HYDROGEN BURNER WITH A SHUT-OFF VALVE NEAR THE GAS JETS

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ABSTRACT
A gas burner includes a distribution chamber formed between walls within the burner, with the walls extending parallel to one another. A shut-off valve, adjacent to an inlet hole through which a gas, preferably hydrogen, used as a fuel, enters the distribution chamber, closes when the pressure of the gas being supplied drops below a predetermined level, so that air is not allowed to flow backward into the apparatus supplying the gas, thus preventing potentially explosive conditions.
HYDROGEN BURNER WITH A SHUT-OFF VALVE NEAR THE GAS JETS

BACKGROUND OF THE INVENTION

[0001] Field of the Invention

[0002] The invention relates to apparatus providing for the combustion of hydrogen in air, and, more particularly to provisions within such apparatus for preventing the formation of an explosive mixture of hydrogen and air.

SUMMARY OF THE BACKGROUND ART

[0003] A conventional gas burner includes a mixing chamber in which the gas used as fuel is mixed with air and a distribution chamber in which the mixture is fed to a number of individual channels to form gas jets, with combustion occurring outside these individual channels. A valve for controlling the rate at which gas flows into the gas burner is located before the mixing chamber, often in a location remote from the gas jets. A problem with using this type of burner for hydrogen gas results from a potential for air to mix with the fuel within the distribution chamber, the mixing chamber, and associated tubing back to the point at which a shut-off valve is provided in the event of a failure in the gas supply pressure. The accumulation of a mixture of hydrogen and oxygen in such a large and extended enclosed space may result in an explosion, particularly when an attempt is made to restart the combustion process.

[0004] The patent literature includes a number of descriptions of apparatus configured particularly for hydrogen combustion. A number of patent documents describe hydrogen burning apparatus in which the hydrogen is mixed with air or oxygen before combustion is applied. In general, a catalyst is used so that combustion can occur at a relatively low temperature. For example, European Patent EP 1179709 B1 describes a hydrogen combustion heater operated by bringing a mixture of hydrogen gas and air into contact with a catalyst to achieve a catalytic oxidation of hydrogen gas. The ratio of air to hydrogen flowing into the mixing area is controlled to limit the combustion to a mild oxidation that avoids firing the hydrogen gas.

[0005] U.S. Pat. No. 6,019,172 describes a flameless process in which air and a fuel gas are heated in separate streams so that, when the streams are combined, the temperature of the mixture exceeds the autoignition temperature, with the temperature being less than that which would result in the oxidation upon mixing being limited by the rate of mixing.

[0006] U.S. Pat. No. 5,190,453 describes a staged combustor including a first combustion stage for burning a fuel rich mixture of a fuel, preferably hydrogen, and an oxidizer, preferably oxygen. A plurality of serially positioned secondary combustion stages, downstream of the first stage, are provided for receiving secondary flows of oxidizer to the increasing mass of combustion efflux. The gradual increase of oxidizer/fuel ratio provides a resultant substantially stoichiometric combustion. A cooling system is provided for cooling these combustion stages.

[0007] International Patent Publication No. WO 2005/024301 A1 describes a burner in which hydrogen is mixed with air and burned in a burning chamber on a catalyst at a low temperature in a flame-free manner.

[0008] U.S. Pat. No. 4,614,176 describes apparatus for heating air by burning hydrogen, with the combustion occurring in direct proximity to a metal hydride fuel storage means in order that the combustion heat effects the release of hydrogen from the metal hydride. The hydrogen mixes with air in a mixing and distributing area before flowing through catalytic combustion reactors. (See abstract, col. 2, lines 44-50).


[0010] While the prior art describes apparatus for providing certain desirable features of hydrogen combustion, what is needed is a gas burner preventing the accumulation of a substantial mixture of hydrogen and air or oxygen in the event of a failure of the combustion process or an interruption in an adequate flow of hydrogen through the gas burner.

