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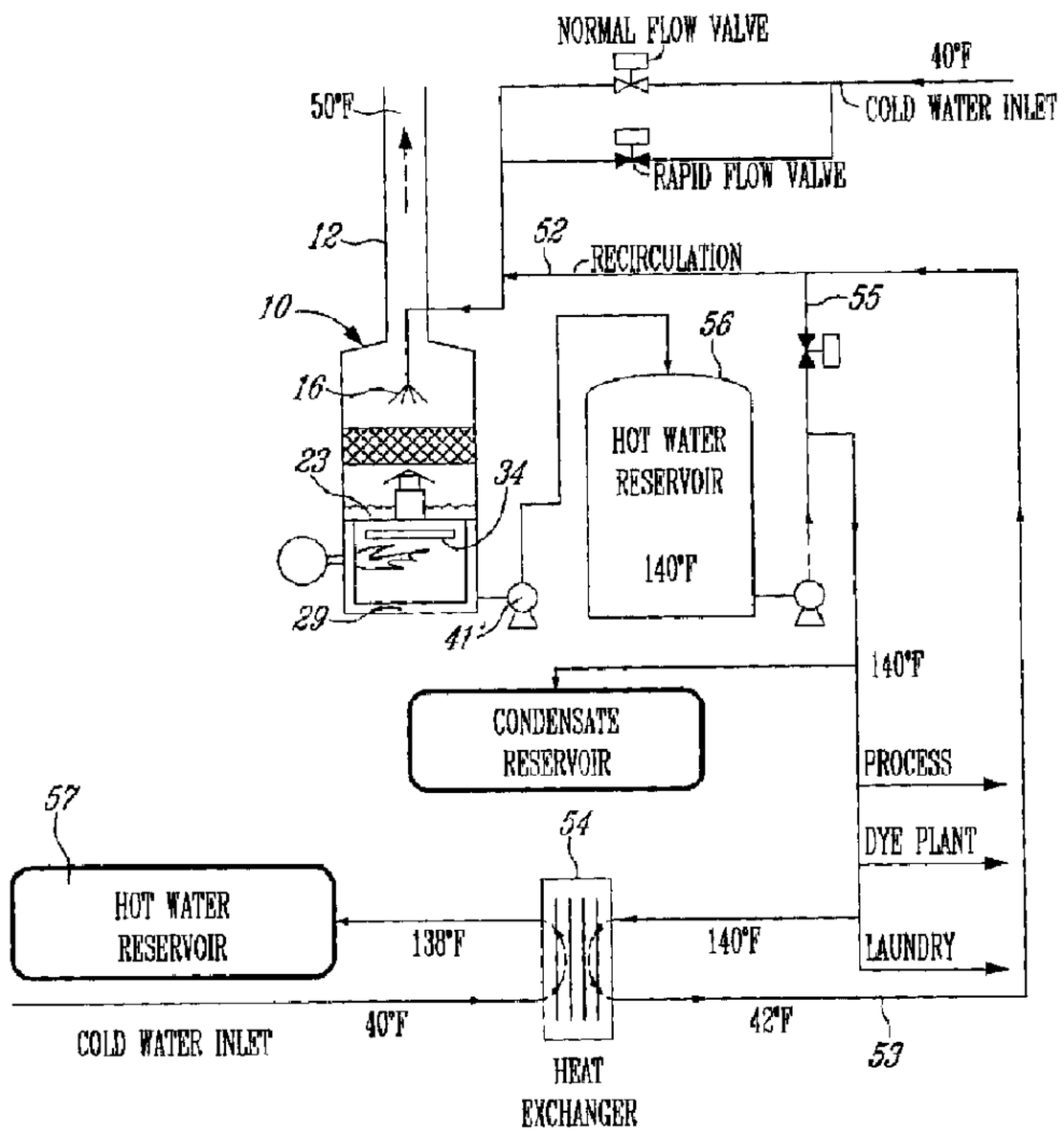
(54) Title: DIRECT CONTACT WATER HEATER WITH INDIRECT CONTACT SECTION




(57) Abrégé/Abstract:
A direct contact water heater having an indirect contact section, and its method of operation are described. The water heater is comprised of an elongated vertical tubular housing having a water spray nozzle in an upper end thereof for spraying water substantially uniformly over a packing of heat exchange bodies. An intermediate space is provided below the packing where begins the direct contact section of the water heater. A burner chamber is provided at the bottom of the housing below an intermediate reservoir and is provided with a heat source. Heat from the heat source circulates in counter-current flow with the water percolating through the housing from the packing located at the top of the housing. The indirect contact section is located at the bottom of the housing and comprises an intermediate reservoir, a cooling chamber around the burner chamber and a heat exchange coil.

## ABSTRACT OF THE DISCLOSURE

A direct contact water heater having an indirect contact section, and its method of operation are described. The water heater is comprised of an elongated vertical tubular housing having a water spray nozzle in an upper end thereof for spraying water substantially uniformly over a packing of heat exchange bodies. An intermediate space is provided below the packing where begins the direct contact section of the water heater. A burner chamber is provided at the bottom of the housing below an intermediate reservoir and is provided with a heat source. Heat from the heat source circulates in counter-current flow with the water percolating through the housing from the packing located at the top of the housing. The indirect contact section is located at the bottom of the housing and comprises an intermediate reservoir, a cooling chamber around the burner chamber and a heat exchange coil.

