Oct. 8, 1940. N. L. DERBY 2,216,809

HEATER AND THERMO CONTROL THEREFOR

Filed Aug. 10, 1937 2 Sheets-Sheet 1

Fig. 1.

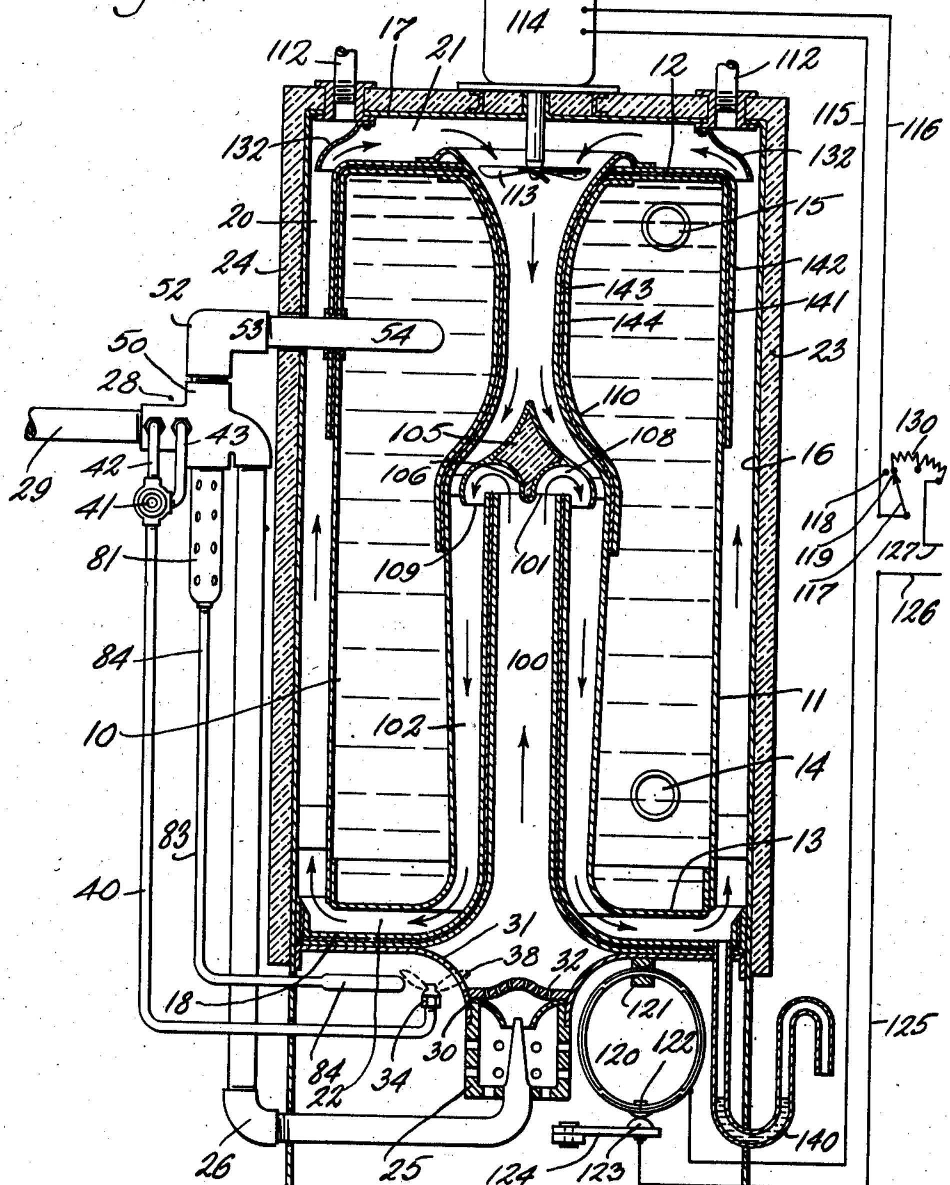


Fig. 2.

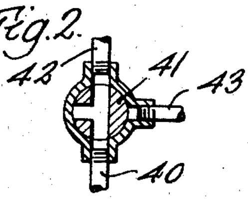
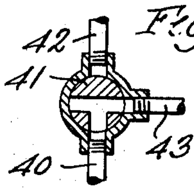


Fig. 3.



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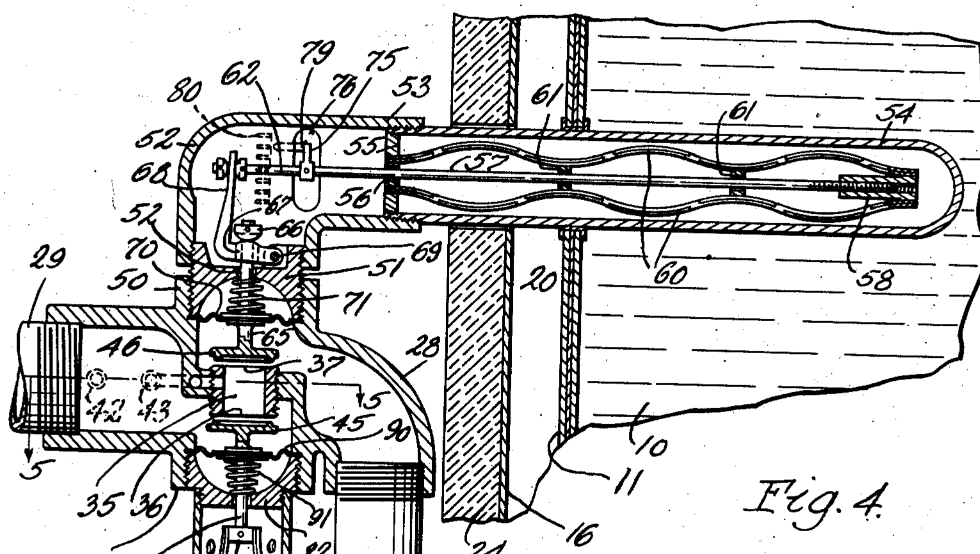
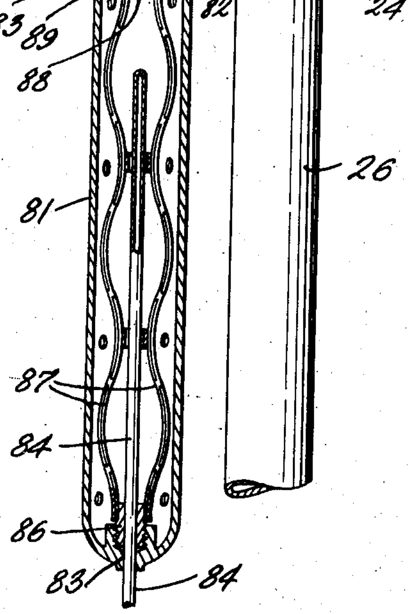

