United States Patent [19]

Wilson

[11] **3,852,147**

[45] **Dec. 3, 1974**

[54] **HEAT EXCHANGER**

[76] Inventor: **Warren M. Wilson,** 809 Superior Dr., Huron, Ohio 44839

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[21] Appl. No.: **246,622**

[52] **U.S. Cl.** **165/36,** 165/101
[51] **Int. Cl.** **G05d 23/00**
[58] **Field of Search** 165/35, 36, 39, 40, 101

[56] **References Cited**

UNITED STATES PATENTS

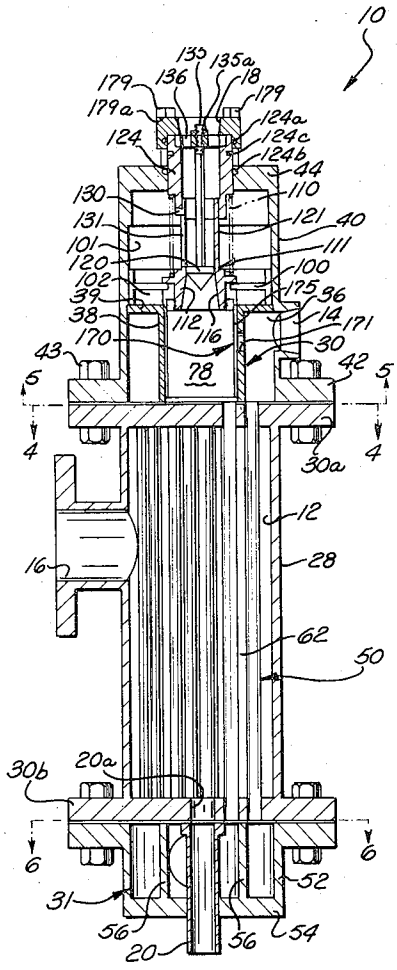
2,501,012 3/1950 St. Clair 165/36

Primary Examiner—Charles Sukalo

[57] **ABSTRACT**

An apparatus for heating water by steam comprises a heat exchanger having a steam chamber. Fluid conduit means directs water through the steam chamber to a hot water outlet chamber. Inlet steam conduit means delivers steam to the chamber. A piston member is located in the water outlet chamber and is movable therein in response to a demand for heated water. The piston member moves to a position in accordance with the desired demand. A blending valve arrangement is utilized in the system so as to continuously blend cold water with hot water exiting from the heat exchange chamber. The blending valve comprises a sleeve valve member which is connected with the piston member and which is movable therewith. The sleeve member has at least one opening therein which cooperates with an opening in an annular baffle in the heat exchanger to control the amount of blending which occurs in accordance with movement of the piston member. In one embodiment, steam is on the heat exchanger at all times, while in other embodiments, a steam inlet valve means located in the steam inlet conduit is controlled by movement of the piston member to apply steam to the heat exchanger only when there is a demand for heated water. In these other embodiments, the piston member is associated with a lever member which pivots upon movement of the piston member. The lever member, when it pivots, controls a valve member which directs fluid to the steam inlet valve means and causes opening of that valve means. Upon return of the piston member to its initial position after the demand for water has been terminated, the lever member is pivoted so as to operate the valve means in the steam inlet conduit to a closed condition. In all embodiments, the fluid conduit means for directing the flow of fluid through the heat exchanger is arranged so as to provide a four-pass system enabling fluid to flow four times through the heat exchange chamber before exiting from the heat exchange chamber.

25 Claims, 19 Drawing Figures



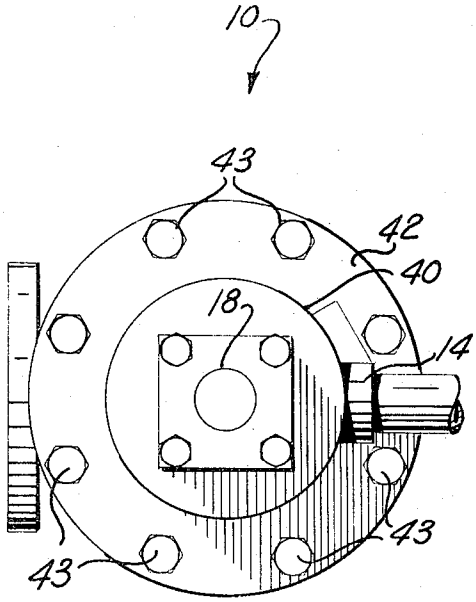

10
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42
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FIG. 2

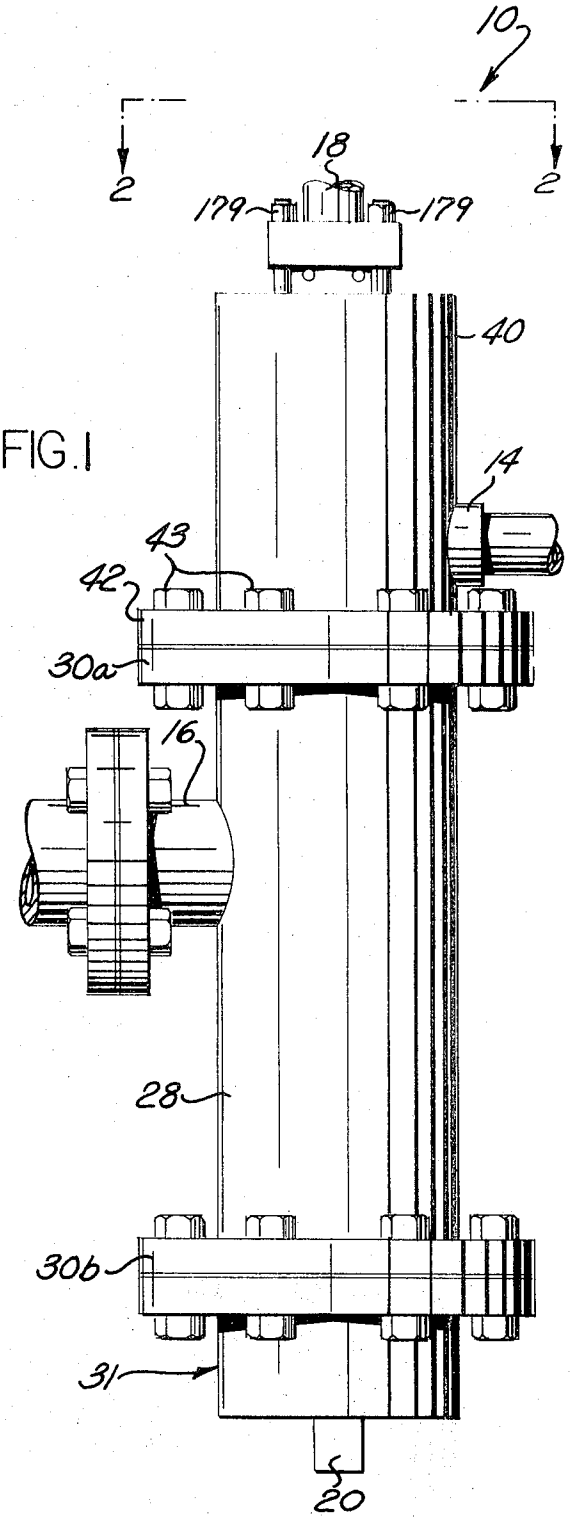

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FIG. 1

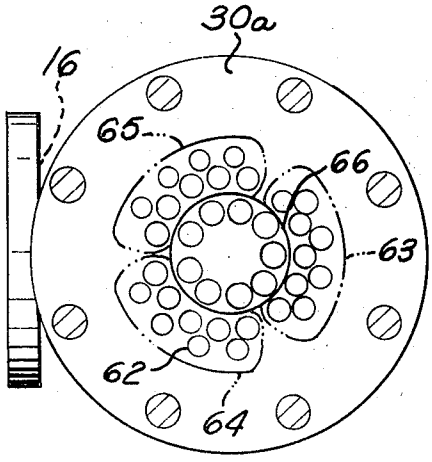

30a
16
65
66
63
62
64

FIG. 4

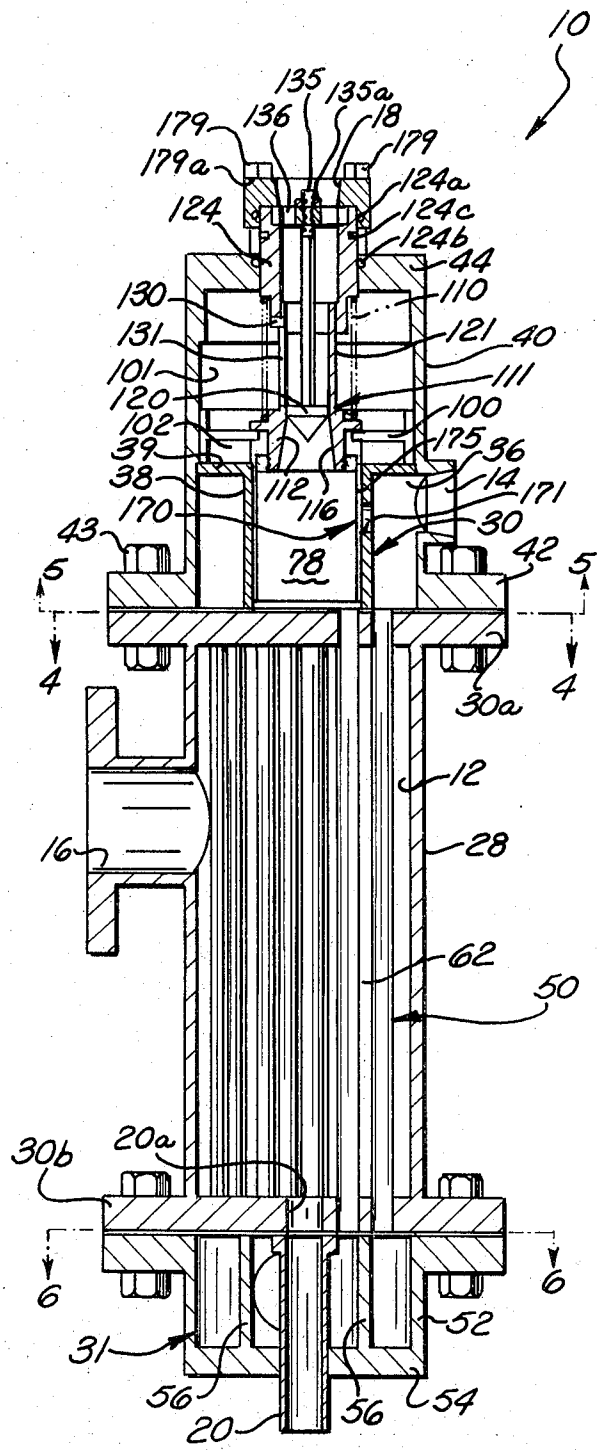

10
135
135a
136
18
179
179a
124a
124c
124b
124
44
110
130
131
121
40
101
111
120
100
102
175
39
36
38
112
14
171
116
170
30
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78
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30a
12
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62
50
30b
20a
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31
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54
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FIG. 3