# DIRECT CONTACT WATER HEATER WITH INDIRECT CONTACT SECTION

## TECHNICAL FIELD

The present invention relates to a direct contact water heater column having particularly, but not exclusively, two sections for heating water, one in indirect contact with the water and one in direct contact with water droplets. This permits the utilization of oil and/or other fossil fuels as a heat source.

## BACKGROUND ART

Direct contact water heater heaters are known, such as described in U.S. Patent N° 4,574,775 issued on March 11, 1986 and comprised of a vertically oriented cylindrical column having a packing of heat exchange elements adjacent an upper end thereof. Water to be heated is sprayed on top of the packing so that the water is heated by the packing and also by hot gases passing through the cylindrical column. The hot gases are usually provided by a fossil fuel burner which is installed at the bottom of the column to produce hot flue gases which are directed upwardly in counter-current flow to water droplets to heat them and these droplets are further heated when entering into direct contact with the flame. Hot water is stored at the bottom of the column from where it is pumped to supply external devices.

Direct contact flue gas stack economizers operate substantially as direct contact water heaters with the exception that the hot flue gases are generated from other sources. Flue gases from those other sources are admitted into the column below the packing and the energy of the flue gases is absorbed by the down coming water droplets. Although these stack economizers are considered to be an efficient way of recovering lost heat, they have one main

disadvantage, and that is the maximum outlet temperature of the column is approximately the dew point temperature of the flue gases entering the column. Therefore, an additional amount of heat may be needed in order to supplement the recovered heat to meet the process demand. This additional amount of heat may be added by a direct contact water heater or by other means. It must be kept in mind, however, that the disadvantages of direct contact stack economizers are compensated by the big advantage of free energy from the existing flue gases recovered from other sources which was previously lost to the atmosphere.

The direct contact water heaters do not have the same outlet water temperature limitation as does the direct contact stack economizer, and can heat water well above the dew point of the combustion gases. Because the direct contact water heater is an atmospheric pressure apparatus, the heating of water above a critical point brings vaporization of water and an efficiency drop. Also, the direct contact water heater can be sized for any amount of energy required, as it has its own burner. However, one of the disadvantages of the conventional direct contact water heater is that it heats water at a very high efficiency level with fossil fuel, but this fossil fuel is costly as compared to free energy being recovered by direct contact economizers. Also, the temperature of the flue gases being exhausted by the direct contact water heater is equal or slightly higher than the incoming water. Furthermore, the direct contact water heater cannot burn oil because this apparatus cannot achieve combustion of oil.

There is therefore a need to provide an ideal water heater arrangement wherein cold water is introduced at the top of a direct contact stack

economizer and is preheated by hot flue gases. Preheated water at the bottom of the direct contact stack economizer would then be transferred to the indirect contact water heater where water will be further heated. Flue gases exhausting from the indirect contact water heater would then be directed to the direct contact stack economizer to be cooled down as much as possible. However, the main disadvantage of this arrangement would be the cost of fabricating and interconnecting two separate pieces of equipment, namely a direct contact stack economizer and an indirect contact water heater. Another disadvantage would be the incapacity of the direct contact economizer to receive flue gases from indirect water heater having oil as a heat source.

SUMMARY OF INVENTION

It is a feature of the present invention to provide a direct-indirect contact water heater capable of heating water at higher temperatures than direct contact water heaters without the above-mentioned disadvantages of the prior art.

Another feature of the present invention is to provide a direct-indirect contact water heater having similar efficiency to that of direct contact water heaters and the capacity to burn oil as a heat source.

Another feature of the present invention is to provide a direct-indirect contact water heater having the advantage of a direct contact water heater and also the advantage of an indirect contact water heater.

Another feature of the present invention is to provide a direct-indirect contact economizer having the advantage of a direct contact economizer and also the advantage of an indirect contact economizer.

According the above features, from a broad aspect, the present invention provides a direct-indirect contact water heater having a fuel heat source. The water heater comprises an elongated vertical tubular housing having a water spray nozzle in an upper end thereof for spraying water downwardly on a packing of heat exchange bodies held in a region of the housing by support means. An exhaust flue gas is provided in the upper end of the housing. An intermediate space is defined in the housing below the packing. An intermediate preheated water reservoir is provided in the intermediate space. A water outlet is provided in the wall of the housing from which water from the reservoir is pumped. A burner chamber is defined below the intermediate reservoir. A burner is connected to the burner chamber for generating a flame in the burner chamber to form a heat source. Passage means interconnects the burner chamber to the intermediate space to permit hot gas from the burner chamber to rise through the intermediate space and packing. The water sprayed on top of the packing is firstly heated by hot gases from the burner chamber rising through the packing, and then is further heated by the heat exchange bodies where water propagates and falls in droplets by gravity from the lower surface of the packing. The droplets falling from the lower surface of the packing are still further heated by contact with the rising flue gases below the packing. The preheated water droplets accumulate in the intermediate reservoir. The preheated water from the intermediate reservoir is pumped to a cooling chamber about the burner chamber to preheat water from the intermediate reservoir therethrough and then this water is directed through a heat exchange coil mounted in the burner chamber where the heated water from the cooling chamber is

furthermore heated by the flame and transferred for further use by the pump circuit.

