July 14, 1942. M. E. FIENE 2,289,879

HEAT TRANSFER SYSTEM

Filed Dec. 20, 1940

Fig. 1.

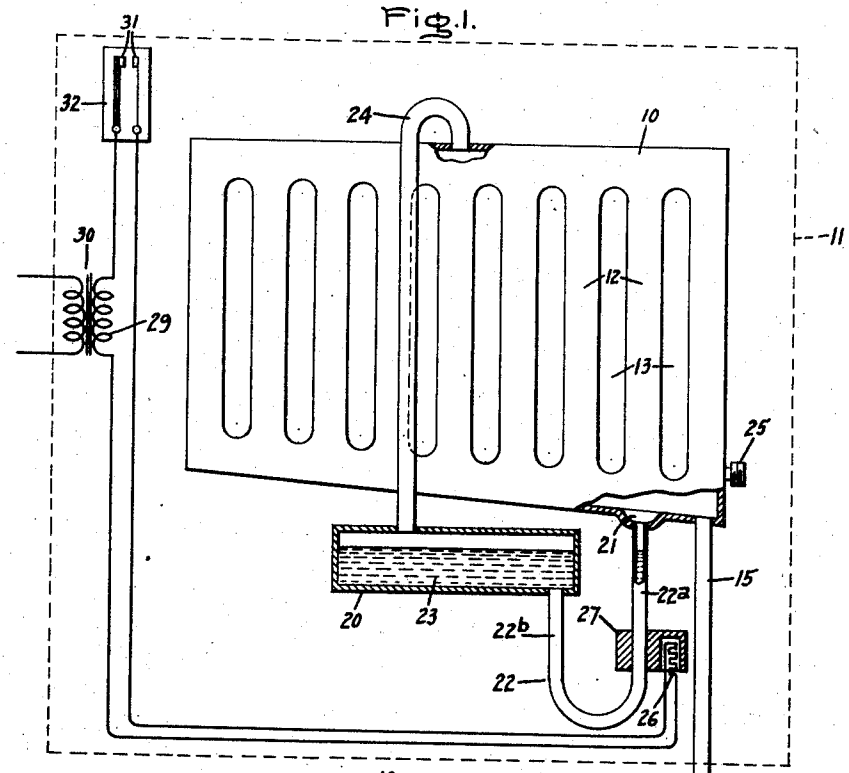
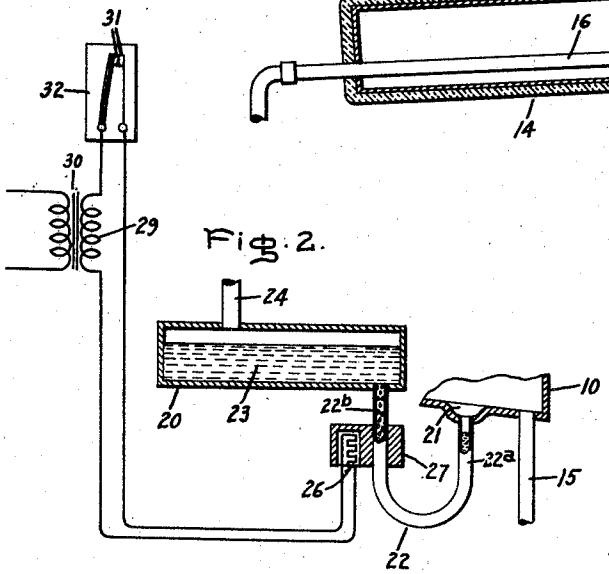


Fig. 2.



Inventor:
Marcus E. Fiene,
by Harry E. Dunham
His Attorney.

Patented July 14, 1942

2,289,879

UNITED STATES PATENT OFFICE

2,289,879

HEAT TRANSFER SYSTEM

Marcus E. Fiene, Caldwell, N. J., assignor to General Electric Company, a corporation of New York

Application December 20, 1940, Serial No. 371,022

9 Claims. (Cl. 237—2)

My invention relates to the transfer of heat, particularly by vaporization and condensation of fluid.