Fig. 4.

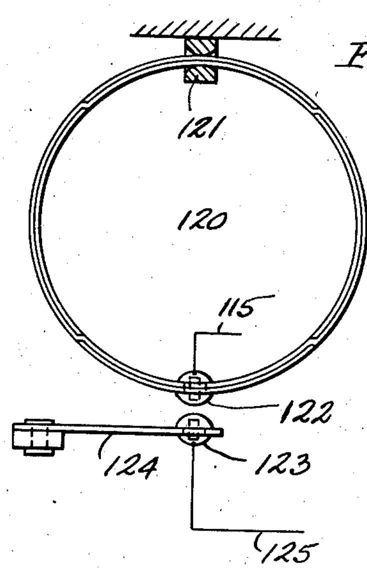

Fig. 6.

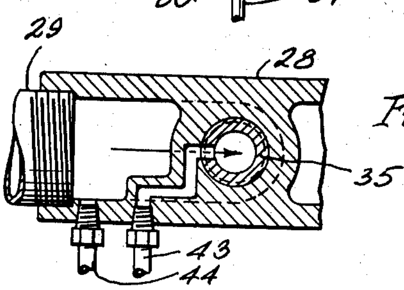

Fig. 5.

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UNITED STATES PATENT OFFICE

2,216,809

HEATER AND THERMO CONTROL THEREFOR

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Application August 10, 1937, Serial No. 158,343

4 Claims. (Cl. 236—21)

This invention relates to improvements in storage water heaters of the type which are heated by gas and to control means therefor.

In storage water heaters of this type as usually constructed, the gases of combustion are mixed with free or secondary air at the burner and the hot gases then pass by natural draft in contact with the walls of the water container to heat the water therein to the required temperature. It is well known that gases of combustion having mixed therewith a minimum of outside air have a far greater heat carrying capacity at elevated temperatures than when mixed with an excess of outside or secondary air. It is also known that if cool gases of combustion are mixed with hot gases of combustion as they pass from the gas burner and the mixture thus produced is passed by forced circulation in contact with the walls of the water container, the heating effect and the efficiency of the heater will be far greater than if the same volume of fuel is burned with an excess of air and is passed by natural draft in contact with the walls of the container.

Furthermore, the recovery, that is, the time necessary to heat a given volume of water through a certain range of temperatures is more rapid and efficient with forced circulation or recirculation than with the natural draft type of heater.

Most types of storage water heaters using a natural draft circulation are equipped with control means including a thermo-responsive device actuated by the temperature of the water being heated to control the supply of fuel to the main burner and another thermo-responsive device actuated by the temperature adjacent a pilot burner to cut off the supply of fuel to the main burner and to the pilot burner when the pilot flame is extinguished. Under natural operating conditions, the main gas burner goes on and off at frequent intervals, depending upon the amount of hot water consumed. The pilot flame, however, burns continuously to ignite the gas at the main gas burner. The foregoing control is usually accomplished by providing two independent valves in the supply line to the heater, one of which is controlled by the thermo-responsive device under influence of temperature of the water in the container to control the quantity of gas flowing to the main gas burner. The other thermostatic device responsive to the temperature adjacent to the pilot burner is arranged to automatically close the second valve, which is arranged between the first valve and the main burner, when the pilot burner is extinguished.

An important object of the present invention is to provide a water heater with an improved, simplified and efficient thermo-responsive device for controlling the delivery of fuel to the main burner of a storage water heater. A further important object is to provide a novel control device of this sort which includes only a single valve under the dual control of thermo-responsive means actuated by the heat of the water in the container and thermo-responsive means actuated by the heat adjacent a pilot flame or other source by which the flow of fuel to the main burner and to the pilot flame is controlled.

Another object is to provide, in a control device of this sort, thermo-responsive means of novel construction which is of relatively great sensitivity and which has a large increment of movement compared to elements of this sort heretofore used so that correspondingly large increments of movement of the closure elements of the gas valve can be effected with slight differences in temperature.

Another object of this invention is to provide a storage water heater of improved construction, in which the maximum efficiency and quick heating of the water may be had with a minimum consumption of fuel; also to construct a water heater of this type in which a minimum amount of free or secondary air is admitted to the burner, and in which cool gases of combustion are mixed and circulated with hot gases of combustion as they leave the burner. Another object is to provide, in a heater of this sort, means for effecting a forced circulation of the gases of combustion, and also to effect a forced mixing of cool and hot gases of combustion in a manner to cause a rapid passage of such mixed gases against the walls of the water container.

