

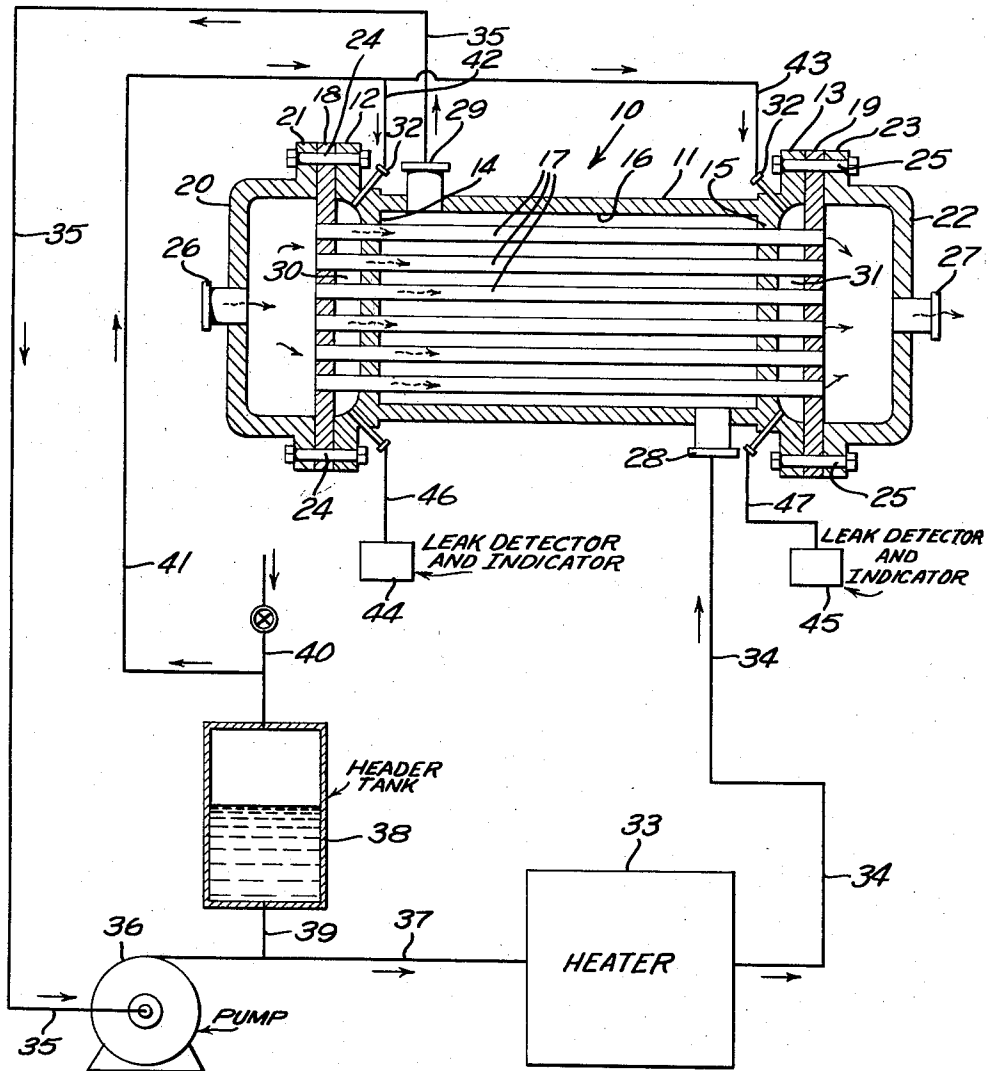
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A. BELL

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PRESSURIZED TUBE PLATE

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INVENTOR.
ALAN BELL

BY
E. Francis Ventworth Jr.
ATTORNEY

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PRESSURIZED TUBE PLATE

Alan Bell, Sutton Courtenay, England, assignor to Foster Wheeler Corporation, New York, N.Y., a corporation of New York

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This invention relates to heat exchangers and more particularly to heat exchangers wherein indirect transfer of heat is effected between a fluid, such as molten sodium or radio-active water and another fluid, such as steam or non-active water.

