmuch as substantially all of the combustion apparatus is submerged in water, any noises generated thereby are considerably suppressed.

A better understanding of the invention will be had by referring to the accompanying drawings, in which:

Figure 1 is a cut-away perspective view of the combustion apparatus as embodied in a hot water heater; and

Figure 2 is an enlarged cross-section taken in the direction of the arrows 2—2 of Figure 1.

Referring to Figure 1, there is shown a cylindrical tank 10 having a lower end closure 11 and a top cover closure member 12 provided with several openings for receiving a corresponding number of pipes. Water is passed into the tank 10 through an inlet pipe 13 terminating in a water outlet end 14 adjacent the upper portion of the tank interior 15. The tank is normally completely filled with water. Heated water flows from the lowermost portion of the tank 10 through a central water pipe 16, passing axially up through the interior of the tank out the central portion of the cover 12. Water entering the tank 10 through pipe 13 and leaving the tank through pipe 16, is heated by combustion apparatus substantially wholly submerged within the water.

As shown in Figs. 1 and 2, this combustion apparatus includes fuel and air inlet pipes 17 and 18 passing through the top cover 12 to the interior of the tank 10. The air inlet pipe 18 connects with an entrance resonant chamber 19 in the form of a flattened cylindrical pill box type structure. The chamber 19 is disposed tangentially to a combustion chamber 20 of somewhat larger cylindrical dimensions. From the combustion chamber 20, uni-directional flow nozzles 21 connect with a helical gas pipe 22 spiraling throughout the interior of the tank 10 and thence into an exit resonant chamber 23. The interior of the exit resonant chamber 23 communicates with an exhaust pipe 24 passing upwardly and outwardly through the top cover 12.

In accordance with a feature of the invention, combustion within the combustion chamber 20 is initiated and maintained by an independent ignition apparatus. As shown in Figure 1, this apparatus includes a pilot fuel inlet tube 25 passing through the top cover 12, and completely through a portion of the combustion chamber 20 to terminate in the exhaust pipe 24. An air inlet supply for the pilot tube 25 is provided by air pipe 26 branching off from the main air inlet pipe 18 to connect into the pilot tube 25 at a restricted portion as shown. The portion of the pilot tube 25 within the combustion chamber 20 is maintained at an extremely high temperature by the burning of fuel and air passed into the tube. The generated heat is such that the outer walls of the pilot tube portion within the combustion chamber are sufficiently hot to initiate and maintain combustion within the chamber 20.

Referring to Figure 2, it will be noted that the principal fuel inlet pipe 17 is tangent to the entrance resonant

chamber 19, the common wall portion therebetween being provided with an elongated slot 27 for the passage of fuel from the pipe 17 into the entrance resonant chamber 19, as indicated by the solid arrows. The air inlet pipe 18, on the other hand, passes within the entrance resonant chamber, its axis being parallel to but radially displaced from the axis of the entrance resonant chamber, whereby a portion of the exterior wall of the air inlet tube 18 together with the inner wall surface of the entrance resonant chamber defines a crescent shaped enclosure. The portion of the air inlet pipe 18 within the entrance resonant chamber 19, is provided with an elongated slot 28 whereby air may pass from the air inlet pipe into the crescent shaped enclosure and pass through the elongated slot 29, the flow following a vortex type path as shown by the arrows. The fuel-air mixture within the combustion chamber is ignited by the exterior hot walls of the pilot tube 25 and rapidly burn to create a substantial pressure increase within the combustion chamber. Most of the hot expanding gases flow downwardly through the uni-directional nozzles 21 within the annular space defined by the nozzles and the exterior of the water pipe 16. Because of the configuration of the flow nozzles 21, the back-resistance to gaseous flow is very high.

From the uni-directional flow nozzles, the hot gases pass through the helical pipe 22 to eventually enter the exit resonant chamber 23 and ultimately pass out the exhaust pipe 24.

The rapid flow of the expanded gases through the uni-directional flow nozzles results in a reduced pressure in the combustion chamber 20 which reduced pressure serves to draw in another charge of fuel-air mixture from the input resonant chamber. This new charge of fuel-air mixture is ignited by the pilot tube 25 and remaining hot combustion gas and a second rapid expansion occurs again increasing the pressure in the combustion chamber 20 so that most of the hot gases pass down through the uni-directional flow nozzles. Because of the geometrical configuration of the elongated slot opening 29 between the input resonant chamber and the combustion chamber, and the cylindrical configuration of the combustion chamber whereby the referred to vortex flow is established, any back-flow through the slot into the input resonant chamber is greatly impeded. The small amount of back-flow that is unavoidable, however, is accompanied by a pressure wave which, together with the back-flow, circulates in an arcuate path about the crescent shaped enclosure as indicated by the dotted arrows. The dimensioning of the input resonant chamber, specifically the crescent shaped enclosure, is such that an increased pressure within this enclosure as a result of such back-flow occurs at the same time a reduced pressure is established in the combustion chamber 25. In other words, the design and dimensioning of the chambers is such that pressure pulsations in the combustion chamber are substantially 180° out of phase with pressure variations in the input resonant chamber.

