Aug. 24, 1965 P. L. GEIRINGER 3,202,208

HEAT EXCHANGE SYSTEM WITH AUTOMATIC PUMP CONTROL

Filed Aug. 22, 1962 2 Sheets-Sheet 1

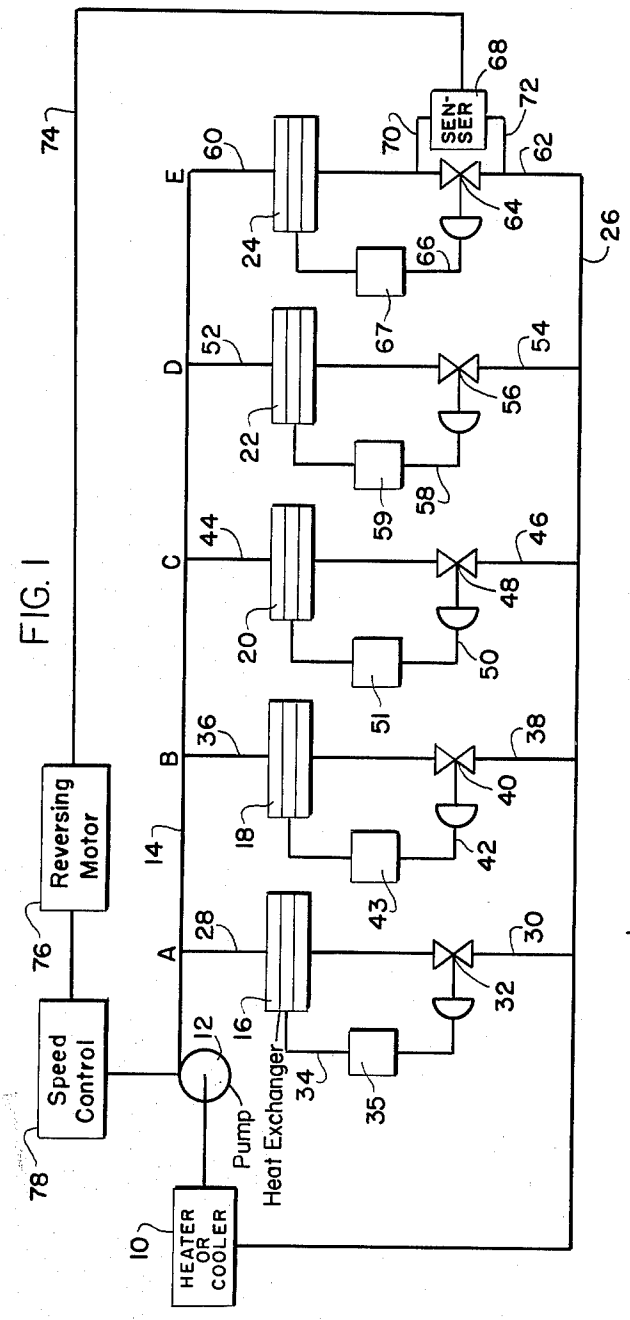


FIG. 1

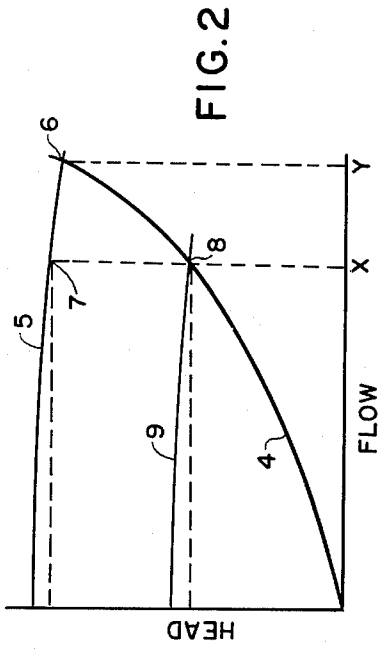


FIG. 2

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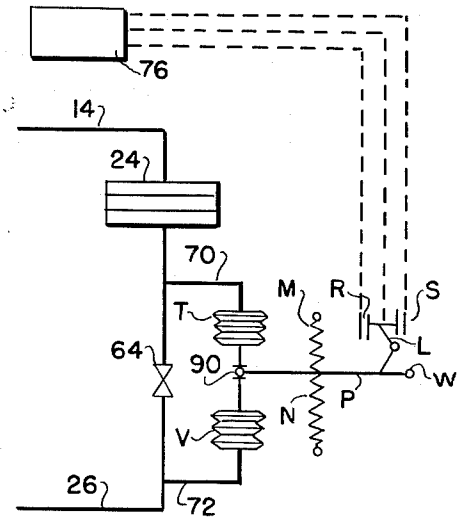


