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CONTINUOUS FLOW WATER HEATER

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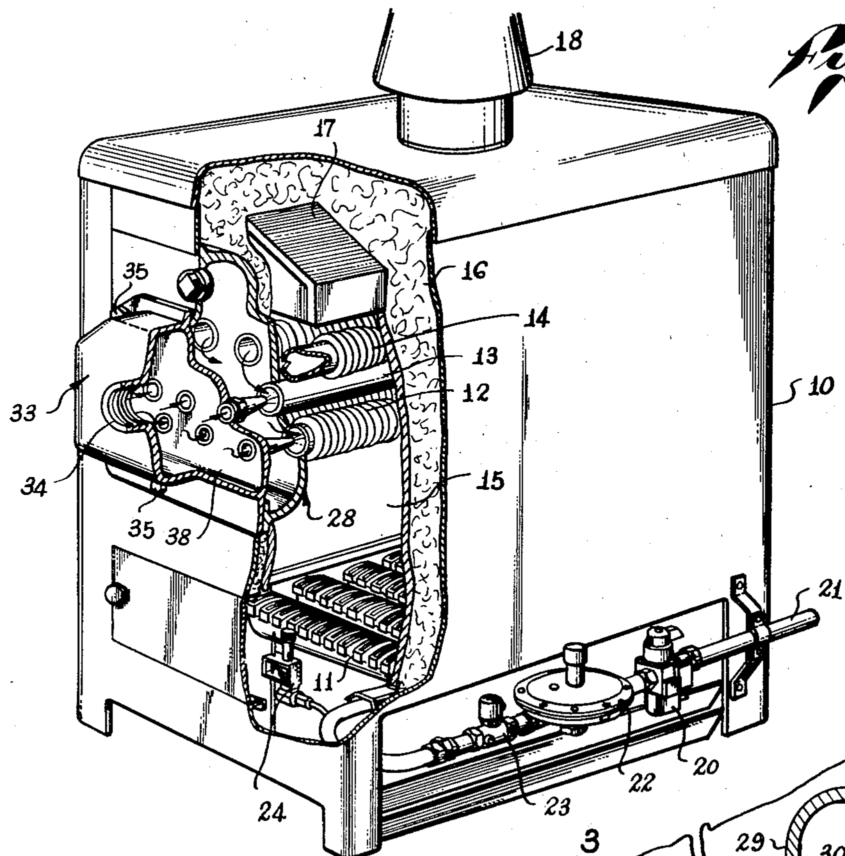

