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[54] **LIQUID METAL HEAT EXCHANGER**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 8,501, Feb. 4, 1970, abandoned.

[52] **U.S. Cl.** **165/161,** 165/158, 165/159, 122/32

[51] **Int. Cl.** **F28f 9/22**

[58] **Field of Search** 165/159, 160, 161, 157, 165/158; 122/32–34

[56] **References Cited**

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[57] **ABSTRACT**

A liquid metal heat exchanger in which one of the heat exchange fluids flows alternately radially inward and outward across a series of circular baffles to exchange heat with another heat exchange fluid flowing through a plurality of tubes perpendicular to the baffles in which the first mentioned fluid is not excessively accelerated at any point in its travel across the baffles. The tubes are arranged in concentric circular rows with the spacing between tubes in each row being smaller at larger circles than at comparatively smaller circles.

4 Claims, 3 Drawing Figures

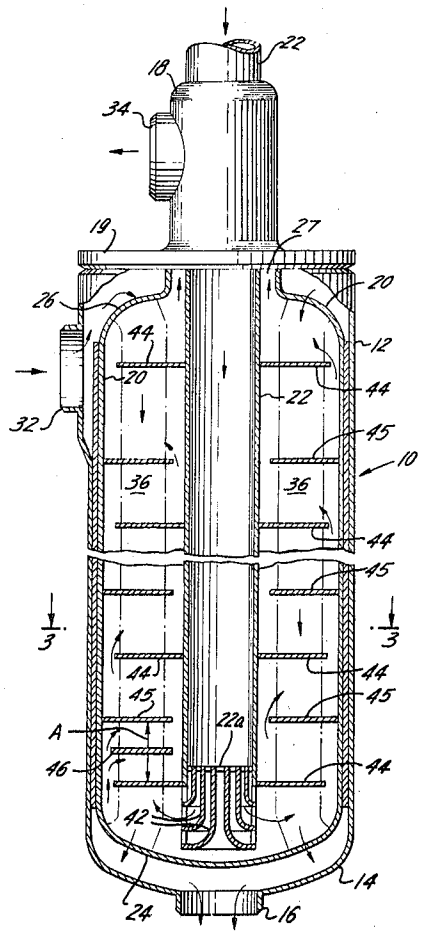
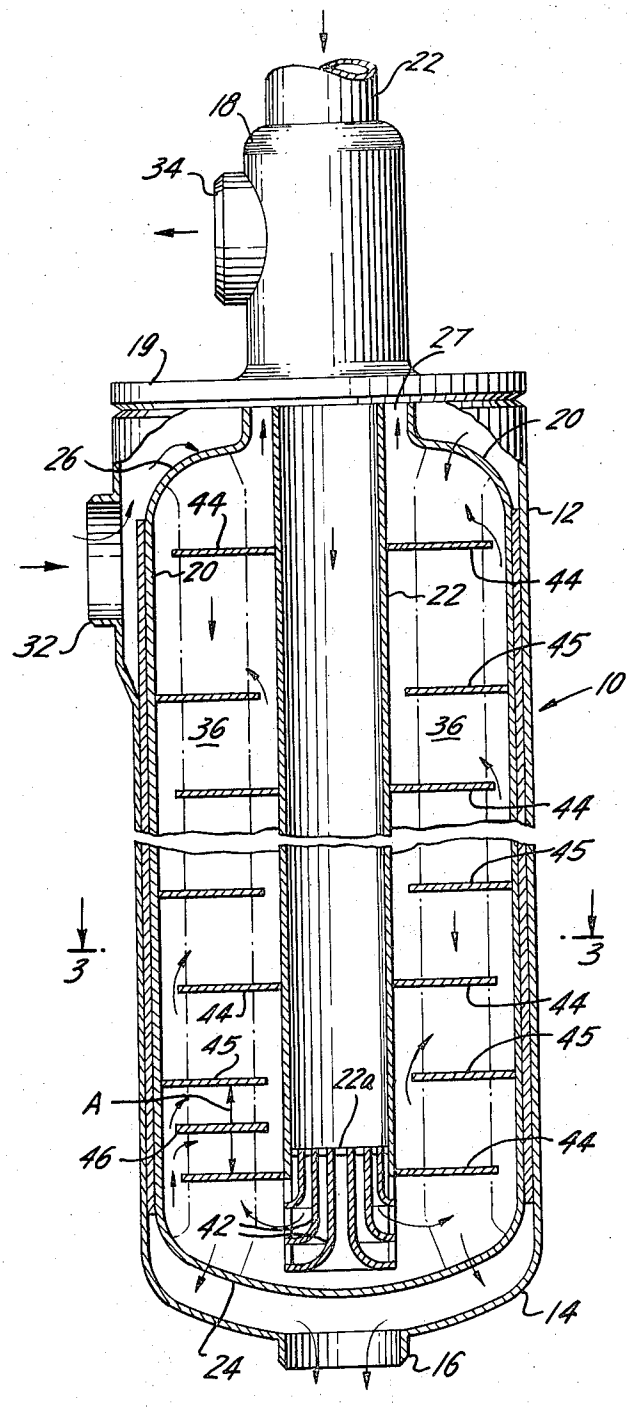