FIG. 3

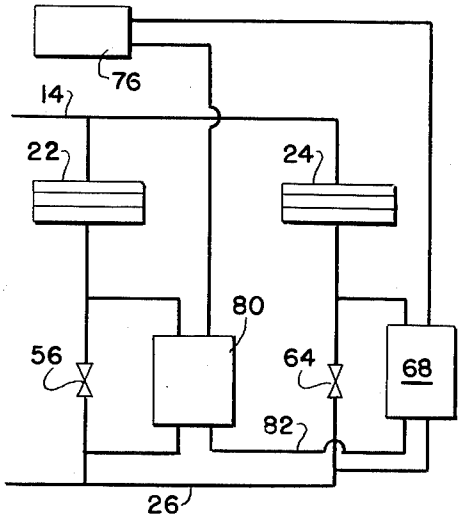


FIG. 4

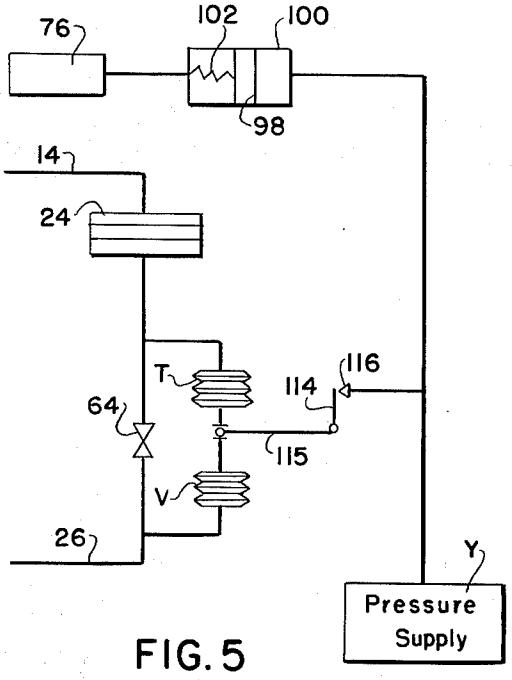


FIG. 5

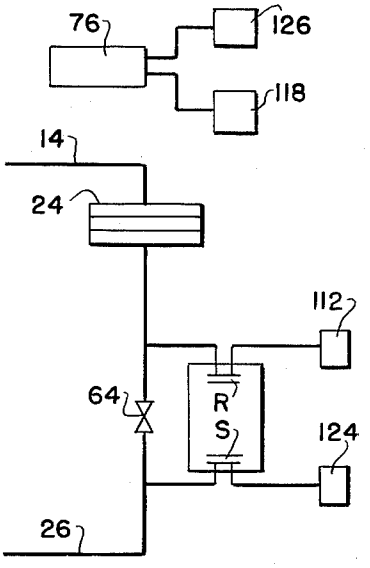


FIG. 6

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HEAT EXCHANGE SYSTEM WITH AUTOMATIC PUMP CONTROL

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9 Claims. (Cl. 165—22)

This invention relates to a closed circulation heat exchange system and is particularly concerned with a sensor to automatically vary the system circulation pressure rate in proportion to the system demand.

The present system has a source of heat transfer fluid which can either be heated or cooled and is circulated by a pumping means such as a centrifugal pump. The liquid coolant can be refrigerated water, or an aqueous solution such as brine, or an organic liquid medium such as glycol. The system includes a main conduit supply to which is connected a plurality of individual heat exchange units for individual consumers. The individual heat exchange units are also connected to the return conduit of the system so that the closed circulation operation is effected by having the centrifugal pump deliver fluid from either the heated or cooled source through the main conduit, and from there it can pass through each individual consumer and then be returned to the source by the return conduit.

In the illustrated and disclosed embodiment reference is made to a heater source supplying hot water for a plurality of consumers, each having an individual heat exchange unit including a control valve which varies the amount of water through an individual heat exchanger in proportion to the demand of the consumer. This arrangement has been such that each control valve would be directly responsive to the heat demand, and if the demand for heat was low, the control valve would close to throttle the flow thereby decreasing the amount of hot water circulation required in the main supply conduit. It should be kept in mind that when a system of this type is installed, the greatest heat demand is first determined, and the capacity and pressure of the pump is set to supply sufficient hot water for the greatest demand at the farthest point. As indicated above, when this demand is less than peak capacity, the control valves will have moved into a throttling position to reduce the water being distributed. However, the pump has been set to deliver the supply for greatest demand so an excess pumping head is created when the demand decreases. Such excess head is taken up in the throttling of the individual control valves, but this is undesirable since it creates a resistance in the system using costly electric power.