According to a still further broad aspect of the present invention, the preheated water from the intermediate reservoir is fed to an indirect contact heating circuit which is provided by a chamber

disposed about the burner chamber whereby to extract heat from that chamber and to provide a cooling effect thereto. The water which is further heated about the burner chamber is then fed into heat exchange coils disposed within the burner chamber below the intermediate reservoir where it goes through a final heating stage.

According to a still further broad aspect of the present invention, the preheated water from the intermediate reservoir is fed to a heat exchanger to heat city water and then fed back to the spray nozzle on top of a packing. The city water passing through the heat exchanger is then heated again in the indirect contact heat circuit by feeding it about the burner chamber and the heat exchange coil whereby to provide a domestic hot water supply.

According to a still further broad aspect of the present invention, there is provided a method of heating water in a direct-indirect contact water heater column and which comprises the steps of providing a packing of heat exchange bodies across an inner space of the column in a top portion thereof. Water is sprayed substantially uniformly over the top of the packing so that water percolates in droplets down into the inner space of the column to an intermediate reservoir. Heat is generated in the column from a heat source in a heating chamber at a bottom of the column whereby the heat rises to exit at the top end of the column. The heat is displaced in counter-current to the percolating water droplets and through heat exchange bodies of the packing. The heat generated in the column is from a burner heat source mounted in a lower end of the column. Preheated water from the intermediate reservoir is then pumped by a pump circuit to a cooling chamber about the heating chamber

and through a heat exchange coil inside the heating chamber to provide a domestic hot water supply.

According to a still further broad aspect of the present invention, the apparatus and method utilize

two sections separated by an intermediate reservoir in the column and the hot gases from the heat source generated by a burner secured in a burner housing at the bottom of the housing. The heat source is cooled first in the indirect section defined below the intermediate reservoir and thereafter is further cooled by the direct contact section above the intermediate reservoir. The flue gases of the heat source are communicated through the intermediate reservoir via a passage means and propagates through the intermediate section and the packing, preheating water droplets falling through the intermediate space and the packing. The intermediate space is defined by the space between the packing and the intermediate reservoir.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 is a fragmented side view of the direct-indirect contact water heater of the present invention incorporating a direct contact section and an indirect contact section;

FIGURE 2 is a side view similar to Figure 1 but showing the direct-indirect contact water heater having two water circuits; and

FIGURE 3 is a schematic diagram showing the direct-indirect contact water heater of the present invention and the heated water and supply water that are connected in a distribution circuit.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, and more particularly to Figure 1, there is shown generally at 10 the direct-indirect contact water heater of the present invention. The water heater comprises a vertically disposed tubular housing 11 formed from

any suitable metallic material capable of withstanding the heat propagated through the column defined inside the tubular housing 11. The column has an exhaust gas flue 12 general centrally disposed with respect to the central longitudinal axis 13 of the housing in a top wall 14 thereof. Side exhaust outlets may also be used. A water inlet feed pipe 15 is connected to the top wall 14 to supply a source of water to a water spray nozzle 16 located in a top end 17 of the housing on the central vertical axis 13. The water spray nozzle faces downwardly to direct a spray 18 of water substantially uniformly over the top of packing 19 of heat exchange bodies 20.

As herein shown, the heat exchange bodies are small hollow cylindrical bodies, or alternatively they could be perforated elements having different shapes. The packing 19 is supported across the inner circumferential wall 21 of the housing 11 by support means, herein constituted by a stainless steel screen 22.

Spaced below the packing at a predetermined distance is an intermediate reservoir 23. As can be seen, a hollow circumferential tube 24, covered by a spaced cap 25 passes through the intermediate reservoir 23 and terminates above the water level 30 in the intermediate space 36. The hollow tube 24 provides a passage between the combustion chamber 26 and intermediate space 36. The intermediate reservoir is created by a metal plate 37 and the inner side 21 of the housing 11. In the intermediate reservoir 23, a water outlet 39 passes through the side wall of the housing 11. Below the intermediate reservoir 23 is defined a combustion chamber 26 wherein a burner 27 is connected thereto to generate a flame 28 within the combustion chamber.

As can be seen, a cooling hollow circumferential chamber 29 is defined between the bottom outer wall section 11' of the burner housing 11 and a tubular casing 32 disposed inside the tubular housing 11 and spaced from the side wall section 11'. The circumferential chamber 29 has a circumferential closed top end 31 which terminates at the level of the bottom of the intermediate reservoir 23. The chamber 29 defines an annular cooling jacket between the tubular casing 32 and the tubular housing 11' and the bottom wall of the housing 11 and between a double floor 40 of the water heater. A cooling water inlet 33 is connected to the discharge end 41' of the pump 41. The inlet 33 is connected to the chamber 29, for feeding the preheated cooling water thereto and circulating same in the chamber for further heating and then through a heat exchange coil, as shown at 34, from the closed top end 31. The cooling water outlet 35 is connected to the heat exchange coil 34 and passes through the wall of the housing 11 where the hot water exits for further use.

