April 25, 1939. M. E. FIENE 2,156,053

VAPOR HEAT TRANSFER SYSTEM

Filed April 24, 1937

Fig. 1.

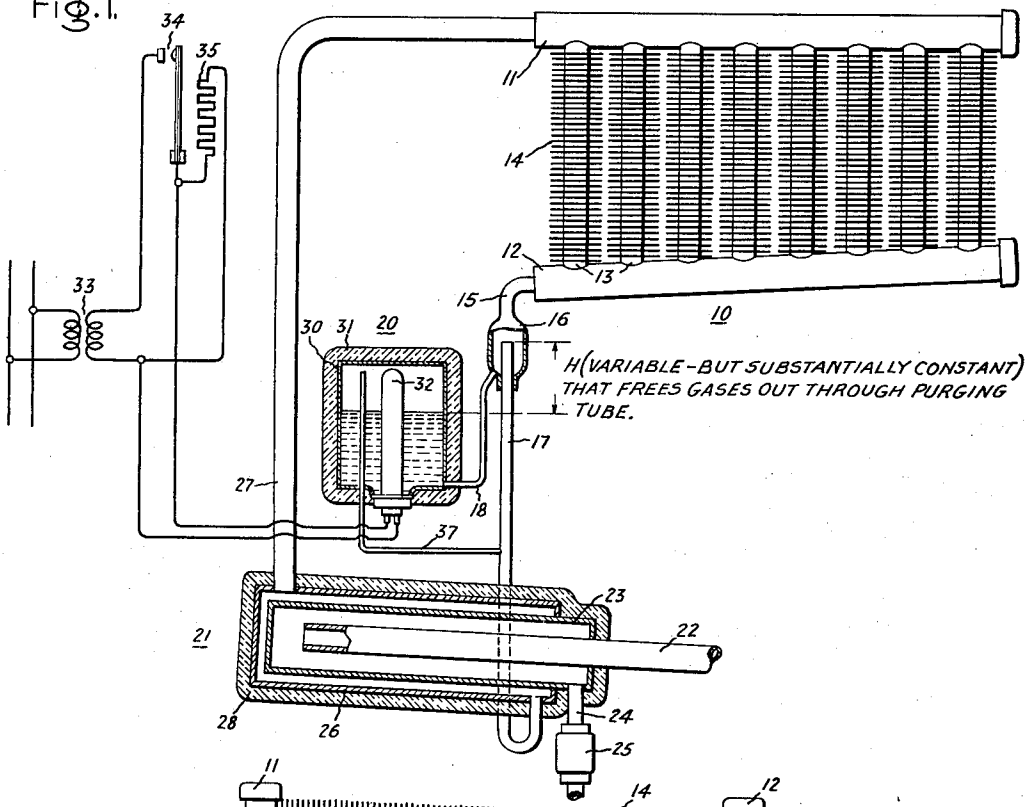
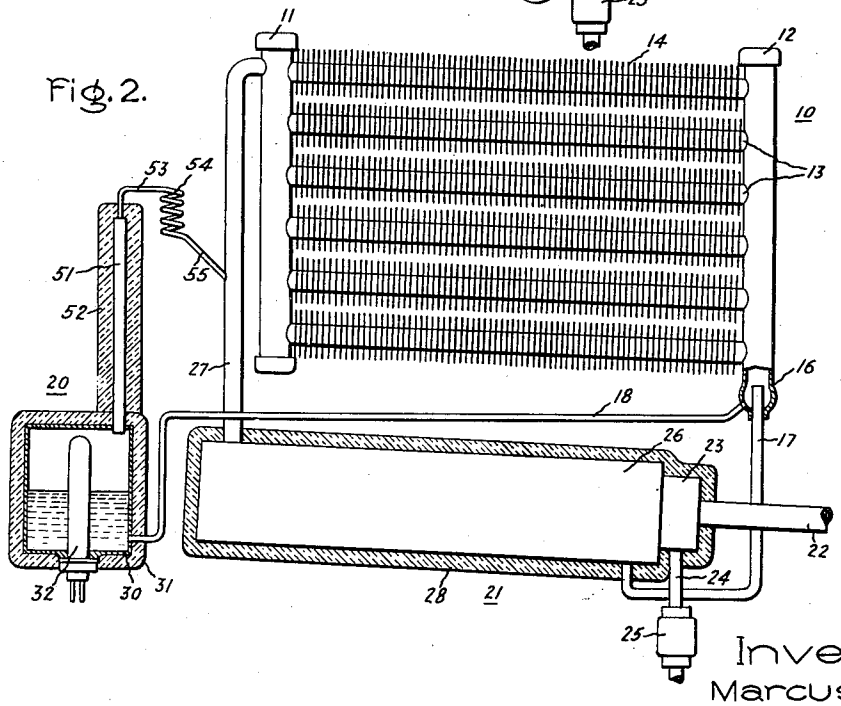


