March 2, 1937. C. H. FOLMSBEE ET AL 2,072,713

METHOD OF AND APPARATUS FOR HEATING AND VAPORIZING LIQUIDS

Filed Jan. 2, 1934 2 Sheets-Sheet 1

Fig. 2.

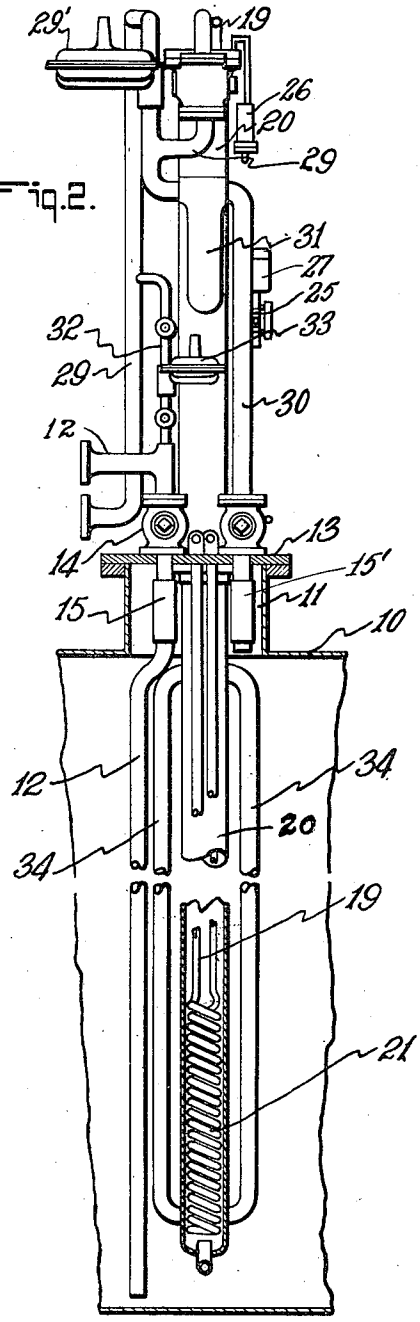
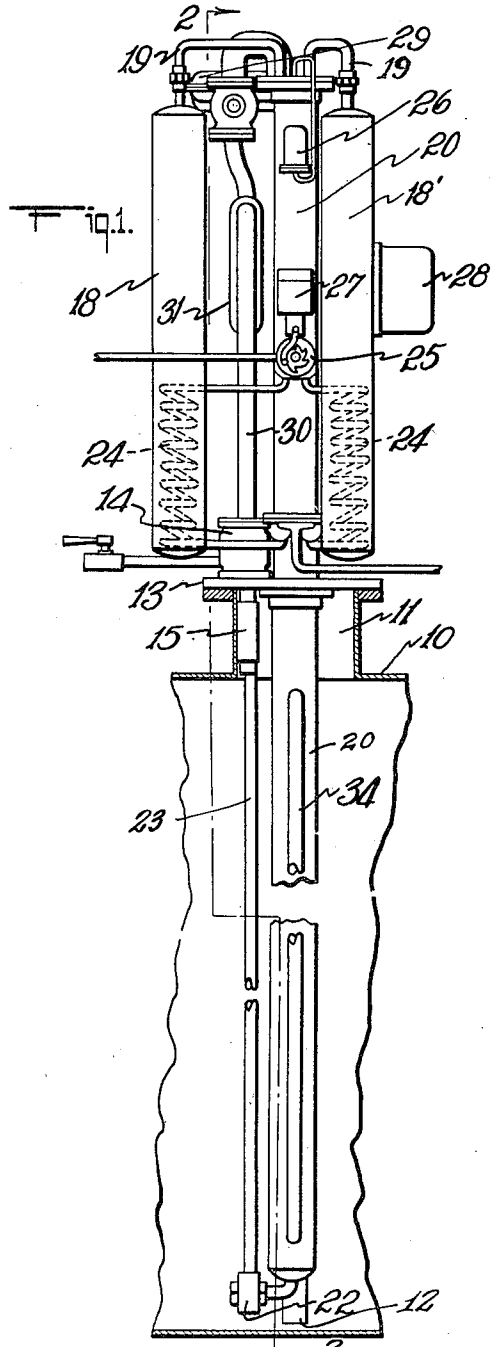


Fig. 1.



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Fig. 4.