It is an object of my invention to provide a heat transfer system comprising fluid vaporizing and condensing elements having improved means for controlling the rate of heat transfer between the vaporizing and condensing elements.

It is a further object of my invention to provide an improved system for controlling the transfer of heat to maintain a predetermined temperature condition constant.

It is a further object of my invention to provide an improved static control capable of regulating the flow of heat from a source to a dissipating body without any moving parts such as valves, baffles or the like, and which may be readily controlled by a thermostatic mechanism.

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 a part of this specification.

Briefly, in carrying out the present invention in its preferred form, a circulating heat transfer system having a fluid vaporizing surface and a condensing surface in fluid circulating relation is connected to receive heat from a suitable source such as a steam supply main or the like. The amount of heat supplied to the condensing surface is varied by varying the amount of heat transfer fluid circulating between the vaporizing and the condensing surfaces. Variation in the amount of circulating heat transfer fluid, and consequently the rate of heat transfer between the condensing and vaporizing elements, is accomplished by means of a thermostatically controlled thermo-siphon device which effects an exchange of heat transfer fluid between a condensate accumulating reservoir or receptacle and a condensate trap which is located in the path of the condensate returning from the condensing surface to the vaporizer.

My invention will be better understood from the following description taken in connection with the accompanying drawing in which the Fig. 1 is a diagrammatic representation of one embodiment of my invention and Fig. 2 is a modification of the arrangement shown in Fig. 1.

For the purpose of illustrating a specific embodiment of my invention I have shown in Fig. 1 of the drawing a thermostatically controlled vapor heat transfer system comprising a condenser or radiator 10 for supplying heat to a medium, the temperature of which is to be controlled, confined within space indicated by the dotted lines 11. The radiator 10 may be formed of suitably pressed metal plates welded together to form a series of interconnected vapor condensing columns 12 with open air circulation passages 13 therebetween to facilitate the dissipation of heat from the radiator to the surrounding medium. A vaporizer 14 is located below the radiator 10 and is connected thereto by means of a conduit 15 which functions to conduct vaporized heat transfer fluid from the vaporizer to the radiator and to return condensate from the radiator to the vaporizer. If desirable a separate conduit may be provided for conducting the vapor from the vaporizer to the radiator.

The vaporizer is heated by suitable means which may be, as illustrated, a steam pipe 16 supplied with live steam from a source not shown. The steam pipe 16 extends through the vaporizer in heat transfer relation therewith and may be inclined slightly to assist in the return of the steam condensate to the source of supply. The usual air vent 17 is provided to assist in eliminating the noncondensable gases from the steam system. Preferably the vaporizer is covered with a suitable insulation or lagging material 18 to prevent undue loss of heat therefrom to the surrounding medium and is also slightly inclined, as shown, to assist in distribution of the vapor condensate over the heat transfer surface of the vaporizer.

To provide means for varying the amount of heat transfer fluid in circulation in a fluid circuit comprising the interconnected vaporizer 14 and radiator 10, and consequently the rate at which the radiator 10 supplies heat to the medium in space 11, a condensate accumulating receptacle 20 is connected by means of a siphon tube or conduit 22 to a condensate trap 21 located in the bottom wall of a radiator 10. The bottom wall of the radiator 10 is preferably inclined so that condensate, in returning to the vaporizer 14, will readily flow into the trap 21 and the conduit 15. The receptacle 20 is located slightly below the level of the condensate trap 21 so that condensate collecting in the trap will flow into the receptacle by gravity.