Fig. 2.



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Patented Apr. 25, 1939 2,156,053

UNITED STATES PATENT OFFICE

2,156,053

VAPOR HEAT TRANSFER SYSTEM

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Application April 24, 1937, Serial No. 138,790

8 Claims. (Cl. 237—2)

This invention relates to the transfer of heat, particularly by the vaporization and condensation of fluid, and provides improvements in systems of the type disclosed in my application Serial No. 25,691, filed June 8, 1935.

In the aforesaid application there is disclosed a substantially evacuated vapor heat transfer system provided with a thermostatic modulating control whereby heat is transferred from a primary source to an enclosure or the like at variable rates to maintain the enclosure at a predetermined substantially constant temperature level. The system consists of a condenser-radiator in heat transfer relation to the enclosure, a vaporizer, and a liquid control chamber of a capacity in excess of the amount of liquid in the system and provided with a pilot heater adapted when energized to expel liquid from the chamber into the vapor transfer system.

The heat transfer system is evacuated of substantially all noncondensable gases and is thereafter filled with an amount of suitable vaporizable liquid such as water, alcohol or the like sufficient to insure utilization of the entire heat transfer surface of the vaporizer under maximum heat transfer conditions. The energization of the pilot heater is controlled in response to temperature variations within the enclosure and the liquid expelled from the chamber is always automatically proportioned to the proper amount to maintain the enclosure temperatures substantially constant.

The condenser surface is subject to widely varying heat dissipating conditions and the amounts of liquid expelled from the control chamber into the vapor heat transfer system varies so that the transfer of heat always occurs at a rate to maintain the condensing surface substantially the same as the temperature of the fluid in the control chamber. In other words, the iproved heat transfer system automatically operates to establish a thermal equilibrium and also a hydrodynamic equilibrium in which the vapor condensing upon the condenser surface is immediately returned to the vaporizing surface and revaporized with the amount of wetted surface of the vaporizer always just sufficient to effect the transfer of heat from the source at the rate required to equalize the temperature of the condenser surface with that of the fluid in the control chamber.

After exhausting and charging the vapor heat transfer system there inherently remains in the system some small amount of noncondensable gas, usually air. The amount of residual gas may be reduced to a practical minimum by baking or the like during the exhausting process. This residual gas may collect in the remote portion of the radiator-condenser where it has little effect on the operation. However it may collect in the liquid control chamber and thereby disturb the pressure balance in the system so that heat is transferred even when none is required. This undesirable heat transfer results from the fact that the collection of the noncondensable gases in the control chamber exerts a pressure on the liquid therein even when the pilot heater is deenergized so that a small portion of the liquid is expelled into the heat transfer system and is effective to transfer heat.

The primary object of this invention is to provide an improved vapor heat transfer system in which any residual non-condensable gases are automatically and continuously purged from the liquid control chamber during operation of the system.

Briefly, this object is accomplished by providing a restricted purging conduit connecting the upper portion of the liquid control chamber to the vapor heat transfer system. The conduit is made small enough to enable the pilot heater to build up a vapor pressure within the chamber sufficient to expel liquid into the system but not too small to prevent an unobstructed, although restricted, flow of gases and vapors from the control chamber into the system.