Fig. 1

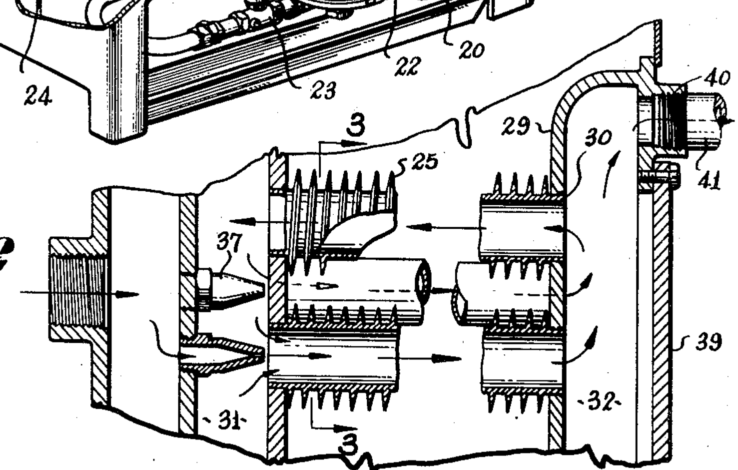

Fig. 2

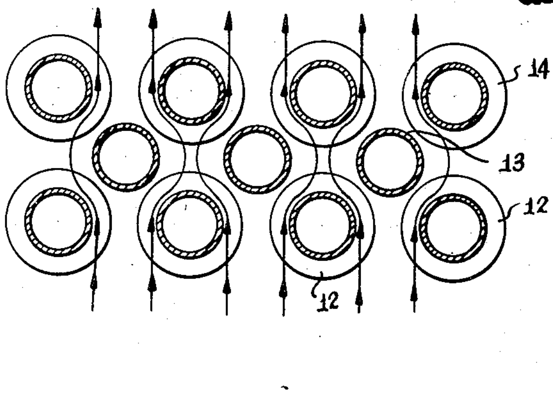

Fig. 3

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CONTINUOUS FLOW WATER HEATER

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The present invention relates generally to water heaters, and more particularly to such devices of the continuous flow type.

Continuous flow water heaters are those in which water is heated only during the supply thereof as opposed to storage type heaters in which the water contained in the storage tank is maintained at the desired supply temperature, and the water is recirculated to bring the temperature up to the desired hot water temperature whenever a portion of the contents of the storage tank is withdrawn.

One of the principal disadvantages encountered in the use of continuous flow heaters, particularly those which are gas fueled, is the fact that one end of the water tube is, due to the incoming cold water, constantly at a temperature considerably below the dew point of the combustion products surrounding the outside of the tube, while the other end of the tube is usually somewhat above the temperature of the desired hot water output due to the fact that the flow rate is fairly slow and of laminar rather than turbulent flow, thus reducing the efficiency of heat transfer between the tube and the water inside the same. Thus, in short, one end of the water tube is too cold and the other end too hot.

Both the low temperature at the incoming end of the boiler tube and the high temperature at the opposite end cause operational difficulties in addition to a loss of heating efficiency. At the cold end of the tube, condensate is formed on the outer surface along a substantial length of the tube due to the fact that the products of combustion are heavily saturated with water vapor, and upon being cooled to the temperature of the inflowing water, condense out most of their moisture. This moisture drips down on the burners into the lining of the fire box, and in general creates serious corrosion problems.

In order to reduce as much as possible the effects of exterior condensation as above described, it has been the practice in some conventional continuous flow heaters, to bypass a major portion of the total flow of water through the heater and heat only a relatively small amount of such total flow to a high enough temperature so that the heated water, when mixed with the bypassed water produces the desired output temperature. Heating the water to such relatively high temperatures reduces the length of the cold portion of the heater tubes which are below the dew point temperature of the flue gases, and thus somewhat reduces the effects of condensation. Such expedient only substitutes another difficulty, however, that of the deposit of minerals on the interior of the heater tubes. As is well known, the deposit of minerals in so-called "hard" waters, increases as the temperature of the water increases. Thus, the above-described expedient of heating a small portion of the total supply to a relatively high temperature may initially be fairly effective insofar as condensation is concerned, but in a relatively short time the interior of the tubes, due to the very high temperatures of the water

therein, become clogged with mineral deposits and the entire system breaks down. Furthermore, even a very slight deposit of minerals acts as an insulator and greatly reduces the heat transfer efficiency.

Another practical disadvantage of continuous flow water heaters of the type heretofore available, has been the low efficiency of heat transfer between the hot products of combustion and the water tubes. In an effort to increase this efficiency, water tubes have been provided, carrying an external helical fin, thus to increase the heat transfer surface on the exterior of the tube. Because it is impractical to concentrate the externally applied heat on a single flow tube, it has been the usual practice to provide a number of parallel water tubes, finned as above described, through all of which the water flows in parallel paths, the tubes being arranged side-by-side in the fire box above the burners.

While the provision of external fins in the manner above described greatly increases the external area of the water tube, and thus improves the efficiency insofar as any particular tube is concerned, these fins interfere with the close spacing of the tubes and thus permit a considerable amount of hot gas to pass between the tubes without coming in intimate contact with either the tubes themselves or the fins thereon. While it would be theoretically possible to arrange the finned tubes in side-by-side relationship with the fins on one interlaced between the fins on the adjacent tube, such mounting presents many practical difficulties, and in any event creates too great a restriction to the hot gases at the point where tube fins are interlaced or meshed with the fins of an adjacent tube.