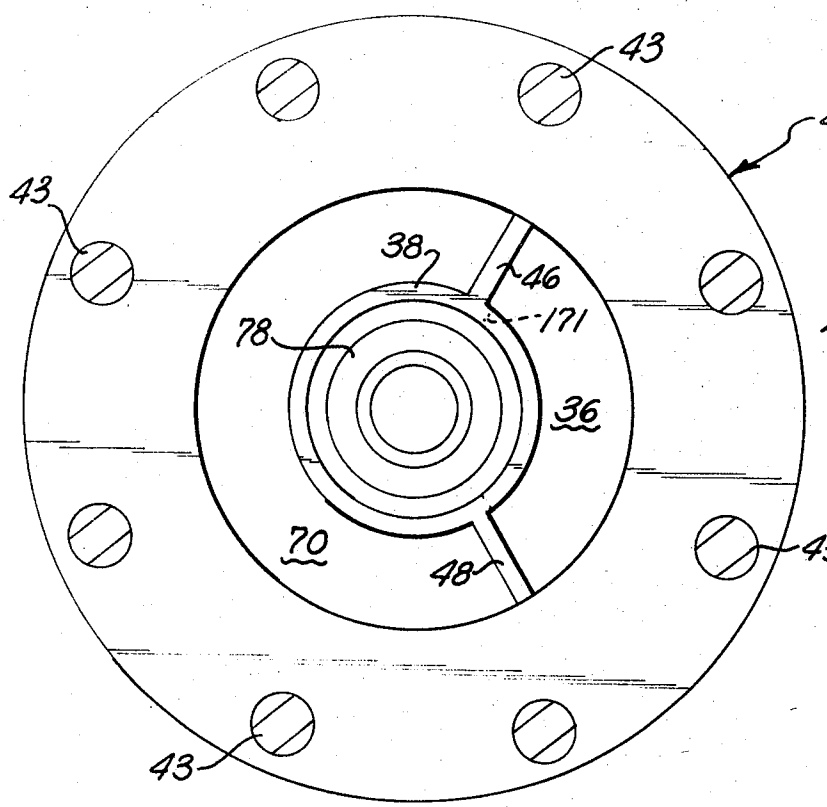


FIG.5

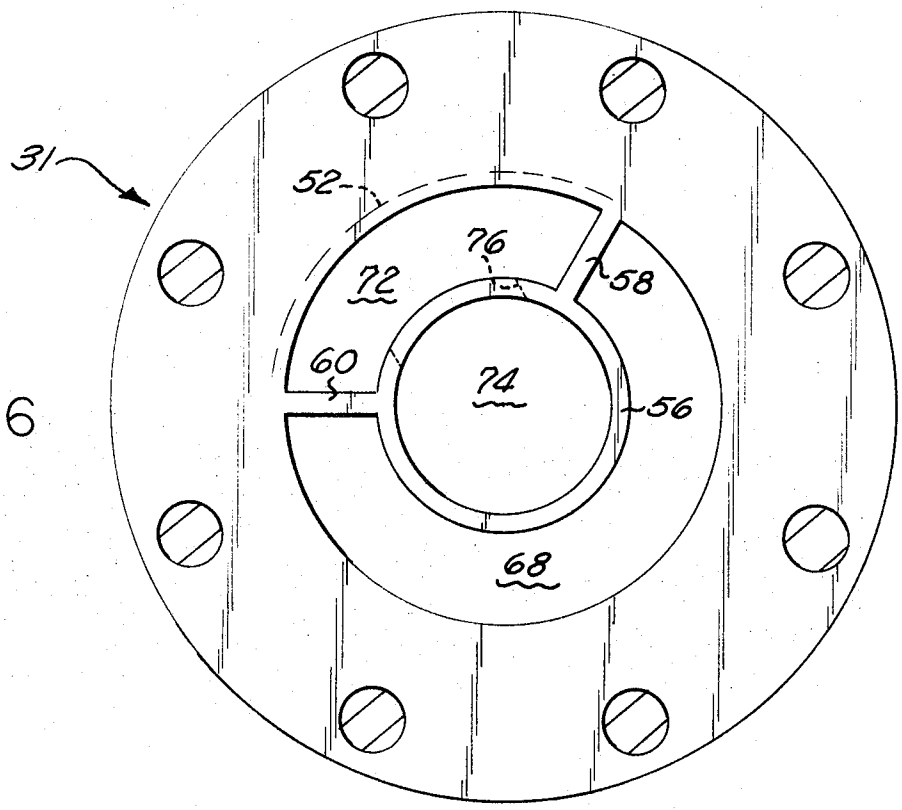


FIG.6

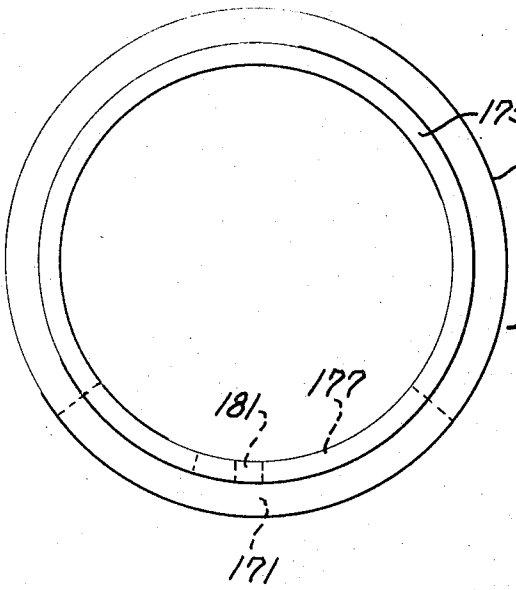


FIG. 9

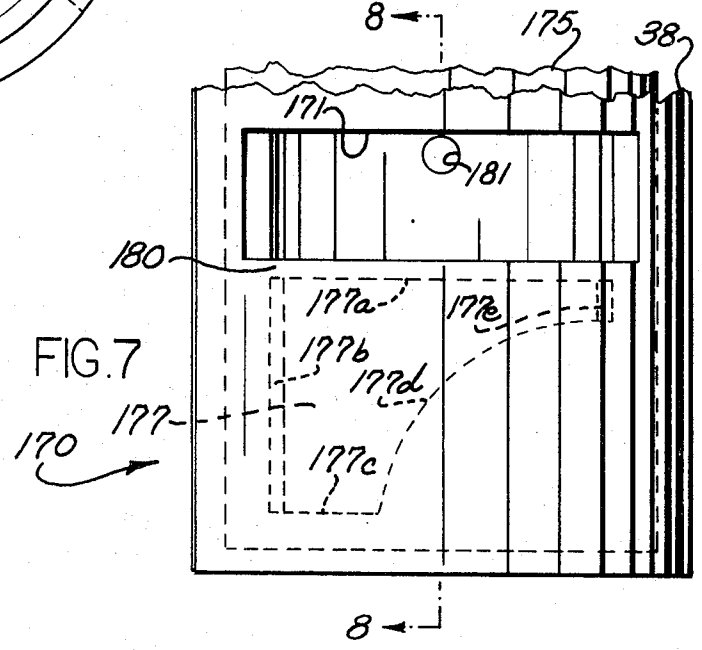


FIG. 7

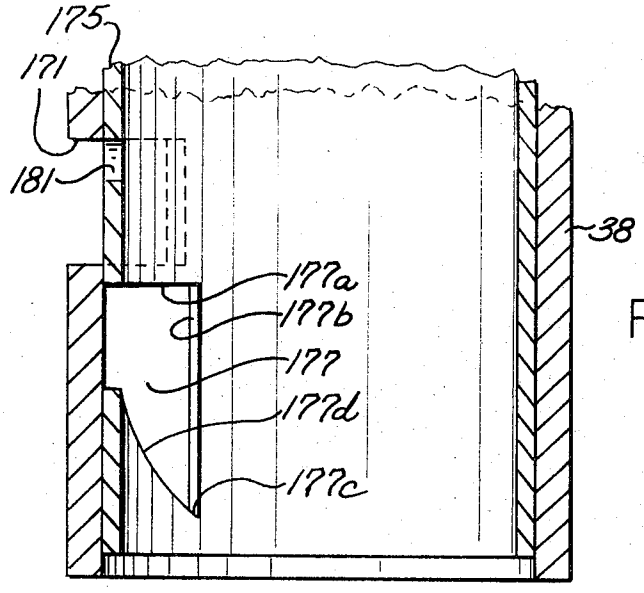


FIG. 8

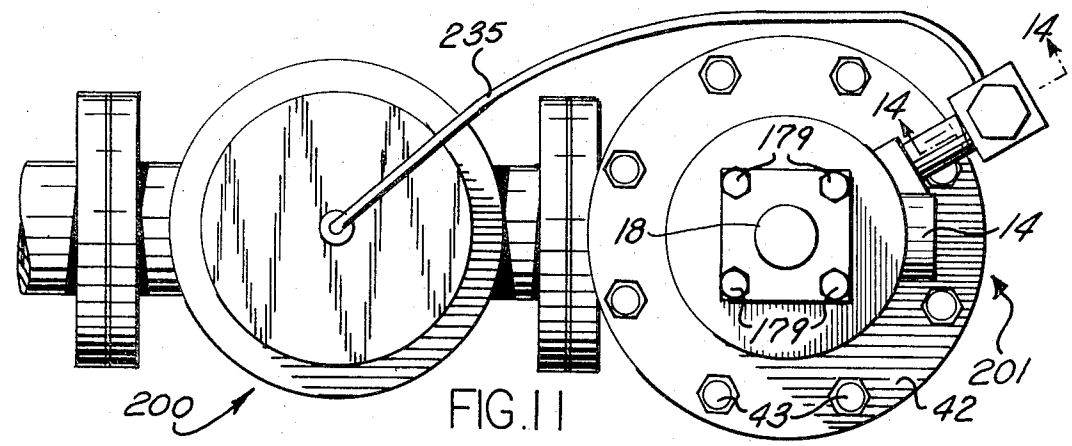

235
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FIG. 11

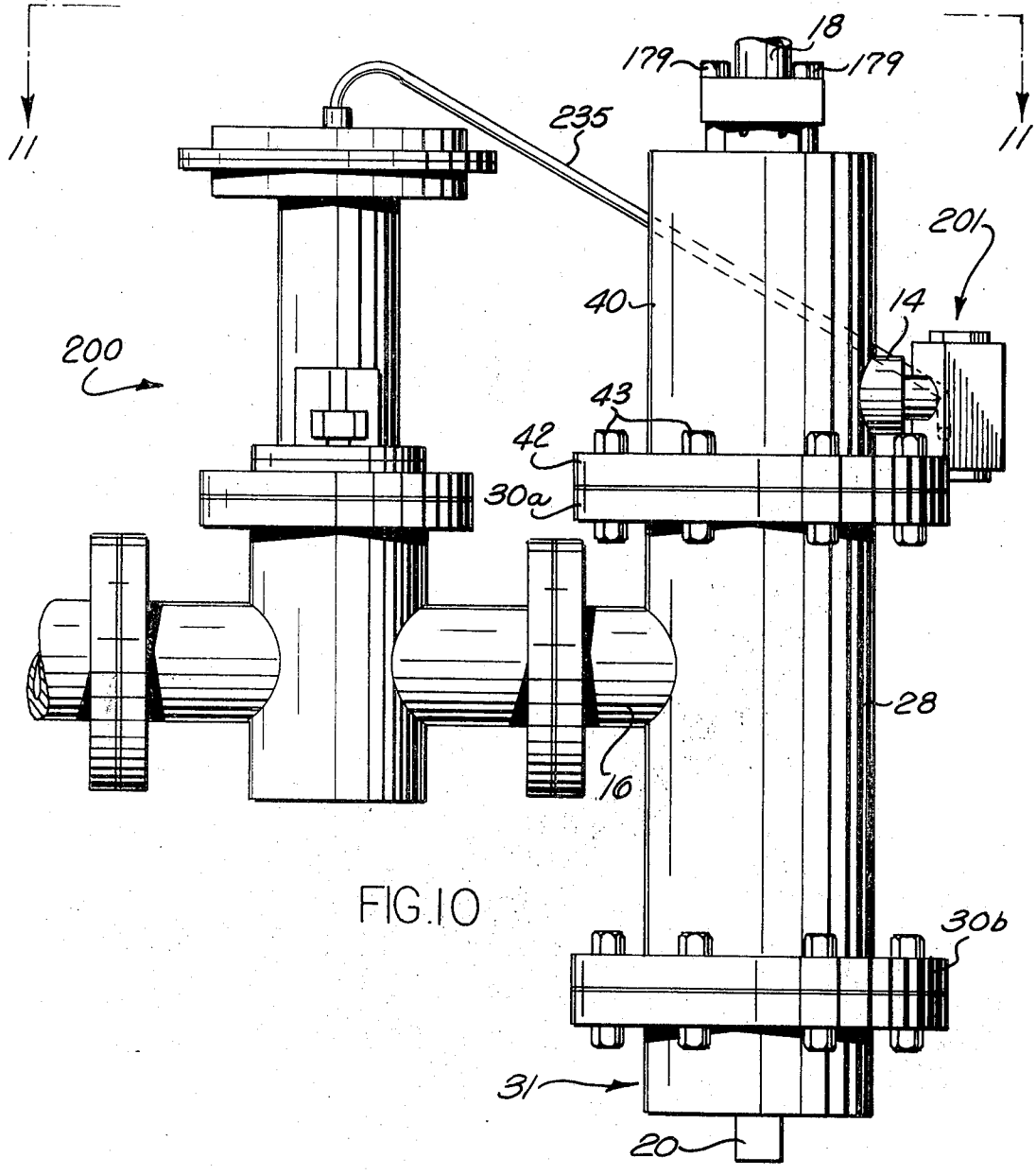

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FIG. 10

FIG. 13

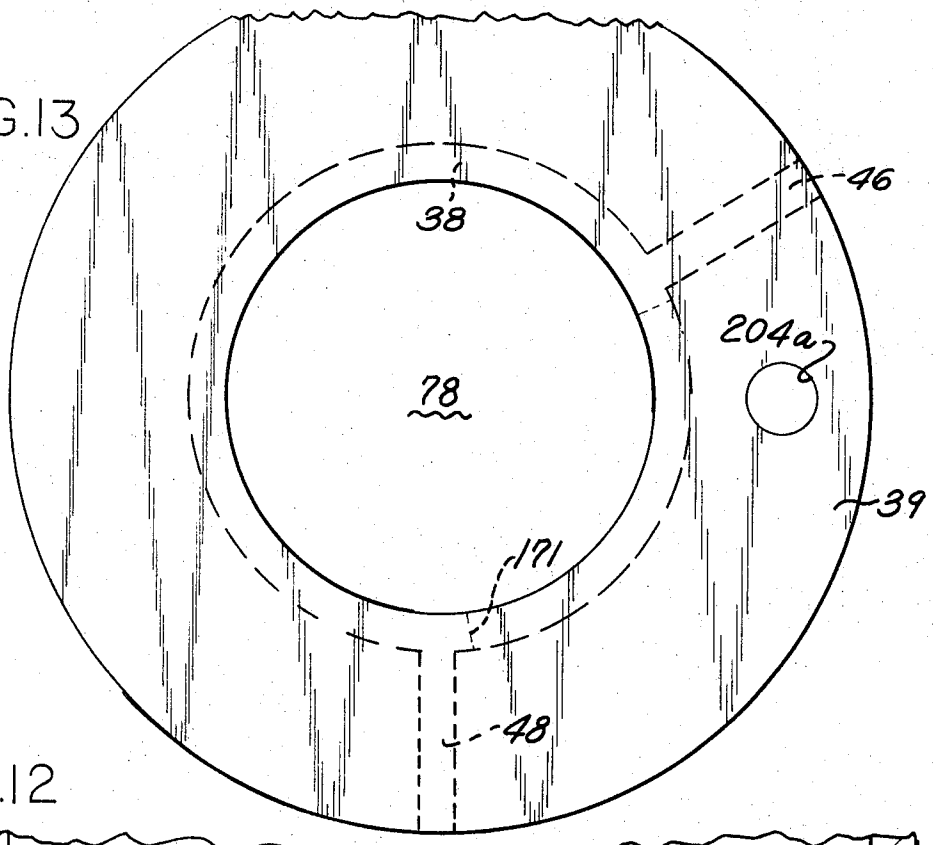
