March 4, 1947. E. G. BAILEY 2,416,674

ATTEMPERATOR

Filed June 2, 1943 5 Sheets-Sheet 1

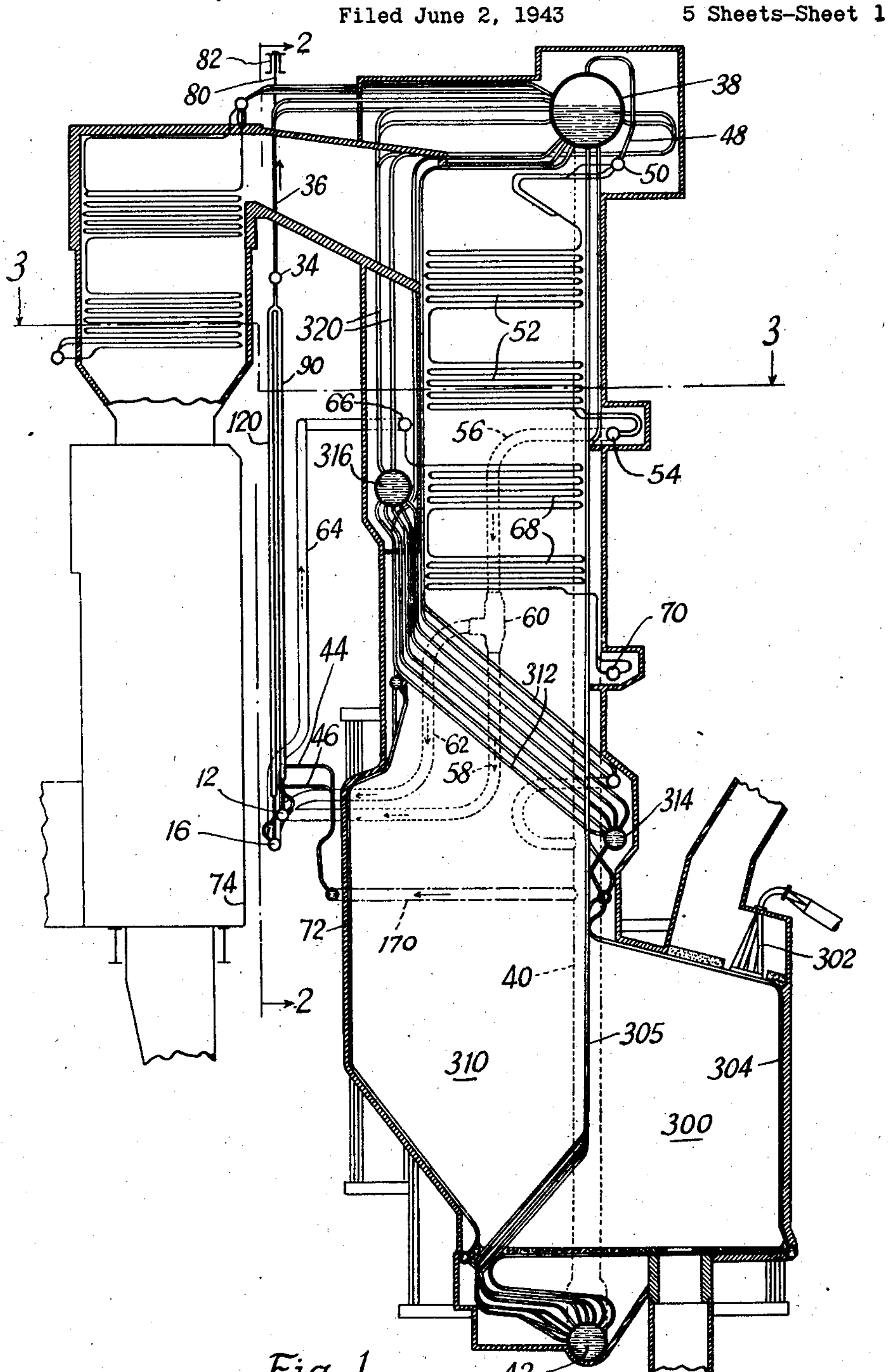

Fig. 1

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