The area between the packing 19 and the intermediate reservoir 23 constitutes an intermediate space 36. The hot gases generated by the flame 28 which rise through the column, via the tube 24, heat the water droplets 38 which fall from the lower end of the packing 19 and also heat the heat exchange bodies 20 in the packing.

It can therefore be seen that with the direct-indirect contact water heater of the present invention, cold water is introduced through the water inlet feed pipe 15 and is distributed substantially uniformly over the top packing 19 by the water spray nozzle 16 located thereover. Preheated water from the direct contact section is accumulated in the intermediate reservoir 23 and is further pumped by

the pump 41 from the water outlet 39 to the coupling inlet 33 into the annular cooling chamber 29 around the burner chamber 26 further into the heat exchange coil 34. A flame is generated in the combustion chamber by the burner 27 which mixes and burns fossil fuel with oxygen, either pure oxygen or oxygen contained in the ambient air.

The incoming cold water sprayed by the nozzle 16 is first heated by the direct contact of the droplets from the spray with the flue gases coming up and out of the packing 19. This occurs in the upper portion 17 of the tubular housing 11 above the packing. This is the first step of heating the water and the last step in cooling the flue gases before they are exhausted through the flue 12. The water then percolates through the packing 19 and substantially all streams of water which tend to form are broken down into droplets by the shape of the heat exchange bodies 20 in the packing. These heat exchange bodies also provide an appropriate time of contact between the flue gases and the down coming water to cool down the gases and heat the water. This is the second step of heating the water and the fifth stage of cooling the flue gases.

Water droplets 38 then fall from the packing 19 into the intermediate space 36 where they continue to be heated by direct contact with flue gases coming from the burner flame 28 in the burner chamber 26 through the tube 24. It is in this intermediate space that water is heated by direct contact for the last time. This is the third step of heating the water and the fourth stage of cooling the flue gases.

The preheated water is accumulated in the intermediate reservoir 23. The water is now heated by the hot flue gases of the combustion chamber 26 in contact with the bottom plate 37 of the intermediate

reservoir 23 and the hollow circumferential tube 24. Again, the flue gases from the burner are cooled down and their energy heats the water. This represents the fourth step of heating the water through the column and the third step in cooling the flue gases from the burner.

The preheated water in the intermediate reservoir 23 passes through the water outlet 39 and is pumped by the pump 41 to the cooling water inlet 33, the cooling chamber 29 and the coil 34 to capture maximum heat from the flame and the flue gases in the combustion chamber 26. The hot flue gases are cooled down by indirect contact with the cooling water of the cooling chamber 29 and heat exchange coil 34. This represents the fifth and sixth steps of heating the water and the first and second steps of cooling the burner flame and flue gases. The hot water then passes through the final hot water outlet 35 and is transferred by pressure of a pump 41 to a suitable device or distribution system, as will be described later with respect to Figure 3.

The flue gases from the burner are mechanically forced toward the top of the column, where they are exhausted through the flue 12 after being cooled to a minimum temperature thereby achieving a maximum efficiency for the water heater. The hottest flue gases are produced at the bottom of the unit in the combustion chamber 26. The median temperature flue gases are the flue gases which enter the direct contact section above the intermediate reservoir 23. These flue gases are directed toward the exhaust flue 12 through the packing 19. This counter-current gas and water flow provides maximum efficiency.

Referring now to Figure 2, there is shown a modified version of the direct-indirect contact water heater wherein two water circuits are provided. The

preheated water of intermediate reservoir 23′ is pumped to a heat exchanger 60 and returned to the nozzle 16 to be sprayed at the top of the unit on the packing 19′. This closed loop circuit in the direct contact section forms the first water circuit. The second water circuit is composed by the incoming cold water from public utility which passes in the heat exchanger 60 and is preheated by the direct contact closed loop water from the intermediate reservoir 23′. The outlet of the heat exchanger is connected by a pipe 61 to the inlet 33′ to feed the incoming water through the cooling chamber 29′ and the heat exchange coil 34′. This provides hot water for domestic use. As shown in both Figures 1 and 2, a control panel 45 and 45′ controls the operation of the burner and the detailed construction thereof will not be described, as it is obvious to a person skilled in the art. However, in the embodiment of Figures 1 and 2, it is important to control the flame temperature of the burner to ensure proper and continued operation.

Figure 3 illustrates the direct-indirect contact water heater 10 of the present invention in an institutional application, i.e., hospital, school, etc. The water in the spray nozzle feed pipe 15 is introduced in the heater 10 via the spray nozzle 16. The hot water tank 56 is fed with hot water by the pump 41 connected to the intermediate reservoir 23, the cooling chamber 29 and the heat exchange coil 34 of the water heater. The hot water from the reservoir 56 is utilized to feed various apparatus in the institutional application and also feeds the heat exchanger 54 to heat hot water for a domestic water tank 57. Accordingly, the water heater of the present invention is utilized at its maximum efficiency in a circuit where the heated water from

the water heater 10 can be utilized to feed various devices, as herein indicated, and some of which is recirculated back into the water heater to be heated to a higher temperature. The flue gases exiting the water heater have been cooled down to a temperature about 50°F with the water in the reservoir having been heated to about 140°F.