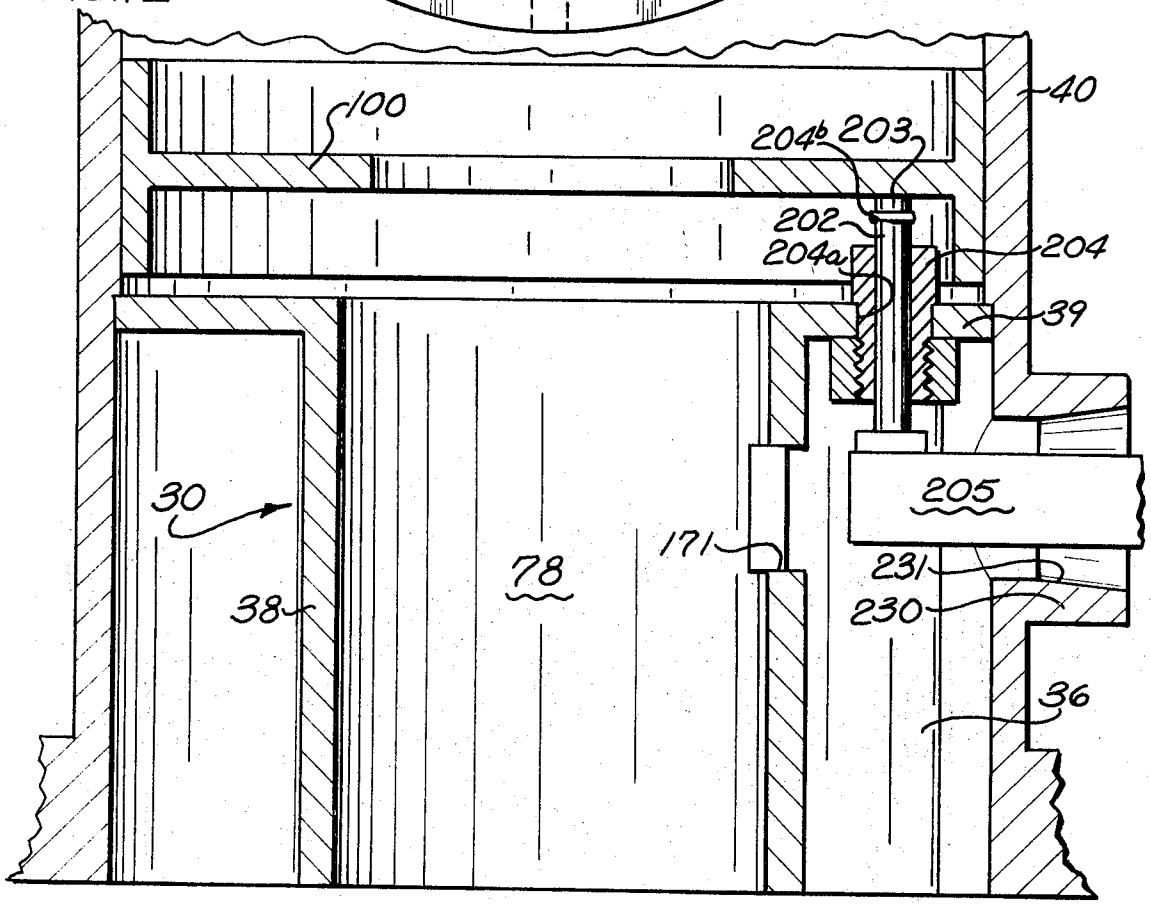

46
38
204a
78
39
171
48

FIG. 12


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100
204b
203
202
204a
204
39
205
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171
231
78
38
230
36

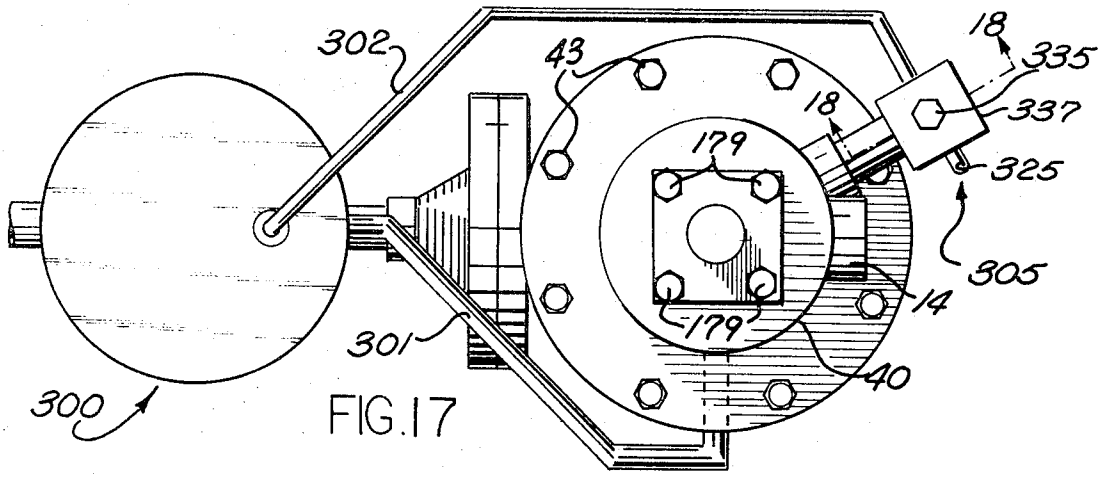

302
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337
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325
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301
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FIG. 17

