July 26, 1955 H. W. ANGELERY 2,713,994

HEAT EXCHANGER

Filed May 3, 1950 4 Sheets-Sheet 1

FIG.1.

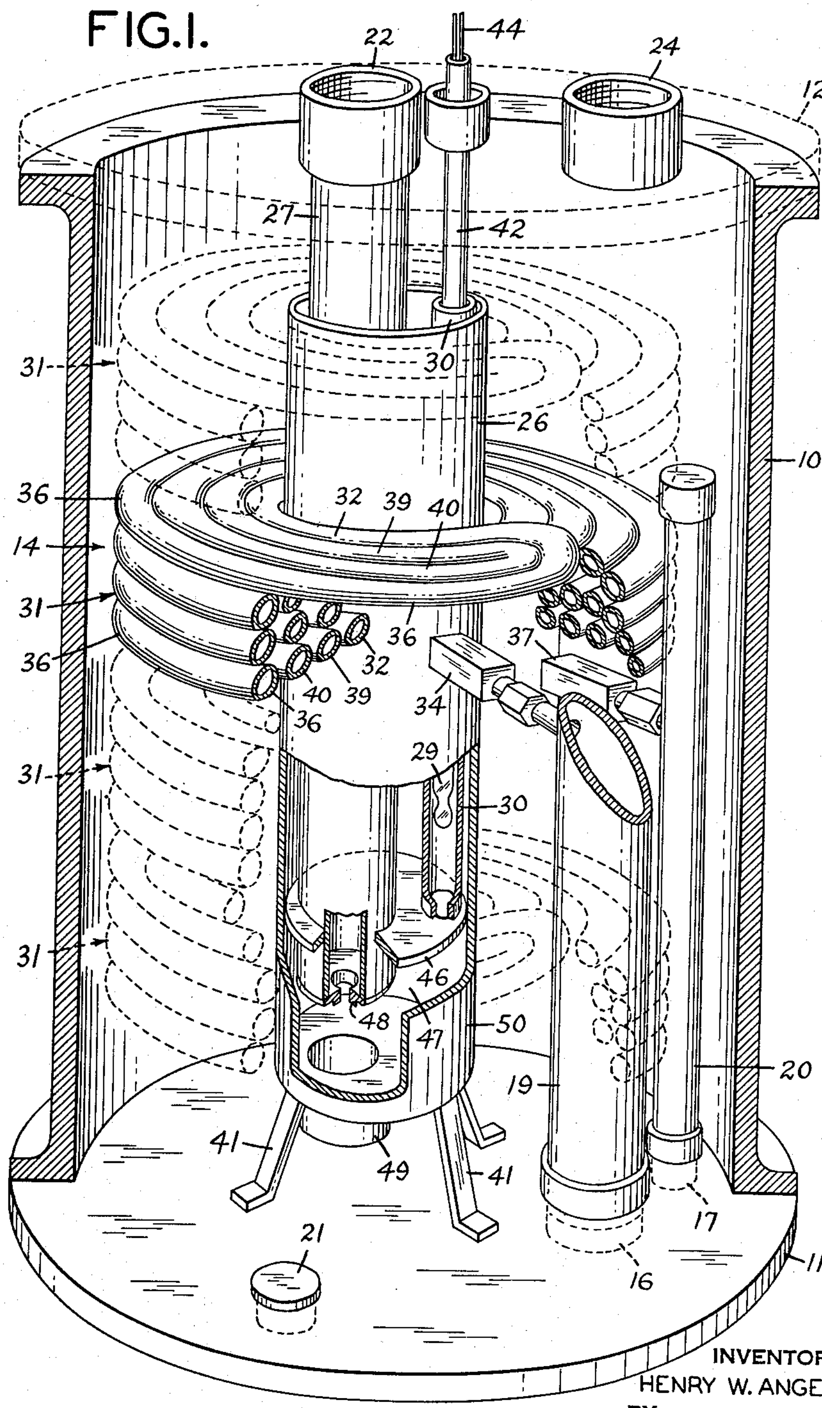

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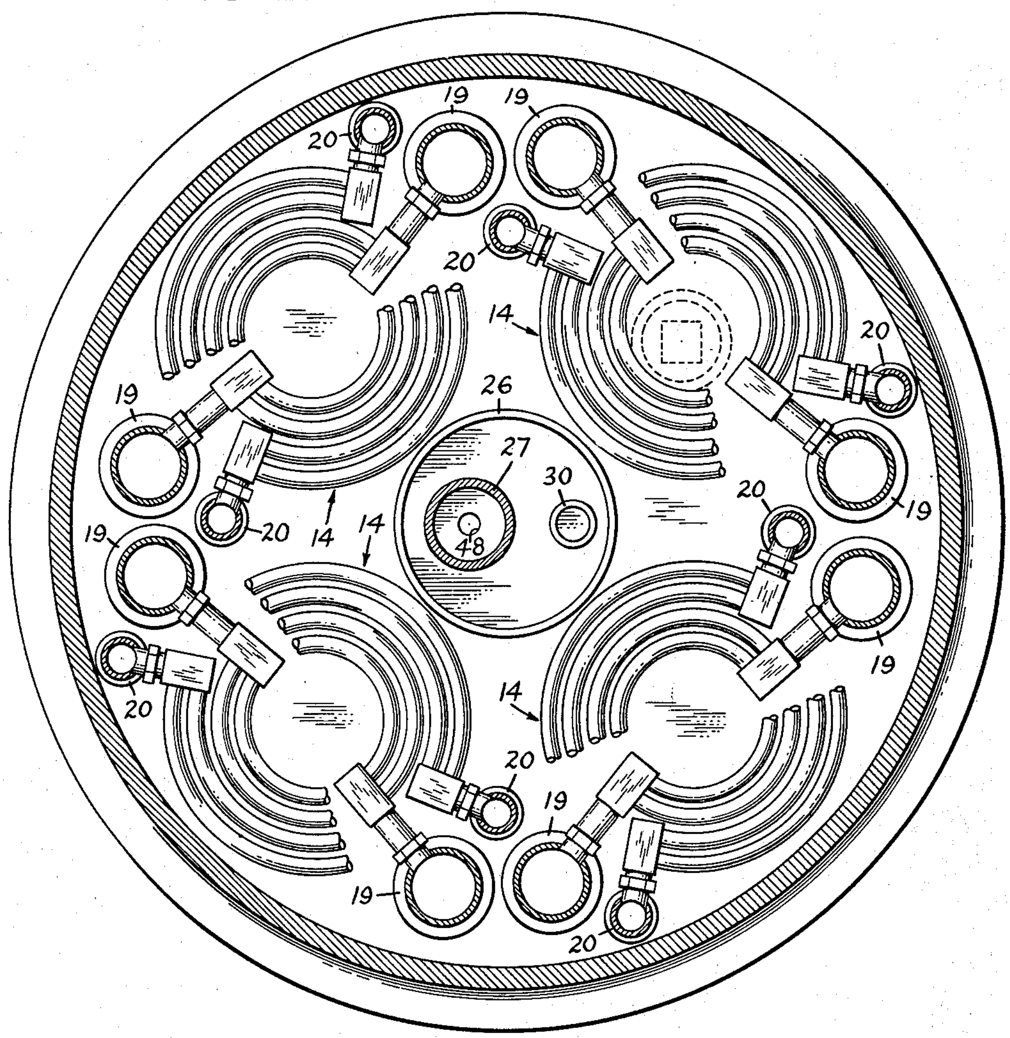