Another object of my invention is to utilize the flow of vapor through the purging conduit to further increase the purging action. This object is accomplished by having a portion of the purging conduit act as a condenser and utilizing the head of liquid condensed therein to provide the desired flow of noncondensable gases.

A further object is to dissipate substantially all the heat from the control chamber by means of the purging conduit and thereby enable a more accurate and reliable control to be obtained.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In the drawing, Fig. 1 illustrates diagrammatically, partly in section, a first modification of the invention, and Fig. 2 illustrates in similar fashion a second modification of the invention in which the control chamber and vaporizer are substantially on the same level.

In Fig. 1 the condenser-radiator 10 for heating either directly or indirectly the air in a room or

enclosure is suitably formed of a pair of tubular headers 11 and 12 connected by a series of substantially vertical condensing columns 13 provided with fins 14 to facilitate dissipation of heat from the radiator to the air. The bottom header 12 forms an outlet for condensed vapor and it is preferably sloped so as readily to drain the condensate into the condensate receiving tube 15. The latter is formed with a downwardly extending bulbous portion 16 which forms, with a conduit 17 extending upwardly therein, a condensate receiving cup or trap connected by a conduit 18 to a control chamber 20 to be described more in detail after a description of the vaporizer 21 to which the conduit 17 is connected.

The vaporizer slopes downwardly and has extending thereinto an open-ended conduit 22 connected to a suitable source of steam. The vaporizing surface is formed of a substantially cylindrical heat conducting member 23 into which the steam inlet 22 extends. The condensed steam flows from the vaporizer through a condensate return line 24 having placed therein a steam trap 25, of any well known construction, preventing the flow of live steam from the vaporizing chamber. The vaporizing surface is partially surrounded by a second cylindrical body 26 spaced apart and offset from the vaporizing surface 23 whereby the latter may be readily contacted by the condensate of the secondary system. Condensate is supplied to the vaporizer through conduit 17 which is connected to the lower end of cylinder 26 and vapor is led from the vaporizer through conduit 27 to the inlet header 11 of the radiator-condenser 10. The vaporizer is substantially entirely covered by heat insulating material 28 for the purpose of cutting down the heat losses from the vaporizer.

The closed liquid control chamber 20 is located remotely from both the vaporizing surface of the vaporizer 21 and the condensing surface of radiator 10 and is positioned at a level intermediate the two. The remote location serves to minimize the transfer of heat between the control chamber 20 and the main heat transfer system consisting of the vaporizer 21 and the condenser-radiator 10. The liquid conduit 18 connecting the control chamber with the vaporizer-condenser-radiator system extends downwardly from the liquid trap 16 to the bottom of a liquid containing chamber 30 forming part of the control chamber. Chamber 30 is substantially surrounded by suitable heat insulating material 31.

An electrical heating unit 32 of the cartridge type is mounted inside of and in sealed relationship with the liquid containing chamber 30. The electrical heating unit is of relatively small capacity and is energized at low voltage from the secondary of a transformer 33 directly under the control of a thermostatic switch 34, as only the wattage of an ordinary electric lamp bulb is required. The thermostatic switch operates in response to variations in the temperature of the enclosure being heated by the condenser-radiator in which the air is to be maintained at a substantially constant predetermined temperature by regulation of the temperature of the condenser-radiator 10. Associated with the thermostatic switch 34 is an auxiliary local source of heat such as the resistor 35 which is energized concurrently with the cartridge heater 32. The purpose of this auxiliary heater is to increase the frequency of operation of the system in a manner hereinafter to be described.

The continuous self-purging means of the present invention consists of a relatively small diameter conduit 37 compared to the larger diameter of conduit 18 and interconnecting the upper unfilled portion of the liquid control chamber 20 with the condensate return conduit 17, at a point below the level of the control chamber. The conduit 37 provides a path for the noncondensable gases collecting in the control chamber so that they may enter the heat transfer system. The control chamber 20 is positioned at a lower level than the liquid trap so that when the trap is filled up to the level of the conduit 17 there is a liquid head of a height H existing between the level of the liquid in the trap and the level in the control chamber. A variable head H is present whenever the system is in operation at which time there is a flow of condensate to the vaporizer through conduit 17 and it acts as a pressure creating head for forcing the noncondensable gases from the unfilled portion of the liquid control chamber through conduit 37 into the conduit 17 and thereby effectively purges the control chamber continuously and automatically at all times. This operation will be more apparent from the following description of the operation of the system as a whole.