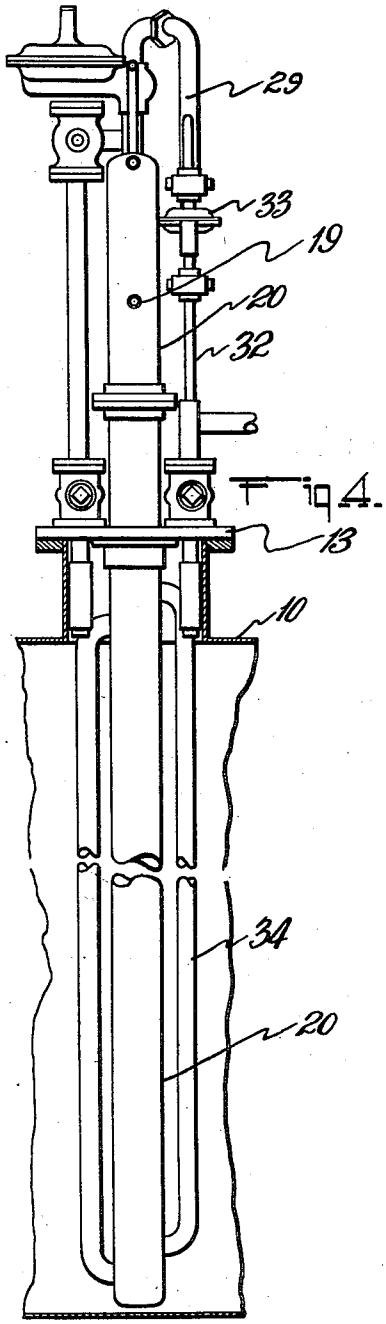
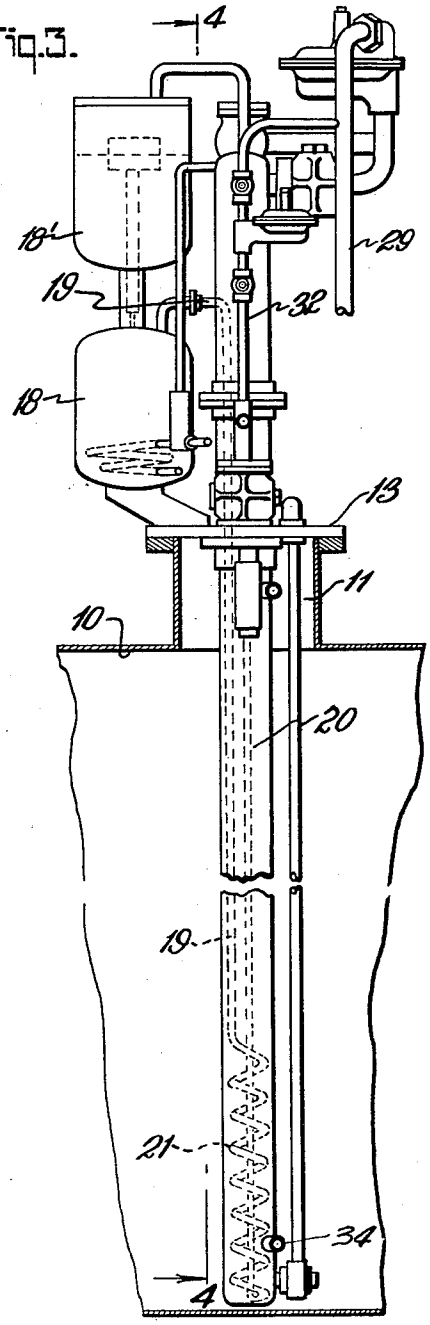


Fig. 3.



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METHOD OF AND APPARATUS FOR HEATING AND VAPORIZING LIQUIDS

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Application January 2, 1934, Serial No. 704,910

20 Claims. (Cl. 257—1)

This invention relates to a method of controlling pressures and flow of fluids, and apparatus for use in connection therewith, and more specifically to a method and apparatus for maintaining the vaporization from a liquid under varying conditions.

In general it is an object of the invention to provide a device of the character described, which will efficiently perform the purpose for which it is intended, which is simple and economical of construction, which can be expeditiously, conveniently and safely manipulated, and which can be readily manufactured and assembled.

Another object of the invention is to provide a method whereby fluids may be utilized directly from bulk storage without first transferring a portion of the fluid to an intermediate container for treatment and to provide such a method whereby the attendant physical conditions such as pressure, temperature, and volume may be automatically controlled without hazards, connected with temperature and pressure, for example, arising in the bulk storage container itself.

