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Linning

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[54] **HEAT EXCHANGERS**

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[51] **Int. Cl.** **F28g 7/00**
[58] **Field of Search** ..... 165/158, 9, 83, 181, 67–69, 165/178; 122/32 L, 32 T, 32 S, 32 F

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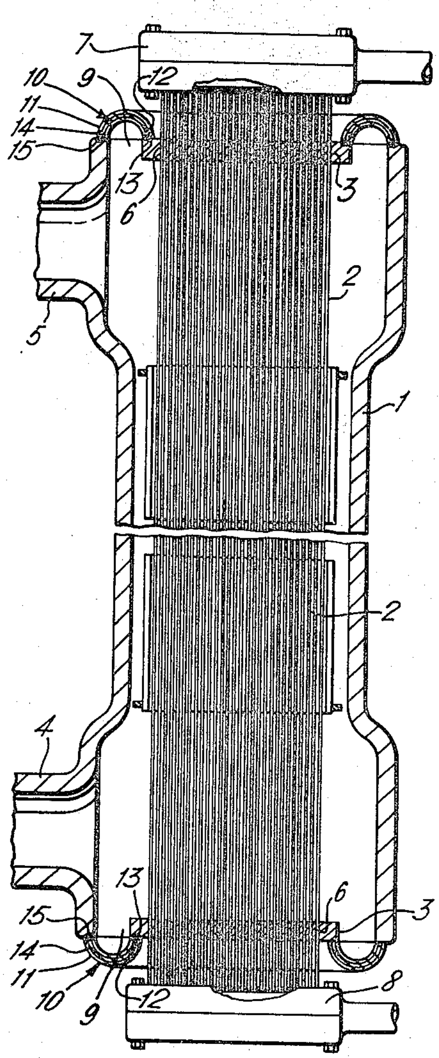
[57] **ABSTRACT**

In a tube-in-shell heat exchanger, each tube plate is secured along its outer edge to the shell of the heat exchanger by an intermediate annular member extending across a gap between the outer edge of the tube plate and the shell, the radial cross-section of the annular member being of arched form. Thermal insulation for the tube plates consisting of a series of plate members edge on to the tube plate and arranged parallel one to another between successive rows of the heat exchanger tubes, is also described.

