

Jan. 8, 1935.

G. DALÉN ET AL

1,987,182

HEAT EXCHANGER

Filed May 24, 1932

3 Sheets-Sheet 1

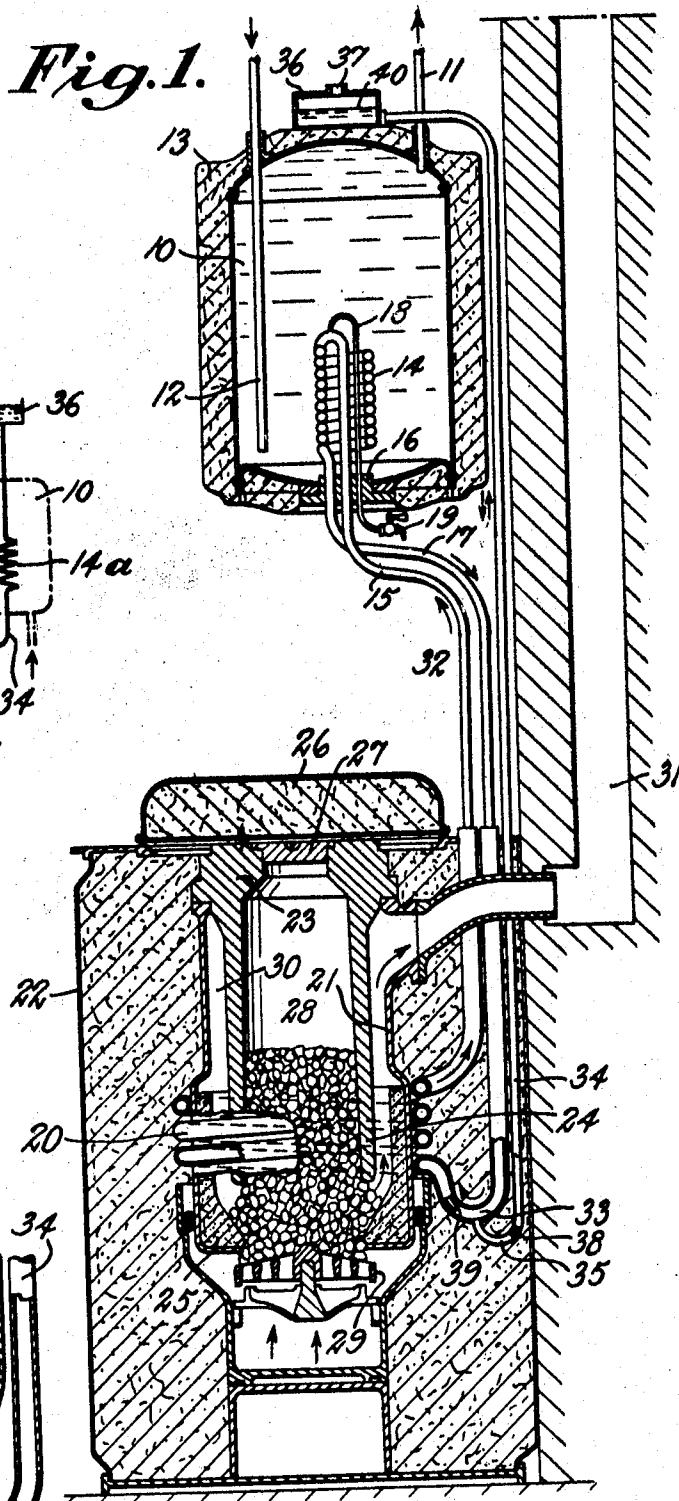
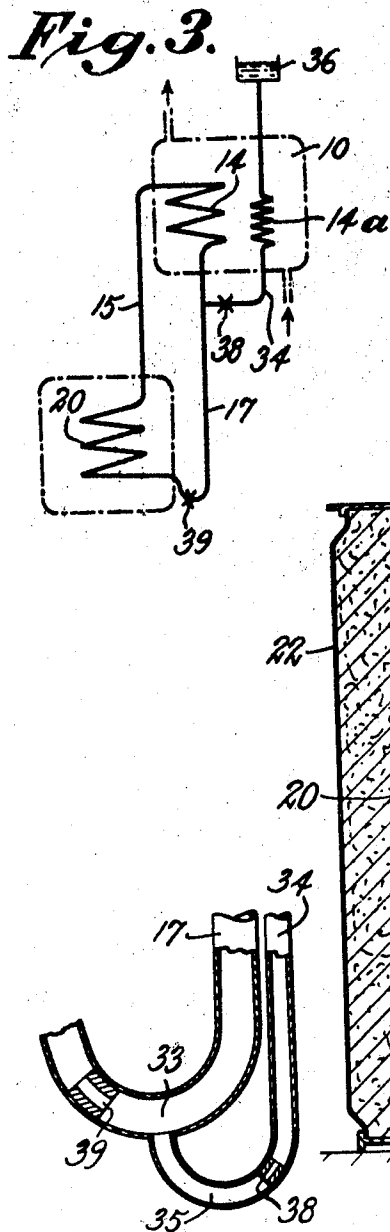


Fig. 1a.