ATTEMPERATOR

Filed June 2, 1943 5 Sheets-Sheet 2

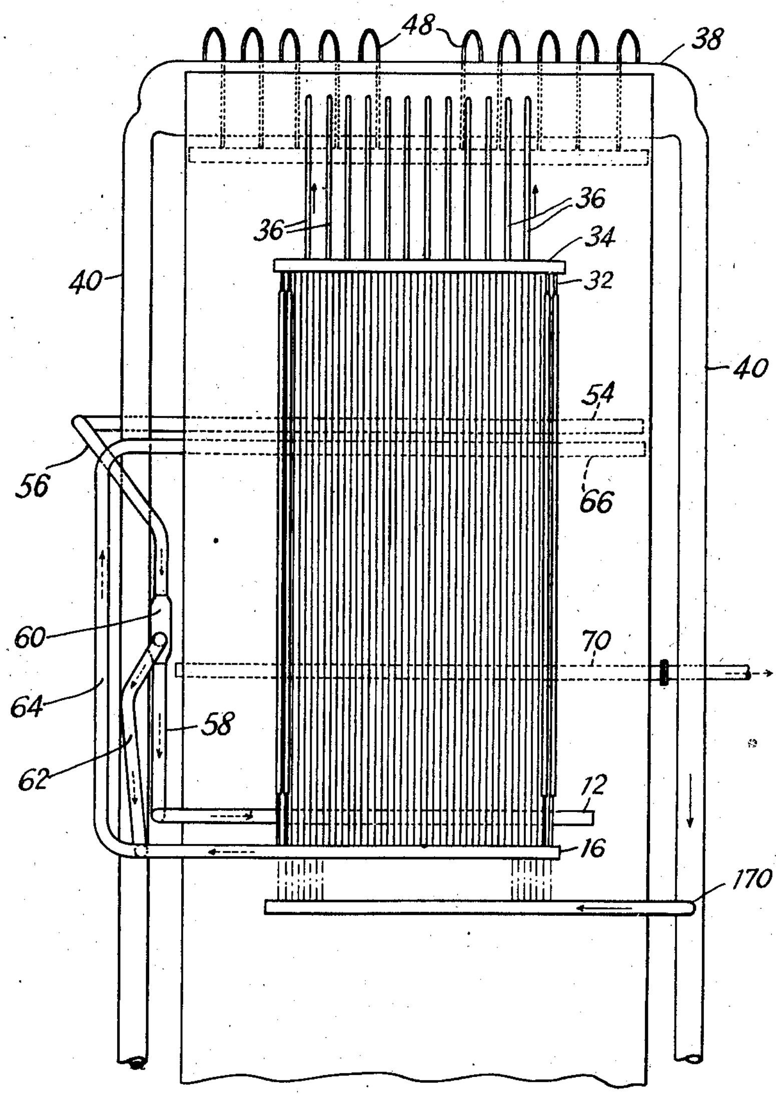

Fig. 2

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