Bearing in mind the above-mentioned difficulties encountered in continuous flow water heaters of the class described, it is a major object of the present invention to materially increase the efficiency of a continuous flow water heater.

It is another object of the invention to provide an arrangement in a continuous flow water heater for preventing wide temperature differentials in the heating tubes, thus to eliminate condensation of moisture on the exterior thereof and deposit of minerals on the interior thereof.

It is still another object of the invention to provide a continous flow water heater in which the rate of flow through the heater tubes is several times greater than that dictated by the rate of hot water delivered whereby to decrease mineral deposits and increase the thermal efficiency at the heat exchange surfaces of the heater tubes.

A still further object of the invention is to provide for turbulent flow through the heater tubes of a continuous flow water heater whereby to increase the thermal efficiency.

Yet a further object of the invention is to provide a water tube mounting-fire box assembly wherein optimum contact with the hot gases is achieved while presenting a minimum constriction to the flow of gases around the tubes.

A still further object of the invention is to provide a water tube mounting assembly in a continuous flow heater wherein it is possible with a minimum of disassembly to clean the interior of the tubes.

The foregoing and additional objects and advantages of the invention will be apparent from the following detailed description of a presently preferred embodiment thereof, consideration being given likewise to the accompanying drawings in which:

Figure 1 is a partially cut away perspective view of a continuous flow water heater embodying the present invention;

Figure 2 is an enlarged fragmentary elevational section taken on a longitudinal plane through the water tube assembly and illustrating the flow path thereto; and

Figure 3 is an elevational transverse section taken on the line 3—3 in Figure 2.

Referring to Figure 1 in the drawings, it will be seen that the heater embodying the present invention is enclosed in an outer, generally rectangular sheet metal housing **10**, having gas fired burners **11** near the bottom of an internal fire box **15**, and horizontal water tubes **12**, **13**, and **14**, extending longitudinally across the fire box **15** near the top. The burners **11** and the water tubes **12**, **13**, and **14**, are completely enclosed by the fire box **15** which is lined with refractory tile and insulated from the outer housing **10** by a layer of rock wool **16** or the like. An interior hood **17** of sheet metal serves to collect the flue gases after they have passed in contact with the water tubes **12**, **13**, and **14**, and direct such gases to the flue **18** at the top of the housing **10**. Fuel gas is supplied by a fuel line **21** and conventional gas control elements are provided in the form of a manual and automatic pilot control valve **20** connected to the gas supply **21**, a pressure regulator **22**, a solenoid control **23** for the main burner, and a conventional safety pilot **24**. Since the just-destcribed elemtns do not form an important part of the present invention, no further detailed description thereof is deemed necessary herein.

The water tubes **12**, **13**, and **14**, are arranged in three transverse banks, one above the other, as can be seen in Figure 3, the lowermost bank being designated by the reference character **12**, the intermediate bank being designated at **13**, and the top bank being designated at **14**. It will be noted that bottom bank of tubes **12**, and the top bank **14** are provided with heat transfer fins **25** which are coined from the parent metal of the tube by a rolling operation, while the intermediate tubes **13** have no external fins. The relative arrangement of the lower bank of tubes **12**, the intermediate bank **13**, and the top bank **14** is such that the peripheries of the fins on the upper and lower banks **12** and **14** are close to, but not quite in tangential contact with the intermediate tubes **13**.