FIG. 2.



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HEAT EXCHANGER

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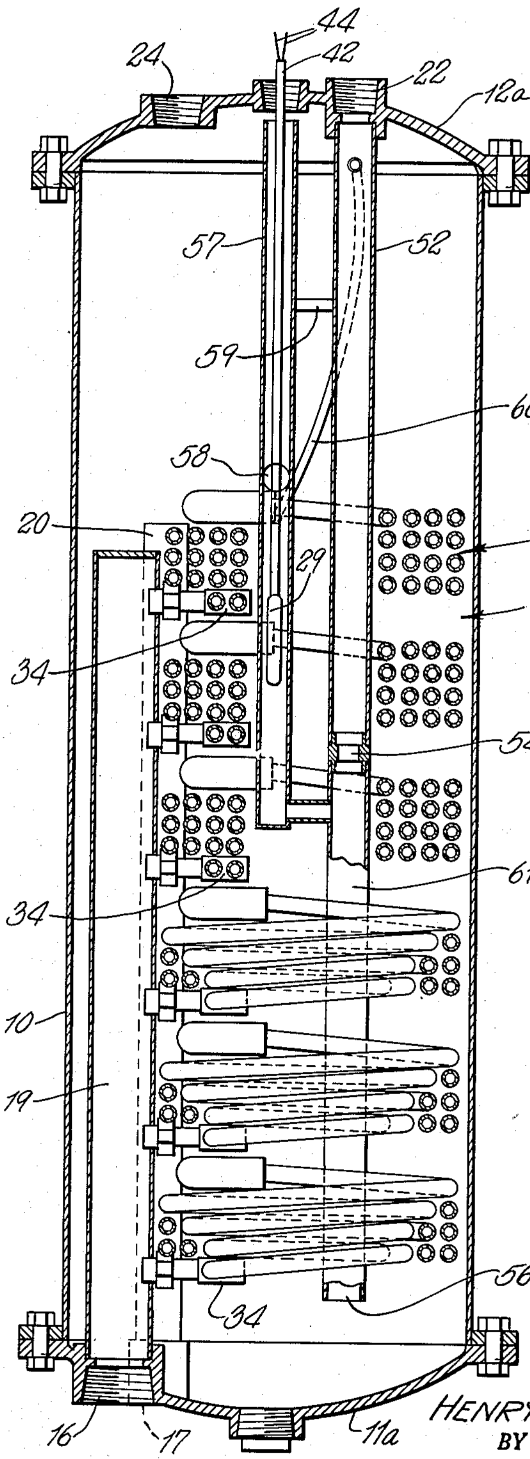

Fig. 3.