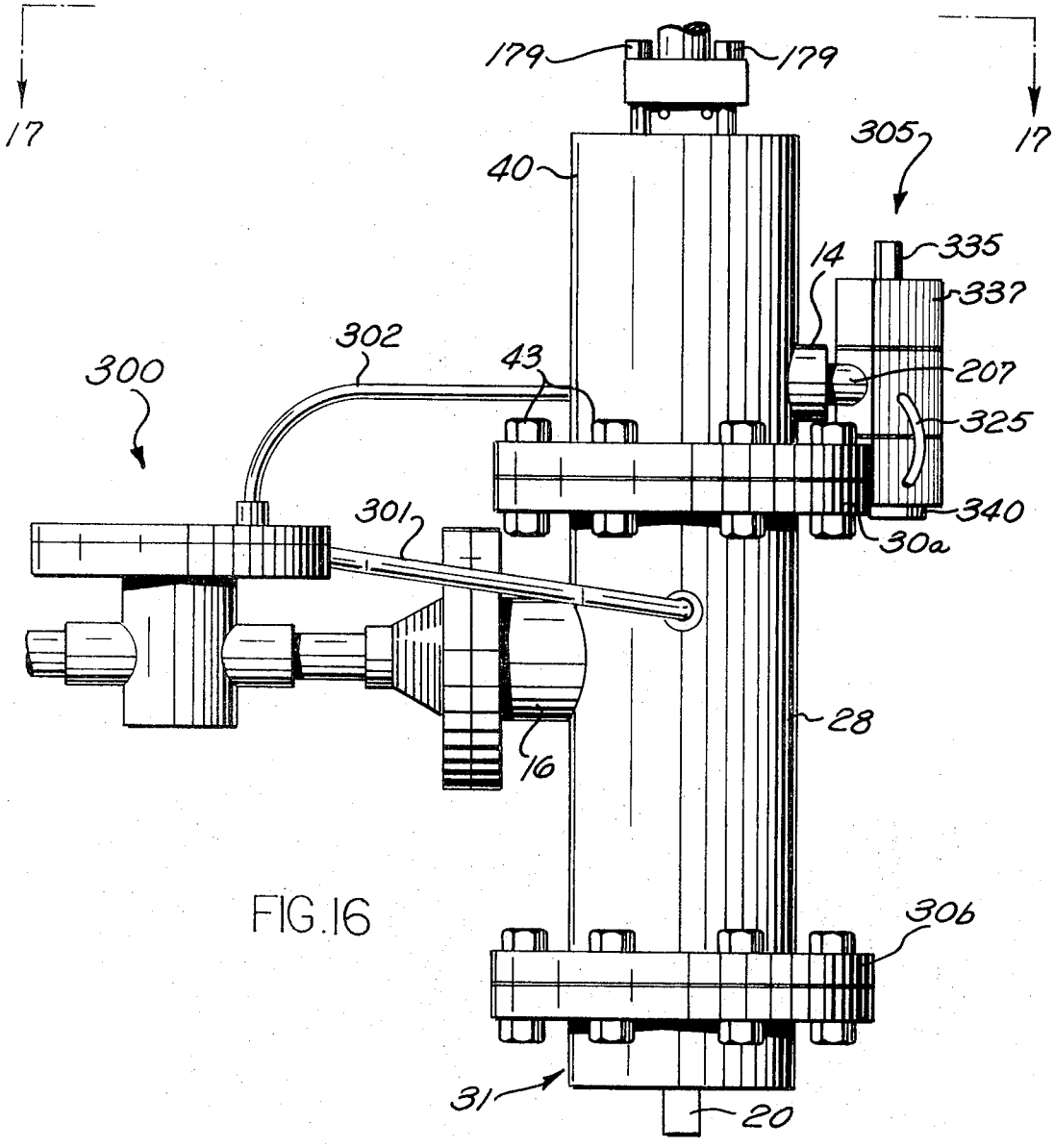

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FIG. 16

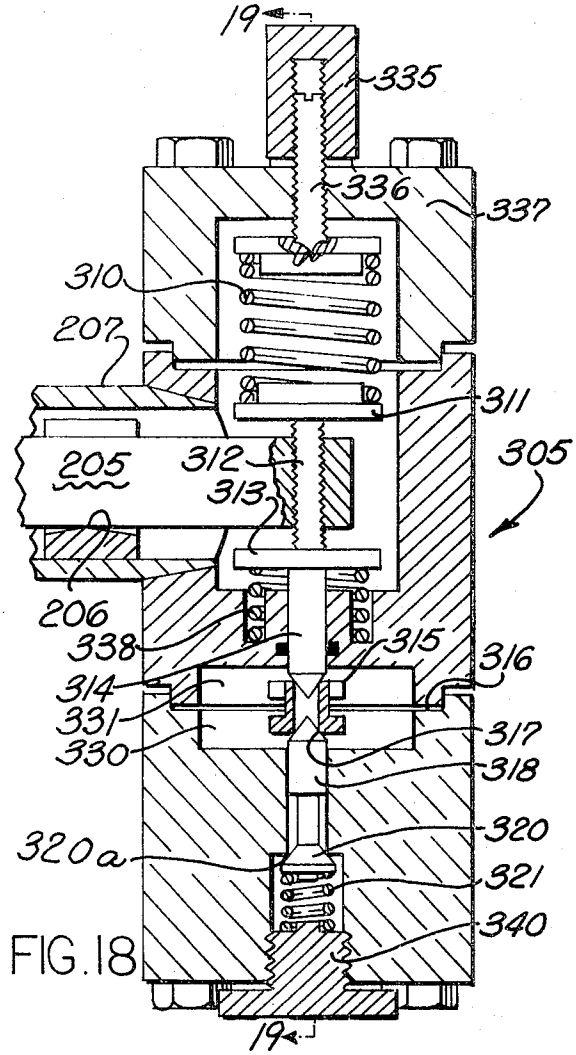


FIG. 18

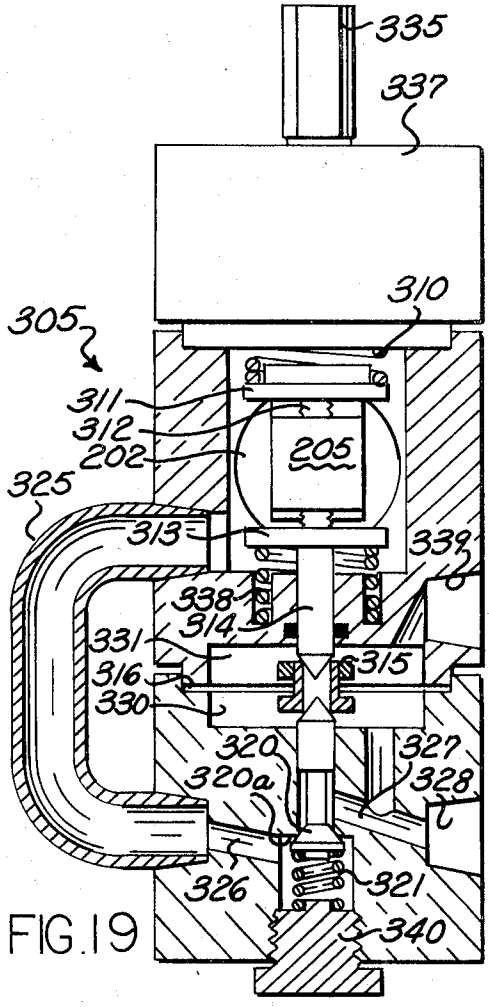


FIG. 19

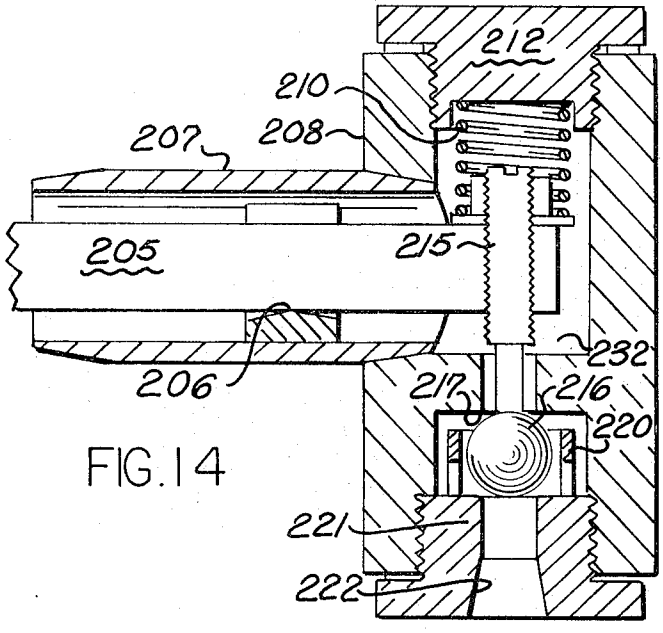
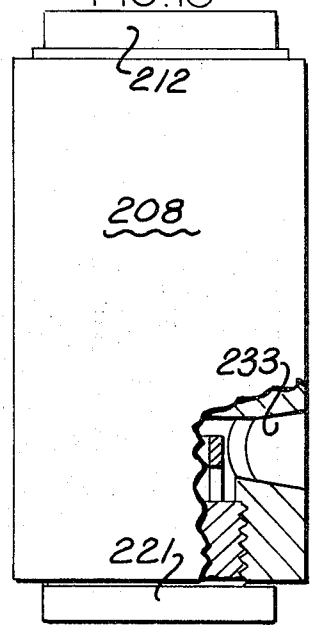


FIG. 14

FIG. 15



HEAT EXCHANGER

The present invention relates to a heat exchanger, and particularly a heat exchanger for heating water by steam.

There is much prior art in the area of heat exchangers and particularly heat exchangers for heating water by steam. The applicant herein has been active in this field and has obtained prior art Pat. Nos. 3,391,729 and 3,489,205 which disclose heat exchangers of the type in which a member moves in response to a demand for hot water and that member, when it moves, controls the application of steam to the heat exchanger. Moreover, Pat. No. 3,489,205 discloses the blending of cold water with hot water exiting from the heat exchanger in order to maintain a control of the exiting water temperature.

The present invention provides an improved heat exchanger in which a blending of hot water with cold water prior to the water exiting from the exchanger is effected to control exit water temperature. The blending occurs through the full range of operation of the heat exchanger, and is controlled by a piston member located in the outlet chamber of the exchanger and which moves in a precise manner in response to a demand for heated water.

The blending is accomplished by a fixed aperture which is sufficiently large to assure that water of an appropriate temperature can be produced when wide open. A moving aperture, attached with the piston, cooperates with the fixed aperture to control the amount of blending. When the piston moves, the overlapping area of the fixed and movable apertures varies so that the proper amount of blending is provided to properly control exit water temperature. Adjustment in the exit water temperature may be provided by shifting the moving aperture relative to the fixed aperture.

To cope with the back pressure on the condensate leaving the heat exchanger, the steam supply pressure must be higher than this back pressure. Once the steam supply pressure is established, only the proper characterizing of the cold water bypass or blending is required to achieve temperature control.

Due to the fact that most piping systems are not drip-tight, if steam is left on the heat exchanger under no-flow conditions, it is possible for leaking water to be overheated. Accordingly, the present invention provides a bypass port so that some cold water is mixed with the hot water so that any leaking water would not under these conditions be excessively overheated. The bypass port comes into effect when the piston is in its null or no-flow position.