FIG. 1


22
18
34
19
27
20
26
12
44
20
22
32
45
10
36
36
44
45
3
3
44
45
A
22a
46
44
42
14
24
16

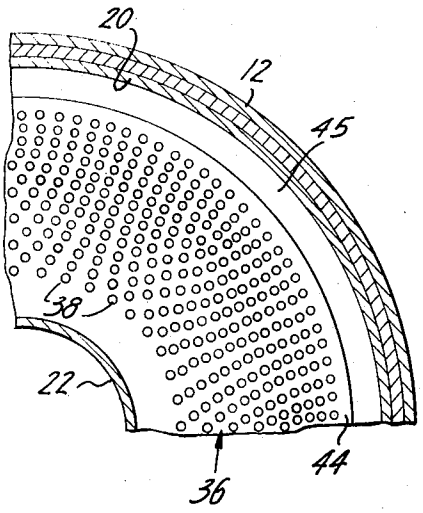
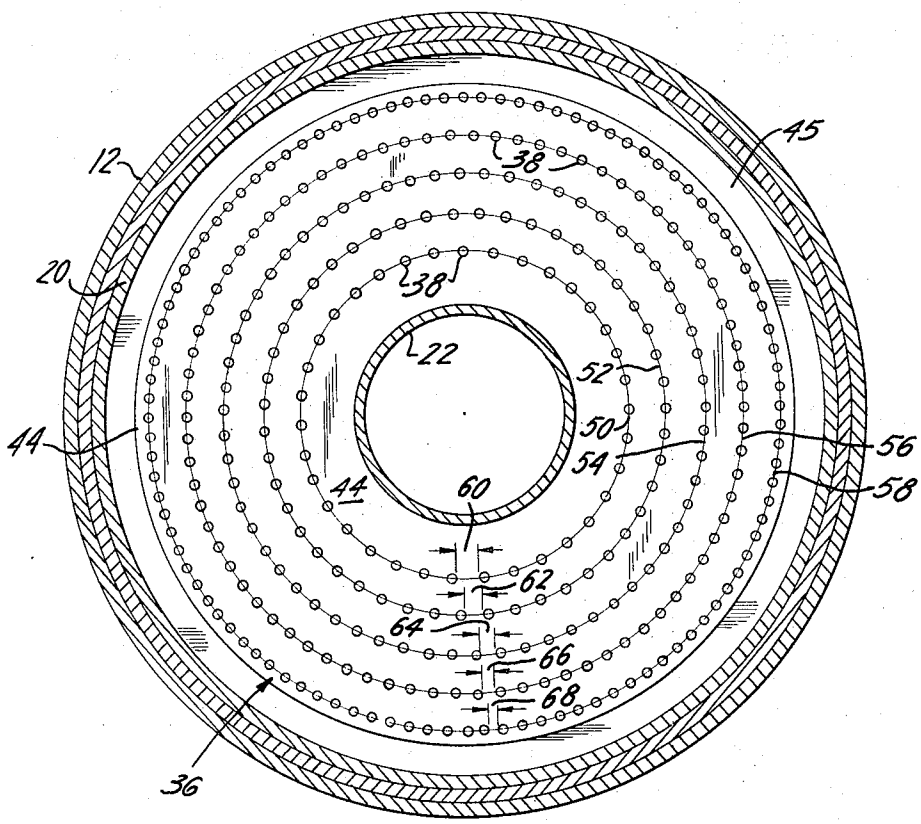

20
12
45
38
22
44
36

FIG. 2

FIG. 3



LIQUID METAL HEAT EXCHANGER

CROSS-REFERENCE TO A RELATED APPLICATION

This application is a continuation-in-part of U.S. Pat. application Ser. No. 8,501 filed on Feb. 4, 1970, now abandoned in the name of Walter Wolowodiuk.

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of or under a contract with the U. S. Atomic Energy Commission.