Another object is to elevate automatically the temperature of fluids or of a portion of a bulk of fluid and to supply thereto in whole or in part the required amount of the latent heat of vaporization.

Another object of the invention is to provide a method of obtaining a predetermined quantity of vapor from a liquid at a predetermined pressure under varying atmospheric conditions; to do so when the atmospheric temperature is at a point where the vapor pressure of the liquid is low; to do so when the temperature suddenly drops to such a low point; to do so satisfactorily with the same equipment after the atmospheric temperature has returned to normal from a lower temperature; and to do so when the main body of liquid is relatively large; and to obtain the above results automatically.

Another object is to provide a method and apparatus for treating a material by means of an intermediary agent under conditions where it would be dangerous to use the primary agent; and to accomplish this by using and reusing the secondary agent.

Another object is to provide a method for heating a portion of the material in a relatively larger container by inserting heating apparatus into a part of the container which is to some extent separated from the remainder of the container.

Another object is to provide a method and apparatus for heating an enclosed tank of liquid and withdrawing the vapor whereby the apparatus may be readily inserted and removed from an opening on the top of the tank.

Another object is to provide a method and apparatus for using material remaining in the main-line inlet to a tank.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation and order of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a view in elevation of the device embodying one form of the invention;

Fig. 2 is a view in elevation of the device shown in Fig. 1, taken along the lines 2—2;

Fig. 3 is a view in elevation of a modification of the device shown in Fig. 1; and

Fig. 4 is a view in elevation of the device shown in Fig. 3, taken along the lines 4—4.

Various fluids are used for one reason or another, the boiling points of which fall within the range of possible outdoor temperatures. When the atmospheric temperature is above the boiling point a fluid may be kept in a tank and may be drawn off as a gas or vapor at will. When the temperature is below the boiling point for ordinary pressures it is necessary, when the gaseous phase is desired, to supply extra heat of vaporization.

In case the supply of liquid is fairly large and it has a relatively high specific heat and the general temperature has unexpectedly been below the boiling point for several hours, it would require considerable time to heat the entire amount of liquid to its boiling point. The present invention is directed to a method and apparatus for heating such a quantity in such a way as to make the desired supply of vapor immediately available.

For example, butane in the gaseous phase is being utilized at the present time as a combustible. It boils at about 32° Fahrenheit. It may therefore be kept in a tank outside a manufacturing plant during the greater part of the year

and the vapor drawn off at will. There are occasions when the temperature may fall below 32° Fahrenheit and it then becomes necessary to heat the butane.

Combustible fluids must be kept in tanks which can be inspected thoroughly. The underwriters and various civil authorities make this requirement. It is accordingly, highly desirable that the mechanism operating upon the contents of the tank be entirely removable. The present device is constructed so that it may be removed from the tank.

While it might be possible to insert steam coils directly into a tank of material, it is not practical. There are many occasions when water might be retained in the coils causing the latter to rupture by freezing. The danger from a cracked coil containing live steam in a tank of butane is apparent, and the presence of water in butane will freeze up regulating equipment. In this invention the heating agent, which is introduced into the tank, has a freezing point below normal atmospheric temperatures and there is therefore no danger of its freezing. Such a material is hexane. Steam, as a usual heating agent, is used outside of the tank to heat the hexane.

A method is described below, together with one form of apparatus adapted to be used therewith, whereby a small quantity of heating agent which may be called an intermediate heating agent, is used over and over again. The method incorporates the concept of using the heat given off during condensation of the intermediate heating agent to vaporize the material in the tank and of using the pressure of the gasified part of the agent to force the condensed part of the agent out of the tank so that the condensed agent may be used again.

Butane, hexane and steam will be used as examples hereinafter of a material to be heated, an intermediate heating agent and the main heating agent respectively. It will be understood, of course, that other materials may be used having similar properties and similar property relationships.

The materials used in place of the butane and hexane may be hydrocarbons. If the material to be heated is eventually to be burned it is convenient that the intermediate heating agent also be inflammable so that a leakage of the latter into the former will not destroy the former's usefulness. Materials normally volatile may be used to advantage.

In the drawings, 10 denotes a vessel or container or tank for the butane, which is to be heated, and having an opening or manhole 11. An inlet pipe 12 passes through the opening cover 13 and is provided with a shut-off valve 14 on the outside of the cover and a flow-check valve 15 on the inside.