It is within the ambit of the present invention to cover any obvious modifications of the preferred embodiments described herein, provided such modifications fall within the scope of the appended claims.

CLAIM,

1. A direct-indirect contact water heater comprising two inner sections, one said section being a direct heat contact section and the other an indirect heat contact section, said water heater having an elongated vertical tubular housing, a water spray nozzle in an upper end of said housing for spraying water downwardly on a packing of heat exchange bodies held in a region of said direct heat contact section of said housing by support means, an exhaust gas flue communicating with said upper end, an intermediate space defined in said housing below said packing, an intermediate reservoir in a lower portion of said intermediate space, a burner chamber below said intermediate reservoir, a burner connected to said burner chamber for generating a flame in said burner chamber to form a heat source, passage means interconnecting said burner chamber to said intermediate space to permit hot gas from said burner chamber to rise through said intermediate space and said packing, said water sprayed on said packing from said nozzle being firstly heated by hot gases from said burner heat source rising from said packing and then being further heated by said heat exchange bodies where water propagates and falls in droplets by gravity from a lower surface of said packing and further heated by contact with said rising heat below said packing, said water droplets being accumulated in an intermediate reservoir to constitute preheated water where it is further heated by indirect contact by heat in said burner housing therebelow, a pump circuit is connected to said intermediate reservoir and to a cooling chamber about said burner chamber to pump said preheated water from said intermediate reservoir therethrough for still further heating and then through a

heat exchange coil mounted in said burner chamber where said heated water from said cooling chamber is furthermore heated by said flame and transferred for further use by said pump circuit.

2. A water heater as claimed in claim 1, wherein a lower section of indirect heat exchange is defined between said intermediate space and the bottom of the said housing, said indirect heat exchange lower section being comprised by said intermediate reservoir, said cooling chamber, and said heat exchange coil to produce a water at higher temperature.

3. A water heater as claimed in claim 1, wherein said intermediate reservoir is defined by the inner wall of said housing and a metal sheet bottom wall, said passage means being a circumferential tube extending through said reservoir and terminating above a top water level thereof, said tube having an open top end covered by a deflector shield.

4. A water heater as claimed in claim 1, wherein said direct heat contact section is principally comprised by said packing of heat exchange bodies.

5. A water heater as claimed in claim 1, wherein a cooling hollow circumferential chamber having a circulating cooling liquid therein is provided about said combustion chamber and extending thereabove a predetermined distance to protect said combustion housing from excessive heat generated by said flame, said cooling liquid being said heated water in said

intermediate reservoir, said pump circuit being connected to said cooling hollow circumferential chamber.

6. A water heater as claimed in claim 5, wherein said cooling hollow circumferential chamber is defined by a space between a double floor of said housing and a tubular casing disposed inside of said tubular housing and spaced from a lower side wall section of said housing, said burner chamber being defined by the inner space of said casing and terminating at a bottom wall of said intermediate reservoir, a circumferential closed top end between said tubular casing and tubular housing, a cooling water inlet connected to said chamber for feeding cooling water thereto and circulating same in said chamber and in a heat exchange coil disposed below said intermediate reservoir.

7. A water heater as claimed in claim 6, wherein said bottom wall of said intermediate reservoir is formed by a heat resistant metal sheet supported on support members.

8. A water heater as claimed in claim 2, wherein said tubular housing is a cylindrical housing of circular cross-section, said exhaust gas flue being disposed above a central longitudinal axis of said housing at a top end thereof, said water spray nozzle being disposed below said exhaust gas flue end aligned on said central longitudinal axis to distribute a water spray substantially evenly over said packing.

9. A water heater as claimed in claim 4, wherein said heat exchange bodies of said packing are hollow shaped metallic bodies.

10. A water heater as claimed in claim 3, wherein said intermediate reservoir constitutes an indirect contact heat exchanger.

11. A method of heating water in a direct contact water heater column comprising the steps of:

i) providing a packing of heat exchange bodies across an inner space of said column in a top portion thereof;

ii) spraying water substantially uniformly over said packing so that said water percolates in droplets down said inner space of said column to an intermediate reservoir;

iii) generating heat in said column from a heat source in a heating chamber at a bottom of said column whereby said heat will rise therealong and exit at a top end of said column, said heat being displaced in counter-current to said percolating water droplets and heating said heat exchange bodies of said packing; and

iv) pumping preheated water from said intermediate reservoir to a cooling chamber about said heating chamber to cool said bottom of said column about said heating chamber and absorb heat and through a heat exchange coil inside said heating chamber to provide a domestic hot water supply.

12. A method as claimed in claim 11, wherein said step (iii) comprises feeding hot gas from said heat source wherein said hot gas is in indirect contact with water circulating in a space between said bottom of said column and intermediate

reservoir, and communicating heat from said heat source in said heating chamber above said intermediate reservoir to said direct contact section where said heat will propagate through said packing.