In the development of nuclear power plants in which the reactor is cooled by liquid metal, it is necessary to use heat exchangers in which the heat is transferred from the liquid metal. If the heat exchanger is a so-called intermediate heat exchanger, the heat is transferred to another stream of liquid metal. If the heat exchanger is a steam generator or a superheater, the heat is transferred to water or steam. In either case, the liquid metal in moving through the heat exchanger can induce high vibration if it is made to change velocity abruptly. The vibration and the high heat densities and thermal gradients which appear in different regions of the heat exchangers necessitate a skillful design if the heat exchanger is to operate safely over an extended period.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome drawbacks found in the prior art such as those discussed above. Accordingly, a heat exchanger which is supplied heat by a stream of flowing liquid metal comprises a plurality of tubes arranged in concentric circles and which pass through a series of annular baffles which cause the liquid metal to flow alternately radially inward and radially outward across the tubes, the tubes being arranged so that the total of the areas between the tubes on any of the circles is approximately the same.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view partly in section showing a preferred embodiment of the present invention;

FIG. **2** is a plan view of a quadrant of the tube bundle of the present invention; and

FIG. **3** is a view taken substantially along the line **3—3** of FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1,** a heat exchanger indicated generally as **10** consists of an outer shell **12** of generally cylindrical shape having a curved bottom **14** with a primary outlet **16** located at the center of the bottom. The heat exchanger **10** has a neck **18** which is of a diameter smaller than that of the outer shell **12** and which extends up from a flange **19** which is secured to the top of the shell **12.** Besides the outer shell **12,** the heat exchanger **10** has an inner shell **20** which is generally cylindrical. Extending down into the shell **20** is a cylindrical tube or center pipe **22,** open at the top to function as the secondary liquid inlet, terminating in a flow guide assembly **22**(*a*) almost touching a tube sheet **24** which is jointed at its periphery to the top of the shell **20.** The space between the lower end of the assembly **22**(*a*) and the tube sheet **24** is large enough to accommodate thermal expansion of the former. Guides (not shown) may be relied upon to maintain center pipe **22** in a vertical direction.

The tube sheet **24** is curved, i.e., it is concave downward and completely closes off the inner shell **20** at the bottom thereof. The top of the inner shell **20** is joined to the periphery of an annular concave upward tube sheet **26** which extends upward and inward to the vertical collar portion **27** which extends up to the flange **19.**

The outer shell **12** is provided with a primary inlet **32** which opens into the space above the upper tube sheet **26** and below the flange **19** while a secondary outlet **34** in the neck **18** communicates with the annular space between the neck **18** and the center pipe **22.**

A tube bundle **36** which is illustrated in phantom in FIG. **1** is positioned in the annular space between the center pipe **22** and the shell **20.** The tube bundle **36** consists of vertically extending tubes **38** some of which are shown in FIG. **2** and all of which are shown in FIG. **3.** The tubes **38** are arranged in circular rows which are radially spaced equally apart. The circumferential pitch of the tubes **38,** that is, the space between them, decreases as the radius increases for a purpose to be later described.

The annular tube bundle **36** terminates at the upper end in the upper tube sheet **26** and at the lower end in the lower tube sheet **24.** Thus, primary fluid entering through the primary inlet **32** fills the space above the upper tube sheet **26** and enters into the tubes **38** through the tube sheet **26,** passes down through the tube bundle **36** and immerges from the tube sheet **34** into the cavity below the tube sheet **24.** Thereafter, the primary liquid leaves the heat exchanger **10** through the primary outlet **16.** Single-headed arrows indicate this flow in FIG. **1.**

The flow guide assembly **22**(*a*) at the lower end of pipe **22** includes a plurality of flow guides **42,** the function of which will be described hereinafter. The tube bundle **36** is supported by a plurality of flow baffles **44** and **45** that alternate along the axis of the heat exchanger **10.** Each of the flow baffles **44** and **45** engages every tube **38** of the tube bundle **36** such that every tube **38** is supported at its intersection with each of the baffles. Baffles **44** may consist of scalloped rings which are mechanically welded together. An expansion loop, as understood in the art, is provided in the region designated by double arrow (*a*) with a support **46** located in the middle of the expansion loop.