To cause the condensate to return from the receptacle 20 to the trap 21 and the vaporizer 14, a thermostatically controlled heating device is located in heat exchange relation with the fluid in leg 22a of the siphon tube for effecting a thermo-siphon pumping action. In the illus-

trated embodiment of my invention the heating device comprises an electrical heater 26 energized from a suitable source such as the secondary winding 29 of a step-down transformer 30. A block of heat conducting material 27 may be mounted on the siphon leg 22a for concentrating the flow of heat from the heater 26 to the siphon leg. The energization of the heater 26 is controlled by the contacts 31 of a thermostat 32 located in the space 11. When the heater 26 is energized it locally heats the fluid in leg 22a of the siphon 22 causing partial vaporization thereof so that the density of the fluid in leg 22a is less than that in the other siphon leg 22b whereby a differential of hydrostatic pressure is produced which forces the fluid in leg 22a upwardly into the trap 21 from which it overflows into the conduit 15 and passes downwardly to the vaporizer 14. This thermo-siphon pumping or percolating action produced by the heater 26 is very similar to the action of a percolating coffee pot.

To permit the free flow of condensate into and out of the chamber 20 through the siphon tube 22 a pressure equalizing venting tube 24 is provided which connects the upper portion of receptacle 20 to the radiator 10. The tube 24 acts to equalize the vapor pressures in the receptacle and the fluid circuit comprising the interconnected vaporizer and radiator.

The vapor condensing radiator 10, the vaporizer 14, the interconnecting conduit 15, the venting pipe 24, the receptacle 20 and the siphon tube 22 are preferably all joined together and hermetically sealed by welding or brazing so that a closed vapor tight heat transfer system is obtained. This entire system is then evacuated of substantially all non-condensable gases through a suitable evacuating connection 25. Thereafter a predetermined charge of suitable vaporizable liquid such as water, alcohol or the like, is introduced into the closed system. The amount of this liqu'd charge is such as to insure that the entire effective heat transfer surface of the vaporizer may be effectively wetted under maximum heat transfer conditions.

In operation, let it be assumed that all of the heat transfer fluid 23 is collected in the receptacle 20 and the siphon tube 22 as illustrated in the drawing, that the temperature of the medium within the enclosure 11 is at the desired value, and that the contacts 31 of the thermostat 32 are in the open position. Since there is no heat transfer fluid circulating between the vaporizer 14 and the radiator 10 the rate of heat transfer therebetween will be substantially zero. If now the temperature of the medium within the enclosure 11 falls below a predetermined value, which is determined by the setting of the thermostat 32, the contacts 31 close, the electric heater 26 is energized and condensate is forced upwardly in the leg 22a by thermo-siphon action into the condensate trap 21. After the condensate trap has become filled, the condensate spills over into the conduit 15 and flows downwardly into the vaporizer 14 where it is vaporized. The vaporized fluid then passes upwardly through the conduit 15 and comes in contact with the surface of the radiator 10 where it condenses giving up its latent heat of vaporization. The condensed heat transfer fluid then immediately returns to the vaporizer, the trap 21 being rendered ineffective since it is filled with condensate which is being pumped upwardly from the receptacle. While the contacts of the thermostat 32 remain closed more and more heat transfer fluid is pumped from the receptacle 23 into the system where it continuously circulates between the vaporizer and condenser. Thus the heat supplied by the radiator 10 to the medium within the space 11 gradually increases until the temperature of the space reaches the predetermined value at which the thermostat contacts open causing deenergization of the electric heater 26 and a cessation of the thermo-siphon pumping action. The heat transfer fluid in circulation between the condenser and the vaporizer then gradually collects in the trap 21 and is returned to the receptacle 20 by gravity causing the heat supplied by the radiator to gradually decrease. This action continues until all of the condensate has been returned to receptacle 20 or until the thermostat contacts close to restart the heat increasing cycle. Thus it will be apparent that the amount of heat transfer fluid in circulation between the vaporizer and condenser, and consequently the rate heat is supplied by the radiator, is either increased or decreased depending on the position of the thermostat contacts with the result that the average heat supplied by the radiator is automatically varied to maintain the temperature of the medium in space 11 constant.