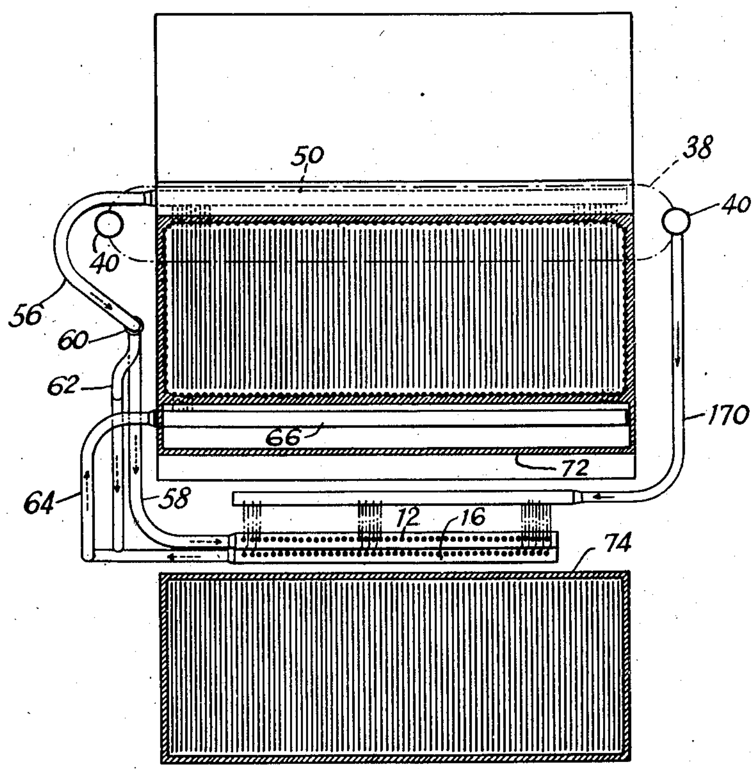

Fig. 3

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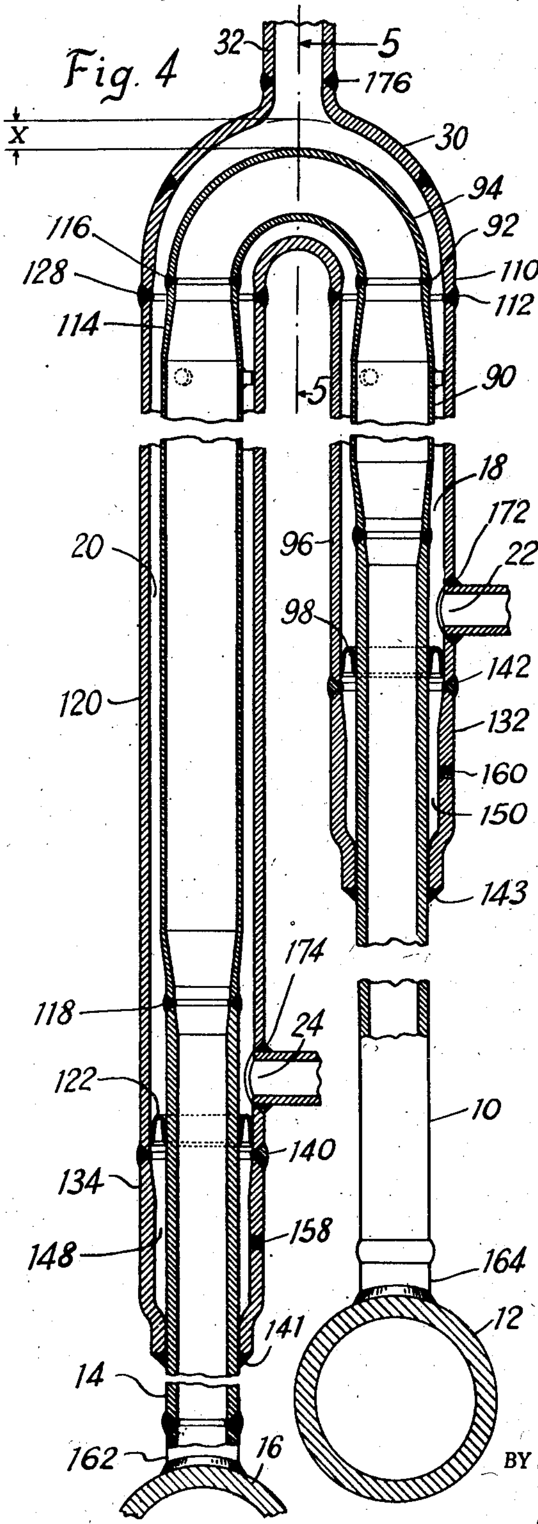
Fig. 4