SUMMARY OF THE INVENTION

[0011] In accordance with a first aspect of the invention, apparatus is provided including a pair of walls extending parallel to one another to form a distribution chamber, an input hole, a plurality of channels, and a shut-off valve. The distribution chamber extends between the walls, one of which includes the input hole. The channels extend outward within the walls from the distribution chamber and along a periphery of the distribution chamber. The shut-off valve, which is outwardly adjacent the input hole extending into the distribution chamber, allows a gas used as fuel to flow into the distribution chamber when the shut-off valve is open. The shut-off valve closes in response to a drop in the pressure at which the gas used as a fuel is supplied through the shut-off valve.

[0012] In one version of the invention, the shut-off valve is a check valve responding directly to a decrease in gas pressure. In another version of the invention, a thermal sensor is provided adjacent a combustion area formed by gas jets, with the shut-off valve being closed in response to a signal from the thermal sensor indicating that a temperature has fallen below a predetermined level due to a failure of the combustion process. Such a failure would naturally occur if the pressure at which the gas used for fuel were to drop below a level supporting combustion in the device. In yet another version of the invention, the shut-off valve is a check valve receiving the gas used as a fuel through a valve that is closed in response to detecting a combustion failure. In each case, the closing of the shut-off valve prevents a backward flow of air into the apparatus supplying the gas used as a fuel, which is preferably hydrogen, so potentially explosive conditions within this apparatus supplying the gas are avoided.

[0013] Potentially explosive conditions may also be avoided by mixing the gas used as a fuel with air only after it has passed through the channels leading from the distribution chamber to form gas jets, or the gas used as a fuel may be mixed with air within the distribution chamber. Preferably, the volume of the distribution chamber is minimized.

BRIEF DESCRIPTION OF THE FIGURES

[0014] FIG. 1 is a transverse cross-sectional elevation of apparatus for hydrogen combustion built in accordance with a first embodiment of the invention;
FIG. 2 is a bottom plan view of the apparatus of FIG. 1;

FIG. 3 is a bottom plan view of a distribution plate within the apparatus of FIG. 1;

FIG. 4 is a fragmentary bottom plan view of a version of the apparatus of FIG. 1 having an alternative cap plate;

FIG. 5 is a fragmentary transverse cross-sectional elevation of the apparatus of FIG. 4, taken as indicated by section lines 5-5 therein;

FIG. 6 is a plan view of an alternate version of the apparatus of FIG. 1 having a valve stopping a flow of fuel in response to a combustion failure;

FIG. 7 is a bottom plan view of apparatus for hydrogen combustion built in accordance with a second embodiment of the invention;

FIG. 8 is a transverse cross-sectional elevation of the apparatus of FIG. 7, taken as indicated by section lines 8-8 therein;

FIG. 9 is a plan view of the apparatus of FIG. 7;

FIG. 10 is a plan view of an intermediate plate within the apparatus of FIG. 7.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a transverse cross-sectional elevation of a gas burner 10 configured particularly for burning hydrogen, built in accordance with a first embodiment of the invention. The gas burner 10 includes a distribution plate 12, a cap plate 14, and a frame plate 16. The gas burner 10 includes a distribution chamber 18 formed between a recessed surface 20 of the distribution plate 12 and the cap plate 14, with these plates 12, 14 thus providing parallel walls between which the distribution chamber 18 extends. Hydrogen gas flows into the distribution chamber 18 through an inlet hole 21 from an inlet tube 22 through a shut-off valve 24, and outward through a number of channels 26, also formed between the distribution plate 12 and the cap plate 14, and a slot 28.

FIG. 2 is a bottom plan view of the gas burner 10, shown in an exemplary version including a pair of cap plates 14, with a slot 28 extending around each of the cap plates 14, being formed between the cap plates 14 and inner surfaces 30 of openings 32 within the frame plate 16.

