June 10, 1947. W. H. ROWAND ET AL 2,421,761

ATTEMPERATOR

Filed Oct. 10, 1941 4 Sheets-Sheet 1

Fig. 1

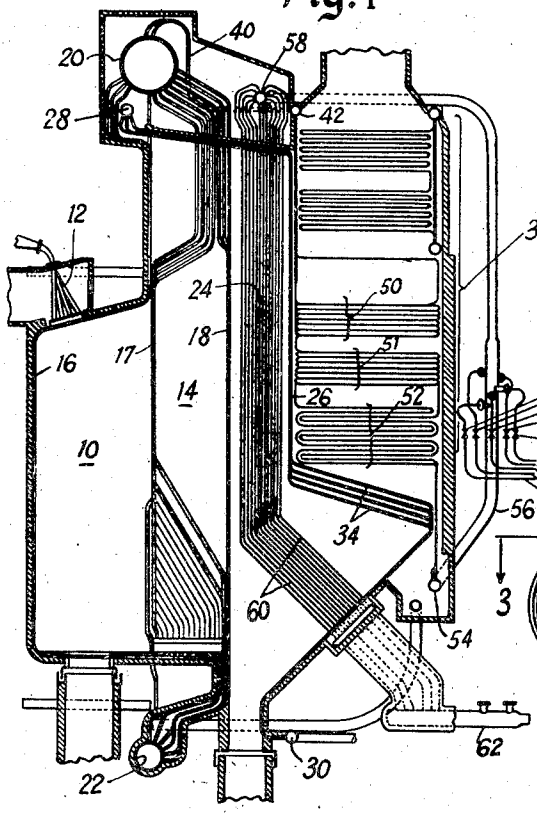
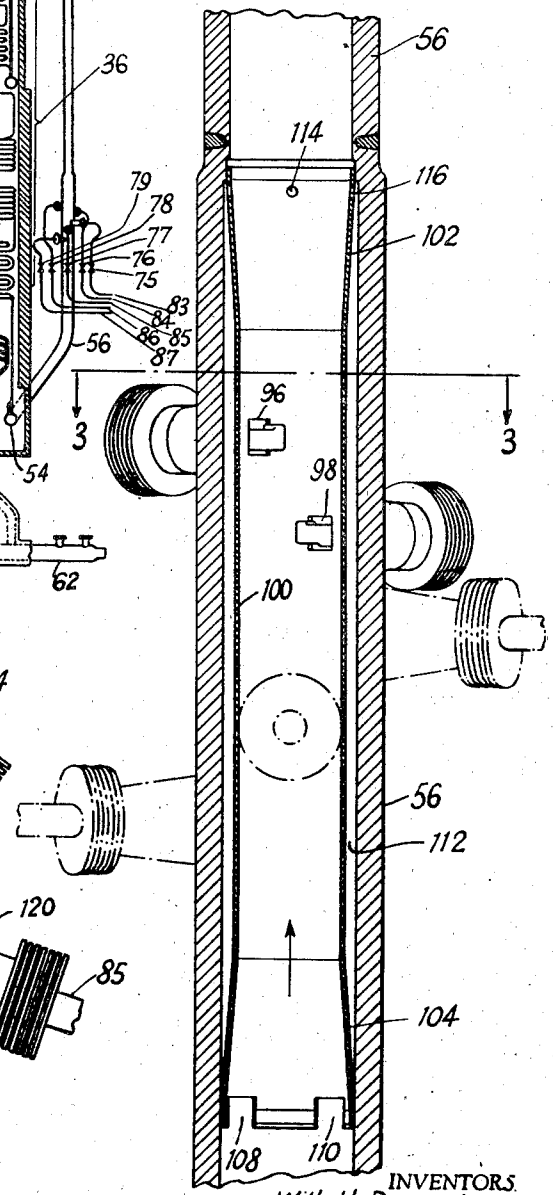


