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Meshii

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[54] **HEAT EXCHANGERS**

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[52] **U.S. Cl.** **122/32**, 165/145

[51] **Int. Cl.** **F22b 1/06**

[58] **Field of Search** 122/32, 34; 165/74, 165/158, 145

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[57] **ABSTRACT**

A heat exchanger having vertically disposed downcomer tubes connected at the bottom to vertically disposed spaced riser heat transfer tube bundles, shrouding forming a first vertically extending independent channel and a second independent channel surrounding downcomer tubes so that a portion of the heating fluid can flow upwardly in the first channel and thence downwardly around said downcomer tubes in the second channel by natural circulation.

3 Claims, 2 Drawing Figures

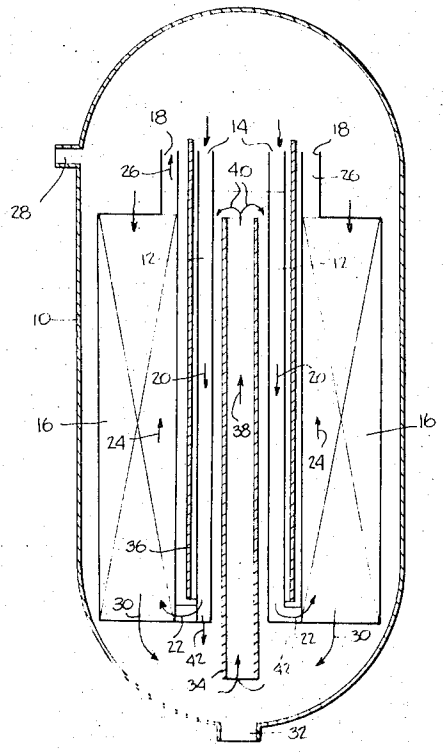


Fig. 2.

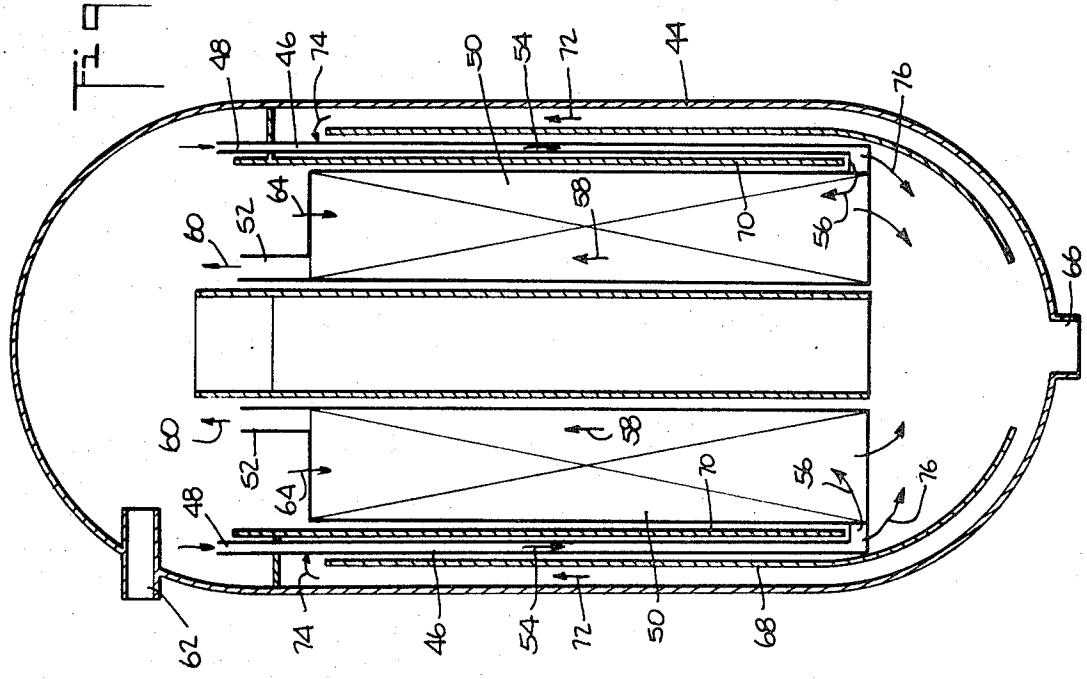
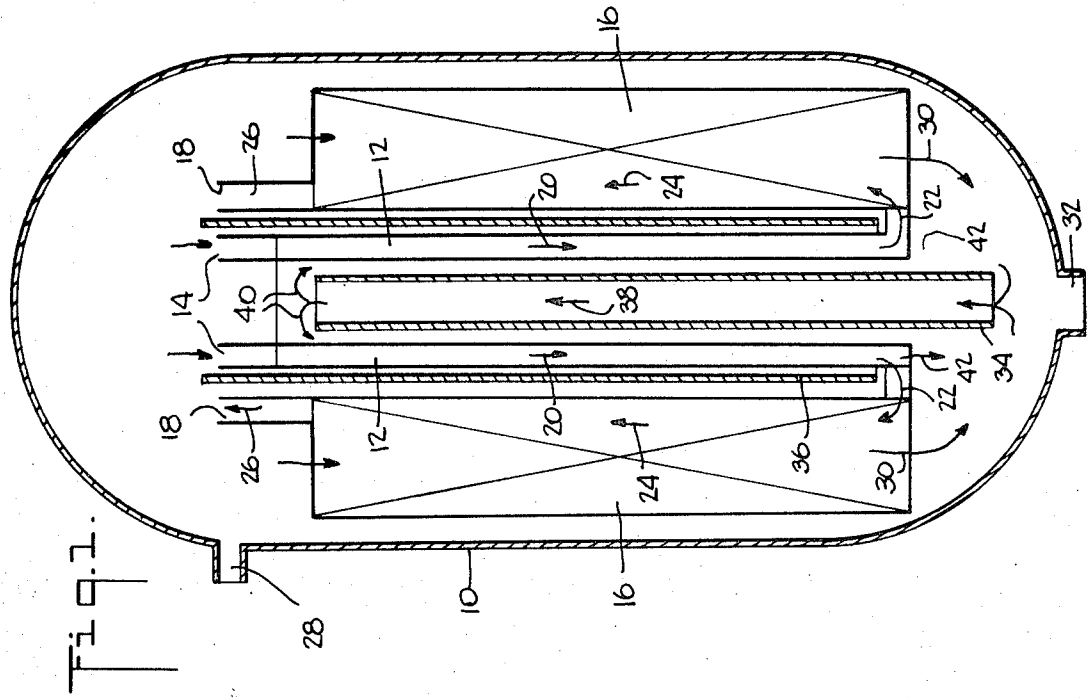