13. A method as claimed in claim 11 wherein there is further provided the steps of:

(v) pumping said preheated water to a heat exchanger to heat a domestic water supply, and

(vi) feeding said water supply from said heat exchanger through a said cooling chamber about said burner housing and through said heat exchange coil inside said heating chamber to provide said domestic hot water supply.

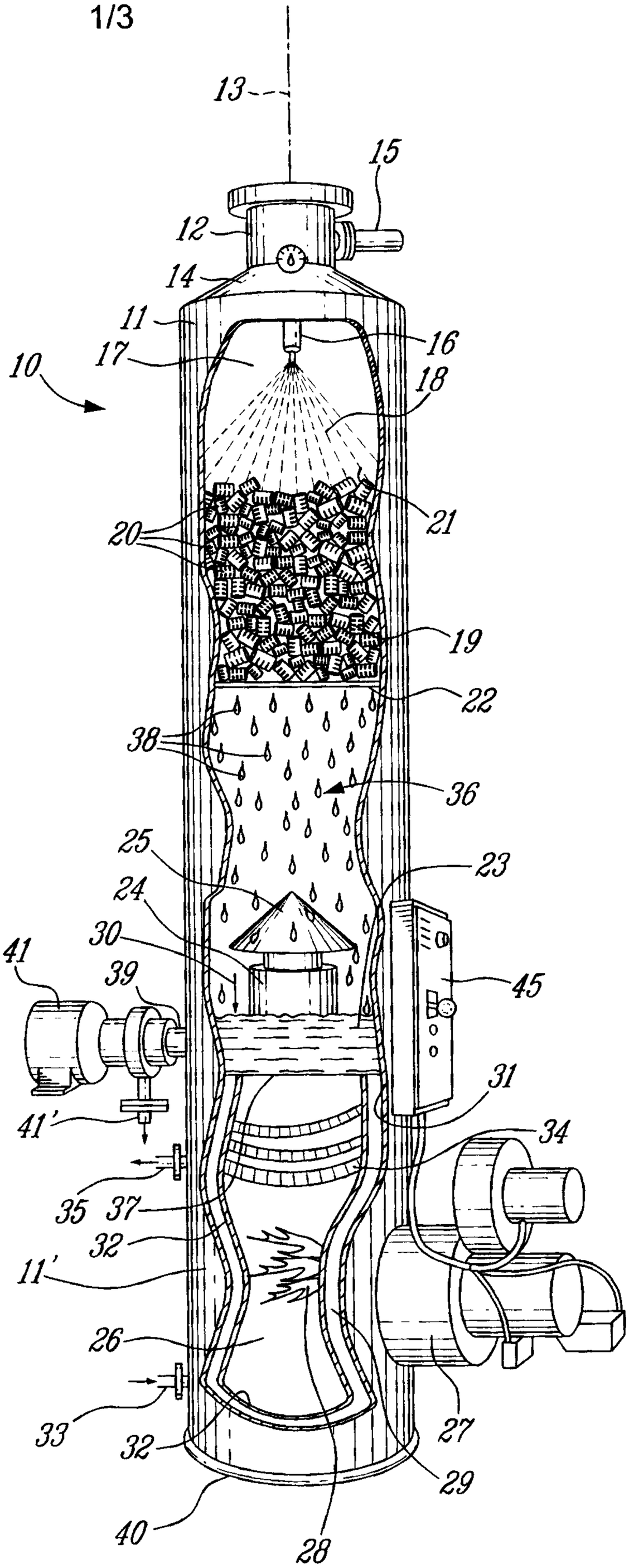

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FIG_1

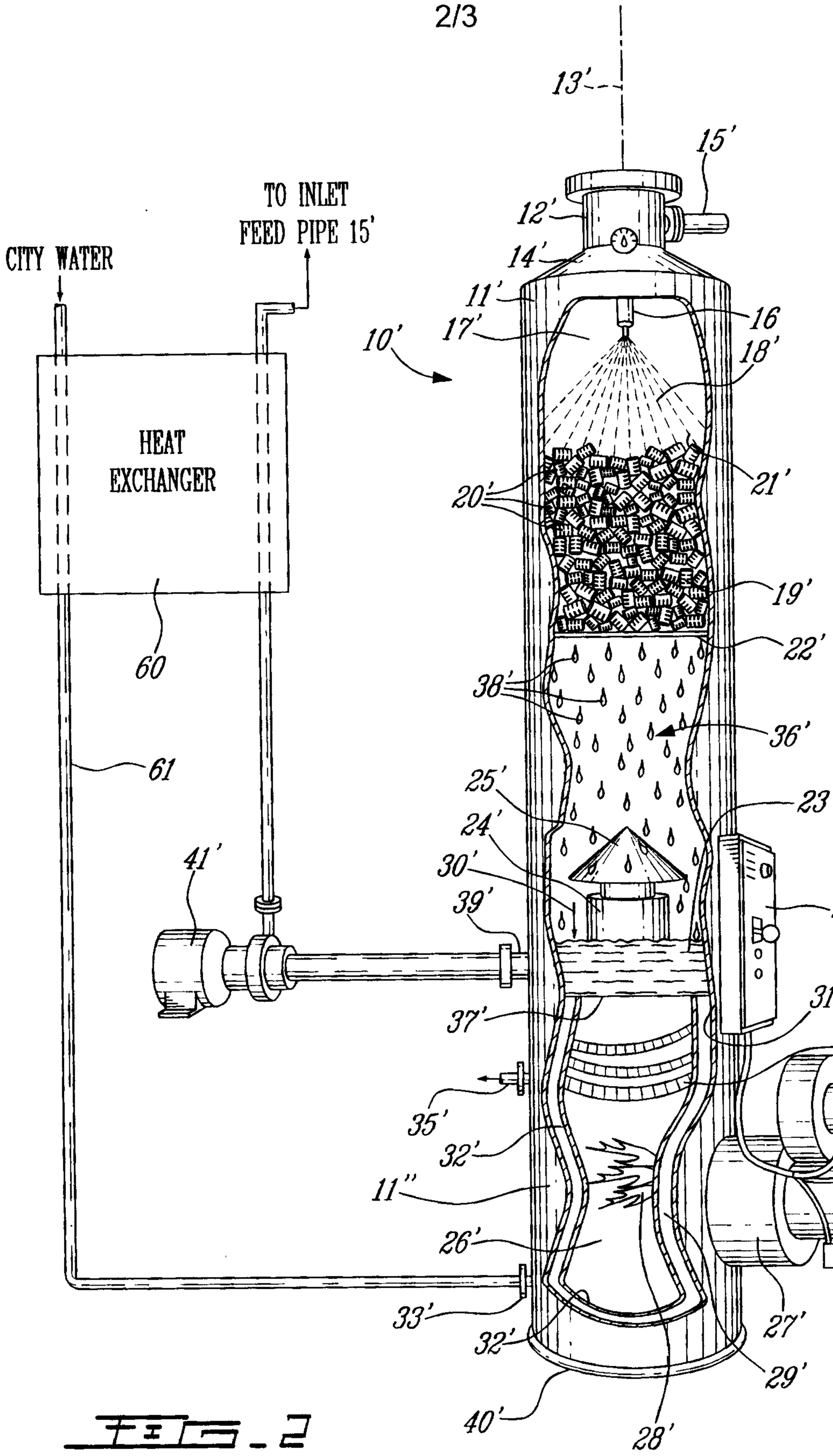
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FIG - 2