FIG. 3 is a bottom plan view of the distribution plate 12 within the apparatus 10. The distribution plate 12 includes a number of blocks 34, extending outward in rows around the recessed surfaces 20 forming the chambers 18, with the channels 26 extending between adjacent blocks 34. The outer surfaces 36 of the blocks 34 form an edge against which the inner surfaces 30 of the openings 32 rests. The distribution plate 12 includes a number of threaded holes 38 through which the frame 18 is attached by means of screws 12 and a number of threaded holes 42 through which the cap plates 14 are attached by means of screws 44, with the cap plates 14 being held against raised surfaces 45 adjacent the recessed surfaces 20 and against the blocks 34.

When hydrogen gas flows downward through the slots 28, gas jets are formed to extend downward from the slots 28, with the hydrogen gas mixing with ambient air immediately below the slots 28 to form a combustible mixture. Preferably, the gas burner 10 additionally includes an igniter 46 forming a spark within a gap 48 as a high voltage is applied for a short duration through an insulated wire 50 to ignite the mixture of hydrogen and air, starting the combustion process, which then continues as long as hydrogen is supplied under appropriate conditions through the inlet tube 22. In the example of FIG. 1, the shut-off valves 24 are check valves, which are commercially available in forms calibrated to operate at specific pressures as low as 0.5 pounds per square inch. Such devices that are well known to those skilled in the art. If the pressure at which hydrogen is supplied through the tube drops below a predetermined level, the valve 24 closes, so that air cannot back up past the valve 24 into the inlet tube 22 and other portions of the apparatus (not shown) supplying hydrogen.

FIG. 4 is a fragmentary bottom plan view of a version 50 of a gas burner that is similar to the gas burner 10, previously described in reference to FIGS. 1-3, except that an alternative cap plate 52 is provided, with the alternative cap plate 52 having a number of blocks 54 extending to be held against the inner surfaces 30 within the frame plate 16, so that a slot between the alternative cap plate 52 and the inner surfaces 30 is broken into a number of small slots 56.

FIG. 5 is a transverse cross-sectional elevation of the gas burner 50, taken as indicated by section lines 5-5 in FIG. 4. Each of the slots 56 is aligned with one of the channels 26 within the distribution plate 12, so that hydrogen gas flows outward, in the direction of arrow 58, and downward, in the direction of arrow 60, through the channels 26 and the slots 56.

FIG. 6 is a plan view of an alternative version 64 of the gas burner 10, with the alternate version 64 having an additional valve 66 for stopping a flow of hydrogen fuel in the event that the combustion process fails. Thus, the additional valve 66 is an electrical device connected by wires 68 to a heat sensor 70, which is, for example, a thermocouple. The additional valve 66 includes electronics operating in response to a signal from the heat sensor 70 to hold the valve open when the temperature measured by the heat sensor 70 exceeds a predetermined value. If combustion fails, a lower temperature measured by the heat sensor 70 causes the valve 66 to close, stopping the flow of hydrogen gas through tubing 82, so that a pair of check valves 24 also close in response to a lowering of the pressure with which the hydrogen gas is supplied, further restricting a backward flow of air through the tubing 82. Preferably, an additional electrical circuit 86 is also provided, being operated by a pushbutton 86 to produce a high-voltage electrical pulse causing the generation of a spark within the igniter 46 and additionally producing a signal holding the valve 66 open during the ignition process until the temperature of the heat sensor 70 is raised by hydrogen combustion to a level holding the valve 66 open.

FIG. 7 is a bottom plan view of a hydrogen burner 90 built in accordance with a second embodiment of the invention to include a bottom plate 92 having a number of holes 94 through which hydrogen is fed to form a number of gas jets.
FIG. 8 is a transverse cross-sectional elevation of the hydrogen burner 90, taken as indicated by section lines 8-8 in FIG. 7, to show a distribution chamber 95 formed between the bottom plate 92 and an intermediate plate 96, which is peripherally attached to the bottom plate 92 by welding. Within the distribution chamber 95, hydrogen gas flows from an inlet hole 98 in the intermediate plate 96 and output channels formed by the holes 94 within the bottom plate 92, being spread among the holes 94. An air supply chamber 100 is additionally formed between the intermediate plate 96 and a top plate 102, which is peripherally joined to the intermediate plate 96 by welding. Air moves into the distribution chamber 95, to mix with the hydrogen therein, through a number of holes 104 within the intermediate plate 96.