A further object of this invention is to provide means for automatically controlling the circulation and recirculation of the gases of combustion and to automatically stop circulation thereof when the main burner is extinguished; also to provide means whereby the rate of circulation and the amount of fuel consumption may be controlled to vary the temperatures to which the water may be heated, and to hasten the speed of recovery of the heater.

Other objects and advantages of the invention will appear in connection with the following description and claims.

In the drawings:

Fig. 1 is a vertical section of a storage type water heater embodying the several improvements in accordance with my invention.

Figs. 2 and 3 are vertical sections of a manually operable valve for controlling the passage of gas to the pilot burner of the heater.

Fig. 4 is an enlarged, fragmentary vertical section showing in detail the unitary assembly of my improved valve and control means for controlling the supply of fuel to the main and pilot burners of a water heater.

Fig. 5 is a horizontal section thereof, on line 5—5, Fig. 4.

Fig. 6 is a face view of the combined thermo-responsive element and switch for controlling the circulating means for the gases of combustion formed in the heater.

In the embodiment of the invention illustrated, see Fig. 1, my improved storage water heater comprises an upright tank or container 10 which may be formed of sheet metal having a cylindrical upright wall 11, a top wall 12 and a bottom wall 13, all forming a water-tight receptacle. Water or other fluid to be heated may be introduced into the container 10 through a pipe 14 near the lower end of the container and withdrawn through a pipe 15 near the upper end of the container.

As shown, the container 10 is surrounded by a substantially air-tight housing having a cylindrical upright wall 16, a top wall 17 and a bottom wall 18. The wall 18 is disposed at a distance above the bottom margin of the wall 16, which preferably rests directly on the floor or other support for the heater. The housing described is disposed in spaced relation to the walls of the container 10 so as to form a narrow or confined space 20 about the sides of the heater 10 which communicates with top and bottom narrow spaces 21 and 22 respectively. The housing is preferably provided with an insulating jacket 24 formed of asbestos plaster or other suitable material adapted to prevent the loss of heat through the walls of the housing.

Within the lower part of the housing, below the bottom wall 18, is arranged a main gas burner 25 which is supplied with gas or other fuel by a pipe 26 which extends horizontally from the burner to the outside of the housing and then passes upwardly alongside the housing, as shown. The upper end of the pipe 26 is connected to the discharge end of a valve 28 which receives a supply of fuel from a supply pipe 29 which is connected to the opposite or inlet end of the valve casing.

I preferably secure the upper or discharge end of the burner 25 in a hole 30 formed centrally in a funnel-like, downwardly extending central part of a plate 31 which is secured to the bottom face of the wall 18 of the enclosure 16. By this arrangement, substantially all outside or secondary air is prevented from mixing with the gases as they ignite at the top face 32 of the burner.

In accordance with this invention, the gas supply valve 28 is the only one used for supplying gas to the main burner 25 and in order to not only control the supply of fuel therethrough in response to the heat of the water in the container 10, but also in response to the heat from a pilot burner 34 disposed adjacent the main burner 25, I provide the valve 28 with a sleeve 35 arranged within the valve casing and which is open at both ends so as to form an inlet port or seat 36 and a discharge port or seat 37. The sleeve 35, as shown, is so disposed that when both ports are uncovered, gas from the supply pipe 29 may pass freely through the sleeve to the pipe 26 and the burner 25, but when either of these ports is closed, the supply of fuel to the main burner is cut off.

The pilot burner 34 is disposed close to the main burner 25, and adjacent a hole 38 in the wall 31 so that a small flame from the pilot burner may enter this opening and ignite the gaseous mixture at the top 32 of the main burner 25. The pilot burner 34 is mounted at the end of a small tube or pipe 40 which extends horizontally out of the lower end of the housing 16 and thence upwardly alongside the pipe 26 where it connects with a spring loaded plug valve 41, shown in detail in Figs. 2 and 3. Two branch pipes 42 and 43 are connected to ports in the casing of the valve 41. The branch pipe 42 communicates with the interior of the casing of the valve 28 between the sleeve 35 and the supply pipe 29 while the branch pipe 43, see Fig. 5, connects with a passage formed in the valve 28 and which terminates at a hole in the sleeve 35 between the seats 36 and 37. The valve 41 is of a well known three-way plug type which is yieldingly held in a definite position by a spring (not shown). In normal operation of the heater, that is, when the main burner 25 is burning, the valve 41 is held by its spring in the position shown in Fig. 3 wherein the supply of gas to the pipe 40 and the pilot burner 34 is delivered by way of the supply pipe 29, port 36, the aperture in the sleeve 35 and branch pipe 43. At this time the pipe 42 is cut off from the pipe 40 at the valve 41, as shown in Fig. 3. The other position of the valve shown in Fig. 2 will be explained later in connection with the thermo-responsive safety control means operating under the influence of the heat of the pilot burner 34.

As shown in detail in Fig. 4, I arrange for cooperative relation with the inlet seat 36 of the valve 28, a disk, valve or closure element 45 which is automatically movable towards and from the seat 36, or into and out of engagement therewith. I arrange a similar valve or closure element 46 for similar cooperative relation with the other seat 37 of the valve 28, and which is moved by automatic action, as will be explained.