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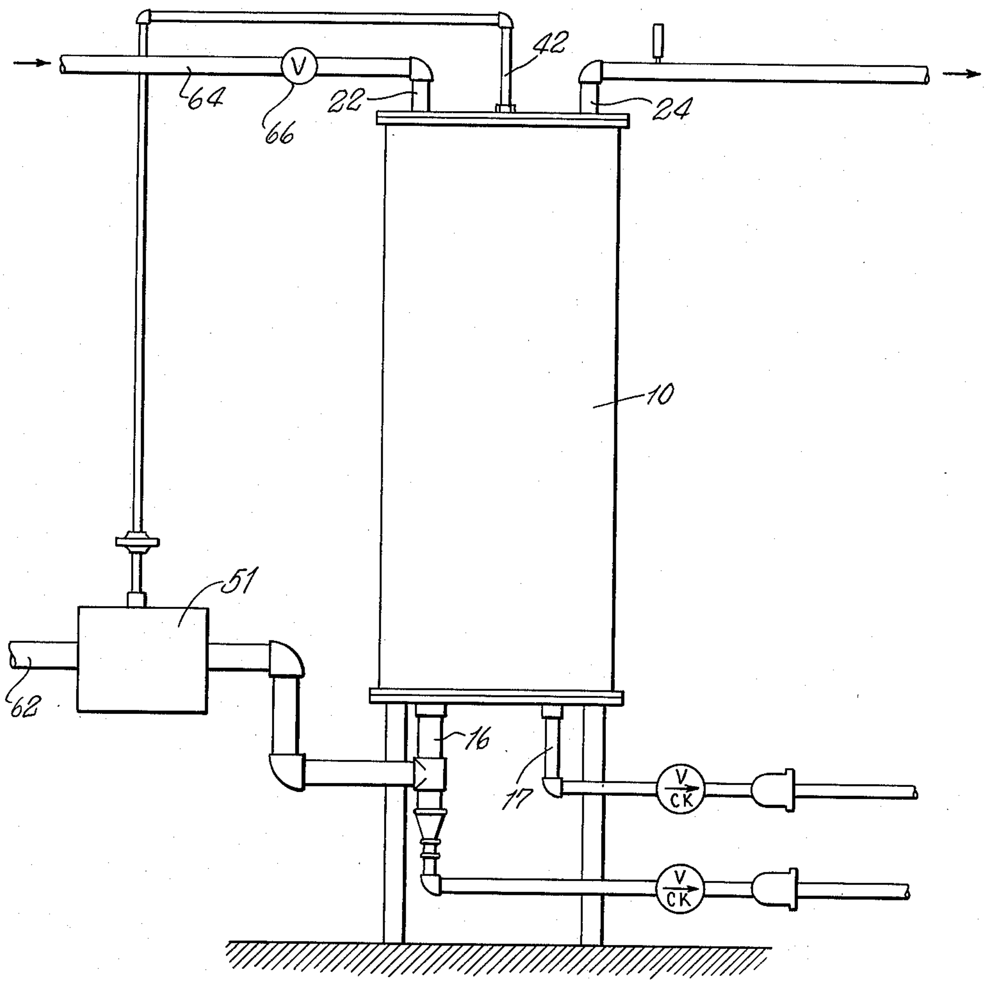

Fig. 4.

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HEAT EXCHANGER

Henry W. Angelery, Englewood, N. J.

Application May 3, 1950, Serial No. 159,695

5 Claims. (Cl. 257—2)

This application is a continuation-in-part of my earlier abandoned application Serial No. 40,959, filed July 27, 1948.

The present invention relates to improvements in heat exchangers designed to effect a transfer of heat between two fluids, to a system for maintaining a mass of fluid at a predetermined temperature, and more particularly to improvements in controlling the rate of heat transfer between two fluids when the flow of the subject fluid varies or becomes intermittent.

The term "subject fluid" as used herein, is applied to the fluid whose final temperature and, if desired, state is to be controlled. The term "regnant fluid" as used herein, is applied to the fluid used to control the temperature or state or both, of the subject fluid.