9 Claims, 4 Drawing Figures



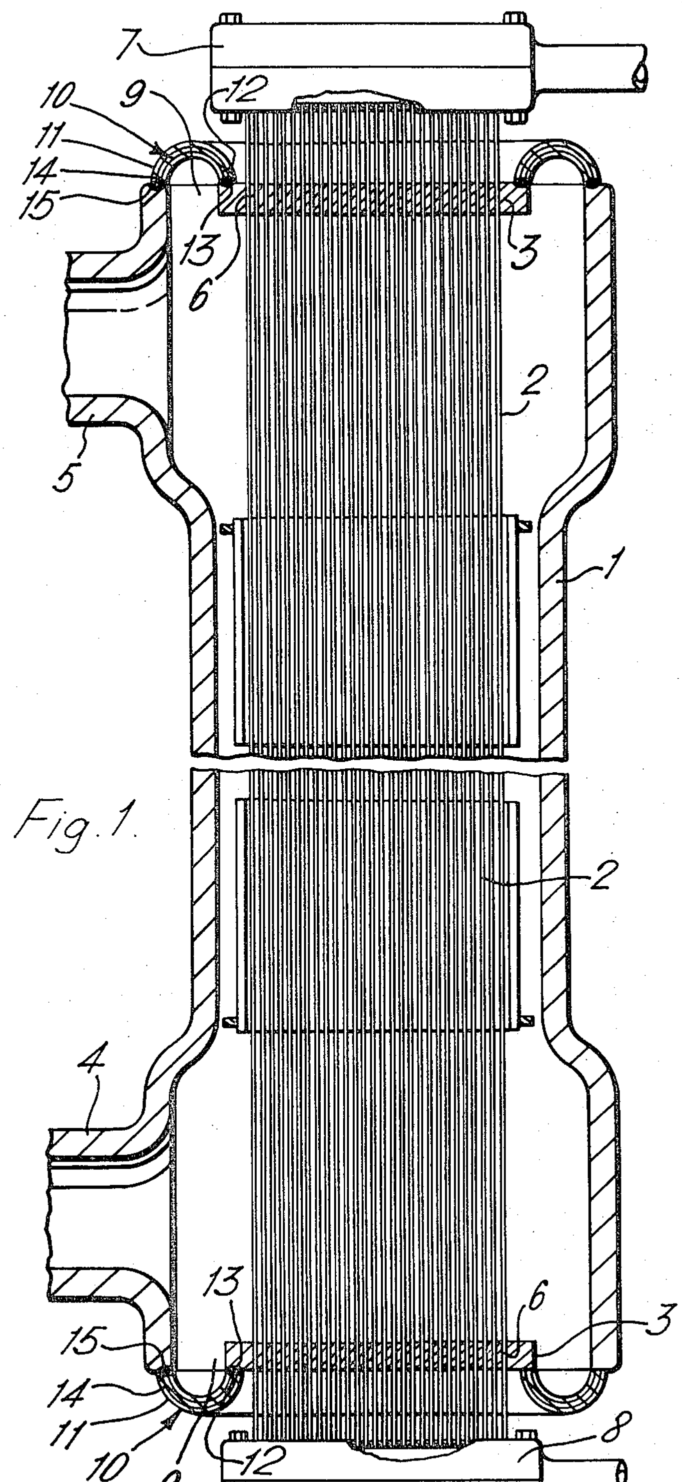


Fig. 1.

Fig. 2.

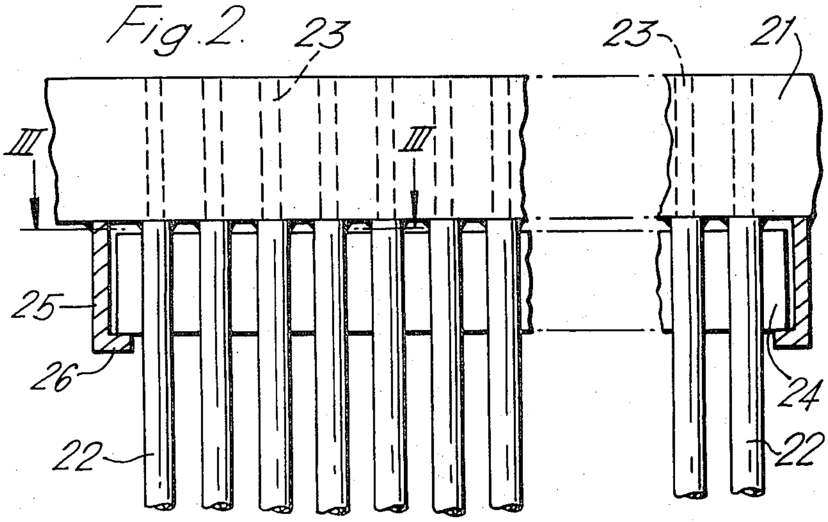
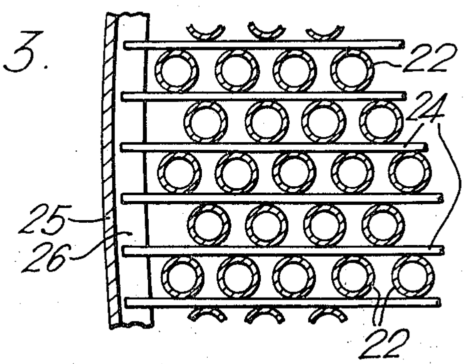


Fig. 3.



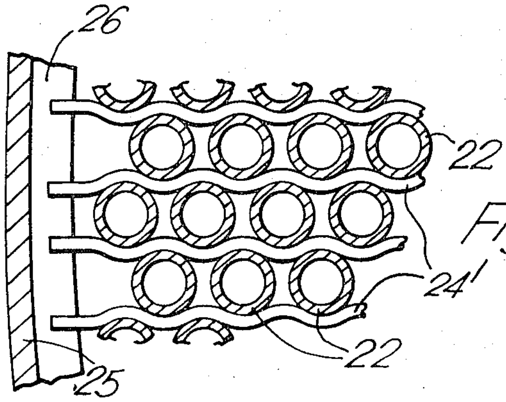


Fig. 4.

HEAT EXCHANGERS

BACKGROUND OF THE INVENTION

This invention relates to heat exchangers and in particular to that kind of heat exchanger in which a bundle of parallel heat exchanger tubes extend between tube plates at either end of the bundle. The heat exchanger tubes are connected at their ends with holes in the tube plates, for example by welding. The bundle of heat exchanger tubes is disposed within an outer shell or container to which the tube plates are secured.