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Fig. 1.


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HEAT EXCHANGERS

This invention relates to improvements in the performance of heat exchangers and it is particularly adapted for heat exchangers employing vertically oriented downcomer tubes and riser heat transfer tube bundles. The invention is particularly adapted, among other possible applications, for use in association with a nuclear reactor, such as one cooled by liquid metal, sodium circulating in the reactor heats, another system containing sodium at a primary heat exchanger, and the sodium of the secondary system is used to heat water at a secondary heat exchanger for purposes of driving a prime mover such as a turbine. Heat exchangers of this type are constructed so that water downcomer tubes are connected at the top to a water inlet and at the bottom to parallel riser heat transfer tube bundles. The top ends of the riser tubes are connected to a vapor outlet. Vapor is generated by the downward flow of liquid metal such as sodium, passing downwardly around the heat transfer tube bundles from an upper inlet to a lower outlet. Heretofore, difficulty was experienced due to the fact that the liquid metal flowed downwardly around the downcomer tube, which had a small diameter. The heat transferred boiled the water before it reached the riser tubes, thereby generating thermal-hydraulic instabilities. To eliminate this, a shroud or bulk head was added between the downcomer tube and the riser heat transfer tube bundles, so that the liquid metal passed around the riser tube bundles, only. As a result of this construction, the instabilities were effectively eliminated, but then the downcomer tubes did not receive any heat but, in fact, were cooled by the water flowing therethrough. This construction created a number of problems. Large temperature differences occurred at the connection between the riser tube bundles and the downcomer tubes, thereby causing high thermal stresses in the tube structure in this area. Also, a hydraulically unstable situation existed which caused cyclic type flow disturbances. In addition, high cyclic fatigue occurred due to the large temperature differences and the hydraulic instability. In addition, it was virtually impossible to utilize leakage detectors to indicate leakage in the tubes due to the uncertain flow pattern in these regions. Moreover, there was a possibility of concentration of impurities in this area due to the stagnant conditions and low temperatures.