I have found that, contrary to what might be expected, a much greater heating efficiency for a given rate of gas consumption can be achieved by the use of an intermediate bank of unfinned tubes staggered with respect to the tubes in the other banks as shown in Figure 3 than can be achieved with an equivalent total number of tubes, all of which have fins. This appears to be due to the fact that the intermediate unfinned tubes **13** act as baffles, diverting and causing the hot flue gases to flow in curvilinear paths as shown by the arrows in Figure 3 whereby to pass the gases in considerably more intimate contact with the total surface of the fins on the finned tubes than would be the case if no intermediate tubes **13** were present. Separate baffles, not containing water to be heated could be employed, but the heat consumed in heating the baffles would be of course be wasted.

If it is attempted to arrange eleven finned tubes in the general pattern indicated in Figure 3 whereby an intermediate bank of finned tubes would serve to a certain extent as baffles, it is found that the increase in efficiency is not achieved due to the geometry of the finned tubes and the necessary increase in spacing therebetween. On the other hand, if it is attempted to use all finned tubes, and to intermesh the fins on the intermediate banks with those of the banks above and below, the constriction to the flow of flue gases which is produced by the intermeshing of the fins, is such as to greatly reduce the efficiency.

The tubes **12**, **13**, and **14**, are mounted between headers **28** and **29** as by brazing indicated at **30**, which headers form ends for the fire box **15** and are hollow to provide water manifold chambers **31** and **32** which respectively divide the flow and recombine it as water passes through the heater.

The cold water input to the heater is at the left end of the device through an external input manifold **33**, having an internally threaded pipe connection **34** to receive the input pipe (not shown). The input manifold **33** forms a separate chamber from the manifold chamber **31** in the header **28**.

The input manifold **33** is bolted to the lefthand header **28** as by bolts **35**, thus forming a closure for the upstream manifold chamber **31**. A similar closure is provided for the chamber **32** in the form of a plate **39** bolted to the header **29**. With both the input manifold **33** and the plate **39** removed, free access is given for cleaning the tubes **12**, **13**, and **14**, as by reaming, or otherwise.

Communication from the interior of the input manifold **33** to the manifold chamber **31** in the header is provided through a plurality of jet nozzles **37** which are secured in threaded openings in the inner wall **38** of the input manifold. The arrangement of the jet nozzles **37** in the wall **38** is such that each one of them aligns axially with one of the tubes **12** and **13** in the bottom and intermediate banks of tubes. No nozzles are provided in alignment with the upper bank of tubes **14**. The internal bore of each nozzle **37** is relatively small whereby to produce a relatively high velocity jet of cold water introduced into each of the tubes **12** and **13**. The kinetic energy in such water jet acts in the manner of an injector pump to draw water from the manifold chamber **31** into the respective tubes **12** and **13** whereby the water flowing from left to right through the tubes **12** and **13** constitutes a mixture of incoming cold water from the jet nozzles **37** and the contents of the manifolding chamber **31**. Such mixture is, due to the action of the jet nozzles **37**, highly turbulent thus promoting a much greater efficiency of heat transfer between the water and the interior walls of the tubes **12** and **13** than would be the case with smooth or laminar flow.

The water issuing from the tubes **13** and **14** into the "downstream" manifold chamber **32** passes upwardly where the flow divides, a portion of the heated water passing out through the output connection **40** and conduit **41**, and the other portion of the flow passing back to the "upstream" manifold chamber **31** through the top bank of tubes **14**.

The back pressure in the hot water supply line (output) **41** is such as to cause a substantial portion of the flow to recirculate from right to left through the top bank of the tubes **14**. To correctly proportion the flow division just described, a restricting orifice member may be inserted in the output connection **40** if needed. The portion of the flow passing from right to left through the top bank of tubes **14** is further heated by the flue gases, and thus the temperature of the water in the upstream manifold chamber **31** at the left header **28** is the highest in the entire system. Such high temperature water mixed with the cold input water issuing from the jets **37** so raises the temperature of the water within the tubes **12** and **13**, that the portion thereof which is below the dew point temperature of the flue gases is substantially eliminated. Thus, the condensation of moisture on the exterior of the tubes **12** and **13** is virtually nil. Since the temperature of the water passing through the upper tubes **14** is even greater than that at the lefthand end of the tubes **12** and **13**, there is no condensation on the top bank of tubes **14**.