The exchanger with which the blending is utilized is a four-pass exchanger which is contructed so that the water flows through the heat exchanger in four passes prior to exiting therefrom and prior to the blending operation. The fourth pass, which is the exiting path, is centrally located with respect to the other passes. A baffle arrangement is provided to separate the passes and direct the water through the heat exchanger. The baffle has the aforementioned fixed aperture which communicates a cold water inlet chamber (defined in part by the baffle) with a centrally located hot water receiving chamber (also defined in part by the baffle) in which the blending or mixing occurs. The steam directed to the heat exchanger may be maintained on the heat exchanger continuously. While allowing the steam

to remain on the heat exchanger at all times causes some fouling of the heat exchanger tubes, the heat exchanger of the present invention is constructed with straight tubes which can be readily cleaned.

Alternatively, the system may have an on-off steam control. This would provide no steam during no-flow conditions. In such a system, the piston which moves to control the blending of the hot and cold water in response to demand also controls a valve in the steam pressure line. The valve is of the on-off type and when operated moves to its on-condition in response to a demand for hot water, and the valve is moved to its off-condition when there is no demand. As a result, steam is not on the heat exchanger during stagnant or no-flow conditions, but is only directed to the heat exchanger when there is a demand for hot water. The piston, when in its null or no-flow condition, engages a pin member and holds the pin member against a lever causing the lever to be in a neutral position. The lever is biased so that when the piston member moves, the lever will move under the bias, which movement results in opening of a loader valve which directs fluid to the steam control valve to effect opening thereof. When the piston member returns to its no-flow position, the valve or loader is moved to its off-position causing the valve in the steam supply line to be actuated to its off-position. In this embodiment of the present invention, the steam pressure which is delivered to the steam supply valve is directed thereby into the heat exchanger. Such a system is particularly advantageously used where the low pressure steam is available.

Where high steam pressure is available, a further embodiment of the present invention may be advantageously utilized. In this embodiment, a differential pressure steam valve is provided in the steam supply conduit and which is operated in an on-off manner by a loader under the control of a lever similar to that in the embodiment noted above. The differential pressure steam valve operates to reduce the steam pressure so that the desired steam pressure is applied to the heat exchanger. This is effected in an on-off manner so that there is no steam pressure on the unit during no-flow conditions, but upon a demand for hot water, a fixed constant steam pressure is applied to the heat exchanger. The steam pressure in the heat exchanger may remain at a constant value as long as hot water is being utilized. The water temperature is controlled continuously via blending, as in the other embodiments noted above. The loader which controls the steam valve is adjustable to meet installation requirements so that a fixed steam pressure which may be adjusted as desired is applied to the heat exchanger.

Further features of the present invention will be apparent from the following description of specific preferred embodiments thereof made with reference to the accompanying drawings forming a part of this specification and in which:

FIG. 1 is a somewhat schematic elevational view of a heat exchanger embodying the present invention;

FIG. 2 is a top view of the heat exchanger in FIG. 1, looking at the heat exchanger of FIG. 1 as indicated by the line 2—2 thereof;

FIG. 3 is an axial sectional view of the heat exchanger of FIG. 1;

FIG. 4 is a sectional view taken approximately along the line 4—4 of FIG. 3;

FIG. 5 is a sectional view taken approximately along the line 5—5 of FIG. 3;

FIG. 6 is a sectional view taken approximately along the line 6—6 of FIG. 3 with parts removed;

FIG. 7 is a view of a portion of the heat exchanger of FIG. 3 on a somewhat enlarged scale;

FIG. 8 is a sectional view of the portion of the heat exchanger shown in FIG. 7 and taken approximately along the line 8—8 thereof;

FIG. 9 is an elevational view looking at the structure of FIG. 7 from the top;

FIG. 10 is a side elevational view of another embodiment of a heat exchanger embodying the present invention;

FIG. 11 is a top view of the heat exchanger embodiment shown in FIG. 10;

FIG. 12 is a sectional view of a portion of the heat exchanger shown in FIG. 10;

FIG. 13 is a view of a part of the heat exchanger shown in FIG. 10;

FIG. 14 is a sectional view of a loader device which is used with the embodiment shown in FIG. 10 and taken approximately along line 14—14 of FIG. 11;

FIG. 15 is another view of the loader of FIG. 14 and partly in section;

FIG. 16 is a side elevational view of a further embodiment of a heat exchanger embodying the present invention;

FIG. 17 is a top elevational view of the heat exchanger of FIG. 16;

FIG. 18 is a sectional view of a loader, utilized in the embodiment of FIG. 17 and taken approximately along the line 18—18 thereof; and

FIG. 19 is a partial, axial sectional view of the loader of FIG. 18, taken approximately along the line 19—19 thereof.

The embodiment of the present invention illustrated in FIG. 1 comprises a heat exchanger 10 which is suitable for heating a variety of fluids, but will be hereinafter described as heating water with steam. The heat exchanger 10 includes a heat exchange chamber 12 (FIG. 3) into which water is introduced through a water inlet 14. The water is conducted through the heat exchange chamber 12 by a plurality of fluid conduits and is heated by steam introduced into the heat exchange chamber 12 through a steam inlet 16. The heated water is discharged from the heat exchanger through a water outlet 18. Steam condensate formed in the heat exchange chamber 12 exits therefrom through a steam condensate line 20 located in the bottom of the heat exchanger. The steam condensate line 20 preferably has a steam trap therein which is vented to the atmosphere so as to prevent the escape of live steam from the heat exchange chamber 12.

The heat exchanger 10 includes a housing or shell 28. The housing 28 is preferably of a generally cylindrical shape and has at its upper end a baffle structure 30 (FIG. 3) and at its lower end a baffle structure 31. The baffles 30 and 31 assist in directing the flow of water through the fluid conduits in the heat exchange chamber 12.

The upper baffle 30 is located within an upper shell portion 40 of the heat exchanger and which shell portion 40 supports the outlet 18. On one end of the shell 40 is a flange 42 through which the fasteners 43 extend and secure the shell 40 to the housing 28. At the outer end of the shell 40 is a circular end portion or wall 44 which supports the water outlet 18.

The water to be heated is introduced into the heat exchanger 10 through the water inlet 14 which is in the cylindrical shell 40, as illustrated in FIG. 3. The inlet 14 communicates with an arcuate water inlet chamber 36. The inlet chamber 36 is defined in part by the baffle structure 30 which, as shown in FIG. 5, includes a cylindrical centrally located sleeve 38 co-axially aligned with the shell 40. A pair of radially extending circumferentially spaced plates 46, 48 extend from the sleeve 38. An upper disc portion or ring portion 39, FIG. 3, overlies the perimeter of the baffle 30 and fits within the shell 40. The chamber 36 is defined at its upper end by the portion 39 and at its lower end by the sheet tube or flange 30*a* formed integrally with the housing 28. The plate portions 46, 48 define the circumferentially spaced sides thereof, and the outer side and bottom are defined by the shell 40 and flange portion 30*a*.

The fluid inlet chamber 36 communicates at its lower end with fluid conduit means 50 which circulates the water to be heated through the heat exchange chamber 12. The water is heated by the steam in the heat exchange chamber 12 as it circulates through the fluid conduit means 50.

The fluid conduit means 50 comprises a substantially circular array of spaced straight conduits or tubular members 62, see FIG. 4. The tubular members 62 are open-ended tubes arranged in circular rows, concentric with the central longitudinal axis of the heat exchange chamber 12, and are supported at their opposite ends by the sheet tubes or flanges 30*a* and 30*b* located at opposite ends of the housing 28. The flanges 30*a*, 30*b* also function to prevent steam leakage from the heat exchange chamber 12.

The water is heated as it flows in parallel paths and in multiple passes through the tubes 62. The water to be heated flows in a first direction through certain of the tubes 62 and in an opposite direction through other tubes 62. The hereinafter-described multiple pass flow of water through the heat exchange chamber 12 permits the chamber 12 to be more compact in length and yet provides sufficient heat exchange surface area between the steam and the water to provide heated water at a predetermined temperature and volume. To provide a flow of water through the tubes 62 in accordance with the present invention, the tubes 62 are divided into four groups of tubes, namely, groups 63, 64, 65 and 66, (FIG. 4). Water flows in a predetermined sequence through the groups of tubes, i.e., first downwardly through the pump 63, upwardly through the group 64, downwardly through the group 65, and upwardly through the centrally located group of tubes 66.

As noted above, the baffle structures 30, 31 assist in directing the water through the heat exchanger. The lower baffle structure 31 (see FIG. 6) includes an outer cylindrical sleeve 52 which is closed at its bottom end by a circular plate portion 54. Attached to the end plate 54 and located coaxially with the outer cylindrical sleeve 52 is an inner cylindrical sleeve 56. Disposed between the cylindrical sleeve 56 and the sleeve 52 is a pair of radially extending plates 58 and 60, which cooperate with the sleeves 52 and 56 to define arcuate chambers therebetween. The condensate outlet 20 is located centrally of the baffle structure 31 and commu-

nicates with the chamber **12** through an opening **20***a* in the flange **30***b*.

Within the lower baffle member is an arcuate chamber **68** located between the cylindrical sleeves **52** and **56.** The chamber **68** is in fluid communication with the lower ends of the groups of tubes **63** and **64.** Water flowing from the lower or outlet ends of the group of tubes **63** enters the arcuate chamber **68** where it mixes and flows into the lower or inlet ends of the group of tubes **64.** The water then flows upwardly through the group of tubes **64** into an arcuate chamber **70** located in the upper baffle **30.**

The arcuate chamber **70** is located between the shell **40** and inner sleeve **38** of the upper baffle **30** and is in fluid communication with the upper or inlet ends of the group of tubes **64.** The arcuate chamber **70** is operable to mix the water as it flows therein and directs the water flow from the upper ends of the group of tubes **64** into the upper ends of the group of tubes **65.** The water flows downwardly through the group of tubes **65** and exits into the arcuate chamber **72** formed in the lower baffle structure **31.**

The arcuate chamber **72** is located between the cylindrical sleeves **52** and **56.** The chamber **72** is in fluid communication with a circular chamber **74** located inside the cylindrical sleeve **56** in the lower annular baffle structure **31.** The cylindrical sleeve **56** has a suitable opening **76** therein which provides for the fluid communication between the arcuate chamber **72** and the circular chamber **74.** When fluid flows from the lower ends of the group of tubes **65** into the arcuate chamber **72,** it is mixed and directed through the opening **76** into the circular chamber **74.** The circular chamber **74** is in fluid communication with the lower or inlet ends of the group of tubes **66.** Fluid flowing into the circular chamber **74** from the arcuate chamber **72** flows upwardly through the group of tubes **66** into a circular chamber **78** in the upper baffle **30,** which chamber **78** is formed within the inner cylindrical sleeve **38.**

It should be apparent from the above that the water flows through the heat exchange chamber **12** in a predetermined sequence. The water flows first through the outwardly disposed groups of tubes **63, 64,** and **65** and located in the heat exchange chamber **12** and then through the inwardly disposed group of tubes **66.** As a result, the water flows in four passes through the heat exchange chamber before exiting therefrom.

