

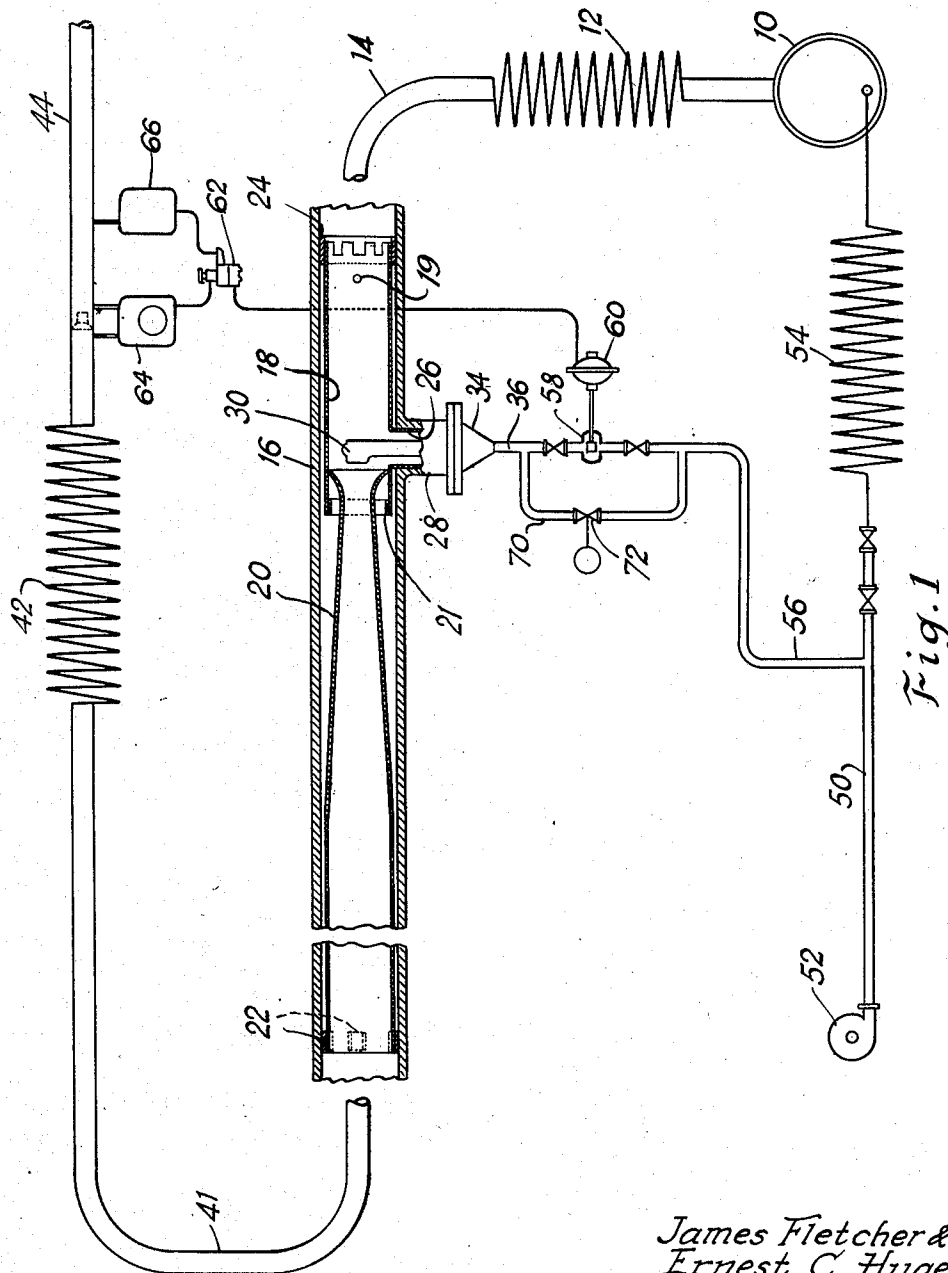
**May 1, 1951**

J. FLETCHER ET AL  
ATTEMPERATOR

**2,550,683**

Filed Aug. 17, 1946

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

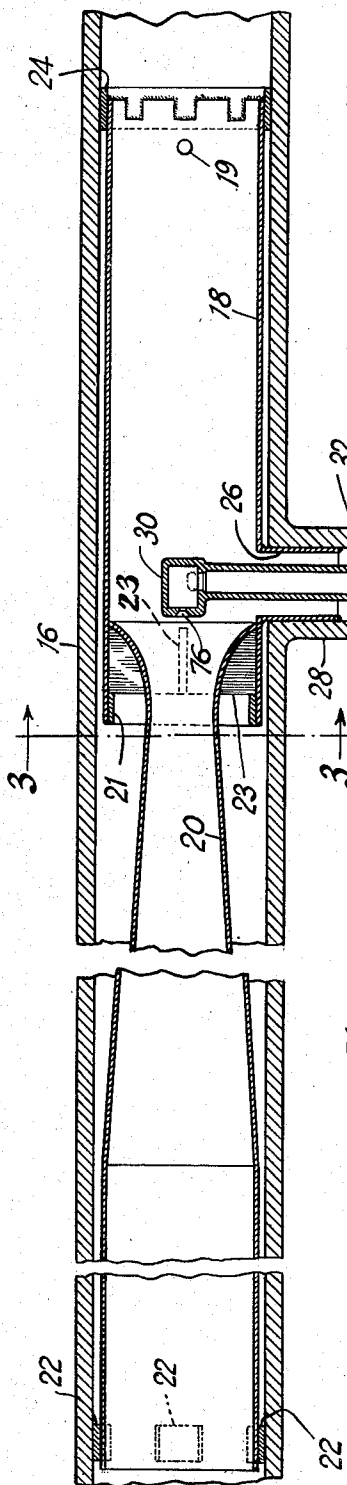


Fig. 2

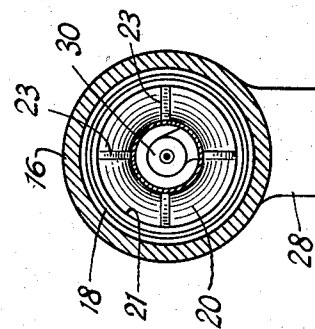


Fig. 3

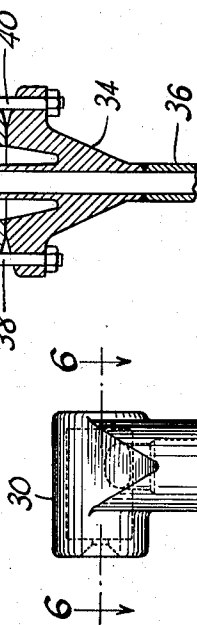


Fig. 4

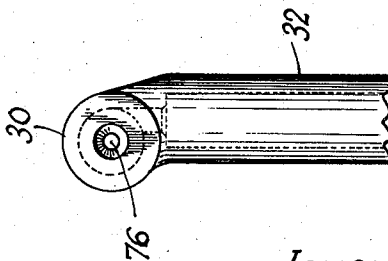


Fig. 5

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## UNITED STATES PATENT OFFICE

2,550,683

## ATTEMPERATOR

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6 Claims. (Cl. 261-116)

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This invention relates broadly to fluid heat exchange apparatus for attemperating steam.

More specifically, the invention relates to a direct contact heat exchanger whereby such a fluid as superheated steam or superheated vapor may be maintained within desired temperature limits by spraying into the superheated steam or vapor a vaporizable liquid, at a lower temperature. In the case of steam the liquid is water.

The invention is herein exemplified in a superheated steam conduit having therein a venturi acting as a part of a thermal sleeve to protect the conduit against thermal stresses. Forwardly of the entrance of the venturi is a spray nozzle through which water is atomized in a conical spray which is enveloped by the high velocity superheated steam. The nozzle is thus disposed in a relatively low velocity zone so that there is a low pressure loss due to minimum turbulence created by the nozzle body. The water leaves the nozzle in the form of a spray cone with a hollow vortex, the outer limits of this cone being within the entrance surfaces of the venturi.

An object of the invention is to provide an effective attemperator for superheated steam, with the atomized water having a minimum chilling effect on the metal of the venturi.

Another object is to provide an attemperator with instant response and marked simplicity of control. Either hand, semi, or full automatic control can be employed.

Another object of the invention is to provide for a maximum surface area of water spray in the surrounding steam atmosphere, with a single spray nozzle atomizing the water into a venturi.

Another object of the invention is to provide an attemperator of the type indicated, with the spray nozzle so disposed with reference to the venturi that the energy required to accelerate the water to steam velocity is reclaimed after leaving the Venturi throat in the same ratio as the recovery characteristics of the nozzle, due to the speed of the reaction between the steam and the water. In the present invention, this reaction is practically instantaneous.