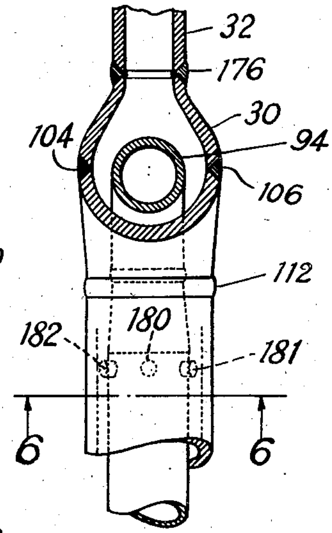


Fig. 5

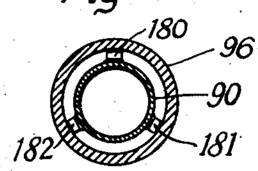


Fig. 6

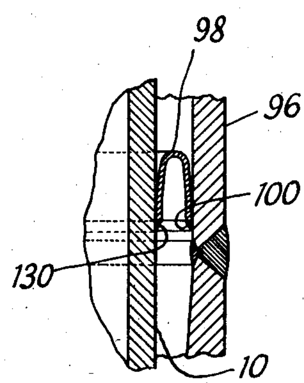


Fig. 7

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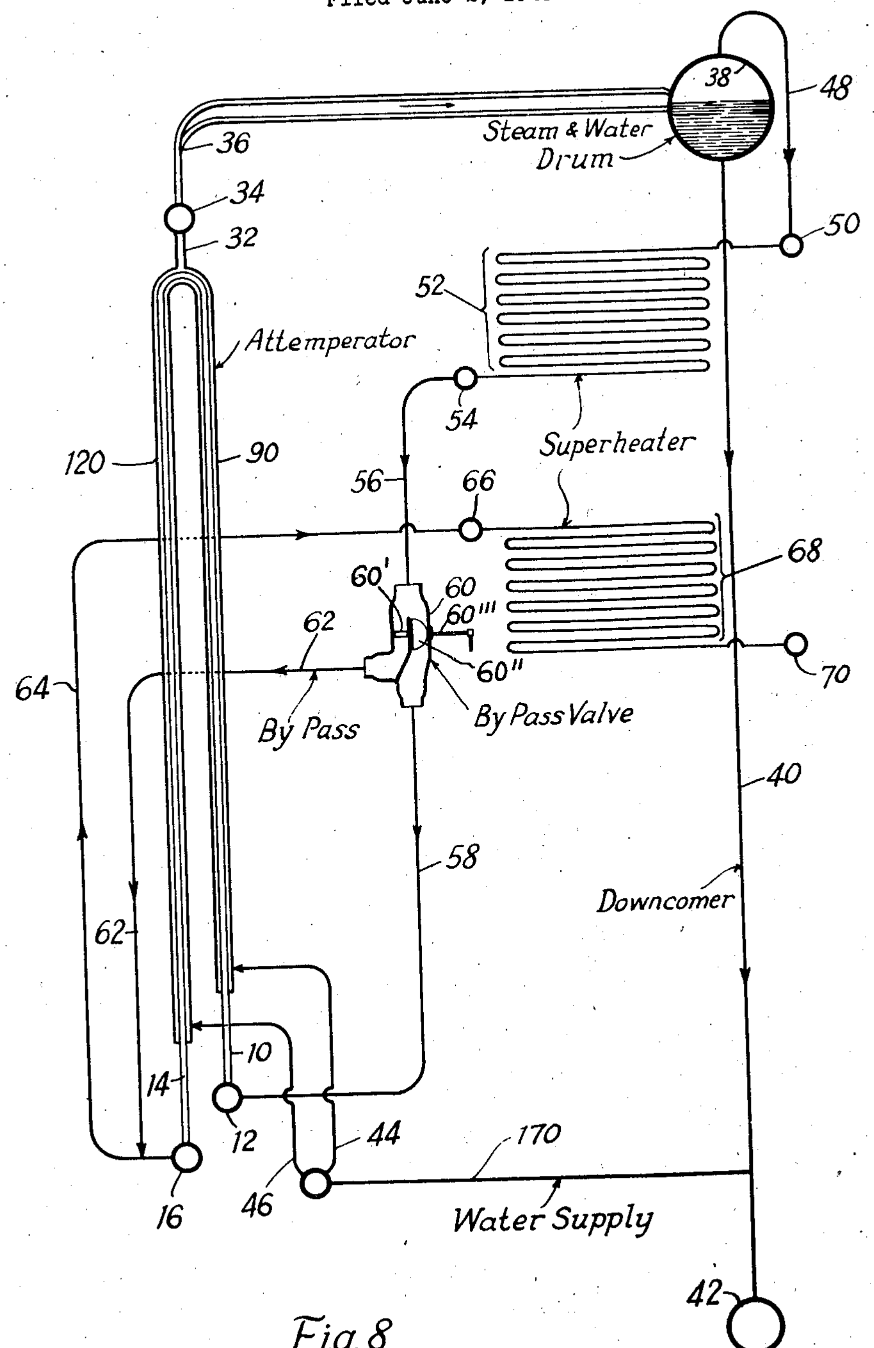