The subject fluid may be a liquid or vapor whose final temperature or state, or both, upon leaving the heat exchanger of this invention is controlled by the rate of heat transfer to or from the regnant fluid, which may likewise be a liquid or vapor. Thus, for example, where it is desired to heat water to a predetermined outlet temperature by bringing it into out of contact heat exchange relation with steam, the water is the subject fluid and the steam is the regnant fluid.

The heat requirements of a subject fluid, i. e., the amount of heat required to be added to or absorbed therefrom to bring it to a predetermined final temperature, is determined by the volume and specific heat of the fluid and by the difference between its initial and final temperatures. The volume of the fluid is in turn determined by, and a direct function of, its rate of flow. Inasmuch as the rate of flow of the subject fluid often varies substantially and the initial temperature thereof may vary as well, it follows that its heat requirements likewise vary widely.

The rate of heat transfer between two fluids depends upon a number of factors which include the mean temperature differential between them and the area and heat conductivity of the surface separating them if they are out of contact with one another. The principles governing heat transfer between fluids are essentially the same whether the fluids involved be liquid or vapor and whether, if they are a liquid and a vapor, the heat be transferred from the vapor to the liquid or vice versa.

For this reason, and in order to promote a most thorough and complete understanding of the principles of this invention, the following description is directed primarily to the application of the invention to the transfer of heat from steam to water, wherein steam is the regnant fluid and water is the subject fluid. It is to be understood, however, that it is not intended to limit the application of the invention solely to such use.

In conventional out of contact heat exchangers, the rate of flow and heat content of the regnant fluid and the effective heat transfer area remain substantially constant although the heat requirements of the subject fluid may vary considerably. The only variations in the amount of heat transferred to or from the subject fluid are, therefore, due to changes in the mean temperature differential between the subject and regnant fluids. This

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is fairly satisfactory when the subject fluid is withdrawn at a more or less constant rate. It is unsatisfactory, however, when the rate of withdrawal of the subject fluid varies appreciably or is intermittent.

Thus, for example, when conventional heat exchangers are used to heat water with steam, difficulties arise due to the overheating of the water when its rate of flow is reduced to a minimum or stopped completely. This is usually due to the simple fact that the amount of heat available from the steam greatly exceeds the amount of heat required by the water at small or zero rates of flow. When, on the other hand, the rate of flow of the water is increased to above average the amount of heat that can be absorbed by a given volume of water is too small to raise its temperature to the desired point for the simple reason that the amount of heat made available by the steam is not sufficient to satisfy the heat requirements of the water.

One object of the present invention is to provide a heat exchanger that is capable of anticipating or sensing the heat requirements of the subject fluid and regulating the flow of the regnant fluid in such a manner as to satisfy those requirements at all times to the end that the final temperature of the subject fluid will remain substantially constant at widely varying rates of flow.

Another object of the invention is to provide, in a heat exchanger, a means for varying the effective area of the surface available for the transfer of heat.

These objects are accomplished by including in the heat exchanger of my invention a novel arrangement of tubular heat transfer elements and utilizing a temperature responsive device to sense the heat requirements of the subject fluid and control the flow of regnant fluid. In its preferred form, my heat exchanger comprises a shell, one or more units of tubular, heat conductive elements in the form of concentric spirals for the passage of steam, and means for circulating water past a thermostat to regulate the flow of steam into the tubular elements.

Another object of the invention is to provide a heat exchanger through which the more viscous fluid such as water, for example, can pass with a minimum pressure drop.

One advantage of the present invention is that it provides a method and means for delivering a fluid at a substantially constant temperature even though the fluid is withdrawn intermittently or at varying rates of flow.

This heater can be used as a booster after a storage tank or accumulator with or without recirculation, because of its ability to accommodate wide changes in the flow rate or temperature differential and still properly control the outlet temperature accurately.

These and other advantages will become apparent from the following detailed description made with reference to the accompanying drawing, wherein

Figure 1 is a sectionalized view in perspective illustrating one preferred embodiment of the apparatus of this invention.

Figure 2 is a plan view in cross section through a heat exchanger designed for relatively large capacities;

Figure 3 is a cross sectional view in elevation illustrating another preferred embodiment of the apparatus of this invention; and

Figure 4 is a diagrammatic view showing a typical piping arrangement with which the heat exchanger of this invention may be employed to advantage as a hot water heater.

The embodiment illustrated in Figure 1 includes a shell **10** having a bottom **11** and a top **12**, a bank of concentric spiral tubular elements **14**, a vapor inlet **16**, a condensate return **17**, a vapor feed header **19**, a vapor or condensate return header 20, a drain plug 21, liquid inlet and outlet connections 22 and 24, a tubular member 26, a conduit 27, a temperature responsive element 29, such as a thermostat, and a circulating tube 30.