In a boss 50 on the upper end of the casing of the valve 28, I secure an apertured screw plug 51 which, at its upper end, receives an elbow or pipe fitting 52 which includes a horizontal open ended branch 53. Into this open end 53 I screw the open, threaded end of a tubular member or shell 54, which is closed at its opposite end and projects through the wall 16 of the housing and the adjacent side wall 11 of the water container 10 so as to extend into the water in the container. Within the threaded outer end of the tube or shell 54, I fix a transverse disk 55 having a central aperture 56 therein through which passes, in axial relation to the tube 54, a long slender rod 57. The inner end of the rod 57 has a screw-threaded, adjustable connection in a sleeve or fitting 58 disposed in and spaced from the inner closed end of the shell 54. Upon this sleeve 58 at diametrically opposite sides of the rod 57, I secure the inner ends of a pair of reversed bimetal thermo-responsive strips or elements 60 of the form shown in Fig. 4. These elements may be constructed in accordance with the construction of such elements, as are disclosed in my Patent No. 2,086,857, Method of making bimetallic elements, to which reference may be had for further details. The strips 60 are of like construction and are bent alternately in opposite directions, and are symmetrically disposed so as to be connected at intervals by apertured bridge members 61 secured to adjacent bends. The rod 57 passes loosely through the holes in the members 61, thereby being confined against any substantial sidewise movement. The other ends of the strips 60 are fixed to the stationary disk 55 before mentioned.

The rod 57 is a thermo-responsive element formed of high expansion metal having a positive rate of heat expansion so as to increase in length with an increase in temperature. The oppositely disposed strips 60 form together a thermo-responsive element having a negative rate of expansion, that is, a decrease in length with an increase in temperature as the result of an increase in curvature of the bends thereof. This arrangement of the positive and negative thermal elements 57 and 60 is such that the movement of the free or outer end 62 of the rod 57 in one direction is equal to the increase in length of this rod plus the decrease in length of the strips 60 as produced by an increase in temperature, and conversely, the movement of the end 62 of the rod in an opposite direction is equal to the contraction in length of this rod 57 plus the increase in length of the strips 60 upon a decrease in temperature.

The construction of the thermo-responsive device just described is very efficient in operation and has the ability to impart relatively large increments of movement to any device to which it is attached, with only slight variations in the temperatures to which it may be subjected.

Any suitable operative connection may be provided between the free end 62 of the rod 57 and the outlet closure element 46 of the valve 28 for controlling the passage of fuel from the valve to the main burner 25 by way of the port 37. That shown in the drawings, consists of a vertical stem 65 formed on the closure element 46 and extending upwardly through the aperture in the plug 51 before mentioned where its free, upper end is provided with a collar or shoulder 66. This collar bears upon the upper face of a laterally extending arm of a lever 67, while the other arm 68 of the lever extends upwardly and has its free end pivotally connected to the free end 62 of the rod 57. The free end of the lateral arm of the lever 67 is pivoted at 69 on the plug 51, or other stationary part of the device.

Between the apertured portion of the plug 51 and the closure disk 46, the stem 65 passes through and is secured to a thin metal plate or corrugated diaphragm, or movable element 70, and between this element 70 and the adjacent face of the plug 51 is arranged an expansion spring 71.

The operation of this form of connection between the rod 57 and the closure element 46 is such that the spring 71, acting upon the diaphragm 70, tends to move the closure element 46 into engagement with the seat 37, while the engagement of the lateral arm of the lever 67 against the collar 66 of the valve stem acts to lift the closure element 46 upwardly into open position against the action of the spring 71 to varying extents, according to the movement of the free end 62 of the rod 57 to the right or left under the influence of variations in temperatures of the water in the container 10, as explained.

In addition to this controlled actuation of the closure member 46, an additional adjusted control may be provided by varying the relative position of the rod 57 with regard to the elements 60. This may be effected in any suitable way, as by a lever 75, fixed upon the free end of the rod 62 and extending radially therefrom outwardly through a slot 76 in the horizontal part 53 of the fitting 52 and which, by swinging the lever or arm 75 in an upward or downward direction, will cause the rod 57 to move lengthwise in one direction or another by means of its threaded connection with the sleeve 58, the direction of movement depending on the direction of movement of the lever 75. This action will result in changing the position of the lever 67, stem 65 and closure element 46 relative to the seat 37. The amount of adjustment may be indicated or set by a pointer 79 on the outer end of the arm or lever 75 which cooperates with a suitable scale 80 on the outside of the part 53.

The means responsive to temperature at the pilot burner 34 or equivalent heat source for controlling the actuation of the other closure element 45 includes a depending tube or shell 81, which is secured at its upper open end to an apertured plug 82 secured in an annular projection 83 extending downwardly from the casing of the valve 28. The lower end of the shell 81 is closed except for a small central aperture 83 therein. A thin walled tube 84, closed at its upper end projects into the shell 81 through the aperture 83, being secured in place by a suitable fitting 86 cooperating with the aperture. The tube 83 extends downwardly from the shell 81 to the lower portion of the heater where it is bent so as to extend through a hole in the side wall 16 of the housing from whence it extends to and terminates at a point adjacent to the pilot burner 34 in a closed end portion 84. Thus the closed end 84 of the tube is under the influence of heat from a flame projecting towards the tube 81 from the pilot burner, see Fig. 1. This tube 83 is vacuum sealed and contains a small quantity of water or other vaporizable fluid, the vapor from which rises to the upper closed end of the tube.

To the plug 86 is fastened the lower ends of a pair of thermo-responsive, reversed bimetal strips or elements 87 similar in construction and in action to the reversed bimetal thermal elements 60 before described. These strips 87 extend upwardly within the shell 81 and terminate near its upper end, and are connected at intervals by apertured bridge pieces, through which the upper end of the closed tube 84 is guided. The free ends of the strips 87 are fastened to a part 88 at the lower end of a rod 89 axially arranged upon and depending from the inlet closure element 45 of the valve 28. This rod 89 passes through the aperture in the plug 82 and between the plug and closure element 45 is secured to a diaphragm 90 between which and the adjacent face of the plug an expansion spring 91 is arranged. The spring 91, as in the case of the spring 71, acts to move the adjacent closure member towards its seat in opposition to the variable action imparted to the rod 89 by the thermo-responsive device to which it is attached.