The parts of the vapor heat transfer system and the control chamber herein above described are preferably all joined together and hermetically sealed by welding or brazing so that a vapor-tight heat transfer system is obtained. This entire system is then evacuated of substantially all the noncondensable gases by any suitable means (not shown or described). Thereafter a predetermined charge of suitable vaporizable fluid, such as water, alcohol or the like, is introduced into the closed system. The amount of this liquid charge is such as to insure that the entire effective heat transfer surface of the vaporizing surface 23 may be effectively wetted under maximum heat transfer conditions. Ordinarily this condition may be obtained when the volume of the liquid charge is substantially less than the capacity of the liquid container 30. This insures that substantially all of the liquid in the system can be withdrawn into the control chamber 20 and thereby practically stop the transfer of heat from the steam chest 23 to the radiator 10 whenever required. Since the system is evacuated and charged with a vaporizable fluid, some extremely small portion of this fluid will, of course, remain in the vapor phase at a pressure corresponding to the temperature of the condenser-radiator. However, since this vapor does not condense, practically no heat transfer can occur. Whenever the temperature of the liquid in the control chamber 20 is raised then liquid is expelled therefrom into the vaporizer to effect transfer of heat.

In operation when the temperature of the air in the enclosure falls below the predetermined value at which the thermostatic switch 34 is set to operate the thermostat closes its contacts thereby energizing the pilot heater 32 and the auxiliary heater 35 from the secondary winding of the transformer 33. The wattage input of the electrical pilot heater is made such that under ordinary ambient air conditions heat will be imparted to the control chamber at the proper rate to effect the vaporization of a small portion of the liquid therein required to generate a vapor pressure sufficient to expel substantially all of the liquid from the chamber in a predetermined time interval, such for example, as fifteen or twenty minutes. Thus, as soon as the tempera-

ture of the liquid in the chamber 20 is raised due to the heat input of the pilot heater a small portion of the liquid is at once vaporized. This creates an excess vapor pressure, equivalent to head H above the liquid in the control chamber that is effective to force liquid from the bottom of chamber 30 through the tube 18 into the condensate return trap 16. As soon as the level in the trap 16 rises above the open end of the conduit 17 the expelled liquid immediately flows downwardly into the vaporizer 21 and into contact with the vaporizing surface 23. The surface of the vaporizing tube is wetted and the liquid immediately absorbs heat and is vaporized so as to be subsequently condensed at the radiator 10 to which it flows through conduit 27. The resulting increase of vapor pressure in the radiator 10 retards or even momentarily stops the further supply of liquid from the control chamber. However, as the temperature of the liquid in the control chamber 20 continues to increase due to the heat input of the pilot heater 32 an additional amount of liquid is vaporized therein and as a result more and more of the liquid is expelled into the vaporizing system. As the rate of heat transfer from the source of primary steam through the vaporizing surface 23 to the radiator 10 varies with the amount of liquid effective to wet the vaporizer surface the heating action of the radiator 10 upon the ambient air of the enclosure is rapidly increased as more and more of the liquid becomes effective to wet the vaporizing surface. Consequently, the temperature of ambient air to which the thermostat 34 is responsive increases. When the temperature is reached at which the thermostat is set to open its contacts the pilot heater and the auxiliary heater become deenergized. As a result further input of the heat to the liquid remaining in the chamber 20 is stopped.

During this process the temperature of the condensing surface of the radiator 10 at all times corresponds substantially to the temperature of the fluid in the control chamber 20. Thus when the input of the heat to the chamber is stopped and the temperature of the control chamber begins to decrease due principally to the transfer of latent heat by vapors passing through the purging tube and also to the dissipation of heat through the insulation to the air surrounding the control chamber, the vapor pressure within the chamber decreases. This allows a part of the vapor condensing in radiator 10 and draining into the conduit 15 to reenter the control chamber 20. As the temperature of the liquid in the control chamber continues to decrease more and more of the liquid is withdrawn from the vapor system.