The bank of tubular elements 14 consists of a plurality of units 31, each unit including two pairs of spiral coil members substantially as shown. The innermost spiral coil member 32 begins at a unit vapor feed header 34 connected to the vapor feed header 19 and, after making four turns, reverses its direction and becomes the outermost spiral coil member 36. After again making four turns, spiral coil member 36 ends at a unit vapor or condensate return header 37 connected to the vertical vapor or condensate return header 20. The spiral coil member 39 next to the innermost spiral coil member 32 begins at the unit vapor feed header 34, makes four turns upwardly adjacent the first spiral coil member 32 and then reverses its direction to become the next to the outermost downward spiral coil member 40 terminating in the unit vapor or condensate return header 37 adjacent the outermost spiral coil member 36.

The four coil members shown in Figure 1 are each of a different diameter but the tubes forming them are preferably of the same diameter. The sum of the coil diameters of spiral coil members 32 and 36 is equal to the sum of the coil diameters of coil members 39 and 40 with the result that the length of the path through one pair of coils, connected in series as shown, is equal to that of the other pair. Inasmuch as the tube diameters and the number of turns of each coil member are the same, it follows that the pressure drop through one pair of coils must be equal to that through the other.

It is to be understood, of course, that the unit 31 of spiral tubular elements 14 is representative only of a plurality of such units that are connected in parallel between the vertical vapor feed header 19 and the vertical vapor or condensate return header 20. If the pressure drop of the vapor flowing through the pairs of spiral coil members and the design capacity of the heat exchanger permit, it is, of course, within the contemplation of this invention to use only one unit of one or more pairs of spiral coil members and to eliminate the vertical vapor feed and vapor or condensate return headers 19 and 20.

By the same token, it is within the contemplation of this invention to have three, four or more pairs of spiral coil members in each of one or more coil units, so long as the sums of the diameters of the coil members in the various pairs are equal.

It is also to be understood that while the members in the various coil units are most advantageously arranged concentrically to utilize to a maximum the space available within the shell, the invention is not limited to such an arrangement but is intended to include any arrangement wherein the heat transfer elements are connected in parallel and offer the same resistance to the flow of fluid.

The tubular member 26 is supported from the bottom 11 by a number of feet 41. The upper end of the tubular member 26 is open for the passage thereinto of the conduit 27 and a tube 42 enclosing the thermostat leads 44. A partition 46 is provided in the lower portion of the tubular member 26 to form a closed well for fluid entering the tube at the open upper end and to support the circulating tube 30 which encloses the thermostat 29 and the thermostat lead enclosing tube 42. The circulating tube 30 is open at the top and opens into an aspirating chamber 47 to permit circulation of at least part of the fluid in the shell through the tube. The conduit 27, after passing through the partition 46, terminates in a nozzle 48 that is in line with a diffuser 49 in the otherwise closed end 50 of the tubular member 26, said diffuser terminating above the level of the bottom 11.

In operation, when it is desired to utilize the heat exchanger for heating a liquid with a vapor, the liquid enters the shell through the conduit 27 whenever liquid is withdrawn from the outlet connection 24 and, by reason of its passage through the aspirator, consisting of the chamber 47, the nozzle 48, and the diffuser 49, induces a circulation of at least part of the liquid in the shell through the circulating tube 30 and past the thermostat 29. The flow of cold liquid through the conduit 27 withdraws heat from the liquid in the well formed by the tubular member 27 and the partition 46. This in turn withdraws heat from and thereby lowers the temperature of the liquid flowing through the circulating tube 30. The thermostat 29 thereupon operates to open a valve 51, such as a "Spence T 100" temperature regulator valve shown in Figure 4, and thereby controls the rate of flow and pressure of vapor through the tubular elements 14. If the temperature drop at the thermostat is slight, the pressure of the vapor admitted to the tubular elements by the valve 51 will be sufficient to fill only a portion thereof with the vapor, with the result that the effective area of the heating surface will be small. If, on the other hand, the temperature drop is appreciable and therefore reflects a high heat demand, the pressure of the vapor admitted by the valve 51 will be sufficient to overcome the pressure drop through the coils with the result that the effective area of the heating surface will be increased to the maximum.

When the flow of liquid withdrawn from the heat exchanger ceases or is brought to a minimum, the flow of liquid through conduit 27 decreases correspondingly. This results in a decrease in the amount of heat withdrawn from the liquid trapped in the well and brings about a rise in the temperature of the liquid in circulating tube 30 that surrounds the thermostat 29. The thermostat 29 thereupon operates to close the control valve so that the amount and pressure of the vapor fed to the tubular elements 14 is decreased. This in turn results in the condensation of a portion of the vapor within the coils and, due to the action of check valves in the vapor supply and condensate return lines, operates to decrease the effective surface area of the tubular elements that is available for transfer of heat from the vapor to the liquid.