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3 Sheets-Sheet 2

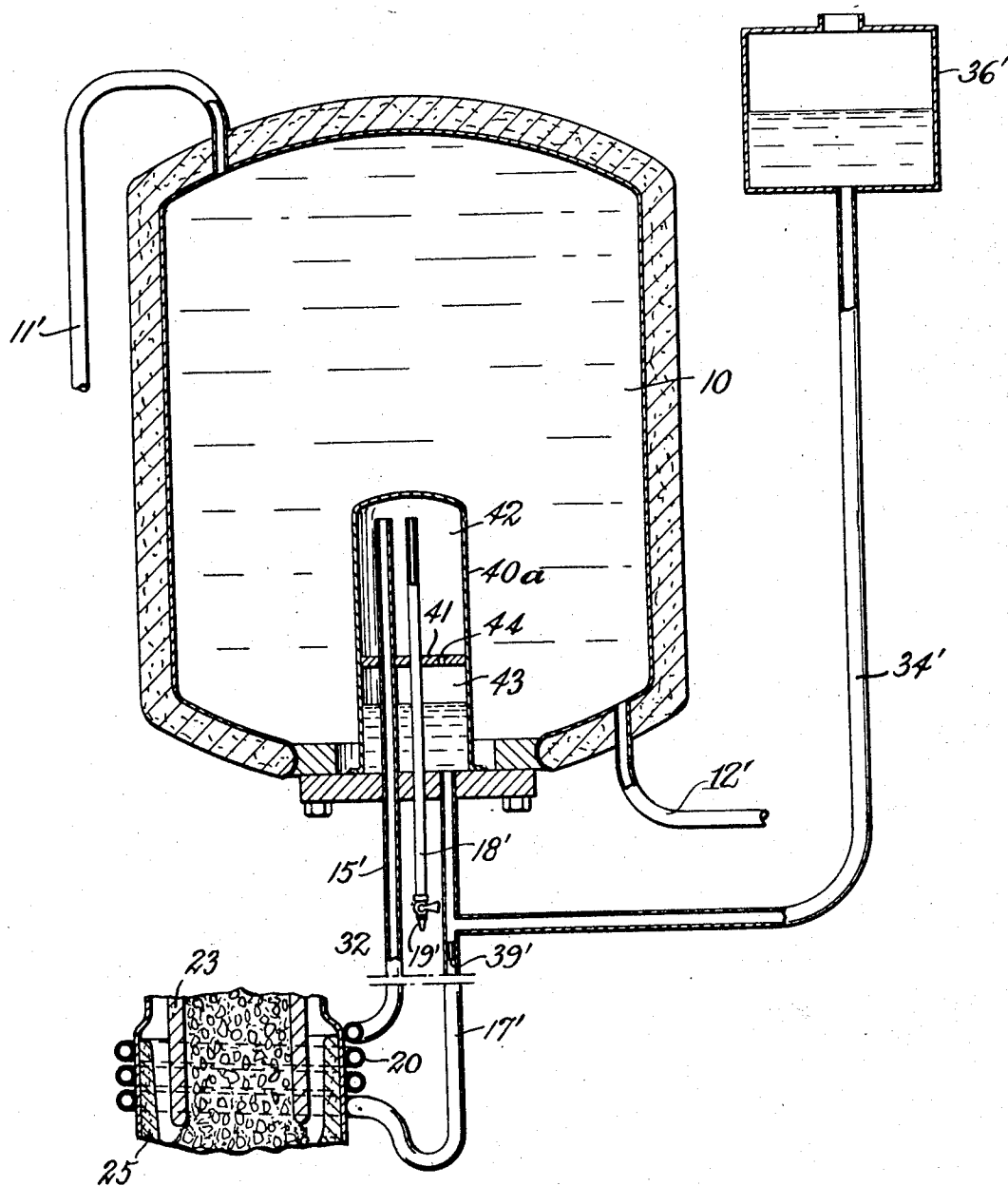


Fig. 2.