Fig. 2



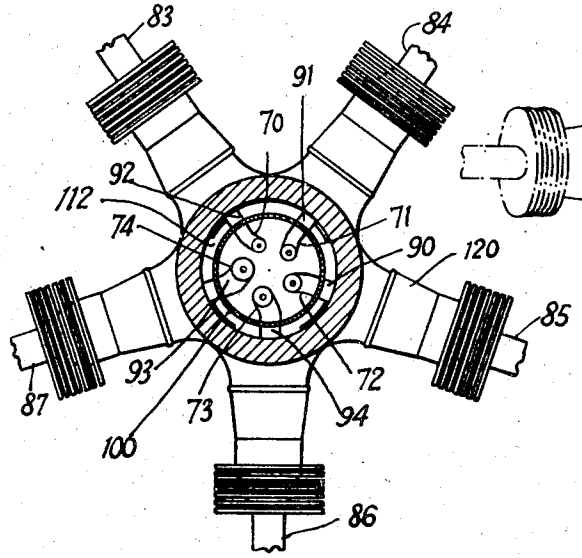


Fig. 3

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Fig. 4

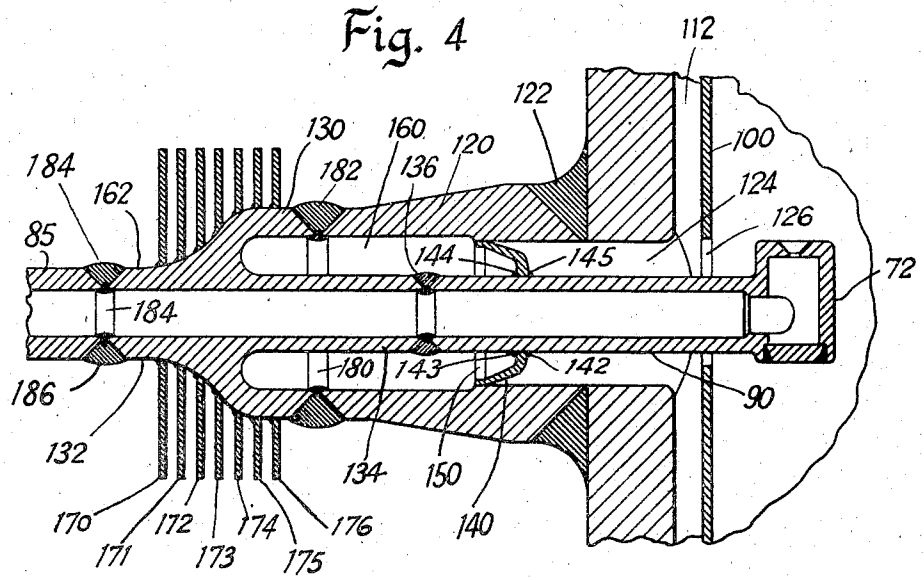


Fig. 5

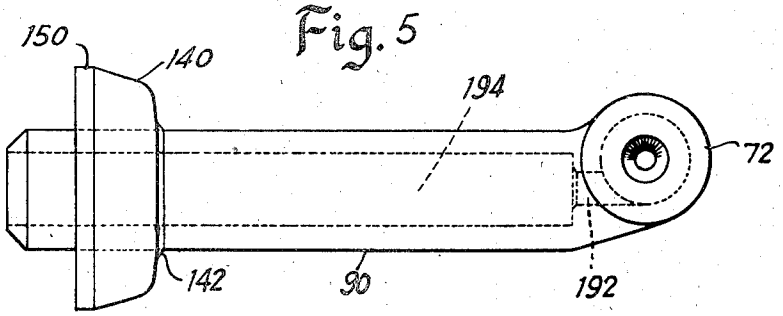


Fig. 6

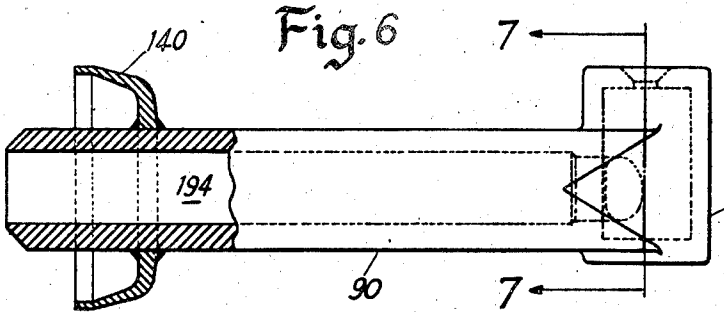
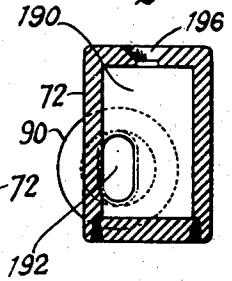