In this particular thermo-active device, the outer shell 81 is the positive element of the structure and expands lengthwise, or downwardly relatively to the valve 28 upon an increase in temperature in the upper end of the tube 83, whereas the strips 87 have a negative rate of heat expansion and decrease in length with an increase in temperature. A reverse action of the parts 81 and 87 takes place upon a decrease in temperature.

The operation of this thermo-responsive device is such that when the pilot burner 34 is lighted and heat therefrom acts upon and vaporizes the liquid in the closed lower end 84 of the tube 83, the vapor which rises into the upper closed end of the tube 83 within the thermo-responsive device effects a transfer of heat to the device in varying degree such that in the presence of a normally high temperature from the vapor in the tube 83, the shell 81 will expand lengthwise in a downward direction, as stated. The negative elements 87 will, at the same time, contract under the influence of the heat from the tube 84, and since the lower ends of the elements 87 are fixed relatively to and move with the lower end of the tube 81, movement is transmitted to the closure member 45 in an amount equal to the expansion of the element 81 plus the contraction of the elements 87 and in a direction to maintain the closure member 45 in open or spaced relation to its seat 36. This condition obtains as long as the pilot burner 34 is ignited.

The operation of the heater as thus far described is as follows: Assuming that the main burner 25 and the pilot burner 34 are both lighted, the closure element 46 for the outlet seat 37 of the valve 28 will be maintained in open relation to the seat and will be moved toward and from the same in accordance with variations in temperature of the hot water in the upper part of the container 10. The temperature of the water, of course, will vary in accordance with the extent and the frequency with which water is withdrawn from the container, and when the temperature of the water in the upper part of the container reaches a predetermined degree, the closure element 46 will engage and close the seat 37 by the action of the thermo-responsive device connected with the element 46, thus shutting off the supply of gas to the main burner 25.

The other closure element 45 which controls the passage of gas into the sleeve 35 by way of the inlet port 36 is maintained in open relation to the seat 36 as long as the pilot 34 is burning and effecting vaporization of the liquid contained in the tube 83, the vapor from which will rise to the upper end of this tube and transfer its heat to and operate the thermostatic device comprising the shell 81 and strips 87. Therefore, as long as the pilot light is burning, the inlet seat 36 of the valve 28 will remain uncovered, and fuel will pass from the supply pipe 29 through both seats 36 and 37 in the valve sleeve 35 and the pipe 26 to the main burner 25, and by way of sleeve 35, branch pipe 42, valve 41 and pipe 40 to the pilot burner 34. The amount of gas delivered to the burner 25 will vary in accordance with the demand required to maintain the water at the desired temperature, as explained, by movement of the closure element 46 toward and from the seat 37. Under operating conditions, when the desired temperature of the water in the upper part of the container has been reached, the thermostatic device controlling the closure member 46 will operate to close this member against the seat 37 of the valve 28 and cut off delivery of fuel to the main burner until such time as the temperature of the water about the thermostatic device is reduced by the withdrawal of water from the container or by the cooling of the water from the lack of heat at the main burner.

As soon as the temperature falls to an appreciable extent, the thermostatic device will act to lift the closure member 46 away from the seat 37 and permit gas to pass to the main burner where it will at once be ignited by the pilot burner to again raise the water to the desired temperature.

During such operation of the heater, the supply of gas to the pilot burner 34 is continued by way of the pipe 29, sleeve 35, passage 43 and valve 41 to the pipe 40, as before explained, regardless of the intermittent closing of the seat 37. Passage of gas through the branch pipe 42 to the pipe 40 is prevented under these conditions by the position of the plug valve 41.

If for any reason the pilot burner should be extinguished, the vaporization of the liquid in the pipe 83 will cease, whereupon the shell 81 surrounding the upper end of said pipe 83 will contract lengthwise while the thermostatic strip elements 87 will extend in a lengthwise direction, and by the combined action of these two elements will cause the closure element 45 to engage the inlet seat 36 and shut off the delivery of fuel, not only to the main burner 25 by way of the pipe 26, but also to the pilot burner by way of the sleeve 35 and passage 43, so that no fuel can now pass to the pilot burner until it is again lighted.

Thus, the thermostatic device composed of elements 81 and 87 acts in the nature of a remotely controlled safety device to positively prevent delivery of fuel to either burner should the pilot burner become extinguished for any reason.

In order to enable the pilot burner 34 to be relighted, the plug valve 41 must be turned through an angle of 90° to the position shown in Fig. 2, which will enable the fuel from the supply pipe 29 to be delivered to the pilot burner pipe 40 by way of the branch pipe 42 and valve 41, while the branch pipe 43 remains cut off from the fuel supply by the seat closure member 45 and the plug of the valve 41.

After the plug valve 41 has been turned to the position shown in Fig. 2, as above described, and the pilot burner has been lighted, the valve is held in this position against the action of its spring until sufficient heat has been developed at the pilot burner to heat the fluid in the lower end 84 of the pipe 83. Generation of vapor which will rise to the upper end of the pipe will cause operation of the associated safety thermostatic device to shift the closure member 45 off of the inlet seat so that fuel may enter through the sleeve 35 and into the passage 43. By now releasing the plug valve 41, its spring will return it to the position shown in Fig. 3, whereupon the fuel which is now enabled to enter the branch pipe 43 through the sleeve 35 will pass to the pipe 40 by way of the valve 41, thus renewing normal automatic operation of the main burner and pilot burner under the control of the unitary fuel supply valve 28 and its associated thermostatic elements, as before explained.