It should be noted that as the water flows into the chambers defined by the baffle structures **30** and **31,** the water from each tube **62** of a group of tubes is mixed with water from the other tubes of the same group of tubes to provide even heating of the water. Thus, if for some reason the tubes **62** are not being evenly heated, the mixing of the water when it flows into the baffle chambers will compensate for any uneven heating of the tubes **62** that is taking place.

The flow of fluid from the heat exchanger **10** through the outlet **18** thereof is controlled by the demand for heated water. The outlet **18** is connected with a faucet or some other type of valve mechanism which is opened when there is a demand for heated water. The degree of opening of the faucet is under the control of the user of the water and the wider the opening, the greater the demand. Located in the shell **40** is a piston member **100** (FIG. **3**). The baffle member **30** is removable from the shell **40** for assembly of the piston **100.**

The piston member **100** divides the shell **40** into two chamber portions **101** and **102.** The chamber portion **102** includes the annular baffle **30.** When the faucet or valve which controls the demand for fluid is closed, the pressure of fluid in the chamber portions **101** and **102** acting on the piston **100** is substantially equal so that the piston **100** takes the position shown in FIG. **3** in which it is biased to its null or no-flow position by a spring **110.**

When the faucet or valve connected with the outlet **18** is opened, the pressure in the upper chamber portion **101** is reduced, and as a result in the piston **100** begins to move upwardly against the bias of the spring **110.** When this movement occurs, a valve mechanism, generally designated **111,** opens and allows fluid flow from the central chamber portion **78** defined by the sleeve **38** through the outlet **18.** The flow provides a pressure drop across the piston **100** which enables the piston to take a position depending upon demand. As an alternative to the flow through the piston and the valve mechanism **111,** a slot could be provided in the inner wall of the shell **40** and through which the flow is controlled by the piston **100.**

The valve mechanism **111** comprises a flow tube member **112** which is substantially secured to the piston **100** so as to move therewith. The flow tube member **112** has a conical end portion or bore **116** therein. The flow tube **112** comprises one part of the valve mechanism, whereas the other valve member of the valve mechanism **111** is a disc member **120** which is located in the flow tube member **112.** The flow tube member **112** has an elongated extent and extends into a rotary joint member **124** and in which the flow tube member **112** is slidable. The rotary joint **124** is suitable located in an opening in the wall **44** of the shell **40.** A suitable seal **124***b* is located and positioned so as to prevent leakage of fluid between the wall opening and the rotary joint member **124.**

When the piston member **100** moves upwardly in the shell **40,** the extension **121** moves upwardly in the rotary joint member **124.** A suitable pin **130** is carried by the rotary joint member **124** and is located so as to be received in a slot **131** in the elongated projection **121** so that as the projection moves vertically upwardly the movement thereof is restricted to a linear movement.

As the member **112** moves vertically upwardly, the valve member **120** does not move vertically. The valve member **120** is connected with a stem **135,** which stem in turn is secured to a spider member **136** which has suitable openings so that water may flow therepast. As the member **112** moves vertically relative to valve member **120,** the degree of opening of the valve mechanism **111** changes, since as the member **112** moves vertically, the space between the valve disc **120** and the bore **116** in the member **112** varies in proportion to the extent of movement of the piston member **100.** Accordingly, depending upon the amount of movement of the piston **100,** the amount or volume of fluid or flow rate of fluid from the exchanger is controlled thereby.

In accordance with the present invention, the temperature of the water exiting from the outlet **18** is continuously controlled by a blending of cold water with the hot water exiting from the outlet conduits **66.** The amount of blending is controlled by movement of piston **100** and the blending is continuous over the entire

range of operation of the unit. In order to effect this blending, a bypass blending valve arrangement, generally designated **170** and shown in detail in FIGS. **7–9**, is provided for directing a controlled flow of cold water directly from the inlet chamber **36** to the outlet chamber **78** centrally located in the baffle **30.** To this end, the annular baffle portion **38** has an opening **171** therein which is in communication with the inlet chamber **36** for cold water. In addition, a valve sleeve member **175** is secured by suitable means to the piston member **100** and projects downwardly into the baffle **38.** The sleeve member **175,** accordingly, moves with the piston member **100.** The valve sleeve **175** has a close fit with sleeve portion **38,** which minimizes uncontrolled flow of cold water. Only a slight clearance is necessary between the valve sleeve **175** and baffle portion **38** to minimize leakage, since there is only a slight pressure drop between chambers **36** and **78.** Since only a slight clearance is provided, there is no adverse effect on the positioning accuracy of the piston.

The sleeve member **175** has an opening **177** therein. The opening **177** is shaped so as to control the amount of blending of cold water with the hot water in accordance with the movement of the piston member **100** so that the desired outlet water temperature is produced. The particular shape of the openings can be varied to meet conditions and specifications.

To cope with back pressure on the condensate leaving the heat exchanger, the steam supply pressure must be greater than that back pressure. Once the steam supply pressure is established, the opening **177** can be shaped to provide the desired temperature control. In addition, as will be described hereinbelow, the opening **177** can be adjusted so as to vary the amount of blending.

As the piston member **100** moves vertically upwardly, the opening **177** uncovers a varying area of opening **171** for purposes of directing of cold water from the inlet chamber **36** to the chamber **78** in the heat exchanger.

It should be apparent that the shape of the opening **177** and arrangement of parts, as shown in FIG. **7,** is such that on initial movement a portion of the opening **177** which has a substantially common circumferential extent with the opening **171** aligns with the opening **171.** Accordingly, at low flow rates a substantially large percentage of cold water is blended with the hot water exiting from the heat exchange tubes **66.** The greater the distance of movement of the piston **100,** however, the lesser the percentage of cold water being blended with the hot water, as should be apparent due to the continuously reducing size of the opening **177.** At the maximum flow rate of the system, the lowest percentage of cold water is blended with the hot. However, it should be emphasized that blending occurs throughout the range of movement of the piston **100,** and is the technique by which exit water temperature is controlled.

As noted above, the specific shape of the opening **177** may take many different forms, and as shown the opening **177** is defined by an upper surface **177***a* and a vertically extending surface **177***b* which extends vertically from the surface **177***a* to a surface **177***c* which extends parallel to the surface **177***a*. The surface **177***c* interconnects with a curved surface **177***d* which curves upwardly and away from the intersection of the surface **177***c* therewith. The surface **177***d* interconnects with a surface **177***e* which is also vertically extending and terminates at the surface **177***a*.

The sleeve member **175** is located concentrically with respect to the sleeve **112** of valve mechanism **111,** and the sleeve **112** and piston member **100** in turn are located concentrically within the circular shell **40.** As a result, the piston member **100** can be rotated within the shell in order to rotate the sleeve **175** and its opening **177** relative to the opening **171** in the baffle portion **38.** As a result of the rotation of the opening **177,** an adjustment of the amount of blending can be effected, as desired. This should be apparent, since by rotating the sleeve **175** to a given position, a different area of overlap of the openings will occur upon vertical movement of the sleeve **175.**

The bolts **179** are threaded into the wall **44** and hold cap member **179a** on the wall **44.** Specifically, member **179a** engages the rotary joint member **124** which in turn engages spring **110** at its end opposite the end which engages piston **100.** By tightening the bolts **179,** the force the spring **110** applies to the piston **100** increases. By loosening the bolts **179,** the spring force on the piston **100** is reduced.

While the above-described embodiment utilizes a single opening in the sleeve **175,** it is possible that a plurality of separate discrete openings could be provided in the sleeve **175** where each opening provides variable blending characteristics as desired.

As illustrated in the drawings, there is a portion or space, generally designated **180** in FIG. **7,** between the upper surface **177***a* of the opening **177** and the lower surface defining the opening **171.** This space may be termed a lap space. Of course, it should be apparent there is no blending occurring when the sleeve **175** moves through that space, since there is no alignment of the opening **177** with any portion of the opening **171.** However, there is also no outlet water flow from the heat exchanger, since the valve **111** is not yet opened. The space **180** is sized so that the blending begins when outlet flow begins.

Also, as shown in FIGS. **8** and **9,** when the piston member **100** is in its lowermost or null position, a small opening **181** in the sleeve member **175** overlaps or communicates with the opening **171** in the sleeve **38.** The opening **181** provides for a slight blending of cold water from the inlet chamber **36** into the hot water outlet chamber **78** in the event of water leakage occurring from the heat exchanger. This has a substantial advantage in reducing the temperature of any water which may leak through the faucet or outlet from the heat exchanger. Such blending is important if steam is on the heat exchanger when in a no-flow condition which would result in extremely hot water exiting from the heat exchanger in the event of such leakage. The blending in such no-flow conditions ensures that extremely hot water does not leak through the outlet.

As is well known, leaving the steam pressure on a heat exchanger during no-flow conditions can result in fouling of the heat exchanger and in order to minimize the fouling of the heat exchanger, it is preferable to cut off the steam pressure in the heat exchanger under no-flow conditions. The embodiment of the present invention, which is illustrated in FIGS. **10** and **11** and which has all of the features described hereinabove in connection with the embodiments of FIGS. **1–9,** provides for a shut-off of the steam to the heat exchanger during no-

flow conditions. The embodiment shown in FIGS. **10** and **11** is particularly adaptable for use with a low pressure steam supply source and the steam is directed to the heat exchanger in an on-off manner, as will be described hereinbelow.

In the embodiment of FIG. **10,** a steam valve **200** is located in the steam supply conduit and the steam valve **200** has an on-position for directing the steam pressure received by it into the heat exchange chamber **12.** The steam valve **200** also has a closed position for blocking any flow of steam into the heat exchanger. A control mechanism, generally designated **201,** controls the actuation of the valve **200** and specifically controls the actuation of the valve **200** upon movement of the piston member **100.**

It should be clear that the piston **100** comprises a member which is located internally of the heat exchanger and moves therein in response to a demand for heated water. The control mechanism **201** includes a pin **202** (FIG. **12**) which has an upper surface which abuts the undersurface of the piston **100** at **203** when the piston **100** is in its null or no-flow position. The pin **202** is slidable in a suitable guide member **204** suitably supported in the shell **40,** and specifically secured to the portion **39** of the baffle **30** which is provided with an opening **204a** for receiving the guide **204.** The lower end of the pin **202** engages, as shown in FIG. **12,** a lever member **205.** The lever member **205** is supported for pivotal movement by a fulcrum member **206** pressfit in a housing **207** (See FIG. **14**). The outer end of the lever member **205** is located in a casing **208** which is connected with the housing **207.** The housing **207** is suitably supported on sleeve portion **40** of the heat exchanger. A spring **210** in the casing **208** has a lower end acting on the lever member **205** tending to pivot the lever **205** clockwise about its fulcrum, as shown in FIG. **14.** The spring **210** at its upper end abuts a nut **212.**

The casing **208** and housing **207** may be bodily removed from the shell **40** along with the lever **205** by simply releasing any suitable connectors holding the housing **207** on the shell **40.** In the event that this disassembly does occur, the pin **202** will not fall from the guide **204** due to a spring clip **204***b* which encircles the upper end of the pin **202** and would prevent any falling movement of the pin **202.** Reassembly may be effected by merely inserting lever **205** into the shell **40** into abutment with the lower end of pin **202** and resecuring the housing **207** to the shell **40.**

The piston member **100,** when in its lower position, as shown in FIG. **12,** holds the lever member **205** in the position shown and prevents the spring **210** from moving the outer end of the lever member downwardly. However, if the piston member **100** moves vertically upwardly, the spring **210** causes the outer end of the lever member **205** to move downwardly (clockwise about fulcrum **206**).