Fig. 8

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Patented Mar. 4, 1947 2,416,674

UNITED STATES PATENT OFFICE

2,416,674

ATTEMPERATOR

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Application June 2, 1943, Serial No. 489,337

2 Claims. (Cl. 257—221)

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My invention relates to heat transfer devices, and particularly to a heat transfer device in which a fluid at high temperature and pressure is brought in heat transfer relation to a fluid at a substantially lower temperature.

More specifically, my invention is concerned with superheated steam attemperators wherein the temperature of the superheated steam is reduced by heat transfer to the walls of water immersed tubes through which the steam is directed.

In prior art installations suggested for cooling highly superheated steam, it is common practice to provide the steam flow elements in the form of U-bent tubes having their ends expanded or otherwise tightly connected to a tube sheet which, because of the many tube hole perforations along with the pressures involved, must be thick. Such thick tube sheets when additionally subjected to high temperature differentials resulting from a flow of highly superheated steam across the face of the sheet at the inlet ends of the tubes, and the immersion of the opposite face to a comparatively low temperature medium, become highly stressed and various expedients have been suggested to avoid or relieve such stressed conditions. None of these has been wholly satisfactory.

My invention is particularly directed to a construction of the apparatus which permits an all-welded assembly and specifically avoids expanded joints and thick tube sheets subjected to high temperature differentials resulting from the direct contact of the highly superheated steam on one side and the direct contact of the cooling medium on the other side.

The attemperator of my invention involves an assembly of a plurality of heat exchange units arranged for parallel flow of steam therethrough, the quantity of steam being under the control of a single valve. Each of the heat exchange units comprise a double tube assembly of a central tubular member through which the superheated steam is directed, and an outer concentric tubular member which is sealed at its ends to the outer tube to form an annular chamber through which water of the boiler is permitted to circulate with its flow induced by the generation of vapor in the annular chamber.

My invention presents a double tube attemperator which not only eliminates the necessity for employing a thick tube sheet subject to superheated steam at a high temperature (of the order of 930° F.) on one side, and water existing at boiler pressure saturation temperature of the order of 590° F. on the other side, but it also

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eliminates heavy flange joints which are expensive and troublesome.

The double tube attemperator of my invention involves independent tubular elements of relatively small diameter. The tubular units of the illustrative attemperator are characterized by the fact that all of the connections between the tubular parts are welded. Thus, the difficulties arising from the use of expanded joints with thick tube sheets are eliminated.