Another object is to provide a combination of spray nozzle and venturi where the static energy of the fluid is converted to kinetic energy of motion in the zone of mixing, utilizing high energies to promote a most efficient and rapid transfer of heat between the fluids and having accomplished that, to reconvert the energy of motion to static energy in a highly efficient man-

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ner with a minimum loss of static energy of the fluids.

Another object is to locate the spray nozzle so that the fluid discharged is so directed that it has an initial component of velocity in the direction of flow which materially reduces the amount of energy obtained from the main stream necessary to accelerate it to main stream velocities. This is particularly true in the region of maximum capacities where a low pressure loss is vital.

A further object of the invention is to provide, in the above indicated combination, a spray nozzle in a relatively low pressure loss zone with a high recovery Venturi combination, where high fluid velocities are utilized to produce heat transfer conditions which are conducive to an instantaneous reaction between the two fluids.

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

In the drawings:

Fig. 1 is a diagrammatic view of the direct contact attemperator in a system for controlling the temperature of superheated steam;

Fig. 2 is an enlarged sectional view of the attemperator;

Fig. 3 is a transverse section on the line 3-3 of Fig. 2;

Fig. 4 is an elevation of the spray nozzle;

Fig. 5 is a plan view of the spray nozzle; and

Fig. 6 is a sectional view of spray nozzle on the line 6-6 of Fig. 4.

In the system indicated in Fig. 1 of the drawings, superheated steam passes from the steam and water drum 10, of a steam generator through a gas heated primary superheater 12, an extension of the outlet tube 14 of the superheater providing the attemperator chamber 16. Within the attemperator chamber is a thermal sleeve including a cylindrical inlet section 18 and a Venturi outlet section 20. This thermal sleeve construction is secured and centered within the chamber 16 at its ends as indicated at 22 and 24, both inlet and outlet sections being spaced from the walls of the chamber. At 22 there are four spacer pads preferably spaced 90° apart and welded to the Venturi outlet section 20. Although fitting against the inner wall of chamber 16, they are not fixed thereto. At 24 there is shown a ring welded to the inlet section 18 and closely fitting the inner wall of the chamber 20. Furthermore, a lateral sleeve 23 secured to the sleeve section 18 fits within the lateral nozzle

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connector 28 to further secure the thermal sleeve construction in its operative position.

As the cylindrical inlet section 18 is supported within the chamber wall at the inlet end by ring 24 to which it is welded and as the cylindrical section up to the Venturi throat will be handling superheated steam, there will be little if any differential movement of the section relative to the casing wall, the longitudinal position of the entire sleeve being fixed by the lateral connector 26. The lateral connector 26 also acts to position the sleeve centrally of the shell at its mid-section.

The outlet end of the Venturi section is supported in spaced relation with the casing wall by pads 22 and is free to expand axially depending on the temperature variations experienced in the Venturi wall metal which will be somewhat lower than the surrounding casing wall metal temperature as superheated steam will flow in the annulus.

The cylindrical inlet section 18 is provided with one or more holes 19 to provide for the flow of superheated steam into the annular space between the inlet section and the chamber 16. As the spaces between the pads 22 of the Venturi section provide outlets there will be some superheated steam flow through the annular space between the sections 18 and 20 and the chamber. Except for out side heat loss at positions in advance of the Venturi throat and the additional cooling effect of the cooler walls of the Venturi section, the superheated steam flowing through the annular space externally of sections 18 and 20 will experience little reduction in temperature and the heavy wall of chamber 16 will therefore have no abrupt temperature gradients.

The Venturi section 20 is supported in axial accurate alignment with the cylindrical inlet section 18 and with the nozzle by four radially positioned plates 23 equally spaced about the entrance of the venturi as indicated in Fig. 3. These plates have their inner edges shaped to closely fit against the exterior surface at the Venturi inlet. Each plate 23 also abuts against the ring 21 which is fixed within the cylindrical inlet section 18 at its left hand end. The plates 23 are preferably welded to the inlet section.

The water spray nozzle 30 is maintained at a position forwardly of and closely adjacent the Venturi entrance by a water nozzle tube including the sections 32, 34, and 36, the section 34 being flanged as indicated for securement to the flange of the nozzle connector 28 by the bolts 38 and 40. The outlet of the nozzle is shown at a spacing upstream from the inlet of the Venturi entrance, of less than the diameter of that entrance.