The outer end of the lever member **205** carries a screw member **215.** The screw member **215** on its lower end has a ball **216** attached thereto in any suitable manner. The ball comprises a valve member which controls the flow of fluid past a valve seat **217** for the ball valve member. When the lever member **205** is in its null or no-flow position, the ball **216** is in engagement with the valve seat **217** and prevents the flow of fluid therepast. When the lever member **205** is moved downwardly, the ball **216** moves downwardly relative to the valve seat **217** and allows for flow of fluid therepast.

The ball member **216,** when moved downwardly, is moved in a guide portion **220** of a nut **221** which is secured in the lower end of the casing **208.** The nut **221** has a bore or passage **222** therein connecting the lower end of the ball **216** to drain. When the ball member **216** is moved downwardly sufficiently, it will block fluid flow through the drain **222.** This movement occurs as the piston **100** and sleeve **175** move through the lap distance **180.**

The housing member **207** which encircles the lever **205** is suitably connected at its end adjacent the shell **40** with a connector portion **230** of the shell **40** and which has an opening **231** therein. The opening **231** communicates with chamber **36,** which, as noted above, is the cold water inlet chamber. The housing **207** being hollow directs the cold water inlet pressure into the chamber **232** located above the ball member **216,** as shown in FIG. **14.** This flow is through the top of the fulcrum support member **206** which is open. When the ball member **216** moves downwardly and blocks drain **222,** the fluid pressure in the chamber **232** is communicated past the valve seat **217** and through an outlet **233** in the casing **208** and through the conduit **235** to the valve **200.**

As noted above, there is an initial or lap movement of the piston **100** which must occur before the valve mechanism **111** opens to direct fluid from the heat exchanger. The lap movement of the piston is such that the ball valve **216** will be moved off its seat **217** and block drain **222** so that practically simultaneously with the beginning of outlet flow, steam will be applied to the exchange chamber **12.** Accordingly, the pressure will remain on the exchanger until water outlet flow ceases and the piston returns to its null position.

The valve **200** is a conventional valve which is moved to its fully open position upon pressure being applied thereto and moves to its fully closed position when the pressure is released. The valve **200** preferably is spring-biased closed and opened by the pressure acting against the spring. Accordingly, location of the ball **216,** as described above, sealing the drain **222** and directing pressure from chamber **232** to the valve **200** causes the valve **200** to open and steam to be applied to the heat exchange chamber **12.** Accordingly, upon a demand for water the piston **100** moves vertically upwardly, as shown in FIG. **12,** and through the action of the lever **205** and the valve **216** fluid pressure is applied to the valve **200** causing opening thereof and steam to be applied to the heat exchanger. At the same time, fluid may flow from the heat exchanger, since the valve mechanism **111** has been opened in dependence upon the demand requirements. The system is constructed so that the valve **200** operates as an on-off valve and the valve **200** is returned to its off-position cutting off the supply of steam to the exchange chamber when the piston **100** moves back to its null or no-flow position. When the piston returns to its null position, the undersurface thereof engages the upper surface of the pin **202.** When this engagement occurs, the piston **100** causes the lever **205** to pivot against the bias of the spring **210** pushing the ball member **216** back into sealing engagement with the valve seat **217.**

Moreover, adjustment of the spring **110** by bolts **179** ensures that the loader valve **200** is shut off when the piston is in neutral. It should be apparent that the

greater the force applied to lever **205** by spring **210,** the greater the force necessary to move the ball **216** back to its seat, and accordingly the greater the force required to be applied to the piston **100** by spring **110.** When the ball member **216** seals against valve seat **217,** the outlet **222** in the casing **208** is connected to the drain. As a result, the actuator for valve **200** is connected with drain and the valve **200** returns to its closed position blocking steam flow to the exchange chamber **12.**

In the event that the source of steam is a high pressure steam source capable of supplying substantial steam pressure to the heat exchange chamber, strictly an on-off steam valve, as in the low pressure embodiment of FIGS. **10–15,** may not be sufficient in order to properly control the steam pressure, but rather a reducing valve, which reduces the steam pressure, should be utilized with the heat exchanger mechanism described in connection with FIGS. **1** to **9.** The embodiment of the present invention shown in FIGS. **16–19** provides a control for the application of steam to the heat exchange chamber through such a pressure-reducing valve **300.**

The valve **300** may be operated in an on-off manner to provide a constant steam pressure to the heat exchange chamber. The valve **300** is a conventional pressure-reducing valve and has a diaphragm, one side of which is loaded by the pressure in the heat exchange chamber through a conduit **301** and the other side of which is provided with a water pressure through a conduit **302.** The water pressure through conduit **302** is controlled by a control mechanism or loader device, generally designated **305.** The loader device **305** is operated under the control of the piston **100,** pin **202,** and lever **205** much in the manner described in connection with FIGS. **14** and **15.** However, the loader device as specifically shown in FIGS. **18** and **19** is of a somewhat different construction than that in FIGS. **14, 15.**

The loader device **305,** shown in FIGS. **18** and **19** includes a spring **310** which acts on a plate or flange member **311** which is connected to a screw member **312** carried by the lever **205.** When the piston member **100** moves upwardly away from the lever **205** and pin **202,** spring member **310** biases the screw **312** downwardly and moves the end of the lever which it engages downwardly, as shown in FIG. **18.**

The screw member **312** has an abutting engagement with a plate member **313** and, when it moves downwardly, it moves the plate member **313** downwardly. When the late member **313** moves downwardly, a stem **314** connected with the plate **313** also moves downwardly. The stem **314** engages a valve seat **315** which is connected with the upper side of a diaphragm member **316** and the diaphragm member **316** on its lower side carries a valve seat **317** which engages a valve stem **318.** When the plate **313** moves downwardly, the diaphragm **316,** valve seat **317** and valve stem **318** also move downwardly. The lower end of the valve stem **318** carries a valve member **320** which engages with a valve seat **320***a* and, when moved downwardly, moves away from the valve seat **320***a* and effects opening for fluid flow between the valve member **320** and the valve seat **320***a* which it normally engages and against which it is biased by a spring **321.**

When the valve member **320** moves downwardly away from the valve seat **320***a*, fluid pressure from the inlet chamber **36** is communicated through the housing **207** and through a conduit **325** into a passageway **326** and past the valve member **320** into a conduit **327.** The conduit **327** communicates with an outlet **328** which in turn communicates with the conduit **302** for directing the pressure to the pressure-reducing valve **300.** The pressure in the pressure-reducing valve **300** increases in a continuing manner until the valve member **320** moves to a closed position in engagement with its valve seat **320***a*.

The valve member **320** moves into a closed position in engagement with its valve seat **320***a* when the stem member **318** moves upwardly, or is allowed to move upwardly under the bias of the spring **321.** This occurs when the diaphragm member **316** moves upwardly. The diaphragm member divides a chamber into two chamber portions **330** and **331.** The chamber portion **330** communicates with the conduit **327** and as the pressure in the valve **300** increases, the pressure in chamber portion **330** also increases, tending to move the diaphragm member **316** vertically upwardly, as shown in FIGS. **18** and **19.**

When the pressure built up in chamber **330** is sufficient to overcome the bias of the spring **310,** the diaphragm member **316** will move vertically upwardly and the valve member **317** and steam **318** will follow the movement of that diaphragm member. The movement eventually will cause a closing of the valve **320** with pressure in the valve **300** and in the chamber portion **330** being substantially equal.

Accordingly, the outlet pressure of the loader **305** is controlled by the bias applied to the spring **310,** since the spring **310** must be overcome by the diaphragm **316** which is moved back to its initial position by the pressure in chamber **330.** The bias on the spring **310** is adjustable by turning a screw **336,** which, when threaded within a housing portion **337,** causes a greater bias to be applied to the spring **310.** When proper adjustment is made, cap **335** and gasket **335***a* seals and locks adjustment stem **336.** The greater the bias applied to the spring **310,** the greater the force which is necessary in chamber **330** to return the diaphragm to its neutral position to effect the closing of the valve **320.** Accordingly, the greater the bias on the spring **310,** the greater the pressure required in the spring **310** and in the chamber **330** to return the diaphragm and valve member **320** to its closed position.

When the piston member returns to its neutral or null position, the lever member **205** is moved upwardly so that the screw **312** which has an abutting engagement with the plate **313** is moved upwardly out of contact with the plate **313.** As a result, spring **338** moves the valve member **314** upwardly away from its valve seat **315** which in turn enables the spring-biased diaphragm to move upwardly under the pressure in chamber **330** away from the valve member **317.**

As a result of these relative sequential movements, the valve member **317** and the valve member **316** are out of engagement with their valve seats simultaneously. The upper chamber portion defined by the diaphragm **331** is in contact with drain through outlet **339.** Since the valve members **315** and **317** are out of contact with their valve seat simultaneously, the pressure in chamber **330,** and likewise in valve **300,** is communicated past the values **317** and **315** through the outlet conduit **339** to drain. As a result, the valve member **300** is returned to its neutral or closed position and

the valve member **300** blocks the flow of steam to the heat exchanger **12.**

Adjustement of screw **336** changes the bias on spring **310** and effectively determines the loader pressure output to be imposed on valve **300** in an "on-off" manner dictated by the piston **100.** Bias of spring **338** and spring **321** is fixed. The loader **305** is identical to a conventional reducing/relief valve mechanism except for the mode of automatic operation via the piston **100** and lever **205.**

It should be apparent from the above, that the embodiment of the present invention described in FIGS. **15–19** does include a loader **305** which operates in an on-off manner. The loader is adjustable, however, in order to control the outlet pressure applied to the steam inlet valve **300.** Moreover, the steam inlet valve is of the pressure-reducing type in that it senses both the pressure directed to it from the loader **305,** as well as the steam pressure in the heat exchanger. Accordingly, the system can, through appropriate adjustment, be controlled so that a given constant inlet steam pressure is provided on the heat exchanger, which is substantially lower than the steam pressure delivered to the valve **300** from the steam supply.

Viewing FIG. **3,** it is clear that valve member **120** is adjustable vertically via threaded stem **135** in spider **136** in which it is threadably engaged. Lock nut **135***a* holds this adjustment. At the null or no-flow position of piston **100,** the vertical position of flow tube **112** is fixed. Therefore, adjustment of stem **135** determines the "lap", or movement required of piston **100** before actual flow takes place. This movement is abrupt and ideally suited to on-off type of control, which is used by either loader **201** or **305.**

Member **124** is, as noted, a rotary joint, which permits 360° rotation of the piston assembly via a rod insert in apertures **124***c* spaced at 60° intervals. This adjustment is relatively stiff due to friction, and once made will remain fixed. Thus, with properly characterized sleeve valve member **175,** the discharge temperture of the water can be changed externally. Once an adjustment is made, pin **130** in member **124** operating in slot **131** permits only vertical movement of the piston assembly and sleeve **175.**

The bias of spring **110** is adjusted by nuts **179,** and in addition to returning piston **100** to its null point, is strong enough to operate lever **205** against the bias of the loader spring and insure turning off the steam to the heat exchanger when no-flow of water occurs. This adjustment is made once at start-up and left fixed.