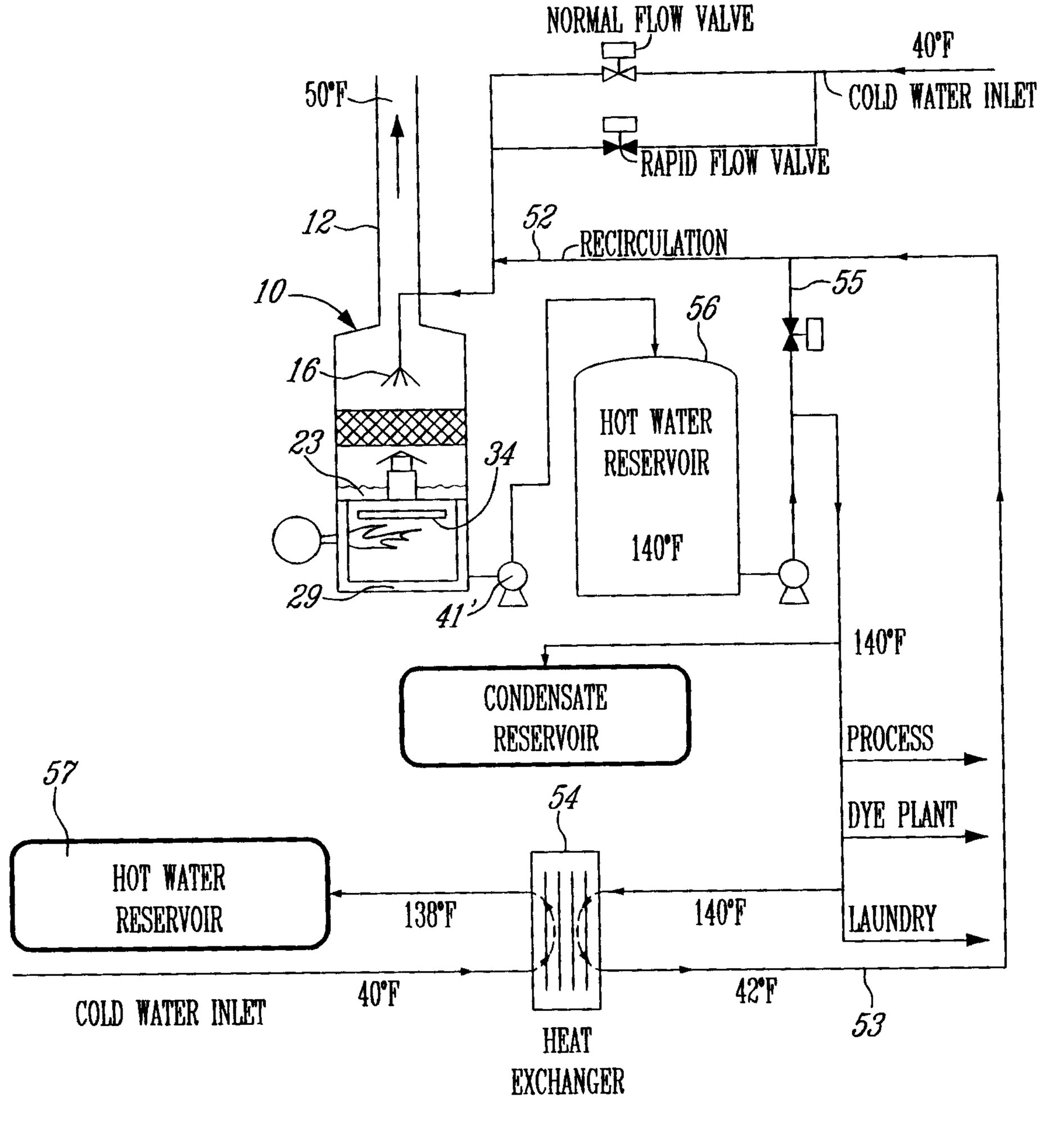
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