In a "shell and tube" heat exchanger wherein one fluid flows through a chamber defined by spaced plates which support the opposite ends of tubes through which flows another fluid, at a different pressure, the most likely point of leakage is at the joints between the tubes and the tube support plates due to the pressure differential across the tube sheet. Leakage at the joint of the tubes and tube support plates results in contact between the two heat exchange fluids which is particularly undesirable when one of the fluids is liquid metal or radio-active water.

It is, therefore, an object of the present invention to provide an improved heat exchanger wherein the possibility of leakage between the tubes and the tube support plates is substantially reduced. Another object is to provide a heat exchanger wherein, when leakage does occur, the fluids are prevented from coming into contact.

Accordingly, the present invention contemplates an improved heat exchanger of the "shell and tube" type which comprises a shell member having spaced plates or tube sheets secured in a fluid tight manner therein to define within the shell member a fluid chamber. A plurality of tubular members are provided which extend through said fluid chamber and are supported at their opposite adjacent ends by the tube sheets. Header cover plates are secured to the opposite ends of the shell member, adjacent the tube sheets, to provide a fluid inlet header communicating with the tubular members at one end and an outlet header communicating with the tubular members at the other end. A wall or plate is disposed within the fluid chamber in close spaced relationship with each tube sheet to define a sealing chamber adjacent each tube sheet. Each sealing chamber is connected to a source of gas or vapor, inert with respect to the fluid flowing through the tubular members and to the fluid in the fluid chamber, to provide inert gas or vapor in the sealing chambers at a pressure substantially equal to the pressure of the fluid within the fluid chamber.

The invention will be more fully understood from the following detailed description thereof when considered with the accompanying drawing in which the single figure is a diagrammatic view of apparatus employing a heat exchanger, shown in section, according to this invention.

Referring to the drawing, 10 generally designates a heat exchanger according to this invention, which, for illustration purposes, is shown embodied in an apparatus, hereinafter described in detail, employing heated liquid metal for the generation of steam or for superheating steam. However, it is to be understood that heat exchanger 10 may be employed in any apparatus wherein it is desirable to prevent the fluids, circulating through the heat exchanger, from contacting each other.

Heat exchanger 10 comprises a cylindrical shell mem-

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ber 11 having flanged ends 12 and 13 and end walls 14 and 15 which walls are disposed slightly inwardly of flanged ends 12 and 13, respectively. End walls 14 and 15 may be formed integral with shell member 11, as shown, or may be separate plates or tube sheets which are secured in a fluid tight manner to the inner surface of shell member 11. End walls 14 and 15 and shell member 11 define therebetween a fluid chamber 16. A plurality of closely spaced tubular members 17 are disposed in chamber 16. Tube sheets 18 and 19 are disposed against flanged ends 12 and 13, respectively, of shell member 11 and in lateral spaced relationship with adjacent end walls 14 and 15. End walls 14 and 15 and tube sheets 18 and 19 are provided with aligned holes which are adapted to receive therethrough the opposite end portions of tubular members 17 to support the latter, the tubular members being secured within aligned holes in end walls 14 and 15 and tube sheets 18 and 19 in such a manner as to provide fluid tight joints, as for example, by expanding and welding or brazing.

A header cover plate 20, having a flanged portion 21, is disposed at the end of shell member 11, adjacent end wall 14 and tube sheet 18, to provide an inlet header in communication with one end of tubular members 17. A second header cover plate 22, similar to cover plate 20 and having a flanged portion 23, is disposed at the opposite end of shell member 11, adjacent end wall 15 and tube sheet 19, to provide an outlet header which communicates with the opposite ends of tubular members 17. Cover plate 20 is secured to shell member 11 in a fluid tight manner by a plurality of circumferentially spaced bolts 24 (only two of which are shown) which pass through aligned circumferentially spaced holes in flange 12 of shell member 11, tube sheet 18 and flanged portion 21 of cover plate 20. Similarly, cover plate 22 is secured to shell member 11 by a plurality of circumferentially spaced bolts 25 (only two of which are shown) which pass through aligned, circumferentially spaced, holes in flange 13 of shell member 11, tube sheet 19 and flanged portion 23 of cover plate 22.