In view of the foregoing, it should be clear that applicant has provided a practical, efficient and novel construction of a heat exchanger system, and that certain modifications, changes, and adaptations may be made therein.

What I claim is:

1. Apparatus for heating water by steam comprising a heat exchanger having a steam chamber, fluid conduit means for directing water through said steam chamber to a water outlet chamber, inlet steam conduit means for delivering steam to said steam chamber, a member located in said water outlet chamber and movable therein in response to a change in the demand for hot water, and bypass valve means controlled by movement of said member for continuously directing some cold water to said outlet chamber without flowing through said fluid conduit means so as to continuously mix with heated water during flow conditions.

2. An apparatus as defined in claim **1** wherein said bypass valve means includes a relatively fixed valve part and a second valve part carried by said member, and said valve parts having cooperable openings which provide a variable flow depending on the extent of member movement.

3. An apparatus as defined in claim **2** wherein said member is of a generally cylindrical shape and is rotatable within said water outlet chamber to adjust the position of the opening in said second valve part relative to the opening in the first valve part and thereby adjusts the amount of mixing of cold water with heated water upon movement of the member.

4. An apparatus as defined in claim **1** wherein said fluid conduit means includes at least four sets of conduits for directing the water through the steam chamber in four passes, said fluid conduits comprising first, second and third groups disposed outwardly from the center of the heat exchange chamber and a fourth group of fluid conduits which is located centrally of the heat exchange chamber and surrounded by the first, second and third groups, said fourth group of fluid conduits directing the flow of fluid from the outlet thereof into the water outlet chamber portion into which the bypass valve means directs cold water.

5. An apparatus as defined in claim **4** further including a pair of annular baffles, one of the annular baffles being located at each end of the groups of conduits, the one annular baffle defining in part said inlet chamber which communicates with the inlet ends of the first group of conduits, the other annular baffle defining in part a chamber communicating with the outlet end of the first group of fluid conduits and the inlet end of the second group of fluid conduits, said first annular baffle defining a chamber communicating with the outlet of the second group of fluid conduits and the inlet ends of the third group of fluid conduits, and said other annular baffle defining a chamber communicating the outlet of the third group of fluid conduits with the inlet of the fourth group of fluid conduits.

6. An apparatus as defined in claim **1** wherein said member has a no-flow position from which it moves in response to a demand for hot water, and means for directing cold water to said outlet chamber when said piston member is in its no-flow position to minimize the temperature of water leakage therefrom.

7. An apparatus as defined in claim **1** further including a steam valve for controlling the application of steam pressure to said steam chamber, means for actuating said steam valve in response to movement of said member, said means including a pin member engageable with the member and movable upon movement of the member and a lever member operatively connected with the pin member and pivotal upon movement of the member, and means operatively interconnecting said lever member and said steam valve for controlling said steam valve upon movement of said lever.

8. An apparatus as defined in claim **7** wherein said means operatively interconnecting the lever member and said steam valve comprises a valve means which is opened upon movement of said lever member and which when opened directs water pressure from said inlet chamber to said steam valve.

9. An apparatus for heating water by steam comprising a heat exchanger having a steam chamber, fluid

conduit means for directing water through said steam chamber to a water outlet chamber, inlet steam conduit means for delivering steam to said steam chamber, a member movable from a no-flow position in response to a demand for hot water, and bypass valve means controlled by movement of said member for directing some cold water to said outlet chamber without flowing through said fluid conduit means so as to mix with heated water during a flow condition, and means for directing cold water to said outlet chamber when said member is in its no-flow position to minimize the temperature of any water leakage therefrom.

10. An apparatus as defined in claim **9** wherein said bypass valve means comprises a relatively fixed valve part and a second valve part carried by said member, said valve parts have cooperable first and second openings respectively which provide a variable area of flow depending upon the extent of piston movement, and said means for directing cold water to said outlet chamber when said member is in its no-flow position comprises a third opening in said second valve part which directs cold water to said outlet chamber when said first and second openings are not overlapping.

11. An apparatus as defined in claim **9** wherein said fluid conduit means includes at least four sets of conduits for directing the water through the steam chamber in four passes, said fluid conduits comprising first, second and third groups disposed outwardly from the center of the heat exchange chamber and a fourth group of fluid conduits which is located centrally of the heat exchange chamber and surrounded by the first, second and third groups, said fourth group of fluid conduits directing the flow of fluid from the outlet thereof into the water outlet chamber portion into which the bypass valve means directs cold water.

12. An apparatus for heating water by steam comprising a heat exchanger having a steam chamber, fluid conduit means for directing water through said steam chamber to a water outlet chamber, said fluid conduit means including at least four sets of conduits for directing the water through the steam chamber in four passes, at least one of said conduits directing the water into the outlet chamber, inlet steam conduit means for delivering steam to said steam chamber, a piston member located in said water outlet chamber and movable therein in response to a change in the demand for heated water, bypass valve means for directing some cold water to said outlet chamber without flowing through said fluid conduit means so as to mix with heated water, said bypass valve means including a relatively fixed sleeve-like valve part and a second sleeve-like valve part carried by said piston, said second sleeve-like valve part being concentrically arranged with the piston, and said valve parts having cooperable openings which provide a variable area of flow depending on the extent of piston movement.

13. An apparatus as defined in claim **12** wherein said fluid conduit means includes at least four sets of conduits for directing the water through the steam chamber in four passes, said fluid conduits comprising first, second and third groups disposed outwardly from the center of the heat exchange chamber and a fourth group of fluid conduits which is located centrally of the heat exchange chamber and surrounded by the first, second and third groups, said fourth group of fluid conduits directing the flow of fluid from the outlet thereof into the water outlet chamber portion into which the bypass valve means directs cold water.

14. An apparatus as defined in claim **12** further including a steam valve for controlling the application of steam on said heat exchanger, said steam valve having an open position for directing steam pressure to the steam chamber and a closed position blocking steam pressure being applied to the steam chamber, said steam valve being moved from its open position to its closed position in response to water pressure being applied thereto, control valve means for directing water pressure to said steam valve, and means for opening said control valve means in response to movement of said piston member.

15. An apparatus as defined in claim **14** wherein said control valve means has a hollow housing portion communicating with said water inlet chamber and a lever extending from said piston member through said hollow housing portion, a valve member operatively associated with the lever member and which is opened upon movement of the lever member in one direction and which is closed upon movement of the lever member in the opposite direction.

16. A heat exchanger for heating a first fluid by a second fluid comprising a heat exchange chamber for receiving the second fluid, a first group of fluid conduit means for directing the first fluid through said heat exchange chamber in a first direction, a second group of fluid conduits for directing the first fluid through said heat exchange chamber in a second direction opposite said first direction after the first fluid has exited from said first fluid conduits, a third group of fluid conduits for directing the first fluid through said heat exchange chamber in the first direction after the first fluid has exited from said second fluid conduits, a fourth group of fluid conduits for directing the first fluid through said heat exchange chamber in the second direction after the first fluid has exited from said third group of fluid conduits, said first, second and third groups of fluid conduits being disposed outwardly from the center of said heat exchange chamber, said fourth group of fluid conduits being located centrally of said heat exchange chamber and surrounded by said first, second and third groups of fluid conduits, annular baffle means for directing the flow of said first fluid sequentially between said first, second, third and fourth groups of fluid conduits and blocking the flow of said first fluid between other of said groups of conduits said annular baffle means including a pair of annular baffles, one of said annular baffles being located at one end of said groups of fluid conduits, and the other of said annular baffles being located at the opposite end of said groups of fluid conduits, said one annular baffle including a first chamber in fluid communication with said first group of fluid conduits, a second chamber in fluid communicawith said second and third groups of fluid conduits and a third chamber in fluid communication with said fourth group of fluid conduits and wherein said plurality of chambers are operable to direct the flow of said first fluid through said groups of fluid conduits in predetermined sequence, said other annular baffle including a first chamber in fluid communication with said first and second groups of conduits, a second chamber in fluid communication with said third group of fluid conduits, and a third chamber in fluid communication with said fourth group of fluid conduits, outlet means for directing the first fluid from said heat exchange chamber and

communicating with said third chamber of said one annular baffle.

17. A heat exchanger as defined in claim **16** further including bypass means for bypassing the flow of fluid from said first chamber of said one annular baffle in order to mix cold water with hot water exiting therefrom.

18. A heat exchanger as defined in claim **16** further including a member movable in response to a demand for said first fluid, and valve means operatively connected with said member and actuated thereby to effect a flow of the first fluid into the outlet chamber which bypasses said fluid conduit means so that cold first fluid is blended with heated first fluid under control of said member.

19. A heat exchanger as defined in claim **18** wherein said member has a no-flow position in which said valve means is closed and means for directing cold water from said first chamber of said one annular baffle to said third chamber of said one annular baffle when said means is in its no-flow position.

20. An apparatus for heating water by steam comprising a heat exchanger having a steam chamber, fluid conduit means for directing water through said steam chamber to a hot water outlet chamber, inlet steam conduit means for delivering steam to said steam chamber, a piston member located in said hot water outlet chamber and movable therein in response to a demand for hot water, steam valve means in said inlet steam conduit means for controlling flow of steam into said steam chamber, means for actuating said valve means in response to movement of said piston member, said means including a pin member engageable with said piston member and movable upon movement of the piston member in response to said demand, a lever operatively connected with said pin member and pivotal upon movement of said piston member, and means operatively interconnecting said lever member and said steam valve means for controlling said steam valve means upon movement of said lever.

21. An apparatus as defined in claim **20** wherein said means operatively interconnecting the lever member and steam valve means comprises a control valve operated by said lever member and for directing water pressure to said steam valve to effect opening of the steam valve upon opening of the control valve.

22. An apparatus as defined in claim **21** wherein said control valve has means for communicating inlet water pressure thereto and when opened directs said pressure to said steam valve to effect opening thereof.

23. An apparatus as defined in claim **22** wherein said valve is spring-biased by a first spring means to an open position for directing water pressure to said steam valve means and said piston member through said lever moves said valve means to said closed position and second spring means acting on said piston member urging said piston member to its no-flow position in which said control valve is in its closed position, and means for adjusting said second spring means which acts on said piston.

24. An apparatus as defined in claim **20** wherein said means operatively interconnecting the lever member and steam valve means comprises a control valve operated by said lever member for directing an adjustable fluid pressure to said steam valve to effect opening of the steam valve upon opening of the control valve.

25. An apparatus as defined in claim **24** wherein said steam valve is a differential diaphragm type so that the adjustable fluid pressure produces an adjustable steam pressure to the heat exchanger.

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