In Fig. 2 of the drawing I have shown a modification in which the directions of flow of heat transfer fluid by gravity and by thermo-siphon action between the condensate trap 21 and the receptacle 20 are the reverse of the arrangement illustrated in Fig. 1. In this modification the receptacle 20 is located slightly above the condensate trap 21 so that the heat transfer fluid will flow from the receptacle to the trap by gravity. In order to cause the heat transfer fluid to return from the condensate trap to the receptacle, the thermostatically controlled electric heater 26 is located in heat exchange relation with the leg 22b of the siphon 22.

In operation when the temperature of the medium within the enclosure 11 is above a predetermined value the contacts 31 of the thermostat 32 are closed, as shown, and the heat transfer fluid is pumped by thermo-siphon action from the trap 21 to the receptacle 20 to decrease the rate of heat transfer between the vaporizer and the condenser. However, when the temperature of the medium within the space 11 falls below the predetermined value the contacts 31 open deenergizing heater 26 and permitting the heat transfer fluid to flow by gravity from the receptacle 20 to the trap 21 whereby the amount of heat transfer fluid in circulation and the rate of heat transfer between the vaporizer and condenser is increased.

It will be seen from the above description of my invention, a vapor heat transfer system has been provided which is entirely free from moving control elements such as valves, baffles etc. This is an important advantage in a sealed and evacuated system since moving control elements wear and generally require seals or packings of some sort which are apt to leak and destroy the vacuum in the system thus rendering it inoperable.

Furthermore, my control system is very economical to operate since only a very small amount of energy is required to operate the thermo-siphon pumping apparatus, the liquid head against which the pump operates being very small. Another control energy saving feature is the fact the thermo-siphon pumping apparatus acts only to change the amount of heat transfer fluid circulating between the condenser and

vaporizer as distinguished from systems in which all of the circulating heat transfer fluid passes through the pumping apparatus to complete the vaporizing and condensing cycle.

While I have shown and described particular embodiments of my invention, it will occur to those skilled in the art that various changes and modifications may be made without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In a vapor heat transfer system of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, means for effecting an exchange of heat transfer fluid between said receptacle and said circuit to vary the rate of heat transfer between said condenser and said vaporizer, said means comprising a condensate trap located in path of condensate returning from said condenser to said vaporizer, said trap being effective to divert heat transfer fluid from said circuit when fluid collected in said trap is withdrawn and effective to add fluid to said circuit when fluid supplied to said trap overflows, a siphon tube having one leg connected to the lower portion of said receptacle and the other leg connected to said condensate trap, said receptacle being located below said trap and vented to said circuit so that heat transfer fluid collecting in said trap will flow into said receptacle through said siphon tube by gravity, and means for locally heating the fluid in the leg of the siphon tube that is connected to said trap for causing heat transfer fluid to return from said receptacle to said trap by thermo-siphon action.

2. In a vapor heat transfer system of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, means comprising a pump for effecting an exchange of heat transfer fluid between said circuit and said receptacle to change the amount of heat transfer fluid in circulation and the rate of heat transfer between said vaporizer and said condenser, and means for controlling said pump to vary said rate of heat transfer.

3. In a vapor heat transfer system of the type in which a heat transfer fluid is circulated in a closed circuit comprising an interconnected vaporizer and condenser by alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, a conduit interconnecting said receptacle and said circuit, means for diverting heat transfer fluid from said circuit through said conduit into said receptacle to decrease the amount of fluid circulating between said condenser and said vaporizer, pumping means for returning the fluid from said receptacle to said circuit through said conduit to increase the fluid circulated between said condenser and vaporizer, and means for controlling said pumping means whereby the amount of fluid circulating and the rate of heat transfer between said condenser and said vaporizer may be varied.