The system can also be explained in terms of the pressure drop. Each individual heat exchange unit connected along the main conduit requires together with the main conduit a certain pressure drop. If all heat consumers are operating at full demand, then the pump has to operate at a certain number of revolutions to create a sufficiently high pressure head to satisfy the demand of the main conduit and each heat consumer. In the past the centrifugal pump has been set for constant speed to provide for this maximum demand. Of course this ideal arrangement exists only when the demand of every heat consumer remained constant at maximum capacity with the control valves nearly wide open. However, in practice it is found that not always maximum demand prevails for each individual user, and this results in the individual control valve throttling to decrease the supply which creates an additional pressure head in the throttled valve while the pump maintains its constant head and speed. Attempts have been made to regulate manually the speed of the pump as the demand varies, but they have involved the use of an operator who had to visit distant heat consumers and from the readings of the gauges of the heat consumers would attempt attempt to set the proper pump speed. However, this manual operation has proved of limited success, for the operator has to be highly skilled to interpret the readings and such manual control is tardy and inaccurate so that considerable undesired valve throttling takes place before the manual speed control can become effective.

Therefore, it is an object of the present invention to provide a closed circulation heat exchange system in which a sensor automatically varies the pressure at the pump outlet in proportion to the demand.

It is another object of the present invention to provide a closed circulation heat exchange system in which the speed of a supply pump is automatically varied by a sensing element connected with at least one individual heat exchange unit.

It is a further object of the present invention to provide a closed circulation heat exchange system having a plurality of individual heat exchange units to automatically vary the supply pump capacity by a sensing element controlled by the demand of the heat exchange unit most distant from the heater.

It is a still further object of the present invention to provide a closed circulation heat exchange system having a plurality of individual heat exchange units to automatically vary the supply pressure head by any one of a plurality of sensing elements controlling the corresponding heat exchange units.

It is another object of the present invention to provide a closed circulation heat exchange system that is automatically operated to accurately deliver only a sufficient pressure head to satisfy the demand and maintain at least one of the control valves of individual heat exchange units open almost wide.

In practice it is known that when a great many individual consumer connections are made on an extended hot water heat exchange system, the demands of the various similar consumers are generally the same at the same time. In other words, during the night it is known that the demand on most units will be at a minimum while at a certain time during the day it will be at its highest. Since the various consumers located near the end of the line represent a homogeneous mass, an individual unit or a small group of individual units can be taken as representative of the demand fluctuations. It is preferable to use the last heat exchange unit in the line to regulate the system, for if a sensing element associated with this last unit provides for proper supply to the last group of units, then it follows that the units up the line will be receiving a proper supply also.

In accordance with the present invention there is provided a hot water heat exchange system having a speed control for a centrifugal pump that varies automatically to maintain the delivered supply pressure equal to a varying demand with the control valves for at least one of the individual heat exchange units close to a wide open position.

In order that the invention will be fully understood, it will be described with reference to and as illustrated in the accompanying drawings, in which:

FIG. 1 schematically illustrates a closed circulation heat exchange system having a plurality of individual heat consumers;

FIG. 2 graphically illustrates for two pump speeds the change in pressure head in comparison with the pumping volume.

FIG. 3 is an embodiment showing a differential pressure sensor;

FIG. 4 is an embodiment showing a plurality of sensors;

FIG. 5 is an embodiment showing a sensor using a pneumatic control; and

FIG. 6 is an embodiment showing a sensor using a wireless control.

Referring to FIG. 1 a heater 10 delivers heated water by means of a centrifugal pump 12 to a main supply line 14. A large number of individual heat consumers are connected with said main supply line 14, but for ease of explanation only individual units 16, 18, 20, 22 and 24 are shown. The individual units are connected between the supply line 14 and a return line 26 so that a complete closed operation is represented by the hot water from heater 10 being forced by pump 12 through supply conduit 14 through the individual units 16–24 to deliver heat, then returned in cooled condition by conduit 26 to the heater 10 to be reheated.