Above the cover 13 is a pair of chambers 18 and 18'. A conduit 19 leads from the chamber 18 through the top wall of a tower 20, which extends into the tank 10, down into the bottom of the tower where it is arranged in a coil 21, back up out of the top of the tower and into the chamber 18'. The chambers and conduit contain hexane or an equivalent material. The term chambers signifies spaces predeterminedly located rather than of predetermined size as the chambers may be portions of the conduit system itself.

The bottom of the tower 20 communicates with the interior of the tank 10 through a valve 22, which may be regulated from outside of the tank. As shown, it is regulated by oil pressure through pipes 23.

Within each chamber 18 and 18' there are any suitable means for supplying heat to the hexane and means are provided for operating the heaters independently, at different times, and automatically. Thus there may be a steam coil 24 in each chamber both of which coils are supplied through a valve 25. The steam coils or equivalent heating means may be on the outsides of chambers. Steam is supplied to the coil in one of the chambers. The hexane in that chamber is vaporized and passes down into coil 21, where it gives up its heat to the butane in the tower 20 and is thereby condensed, the condensate being raised by the pressure of the hexane vapor into the other chamber. When the first chamber has been emptied and the second filled, the steam is shut off from the coil in the first chamber and turned onto the coil in the other chamber.

Various means such as float valves, etc. may be used to accomplish this but the following arrangement has been found to be particularly efficient. A vaporstat 26 closes an electrical circuit when the vapor pressure of the butane falls below a predetermined amount and the current operates a solenoid 27 which in turn operates the valve 25 and a motor and relay timer 28. The valve 25 turns the steam into one coil 24 and the timer 28 after the proper period of time, operates the solenoid and valve 25 again to shift the steam to the coil 24 in the other chamber. The time period is, of course, calculated in accordance with the temperature of the steam and the temperature and quantity of the hexane. The timer continues to send the steam first into one chamber and then into the other until the butane vapor pressure is sufficient to shut off the vaporstat. A thermostat or other device might replace the vaporstat.

An outlet pipe 29 extends away from tower 20, and may have a pressure governor 29' associated with it. Between pipe 29 and the interior of the tank 10 there may be another pipe 30 in which there is a pressure differential valve 31. The latter may take the form of an inverted U having a mercury seal. If the pressure in the tower 20 becomes greater than a predetermined amount the butane vapor is shunted from the outlet pipe 29 back into the tank 10, through valve 31 and pipe 30, where it gives up its heat of vaporization to the main body of cold liquid butane. In this manner, when the atmosphere and tank 10 undergo an unexpected decrease in temperature, the supply of butane vapor is immediately maintained by the heating of the butane in the tower and any excess heat from the steam is applied to the raising of the temperature of the entire quantity of butane.

The pressure differential valve has another function. When the atmosphere and the tank 10 are at an increased temperature, there will be an increased pressure in the tank. If a large quantity of butane vapor is withdrawn from the tower 20 the pressure in the tower is decreased. The resultant pressure difference tends to raise the liquid level in the tower. The pressure-differential valve permits, under these conditions, the butane vapor to pass directly from the tank 10 to the outlet pipe 29, through flow-check valve 15', pipe 30 and valve 31.

In case the inlet pipe 12 goes for a considerable distance, to a railway siding, for example, it may be heated by the sun. If it is closed at the far end and if the valve 14 is shut, an un-

desired high pressure may develop in the inlet pipe. A bleeder line 32 connects the inlet pipe with the outlet pipe 29 and has a pressure valve 33 therein.

The various parts and connections are made detachable so that the chambers, the piping and the entire tower may be removed as a unit from the manhole, or the parts may be separated so as to take away as a unit the chambers, the steam coils and the hexane coil leaving the tower in place.

There may be one or more pipes 34 leading out of and back into the tower 20 within the tank 10. These act as fins to heat the material adjacent the tower on the outside thereof.

Flow-check valves 15 and 15' on the inlet pipe 12 and the pipe 30 leading to the outlet pipe 29 are positioned just within the manhole. These do not disturb normal flow but if any of the superstructure is broken by chance, they serve to prevent the contents of the main tank from blowing off.