Preferably the control chamber and the purging tube are so proportioned and designed that the rate of heat dissipation under normal conditions will reduce the temperature of the chamber to substantially room temperature in a period of approximately fifteen or twenty minutes. In other words, the cooling time of the chamber 20 is made to correspond roughly to the heating time in order to provide the best conditions for modulated heating control operation by the thermostatic switch 34.

When the time of response of the thermostatic switch 34 is varied and made appreciably less than the heating and cooling time of the control chamber 20, as by means of the preheat coil 35 energized concurrently with the pilot heater, substantially modulated heating control of the enclosure results from the intermittent action of the thermostat. If the thermostat is made quickly responsive to an increase or decrease in the temperature of the ambient air in the enclosure and the heat input of the pilot heater is started and stopped at relatively frequent intervals, then, due to the intermittent heating action as well as the heat storage capacity of chamber 20, the temperature of the liquid in the chamber is practically maintained at an average vaue which varies only slightly from the desired predetermined temperature value. The temperature of the radiator-condenser 10 is thus maintained at a corresponding average value such as is required to maintain the ambient air in the enclosure substantially at the predetermined temperature value determined by the setting of the thermostat.

If, during the normal operation of the vapor heat transfer system the noncondensable gases collect in the upper unfilled portion of the liquid control chamber 20 and no provision were made to purge them therefrom, the action of the heat transfer system would be deleteriously affected as previously explained. In order to overcome this objectionable collection of noncondensable gases there has been provided the purging conduit 37 connecting the unfilled upper portion of the control chamber with the conduit 17. In case noncondensable gases collect in this upper portion they flow through conduit 37 through conduit 17 and are forced into the vapor heat transfer system. In operation the flow of noncondensable gases is dependent upon the head H of liquid which, under steady state conditions, exerts a continuous although variable pressure effecting purging of the gases as will be more obvious from the following description. When the heat transfer system is not in operation and is at ambient temperature the pressure within the control chamber and the condenser-radiator are equal and the vaporizable liquid in the control chamber and conduit 18 are at the same level. With the system in operation under substantially steady state heat transfer conditions there is always created a pressure within the control chamber which maintains the liquid in conduit 18 substantially level with the upper open end of conduit 17. Under these conditions the pressure in the condenser-radiator is equal to the pressure in the control chamber minus the pressure head H of the liquid in conduit 18. Likewise the pressure drop of the vapors passing through the purging conduit 37 must equal the value of the pressure head H. Therefore, the head H represents the excess pressure within the control chamber effective to create a flow of vapor and noncondensable gases to the condenser-radiator system through the purging conduit 37.

With the arrangement described above a continuous purging action always occurs when the system is in operation the rate of purging being dependent upon the head H. Under minimum heat transfer conditions the head H will be at a minimum value and under maximum heat transfer conditions the head H increases to its maximum value due to variations in the level of the liquid in the control chamber. Under these variable conditions there is continuous purging but at different pressure differentials, the differential being dependent upon the head H effective to create flow of noncondensables and vapor from the control chamber into the condenser-radiator system.

It should be noted in Fig. 1 that the purging conduit extends downwardly from the upper portion of the liquid control chamber, through the

bottom of the latter and then substantially horizontally to the conduit 17. This construction substantially prevents any of the vapor condensed in the purging conduit from opposing the free flow of noncondensables and vapor through the conduit.

The modified construction disclosed in Fig. 2 is particularly advantageous where the condensate trap must be located only slightly above the level of the vaporizer due to space limitations. In this modified construction it may be noted that the headers 11 and 12 are vertically disposed and the condensing columns 13 are horizontally disposed. The condensate trap 16 is formed by extending the conduit 17 upwardly within the expanded lower portion of the outlet header 12. The liquid conduit 18 extends downwardly from the trap 16 to the control chamber 20 which, in this modification, is located substantially on the same level as the vaporized 21 in order to meet space limitations. The vaporizer is supplied with steam through the steam inlet 22 and the condensed steam flows out through the condensate outlet 24 and steam trap 25. The vaporizer comprises the steam condensing surface 23 and the partially offset cylindrical portion 26 forming therewith a vaporizing chamber. The vapor flows from the vaporizer to the inlet header through a conduit 27 just as in the previously described modification.