Each individual unit is located at a certain distance down the line or downstream of the heater 10. As illustrated in FIG. 1, unit 16 is located at point A down the line, unit 18 at point B, unit 20 at point C, unit 22 at point D and the last unit 24 at point E. As the hot water is pumped along in the conduit 14 and returned through conduit 26, it will be appreciated that for each point along this conduit a certain pressure drop exists due to the friction loss in the conduit and the resistance in the individual unit and its control valve. Point E is the farthest along the line and therefore can be considered representative of the maximum pressure drop in the supply and return line. Pump 12 must have a pressure head sufficient to overcome this pressure drop and the resistance of the unit and its control valve. The available pump head therefore must be of a value equal to the friction loss in the supply and return lines at the maximum demand of the various individual units.

Each individual unit includes an inlet conduit from main conduit 14 and an outlet connection to return conduit 26. Heat exchanger unit 16 has inlet conduit 28 and outlet conduit 30. A control valve 32 is located in outlet conduit 30 and regulated according to heat demand by an instrument 35 located in conduit 34 connecting valve 32 to the heat exchanger unit 16. Heat exchanger unit 18 has inlet conduit 36 and outlet conduit 38. A control valve 40 is located in outlet conduit 38 and regulated according to heat demand by an instrument 43 located in conduit 42 connecting valve 40 to the heat exchanger unit 18. Heat exchanger unit 20 has inlet conduit 44 and outlet conduit 46. A control valve 48 is located in outlet conduit 46 and regulated according to heat demand by an instrument 51 located in conduit 50 connecting valve 48 to heat exchanger unit 20. Heat exchanger unit 22 has inlet conduit 52 and outlet conduit 54. A control valve 56 is located in outlet conduit 54 and regulated according to heat demand by an instrument 59 located in conduit 58 connecting valve 56 to heat exchanger unit 22. The last heat exchanger unit 24 has inlet conduit 60 and outlet conduit 62. A control valve 64 is located in outlet conduit 62 and regulated according to heat demand by an instrument 67 located in conduit 66 connecting valve 64 to heat exchanger unit 24.

As illustrated in the preferred embodiment of FIG. 1 a sensing element 68 is associated with control valve 64 which is connected to the last individual heat exchange unit 24. Sensor 68 is connected to conduit 62 by a pair of connections 70, 72, connection 70 being upstream of control valve 64 and connection 72 being downstream of control valve 64. These connections 70, 72 sense the differential pressure between the two sides of control valve 64 representing the pressure drop across the valve. If the system is calling for full capacity from pump 12, then all control valves 32, 40, 48, 56 and 64 will be wide open and there will be practically no pressure drop across valve 64. Under such circumstances the sensor 68 will not pick up a signal from the connections 70, 72.

Now if there is a decrease in demand for an individual consumer, such as at the last point E, the instrument 67 will react to this decrease demand and effect throttling of valve 64. This throttling action creates a pressure drop across valve 64 which produces a signal in sensor 68. In the illustrated embodiment this signal is shown as being transmitted by a connection 74 to a reversing gear motor 76. The signal may be positive or negative for driving the reversing gear motor 76 in one direction or the other to establish an increasing or decreasing speed setting on a speed control 78, the specific setting being determined by the strength of the signal in proportion to the throttling. Pump 12 is driven by a motor (not shown), the speed of which is controlled by speed control 78. Accordingly, the aforementioned decrease in demand is seen to create a signal in sensor 68 which will decrease the speed of pump 12 so that water is pumped into the system at a smaller head. The decreased pumping speed is commensurate with the amount of throttling of the control valve and will continue to decrease until the control valve 64 is again almost wide open to supply the decreased demand at the preset pressure drop at which time no signal appears in sensor 68.

This change in supply can be better understood by referring to FIG. 2 in which the abscissa represents the demand such as in gallons per minute and the ordinate represents the pressure head of the pump. Curve 4 represents a plot of the pump head required to provide a maximum flow in the illustrated system taken at points A, B, C, D and E along the consumer line. Point Y on the abscissa represents the maximum flow required in the line with all valves open, and point 6 represents the pump head required to supply this demand. The specific values on curve 4 therefore represent the pressure loss in the supply and return conduits between heater 10 and the most remote valve 64 for varying supply conditions. Curve 5 represents the relation of varying water volume pumped and the head produced by the pump at the maximum pump speed. It is seen that the pump head at the flow volume Y corresponding to point 6 is sufficient to overcome the friction loss along the line and supply enough water for maximum demand Y. Accordingly, at point 6 there is no wasted energy or heat from a throttled valve. Now if conditions should change so that there is a decrease from the maximum heat demand, then the system will only require a flow amount as represented by a point X on the abscissa. If the pump continues to run at full speed, the total pump head available is represented by point 7, but as clearly shown by curve 4 the head required to supply the flow at point X is represented by point 8 when the control valves are wide open. Therefore, it is seen that the pump head between points 7 and 8 is excess and is taken up in the throttled valves. This excess head is taken up as a heat and friction loss in the throttled control valves. With the present invention such excess head is avoided since as soon as the flow decreases, the sensor 68 automatically causes the pump 12 to run at slower speed with a smaller head, and an equilibrium condition of supply and demand is achieved with the control valves wide open as represented by the new pump curve 9 which corresponds to the reduced speed. Curve 9 illustrates how the lower head of the pump is sufficient to overcome the friction loss and accommodate the decreased demand without any excess head.