As previously stated, in storage water heaters of this type, the usual procedure has heretofore been to cause the gases of combustion from the burner to rise by natural draft upwardly around the outside wall of the container 11 and then pass from the heater.

In accordance with the present invention, I provide a water heater construction whereby the gases of combustion, with the addition of almost no secondary air, are passed under forced draft or circulation quickly over the walls of the container, and I also further provide means whereby a portion of the gases of combustion, after passing over the walls of the water container and becoming cooled by such action, are mixed with and recirculated with freshly rising hot gases of combustion as they leave the burner.

For this purpose, I form in the heater construction illustrated, a column or passage 100 which extends upwardly from the burner 25 and is open at its upper end, as indicated at 101. The burner 25 and the column or passage 100 are preferably disposed substantially in axial alinement with or upon the center line of the container 10, and the upper end 101 of said passage preferably terminates approximately midway between the upper and lower ends of said container.

The lower end of the column 100 terminates at the bottom wall 18 of the enclosure and registers with the opening of the part 31, and in turn is closed by the burner 25.

Surrounding and disposed in spaced relation to the column or passage 100 is an upright annular duct 102 which communicates at its lower end with the space 22 before mentioned, between the bottom wall 13 of the container and the bottom wall 18 of the outer housing. The upper end of the duct 102 terminates in the upper space 21 between the top wall 12 of the container and the upper wall 17 of the housing, so that the upper and lower ends of the duct 102 are in communication with the annular space 20 surrounding the container 10 between the wall 11 and the housing. I also preferably arrange in the duct 102 adjacent and in spaced relation to the upper end 101 of the passage 100, a deflector 105 which has a central, depending more or less conical projection 106 terminating at or just within the upper end 101 of the passage 100. Surrounding the central portion 106 of the deflector 105 is an annular, downwardly facing concave space or passage 108, the lower outside edge of which is defined by the margin 109 of the deflector, as shown. The deflector 105 is also provided with a central upstanding substantially conical part 110, the side walls of which are arranged in spaced relation to the walls of the duct 102 which are preferably curved as shown adjacent the deflector for this purpose. Thus, it will be seen that gases rising upwardly in the column or passage 100 will, as they arrive at the open upper end 101 thereof, be diverted into the annular concaved passage 108, and as they impinge against the inner walls thereof, will be deflected downwardly thereby in a direction towards the lower portion of the duct 102.

Should the heater as thus described be operated under natural draft conditions, most, if not all of the gases of combustion entering the central part of the duct 102 in the manner just described, would pass upwardly into the space between the deflector 105 and the adjacent sides of the duct 102 and out of the upper end of the latter into the space 21. I have shown in Fig. 1, two relatively small outlet pipes or openings 112 disposed in the top wall 17 of the housing 16 so as to permit a limited escape of the products of combustion from the heater. However, it is desirable, in order to effect the maximum efficiency in this heater, to provide means for causing the gases of combustion, after leaving the upper end of the passage 100, to pass downwardly in the duct 102 to the space 22 and thence upwardly in the space 20 about and in contact with the outside walls of the container, so that heat from the products of combustion will heat the water not only through the walls of the duct 102, but also through the outside wall 11 of the container. For this purpose, I provide means for causing this downward movement of the gases of combustion, preferably at a rate of speed in excess of normal draft conditions, the means shown in the drawings comprising a fan or other impelling device 113 which is disposed in or adjacent the upper, open flaring end of the duct 102, as shown in Fig. 1. This fan or impeller may be mounted on a shaft which extends downwardly through the top wall 17 of the outer housing of the heater and is operatively secured to an electric motor or the like driving unit 114 mounted upon the top of the heater, as shown. The motor circuit includes a pair of conductors 115 and 116, one of which leads to a movable switch member 117 cooperating with contacts 118 and 119 for opening and closing the circuit in the usual manner. The other conductor 115 extends into the space within the lower portion of the housing and there makes contact with a reversed bimetal thermoresponsive element 120 which is preferably of substantially circular or ring-like formation, as shown in Fig. 6, and which may be constructed in accordance with the disclosure in my Patent No. 2,086,857, before referred to. This thermoresponsive element 120 has one of its sides secured in a bracket 121 in fixed relation to or upon an adjacent part of the heater while at the diametrically opposite side of the device 120 to the bracket 121, the device 120 is provided with a contact member 122. This contact 122 is arrange to engage a contact 123 supported upon a fixed bar 124 suitably mounted upon and insulated from the housing 16, see Fig. 1. Extending from the contact 123 is a conductor 125 which connects with the supply line 126 from the source of electric current. The other supply line 127 is connected to the contact 119 for the switch member 117, preferably through an interposed rheostat or other variable resistance device 130, as shown in Fig. 1.

The thermoresponsive element 120 is so constructed that it will, under the influence of heat, be distended or deformed in a vertical direction out of its circular form into a more or less elliptical formation, as indicated in Fig. 1, and when in this condition, it will carry its contact 122 into engagement with the fixed contact 123 to complete the circuit to the motor through the connections just described.

Accordingly, I mount the element 120 adjacent the main burner 125, as shown in Fig. 1, so that when said burner is ignited, heat therefrom will cause the motor circuit to be closed and the motor placed in operation to rotate the fan or impeller 113.

