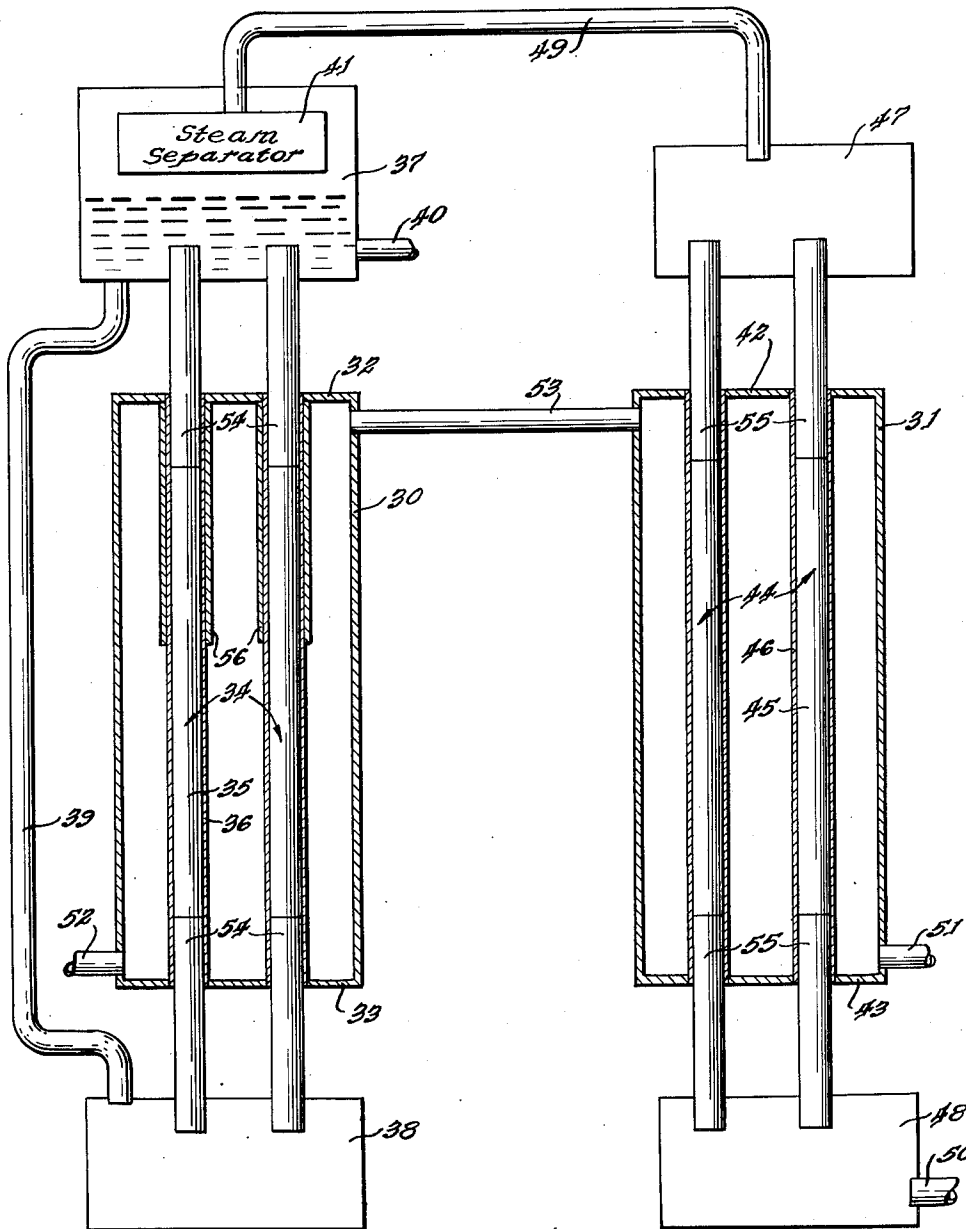


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SODIUM-WATER HEAT EXCHANGER

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SODIUM-WATER HEAT EXCHANGER

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1 Claim. (Cl. 122-32)

This invention relates to a heat exchanger. In more detail the invention relates to an apparatus for exchanging heat between two reactive liquids.