If no heated liquid is withdrawn for a period of time sufficient to result in the cooling thereof due to radiation losses from the shell, the liquid will circulate due to thermal action through the circulating tube 30 and any appreciable temperature drop will be sensed by the thermostat 29 and be reflected in a resumption or increase in flow of vapor through the tubular elements 14.

The embodiment illustrated in Fig. 2 is intended to show how a heat exchanger constructed in accordance with the principle of this invention may have its capacity increased to any desired degree. Any one bank of coils 14 can be increased practically without limit but, in order to avoid too great a pressure drop in the fluid flowing therethrough, it has been found to be desirable to utilize two or more sets of vertical headers 19 and 20 for the feed and return of vapor and vapor condensate. In this event the top unit will be connected to one set of headers 19 and 20, the next unit to the other set of headers, and so on. Still more capacity may be obtained by utilizing two or more banks of coils 14. The modification illustrated in Fig. 2 shows how four banks of coils may be placed in a single heat exchanger, each bank having two sets of feed and return headers. In this event, it is not necessary to have a well and thermostat within each bank of coils. It is sufficient to have one such control means in only one of the coil banks and it is preferred, as shown in the drawing, to position the control means, including a tubular member 26, conduit 27 and circulating tube 30, centrally among the various banks of coils. The essential details of the control means are the same as described with reference to Figure 1.

The operation of this modification is likewise essentially the same as that of the embodiment illustrated in Fig. 1. If desired, the heat exchanger of this type may be provided with any suitable arrangement of vertical and horizontal baffles to secure maximum contact of the fluids in the shell with the surfaces of the reverse spiral coils.

The embodiment illustrated in Figure 3 is a modification of that illustrated in Figure 1 and is designed to reduce to an absolute minimum the "hunting" of the temperature control system and to increase to a maximum the sensitivity of the thermostat to changes in the temperature and/or flow conditions of the subject fluid in the heat exchanger.

The heat exchanger illustrated in Figure 3 includes a shell **10** having a bottom **11***a* and a top **12***a*, a bank of concentric spiral tubular elements **14**, a vapor inlet **16**, a condensate return **17**, a vapor feed header **19**, a vapor or condensate return header **20**, liquid inlet and outlet connections **22** and **24** and a thermostat **29**. The bank of tubular elements **14** of Figure 3 is substantially identical with the bank of tubular elements **14** illustrated in Figure 1 of the drawing. The unit vapor feed headers **34** and unit vapor or condensate return headers **37** (behind headers **34** in Figure 3) are likewise similar to those illustrated and described with reference to Figure 1.

An inlet conduit **52** is secured to the inlet connection **22** and is provided with a constriction or nozzle **54** at a point spaced from its lower end **56**. The thermostat leads **44** are enclosed in a cable or tube **42** which is, in turn, enclosed in a circulating tube **57** that is substantially parallel to the conduit **52**. The upper end of the tube **57** is spaced from the top **12***a* of the shell or suitably provided with one or more openings **58** to permit the entry into the tube of at least a part of the liquid from within the shell. A support bracket **59** may be provided between conduit **52** and tube **57** to support the latter. A by-pass **60** is provided between the conduit **52** and the tube **57**, the connection of the by-pass with conduit **52** being upstream of the nozzle **54** and the connection of the by-pass to the tube **57** being upstream of the location of the thermostat **29** therein. It will be understood that additional by-pass or sensing tubes may be connected to the tube **57**, these additional tubes taking fluid from one or more points at lower levels than the by-pass **60**. The lower end of the tube **57** communicates with the aspirating chamber and diffuser **61**.

It will be apparent from this description that the thermostat **29** will sense immediately the introduction of fresh water due to the admixture thereof, at a point upstream from the thermostat, with the heated water in the interior of the shell and in the upper portion of the tube **57** and that the operation of the thermostat does not depend solely upon the withdrawal of heat from the water in tube **57**. Consequently, the thermostat **29**, in effect, anticipates the heat transfer requirements within the shell **10** prior to an actual change in the temperature of the water within the body of the shell.

When the discharge of water by way of the outlet connection **24** is suddenly stopped, the flow of fresh water through the by-pass **60** also ceases immediately. If the water entering through inlet connection **22** is colder than the water within the shell, as it will be when the heat exchanger is utilized as a water heater, and the movement of water through the heat exchanger is stopped, the water surrounding the thermostat **29** quickly reaches the average temperature of the water in the shell and is thus able to control effectively the further entry of steam into the tubular elements **14**.

While the circulating means illustrated in Figures 1–3 and described in detail herein are preferred as being the most simple in construction and dependable in performance, it is to be understood that it is within the contemplation of the invention to place the thermostat and recirculating tubes in a separate vessel connected with the shell for circulation of the water.