Fig. 7



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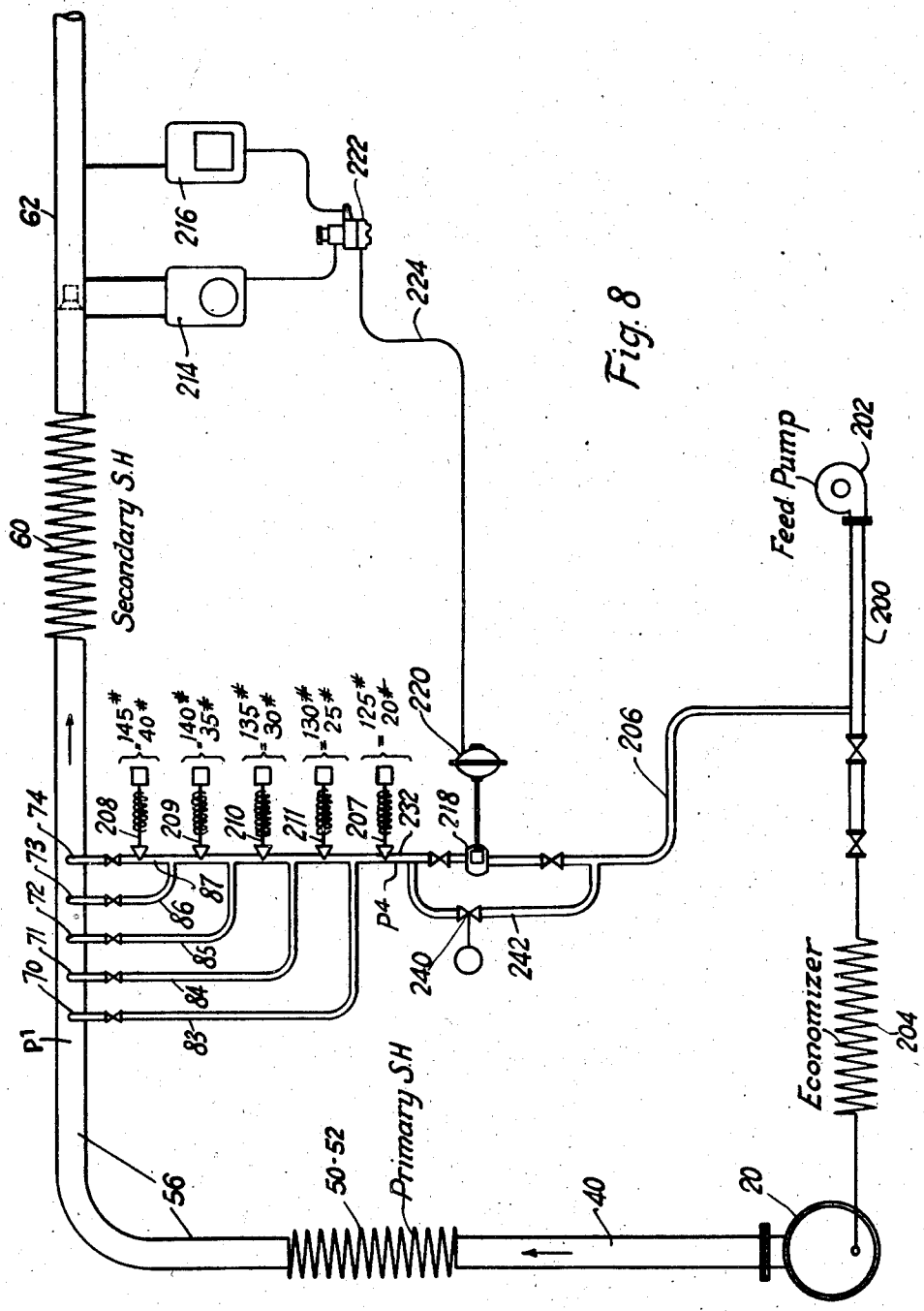


Fig. 8

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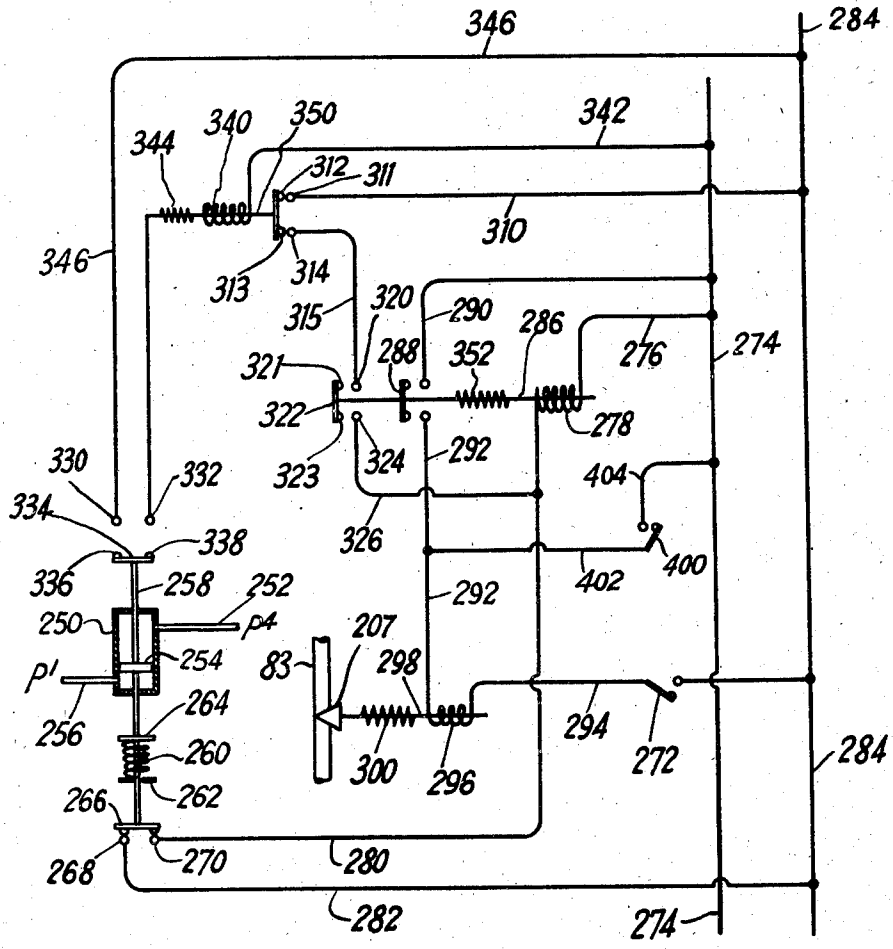
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ATTEMPERATOR

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Fig. 9



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UNITED STATES PATENT OFFICE

2,421,761

ATTEMPERATOR

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Application October 10, 1941, Serial No. 414,446

11 Claims. (Cl. 261—116)

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Our invention relates to a method of, and apparatus for, effecting fluid heat exchange.