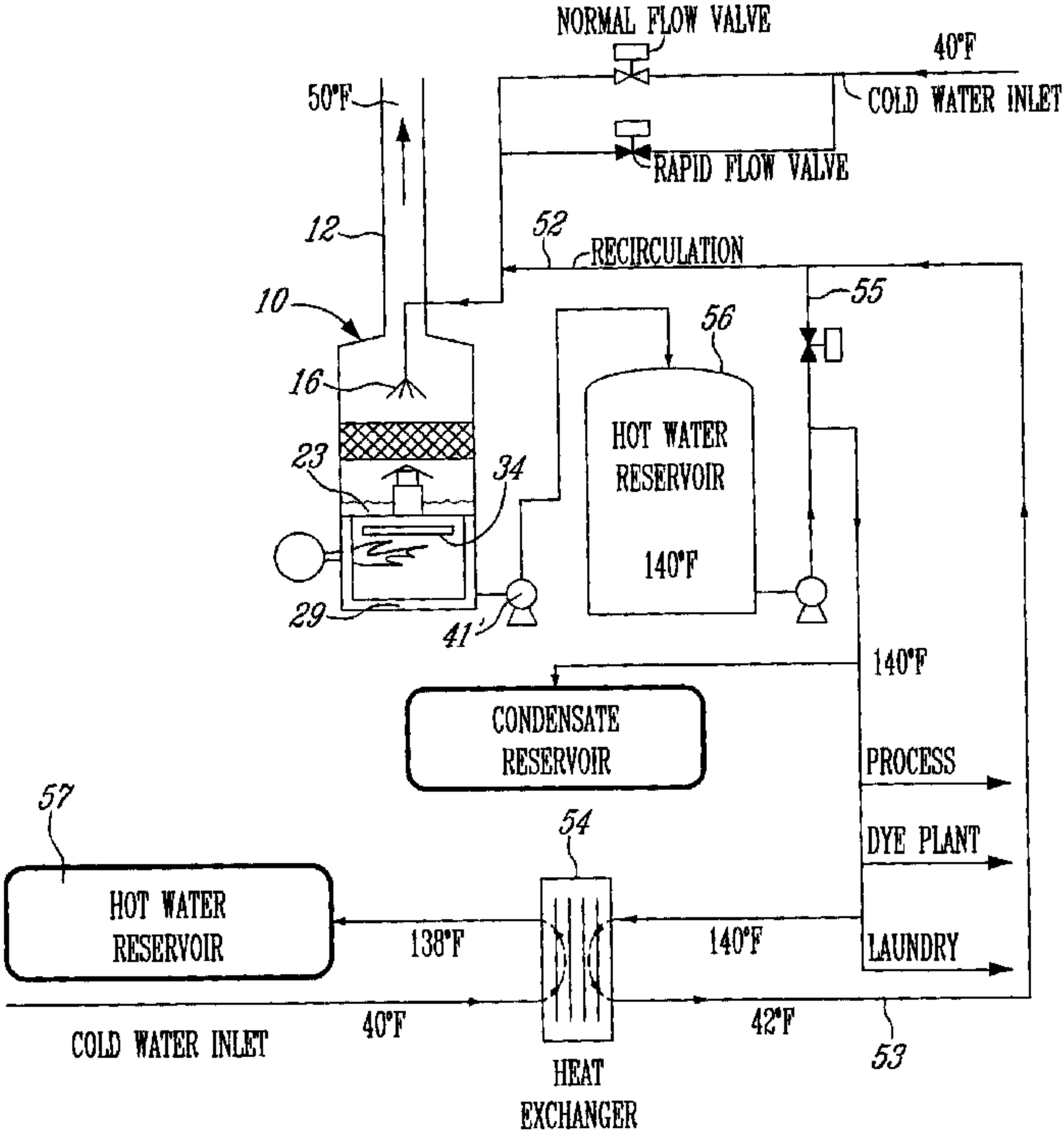
FIG. 3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