The present invention involves a novel combination of elements combined in such a way as to afford a very efficient solution to the difficulties encountered with the prior art, as will become apparent as the description proceeds.

In view of the foregoing, this invention contemplates the provision of a new and improved heat exchanger embodying a steam generator shell, a plurality of vertically disposed downcomer tubes mounted within the shell and having upper inlets for a first fluid. Riser heat transfer tube bundles are mounted in parallel, spaced relationship with respect to the downcomer tubes, and the lower ends of the downcomer tubes are connected to the lower ends of said tube bundles. The riser tube bundles have an upper outlet for the first fluid. The shell has an upper inlet for a second fluid which is connected in fluid flow relationship with the upper ends of the riser heat transfer tube bundles. The shell has a lower outlet for the second fluid which is in fluid flow relationship with the lower ends of the riser heat transfer tube bundles. A first cylindrically shaped adjusting shroud is mounted adjacent the downcomer tubes and extends from the upper ends of these tubes to a location adjacent the second fluid outlet. The first adjusting shroud forms a first substantially vertically extending independent channel, and a second cylindrically shaped shroud is mounted is spaced relationship between the downcomer tubes and the riser tube bundles and extends substantially the length of the downcomer tubes. The first and second shrouds coact to define a second substantially vertically extending independent channel surrounding the downcomer tubes so that a portion of the second fluid can flow upwardly in the first channel and thence downwardly around the downcomer tubes in the second channel by means of natural circulation.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described more fully hereinafter. Those skilled in the art will appreciate that the concept on which this disclosure is based may readily be utilized as the basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that this disclosure be regarded as including such equivalent constructions as do not depart from the spirit and scope of the invention.

Several embodiments of the invention have been chosen for purposes of illustration and description, and are shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is a vertical, medial, sectional view of a heat exchanger constructed in accordance with the concept of this invention; and

FIG. 2 is a vertical, medial, sectional view of a heat exchanger showing another embodiment of my invention.

In the embodiment of FIG. 1, there is shown a steam generator shell **10**, containing water downcomer tubes **12** which are connected to water inlets **14**. The downcomer tubes **12** are connected at the bottom to parallel riser heat transfer tube bundles **16** having upper outlets **18**. Accordingly, boiler feed water enters through the inlets **14** and passes downwardly through the downcomer tubes **12**, as indicated by arrows **20**, and thence around, as indicated by the arrows **22**, and up through the riser tube bundles **16**, as indicated by arrows **24**, and out as steam through the outlets **18**, as indicated by arrows **26**.

Still referring to FIG. 1, liquid metal, such as sodium, enters through an upper inlet **28** and flows downwardly through the riser heat transfer tube bundles **16**, as indicated by arrows **30** and out through a lower outlet **32**, provided for the purpose. A tube-shaped adjusting shroud **34** is mounted medially of the downcomer tubes **12**. This shroud extends from adjacent the water inlet **14** of the downcomer tubes to adjacent the sodium outlet **32**. A second cylindrically shaped shroud **36** is mounted in spaced relationship between the downcomer tubes **12** and the riser tube bundles **16**. This second shroud extends substantially the length of the downcomer tubes. The two shrouds are arranged to provide a suitable space around the downcomer tubes **12**.

While the greater portion of the liquid metal or sodium which flows downwardly through the riser tube bundles **16** and thence out through the outlet **32**, a smaller secondary portion of this sodium continuously flows upwardly inside the shroud **34**, as indicated by arrow **38** and, thence, outwardly and downwardly, as indicated by arrows **40** around the downcomer tubes **12**, and back out the bottom as indicated by arrows **42**, to return to the main body of sodium flow. This secondary flow is effected by means of natural circulation caused by the increase in the density of the sodium which is cooled at the periphery of the downcomer tubes **12**. That is, the sodium is continuously cooled by the downcomer tubes in the region surrounding same, thereby causing the natural circulation. This flow of sodium raises the temperature of the water in the downcomer tube **12** so that the difference between the water in the lower portion of the downcomer tube and in the lower portion of the riser tube bundle **16** is substantially reduced in comparison with conventional structures. Therefore, thermal stress in this region, as well as plate-out of the impurities, is substantially eliminated and, in addition, heat transfer is effected in the downcomer tube, thereby adding to the efficiency of the system.