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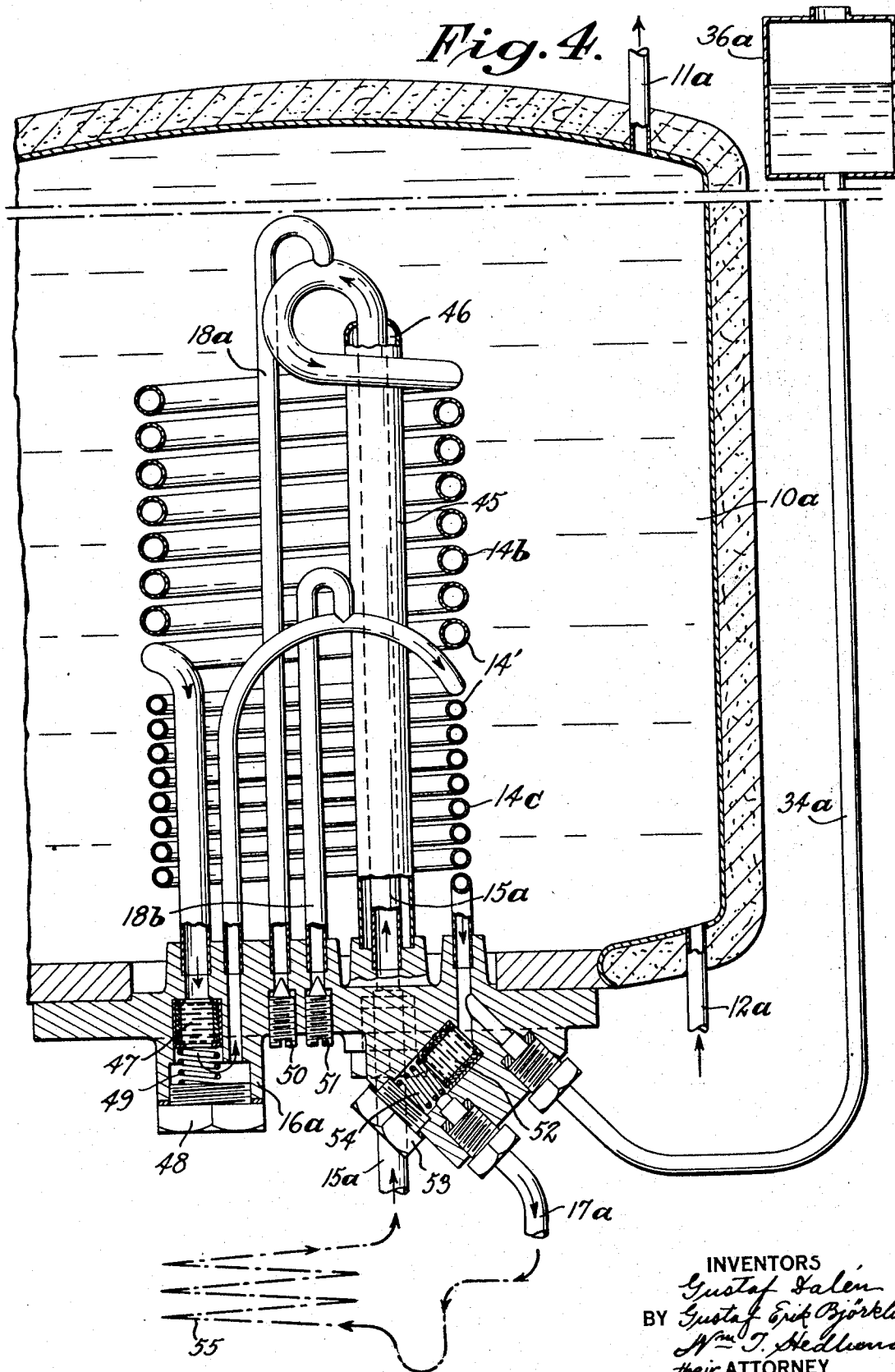
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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

1,987,182

HEAT EXCHANGER

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In Sweden September 25, 1931

18 Claims. (Cl. 122—33)

The present invention relates to heat exchange and has particular reference to heat exchange systems wherein heat is transferred indirectly from a source of heat to the body to be heated through the medium of heat transmitting fluid circulating in a closed path in which it is vaporized at the source of heat and condensed by delivering heat to the body to be heated.

More particularly, the invention relates to improved method and means for governing the rate at which heat is transferred by the circulating fluid in accordance with the momentary heat requirements of the body to be heated.

The invention is particularly useful for the purpose of heating a supply of hot water for domestic purposes with heat derived from a continuously fired domestic cooking stove of the heat accumulating type, such as is disclosed in U. S. Patent No. 1,559,162 granted October 27, 1925 on the application of Gustaf Dalén, but it is to be understood that the invention is applicable in other fields in which the body to be heated may be fluids other than water, or solids, and the source of heat may be of any suitable character. In domestic water heating installations of the above mentioned character, water is advantageously used as the circulating heat transmitting fluid but other fluids may be employed, particularly in cases where the temperature level of the body to be heated is such that a fluid having a vaporizing temperature above or below the vaporizing temperature of water is suitable.