The safe, yet efficient, transfer of heat between reactive liquids is a problem which must be solved to make practical power plants wherein the heat source is a liquid-metal-cooled nuclear reactor and the heat is utilized in a conventional steam-powered turbine. In power plants of this type the heat developed in the liquid metal must be transferred to water to form steam.

All liquid metals which have been suggested for the purpose are reactive with water and this is particularly true of sodium and the alloy of sodium and potassium known as NaK which probably have the greatest potential of any liquid metal reactor coolants.

There is therefore an absolute necessity that the two liquids be kept separate at all times and that the possibility of interleakage between the liquids be reduced as near to zero as it is possible so to do and if, in fact, the possibility of contact is anything more than vanishingly small the heat exchanger will not be practical for large-scale use.

In addition to the above requirement, of course, the heat exchanger must be efficient in transferring heat in order to be practical. This, of course, eliminates all schemes which make it completely impossible for the two liquids to come into contact but at the same time involve a considerable loss of heat within the heat exchanger.

It is accordingly an object of the present invention to develop a heat exchanger capable of transferring heat efficiently between reactive liquids.

This and other objects of the present invention are attained by our novel heat exchanger wherein points of weakness subject to rupture due to thermal shock have been eliminated. In particular, in our heat exchanger there are no welds contacting both water and sodium. Other advantages will become apparent from a further reading of this specification.

The invention will next be described with reference to the accompanying drawing wherein the FIGURE is a diagrammatic view of a heat exchanger according to the present invention.

According to the invention two tanks for a hot liquid are employed—an evaporating tank 30 and a superheating tank 31. Tank 30 includes a tube sheet 32 forming the top thereof and a tube sheet 33 forming the bottom thereof. Vertically disposed within tank 30 are a plurality of double tubes 34 serving as evaporating tubes, each of which consists of an inner tube 35 and an outer tube 36 concentric therewith. Inner tubes 35 extend between a steam drum 37 and a water header 38. Steam drum 37 and water header 38 are connected by downcomer 39 while a steam drum 37 has an inlet 40 for water and includes a steam separator 41.

Tank 31 includes a tube sheet 42 forming the top thereof and a tube sheet 43 forming the bottom thereof. A plurality of double tubes 44 serving as superheating tubes are vertically disposed within superheating tank 31 and each consists of an inner tube 45 and an outer tube 46. Inner tubes 45 extend between headers 47 and 48. Header 47 is connected to steam separator 41 by steam line

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49 while header 48 has an outlet 50 for superheated steam. Also tank 31 is provided with an inlet line 51 and tank 30 is provided with an outlet line 52 while connecting line 53 connects tanks 30 and 31.

Double tubes 34 and 44 are metallurgically bonded over most of their length but include end portions 54 and 55 which are not bonded. The ends of outer tubes 36 and 46 are welded to tube sheets 32 and 33, and 42 and 43, respectively, with the weld being located in the portion of the double tube which is unbonded.

Finally, double tubes 34 have tubes 56 relatively loosely disposed thereabout. These tubes 56 are not bonded to the double tubes 34 but may be tack-welded thereto to hold them in place.

Operation of the heat exchanger will next be described. Hot sodium enters superheating tank 31 through line 51, passes through line 53 to tank 30 and cooled sodium leaves through line 52. Water is introduced into steam drum 37 through line 40 and circulates through downcomer 39, header 38 and inner tube 35 back to steam drum 37. A portion of the water passing through evaporator tank 30 becomes steam which rises in steam drum 37 and passes through steam separator 41 to the superheater section of the heat exchanger. In the superheater section of the heat exchanger the steam passes through inner tubes 45, header 48, and outlet line 50. The water circulates through the downcomer and the tubes 35 due to thermal convection. The advantages of the above construction will next be described. First, there is a double tube separating the two reactive liquids. Both of these tubes must fail before there is contact between the reactive liquids. For a sodium-water heat exchanger these tubes may be constructed of stainless or ferretic steel. Since the tubes are metallurgically bonded there is very good heat transfer therebetween.