More specifically, our invention relates to steam generation and superheating and is concerned with the control of superheat by direct contact desuperheating.

In this method of superheat control it is advantageous to spray a cooling liquid into superheated steam when cooling of the steam is desired for superheat control. It is, however, important that the spraying action be such as to result in a fairly complete and quick atomization of the liquid and a quick and thorough mixing of the atomized liquid with the steam.

Our invention solves this problem by providing a plurality of successively arranged spray nozzles which are successively cut in or cut out in response to changes in demand for desuperheating effect, the operation of the nozzles being limited to differential pressures within an effective atomizing range. We provide one nozzle of such atomizing capacity that it alone can take care of the lowest boiler loads and yet be operated at such a differential pressure that the desired quick and thorough atomization of the liquid takes place. As the load increases, or as the variation of superheat increases, additional spray nozzles are cut in, the nozzles operating under such conditions that complete atomization is quickly attained and smooth control characteristics are afforded. Preferably, the nozzles are of different and successively greater capacities.

Our invention will be described with reference to the accompanying drawings and other attributes and objects of the invention will appear as the description proceeds.

In the drawings:

Fig. 1 is a diagrammatic view in the nature of a vertical section showing a steam generator installation with which an embodiment of the invention is associated;

Fig. 2 is a vertical longitudinal section through the illustrative attemperator;

Fig. 3 is a horizontal section of the attemperator on the line 3—3 of Fig. 2;

Fig. 4 is a section through an attemperator nozzle and the associated temperature gradient construction;

Fig. 5 is a plan of one of the spray nozzles;

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Fig. 6 is partially a side elevation and partially a section of an illustrative spray nozzle;

Fig. 7 is a vertical section through the nozzle head, on the line 7—7 of Fig. 6;

Fig. 8 is a diagram illustrating a system by which the desired sequential operation of the spray nozzles is effected; and

Fig. 9 is a diagrammatic view illustrating the pressure differential control for the nozzle valves.

The Fig. 1 steam generator installation includes a water wall furnace 10 fired by burners 12 and supplying furnace gases for upward passage through the first open pass 14. The walls, such as the walls 16—18 of the furnace and the open pass 14 are defined by steam generating tubes connected to upper and lower drums 20—22.

From the top of the open pass 14 the furnace gases pass downwardly through a second open pass 24. The rear wall 26 of the second open pass is defined by steam heater tubes connecting the headers 28 and 30. Parts of these tubes are shown as forming a screen 34 extending across the gas inlet of the convection section 36.

Steam from the drum 20 passes through the tubular connections 40 to the superheater inlet header 42 and thence to a convection superheater including the banks of tubes 50—52 extending across the path of the gases in the convection section. Successive tubes of these sections are in series as to steam flow, all the tubes being connected to the superheater outlet header 54.

From the header 54, the vertically extending attemperator pipe 56 leads to the inlet header 58 of a second superheater. The tubes 60 of this superheater have their inlet ends connected to the header 58 as shown, and they are disposed in rows or groups extending transversely of the second open pass 24. Their outlet ends are connected to the superheater outlet header 62 from which steam is conducted to a point of use.

The temperature of the steam at the outlet header 62 is regulated by a spray type attemperator which is indicated in Fig. 2 in which a section of the pipe 56 provides the attemperator chamber. As the steam temperature rises above a desired value water is atomized by one or more of the spray nozzles 70—74 disposed within the chamber. If the steam flow increases concomitantly with such a steam temperature rise, more water is atomized by increasing the water flow

by the operation of one or more of the valves 75—79 which control the flow through the lines 83—87 supplying the respective nozzles. Preferably the water flow is regulated automatically by devices which respond to changes in steam flow and to changes in steam temperature.

As shown in the drawings (Figs. 2 and 3) the nozzles, or their tubular connections 90—94 extend through openings (such as 96 and 98) in a liner 100 the main body of which is spaced from the pipe 56 and is provided for the purpose of preventing the water spray from contacting the pipe. Otherwise, undesirable local stresses would be developed in the heavy-walled pipe by contact of the relatively low temperature water spray with the pipe metal the temperature of which may be considerably higher.

The liner has end portions 102 and 104 so tapered that the extreme ends of the liner contact the inner pipe surface beyond the zone of water spray. The liner is secured to the pipe 56 in such a manner that there will be no damage as a result of expansion changes due to temperature.

By way of example, and not of limitation, reference will be made to an installation of the invention for the purpose of indicating the temperature differential problem which is solved by the internal protector sleeve and the thermal gradient connections for conducting spray water to the nozzles. The latter, as elsewhere explained herein, include the radiant fins to dissipate the heat from a connection when its individual nozzle is inoperative and there is no water flow through the connection. In the installation, and at a boiler output of 300,000 pounds of steam per hour, the expanded steam temperature at the inlet to the attemperator is of the order of 825° F. the temperature of the feed water under these conditions being 470° F. This means that at this capacity, the temperature of the water that is sprayed into the attemperator chamber may have a temperature lower than the temperature of the metal of the attemperator by more than 300° F. In the same installation, at a maximum load of 550,000 lbs. of steam per hour, the expanded steam temperature is 875° F. at the inlet of the attemperator, while the feed water temperature is 487° F., these conditions presenting to the attemperator a greater temperature differential.