In one use of such a heat exchanger, for example, as a steam generator or steam superheater, a liquid metal heat transfer medium, such as sodium, is passed through the shell over the tubes and water, for steam generation, or steam for superheating is passed through the tubes. In this case the heat exchange is between fluids which will react violently if they come into contact for example by escape of steam or water into the bulk sodium in the shell through a faulty tube/tube plate weld. Current designs of sodium/water heat exchangers rely on the excellence of tube and tube/tube plate weld production and inspection to provide a high degree of integrity. However, the possibility of a major sodium water reaction has to be allowed for and it is therefore necessary to design the heat exchanger shell to withstand the substantial internal pressures which would arise on the occurrence of such a reaction. Thus the heat exchanger shall and the tube plates have to be made of considerable thickness.

Copending U.S. Pat. application Ser. No. 20,903, now U.S. Pat. No. 3,680,627 relates to a "tube-in-shell" type of heat exchanger in which the high pressure water/steam is accommodated in the shell and the sodium within the tubes, so that tube failure cannot propogate by overheating and corrosion of further tubes adjacent to the failed tube. In this case as the high pressure medium is contained within the shell, the shell and tube plates again have to be of considerable thickness to withstand the high internal pressure.

Also in "tube in shell" type heat exchangers means have to be provided to accommodate for differential longitudinal thermal expansion of the tubes relative to the shell both on rise to the steady thermal state and under transient conditions. This can be achieved by making the tubes of U-shaped configuration within the shell, with both tube plates located at the one end of the shell. In another arrangement the tubes are of J or hockey stick configuration within a shell of similar shape, so that the tube plate at one end of the shell is in a plane at right angles to the plane of location of the tube plate at the other end of the shell. Both these solutions add to the cost and complication of manufacture of such heat exchangers.

SUMMARY OF THE INVENTION

According to the present invention, in a "tube in shell" heat exchanger, each tube plate is secured along its outer edge to the shell of the heat exchanger by an intermediate annular member extending across a gap between the outer edge of the tube plate and the shell, the radial cross-section of the annular member being of arched form.

Preferably the radial cross section of the annular member is semi-circular so that the annular member is in the form of half of a tubular toroid. The annular

member is preferably arranged with its inner and outer edges substantially in the plane in which the tube plate lies, the inner and outer edges of the annular member being joined with the tube plate and the shell by welding. The arched radial cross section of the annular member makes it of a high pressure containing capacity so that the annular member can be made of relatively thin material. Thus the annular member has a degree of flexibility in the direction normal to the plane of the tube plate so that the tube plate can move longitudinally with respect to the heat exchanger shell, to accommodate for relative longitudinal thermal expansion between the heat exchanger tubes and the shell. In order to increase the flexibility of the annular member whilst retaining the pressure retaining capacity, the annular member can be made of laminated form.

Furthermore, in such sodium/water heat exchangers of the "tube in shell" type wherein heated sodium is passed through the heat exchanger tubes and water is passed through the shell over the tubes for the generation of steam, it is advantageous to also provide thermal insulation on the faces of the tube plates inside the shell, since the tube plates are simultaneously in close thermal contact with sodium and water or steam. The thermal insulation is effective to minimise steady state thermal stresses in the tube plates as well as transient stresses due to sudden changes in operating conditions. In particular the tube plate at the steam outlet end of the heat exchanger shell, if uninsulated, would be exposed to particularly severe conditions, since if the steam were wet liquid droplets would impact on the tube plate through which sodium is passing at the high inlet temperature.

A known form of thermal insulation structure comprises a number of baffle plates arranged parallel to the tube plate and parallel to each other. The baffle plates are drilled for penetration by the tubes at their ends adjacent the tube plate and are arranged to ensure that stagnant fluid, ie steam or water, is trapped in spaces between the baffle plates to provide the required thermal insulation.

This type of thermal insulation structure has a main disadvantage of high cost of manufacture, since it is necessary to drill several thousands of holes in the baffle plate for penetration of the baffle plates by the ends of the heat exchanger tubes. The economic penalty is particularly high where a high degree of thermal insulation is required which is achieved by the provision of such a thermal insulation structure consisting of a substantial number of baffle plates. A further possible disadvantage stems from the fact that the spaces between the tube plates have only limited access to the main body of the heat exchanger shell. Thus rapid evaporation of water in the spaces between the baffle plates, on start up of the heat exchanger, or due to a transient change in the operating conditions, might lead to a rapid pressure build up in the spaces which cannot readily be relieved by venting from the spaces between the baffle plates to the main body of the shell. Thus there could be danger of local tube failure due to excessive pressure build up.

