

Nov. 3, 1942.

J. C. MORRELL ET AL

2,300,430

METHOD OF AND APPARATUS FOR HEATING WATER

Filed March 25, 1938

2 Sheets-Sheet 1

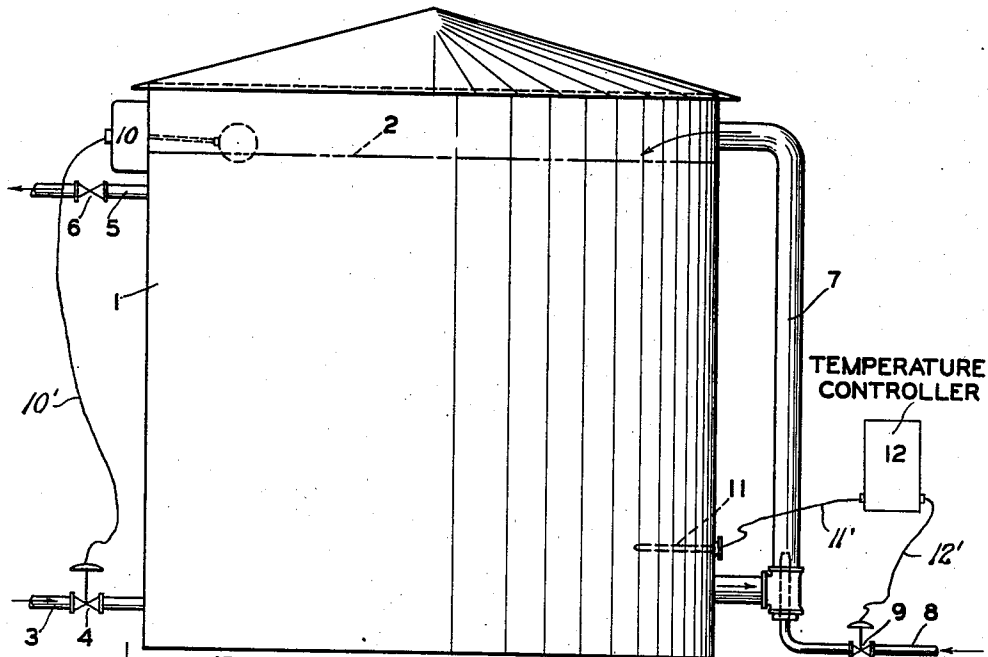


FIG. 1

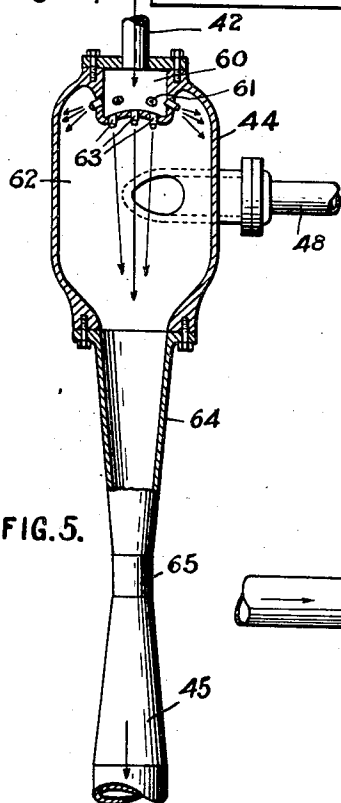


FIG. 5.