Notches 108 and 110 permit steam to enter the space (or chamber) 112 between the liner and the pipe. Steam may flow from that space through the openings 114 and 116 at the other end of the liner. These openings, as well as those at 96 and 98 may be considered as means for equalizing pressures internally and externally of the liner.

The relative arrangement of the liner 100, wall of the attemperator pipe 56, and a spray nozzle is indicated on an enlarged scale in Fig. 4. This figure also shows a thermal gradient connection minimizing the development of undesirable temperature created stresses in the metal of the attemperator pipe due to the admission of water at a temperature considerably below the temperature of the superheated steam and hence below the temperature of the metal of the pipe 56. This thermal gradient connection includes a sleeve 120 welded to the pipe 56 as indicated at 122 and having its bore aligned with the opening 124 in the pipe 56 and opening 126 in the liner 100. Welded to the outer end of the sleeve 120 is the outer annulus 130 of a tubular fitting 132, this fitting having an inner annulus, or tubular portion 134 welded, as indicated at 136, to the outer end of the tubular nozzle connection 90.

An annular sealing member 140, somewhat conically shaped, as shown, is fitted over the tubular connection 90 and welded thereto as indicated at 142—145. The outer portion 150 of said member is preferably in tightly fitted relationship to the sleeve 120 as indicated. The elements described immediately above form an annular insulating chamber 160, which may be closed, or provided with one or more openings for the ingress or egress of a fluid. In either case, the effect of this construction is to prevent lower temperatures of water in the tubular connections 134 and 90 from exercising an excessive cooling effect upon the metal of the pipe 56. The metal temperature of the outer tubular end 162 of the fitting 132 is substantially the same as that of the temperature of the water passing through the fitting, and from that position to a position in the sleeve 120 adjacent the outer portion 150 of the annular member 140 there is a temperature gradient the upper limit of which is of the order of the temperature of the metal of the pipe 56. This thermal gradient condition is promoted by the heat transfer effect of the extended surface fins 170—176 which are welded to the exterior of the fitting 132. These fins are preferably exposed to the atmosphere, and act to transfer heat thereto from the metal of the fitting 132. This construction is necessary to keep the metal of the extension (as at "132"), from attaining a high temperature due to conduction of heat from the walls of pipe 56 when there is no flow of water through the individual nozzle.

The Fig. 4 thermal gradient construction is such that the fitting 132 with its nozzle 72, tubular nozzle connection 90 and annular sealing member 140 may be fabricated as a unit and thereafter brought into operative position relative to the sleeve 120. The outer annular member 130 of this unit is then aligned with the outer end of the sleeve 120 by the welding ring 180 and the unit is then united with the sleeve by the circumferential weld 182. Thereafter, the outer portion 162 of the unit is similarly welded to the pipe 85, as indicated at 184 and 186.

It is understood, of course, that the thermal gradient construction above described is representative of similar constructions between the attemperator pipe 56 and the other spray water lines 83, 84, 86, and 87, the radial arrangement of which with reference to the attemperator pipe is indicated in Figs. 2 and 3 of the drawings.

The preferred construction of spray nozzle is indicated in Figs. 5, 6, and 7, wherein the cylindrical atomizing chamber of the nozzle receives water through a tangential inlet 192 communicating with the bore 194 of the tubular connection 90. The atomizing orifice construction 196 at the top of the chamber 190 is particularly indicated in Fig. 7.

At low capacities only one of the spray nozzles, such as the nozzle 70, may be needed for the purpose of controlling the super heat, but the capacity and atomizing characteristics of this nozzle are such that it may be operated with a minimum differential pressure sufficient to effect the substantially complete atomization of the water. If this nozzle or any of the other nozzles are operated at a lower differential pressure, the water will not be quickly or thoroughly atomized, and, under extreme conditions, such unatomized water may be carried along in the steam to such an extent that very undesirable effects are produced.

By way of example, rather than limitation, the following table is given as illustrating the different capacities of the nozzles which may be employed in an installation involving the invention:

Nozzle	Water flow at 25 p. s. i. nozzle pressure differential	Water flow at 100 p. s. i. nozzle pressure differential
	Lbs./hr.	*Lbs./hr.*
70	1,500	3,000
71	1,800	3,600
72	3,000	6,000
73	4,000	8,000
74	5,500	11,000

If while only one of the spray nozzles is in operation the steam flow through the attemperator is suddenly increased, one or more of the other spray nozzles, dependent upon the steam cooling effect desired, may be automatically brought into operation by control means which is responsive to steam flow. All of the flow of water to the spray nozzles is under control of such means, and it is also within the purview of the invention that such means, and such control, is effected by means responsive to changes in temperature of the steam at a position beyond the second superheater section which includes the tubes 60, as well as responsive to changes in steam flow.