By an appropriate adjustment of the back pressure in the hot water supply conduit **41**, the proportion of the flow which passes in a counter direction through the upper tubes **14** can be adjusted. It has been found that with the arrangement of 11 tubes illustrated in Figure 3, an optimum overall efficiency is achieved when the flow rate is such as to cause approximately 25% of the total heat transfer to occur in the top bank of tubes **14**. This percentage can be determined by measurement of flue gas temperatures at various points in the tube banks.

By way of example, but not by way of limitation, an adjustment as just described when used in connection with a heater such as shown in Figure 1 adapted to heat 4.8 gallons of water per minute at a temperature rise of 50°

F. was found to have a water temperature rise as between the right and left ends respectively of the top bank of tubes **14** of only 2°. This relatively small temperature rise in the counter flow tubes **14** indicates the high flow rate through the individual tubes as compared to the overall effective flow rate through the entire system. Putting it another way, the sum in the flow rates of the individual tubes is much greater than the flow rate at which heated water is delivered at the output **41**. If the water flowed from left to right in all tubes as in most conventional heaters, the sum of the flow rates would merely equal the delivery rate and the flow rate through any tube would be very much smaller than in the present case, and the efficiency correspondingly reduced. The above-mentioned high rate of flow in the heater described herein has the advantages already mentioned of greatly reducing the deposition of minerals on the interior walls of the tubes, and also producing and augmenting the turbulence within the tubes thus to increase the heat transfer efficiency.

While the heater construction shown and described herein is fully capable of achieving the objects and providing the advantages hereinbefore stated, it is capable of some modification without departure from the spirit of the invention. For this reason I do not mean to be limited to the forms shown and described, but rather to the scope of the appended claims.

I claim:

1. In a continuous flow water heater: an input chamber having means to receive water to be heated; an output chamber having means to deliver heated water from the heater; a plurality of substantially parallel water tubes substantially horizontally disposed and arranged in successively vertically displaced banks; each of said tubes having open ends communicating directly respectively with said input chamber and said output chamber; said means to receive water to be heated comprising a plurality of jet nozzles, each positioned opposite and directed respectively toward a corresponding one of the plurality of tubes in at least the lowermost of said banks; at least the uppermost of said banks of tubes having no obstruction in said input chamber opposite the open ends of said tubes; the open ends of the tubes in said output chamber being unobstructed; said jet nozzles being arranged to effect high velocity circulation of water through at least said plurality of tubes in said lowermost bank to said output chamber; means to pass a hot fluid upwardly around said banks of tubes to heat the same; whereby the apparatus is adapted to induct heated water into tubes in at least the lowermost bank wherein the same is mixed with injected unheated water and the mixture is passed at a high velocity to the outlet chamber, a part of the water is recirculated through tubes in the uppermost bank to the input chamber, and at least a portion of the highly heated water entering the input chamber from the upper bank of tubes is drawn downwardly and said induction takes place.

2. The apparatus of claim 1 in which said plurality of substantially parallel and horizontal water tubes are of equal diameter; the tubes in alternate banks having external circumferential heat transfer fins thereon and the tubes in any intermediate bank being unfinned; the tubes being spaced apart, in a horizontal direction, a distance substantially equal to the diameter of said tubes; the finned tubes being in vertical alignment with one another and spaced apart in the vertical direction a distance substantially equal to the diameter of said tubes; said unfinned tubes being in vertical alignment with the spaces between said finned tubes; whereby the tubes in one bank act as baffles for said hot fluid passing transversely of said tubes to divert the said hot fluid into intimate heat transfer contact with the tubes in the next succeeding bank.

3. The apparatus of claim 1 in which said jet nozzles are mounted in a removable plate defining at least a portion of one wall of said input chamber.

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