The tubular elements of my attemperator being of relatively small diameter permit a wall-like arrangement in which a plurality of the elements are disposed in a row adjacent a wall of the steam generator. This avoids an undesirable concentration of weight, and, in many instances, effects a considerable saving in the space requirements for the steam generator unit.

The invention will be described with reference to a preferred embodiment shown in the accompanying drawings and other objects of the invention will appear as the description proceeds.

In the drawings:

Fig. 1 is a view in the nature of a vertical section illustrating a steam generating and superheating installation including an embodiment of the invention;

Fig. 2 is a view showing the attemperator in elevation. This view is taken from the plane indicated at 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a horizontal section on the line 3—3 of Fig. 1;

Fig. 4 is a vertical section through one of the heat exchange units of the attemperator;

Fig. 5 is a detailed view showing the U-bend construction of the attemperator unit on the vertical plane indicated by the line 5—5 of Fig. 4;

Fig. 6 is a transverse section on the line 6—6 of Fig. 5;

Fig. 7 is a detailed view illustrating the welded sealing ring construction employed between the inner and outer tubular elements of the attemperator units; and

Fig. 8 is a diagrammatic view in the nature of a flow diagram showing an arrangement of the attemperator with respect to the superheater sections which are associated with the steam generating installation.

The illustrative attemperator is shown in Fig. 1 in association with a steam generating installation of high capacity (750,000 lbs. steam per hour) operating at pressures of the order of 1450 p. s. i. and at steam temperatures of the order of 935° F. (the temperature corresponding to the operating pressure of 1450 p. s. i. being 590° F.).

The smaller U-tube of each unit has an upright inlet leg 10 receiving superheated steam from a header 12, its outlet 14 being connected to the outlet header 16.

The inner U-tube of each attemperator unit is substantially enclosed by an outer U-tube so as to form annular chambers 18 and 20 around the inlet and outlet legs, respectively, of the inner U-tube.

Water is supplied through an inlet 22 for each cooling chamber 18, a similar inlet 24 conducting water to the lower part of each annular chamber 20.

The annular chambers 18 and 20 are connected at their upper ends by an enlarged return bend 30 from which water and whatever steam there may be generated in the annular chambers 18 and 20, are conducted through the tube 32 to a header 34, (Figs. 1 and 8 of the drawings).

The header 34 is connected by the circulators 36 to the steam and water drum 38 of the steam generator. The latter includes a downcomer 40 connecting the water space of the drum 38 to a lower drum or header 42, and water supply lines 44—46 leading to the water inlets 22 and 24 of the annular chambers of the attemperator units from the header 170 connected to the downcomer 40.

The annular chambers are provided with a supply of water from the steam and water drum, and because of this, and in consequence of the venting off of the upper ends of these chambers to the steam and water drum, there is an active circulation with progressive vaporization of the water, the height of the unit being such as to give an increased effective head.

Referring particularly to Fig. 8, steam flows from the steam space of the drum 38 through the tubes 48 to the inlet header 50 for the superheater section 52, which preferably consists of return bend coils extending across a gas pass, each coil being connected at its outlet end to a header 54 from which superheated steam passes through the lines 56 and 58 to the attemperator inlet header 12.

Between, and connecting the lines 56 and 58, is a bypass valve construction indicated generally by the reference character 60. This valve functions to permit varying amounts of superheated steam from the line 56 to be conducted through the bypass line 62 directly to a position beyond the attemperator outlet header 16, thus bypassing the heat exchange units of the attemperator, with a portion of the steam flowing from header 54. The steam flowing from header 16 and the steam from the bypass mix in the pipe 64 leading to the inlet header 66 of superheater section 68. When the temperature of the steam passing to the inlet header 66 exceeds a desired value the valve is so operated as to cause a greater proportion of the superheated steam from the line 56 to pass to the line 58, and thence through the inlet header 12 to the attemperator units. Conversely, should the final temperature of the steam fall below a desired value, the bypass valve is so operated as to decrease the proportion of the superheated steam passing through the line 58 and to proportionately increase the amount of the superheated steam passing through the bypass line 62. For this mode of operation, the valve includes the elements (dampers) 60′ and 60″ fixed at right angles to each other upon the same valve stem 60‴. Preferably, the bypass valve is automatically controlled from one or more characteristics of the steam generating and superheating installation.