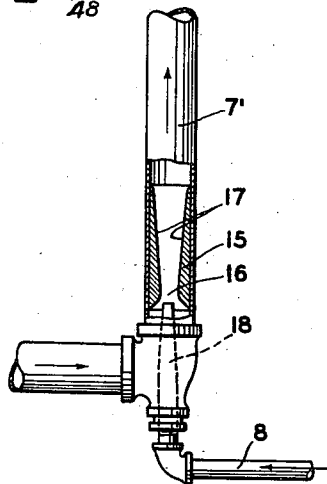


FIG. 2

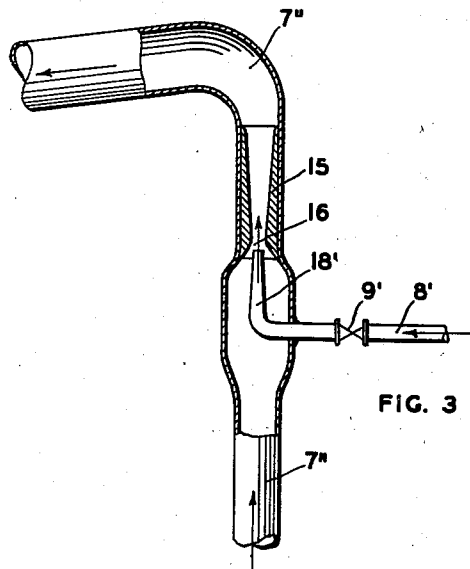


FIG. 3

INVENTORS

Jacques C. Morrell
Charles H. Angell

Nov. 3, 1942.