Among the several objects of the invention are: to provide indirect heating apparatus in which a heat transferring fluid is circulated and alternately vaporized and condensed in a closed path of circulation and is permitted to have substantially unrestricted opportunity to expand upon vaporization of a portion of the fluid; to provide indirect heating apparatus of the character referred to in which a closed circuit for circulation of heat transferring fluid is connected at a point in the circuit where the fluid is in liquid form to an expansion line adapted to contain a variable quantity of fluid, depending upon the amount of fluid forced from the circuit of circulation due to vaporization of fluid therein, and to maintain a static pressure of liquid head on said circuit; to provide indirect heating apparatus for automatically raising the temperature of a body to be heated to a desired temperature level and thereafter automatically maintaining such body at a temperature level not exceeding the desired temperature; to provide, in an indirect heating system, means for automatically governing the rate

of circulation and of heat transmission in a closed circuit for heat transferring fluid; to provide, in a domestic hot water supply system, indirect heating means in which the flow of heat transmitting fluid is automatically governed within the path of flow of the fluid in accordance with the rate of condensation due to the momentary requirements of the domestic supply to be heated; to provide an indirect heating system in which vapor is generated in a relatively even manner and at a rate not exceeding the requirements of the system; and to provide an indirect heating system of the character described in which automatic regulation of the rate of vapor generation and of heat transfer through the system is effected by a restriction in the path of circulation of the heat transferring medium. Other objects of the invention will appear in the description to follow.

For purposes of illustrating the invention, we have shown in the accompanying drawings a number of forms of apparatus of the type designed to provide a supply of hot water for domestic uses, such supply being heated from a domestic stove of the accumulating type disclosed in the patent above referred to. It is to be understood, however, that the apparatus shown in the drawings is illustrative only and that the invention is not to be limited to the general type of apparatus disclosed but may equally well be utilized in other forms of apparatus employed for other purposes.

In the drawings:

Fig. 1 is a more or less diagrammatic vertical section of a domestic water heating apparatus embodying the invention;

Fig. 1a is a view on an enlarged scale of part of the apparatus shown in Fig. 1;

Fig. 2 is a view similar to Fig. 1 showing another type of the apparatus;

Fig. 3 is a view showing schematically another form of apparatus of the type illustrated in Fig. 1;

Fig. 4 is a view, on a larger scale, showing part of still another type of apparatus.

Referring now to Fig. 1 of the drawings, reference numeral 10 indicates a hot water storage supply tank for a domestic or like supply, from which hot water is withdrawn through pipe 11 and to which water is supplied by pipe 12. Tank 10 is preferably covered by a layer of insulating material 13 to prevent undue loss of heat by radiation.

Situated within tank 10, preferably in the lower portion thereof, is the pipe coil 14, from the upper end of which the pipe 15 passes through a suitable closure 16 in the bottom of the tank and from

the lower end of which the pipe 17 passes through closure 16 to the exterior of the tank. From the highest point of pipe 15 the pipe 18 leads to the exterior of the tank, this pipe being provided with a shut-off valve 19 outside of the tank.

Pipes 15 and 17 are connected at their lower ends to the upper and lower ends, respectively, of a coil 20 surrounding the combustion chamber casing 21 of a cook stove of the accumulator type indicated generally at 22. This stove comprises an annular heat accumulating member 23, the lower skirt portion 24 of which extends into an annular refractory fire box 25 within the casing 21. Removable covers 26 and 27 permit the introduction of solid fuel into the magazine space 28 within the skirt 24 and the fuel is burned on a grate 29. Air is admitted through any suitable opening below grate 29 and the combustion gases pass through the annular flue space 30 to the stack or chimney indicated at 31.

As will be evident from the drawings, coils 14 and 20 and pipes 15 and 17 constitute a closed circuit designated generally by reference numeral 32. Coil 20 may be said to constitute a vapor generator and coil 14 to constitute a condenser for condensing vapor generated in coil 20. In this circuit a trap adapted to be filled with liquid at all times is provided by the elbow 33 at the lower end of pipe 17, this elbow extending below the lowest part of the coil 20. Connected to the lowest point in the circuit 32 is the pipe 34 which at its lower end advantageously terminates in a depending loop or elbow 35 and at its upper end is connected to the lower portion of the receptacle 36. Receptacle 36 is advantageously above the highest level of the circuit 32 and may be in open communication with the atmosphere through a suitable vent 37. The receptacle 36 may conveniently be mounted on top of the tank 10 as illustrated. A restriction providing an orifice 38 of small diameter is preferably provided in the pipe 34.

Turning again to the circuit 32, a restriction 39 providing an orifice of small diameter is provided in the circuit, this orifice being advantageously located in the elbow 33 between coil 20 and pipe 34.

The operation of the apparatus is as follows, it being assumed that the tank 10 is filled with water to be heated.

The circuit 32 is filled with water through the receptacle 36 and the pipe 34, the flow of water into the closed circuit from the lowest point thereof being permitted by opening valve 19 to vent the trapped air from the highest point in the circuit through pipe 18. Preferably the system is filled until the water reaches a height such that the receptacle 36 is partially filled, as to the level indicated at 40.

If, now, fuel is burned in the stove 22, heat is transmitted to coil 20 by conduction and radiation from the adjacent parts providing the fire space in the stove and steam is generated in this coil. The steam generated passes upwardly through pipe 15 into coil 14, displacing water from pipe 15 and coil 14. The water displaced by the generation of steam flows into pipe 34 and thus to the receptacle 36 which acts as an expansion tank. Due to the relatively large horizontal cross-sectional area of the receptacle 36, the water forced into this receptacle by expansion in the closed circuit does not materially alter the height of the water level 40 so that the variation in static pressure due to head of liquid on the system is substantially negligible and the system

can be considered for all practical purposes as operating under constant pressure.