The pulsating nature of the combustion as described, results in pressure variations in the exit resonant chamber 23. This chamber is also dimensioned such that these pressure variations will be 180° out of phase with the pressure pulsations in the combustion chamber. In other words, when a large pressure occurs in the combustion chamber, there will be a reduced pressure in the exit resonant chamber 23, so that there is a maximum pressure differential tending to cause the combusted gases to flow from the combustion chamber, through the uni-directional flow nozzles and helical pipe 22, into the exit resonant chamber to ultimately pass out the exhaust pipe 24.

As previously described herein, the water within the tank is removed through the pipe 16 which passes axially upwardly through the exit resonant chamber, the uni-directional flow nozzle, and the combustion chamber, so that a large heat transfer occurs throughout this portion of the water pipe in addition to the large heat transfer between the helical pipe 22 and the body of water within the tank.

It will thus be seen that the present invention provides a combustion apparatus in which there are no moving parts such as valves and the like, and in which the configuration is such that sufficient pressure differentials are established to maintain gaseous flow without the necessity of blowers or fans. Furthermore, and as previously mentioned, because of the pulsating flow conditions and the large contact area between the pipes and conduits carrying the heated gases and the water within the tank, maximum heat transfer between the gases and water is effected.

As also described, by submersion of the combustion apparatus in the water filling the tank 10, noises accompanying the pulsating combustion process are suppressed to a considerable extent.

Modifications within the scope and spirit of the present invention will occur to those skilled in the art. The combustion apparatus is, therefore, not to be thought of as limited to the specific embodiment disclosed for illustrative purposes.

What is claimed is:

1. A resonant combustion apparatus comprising, in combination: an entrance resonant chamber of cylindrical shape; an air inlet comprising a cylindrical pipe having its axis parallel to and displaced radially from the axis of said entrance resonant chamber, said pipe extending into said entrance resonant chamber and including an elongated slot parallel to the axis of said pipe and providing an opening for passing air from said pipe into said entrance resonant chamber, the exterior cylindrical surface of the portion of said pipe within said entrance resonant chamber defining, together with an inside cylindrical portion of the wall of said entrance resonant chamber, a crescent shaped enclosure; a fuel inlet comprising a cylindrical fuel pipe having its axis parallel to the axis of said entrance resonant chamber and being exteriorly tangential thereto, the common wall portion of said fuel pipe and entrance resonant chamber at the point of tangency having an elongated slot for passing fuel from said fuel pipe into said crescent shaped enclosure; a combustion chamber; means defining a passage between said combustion chamber and said entrance resonant chamber to establish a vortex flow condition of fuel and air from said entrance resonant chamber into and within said combustion chamber; an exit resonant chamber; and unidirectional flow means for passing combustion gases from said combustion chamber to said exit resonant chamber.

2. An apparatus according to claim 1, including means for igniting fuel-air mixtures within said combustion chamber comprising: a tube member passing through a portion of said combustion chamber; and means for passing hot gases through said tube member whereby the exterior walls of said tube member within said combustion chamber portion are sufficiently hot to ignite said fuel-air mixtures.

3. A resonant combustion apparatus comprising, in combination: an entrance resonant chamber; air and fuel inlet means communicating with said entrance resonant chamber; a cylindrically shaped combustion chamber having a common wall portion with said entrance resonant chamber, said common wall having an elongated slot opening, the sides of said slot being angulated such that fuel and air will flow in a direction substantially tangential to one wall of said combustion chamber to establish a vortex flow condition in said combustion chamber; an exit resonant chamber; a series of unidirectional axially aligned flow nozzles extending from said combustion chamber and having a low resistance to combustion gases passing from said combustion chamber towards said exit resonant chamber and high resistance to the flow of gases in an opposite direction; a helical conduit connected between the end portion of said flow nozzles and the entrance portion to said exit resonant

chamber; and a pipe co-axially positioned within said flow nozzles communicating with the environment exterior to said helical conduit, said pipe extending co-axially through said combustion chamber to define an annular combustion area for said vortex flow, the exterior surface of said pipe and the interior walls of said axially aligned flow nozzles defining annular shaped passages for establishing said high resistance to combustion gas back flow from said exit resonant chamber to said combustion chamber, whereby pulsating gas flow conditions are established as a consequence of said high resistance to the back flow of said gases through said nozzles, the pulsating pressure in said combustion chamber being 180° out of phase with the pressure in said exit resonant chamber, whereby heat

exchange between the pulsating hot combustion gases in passing through said nozzles and said helical conduit, and the environment of said apparatus, is effected.

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