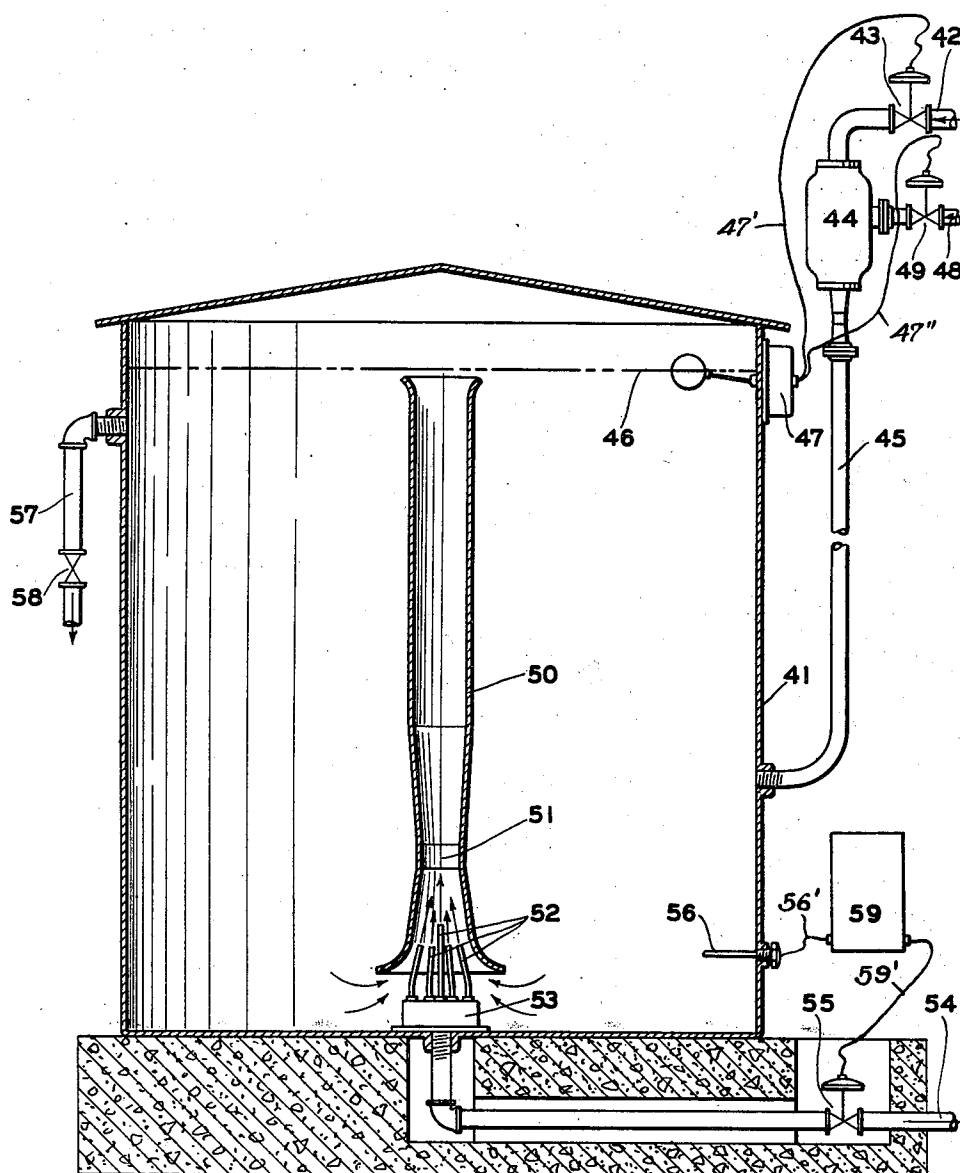
J. C. MORRELL ET AL

2,300,430

METHOD OF AND APPARATUS FOR HEATING WATER

Filed March 25, 1938

2 Sheets-Sheet 2



INVENTORS

FIG. 4

Jacques C. Morrell
Charles T. Angell

UNITED STATES PATENT OFFICE

2,300,430

METHOD OF AND APPARATUS FOR HEATING WATER

Jacque C. Morrell, Oak Park, and Charles H. Angell, Mount Prospect, Ill.

Application March 25, 1938, Serial No. 198,046

7 Claims. (Cl. 261—76)

This invention particularly refers to an improved method and means of obtaining heated water by circulating one or more confined streams of water from one portion to another (preferably remote) portion of a main body thereof and heating said stream or streams during said circulation. The improvement resides in the method and means provided for both circulating and heating said stream or streams. This is accomplished by directly commingling steam with the confined stream or streams of water whereby the steam is substantially condensed, the resulting condensate commingled with the colder water of said stream to heat the same and circulation of said stream effected by the action of the steam without the use of a water circulating pump or the like.

The broad concept of the invention above outlined is a novel and advantageous departure from conventional practice and may be utilized either alone or in conjunction with other advantageous features herein provided.

Since the invention may employ exhaust or low pressure steam for heating and circulation of the water, it is particularly advantageous and well adapted to use in laundries, dairies and similar industrial establishments where a large and continuous supply of hot water is needed and where there is an adequate supply of exhaust or low pressure steam which would otherwise be wasted.

In the preferred embodiment of the invention, a relatively large body of water undergoing heating is maintained in a storage tank or reservoir and by the circulation of one or more confined streams of water in the manner above outlined, from the lower to the upper portion of said body, without excessive turbulence in the latter, the hottest water tends to stratify in the upper portion of said body, hot water being withdrawn for use preferably from the relatively hot upper stratum and cold or preheated make-up water being introduced into a cooler lower stratum so that only substantially the coldest water in the storage reservoir comes in contact with the steam and, upon being heated by the steam, is introduced into a relatively hot upper stratum. This avoids the necessity of heating substantially the entire large body of water to a high temperature before water can be withdrawn therefrom for use at the desired temperature and also insures efficient use of the steam. By this method of operation hot water is available from the upper portion of the storage reservoir almost immediately after steam is introduced into the

system and circulation started. Also, a high degree of heating efficiency may be maintained from the moment steam is supplied to the system and the heating operation started until substantially the entire body of water in the storage reservoir has reached the desired temperature. As heating and circulation progresses substantially the coldest water in the storage reservoir passes into contact with the steam and the greatest possible heating efficiency is thereby maintained. Furthermore, by introducing the steam into direct and intimate contact with a relatively high column of circulating water, substantially complete condensation of the steam is insured until practically the entire body of water in the storage reservoir, and particularly the upper portion of said body from which hot water is withdrawn for use, closely approaches its vaporization point.

The invention also provides, in its preferred embodiment, for maintaining a substantially constant liquid level in the storage reservoir. By so doing and by introducing relatively cool make-up water from an external source into the lower portion of the body of water as heated water is withdrawn from the upper portion thereof, good heating efficiency is maintained even after the water in the relatively hot upper stratum of said body closely approaches its vaporization point, so long as heated water is being withdrawn therefrom for use.

The invention provides several specific alternative methods and means of introducing steam into the system and effecting heating and circulation of the water in the storage reservoir. These alternative methods are not fully equivalent, but in each case the steam employed for effecting circulation is directly and intimately contacted with a confined stream of water which circulates from one portion to another portion of the storage reservoir.