According to a further feature of the present invention, the tube plates of a "tube-in-shell" type heat exchanger as aforesaid have thermal insulation comprising a series of plate members edge on to the tube plate and arranged parallel one to another between successive rows of the heat exchanger tubes. Where straight runs exist between the rows of tubes the plate members can be of plane form. In the case of a heat exchanger having closely pitched tubes where no straight runs exist between the tubes the plate members may be of convoluted form so as to fit between the rows of tubes. This arrangement ensures that each heat exchanger tube at its point of connection with the tube plate is enclosed in stagnant fluid either steam or water according to the conditions, which is trapped in the pockets defined between the plate members and the tubes. Thus a change of conditions leading to rapid evaporation of water trapped in the pockets cannot produce local excess pressure since each of the pockets is fully open to the main body of the shell.

The said thermal insulation also has the advantage of cheapness since, for instance, it is not necessary to drill large numbers of holes in a series of plates to produce the necessary baffles. The degree of thermal insulation achieved is merely dependent on the depth of the plate members. A high degree of thermal insulation can be achieved by simply making the plate members of sufficient depth. Also the thermal insulation of the invention is easy to assembly with respect to the tube plates it merely being necessary to interpose the series of plate members edge on to the tube plate between parallel rows of the heat exchanger tubes. The plate members forming the insulation may be supported from their ends by a ring mounted on the face of the tube plate encircling the heat exchanger tubes. Alternatively a supporting ring for the plate members may be mounted around the inner wall of the heat exchanger shell just beneath the level of the tube plate.

DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a longitudinal section of a heat exchanger incorporating the present invention,

FIG. 2 is an enlarged longitudinal section illustrating a modification of the tube/tube plate assembly of the heat exchanger shown in FIG. 1,

FIG. 3 is a section along the line III—III in FIG. 2, and

FIG. 4 corresponds to FIG. 3 and shows, on a larger scale, a detail of an alternative arrangement.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The heat exchanger shown in the FIG. 1 of the drawings comprises a cylindrical shell **1** containing a bundle of parallel heat exchanger tubes **2.** The heat exchanger tubes **2** extend longitudinally through the shell **1** between tube plates **3** located at each end of the shell **1.** The heat exchanger tubes **2** are spaced and transversely located in the shell **1,** either by grids at spaced intervals along the length of the tubes **1,** or, alternatively, the tubes **2** may be spaced by being wire wrapped or by integral fins on the tubes the tubes being held together in the bundle by an outer wrapper arrangement such as is disclosed in said copending application Ser. No. 20,903,

The shell **1** has an inlet branch **4** at its lower end and an outlet branch **5** at its upper end. The tubes **2** extend through holes **6** in the tube plate **3** at the upper end of the shell **1** and connect at their upper ends with an inlet header **7.** Similarly the tubes **2** extend through holes **6** in the tube plate **3** at the lower end of the shell **1** and connect at their lower ends with an outlet header **8.** The tubes **2** are brazed in passage through the holes **6** in the tube plates **3** and are also brazed at their ends in connection with the inlet and outlet headers **7** and **8.**

Each of the tube plates **3** is connected with the shell **1** in a similar manner. Referring to the tube plate **3** at the upper end of the shell **1,** the tube plate **3** is of smaller outside diameter than the internal diameter of the upper end of the shell **1** so that an annular gap **9** exists between the outer edge of the tube plate **1** and the edge of the shell **1.** The gap **9** is bridged by an annular member **10** which is of semi-circular radial cross section. The member **10** may be described as being in the form of half a tubular toroid and is made up of several nesting laminations **11.** The member **10** is joined at its inner edge **12** with the outer edge of the tube plate **3** by a weld **13.** The member **10** is joined at its outer edge **14** with the edge of the shell **1** by a weld **15.**

In use of the heat exchanger, for example as a once through boiler, water is passed into the shell **1** through the lower inlet branch **4** and steam is generated in the shell **1** by heat exchange with, for example, heated sodium which is passed through the heat exchanger tubes **2.** The heated sodium is passed into the tubes **2** through the upper inlet header **7** and after passing downwards through the heat exchanger tubes **2** passes out through the lower outlet header **8.** Steam generated for example at a pressure of 2,500 psi in the shell **1** passes out of the shell **1** through the upper outlet branch **5.**

There will be a high axial pressure force acting on the tube plates **3** but the heat exchanger tubes will carry the main part of this axial pressure force by being under longitudinal tension. Therefore the tube plates **3** can be of relatively small thickness, for example 3 inches as compared with a thickness of 12 inches which would be required for tube plates which carry the whole of the internal pressure back to the shell **1.**

The shape of the annular members **10** makes it possible to contain the high internal pressure in the shell **1** with a relatively small thickness of metal in the annular members **10.** Due to geometrical factors and because the annular members **10** are of relatively thin laminations **11** the annular member **10** have flexibility in the direction of the longitudinal axis of the shell **1** ie in the direction normal to the plane of the tube plates **3.** This allows the tube plates **3** to move longitudinally with respect to the heat exchanger shell **1,** by flexing of the annular members **10,** to accommodate for longitudinal thermal expansion of the heat exchanger tubes **2** relative to the shell **1.** Longitudinal thermal expansion of the heat exchanger tubes **2** relative to the shell **1** occurs due to the temperature differential which arises between the tubes **2** and the shell **1** on bringing the heat exchanger to its state of operating temperature.