Second, double tubes 34 and 44 include end portions 54 and 55 which are not bonded and the weld connections between tube sheets 32, 33, 42 and 43 and the outer tubes 36 and 46 are made in the unbonded portion thereof. It has been found that the weld can be made so that the inner tubes 35 and 45 are not affected. There is therefore no weld contacting both water and sodium. Experience has shown that such a weld is a point of weakness that would be likely to fail if the heat exchanger were to be used over a period of time. Although great care must be taken in making the welds, this is within the province of an experienced welder.

Third, relatively loose tubes are disposed about the steam ends of the double tubes in the evaporator section of the tank. These tubes are for the purpose of limiting heat transfer from the sodium to this part of the double tubes. Since the steam in this portion of the tubes does not cool the tubes as well as the water in the other portion of the tubes, the steam end of the double tubes will operate at a higher temperature than the water end unless means are taken to limit heat transfer from the sodium to the steam end of the tubes. This is the function of relatively loose tubes 56. By preventing overheating in the evaporating section of the heat exchanger another potential source of trouble is eliminated.

To construct the double tubes 34 and 44 so that the tubes are metallurgically bonded over most of their length but are not bonded at their ends, the portion of the inner tube which should be bonded to the outer tube is covered with a few mils of a bonding material such as copper or nickel. The outer tube is then drawn down on the inner tube and the double tube subjected to heat to metallurgically bond the tubes throughout the portion of the tubes wherein is located the bonding material.

Although the double tube has the same appearance to the eye whether it is bonded or unbonded, the difference

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in results is very apparent. Heat transfer between bonded tubes is very much better than between unbonded tubes for which reason it is necessary that the inner and outer tubes be bonded for efficiency. However if this bonding extends all the way between the locations where the outer tubes are welded to the tube sheets, the welding operation will affect the inner tube adversely causing a point of weakness that is liable to failure. By the comparatively simple procedure of leaving an unbonded section at the ends of the tubes, this disadvantage is avoided.

It will be understood that this invention is not to be limited by the details given herein but that it may be modified within the scope of the appended claim.

What is claimed is:

An apparatus for exchanging heat between sodium and water comprising an evaporating tank and a superheating tank, an inlet for sodium near the bottom of the superheating tank, an outlet for sodium near the bottom of the evaporating tank, a line connecting the top of both tanks, a plurality of double tubes each consisting of two concentric tubes metallurgically bonded through the greater portion of their length but with unbonded portions at the ends thereof vertically disposed in both of said evaporating and superheating tanks, headers located below each of said tanks, a steam drum containing a steam separator located above the evaporating tank, a downcomer con-

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necting the steam drum with the header located below the evaporating tank, a header located above the superheating tank, a line connecting the steam drum with the last-mentioned header, an inlet for water in the steam drum, an outlet for superheated steam in the header located below the superheater tank, the inner of the two concentric tubes extending between the headers located below each of said tanks and the steam drum located above the evaporating tank and the header located above the superheating tank respectively, the outer of the two concentric tubes being welded into the top and bottom of one of the tanks.

References Cited in the file of this patent

UNITED STATES PATENTS

2,229,554	Cummings	Jan. 21, 1941
2,234,423	Wittmann	Mar. 11, 1941
2,743,089	Gardiner et al.	Apr. 24, 1956
2,865,827	Dwyer	Dec. 23, 1958
2,922,404	Kopp	Jan. 26, 1960

OTHER REFERENCES

A.E.C. Document TID 5277, Liquid Metals Handbook, Sodium NaK Supplement, July 1, 1955 (FIG. IV-15A and pages 284 and 286).