The control chamber 20 consists of a liquid containing chamber 30 surrounded by insulating material 31. Within the container is poistioned a cartridge heating element 32 adapted to be controlled in the same manner as the cartridge or pilot heater of Fig. 1. For sake of convenience the control and energizing circuit for the pilot heater have been omitted from Fig. 2.

The purging conduit in the present modification consists of a substantially large diameter conduit 51 extending upwardly from the top of the liquid control chamber 30 and surrounded by heat insulating material 52. The upper end of the tube 51 is connected to a comparatively small diameter purging tube 53 provided with a downwardly extending convoluted portion 54 and a further downwardly extending straight portion 55 leading to the vapor conduit 27.

The primary distinction between the two modifications lies in the change in the construction of the purging means necessitated by the location of the liquid control chamber at the level of the vaporizer and the utilization of the condensation of vapor in the purging conduit for providing an additional pressure head for obtaining a better purging action. In some installations it is necessary because of space requirements, to place the control chamber at the level of the vaporizer, as illustrated in Fig. 2. By constructiong the purging conduit as illustrated restriction of flow resulting from condensation in portion 54 of the conduit is avoided and in fact, the condensate is utilized to provide a better purging action.

In operation the vapor in the liquid control chamber fills not only the control chamber proper but the large diameter tube 51 as well and, under substantially steady state operation the vapor and the noncondensable gases are forced therefrom into the purging conduit 53—54—55. Since the latter extends downwardly from the top of conduit 51 and provision is made for condensing any vapor in the purging conduit the head of condensed liquid is added to the head H available for creating a purging action. Thus the condensed liquid head in the purging tube amplifies the purging action by a certain amount dependent upon the condensation of vapor in the purging conduit.

It is obvious that the control chamber and purging conduit illustrated in Fig. 2 may be utilized with the condenser-radiator and vaporizer of Fig. 1.

In both modifications the vaporizer is illustrated as being made up of concentric cylinders 23 and 26. In actual practice it has been found better to offset these cylindrical portions and mount them eccentrically so that the distance between the two at the bottom is less than the distance at the top. This construction, is more effective in vaporizing the condensate supplied to the vaporizer through conduit 17 for the reason that even when small amounts of condensate are supplied it may be vaporized readily by the vaporizing surface 23 and the volumetric expansion upon vaporization is more readily taken care of by providing a greater volume at the top of the vaporizer.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, an evacuated enclosure forming a fluid vaporizing and condensing heat transfer system, a liquid containing control chamber having a tube extending upwardly from the bottom thereof and provided with a trap connected with said enclosure, means for vaporizing liquid in said control chamber to expel liquid therefrom through said tube and trap to said enclosure, and a restricted tube connected between said control chamber and said enclosure to be responsive to the hydrostatic head of fluid in said first tube and trap for purging said control chamber of non-condensible gases.

2. In an evacuated vapor heat transfer system, the combination of a condenser radiator, a vaporizer, vapor and condensate conduits interconnecting said radiator and vaporizer in a closed system, a liquid containing control chamber having a tube extending upwardly from the bottom thereof and provided with a trap communicating with said condensate conduit at a point above the level of the liquid in said chamber for draining liquid therefrom into said chamber, means for vaporizing liquid in said control chamber to expel liquid therefrom through said tube and trap, and a restricted conduit communicating between the top of said control chamber and said closed system to be responsive to the hydrostatic head of fluid in said tube and trap for purging said control chamber of non-condensible gases.

3. In a vapor heat transfer system, the combination of a condenser radiator and a vaporizer connected in a closed fluid circulating heat transfer system, a partially filled fluid containing control chamber having a tube extending upwardly from the bottom thereof above the level of the fluid in said chamber and provided with a trap communicating with said closed system at a point above the level of the liquid in said control chamber to drain condensate therefrom into said chamber, means for vaporizing fluid in said chamber to expel fluid therefrom through said tube, and a restricted conduit connecting the upper portion of said chamber to said closed system and having a portion extending downwardly and responsive to the joint hydrostatic heads of the liquid condensing in said portion and of the liquid in said first mentioned tube for purging said control chamber of noncondensible gases.