Figs. 3 and 4 show a modification of the device described above. In this modification the chambers 18 and 18' are placed one above the other with a steam coil only associated with the lower one. After the hexane has been vaporized in the latter, passed into the tank coil, been condensed, and forced into the upper chamber so that there is a predetermined amount in the upper chamber, any suitable valve arrangement may cause the hexane to be dropped into the lower chamber so that the cycle may be repeated. In this case the steam is maintained in the single steam coil until the proper pressure is attained in the tower 20. The chambers may, with the necessary valve changes, be on the same level. The one chamber, in this form of the invention, is a place where the heating agent may be reheated and the other chamber is merely a part of the return conduit system.

From the foregoing description, the method of maintaining a continued supply of vapor from a large liquid supply which has been unexpectedly chilled, will be clear. The construction and operation of a device which will carry out this method is evident from the preceding paragraphs.

The operation of the device is as follows:

Should the temperature in the tank 10 fall to such a degree that the vapor pressure of the liquid is low, and particularly if it should fall to that temperature suddenly so that an inconvenient amount of heat would be required to raise the contents of the entire tank immediately to a temperature sufficient to give a proper vapor pressure, the entire device, including the chambers 18—18' and the tower 20, may be inserted through the manhole 11. This is especially simple where electrical coils are used in place of the coils 24. The only other connection in that case which is necessary is the electrical connection. Or, if the device is already in position and at any event when it is in position, the vaporstat 26 closes the electrical circuit due to the low vapor pressure of the material within the tank 10, and the current operates the solenoid 27, which, in turn, operates the valve 25, and the motor and relay timer 28. The valve 25 turns the steam, if that is to be the source of heat, into one of the coils 24. The hexane in the respective chamber 18, say, is vaporized and passes down into the coil 21, where it condenses and gives up its heat to that portion of the material in the tank 10 which is enclosed in the tower 20. The further vapor pressure in the chamber 18 raises the condensed hexane from the coil 21 into the other chamber 18'. After the proper period of time has elapsed for using a sufficient quantity of the hexane from the chamber 18, the timer 28 operates the solenoid and valve 25 to shift the steam to the coil 24 in the other chamber 18'. The process then continues whereby the hexane continuously gives up its heat to the material surrounding the coil 21.

Should more of the material in the tank 10 be vaporized so as to pass out of the outlet pipe 29 than it is desired to use, the pressure governor 29', associated with the outlet pipe 29, comes into play. The excess vapor by its pressure passes through the pressure-differential valve 31, which is shown as an inverted U-tube having a mercury seal, and back into the main body of the tank 10, whereby the excess heat is utilized in raising the general temperature of the entire tank.

Should the temperature of the entire tank be somewhat higher and should a large quantity of the butane vapor be withdrawn, there might be a resultant pressure difference tending to raise the liquid level in the tower. The pressure-differential valve under these conditions permits the butane vapor to pass directly from the tank 10 to the outlet pipe 29.

Since certain changes in carrying out the above process and in the constructions set forth, which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described our invention what we claim as new and desire to secure by Letters Patent is:

1. In a device of the character described, in combination, a containing system for a heat-transferring medium, means for adding heat to said medium at a plurality of spaced portions of said system, said system having a surface spaced from said portions and adapted for removing heat from said medium, and means adapted for controlling the addition of heat whereby heat is added to only one portion of said system at any one time.

2. In a device of the character described, in combination, a containing system for a heat-transferring medium, means adapted for gasifying said medium at one point in said system, means for absorbing and utilizing the heat given off during the condensation of said medium at another point in said system, means for receiving the condensed medium at a third point in said system, and means for gasifying said medium at said third point.

3. In a device of the character described, in combination, a containing system for a heat-transferring medium, means for absorbing the heat given off during condensation at a relatively low portion of said system, means for developing gaseous pressure in one portion of said system whereby the condensate may be forced up from said low portion into a third portion, and means for developing gaseous pressure in said third portion whereby the condensate may be forced up from said low portion into said one portion.

4. Apparatus for heating the contents of a vessel from above, comprising means providing

a plurality of chambers, means for conducting material between said chambers and adapted for extending down into said vessel, and means for heating said material in one chamber at one time and in another chamber at another time.

5. Apparatus for heating a portion of the contents of a vessel from above, comprising means providing a plurality of chambers, means for conducting material between said chambers and adapted for extending down into said vessel, means for heating said material in one chamber at one time and in another chamber at another time, and means separating that portion of said contents adjacent said conducting means from the remainder of said contents.

6. Apparatus for heating the contents of a vessel from above, comprising means providing a plurality of chambers, means for conducting material between said chambers and adapted for extending down into said vessel, and means for heating said material in one chamber at one time and in another chamber at another time, all of said means being removable as a unit from the vessel, the contents of which are to be heated.