The invention makes use of several well known phenomena in order to accomplish heating and circulation of the confined stream of water without the use of a water circulating pump or the like. These phenomena include the well known gas-lift principle and, in some cases, the principle of the jet ejector. The principle of thermally induced or thermo-siphon circulation is also involved. Although steam is not a fixed gas, when it is introduced into the confined column of water in the form of a submerged jet, as provided in one concept of the invention, it functions as a gas until it is substantially condensed, thereby reducing the weight of the confined col-

umn of water and inducing its flow upwardly through the column. The jet action of the steam also assists circulation of the water and its circulation is further assisted by the heating effect of the steam and water condensed therefrom, the heating serving to expand the water in the column and reduce its weight per unit height, thereby inducing thermal circulation.

Some of the many possible specific forms of apparatus, capable of accomplishing the desired results in accordance with the provisions of the invention, are illustrated in the accompanying diagrammatic drawing and several of the various specific modes of operation contemplated by the invention are more fully described in conjunction with the following description of the drawings.

Figure 1 of the drawings in an elevational view of a hot water storage tank or reservoir equipped with a side-arm type of circulating and heating column, wherein steam is utilized to effect said circulation and heating, and equipped with automatic control means.

Figure 2 illustrates one of the many possible modifications of the side-arm type of circulating and heating column shown in Figure 1.

Figure 3 illustrates another modification of the side-arm type of circulating and heating column shown in Figure 1.

Figure 4 is an elevational view, partly in cross-section, of a hot water storage reservoir equipped with an internal type of heating and circulating column, to which steam is supplied for circulating and heating the water, and also equipped with means for preheating the water supplied to the storage reservoir and automatic control equipment.

Figure 5 is an enlarged detail, partly in section, of one specific form of preheating equipment, such as shown in Figure 4.

Referring now to Figure 1, a hot water storage tank or reservoir is indicated at 1 and contains a substantial body of water, the upper level of which is indicated at 2. Line 3 and valve 4 are provided for introducing water from any desired external source into the lower portion of tank 1, while line 5 and valve 6 permit the removal of heated water from its upper stratum in the tank to be used in any desired manner. The water supplied to the storage tank through line 3 and valve 4 may be from the city main or from any conventional water supply equipment and preferably the storage reservoir is so situated that the heated water may flow through line 5 and valve 6 by gravity to the equipment in which it is used.

An elongated conduit 7, of small cross-sectional area relative to that of the storage reservoir, is connected as a side-arm to the storage tank in such a manner that it communicates at its lower end with the lower portion of the body of water in the storage tank and, at its upper end, with the upper portion of the space within the storage reservoir either at, above or beneath the liquid level maintained in this zone.

The type of side-arm column illustrated in Figure 1 provides no substantial restriction to the flow of water therethrough and the water entering the lower portion of conduit 7 from the lower portion of the body of water in the storage reservoir comes into direct and intimate contact with steam introduced into this conduit through line 8 and valve 9. The pressure of the steam thus introduced need be only sufficient to overcome the liquid head in column 7 and, when

sufficient steam is not available to overcome the pressure of the entire height of this column, it may be introduced at a suitable intermediate point therein.

The steam introduced into column 7 is substantially entirely condensed by contact with the relatively cold water and the condensing steam and resulting condensate not only serve to heat the stream of water passing through column 7, but also serve to effect its circulation from the lower to the upper portion of the storage tank.

In the device illustrated in Figure 1, circulation through column 7 results, in part, from the gas-lift action of the steam introduced thereto and, in part, from a thermo-siphon induced by the heating action of the steam. It is also assisted by the impelling action or force of the steam which is directed upwardly into the column.

Preferably, the quantity of steam supplied to column 7 is regulated to insure positive and substantially continuous circulation without allowing the escape of any appreciable quantity of uncondensed steam from the upper portion of the column.