In the superheat control system indicated in Fig. 8 of the drawings the source of spray water for the nozzles is the boiler feed water line 200 leading from the feed pump 202 and through the economizer 204 to the steam and water drum 20. A single spray water line 206 supplies water for all of the sequentially operated nozzle valves 207—211, and the flow through the line 206 is regulated in accordance with a demand for desuperheating effect. The means for producing this result includes a steam flow meter 214 and steam temperature responsive means 216 which are indicated as associated with the outlet header 62 of the secondary superheater 60. The flow meter and the temperature responsive means 216 are effective upon the flow control valve 218 through the valve operator 220 and a relay 222, connected by the line 224.

Beyond the main control valve 218 the sequential flow of spray water to the nozzle lines 83—87 is controlled by the nozzle shut-off valves 207—211 which are opened and closed by means responsive to the differences between the pressure P_4 of the spray water at a position beyond the valve 218, and the pressure P_1 of the superheated steam in the attemperator chamber 56.

Assuming the superheaters 50 and 60 to be in operation and that an increase in steam flow or increase in steam temperature (or both) in the superheater outlet header 62 has caused the main control valve 218 to be opened, the pressure differential (P_4—P_1) will be built up until it reaches a value at which the valve 207 will open—125 p. s. i. is chosen as this pressure.

The nozzle line 83 will then have communication with the line 206 and, thereupon, the nozzle 70 will operate at a pressure well above the lower limit of its effective atomizing range. If, then the demand for superheating effect still increases, the valve 218 will be further opened to cause another build-up of pressure in the line 83 and connection 232 until 130 p. s. i. pressure differential (P_4—P_1) is reached. Then the valve 211 will be opened to permit water to flow through the line 84 to the nozzle 71.

Further increases in superheating demand will

similarly cause the valves 210, 209, and 208 to be cut in in that order, at pressure differentials of 135, 140, and 145 p. s. i. respectively, until all nozzles are in simultaneous operation.

Now, if the demand for desuperheating effect decreases, the valve 218 will be operated to restrict water flow from the line 206, and the differential pressure (P_4—P_1) will drop. The valve 208 is set to close when the pressure differential reaches 40 p. s. i. Upon closure of this valve the differential pressure may vary between 40 p. s. i. and 140 p. s. i. without opening or closing any of the valves, but further closing of the valve 218 to reduce the pressure differential to 35 p. s. i. will then cause the valve 209 to be closed and the nozzle 73 to be cut out.

Similarly, the valves 210, 211 and 207 and their nozzles 72, 71, and 70 will be successively cut out at differential pressures of 30, 25, and 20 p. s. i., respectively. Such operation of the nozzle valves is co-ordinated with the different capacities of the nozzle sizes to give smooth control characteristics with a desirable minimum of cutting in and cutting out of the nozzles and to stay within the available pressure differential.

The illustrative control of the sequential operation of the nozzles thus substantially prevents nozzle operation at differential pressures beyond the range of effective atomization.

Fig. 8 shows the motor operated valve 240, provided for control of flow in the by-pass 242 around the main control valve 218.

Fig. 9 of the drawings illustrates means by which the nozzle shut-off valves are operated. As shown, the pressure cylinder 250 has a connection 252 in communication with the spray water line at some position such as 232 so as to afford the pressure P_4 on one side of the piston head 254. At the opposite end of the cylinder the pressure P_1 is communicated from the attemperator chamber within the pike 56 by the connection 256.

The head 254 is fixed to a stem 258 slidable through the end walls of cylinder 250 and the movement of the stem toward the P_1 end of the cylinder is adjustably resisted by a spring 260 which may be confined between a fixed stop 262 and a co-acting abutment member 264 carried by the stem 258.

The lower end of the stem carries an electrical conductor in the form of a bridge piece 266 adapted to close an electrical circuit by engaging the contacts 268 and 270.

Assuming that the Fig. 9 hook-up is applied for the operation of the nozzle shut-off valve 207, the contacts 268 and 270 are connected by the bridge piece 266 when the pressure differential (P_4—P_1) is 125 p. s. i. Then, assuming that the panel board push button has been operated to close the switch 272, current flows from the line conductor 274 through the lead 276, the coil 278, connection 280 and elements 266 and 282 to the other conductor 284 of the current supply line. The coil 278 pulls the armature 286 and its contact member 288 to the right to establish electrical connection between the elements 290 and 292. The latter leads to the coil 296 which is connected to the line wire 284 through the element 294 and the switch 272. The element 290 being connected to the opposite line wire 274, current then flows through the coil 296 and causes the valve 207 and its valve stem 298 to move to the right against the spring 300. The valve is thus opened and spray water is admitted to the line 83 and its spray nozzle 70.

With the nozzles 70 and 71 in operation the

differential pressure (P_4—P_1) may drop to such a value that the connection between the contacts 268 and 270 is broken by the movement of the head 254 toward the P_4 end of the cylinder 250. Such action (short of a drop to a 25 p. s. i. pressure drop) will not however, allow the valve 207 to close because its actuating coil 296 is still energized by the flow of current through the circuit including the contact or switch 288, the connections 290, 292, and 294 and the switch 272. This circuit is still held closed by the energization of the coil 278 through the circuit including the lead 310, contacts 311—314, element 315, contacts 320—324, element 326, the coil, and the lead 276, it being noted that the contacts 320 and 324 were connected by the member 322 when the coil 278 was originally energized by connection of the contacts 268 and 270, and its armature 286 moved to the right.