FIG. 3 illustrates a sensor having a pressure differential control. In this embodiment, as in other embodiments hereinafter illustrated, the same numerals are used for the same elements shown in FIG. 1. In FIG. 3 a change in heat demand will cause a throttling of valve 64, and the pressure differential on either side of valve 64 is directed through connections 70 and 72 to bellows T and V. The difference in pressure in bellows T and V results in movement of contact 90 to which is attached lever P that is pivoted at point W. Lever P is biased in position by opposing springs M and N so that a predetermined pressure differential is required before lever P is moved. The

movement of lever P actuates a further pivoted lever L which closes either switch R or switch S depending on which way lever P is moved. Switches R and S are conventional, and operation thereof energizes reversing motor **76** in one or the reverse direction depending on which switch is closed. If closing switch R energizes reversing motor **76** to increase the speed of pump **12**, then more hot water will flow, and this will decrease the pressure drop around valve **64** and open switch R to automatically maintain the desired flow around substantially unthrottled valve **64**. A decrease in demand will move lever P in the opposite direction to close switch S and reversely energize reversing motor **76** and reduce the speed of pump **12** to automatically maintain the desired flow around substantially unthrottled valve **64**.

In FIG. 4 a plurality of sensors **68** and **80** are shown connected in parallel to provide the automatic control. As shown in FIG. 1, the sensing control is substantially at the end of the supply line **14**, and this is true also when a plurality of sensors are used. Sensors **68** and **80** may operate conventional switches R and S as described in connection with FIG. 3. In operation any one of these sensors remote from the supply and shown with a parallel connection **82** may provide the automatic control by sending the appropriate signal to reversing motor **76** as described in connection with FIG. 3.

It will be appreciated from an examination of FIGS. 1 and 2 that the pumping head decreases proportionately out to the last consumer at the end of the supply line **14**. The automatic control hereinbefore described provides for maintaining the last control valve substantially open, and at the same time the control valves, such as valves **32**, **40**, **48** and **56** operate in a degree of throttled condition proportional to the demand of the particular consumer involved at that particular location.

In FIG. 5 a sensor using a pneumatic control is illustrated. Bellows T and V as shown in FIG. 3 are connected around valve **64**, and a differential in pressure moves a pivoted lever **115**. This in turn moves a flapper **114** which controls a bleed nozzle **116**. A pressure supply Y is provided which actuates a piston **98** in a cylinder **100** that is biased by spring **102**. Movement of piston **98** increases or decreases energization of reversing motor **76** as described in connection with FIG. 3. It is seen that a change in heat demand will change the throttling relationship of valve **64** and provide a differential pressure in bellows T and V. This will cause movement of lever **115** and flapper **114** to open or close the pressure bleed from nozzle **116**. For example, if nozzle **116** is closed, then the pressure supply Y, which may be air or fluid, will actuate piston **98** against the bias of spring **102** which changes reversing motor **76** and the speed of pump **12**.

In FIG. 6 is shown a wireless embodiment of the sensor. As described for FIG. 3 switches R and S can be used to provide a signal to transmitter **112** or **124** depending on whether there is an increase or decrease in heat demand. The signal is picked up by either receiver **126** or **118** and reversing motor **76** is changed appropriately.

It will be appreciated that in actual practice the required pump head is continually fluctuating, and an efficient operation can only be supplied by the automatic control afforded by the present invention.

The particular embodiment of the invention illustrated and described is to be considered illustrative only. For example, the invention is not limited to hot water systems as other heat transfer fluids for heating or cooling can equally well be used. The present invention includes such other modifications and equivalents as may readily occur to those skilled in the art, within the scope of the appended claims.