In the embodiment of my invention shown in FIG. **2**, there is provided a steam generator shell **44** containing water downcomer tubes **46** which are connected to water inlets **48**. The downcomer tubes are connected at the bottom to parallel riser heat transfer tube bundles **50** having upper outlets **52**. In this embodiment the boiler feed water enters through the inlets **48** and passes downwardly through the downcomer tubes, as indicated by arrows **54**, and thence flows around, as indicated by arrows **56**, and up through the riser tube bundles **50**, as shown by arrows **58**, and out through the outlet **52**, as indicated by arrows **60**.

Still referring to FIG. **2**, liquid metal, such as sodium, enters through an upper inlet **62** and flows downwardly through the riser heat transfer tube bundles **50**, as indicated by arrows **64**, and out through the lower outlet **66**. A tube-shaped adjusting shroud **68** is mounted outwardly of, and surrounding the downcomer tubes **46**. It extends from the upper ends of the downcomer tubes down to a location adjacent the sodium outlet **66**. This shroud is mounted in spaced relationship with respect to the generator shell **10** and in spaced relationship with respect to the downcomer tubes **46**. A second cylindrically shaped shroud **70** is mounted in spaced relationship between the downcomer tubes **46** and the riser tube bundles **50**, and extends substantially the length of the downcomer tubes. The two shrouds are arranged to provide suitable space around the downcomer tubes **46**.

While the greater portion of the sodium which flows downwardly through the riser tube bundles **50** and thence out through the outlet **66**, a smaller secondary portion thereof continuously flows upwardly in the cylindrical space between the shell and the first shroud **68**, as indicated by arrows **72** and, thence, inwardly and downwardly, as indicated by arrows **74**, around the downcomer tubes **46**, and back out the bottom as indicated by arrows **76**, to return to the main body of sodium flow. This secondary flow is by means of natural circulation caused by the increase in the density of the sodium which is cooled at the periphery of the downcomer tubes **46**. In the same manner as pointed out in connection with the description of the embodiment of FIG. **1**, this also raises the temperature of the water in the downcomer tube so that the temperature difference between the water in the lower portion of the downcomer tube and in the lower portion of the riser tube bundles **50** is substantially reduced in comparison with conventional structures.

It will thus be seen that the present invention does indeed provide an improved heat transfer apparatus which is superior because of the reduction of temperature differentials, hydraulic instability, reduction of thermal stresses, reduction of cyclic fatigue, which has an increased heat transfer area, and which reduces the possibility of concentration of impurities, as compared to prior art such devices.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains.

What is claimed and desired to be secured by Letters Patent is:

1. A heat exchanger comprising a steam generator shell, a plurality of substantially vertically disposed downcomer tubes mounted within said shell and having upper inlets for a first fluid, riser heat transfer tube bundles mounted in parallel spaced relationship with respect to said downcomer tubes, the lower ends of said downcomer tubes being connected to the lower ends of said tube bundles, said riser tube bundles having an upper outlet for said first fluid, said shell having an upper inlet for a second fluid and being in fluid flow relationship with the upper ends of said riser heat transfer tube bundles, said shell having a lower outlet for said second fluid, said lower outlet being in fluid flow relationship with the lower ends of said riser heat transfer tube bundles, a first cylindrically shaped adjusting shroud mounted adjacent said downcomer tubes and extending from the upper ends of the downcomer tubes to a location adjacent the second fluid outlet, said first adjusting shroud defining a first substantially vertically extending independent channel, a second cylindrically shaped shroud mounted in spaced relationship between the downcomer tubes and the riser tube bundles and extending substantially the length of the downcomer tubes, said first and second shrouds defining a second substantially vertically extending independent channel surrounding said downcomer tubes, means interconnecting the upper ends of said channels in fluid flow communication, whereby a portion of the second fluid can flow upwardly in the first channel and thence downwardly around said downcomer tubes in the second channel by means of natural circulation.

2. A heat exchanger according to claim **1** wherein said downcomer tubes are disposed inwardly of said riser heat transfer tube bundles and said first adjusting shroud is disposed inwardly of said downcomer tubes.

3. A heat exchanger according to claim **1** wherein said downcomer tubes are disposed outwardly of said riser heat transfer tube bundles and said first adjusting shroud is disposed between said downcomer tubes and said shell.

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