The spring 260 is so adjusted that the valve 207 will not close until the differential pressure reaches 20 p. s. i. When this differential pressure is reached the stem 258 has moved upwardly so that the contacts 330 and 332 are connected by the bridge piece 334 and its contacts 336 and 338. Current then flows through the coil 340 from the lead 342 and around through elements 344, 332, 338, 334, 336, 330 and 346 back to the supply line 284. The coil 340, thus energized, pulls back the armature 350 which carries the contacts 312 and 313. This action breaks the flow of current through the coil 278 and permits the armature 286 to be withdrawn by its spring 352. Thus, connection between the elements 290 and 292 is broken and the valve coil 296 de-energized, permitting the spring 300 to close the nozzle valve 207. When this occurs, parts of the described system will be reset, the resetting to original positions being completed when the differential pressure rises above 25 p. s. i. to cause contacts 330 and 332 to be disconnected and the coil 340 de-energized, the latter action permitting the spring of the armature 350 to establish connection between the contacts 311 and 314.

Manual operation of the valve 207 may be independently effected by the switch 400 connected to the lines 274 and 284 by leads 402 and 404.

It will be understood that the above description of the mode of operation of the spray nozzle valve 207 is by way of example, and that the remaining nozzle valves 211, 208, 209 and 210 may be similarly operated. In order, however, that there may be an effective sequence of nozzle operation, the respective valves are caused to cut-in at and cut out at different differential pressures. For example, the valves 207 may cut in at 125 p. s. i., the valve 210 at 135 p. s. i., the valve 209 at 140 p. s. i., and the valve 208 at 145 p. s. i. If, when all nozzles are in operation, the differential pressure drops to 40 p. s. i. the valve 208 and its nozzle 74 only will be cut out. Thereupon the differential pressure may vary between 35 p. s. i. and 140 p. s. i. without the cutting in or out of any nozzle. When, however, the decrease in demand for desuperheating effect causes such a reduction of spray water flow through valve 218 as to reduce the differential pressure to 35 p. s. i. the valve 209 and its nozzle are automatically cut out. Similar conditions subsequently prevail, further differential pressure reductions to 30 p. s. i., 25 p. s. i., and 20 p. s. i. causing the cutting out of valves 210, 211, and 207, respectively, with the cutting out of their associated nozzles.

Although the spray nozzles 70—74 are disposed at successive positions along the flow of the steam in the attemperator pipe 56, it will be noted from inspection of Fig. 1 of the drawings that all of the nozzles are located within an attemperator zone which is relatively short. Thus, when a plurality of the nozzles are in operation, the spraying actions of the nozzles will involve additional mixing effects, permitting a quick and thorough mixing of the atomized water with the steam.

It is particularly desirable in a spray type attemperator that the spray be arranged symmetrically relative to the section of the steam and in such a manner that any atomized particles of water not immediately evaporated and absorbed into the steam stream will be prevented from accumulating. The arrangement of the spray nozzle in a vertical pipe with the steam flow in an upward direction in opposition of the tendency for water particles to pass downward due to gravity is particularly important in a unit of this type where high efficiency of operation is required.

By the utilization of the feed water line as a source of supply of the desuperheating (or attemperating) liquid, an important safety factor is provided. It resides in the substantial assurance, that, whenever steam is being generated, there will be a supply of desuperheating liquid for the attemperator.

Also, by this provision there is assurance that, when no steam is being generated, no liquid will be atomized in the attemperator.

What is claimed is:

1. A spray type desuperheater including an attemperator chamber receiving superheated steam, a tubular liner spaced from the wall of the chamber, a plurality of spray nozzles of differing water atomizing capacities disposed within the chamber, and means connecting the spray nozzles to a source of water under a pressure higher than the pressure of the steam, the nozzles being disposed interiorly of the liner so that contact of water with a wall of the chamber will be limited, the arrangement being such that additional nozzles can be cut in as the need for a steam cooling agent increases.

2. In combination; a direct contact desuperheater comprising an attemperator pipe through which superheated steam flows at high pressure, a liner fixed inside said pipe and having its main portion spaced inwardly of the pipe in the desuperheating zone, a plurality of water spray nozzles disposed within said pipe and connected by nipples through the liner and the pipe with a source of water under pressure, and temperature gradient constructions associating the nipples and the pipe to prevent excessive local stresses which might otherwise be created by the temperature differential between the incoming water and the steam in the pipe, the liner being provided with openings permitting substantially free steam communication therethrough while substantially preventing contact of the atomizing water with the pipe in the spray or desuperheating zone.

3. In combination an attemperator pipe subject to the flow of superheated steam, a tubular liner secured within the pipe and having its main body spaced from the pipe, a plurality of fluid atomizing nozzles disposed within the liner and spaced longitudinally thereof, tubular connections extending through openings in the liner and connected to supply water to the nozzles, and means whereby the nozzles may be selectively cut into or out of operation as the steam flow varies

through the attemperator pipe, the space between the liner and the attemperator pipe being in communication with the atomizing chamber through openings in the liner.