What is claimed is:

1. A closed circulation heat exchange system having a source of hot water supply connected to a supply line and a return line with a pumping means to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of supply to sense the pressure differential across said one valve in response to a change in heating demand and maintain said one control valve substantially unthrottled by proportionately varying the speed of the pumping means to establish automatic regulation of the water supply.

2. A closed circulation heat exchange system having a source of liquid coolant connected to a supply line and a return line with a pumping means to force said liquid coolant through said lines for return to said source, a plurality of heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of coolant to sense the pressure differential across said valve in response to a change in cooling demand and maintain said one control valve substantially unthrottled by proportionately varying the speed of the pumping means to establish automatic regulation of the liquid coolant supply.

3. A closed circulation heat exchange system having a source of refrigerated water supply connected to a supply line and a return line with a pumping means to force said refrigerated water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of supply to sense the pressure differential across said valve in response to a change in cooling demand and maintain said one control valve substantially unthrottled by proportionately varying the speed of the pumping means to establish automatic regulation of the refrigerated water supply.

4. A closed circulation heat exchange system having a source of hot fluid supply connected to a supply line and a return line with a variable speed centrifugal pump to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of supply to sense the pressure differential across the valve as it responds to a change in heating demand, said means operable to create an electrical signal when said pressure differential exceeds a predetermined value to drive a reversing motor to set the speed of said centrifugal pump in proportion to the amount of the heating demand and maintain said one control valve substantially unthrottled to establish automatic regulation of the fluid supply.

5. A closed circulation heat exchange system having a source of hot water supply connected to a supply line and a return line with a variable speed centrifugal pump to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough,

and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of supply to sense the pressure differential across the valve as it responds to a change in heating demand, said means having two switches each for controlling an electric circuit, a pressure differential across the valve below a predetermined value actuating one switch and a pressure differerntial across the valve above the predetermined value actuating the other switch, said switch actuation sending a signal through the circuits to drive a reversing motor to set the speed of said centrifugal pump in proportion to the amount of the heating demand and maintain said one control valve substantially unthrottled to establish automatic regulation of the supply.

6. A closed circulation heat exchange system having a source of hot water supply connected to a supply line and a return line with a pumping means to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of supply to sense the pressure differential across the valve in response to a change in heating demand, said means operable to actuate a compressed air device connected to vary a speed control for changing the pressure head of said pumping means in proportion to the variation in the pressure differential and maintain said one control valve substantially unthrottled to establish automatic regulation of the supply.

7. A closed circulation heat exchange system having a source of hot water supply connected to a supply line and a return line with a pumping means to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a pressure differential control unit having pressure connections on either side of at least one of said control valves that is located substantially at the end of the supply line remote from said source of supply to sense the pressure differential across the valve in response to a change in heating demand, said means operable to transmit a wireless signal to a receiving transducer on a speed control for changing the pressure head of said pumping means in proportion to the variation in the pressure differential and maintain said one control valve substantially unthrottled to establish automatic regulation of the supply.

8. A closed circulation heat exchange system having a source of hot water supply connected to a supply line and a return line with a pumping means to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a plurality of pressure differential control units individually connected with pressure connections on either side of a corresponding number of control valves that are located at the end of the supply line remote from said source of supply to sense the pressure differential across each valve as it responds to a change in heating demand, said means first responding to said change in heating demand operable to maintain its individual control valve substantially unthrottled by proportionately varying the speed of the pumping means to establish automatic regulation of said water supply.

9. A closed circulation heat exchange system having a source of hot water supply connected to a supply line and a return line with a variable speed centrifugal pump to force said hot water through said lines for return to said source, a plurality of individual heat exchanger units each connected in parallel between said supply and return lines with a throttling control valve associated with each individual heat exchanger unit for controlling the flow therethrough, and means including a plurality of pressure differential control units individually connected with connections on each side of a corresponding number of control valves that are located at the end of the supply line remote from said source of supply to sense the pressure differential across each valve as it responds to a change in heating demand, said means having a first switch for controlling a circuit to drive a reversing motor in one direction and a second switch for controlling a circuit to drive a reversing motor in the other direction, said first switches connected in series and said second switches separately connected in series, a pressure differential across one of the control valves below a predetermined value actuating one of the first switches, and a pressure differential across one of the control valves above a predetermined value actuating one of the second switches, said switch actuation sending a signal to drive said reversing motor to set the speed of said centrifugal pump in proportion to the amount of the heating demand to maintain said one control valve substantially unthrottled to establish automatic regulation of said water supply.

No references cited.

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