Cover plate 20 is provided with an inlet connection 26 which is connected to a source of fluid (not shown), as for example, water or steam, to receive fluid from the latter and to deliver the fluid to tubular members 17. Cover plate 22 has an outlet connection 27 which passes the heated fluid, as for example, steam or superheated steam, generated in tubular members 17 to a place of use (not shown), for example, a turbine. An inlet connection 28 is provided in the lower portion of shell member 11, adjacent end wall 15, to receive heated fluid, as for example, liquid metal, and to pass the heated fluid into chamber 16. An outlet connection 29 is positioned in the upper portion of shell member 11, adjacent end wall 14, to pass cooled heated fluid from chamber 16.

In the assembled heat exchanger 10, end walls 14 and 15 are laterally spaced from the respective tube sheets 18 and 19 thereby providing fluid tight chambers 30 and 31 therebetween. Chambers 30 and 31 each have an inlet connection 32 which is connected to a suitable source of inert gas for the purpose hereinafter described.

In the apparatus as shown embodying heat exchanger 10, a suitable heater 33, as for example an atomic reactor, is provided to heat a liquid metal, such as sodium. A line 34 is connected at one end to heater 33 and at the other end to inlet connection 28 to deliver heated liquid metal to chamber 16 of heat exchanger 10. A line 35 is connected at one end to outlet connection 29 of heat exchanger 10 and at the opposite end to the low pressure side of a pump 36. The high pressure side of pump 36 is connected to heater 33 by a line 37 to deliver cooled liquid metal to the latter. A header tank 38 is disposed between pump 36 and heater 33 and is connected

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by a line 39 to line 37 to receive liquid sodium. Header tank 38 serves to allow for expansion and contraction of the liquid metal due to variations in the temperature and pressure to which the liquid metal may be subjected. A valved line 40 is connected to the top of header tank 38 and to a source of pressurized gas (not shown), inert with respect to the liquid metal and to water or steam. The pressurized gas supplied to header tank 38 maintains the liquid metal under a relatively high pressure. A line 41 is connected to line 40 and lines 42 and 43, which lines 42 and 43 are in turn connected to inlet connections 32 of chambers 30 and 31 whereby the latter are supplied with inert gas under substantially the same pressure as the gas supplied to header tank 38.

In the operation of the apparatus afordescribed, liquid metal, such as sodium, potassium or the like, is heated in heater 33 and is delivered to fluid chamber 16 of heat exchanger 10 through line 34 and inlet connection 28. Simultaneously, fluid, such as water, passes from a suitable source thereof (not shown) into inlet connection 26 of header cover plate 20 and thence through tubular members 17 and in indirect heat exchange relationship with the heated liquid metal in chamber 16. In passing through tubular members 17, the water is heated and converted to steam, which passes therefrom into outlet header of cover plate 22 and, thereafter, through outlet connection 27 to a place of use (not shown), as for example, a turbine. The liquid metal is cooled in passing in indirect heat exchange relationship with the water flowing through tubular members 17 and thereafter passes from chamber 16 through outlet connection 29 and line 35. Pump 36 draws the cooled liquid metal through line 35 and delivers the liquid metal to heater 33 via line 37 for reheating. The liquid metal, which is circulated by pump 36 through heater 33 and heat exchanger 10, is maintained under a relatively high pressure by the inert gas which is supplied to header tank 38, through line 40.

Since chambers 30 and 31 are in communication with the inert gas supplied to header tank 38 by way of lines 41, 42 and 43 and inlet connections 32, the pressure within chambers 30 and 31 is substantially equal to the pressure of the liquid metal in chamber 16. With the pressures on either side of end walls 14 and 15 substantially the same, there is no appreciable pressure drop across end walls 14 and 15 and the possibility of failure of a tube joint between tubular members 17 and walls 14 and 15 is greatly minimized. In the event of failure of a tube joint in end walls 14 and 15 and leakage of liquid metal from chamber 16, the liquid metal will only penetrate to chamber 30 or 31 and will not contact the fluid in inlet header cover 20 or outlet header cover 22. In the event of failure of a tube joint in tube sheet 18 or 19 and consequent leakage of fluid from inlet header cover 20 or outlet header cover 22, the fluid will only pass into chamber 30 or 31 and will not come into contact with fluid in chamber 16.