Preferably, steam from the attemperator units and the bypass flows from the header 16 through the lines 64 to the inlet header 66 of the second superheater section 68 which consists of a plurality of return bend coils and tubular sections extending across the path of the furnace gases of the steam generator. Each coil is connected at its outlet end to a header 70 from which the steam is conducted to a point of use.

The attemperator steam inlet and outlet headers are of considerable length and they are disposed along and between wall 72 of the furnace chamber and the air heater 74, as indicated in Figs. 1 and 3 of the drawings. The attemperator units are connected to the inlet and outlet headers at closely spaced positions, and they are disposed in wall-like arrangement as indicated in Fig. 2. Thus, the entire attemperator may be disposed in a narrow space alongside a component of the steam generator, so as to add very little, if any, to the floor space requirements for the entire installation. Furthermore, this arrangement affords an advantage with reference to the support of the attemperator. The load is not concentrated at one position, but is distributed throughout a line parallel to a wall of the installation. Thus, the attemperator may be supported by a plurality of hangers 80 secured at their upper ends to a beam 82 of the steel work at the upper part of the installation.

Referring to Fig. 4 of the drawings, the unit inlet tube 10 has welded thereto at its upper end a tubular section 90 of somewhat thinner wall construction and larger diameter. This section 90 is united at its upper end by circumferential weld 92 to a tubular return bend 94. Then the external tube 96, with the flexible metallic sealing 98 secured thereto by the weld 100, is slipped over the elements 10 and 90, the former having a sliding fit within the sealing ring 98.

The outer return bend construction 30 consists of elements united by such welds as indicated at 104 and 106 in Fig. 5, and this construction is considerably enlarged at its mid-section so as to permit of the relative movements of the return bends 94 and 30 resulting from differential expansion or contraction due to the large temperature differential between the fluids to which those elements are subjected in operation. This construction also facilitates the assembly of each attemperator unit by welding.

After the external tube 96 has been slipped over the united tubular elements 10 and 90 to a position such as that indicated in Fig. 4 of the drawings, the element 30 may be turned so that it slips over the element 94 and its end portion 110 brought into alignment with the upper end of the exterior tube 96. Then the weld 112 is made, and the inner return bend 94 is moved outwardly of the return bend 30 so that the upper end of the tubular section 114 may be brought into alignment with the free end of the return bend 94 at a position externally of the confines of the return bend 30 in order that the weld 116 may be formed. The tubular section 114 is united to the inlet tube 14 by the weld 118, before the weld 116 is formed.

The external tubular section 120 has a sealing ring 122 welded internally thereof near its lower end, this construction being similar to that indicated in Fig. 7. The sealing ring closely fits the tubular element 14 so that the combined elements 120, 122 may be slipped over the combined tubular elements 14 and 114 to bring the upper end of the external tube 120 adjacent to and in alignment with the left hand branch of the outer U-bend 30. The weld 128 is then formed.

The inner U-tube construction including the elements 90, 114 and 94 is then moved to its proper position within the outer U-tube construction, and the inner components of the sealing rings 98 and 122 are welded to the tubular elements 10 and 14 as indicated at 130 in Fig. 7. The annular chambers 18 and 20 are then put under hydraulic pressure for test purposes, and after it has been determined that the welds, and more particularly, the sealing ring welds 100, 130, are satisfactory, the thermal temperature gradient tubes 132 and 134 are slipped over to tubular elements 14 and 10, respectively, the welds 140—143 at the ends of these elements are then completed and the annular thermal gradient chambers 148 and 150 are put under hydraulic test. This test completed, these chambers may be closed by the plugs at 158 and 160.