Despite the positive and relatively rapid circulation of water through column 7, in the manner above described, the large body of water in the storage reservoir will remain in relatively quiescent state, as compared to the turbulence which would result from the introduction of open steam into the main body of water in the storage reservoir, and the heated water issuing from the upper portion of column 7 thereby tends to stratify in the upper portion of the storage tank. Relatively hot water may thus be withdrawn for use from this relatively hot upper stratum as it accumulates therein without waiting for a large portion of the body of water in the storage reservoir to reach the desired temperature. However, heating and circulation may be continued by the continuous introduction of steam until the temperature of substantially the entire body of water approaches its vaporization point. By continuously or intermittently introducing relatively cold make-up water into the lower portion of the storage tank, as heated water is withdrawn from the upper portion thereof, a stratum of relatively cold water is maintained in the lower portion of the storage tank and only water from this relatively cold lower stratum passes into column 7 to contact the steam. In this manner good heating efficiency is maintained as long as hot water is being withdrawn from the storage reservoir and relatively cool make-up water supplied thereto.

Although the introduction of steam and make-up water into the system may be manually controlled, the ease with which the system may be rendered fully or partially automatic by the application of relatively simple control means is an advantageous feature of the invention and makes such automatic control desirable in most cases.

A liquid level controller 10, of any desired well known form, communicating through line 10' with valve 4 in the inlet water line 3 and actuating the valve, may be utilized for controlling the admission of make-up water into the storage tank in response to variations in the liquid level, so that a substantially constant liquid level is automatically maintained in the storage reservoir.

The admission of steam through line 8 and valve 9 into column 7 is automatically controlled, in the case here illustrated, by an electrical or air-operated controller 12 which communicates

through line 12' with valve 9 to open and close or regulate the opening therethrough in response to impulses transmitted to the controller from a suitable temperature-sensitive device, such as thermostat 11, which may be located at any desired point in the body of water in the storage reservoir and communicating through line 11' with controller 12. In the particular case here illustrated, thermostat 11 is located adjacent the bottom of the storage tank and, through controller 12, functions to close valve 9 in steam line 8 when the water at this point has reached the desired temperature and the storage reservoir is substantially filled with hot water.

Figure 2 illustrates the lower portion of a side-arm type of circulating and heating column similar to that of column 7 in Figure 1, except that the nozzle 18 which, in Figure 2, comprises the discharge end of steam line 8, discharges a submerged jet of steam through restricted throat 16 in the vertical portion of the tubular column 7'. The restricted throat 16 forms a portion of member 15 in tube 7' which is flared upwardly and outwardly at 17 to substantially the walls of tube 7'. The ejector action of the jet discharging through member 15 augments the gas-lift action of the steam and accelerates the flow of the confined stream of water through the circulating device.

The device illustrated in Figure 2 may be connected to the storage reservoir in the same manner as column 7 of Figure 1.

When desired, a steam jet ejector similar to that of Figure 2 may be disposed adjacent the upper end or at an intermediate point in the circulating column either substantially at, beneath or slightly above the liquid level in the storage reservoir. This is exemplified in Figure 3 which illustrates the upper portion of a side-arm type of circulating column 7'' similar to column 7 of Figure 1 but having the ejector elements of Figure 2 disposed adjacent the upper portion of the column with the restricted throat 16 of member 15 either at or slightly above or beneath the level of the body of water maintained in the storage reservoir.

In the device illustrated in Figure 3, steam is supplied thereto through line 8', valve 9' and nozzle 18'. The ejector action of the steam jet induces a decreased pressure in that portion of the circulating column beneath member 15 whereby water is drawn from the lower portion of the storage reservoir through the restricted throat 16 into the steam jet with which it is carried into the upper portion of the storage tank and heated by the steam which it serves to substantially condense.

With the device of Figure 3 the gas-lift action of the steam is less pronounced and the ejector action of the steam jet more pronounced as compared with the device of Figure 2. Also, with the device of Figure 3, the temperature of the circulated water issuing therefrom may be made to more closely approach the temperature of the steam at the expense of a somewhat decreased heating efficiency (i. e., less complete condensation of the steam). The device of Figure 3 may therefore be employed in preference to the submerged steam jet of Figures 1 and 2, or, when desired, in conjunction with the use of a submerged jet, when it is desired to obtain hot water at a temperature close to its vaporization point.

When desired, a jet ejector similar to that of Figure 3 may be disposed in the horizontal upper

section of the circulating column instead of in the vertical section thereof.