4. In an attemperator of the spray type, means forming an attemperator chamber, means providing for the flow of the superheated vapor through the said chamber, a plurality of independent operable spray nozzles effective to atomize into said chamber, a liquid with a temperature lower than the superheated vapor, means responsive to the temperature of the superheated vapor beyond said chamber to control the pressure of atomizing liquid on the inlet sides of said nozzles, and means responsive to the differences between the pressure of the atomizable liquid and the pressure of the superheated vapor in said chamber to render additional nozzles operative or inoperative, said last named means maintaining on any operating nozzle a differential pressure sufficient to effectively atomize all of the liquid passing through the nozzle.

5. In combination, means forming an attemperator chamber receiving steam from a superheater, a pluraltiy of independently operable spray nozzles disposed within said chamber for atomizing water at a temperature considerably lower than the temperature of the steam entering said chamber, water supply means, a tubular connector through which water may flow to any of said nozzles, means including a valve through which water may flow from said supply means to said connector, means operable from one or more factors measuring the demand for atomized water in the attemperator chamber for acting upon said valve to control the flow of water to said connector, separate water supply lines leading from said connector to the separate nozzles, and a pressure controlled valve in each of said last named lines for effecting selective operation of the nozzles and cutting successive nozzles into operation at different pressures which are within an effective atomizing range.

6. In an attemperator of the spray type, means forming an attemperator chamber, means providing for the flow of the superheated vapor through the said chamber, a plurality of independent operable spray nozzles effective to atomize into said chamber a liquid with a temperature lower than the superheated vapor, means responsive to the temperature of the superheated vapor beyond said chamber to control the supply of atomizing liquid for one or more of said nozzles, and means responsive to the pressure differential between the pressure of the atomizable liquid at the inlets of the nozzles and the pressure of the superheated vapor to render additional nozzles operative or inoperative, said last named means rendering any nozzle operative only when said differential pressure is well above a value sufficient to atomize all of the liquid which will pass through the nozzle.

7. In a fluid heat exchange installation, means forming an attemperator chamber receiving superheated steam, a plurality of independently operable spray nozzles disposed within said chamber for atomizing water at a temperature considerably lower than the temperature of the steam entering said chamber, water supply means, a tubular connector through which water may flow to any of said nozzles, means including a main flow control valve through which water may flow from said supply means to said connector, means responsive to one or more factors indicating desuperheating demand for acting upon said valve

to control the flow of water to said connector, separate feed water supply lines leading to the separate nozzles, and separate pressure differential operative valves in said last named lines for effecting sequential operation of the nozzles and cutting successive nozzles into operation at different pressure differentials all of which are within effective atomizing ranges of the nozzles, the pertinent pressure differentials accruing between the superheated steam and the water at a position on the outlet side of the main flow control valve.

8. In a heat exchanger of the direct contact type; outer metallic structure acting as a pressure part; a thermal shield disposed inwardly of the outer structure to define a fluid mixing zone through which a vapor flows; and means atomizing into said vapor flow a liquid at a temperature materially differing from the vapor temperature; said shield lining said outer structure in the mixing zone and causing a heat flow barrier to be presented between the outer structure and the mixing zone.

9. In fluid heat exchange apparatus of the direct contact type, means providing for the flow of the heated vapor through a heat exchange zone, a plurality of independently operable spray nozzles effective to atomize into said zone a liquid at a temperature lower than the temperature of the vapor, means responsive to changes in the temperature of the vapor from a predetermined value to control the supply and pressure of atomizing liquid to the inlet sides of said nozzles, and means responsive to the pressure differentials between the atomizable liquid on the inlet sides of the nozzles and the pressure of the vapor to render the nozzles successively operative or inoperative upon the occurrence of pressure differentials of different values, said last named means rendering any nozzle operative only while said differential pressure is of a value sufficient to atomize substantially all of the liquid which passes through the nozzle.

10. In a spray type attemperator, an attemperator pipe, means providing for the flow of superheated steam through said pipe, steam desuperheating means including a plurality of spray nozzles of different atomizing capacity disposed within the pipe, means connecting the nozzles with a source of water under a pressure greater than the pressure of the superheated steam, and means responsive to the temperature of the desuperheated steam to cut in successive nozzles as increasing amounts of cooling fluid are necessary to reduce the temperature of the steam to a desired value, said last named means including a separate mechanism for each nozzle responsive to the differential between the pressure of the steam and the pressure of the water to limit the initiation of the operation of each nozzle to periods during which a predetermined pressure differential obtains.

11. In a spray type attemperator, means forming an attemperator chamber, means providing for a flow of superheated vapor through the chamber, a spray nozzle for atomizing liquid at a temperature considerably lower than the temperature of the superheated vapor entering the chamber, said spray nozzle being disposed within the chamber so as to atomize the liquid into the vapor, and a metallic shield spaced from the wall of the chamber and arranged on the downflow side of the nozzle to prevent the atomized liquid from contacting the chamber wall, said shield enclosing the nozzle and the superheated vapor

flow for a substantial distance on the downstream side of the nozzle.

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