Although the source of inert gas supplied to chambers 30 and 31 has been described as the same as that supplied to header tank 38, it is contemplated that any other source of inert gas or vapor may be employed to deliver inert gas or vapor to chambers 30 and 31, under a pressure substantially equal to the pressure of the liquid metal in chamber 16.

When failure occurs in a tube joint in tube sheet 18 or 19, end walls 14 or 15, an operator is apprised of the condition by leak detecting and indicating instruments 44 and 45 which are in communication with chambers 30 and 31, respectively, through lines 46 and 47. Leak detecting and indicating instruments 44 and 45 are adapted to react to the leakage of either fluid which passes into chambers 30 and 31, as a result of failure of a tube joint.

From the foregoing description, it can be readily seen that an improved heat exchanger of the "shell and tube" type has been provided wherein failure of a tube joint in the tube sheets is minimized by supplying a gas under pressure to sealing chambers which are disposed adja-

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cent the tube sheets. The sealing chambers also serve to prevent the heat exchange fluids from coming into contact when fluid leakage at a tube joint occurs. Sealing chambers are supplied with a gas which is inert with respect to the heat exchange fluids, so that when fluid leakage occurs an undesirable reaction will not take place between the fluid leakage and the gas in the sealing chambers.

Although one embodiment of the invention has been illustrated and described in detail it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the arrangement of parts without departing from the spirit and scope of the invention, as the same will now be understood by those skilled in the art.

What is claimed is:

1. In a heat exchange system, a heat exchanger comprising a shell member having two spaced pairs of closely spaced tube sheets disposed therein in a fluid-tight manner, the innermost tube sheet of each pair defining a first fluid chamber within said shell member adapted to receive therethrough a heated liquid, a plurality of tubular members disposed in said first fluid chamber for conducting fluid to be heated in indirect heat exchange relationship with the heated fluid flowing through said fluid chamber, each pair of tube sheets being adapted to receive the opposite end portions of each of said tubular members in a fluid-tight manner to support the tubular members in the first fluid chamber, the heat exchanger in combination with a pressurizer having a gas space and a liquid space therein, said pressurizer being in communication with a source of gas under pressure to receive gas in said gas space and in communication with said first fluid chamber to receive liquid in said liquid space to maintain the liquid under a predetermined pressure, conduit means communicating with the space between the tube sheets of each pair of tube sheets and with the gas space of said pressurizer to provide gas in said space between the tube sheets of each pair of tube sheets at a pressure substantially equal to the heated liquid within the first fluid chamber to provide substantially zero pressure drop across each inner tube sheet of said pairs of tube sheets.

2. The apparatus of claim 1 wherein each space between the tube sheets of each pair of tube sheets is in communication with a leak detecting and indicating instrument so that when leakage of either fluid occurs between a tubular member and a tube sheet, such leakage conditions will be indicated by the instruments associated with each of said spaces defined between the tube sheets of each pair of tube sheets.

3. In a heat exchange system for achieving indirect transfer of heat between a heated liquid metal and a liquid to be heated, a heat exchanger comprising a shell member having two spaced pairs of closely spaced tube sheets disposed therein in a fluid-tight manner, the innermost tube sheet of each pair defining a first fluid chamber within said shell member, said shell having inlet means receiving heated liquid metal and outlet means for passing said liquid metal therefrom, a plurality of tubes disposed in said first fluid chamber for conducting liquid to be heated in indirect heat exchange relationship with the heated liquid metal flowing through said first fluid chamber, each pair of tube sheets being adapted to receive the opposite end portions of each of said tubes in a fluid-tight manner to support the tubular members in said first fluid chamber, said heat exchanger in combination with heating means, conduit means connected to said heat exchanger outlet and said heating means for passing liquid metal from said heat exchanger to said heating means, a second conduit means connected to said heating means and to said heat exchanger inlet means for passing heated liquid metal to the latter, a pressurizer having a gas and a liquid space therein, said pressurizer being in communication with said first conduit means to receive

liquid in said liquid space, said pressurizer being connected to a source of gas under pressure to receive gas in said gas space to maintain the liquid metal under a predetermined pressure, a third conduit means connected to the pressurizer to receive gas from said gas space and connected to the heat exchanger to deliver gas to each space defined between the tube sheets of each pair of tube sheets at pressure substantially equal to the liquid metal pressure in said first fluid chamber.

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