4. In a vapor heat transfer system of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, means for effecting an exchange of heat transfer fluid between said receptacle and said circuit to vary the rate of heat transfer between said condenser and said vaporizer, said means comprising a condensate trap located in the path of condensate returning from said condenser to said vaporizer, said trap being effective to divert heat transfer fluid from said circuit when fluid collected in said trap is withdrawn and effective to add fluid to said circuit when fluid supplied to said trap overflows, a pump for pumping heat transfer fluid in one direction through a conduit interconnecting said trap and said receptacle, said receptacle and said conduit being located relative to said trap so that fluid flows in the opposite direction through said conduit by gravity when said pump is not in operation, and means for controlling the operation of said pump whereby an exchange of heat transfer fluid in either direction between said circuit and said receptacle may be effected.

5. In a vapor heat transfer system of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, means for effecting an exchange of heat transfer fluid between said receptacle and said circuit to vary the rate of heat transfer between said condenser and said vaporizer, said means comprising a condensate trap located in the path of condensate returning from said condenser to said vaporizer, said trap being effective to divert heat transfer fluid from said circuit when fluid collected in said trap is withdrawn and effective to add fluid to said circuit when fluid supplied to said trap overflows, a siphon tube having one leg connected to said receptacle and the other leg connected to said trap, venting means interconnecting said receptacle and said circuit for equalizing the vapor pressures therebetween, said receptacle and said tube being located relative to said trap so that fluid flows through said tube in one direction by gravity, means for locally heating the fluid in one of the legs of said tube to cause fluid to flow through said tube in the opposite direction by thermo-siphon action, and means for controlling said heating means whereby an exchange of heat transfer fluid in either direction between said circuit and said receptacle may be effected.

6. In a system for transferring heat from a heat source to a medium the temperature of which is to be controlled by a vapor heat transfer means of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, means comprising a pump for effecting an exchange of heat transfer fluid between said circuit and said receptacle to change the amount of heat transfer fluid in circulation and the rate of heat transfer between said vaporizer and said condenser, and means responsive to the temperature of said medium for controlling said pump to vary said rate of heat transfer.

7. In a system for transferring heat from a heat source to a medium the temperature of which is to be controlled by vapor heat transfer means of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by

alternate evaporation and condensation of said fluid, a condensate accumulating receptacle, a condensate trap located in the path of condensate returning from said condenser to said vaporizer, said trap being effective to divert heat transfer fluid from said circuit when fluid collected in said trap is withdrawn and effective to add fluid to said circuit when fluid supplied to said trap overflows, a siphon tube having one leg connected to said receptacle and the other leg connected to said trap, venting means interconnecting said receptacle and said circuit for equalizing the vapor pressures therebetween, said receptacle and said tube being located relative to said trap so that fluid flows through said tube in one direction by gravity, means for locally heating the fluid in one of the legs of said tube to cause fluid to flow through said tube in the opposite direction by thermo-siphon action, and means for controlling said heating means to vary the amount of heat transfer fluid in circulation and the rate of heat transfer between said condenser and said vaporizer in accordance with the temperature of said medium.

8. In a vapor heat transfer system of the type in which heat transfer fluid is circulated in a closed fluid circuit comprising an interconnected vaporizer and condenser by alternate evaporization and condensation of said fluid, a condensate accumulating receptacle, a siphon tube interconnecting said receptacle and said circuit, and means for applying heat to one of the legs of said siphon tube to effect an exchange of heat transfer fluid between said receptacle and said circuit by thermo-siphon action.

9. In a vapor heat transfer system, a vaporizer, a condenser, means for circulating heat transfer fluid in a closed fluid circuit including said vaporizer and said condenser, a condensate accumulating receptacle, means for effecting an exchange of heat transfer fluid between said receptacle and said circuit to change the amount of heat transfer fluid circulating between said vaporizer and said condenser, said last-mentioned means comprising a siphon tube interconnecting said receptacle and said circuit, and a heater located in heat exchange relation with one of the legs of said siphon tube for effecting a thermo-siphon action.

MARCUS E. FIENE.