7. Apparatus for heating a portion of the contents of a vessel, comprising means providing a plurality of chambers, means for conducting material between said chambers and adapted for extending into said vessel, and means for heating said material in one chamber at one time and another chamber at another time, an outlet for said portion of said contents and leading away from said vessel, connecting means between said outlet and the said vessel, and a pressure-differential valve in said connecting means which is adapted for permitting flow to whichever side has a pressure lower by a predetermined amount.

8. In a device of the character described, in combination, containing means, means for separating off a portion of the space enclosed, means adapted for heating said portion, a passage between said portion and remainder of said space, an outlet from said portion and leading away from said containing means, connecting means between said outlet and said remainder, valve means in said connecting means and adapted for permitting flow to whichever side has a pressure lower by a predetermined amount.

9. In a device of the character described, in combination, containing means, means for separating off a portion of the space enclosed, a passage between said portion and the remainder of said space, an outlet from said portion and leading away from said containing means, conduit means adapted for conducting material into said containing means, and adapted to be closed at a point remote from said containing means, valve means in said conducting means adjacent said containing means, a conduit from a point in said conducting means between said valve means and said remote point.

10. Apparatus for heating the contents of a vessel from above, comprising means providing a plurality of chambers, means for conducting material between said chambers and adapted for extending down into said vessel, means for heating the material in one of said chambers, and means outside of said vessel for conducting material from the other of said chambers to said one chamber.

11. A method of heat transfer, comprising heating a transfer medium from a source of heat, passing said medium through material to be heated, heating said medium from another heat source and passing said medium back through said material to said first source.

12. A method of heat transfer, comprising vaporizing a transfer medium by contact with a heat source, passing said medium through material to be heated and under conditions to condense said medium, forcing said condensed medium by the pressure of said vapor into contact with a potential heat source, making said later source an actual source by supplying heat to said later source and shutting heat off from said first source, vaporizing said medium by contact with said second source, and passing said medium through said material thereby condensing said medium.

13. A method of securing, in appreciable amounts, vapor from a relatively chilled, relatively large quantity of liquid comprising enclosing a portion of said liquid within the remainder of said liquid, heating said portion and returning to said large amount any undesired excess of the vapor arising from said portion.

14. The method comprising gasifying a relatively small amount of a volatile liquid, conducting the gas down into a relatively large volume of a second volatile liquid, transferring continuously the heat of vaporization of said gas to said second liquid, and moving the condensate thereby formed from said gas upward out of said second liquid at substantially the same rate at which said condensate is formed, and repeating the process by reusing said first liquid.

15. In combination, a container, means adapted for heating a heat transfer agent, means for transferring heat from said agent to the material in said container, and means responsive to the pressure in said container for regulating said heating means.

16. Apparatus for heating the contents of a vessel from above comprising means providing a chamber above said vessel, means for heating the material in said chamber, means adapted for conducting said material from said chamber down through the top of and into said vessel, and means adapted for conducting said material back through the top and out of said vessel to said chamber, all of said means being removable away from said vessel.

17. Apparatus for heating the contents of a vessel from above comprising means providing a chamber above said vessel, means for heating the material in said chamber, means adapted for conducting said material from said chamber down into said vessel, and for conducting said material back to said chamber, and means responsive to the pressure in said vessel and adapted for regulating said heating means.

18. The combination with a container, of heating means therefor, including conduit means extending downward into the container and providing a flow path comprising two portions connected to one another within the container and each extending upwardly out of the container, and means to which said portions are connected externally of said container for supplying to one of said portions vapors condensing at a temperature above that in the container to one of said portions, and for removing the condensate formed in the last mentioned portion from said vapors through said other portion.

19. The method of heating the contents of a chamber which consists in moving a fluid heating agent condensing into liquid form at a temperature above that of said contents along a path including a first portion extending downward into the container, and a second portion communicat-

ing with the first portion within the container and extending upward out of the latter by passing said agent into said first portion in the form of vapor under pressure sufficient to expel the condensate formed therein into said second portion.

20. In heating a container, the method which consists in moving a fluid heating agent condensing into liquid form at a temperature above that existing in said container along a path including a first portion extending downward into said chamber and a second portion communicating with the first portion within said container and extending upward out of the latter, by vaporizing said agent, and passing the vapors formed into said first portion, and condensing them therein and withdrawing the condensate thereby formed through said second portion.

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