Secondary liquid metal enters heat exchanger **10** through the center pipe **22** and flows downward through it to exit at its bottom being directed outward by the flow guides **42** of the flow guide assembly **22**(*a*). Thus, the secondary liquid metal flows out into the annular space between the center pipe **22** and the inner shell **20** to flow upward between and in contact with the tubes **38** and then through the annular collar portion **27** and out of the heat exchanger **10** through the secondary outlet **34.**

The flow baffles **44** differ from the flow baffles **45** in that the flow baffles **44** contact at their inner edges the center pipe **22** and extend outward to a circle spaced from the inner shell **20.** The flow baffles **45** contact at their outer peripheries the inner shell **20** and extend inward to a circle spaced from the center pipe **22.** These two types of flow baffles **44** and **45** are alternately spaced so that secondary fluid when flowing upward in

the annular space between the center pipe **22** and the inner shell **20** will flow alternately inward and outward as it makes its way through the tube bundle **36.** This arrangement allows for an effective transfer of heat between the primary and secondary fluid.

One problem in heat exchangers of this type is that the secondary fluid will experience acceleration forces as it moves radially over the tube **38.** The acceleration forces are caused primarily because as the secondary fluid flows radially, it encounters varying resistance to flow as it moves between adjacent tubes **38.** This is so because if the tubes are uniformly spaced as is common in heat exchangers, there will be progressively more spaces and thus more area for the fluid to move through as the fluid moves radially outward. Thus, the resistance to flow will become less as the fluid moves outward and more as it moves inward. The result is acceleration forces on the fluid and consequently, vibration will develop in the heat exchanger.

In the present invention, this problem is overcome by placing all of the tubes **38** on concentric circles as shown best perhaps in FIG. **3.** Thus, the tubes **38** are all positioned in rows which lie on one of a number of concentric circles **50, 52, 54, 56** or **58.** FIG. **3** shows only five circumferential rows of tubes. This is for the sake of simplicity and in all probability, in practice, there would be more rows of tubes, as indicated in FIG. **2.**

As shown in FIG. **3,** the tubes **38** on the circular row **50** are separated by a distance **60** between adjacent tubes. Similarily, adjacent tubes in row **52** are separated by a distance **62,** adjacent tubes in row **54** are separated by a distance **64,** adjacent tubes in row **56** are separated by a distance **66** and adjacent tubes in row **58** are separated by a distance **68.** The distance **68** is less than the distance **66** which is less than the distance **64,** which is less than the distance **62,** which is less than the distance **60.** Furthermore, the distances **60, 62, 64, 66** and **68** are chosen so that the sum of the distances between all of the tubes on any one of the circles **50, 52, 54, 56** or **58** is the same as the sum of the distances between tubes on any other of those circles. Since the flow baffles **44** and **45** are parallel, this means that the sum of the areas between tubes on any of the concentric circles will be the same and therefore, the total resistance to flow at any circle as to any fluid moving radially over the circles will be the same. The elimination of excessive acceleration greatly reduces vibration which would otherwise be inclined by the flowing fluid.

The use of curved tube sheets instead of the customary flat tube sheets reduces the minimum allowable thickness of the metal so that the construction is more economical and thermal stresses are minimized. Any vibration which does occur in the present invention is handled because of the annular construction of the baffles **44** and **45** which allows them to support each tube at many points along its length.

The foregoing describes but one embodiment of the present invention, other embodiments being possible without exceeding the scope of the present invention as defined in the following claims.

I claim:

1. A heat exchanger where liquid metal flows over tubes which contain another flowing heat exchange fluid comprising:

a. a shell;

b. a pipe extending down into said shell and forming a central passageway surrounded by and communicating at one of its ends with an annular passageway between said pipe and said shell forming a double pass for said liquid metal;

c. an annularly arranged tube bundle having a plurality of tubes extending through said annular passageway for carrying a single pass of said other heat exchange liquid, said tubes being arranged in a number of concentric circles with the distance between adjacent tubes on each circle being chosen so that the sum of the distances between adjacent tubes will be substantially equal at each circle; and

d. annular baffles for supporting said tubes, said baffles being parallel to each other and axially spaced and encircling said tube bundle and being of two types, one of said types of baffles extending outwardly from said pipe to a circle spaced inwardly from said shell, the other of said types extending inwardly from said shell to a circle spaced outwardly from said pipes, said types being alternately spaced so that they direct said liquid metal alternately radially inward and radially outward across said tubes as said liquid metal passes along the length of said passageway, said arrangement of tubes being such as to assure a substantially constant velocity of said liquid metal across each of said baffles.

2. The heat exchanger of claim **1** in which said tube bundle at each of its ends is provided with curved tube sheets to support and seal the ends of said tubes.

3. The heat exchanger of claim **2** in which flow vanes are provided at the exit of said pipe for directing said liquid metal into the entrance of said annular passageway to insure smooth flow conditions.

4. The heat exchanger of claim **3** in which the passageways are vertically disposed and the other heat exchange fluid makes a single pass downward through said tube sheets.

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