The steam which passes to the coil 14 is condensed by delivering its heat to the water in tank 10 and the condensate from coil 14 returns to the lower end of coil 20 through the return or drain pipe 17. Circulation of steam through the system is effected due to the difference in the weight of the column of water in pipe 17 and the weight of the column of steam in pipe 15.

The heat absorbing area of the coil 20, which governs the rate of vaporization of water in the circuit and the area provided by coil 14 for the condensation of steam, may be calculated in accordance with well known principles of heat transmission so that the rate at which heat is supplied to the water in tank 10 and consequently the rate at which a tank of cold water can be brought to desired temperature, meets the requirements of the individual installation.

During periods when cold water is being heated in the tank 10, all of the steam generated in coil 20 should be condensed in the coil 14 so that there is a liquid column in pipe 17 for the full height thereof, thereby providing the maximum speed of heat transfer. As the temperature of the water in tank 10 rises, the rate of heat transfer through the walls of the pipe coil 14, decreases and the rate of steam condensation accordingly decreases. If the rate of vaporization in coil 20 is higher than the rate of condensation in coil 14, a certain amount of steam will pass through coil 14 without being condensed and as a result, the height of the liquid column in the return pipe 17 will be decreased. This will operate to reduce the hydrostatic head effecting circulation and will accordingly slow down the rate of circulation. Thus the rate of vaporization also will be decreased. It will be evident that variations in the quantity of water in the closed circuit 32 will produce variations in the amount of water in receptacle 36 and will also produce reversals of flow in pipe 34.

Assuming that the condenser and generator are both steam filled, it is important to prevent unrestricted flow of a solid column or jet of water into the generator coils since if this were permitted, a considerable amount of water might flow into the generator in such a manner as to be flashed into steam, thereby producing explosive action of a nature causing violent surges and water hammer in the system. In order to minimize such surges, the small orifice 38 is provided in pipe 34, this orifice acting as a check and another small orifice 39 is provided for the same effect in pipe 17.

By connecting the expansion line into the elbow 33 at the lowest part of the closed circuit 32, it will be evident that expansion of the fluid in the closed circuit will operate to force water and not steam from this circuit into the expansion line.

It is one of the objects of the present invention to provide apparatus which will automatically raise the temperature of the water in tank 10 to a predetermined desired level and thereafter maintain the temperature of the water at a substantially constant level. In a domestic hot water system this temperature level is below the temperature of the steam being condensed and in the event that water is not withdrawn from tank 10 for an extended period the amount of heat supplied to the water in this tank should just compensate for the radiation losses if the temperature of the water is to be kept from exceeding the predetermined desired level.

This control of temperature in the tank as above mentioned is effected according to the present invention by automatically altering the rate of circulation in the closed system 32 in accordance with the rate at which steam is condensed in the coil 14.

Turning now to Fig. 2, there is illustrated another form of apparatus, according to the invention. It has proved convenient to connect the expansion pipe 34' to pipe 17' at a point close to the tank 10. This arrangement, among other things, facilitates the removal of air from the circulating system. To eliminate the fear of getting vapor into the expansion pipe the condenser is formed in a special manner. The steam generated in coil 20 is carried upwardly through a pipe 15' which terminates at its upper end in the upper portion of a condenser comprising a closed cylinder 40a. Cylinder 40a is divided by a diaphragm 41 into an upper chamber 42 and a lower chamber 43. Diaphragm 41 is provided with a small orifice 44 affording restricted communication between the two chambers. To enable the circulating system 32 to be filled, pipe 18' is provided, this pipe being in communication with the upper portion of chamber 42. Flow through this pipe is controlled by means of the valve 19' located outside of tank 10.

Cold water is admitted to tank 10 through the inlet pipe 12' and hot water is withdrawn through the pipe 11'.

The expansion receptacle 36' is connected to the return pipe 17' by the pipe 34', but as will be observed from the figure, pipe 34' is connected into the closed circuit 32 at a higher level than in the arrangement shown in Fig. 1 and the restriction 39' is placed in the pipe 17' below the point where pipes 17' and 34' join. The restriction 39' prevents too rapid flow of water to the generator from either the supply in the expansion line or the supply in the lower portion of the condenser.

The function of the diaphragm 41 and the orifice 44 is to prevent vapor from entering the expansion pipe 34'. This is accomplished by the throttling effect of orifice 44. It is a known fact that an orifice transmits a weight of vapor, which is approximately only .03 of the weight of water, transmitted by the same orifice and at the same difference of pressure, assuming that the vapor has a temperature of 100° C. and substantially atmospheric pressure.