4. In combination, a partially evacuated vapor heat transfer device having a condenser and a separate vaporizer with conduit means communicating therebetween, a condensate trap in said conduit means, a closed fluid containing control chamber located below the level of said trap and having a tube extending upwardly from the bottom thereof to said trap for draining condensate theerfrom, heating means for vaporizing a portion of the liquid in said control chamber to provide a pressure in said chamber for expelling liquid through said tube, said trap and said conduit means to said vaporizer, and a separate restricted tube communicating between the upper portion of said chamber and said conduit means for purging said chamber of noncondensible gas.

5. In combination, a partially evacuated vapor heat transfer enclosure having a condenser and a vaporizer interconnected to drain condensate from the condenser to the vaporizer and return vapor to said condenser and provided with a condensate trap below the level of said condenser and above the level of said vaporizer and intercommunicating therewith, a condensate collecting chamber connected in liquid exchange relation with said trap and located at a level below said trap, heating means for vaporizing a variable amount of the condensate in said chambber to provide a vapor pressure differential for controlling the exchange of condensate between said trap and chamber to regulate the amount of fluid in vaporizing and condensing fluid circulation between said condenser radiator and said vaporizer, and a restricted conduit communicating between the upper portion of said chamber and said enclosure and operable in response to said vapor pressure differential for purging non-condensible gas from said control chamber.

6. In combination, a partially evacuated vapor heat transfer enclosure having a condenser and a vaporizer connected in vaporizing and condensing fluid circulating relation and provided with a condensate trap for receiving condensate from said condenser-radiator and for supplying condensate to said vaporizer, a condensate accumulating chamber having a tube extending upwardly from the bottom thereof into communication with said trap for exchanging condensate therebetween, heating means for vaporizing a variable portion of the liquid in said control chamber to set up a pressure differential for regulating the exchange of condensate between said chamber and trap, and a conduit communicating with the upper portion of said chamber and having a downwardly extending portion for condensing vapor therein with the end thereof communicating with said enclosure below the level of condensed vapor in said downwardly extending portion and thereby setting up a condensate syphon action to purge said control chamber of non-condensible gas.

7. In combination, a partially evacuated vapor heat transfer enclosure having a condenser and a vaporizer located below the condenser and connected in vaporizing and condensing fluid circulating relation therewith, a trap connected between said condenser radiator and said vaporizer for receiving condensate from said condenser radiator and supplying condensate to said vaporizer, a condensate accumulating chamber located at substantially the same level as said vaporizer and having a tube extending upwardly from the bottom thereof into communication with said trap, heating means for vaporizing a variable portion of the condensate in said control chamber to set up a pressure differential for regulating the exchange of condensate between said chamber and trap, and means including a relatively large diameter tube extending upwardly from the upper portion of said chamber and a smaller diameter conduit connected with the top of said large diameter tube and extending downwardly into communication with said enclosure for providing syphon action of the vapor condensing therein to purge said control chamber of non-condensible gas.

8. In combination with a vapor heat transfer system evacuated of substantially all noncondensable gases and provided with condenser-radiator and a vaporizer connected in a closed vaporizing and condensing fluid circulating system by vapor and condensate conduits, a condensate trap in the latter conduit below the level of said condenser radiator and above the level of said vaporizer, a control chamber partially filled with a vaporizable medium and connected to said trap through a relatively large diameter conduit the level of medium in said chamber being substantially below the level of said trap, a relatively small diameter conduit connecting the unfilled portion of the chamber to the condensate conduit at a point below the trap and above the vaporizer, means adapted to create regulated pressures in said chamber for forcing regulated quantities of said medium into the system through said large diameter conduit and operable under steady state conditions to force vaporizable medium and noncondensable gases into the system tthrough the small diameter conduit while maintaining the supply of medium in the system substantially constant.

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