The spray nozzle tube is connected to a source of relatively pure water at a pressure greater than the pressure of the steam passing through the attemperator, and this water is supplied to the nozzle 30 at such a position that there is a minimum chilling effect upon the metal of the venturi and, particularly upon the metal at the Venturi throat. This results from the location of the spray nozzle relative to the entrance of the venturi in such a manner that the spray from the nozzle is disposed in an envelope of steam accelerating to throat velocity and aspirating the water spray. The nozzle is also located in a relatively low velocity zone which means low pressure loss due to whatever turbulence is created by the nozzle body.

The spray nozzle 30 is also so disposed that the initially accelerated water leaves the nozzle in

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the form of a cone with a hollow vortex, exposing the maximum surface of water spray in the surrounding steam atmosphere.

The energy required to accelerate the water to steam velocity is reclaimed after leaving the Venturi throat in the same ratio as the recovery characteristics of the nozzle, due to the speed of reaction between the steam and water, this reaction vaporizing the atomized water by heat transfer from the superheated steam. In the illustrated apparatus this reaction is practically instantaneous.

The steam approaches the attemperator chamber 20 at high velocity through a conduit such as that indicated at 14, and this means that the velocity of the fluid through the throat of the venturi is extremely high. In the illustrated apparatus fluid velocities through the Venturi throat approaching the speed of sound are utilized to produce heat transfer between the two fluids, and these conditions, in combination with the disposition of the spray nozzle, in a relatively low pressure loss zone with a high recovery venturi, are conducive to the instantaneous thermal reaction of the two fluids.

Beyond the attemperator, the steam passes through a conduit 41 to a second gas heated superheater 42 and thence through conduit 44 to a point of use.

In the system indicated in Fig. 1 the source of attemperator water for the spray nozzle 30 is the boiler feed water line 50 leading from the feed pump 52 through the economizer 54 and to the steam and water drum 10. A branch line 56 leads from the line 50 to the spray nozzle tube 36, a flow control valve 58 being interposed. This valve is activated by valve operator 60 which in turn is controlled through a relay 62 subject to the steam flow indicator and recorder 64, and the steam temperature responsive means 66. The flow of attemperating water to the nozzle 30 is thus controlled in response to the demands for a steam attemperating effect indicated by the steam flow and by the departure of the steam temperature in the steam outlet line 44, from a predetermined value.

A by-pass 70, around the water flow control valve 58 includes a motor operated valve 72 for control of the flow of water through the by-pass.

As indicated in Figs. 4, 5, and 6, the spray nozzle 30 has a circular chamber with its inlet connected with the nozzle tube section 32 and disposed tangentially to produce a whirling movement of the water within the nozzle chamber and a conical spray through the central nozzle outlet 76. The center of this outlet, and the centerline of the chamber of the spray nozzle are coaxial with the longitudinal axis of the Venturi section 20 of the thermal sleeve construction.

The illustrative apparatus has a wide range of operation, and it is characterized by a low pressure drop. It is also characterized by simplicity of control and by a simple compact arrangement of a minimum number of component parts. Long life of the apparatus is promoted by the use of a thermal sleeve construction which also eliminates thermal stresses and strains in the walls of the attemperator chamber.

The apparatus is so constructed that stresses induced by temperature differentials are avoided in the thicker chamber wall which is the effective pressure confining element. Deterioration of the thick chamber wall therefore does not take place.

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In the illustrated apparatus the spray nozzle is positioned so as to discharge centrally into the venturi so that the spray cone will be uniformly enveloped by the high velocity stream passing to the venturi. The spray nozzle is so disposed with respect to the Venturi entrance that the attemperor has been found to accomplish instantaneous mixing of water and steam through the entire range of operation requiring attemperation.

What is claimed is:

1. In an attemperor for controlling the temperature of superheated steam, pressure part means subject to the flow of superheated steam therethrough, a water spray nozzle within said means and so-axial therewith, tubular connections through which the spray nozzle is supplied with water at a temperature lower than that of the steam, tubular means including a Venturi unit within said pressure part means and forming a thermal stress shield extending longitudinally of the pressure part a substantial amount on both the upstream and downstream sides of the nozzle outlet, said unit being co-axial with the spray head outlet and having its inlet closely adjacent the outlet of the spray nozzle and on the downstream side thereof relative to the flow of superheated steam, and flow control means varying the flow of water through said tubular connections to maintain the temperature of the steam at a predetermined value, said spray head being so spaced in advance of the Venturi throat in a relatively low steam velocity zone that the pressure loss due to turbulence is of a low value.