Figure 4 illustrates a typical manner in which the heat exchanger of the present invention can be utilized as a hot water heater. A steam line **62** having a thermostatically controlled pressure valve **51** of the type exemplified by the "Spence T 100" temperature regulator valve, is connected to the vapor inlet **16**. The water inlet **22** is connected to a suitable source **64** of water, a valve **66** being provided in the line **64**. When the thermostat **29** senses a preselected maximum temperature, it operates to completely close the valve **51** in a known manner. If the temperature at the thermostat goes below said preselected temperature, it will operate to open the valve **51** sufficiently to permit steam to enter the tubular elements **14** under a preselected pressure until sufficient heat is absorbed by the liquid to raise the temperature to the preselected temperature at which the thermostat will operate to close the valve **51**.

It is to be understood that the arrangement illustrated in Figure 4 may be utilized with either of the embodiments illustrated in Figures 1, 2 or 3.

When it is desired to cool or condense vapor with a liquid, the conditions within the heat exchanger are approximately the same because the direction of the heat transfer is the same. Inasmuch, however, as the liquid is the regnant or working fluid and the vapor is the subject fluid whose temperature and state is to be controlled by the liquid, the thermostat is connected by well known means to actuate a valve, such as valve **66** of Figure 4, for the control of the flow of liquid into the heat exchanger. If the rate of introduction or the heat content of the vapor is increased or the withdrawal of condensed or cooled vapor from the coils is increased, the temperature of the liquid in the vicinity of the thermostat will increase and the thermostat will thus sense the demand for more rapid heat absorption by the liquid. In this modification, the thermostat is connected to actuate the valve **66** controlling the rate of flow of the incoming liquid to increase the rate of flow until the correct heat balance is restored. If the rate of introduction of vapor is decreased or the heat transfer requirements thereof are otherwise diminished, or if the flow of vapor into the tubular elements **14** is stopped altogether, the amount of heat that is absorbed by the liquid from the tubular elements will also decrease and the resultant lower temperature thereof will be sensed by the thermostat **29** due to the circulation of the liquid past it. The thermostat **29** will therefore actuate the flow control valve for the incoming liquid to decrease the rate of flow or stop it altogether until the correct heat balance is restored.

It is obvious that the principle of this invention can be applied likewise to the cooling of a fluid with a vapor wherein the tubular elements are utilized as expansion coils for the vapor. In this event, however, the heat exchanger would be used in a position upside down from that shown in Figures 1–3 so as not to interfere with the thermal circulation of the fluid around the coils. Furthermore, the headers for the coils, if more than one unit of coils is used, would be reversed, i. e., the inlet for the vapor would be the smaller of the two or they may be of the same size.

In operating a heat exchanger thus modified, the subject fluid would enter the top of the heat exchanger after passing upwardly through the circulating system and descend around the coils as the heat is being absorbed from it. The aspirator would operate to induce upward circulation of the fluid past the thermostat **29**.

If the demands of the cooled fluid are increased to above normal, the increased flow of the warm input fluid will be reflected in the temperature of the fluid circulating past the thermostat **29** which will then actuate a compression pump or valve to increase the rate of expansion of the vapor within the coils and thus increase the heat absorbing capacity thereof to meet the higher demand. If, on the other hand, the flow of cooled fluid is decreased to below normal or stopped, the transfer of heat from the fluid will decrease correspondingly with a further reduction in the temperature thereof, with the result that the thermostat will sense the lowering of demand for heat absorption. This in turn will result in the actuation of a compressor or control valve to limit the amount of vapor introduced for expansion in the coils and thereby reestablish the desired heat balance.

In order to more fully illustrate the invention without, however, intending to limit its scope in any way, the following example is included.

Example

A heat exchanger similar to that illustrated in Fig. 1 was designed to operate on steam at a pressure of 30 lbs. per square inch gauge and to raise the temperature of water from 65° F. to 160° F. while flowing at a rate of 50 gallons per minute.

The shell had an internal diameter of 10½ inches and a height of 31 inches. It contained three coil units, each unit consisting of four concentric coil members having nine turns each and coil diameters of 5, 6½, 8 and 9½ inches. The 5" and the 9½" coil members were connected in series and the 6½" and 8" coil members were likwise connected in series to form two pairs of spiral coils, the sum of the diameters of the coil members in each pair being 14½ inches. Each coil was a ⅝" diameter copper tube.

A thermostat located within the bank of coils as shown in Fig. 1 was connected to a Spence T 100 temperature regulator valve on the steam line. A thermometer having scale graduations at 5° F. intervals was inserted into the water line at the outlet connection.