The vapor generated in generator 20 rises in the pipe 15' and displaces a certain amount of water in the chamber 42 of condenser 40. If the water in tank 10 is relatively cold, rapid condensation takes place. The water level in chamber 42 is determined by the temperature of the water in tank 10 in such manner, that the rate of condensation of the upper part of chamber 42, above the water level, is enough to condense the vapor from the generator 20. When the temperature of water in tank 10 increases, the rate of condensation decreases. The balance between generating and condensing is maintained by the water level in chamber 42 sinking. At a predetermined temperature of water in tank 10, the water level in chamber 42 reaches the diaphragm 41, and if now the temperature of water in tank 10 furthermore increases, the water level tends to sink below the diaphragm 41. In this case the upper part of chamber 43 also will contain vapor, which has to pass through orifice 44. The throttling effect of the orifice 44 now takes place and the rate of circulation in the circuit 32 de-

creases thereby causing less vapor to pass from the generator to the condenser. In this way the heat transmission automatically slows down.

The condensing efficiency of the lower chamber 43 of condenser 40a should be great enough to condense all vapor, passing through the orifice 44, thereby preventing vapor from entering the pipe 34'.

Turning now to Fig. 3, there is illustrated schematically another arrangement, in which the expansion pipe 34 is connected to the return pipe 17 close to the condenser 14. To prevent the vapor from entering the receptacle 36 another condenser 14a is arranged in the lower part of the expansion pipe 34. If any vapor should enter the pipe 34, it will be condensed in condenser 14a, giving up its heat to the water in the tank 10.

Another feature of this arrangement is, that if air should have entered the system, for example by entrainment or absorption in the water in the system, this air will collect in condenser 14, there mixing with vapor, and slowing down the rate of condensation. When tank 10 is at high temperature, the vapor can not fully condense in condenser 14 and so causes vapor mixed with air to enter the pipes 17 and 34. The vapor and the air rise to condenser 14a, where the vapor condenses. The air continues to rise through pipe 34 and leaves the system by way of receptacle 36. In this way from time to time the air will automatically be expelled from the system, thus ensuring continuous heat transmission.

In the figure, 20 indicates the generator, connected to the return pipe 17 and to the steam pipe 15.

One orifice 38 is arranged in the expansion pipe 34 and another orifice 39 in the lowest part of return pipe 17. The function of these orifices is the same as before mentioned in connection with Figs. 1 and 2.

Turning now to Fig. 4 there is illustrated on an enlarged scale a portion of an apparatus of preferred commercial form. In the arrangement shown in this figure, the condenser 14' is of the coil type illustrated in Fig. 1 and is located at the bottom of a tank 10a having an outlet pipe 11a and inlet pipe 12a.

Coil 14' is divided into upper and lower portions 14b and 14c, respectively, and the portion of the steam supply pipe 15a inside of the tank is preferably insulated by means of a sleeve spaced from this portion of pipe 15a to provide an insulating chamber 46 between the two pipes. This arrangement minimizes condensation of steam at a point in the system such that the condensate will have to return through the upflow pipe 15a.

The two portions of the condenser 14b and 14c are joined through a restriction which instead of being provided by one small orifice is provided by a plurality of orifices in series which, in the present form of the apparatus are held in position in the closure member 16a by means of the cap 48 and spring 49.

The topmost portion of the condenser is vented through pipe 18a, through which flow may be controlled by an external cock such as that shown in Fig. 1 or through the medium of a removable closure plug 50. A second vent pipe 18b is advantageously provided for venting the lower portion 14c of the condenser. This pipe may also be controlled by an external cock or a removable plug 51.

Between the discharge end of the coil forming

the portion 14c of the condenser and the return line 17a there is placed a second restriction 52 which is removably secured in position by a cap 53 and spring 54.

- 5 The expansion line 34a leading from the receptacle 36a is connected into the closed circuit above the restriction provided at 52. Upflow pipe 15a and the return line 17a are connected to a generator preferably of the form shown in Fig. 1.
- 10 This remaining portion of the closed circuit 32 is indicated diagrammatically at 55.

The operation of this system is generally similar to the operation of the systems heretofore described. The restriction provided at 47 provides the desired resistance to flow of steam at a point intermediate the ends of the condenser so that when the rate of condensation is low, the steam which does pass through the restriction is condensed in the lower portion 14c of the condenser.

20 The restriction 52 provides the necessary resistance to prevent unduly rapid flow of water to the generator so that hammering in the system due to rapid local generation of steam in the generator is avoided.

- 25 It has been found in practice that a satisfactory form of apparatus is one in which the differential pressure or liquid head tending to maintain circulation in the system is provided by a column (assuming water to be the liquid circulated) having a height of approximately .08 of a meter, and in which the restriction to flow provided in the closed circuit is such that the restriction is capable of passing, under the existing pressure conditions, only a small fraction of the weight of steam as compared with the weight of water which it will pass. When the restriction takes the form of an orifice, an orifice of 0.6 of a millimeter has been found satisfactory in operation, an orifice of this size being capable of passing, in the form of steam, only about 3% of the weight of fluid which it will pass in the form of water. Instead of one orifice with a very small opening, in Fig. 4 there is shown a series of 6 orifices with a diameter of 1.2 m/m. this series of orifices tending to provide the same throttling effect as that provided by a single orifice of very much smaller diameter.