Under these operative conditions, the fan 113 will draw a considerable portion of the relatively cool gases of combustion from the space 20 through the space 21 and force it downwardly through the upright duct 102 where, as it passes over the upper diverting face of the deflector 105, it will mix with the freshly produced heated gases of combustion rising from the burner through the passage 100 as these gases are discharged into the duct 102. The construction of the deflector and associated parts of the passage 100 and the duct 102 is such that an intimate mixture of the cool and hot gases will take place and the mixed gases will be forced downwardly through the duct 102 along the inside walls of the container 10 across the bottom wall 13 thereof, and hence upwardly along the outside wall 11 of the container 10, as long as the fan 113 is operating.

Preferably, I arrange adjacent the inner ends of the openings 112, deflectors 132 which are so formed and positioned that they aid in directing the gases ascending upwardly in the space 20, largely towards the center of the heater, where they will be carried downwardly into the duct 102 to be mixed with the rising gases of combustion as they leave the passage 100, as explained.

As a result of the novel construction and arrangement of the parts of the heater as just described, the streams of hot and cool gases of combustion flow smoothly together and mix below the deflector 105 without building up an opposing pressure. The velocity of the cool gases passing the deflector and the action of the fan is such as to cause an upward suction in the passage 100 to draw a large combustible charge into the burner 25.

The mixed cool and hot gases forced downwardly through the lower portion of the conduit 102 and upwardly through the outer space 20, give up their heat to the inner and outer walls of the water container. A portion of the mixed cool gases passes to the open air at the outer side of the deflectors 132 and the outlets 112, the remainder of these gases being drawn by the fan or impeller into the duct 102 where they are forced downwardly again and mixed with the new hot gases below the deflector. This mixture resulting from the passage of these gases into the lower portion of the duct 102 where they mix with the hot gases arising from the passage 100 is recirculated, as before stated. The deflectors 132 are so designed that while permitting a portion of the circulating and recirculating gases to pass into the open air, no outside air may enter the heater through the passages 112, since the static pressure in the duct 102 and in the upper and lower connecting spaces 20 and 22 is such as to prevent the outside air from entering the heater as long as the fan is in operation.

On the other hand, the relatively small area of the discharge passages 112 is such that, when the burner 25 is extinguished and the fan is stopped, very little outside air will pass into the heater by natural draft, so that the standby efficiency of the heater will be affected but little under these conditions.

The suction in the passage 100 may be regulated by regulating the speed of the circulating gases, which in turn is controlled by the speed of the motor 114 and its associated fan 113. Therefore, by moving the switch member 117 from the contact 119 into contact with one or another of the contacts of the rheostat 130, the speed of the motor and, consequently the speed of the fan 113 and the movement of the gases through the heater, can be varied and controlled, if desired.

With the switch 117 in closed position, either engaging with its contact 119 or one of the contacts of the rheostat 130, the fan 113 will be in operation as long as the main burner 25 remains ignited, since the heat from this burner actuating the thermostatic element 120, as explained, will cause the contacts 122 and 123 to be held in engagement to maintain the motor circuit in closed position. However, should the main gas burner 25 become extinguished for any reason, the removal of heat from the vicinity of the element 120 will cause the latter to resume its circular formation and thereby move its contact 122 out of engagement with the contact 123, thus opening the motor circuit and stopping the fan 113.

I have shown in Fig. 1 a trap 140 which comprises a pipe having reverse bends and which has one of its ends secured in the bottom wall 18 of the housing and in communication with the space 22 of the housing. This trap is water sealed and acts to relieve the spaces between the housing, the central duct 102 and the walls of the water container of any water of condensation that may accumulate, as the burning gases always contain water vapor as a product of combustion.

I preferably provide the upper portion of the water container 10 with suitable heat insulation to prevent the hottest water at the top of the container from giving up heat to the cool circulating gases in the upper end of the duct 120 and in the spaces 20 and 21. Any suitable means may be provided for accomplishing this result, such as the provision of a layer of aluminum or similar thin sheet metal or foil 141 arranged between the outside surface of the upper portion of the container 10 and an outer contacting layer of metal as indicated at 142.

The upper portion of the duct 102 is similarly insulated by a layer of foil 143 and a contacting sheet metal wall 144, while the walls of the passage 100 and the lower wall 18 of the housing to which it connects are similarly insulated as shown in Fig. 1.

The tube heater 83 containing the volatile liquid for heating the safety thermostat from heat at the pilot burner 34 may be insulated with an asbestos or the like covering (not shown), or may be coated with aluminum paint, with the exception of the generator end 84 and the upper end within the safety thermostatic device.

I preferably form in the shell 81 of the safety thermostatic device a plurality of small holes for the circulation of air therethrough. This will help the heating action of the tube 83 and cause a more rapid cooling of the thermoresponsive members 81 and 87 with consequent quicker closing action of the closure element 45, in the event that the pilot burner is extinguished.

Preferably, I form the sleeve member 35 of the valve 28 of some suitable permanently magnetic material, such for example as that known in the trade as "Alnico", while the closure members 45 and 46 are preferably formed of a paramagnetic material such as 50% nickel steel, which is attracted by the permanent magnetic sleeve so as to effect quick opening and closing action of the closure elements when such movements thereof are initiated by their respective thermostatic devices.

Preferably, though not necessarily, I also provide in the contact members 122 and 123 which are associated with the thermoresponsive device 120 at the lower part of the heater, small permanent magnets of "Alnico" or the like, which are embedded in the contacts and operate to assist in effecting quick action between the contacts 122 and 123.