Referring now to Figure 4, water from an external source is supplied to storage tank 41 through line 42, valve 43, preheater 44 and line 45 and preferably enters the lower or mid-portion of the storage tank wherein it is allowed to accumulate until the desired liquid level indicated, for example, at 46 is reached.

In this particular case, liquid level controller 47 of any desired form is operatively connected through line 47' to valve 43 in line 42, to regulate the admission of water to the system and maintain the desired liquid level. Controller 47 is also operatively connected by means of line 47'' to valve 49 in line 48 through which steam is admitted to preheater 44, so that when the supply of make-up water to the storage tank is discontinued, the supply of steam to preheater 44 is also discontinued.

Preheater 44 comprises a condenser of any suitable form wherein steam is contacted with the make-up water supplied to the system, the steam being condensed and serving to preheat the make-up water prior to its introduction into the storage tank. One specific form of such preheating condenser is illustrated in greater detail in Figure 5 and will be later described.

In the particular case illustrated in Figure 4, the circulating device employed comprises a relatively large circulating column or tubular element 50 having a restricted throat 51 disposed adjacent the lower end of the column and flared outwardly in both directions from the restricted portion 51. Column 50 is open at the top and bottom in free communication with the body of water in the storage tank and a plurality of steam jets 52, communicating with a header or manifold 53, direct steam supplied to header 53 through line 54 and valve 55 upwardly into the lower portion of column 50 to induce the circulation of water from a relatively cold stratum in the lower portion of the storage reservoir upwardly through the column into a relatively hot stratum in the upper portion of the storage reservoir.

Circulation of water through column 50 is preferably started by the introduction of steam through line 54 and valve 55 as soon as a sufficient quantity of preheated water has been supplied to tank 41, in the manner above described, to bring the water level in the storage tank and in column 1 to a point where circulation through the latter can be established. This circulation through column 50 may be continued until substantially the entire body of water in the storage reservoir has reached the desired temperature, whereupon the supply of steam through line 54 and valve 55 may be discontinued and circulation through column 50 stopped by closing valve 55. This may be accomplished automatically, when desired, by providing a motor-operated or pressure-operated valve at 55 which is responsive, through any suitable type of controller, illustrated at 59, to a predetermined temperature at a suitable point in the body of water in the storage reservoir, at which selected point any desired form of temperature-sensitive element, such as thermostat 56, is provided. This temperature responsive element 56 is operatively connected to the controller by line 56' and transmits an impulse to the controller whereby the latter is caused to actuate valve 55 to which it is operatively connected by means of line 59'.

Although the heated water may be withdrawn from the storage reservoir at any desired point or plurality of points therein, preferably, as in the other cases herein illustrated, it is removed from a relatively hot upper stratum, line 57 and valve 58 being provided, in the case here illustrated, for this purpose.

Column 59 and the steam injecting means illustrated in Figure 4 function in much the same manner as the side-arm type of column illustrated in Figures 1 and 2, except that, with the device of Figure 4, the same amount of steam may be introduced in the form of a plurality of smaller streams or a larger column may be employed and a greater amount of steam introduced, by the use of a plurality of steam jets, to circulate a greater volume of water in a given time. A circulating device, such as illustrated in Figure 4, may therefore be utilized when a quantity of water to be heated in a given time is too large to be efficiently handled by a single relatively small circulating column and, conversely, a plurality of relatively small columns may be employed in the place of the type illustrated in Figure 4, when desired.

Referring now to Figure 5 which, as previously mentioned, illustrates one specific form of condenser-preheater which may be employed, for example, in the manner illustrated in Figure 4; relatively cold water from an external source is admitted to this device through line 42, entering a spray head or chamber 60 from which it passes, in part, through a plurality of spray nozzles 61 into the condensing chamber 62 and, in part, through a plurality of downwardly directed jets 63 into the tail pipe 64 which has a restricted throat 65 and forms the upper portion of the line 45, through which the preheated water and condensed steam is supplied to the storage reservoir.