The expansion line may be open to atmosphere or not as desired and, obviously, this expansion line need not comprise a separate pipe and tank but may be formed by a pipe alone, provided the pipe has sufficient capacity to take care of the desired expansion.

- 55 If water is used as the heat transmitting medium, the liquid in the expansion line may advantageously be covered by a layer of some lighter liquid such as oil which will act to prevent evaporation of the water and will also act to prevent the absorption of air by the water.

60 If the temperature to which it is desired to heat the body to be heated is greater than the vaporizing temperature of the heat transferring fluid at about atmospheric pressure, the latter fluid may be maintained under any desired pressure in order to raise its vaporizing temperature by connecting the expansion line, which in this instance would be closed to the atmosphere, to any suitable source of fluid pressure. Variations in the pressure to which the heat transferring fluid is subjected may also be effected by varying the height of the liquid column in the expansion line.

75 From the foregoing description, it will be evident that in accordance with the present invention automatic control of the rate of heat trans-

fer to the body to be heated is effected in response to variations in the temperature of the body to be heated by the direct influence of the heat absorbing capacity of the body to be heated and without the intermediary of auxiliary regulating mechanism, so that the apparatus provides the important advantage of elimination of thermostats and other equipment of the type which is subject to derangement from time to time.

What is claimed is:

1. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body to be heated, means providing a closed circuit for circulating a heat transferring fluid between said source and said tank, said means comprising a vapor generator adjacent to said source, a condenser in said tank, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensed vapor from the condenser to the generator said return line having a restriction therein of less cross-sectional area than the minimum cross-sectional area of said vapor conducting conduit, and expansion means associated with said return line between said condenser and said restriction.

2. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body to be heated, means providing a closed circuit for circulating a heat transferring fluid between said source and said tank, said means comprising a vapor generator adjacent to said source, a condenser in said tank, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensed vapor from the condenser to the generator, and an expansion line connected to said return line, said return line having a restriction therein between the generator and the connection to the expansion line providing a smaller cross-sectional area in said return line than anywhere in the vapor conducting conduit, and said expansion line having a restriction therein.

3. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body to be heated, means providing a closed circuit for circulating a heat transferring fluid between said source and said tank, said means comprising a vapor generator adjacent to said source, a condenser in said tank, an upflow conduit for conducting vapor from the generator to the condenser and a return line for conducting condensed vapor from the condenser to the generator, a restriction in the return line providing a smaller area of flow in said return line than anywhere in said upflow conduit, and an expansion line connected to the return line between the restriction and the condenser.

4. Apparatus of the character described comprising a stove of the type intended for continuous operation, a tank for heating water, means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator arranged to be heated by said stove, a condenser located in said tank, an upflow conduit for conducting vapor from the generator to the condenser, a return line for conducting condensed vapor from the condenser to the generator and an expansion line connected to the return line, said return line having a reduced cross-section of less area than the smallest cross-sectional area in said upflow conduit and said expansion line being connected to the return line between the condenser and the place of reduced cross-sectional area.

5. Apparatus of the character described com-

prising means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator, a condenser, an upflow conduit for conducting vapor from the generator to the condenser and a return line for conducting condensate from the condenser to the generator, an expansion line connected to said return line, means for applying heat to said generator, means for maintaining a body to be heated in heat transfer relation with said condenser, and a restriction in said return line between the generator and the connection to the expansion line providing a smaller cross-section for flow in said return line than anywhere in said upflow conduit for governing the rate of admission of liquid to said generator.

6. Apparatus of the character described comprising means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator, a condenser, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensate from the condenser to the generator, means for applying heat to said generator, means for maintaining a body to be heated in heat transfer relation with said condenser, means in said circuit for automatically governing the rate of circulation of the heat transferring fluid therethrough in response to variation in the rate of condensation of vapor in said condenser, said last named means comprising a restriction located within the condenser so that only condensate passes therethrough when the rate of condensation in the condenser is relatively high and vapor and condensate pass therethrough when the rate of condensation in the condenser is relatively low and an expansion line connected to the return line.

7. Apparatus of the character described comprising means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator, a condenser, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensate from the condenser to the generator, means for applying heat to said generator, means for maintaining a body to be heated in heat transfer relation with said condenser, means in said circuit for automatically governing the rate of circulation of the heat transfer fluid therethrough in response to variation in the rate of condensation of vapor in said condenser, said means comprising a restriction in said circuit located so as to divide the space within the condenser into two parts, and an expansion line connected to the return line.

8. Apparatus of the character described comprising means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator, a condenser, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensate from the condenser to the generator, means for applying heat to said generator, means for maintaining a body to be heated in heat transfer relation with said condenser, means in said circuit for automatically governing the rate of circulation of the heat transfer fluid therethrough in response to variation in the rate of condensation of vapor in said condenser, said means comprising a restriction in said circuit located so as to divide the space within the condenser into two parts, an expansion line connected to said return line, and a restriction in the return line between the expansion line and the generator.