The heat exchanger of the invention has the advantage of ease of assembly as the tubes **2** can be assembled with the tube plates **2** outside the heat exchanger shell **1** and the assembly of the tubes **2** and tube plates **3** can then be inserted into the shell **1** and the tube plates **3** connected with the ends of the shell **1** by welding the annular members **10** bridging the gap **9** between the tube plates **3** and the ends of the shell **1.** The laminations **11** of the annular members **10** may be welded individually one by one into position or alternatively the laminations **11** may be welded to separate rings, the rings being subsequently welded to the tube plates **3** and the shell **1**. This latter procedure eases the inspection and heat treatment of the lamination welds.

The modified tube/tube plate assembly shown in FIGS. **2** and **3** of the drawings comprises a tube plate **21** with which there is connected a series of heat exchanger tubes **22**. The heat exchanger tubes **22** are arranged in a bundle parallel to one another and are welded at their ends in connection with holes **23** in the tube plate **21**. A heat insulation structure for the under face of the tube plate **21** comprises a series of parallel plates **24** arranged edge on to the face of the tube plate **21**. The plates **24** are interposed between parallel rows of the heat exchanger tubes **22**. A supporting ring **25** for the plates **24** is welded to the face of the tube plate **21** encircling the bundle of heat exchanger tubes **22**. The ends of the plates **24** rest on an internal flange **26** at the bottom of the ring **25**. The bundle of heat exchanger tubes **22** is fitted inside the shell **1** (FIG. **1**) to which the tube plates at either end of the bundle of tubes **22** are secured via the annular members **10** (FIG. **1**).

Where the heat exchanger is of sodium/water type, heated sodium is passed through the heat exchanger tubes **22** and water for the generation of steam is passed through the shell **1** over the tubes **22**.

The thermal insulation structure of the invention provides thermal insulation for the tube plates **21** by the trapping of stagnant steam or water in the pockets defined at the face of the tube plates between the plates **24** and the ends of the heat exchanger tubes **22**.

In the arrangement of FIG. **3**, straight paths exist between the rows of heat exchanger tubes **22** so that the plates **24** can be of plane form. In the alternative arrangement of FIG. **4**, the tubes **22** are of closer pitch so that there are no straight paths between the rows of tubes. In this case the plates **24'** are made of convoluted or corrugated form to fit between the tubes **22**.

I claim:

1. In a tube-in-shell heat exchanger in which a bundle of parallel heat exchanger tubes extend between tube plates at either end of the bundle, said tubes being connected with holes in the tube plates, and a shell within which said bundle of tubes is disposed with means for securing said tube plates to said shell, the improvement wherein said means for securing each tube plate to said shell comprises an annular member intermediate each said tube plate and said shell, said member being secured to the outer edge of the respective tube plate and to said shell to extend across a gap therebetween, and the radial cross section of said annular member being of arched form.

2. A heat exchanger according to claim **1**, characterised by the radial cross section of said member being semi-circular.

3. A heat exchanger according to claim **2**, characterised in that said annular member is arranged so that its inner and outer edges are substantially in the plane in which the respective tube plate lies and are joined with said tube plate and said shell by welding.

4. A heat exchanger according to claim **1**, characterised by said annular member being made of laminated form.

5. A heat exchanger according to claim **1**, characterised by said tube plates each having thermal insulation comprising a series of individual and mutually isolated plate members edge on to the respective tube plate and arranged parallel to one another between successive rows of the heat exchanger tubes.

6. A heat exchanger according to claim **5**, characterised by said plate members being plane for extending in straight runs between said tubes.

7. A heat exchanger according to claim **5**, characterised by said plate members being of convoluted form for extending between said tubes where these are closely pitched.

8. A heat exchanger according to claim **5**, characterised by said plate members being supported from their ends by a ring mounted on the face of the respective tube plate and encircling said heat exchanger tubes.

9. A heat exchanger according to claim **1** wherein the inner periphery of said annular arched member is secured to the outer edge of the respective tube plate, and the outer periphery of said member is secured to said shell.

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