The improved heater above described is well adapted to reduce heat losses to a minimum by preventing excess outside air from entering at the base around the main burner so that no cool air may pass in contact with and carry heat from the water container by natural draft when the heater is in the standby condition, that is, with the burner 25 extinguished during which time hot gases are being generated only by the pilot flame.

The heater described may be operated as a condensing heater or non-condensing heater, as desired, by regulating the volume of combustible gases entering the main burner. If a relatively small amount of hot gases of combustion are generated and circulated in the heater, they will be cooled below the condensation temperature of the vapor that is a product of combustion. In this case, the latent heat of vaporization of the water vapor will go to heat the water in the container and the condensate will pass from the heater through the trap 140.

If the heater is operated as a condensing heater, it will be necessary to make all parts coming in contact with the condensate of stainless steel or some other material that is not attacked by the highly corrosive acids dissolved in the condensate.

While I have shown and described my invention in connection with a domestic water heater, the application of the invention is not limited to such structures, since the same may be employed in connection with many other forms or types of water heaters or systems.

It will be understood that various changes in the details, materials and arrangements of parts, which have been herein described and illustrated in order to explain the nature of my invention, may be made by those skilled in the art within the principle and scope of the invention, as expressed in the appended claims.

For example, while I have shown and described the pilot flame as being produced by a separate pilot burner, it should be obvious that the supply of fuel for the pilot flame could be delivered to the main burner gas pipe 26 and the main burner 25, with equally good results. Also, if desired, I may substitute for the motor 114, a two speed motor, that is, one having two independent windings with a switch to vary the speed of the fan 113. Such motors are well known, and it is deemed unnecessary to illustrate the same.

I claim:

1. The combination in a water heater having a water container, of a main fuel burner for heating the water therein, means for producing a pilot flame, and a pipe for supplying fuel to said main burner and pilot flame, of a single valve in said pipe having a casing, a sleeve therein formed of permanently magnetic material and having a seat at each end forming an inlet port and an outlet port respectively, closure elements for each of said ports formed of paramagnetic material, a passage in said sleeve communicating with said pilot flame for conducting fuel from said valve to said pilot flame, a thermostat responsive to the temperature of water in said container and operatively connected to said outlet closure element to regulate the flow of fuel to said main burner, and a second thermostat operatively connected to said inlet closure element and responsive to temperatures adjacent said pilot flame to control the flow of fuel through said inlet port and said passage to said pilot flame, and said connections between said thermostats and said inlet and outlet closure elements including means for facilitating quick opening and closing of said valve ports under the cooperative magnetic influence of the materials of which said sleeve and closure elements are formed.

2. The combination in a water heater having a water container, of a fuel burner for heating the water therein and a valve for supplying fuel thereto and including a closure member cooperating with a seat in said valve, of thermostatic means for actuating said closure member under the influence of the temperature of the water in said container, said thermostatic means including a thermo-active element having a positive rate of expansion with an increase in temperature, a second thermo-active element having a negative rate of expansion and comprising a pair of reversed bimetal strips formed to contract lengthwise with an increase in temperature, said strips being joined at intervals and each connected at one end to an end of said positive element, and said strips being fixed at their opposite ends, said other end of said positive element being operatively connected to said closure member for moving the same towards and from said valve seat in response to changes in the temperature of the water, the movement of the free end of said positive thermo-active element being equal to the increase in length of said positive element plus the decrease in length of said negative element and vice versa.

3. The combination in a water heater having a water container, of a main fuel burner for heating the water therein, a pilot burner adjacent said main burner and a pipe for supplying fuel to both burners, of a single valve in said pipe having an inlet port and an outlet port, a closure element for each port operable to independently open and close its port, thermostatic means operatively connected to one of said closure elements and which is responsive to the temperature of the water in said container to regulate the flow of fuel through said outlet port to the main burner, and other thermostatic means disposed at a point remote from said pilot burner, said thermostatic means including a thermo-active element having a positive rate of expansion with an increase in temperature, and which is fixed at one end, a second thermo-active element having a negative rate of expansion so as to contract lengthwise with an increase in temperature, this element being fixed to the free end of said first element and having its other end operatively connected to said other closure member, and a conduit closed at both ends and containing a vaporizable liquid, one end of said conduit being disposed adjacent said pilot burner so that heat therefrom may vaporize said liquid and the other end of said conduit being associated with said second thermostatic means so that the same will be affected by the presence of vapor in that end of said conduit to move said closure member towards and from said inlet port to control the flow of fluid therethrough to said outlet port, and the movement of the free end of said negative element being equal to the increase in length of said positive element and the decrease in length of said negative element and vice versa.

4. The combination in a water heater having a shell which contains the water, of a burner for heating the water, valve means for delivering fuel to said burner, thermo-responsive means actuated by the temperature of the water for controlling the supply of fuel through said valve to said burner and for automatically cutting off the supply of fuel thereto when a predetermined high temperature of the water is reached, whereby said burner is intermittently extinguished and for again automatically effecting delivery of fuel through said valve to said burner when said water temperature is lowered, a pilot for igniting the fuel delivered to said burner, means for effecting forced circulation of the products of combustion from said burner into intimate contact with the walls of said shell including a motor driven fan, a switch and a thermostatic device, the latter being positioned so that, when products of combus-

tion are being produced at said burner in accordance with the delivery of fuel thereto under the action of said other thermo-responsive means, said thermostatic device will be influenced by the heat from said products of combustion to effect closing of said switch and the operation of said fan, and, when said thermo-responsive means operates to automatically cut off the supply of fuel to and extinguish said burner and the production of products of combustion thereby ceases, said thermostatic device will act to open said switch and stop actuation of said motor driven fan.

NORMAN L. DERBY.