2. In an attemperor for controlling the temperature of superheated steam, pressure part means subjected to flow of superheated steam and presenting an attemperor chamber, a cylindrical inlet section disposed within said chamber and spaced inwardly of the walls thereof, a Venturi outlet section within the chamber and disposed coaxially with the chamber and said inlet section, means for supporting the outlet end of the Venturi section in uniformly spaced relation to the inner wall of said chamber, means for supporting the inlet of the Venturi section rigidly within the inlet section, a lateral nozzle connection integral with said pressure part means at a position just forwardly of the inlet to the Venturi section, a lateral tubular connection integral with said inlet section and extending within said lateral nozzle connection and in closely fitting relationship therewith, a spray nozzle having its outlet axially aligned with the Venturi section and disposed just forwardly thereof, tubular means extending through said lateral nozzle connection and connected to the spray nozzle to support the same and supply it with water, and means for regulating the supply of water to said spray nozzle in order that said supply may correspond with the demand for attemperation, said inlet section being provided with one or more openings near its inlet end to permit the flow of superheated steam through the annular space between the attemperor chamber and the combined inlet section and Venturi section.

3. In an attemperor for controlling the temperature of superheated fluid, pressure part means subjected to flow of the superheated fluid and presenting an attemperor chamber, a cylindrical inlet section disposed within said chamber and spaced inwardly of the walls thereof, a Venturi outlet section within the chamber and disposed coaxially with the chamber and said inlet section, said inlet section and Venturi sec-

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tion constituting a thermal shield for said pressure part means, means for supporting the outlet end of the Venturi section in uniformly spaced relation to the inner wall of said chamber, means for securing the Venturi section rigidly to said inlet section, a spray nozzle having its outlet axially aligned with the Venturi section and disposed just forwardly thereof, tubular means connected to the spray nozzle to support the same and supply it with an atomizable liquid, and means for regulating the supply of liquid to said spray nozzle in order that said supply may correspond with the demand for attemperation.

4. In a sleeve-like Venturi construction adapted to be employed as a thermal shock protector for conduits subjected to the flow of high temperature fluid under high pressure, a cylindrical inlet section having means at its inlet end to space it radially inwardly of the inner surface of a conduit, a tubular Venturi section having exterior means at its outlet for spacing the Venturi construction radially inwardly of the conduit, means secured to the inlet section for reinforcing the inlet end of the Venturi section and supporting it in axial alignment with the inlet section, said inlet section and Venturi section being rigidly secured together at the position of said reinforcing means to constitute a tubular thermal shield for said conduit, a spray nozzle within the shield, and a transverse sleeve or connector secured to the inlet section at a position just forwardly of the inlet of the Venturi section to provide support for the spray nozzle at that position.

5. In an attemperor for controlling the temperature of superheated steam, pressure part means subject to the flow of superheated steam therethrough, a water spray nozzle within said means and co-axial therewith, transverse tubular connections through which the spray nozzle is supplied with water at a temperature lower than that of the steam, tubular means including a Venturi unit within said pressure part means and forming a tubular thermal stress shield extending upstream and downstream from the nozzle outlet for a substantial distance longitudinally of said pressure part, said unit being co-axial with the spray head outlet and having its inlet closely adjacent the outlet of the spray nozzle and on the downstream side thereof relative to the flow of superheated steam, transverse tubular means fixed relative to said pressure part and the tubular shield and thereby anchoring the tubular shield at the position of the spray nozzle, the ends of the thermal shield being slidably movable relative to said pressure part, and flow control means varying the flow of water to the spray nozzle to maintain the temperature of the steam at a predetermined value, said spray head being so spaced in advance of the Venturi throat in a relatively low steam velocity zone that the pressure loss due to turbulence is of a low value.

6. In an attemperor, a pressure part enclosing a mixture zone, a metallic shield including a Venturi-shaped component and forming a thermal stress protective liner spaced inwardly of the inner wall of the pressure part and subject to the flow therethrough of a superheated vapor, said Venturi section including a contracting entry part united with an expanding outlet part by a throat portion of smallest diameter, said throat portion joining said other Venturi parts in smooth curvatures, and means for atomizing into said vapor a liquid at a temperature materially less than the temperature of the vapor, said last named means including a liquid spray head dis-

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posed centrally of the liner and having its spray outlet upstream from the Venturi entry part and in a relatively low vapor velocity zone, said spray head spraying atomizing liquid into the Venturi throat in the same general direction as the vapor flow, the atomizer accomplishing a high speed thermal exchange and mixing of the vapor and liquid with minimized pressure loss.

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