It was found a sudden increase in flow rate of the water from 5 to 50 gallons per minute, and vice versa, had no perceptible effect on the thermometer reading, although the temperatures may actually vary by one or two degrees F. At the maximum rate of flow, the pressure of the steam was 26 lbs. per square inch gauge at the steam inlet and 6 lbs. per square inch gauge at the steam outlet.

It is to be understood that the embodiments of the invention described herein are the preferred forms thereof and that various changes in size, shape, location and arrangement of parts may be resorted to without departing from the principles of this invention or the scope thereof as defined in the appended claims.

I claim:

1. A heat exchanger comprising a tank for receiving liquid, a substantially vertical inlet tube having an open inner end within said tank to introduce cold liquid into said tank, an aspirator in said inlet tube for creating a zone of reduced pressure, an outlet to discharge liquid from said tank, a conduit spaced from said inlet tube having one end communicating with the tank and the other end communicating with the inlet pipe at said zone to induce flow of liquid from said tank through said conduit in response to flow of liquid through the inlet tube, means outside of said conduit and tube and within said tank for heating the liquid therein, and a temperature-responsive device within said conduit upstream of said zone in contact with the liquid in said conduit for regulating the heating means, said temperature-responsive device being shielded from said heating means and the water in said tank by said conduit.

2. A water heater comprising a closed shell, an inlet conduit for cold water, a second conduit in the shell, a heating element in said shell outside of said conduits, said second conduit being open at one end to heated water in the shell and connected at its opposite end to the inlet conduit between the ends of the latter, a thermostat within the second conduit, aspirator means in the inlet conduit operable by a flow of water through the inlet conduit to induce a flow of heated water through said second conduit from near the top of said shell and past the thermostat, said thermostat being upstream of said aspirator, means to supply cold water from said inlet conduit to said second conduit in proportion to the flow of water through the inlet conduit for mixing with the hot water in the second conduit prior to its flow past said thermostat, and means responsive to the thermostat to control the operation of the heating element.

3. A heat exchanger for out of contact heat exchange between steam and water which comprises a closed shell for heated water, a bank of tubular elements within the shell for the flow of steam therethrough, a cold water inlet conduit spaced from said tubular elements for discharging cold water into the shell for flow around the outside of the conduit into contact with the tubular elements, said conduit extending downward from the upper portion of the shell, a second conduit in contact with the water in said tank, said second conduit being open at one end to receive heated water from the shell, a third conduit connecting and communicating with the first and second conduits, a thermostat within the second conduit, means responsive to the flow of cold water through the inlet conduit for causing a portion of the heated water and a portion of the cold water to mix and to flow through the second conduit wherein said thermostat is subjected to the temperature of the mixed cold water and hot water, and means responsive to the thermostat to control the flow of steam into the tubular elements.

4. A heat exchanger comprising a receiver for receiving liquid, means for heating the liquid therein, an inlet pipe to said receiver having an open inner end to supply cold liquid to said receiver to be heated in said receiver by said heating means, an outlet from said receiver, a restriction in said pipe between its ends, a conduit connected with said pipe downstream of said restriction and subjected to reduced pressure by flow of cold liquid through said restriction, metering connections between said conduit and the interior of said receiver and between the conduit and the pipe upstream of said restriction for withdrawing heated liquid from said receiver and cold liquid from said inlet pipe and metering the flow of heated and cold liquid through said conduit induced by the flow of cold liquid through said restriction, and a thermoresponsive device in said conduit responsive to the temperature of the liquid therein for controlling the means for heating the liquid.

5. The heat exchanger set forth in claim 4 in which the inner end of said inlet pipe is adjacent to the bottom of the receiver, and the means for heating the liquid comprises a plurality of substantially axially aligned coils having multiple convolutions, the inlet pipe and the conduit extending through said coils substantially parallel with their axes.

References Cited in the file of this patent

UNITED STATES PATENTS

1,485,897	West et al.	Mar. 4, 1924
1,542,573	Paige	June 16, 1925
1,714,843	Brown et al.	May 28, 1929
1,727,881	Hoyt	Sept. 10, 1929
1,898,703	Williamson	Feb. 21, 1933
1,901,761	McCorquodale	Mar. 14, 1933
1,926,342	Lippencott	Sept. 12, 1933
2,071,624	Graham	Feb. 23, 1937
2,149,737	Jewell	Mar. 7, 1939
2,266,242	Osterheld	Dec. 16, 1941
2,297,768	Hutchins	Oct. 8, 1942
2,337,484	McCollum	Dec. 21, 1943
2,372,533	Torbett	Mar. 27, 1945
2,481,630	Tramontini	Sept. 13, 1949
2,501,012	St. Clair	Mar. 21, 1950
2,545,966	McQuitty	Mar. 20, 1951

FOREIGN PATENTS

165,336	Great Britain	June 30, 1921