The U-shaped sealing rings 98 and 122 provide a pressure seal between the inner tubes 10 and 14 and the respective outer tubes 96 and 120 while permitting the radial expansion or contraction of the tubes with changes in temperature. The welds 141 and 143 fix the inner and outer tubes together so that differential longitudinal expansion and contraction of the tubes will be away from the position of the welds. The seal rings 98 and 122 by their flexure allow for whatever differential longitudinal movement may occur between the concentric tubes at the position of the rings.

The inner tubular sections 90 and 114 of each attemperator unit are held properly centered within the external tubes 96 and 120 by groups of radial studs 180—182, indicated in Figs. 5 and 6 of the drawings.

The headers 12 and 16 are fabricated with stub tubes 162 and 164 welded thereto, and after these headers with their stub tubes are heat treated, the lower ends 10 and 14 of the attemperator units are welded to the upper ends of the stub tubes 162 and 164, this construction method avoiding undesirably high stresses in the header metal.

The inlet ends 22 and 24 of the water supply lines leading from the header or conduit 170 are secured to the external tubes 96 and 120 of the units by the welds 172 and 174 and the outlet tubes 32 are connected to the upper ends of the return bends 30 by the welds 176.

The steam generating installation shown in Fig. 1 includes a furnace 300 fired by pulverized fuel burners 302. The walls of the furnace include steam generating tubes 304 and 305 connected into the fluid circulation system of the generator and supplied with water through the downcomers 40 and the submerged drum 42. The upper ends of these tubes are in communication with the steam and water drum 38.

The furnace gases pass from the furnace 300 into the secondary furnace chamber 310, the walls of which likewise include steam generating tubes connected into the circulation system of the boiler. Above the second furnace chamber 310 there is a bank of steam generating tubes 312 over which the furnace gases pass before they contact with the superheater section 68. These steam generating tubes are connected at their lower ends to a header 314 and at their upper ends to a drum 316 which is in communication with the main steam and water drum 38 through the circulators 320.

Although the invention has been described with reference to the structural details of the preferred embodiment illustrated in the drawings, it is to be appreciated that the invention is not to be considered as limited to all of the details thereof. The invention may, rather, involve various combinations of the structural features of the illustrative embodiment, within the scope of the subjoined claims.

I claim:

1. In an attemperator for high pressure steam; a plurality of inverted U-tube constructions arranged in a narrow upright wall-like formation; each of said constructions including an inverted inner U-tube one leg of which constitutes an inlet for high pressure superheated steam, the lower end of the other leg of the inner U-tube constituting a superheated steam outlet, an outer U-tube presenting a separate annular envelope for each inner tube, each outer tube enclosing an inner U-tube so as to provide a closed annular cooling chamber in each leg of the construction, means conducting water to the lower part of each cooling chamber, and a steam and water outlet communicating with the upper ends of said chambers, the arrangement presenting two water flow paths for each steam flow path and the water entering the cooling chambers having a temperature materially less than that of the superheated steam.

2. In a heat exchanger, an inner inverted U-tube construction, an outer inverted U-tube construction enclosing the inner construction and spaced therefrom to present therebetween an inverted U-shaped chamber annular in cross-section with the thickness of the annulus less than the diameter of the inner tube, means providing for the supply of fluid to the inner construction, means connected to the lower ends of the legs of the outer U-tube and the annular chamber and providing for the supply of cooling fluid thereto of a temperature materially differing from the temperature of the fluid supplied to the inner construction, the bight of the outer U-tube having a cooling fluid outlet, and means joining ends of the legs of said inner and outer constructions to close off the annular chamber, the relative expansion or contraction of the legs of said constructions being provided for by the movement of the U-bend of the inner construction within the U-bend of the outer construction.

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