Steam enters the condensing chamber 62 of preheater 44 through line 43 and is preferably supplied tangentially to the condensing chamber. The water sprays from nozzles 61 serve to condense at least a portion of the steam thus admitted to the condensing chamber. Any remaining uncondensed steam, as well as the condensate and condensing water, is drawn into the line 45 with the assistance of the downwardly directed water jets from 63.

Due to the condensation of steam in chamber 62 and the action of the downwardly directed water jets, a slight sub-atmospheric pressure will normally prevail in this zone and, in order that the preheated water and condensed steam may flow freely into the storage reservoir, the line 45 is of sufficient length that, when the storage reservoir is filled to the desired level, the column of water in leg 45 will extend only to or beneath the restricted throat 65 of tail pipe 64. In other words, the normal height of the column of water in leg 45 is sufficiently greater than that of the body of water in the storage reservoir to compensate for the slight sub-atmospheric pressure in chamber 62.

We claim:

1. A method of obtaining a continuous supply of hot water which comprises, maintaining a body of water in a confined zone, circulating a confined stream of water from the lower to the upper portion of said body, supplying steam to said confined stream in such a manner as to effect said circulation, heat said stream and substantially completely condense the steam, supplying resulting heated water and condensed steam to the

upper portion of said body and causing it to stratify above the cooler water thereof during the initial stages of the operation, removing hot water from the upper portion of said body and maintaining a predetermined level of water in said confined zone by supplying relatively cool make-up water to the lower portion of said body to replace heated water withdrawn therefrom.

2. The method defined in claim 1, wherein substantially complete condensation of the steam is assisted and its waste obviated by controlling its introduction into said confined stream in response to variations in the temperature of the water in that zone of the main body thereof wherefrom water is supplied to the confined stream, the introduction of steam being diminished as the temperature increases and discontinued as the temperature approaches the boiling point of water.

3. A water heating apparatus comprising, in combination, a storage tank, an elongated upwardly extending duct disposed outside the storage tank, said duct communicating at its lower end with the lower portion of the main body of water in the storage tank and communicating at its upper end with the upper portion of said body, a steam conduit disposed to introduce steam into direct contact with water transmitted to the duct from the lower portion of said body whereby to propel a stream of water upward through said duct from the lower to the upper portion of said body and substantially completely condense the steam, a conduit communicating with the upper portion of said body of water in the storage tank for removing heated water therefrom and a conduit communicating with the lower portion of said body of water in the storage tank for introducing relatively cool make-up water thereto.

4. A water heating apparatus comprising, in combination, a storage tank, an elongated upwardly extending duct disposed outside the storage tank and communicating at its lower end with the body of water in the storage tank, a steam conduit disposed to introduce steam into direct contact with a flowing stream of water passing upwardly through said duct from the lower to the upper portion of said body whereby to heat said stream, propel it upward and substantially completely condense the steam, said duct terminating in an open upper end so disposed in relation to the body of water in the storage tank that heated water and condensed steam issuing from said duct will stratify above the cooler portion of said body, a conduit for removing heated water from the upper portion of the storage tank and a conduit for introducing relatively cool make-up water into the lower portion of the storage tank, as heated water is withdrawn therefrom, to maintain a predetermined relatively high level of water in the storage tank.

5. The apparatus defined in claim 4, wherein said steam conduit terminates in an open outlet end disposed within said duct at a point substantially beneath the level of water in the storage tank.

6. The apparatus defined in claim 4, wherein said duct is provided with a restricted throat and wherein said steam conduit terminates in an open outlet end adjacent said restricted throat, the throat and steam conduit comprising a steam impeller for inducing the circulation of water upwardly through the duct.

7. The method of obtaining a continuous supply of hot water, which comprises maintaining a body of water in a confined zone, circulating a confined stream of water from the lower to the

upper portion of said body, supplying steam upwardly into said confined stream, thereby effecting heating and circulation of the water and substantially completely condensing the steam, supplying the resulting heated water and condensed steam to the upper portion of said body and, during the initial stages of the operation causing it

to stratify above the cooler water thereof, removing hot water from the upper portion of said body and introducing relatively cool make-up water into the lower portion of said body.

JACQUE C. MORRELL.
CHARLES H. ANGELL.