9. Apparatus of the character described comprising means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator, a condenser, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensate from the condenser to the generator, means for applying heat to said generator, means for maintaining a body to be heated in heat transfer relation with said condenser, means in said circuit for automatically governing the rate of circulation of heat transfer fluid therethrough in response to variation in the rate of condensation of vapor in said condenser, said means comprising an orifice in said return line adjacent to the outlet of said condenser, and an expansion line connected to the return line at a point between the condenser and the orifice.

10. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body of fluid to be heated, means providing a closed circuit for a heat transferring fluid, said means comprising a vapor generator arranged to be heated by said source of heat, a condenser comprising a pipe coil located in said tank, a conduit for vapor connecting the upper portion of said generator with the upper end of said pipe coil, a return line connecting the lower end of said pipe coil to the lower portion of said generator and a restriction in said pipe coil intermediate its ends, and an expansion line connected to said return line.

11. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body of fluid to be heated, means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator arranged to receive heat from said source, a closed vessel in said tank, means having an orifice therein for dividing the interior of said vessel into an upper and a lower chamber, a conduit for conducting vapor from said generator to said upper chamber and a return line for conducting condensate from the lower chamber to the generator, and an expansion line connected to said return line.

12. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body of fluid to be heated, means providing a closed circuit for circulation of a heat transferring fluid, said means comprising a vapor generator arranged to receive heat from said source, a closed vessel in said tank, flow restricting means in said vessel, a conduit for conducting vapor from said generator to said vessel, a return line for conducting condensate from the lower portion of said vessel to said generator and a restriction in said return line of smaller cross-sectional area than the minimum cross-sectional area of said vapor conducting conduit, and an expansion line connected to the return line between said last-mentioned restriction and said vessel.

13. In apparatus of the character described, a closed circuit for circulation of a heat transferring fluid comprising a condenser having a first portion to which vapor is admitted and a second portion from which condensate is withdrawn, and a connection between said portions comprising a number of holes in series for restricting flow of vapor from said first portion to said second portion.

14. In apparatus of the character described, a tank adapted to contain fluid to be heated, a condenser for heating fluid located in the lower

portion of said tank, said condenser comprising a pipe coil divided into an upper portion and a lower portion, a conduit for conducting vapor to the upper part of said upper portion, a conduit for conducting condensate from the lower part of said lower portion and a connection between said portions, said connection being accessible from the exterior of said tank and comprising a removable body forming a series of restrictions between said two portions.

15. In apparatus of the character described, a tank adapted to contain a fluid to be heated, a removable closure in the lower portion of said tank, a condenser for heating fluid mounted on said closure and extending into the tank, said condenser comprising an upper portion and a lower portion, each of said portions comprising a pipe coil having its ends connected to openings in said closure, a vapor supply conduit connected to the opening in the closure in communication with the inlet end of said upper portion, a condensate return line connected to an opening in said closure in communication with the discharge end of said lower portion, a passage in said closure connecting the discharge end of the upper portion and the inlet end of the lower portion and means arranged in the passage providing a restriction for flow of vapor from said upper portion to said lower portion, said means being removable from the exterior of said closure.

16. Apparatus of the character described comprising a vapor generator, a tank adapted to contain fluid to be heated, a plurality of condensers for heating fluid located in said tank, means to conduct vapor from said generator to one of said condensers, a return line for conducting liquid from another of said condensers to the vapor generator, connecting means between said condensers including flow restricting means accessible from outside said tank, a restriction in said return line providing a smaller cross-sectional area of flow in said return line than in said vapor conducting means, and ex-

pansion means connected to said return line between the restriction therein and said tank.

17. Apparatus of the character described comprising a source of heat, a tank adapted to contain a body to be heated, means providing a closed circuit for circulating a heat transferring fluid between said source and said tank, said means comprising a vapor generator adjacent to said source, a condenser in said tank, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensed vapor from the condenser to the generator, said return line having a restriction therein of less cross-sectional area than the minimum cross-sectional area of said vapor conducting conduit, an expansion line connected to said return line between said condenser and said restriction, an expansion vessel connected to said expansion line and positioned above said tank, and means to relieve fluid from the top of said condenser.

18. Apparatus of the character described comprising a source of heat, means adapted to contain a body to be heated, means providing a closed circuit for circulating a heat transferring fluid and transferring heat between said source and said first named means, said second named means comprising a vapor generator adjacent to said source, a condenser in heat transmitting relation with said first named means, a conduit for conducting vapor from the generator to the condenser and a return line for conducting condensed vapor from the condenser to the generator, expansion means, an expansion line connecting said return line with said expansion means, and a restriction of less cross-sectional area than the minimum cross-sectional area of said vapor conducting conduit, said restriction being located in the line of flow between the expansion means and the generator.

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