FIG. 9 is a plan view of the hydrogen burner 90, showing, within the top plate 102, an opening 106, into which air is introduced, preferably under pressure by means of an external fan (not shown).

FIG. 10 is a plan view of the intermediate plate 96, showing the holes 104, through which air is introduced into the distribution chamber 95, extending within a circular pattern around the inlet hole 98, through which hydrogen is introduced into the distribution chamber 95. This arrangement provides for mixing with the air as the hydrogen is moved within the distribution chamber 95 to the channels formed by the holes 94 within the bottom plate 92. Alternatively, another oxidizing agent, such as oxygen itself, may be admitted to the distribution chamber 95 through the holes 104.

The hydrogen burner 90 is additionally provided with an igniter 108, producing a spark between a gap 110 when a high voltage pulse is applied to an electrical wire 112 and with a shut-off valve 114 that is electrically operated to remain open only when a temperature measured by a thermal sensor 116 remains above a predetermined minimum level, indicating that the combustion process has not failed.

Since the combustion process will fail when there is a sufficient loss in the pressure with which hydrogen is supplied, the valve 114 closes in the event of such a pressure loss, preventing a backward flow of air through the inlet tube 118 into the apparatus supplying hydrogen. Like the check valve 24 described above in reference to FIG. 6, the valve 118 is placed immediately adjacent a distribution chamber through which hydrogen is moved to a number of channels forming gas jets, so that the space that can be occupied by air flowing backward into the burner is minimized. For example, the distribution chamber preferably has a volume of one cubic inch or less.

The various features described as being included within the different versions and embodiments may be interchangeably used. For example, the formed and welded construction of the second embodiment of gas burner 90 may be used without the air supply chamber, with the mixing of air with hydrogen occurring only after pure hydrogen is supplied through the holes 94. A catalyst may be applied to surface of the burner to encourage the burning of hydrogen at low temperatures.

While the apparatus has been described as using hydrogen gas as a fuel, it is understood that the apparatus may effectively be used with other gaseous substances that may be used as a fuel. While the invention has been described and shown in its preferred versions and embodiments with some degree of particularity, it is understood that this description has been given only by way of example, and that many variations can be made without departing from the spirit and scope of the invention, as defined in the appended claims.

What is claimed is:
1. A gas burner comprising:
   a pair of walls extending parallel to one another to form a distribution chamber extending between the walls;
   an input hole in one of the walls, extending into the distribution chamber;
   a plurality of channels extending outward within the walls from the distribution chamber and along a periphery of the distribution chamber; and
   a shut-off valve outwardly adjacent the input hole in the distribution chamber, wherein the shut-off valve allows a gas used as a fuel to flow into the distribution chamber when the valve is open, and wherein the shut-off valve closes in response to a drop in a pressure level at which the gas is supplied through the shut-off valve.
2. The gas burner of claim 1, wherein the shut-off valve comprises a check valve.
3. The gas burner of claim 2, additionally comprising a temperature sensor outwardly adjacent to some of the plurality of channels; and
   an additional valve allowing the gas used as a fuel to flow into the check valve when the additional valve is open, and closing in response to a drop in a temperature measured by the temperature sensor below a predetermined level.
4. The gas burner of claim 1, additionally comprising a temperature sensor outwardly adjacent to some of the plurality of channels, wherein the shut-off valve closes in response to a drop in a temperature measured by the temperature sensor below a predetermined level.
5. The gas burner of claim 1, wherein the gas used as a fuel is not mixed with an oxidizing agent before passing through the plurality of channels.
6. The gas burner of claim 1, wherein a wall extending adjacent the distribution chamber includes a plurality of holes admitting an oxidizing agent to be mixed with the gas used as a fuel within the distribution chamber.
7. The gas burner of claim 1, wherein the gas used as a fuel is hydrogen.

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