United States Patent [19]

Hayden et al.

[11] **3,831,673**

[45] **Aug. 27, 1974**

[54] **HEAT EXCHANGERS**

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[73] Assignee: **United Kingdom Atomic Energy Authority**, London, England

[22] Filed: **Sept. 4, 1973**

[21] Appl. No.: **393,951**

Related U.S. Application Data

[63] Continuation of Ser. No. 179,342, Sept. 10, 1971, abandoned.

[30] **Foreign Application Priority Data**

Sept. 18, 1970 Great Britain 44621/70

[52] **U.S. Cl.** **165/158**, 165/70, 122/32

[51] **Int. Cl.** **F28f 9/00**

[58] **Field of Search** 122/32, 34; 165/70, 158, 165/9, 81–33

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Primary Examiner—Charles J. Myhre
Assistant Examiner—Theophil W. Streule, Jr.

[57] **ABSTRACT**

A heat exchanger of the type comprising a shell containing an array of U-shaped tubes arranged longitudinally in the shell. The tubes are assembled in a number of separate tube bundles with the ends of the tubes connected with individual tube plates in separate inlet and outlet header pipes in an end closure head for the shell. Each tube bundle is contained within an individual tubular shroud with ducting for passing heat transfer fluid from outside the shell into one end of the shroud, so that the heat transfer fluid passes through the shroud over the surface of the tubes in the tube bundle and enters the shell of the heat exchanger from the other end of the shroud. The tubes in the individual tube bundles are spaced at points along their length by grids which are connected in an articulated manner by tie bars. The shrouds for the tube bundles comprise individual tubular sleeves extending between adjacent grids so that the shrouds can flex with flexing of the tubes of the tube bundles.

13 Claims, 9 Drawing Figures

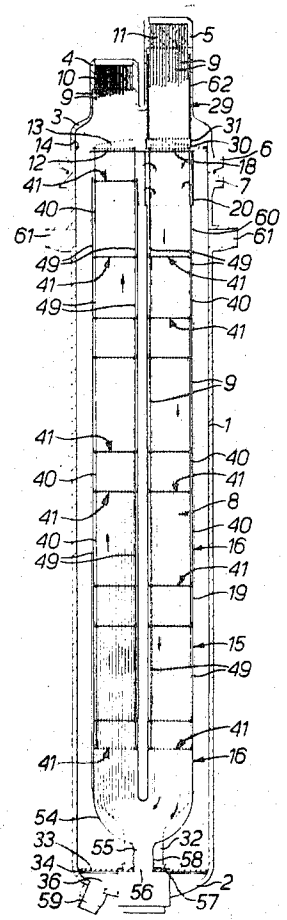


FIG.1.

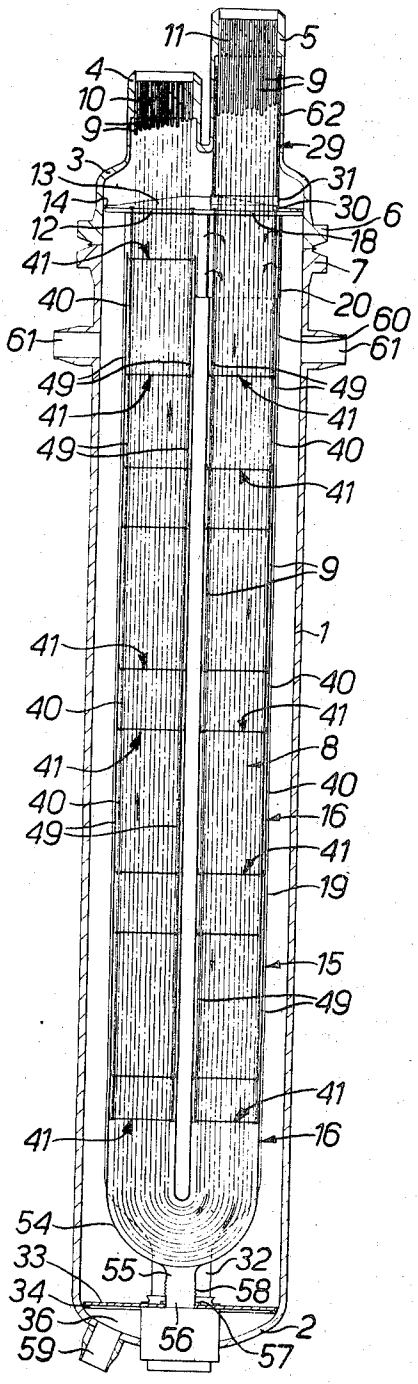

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FIG.2.

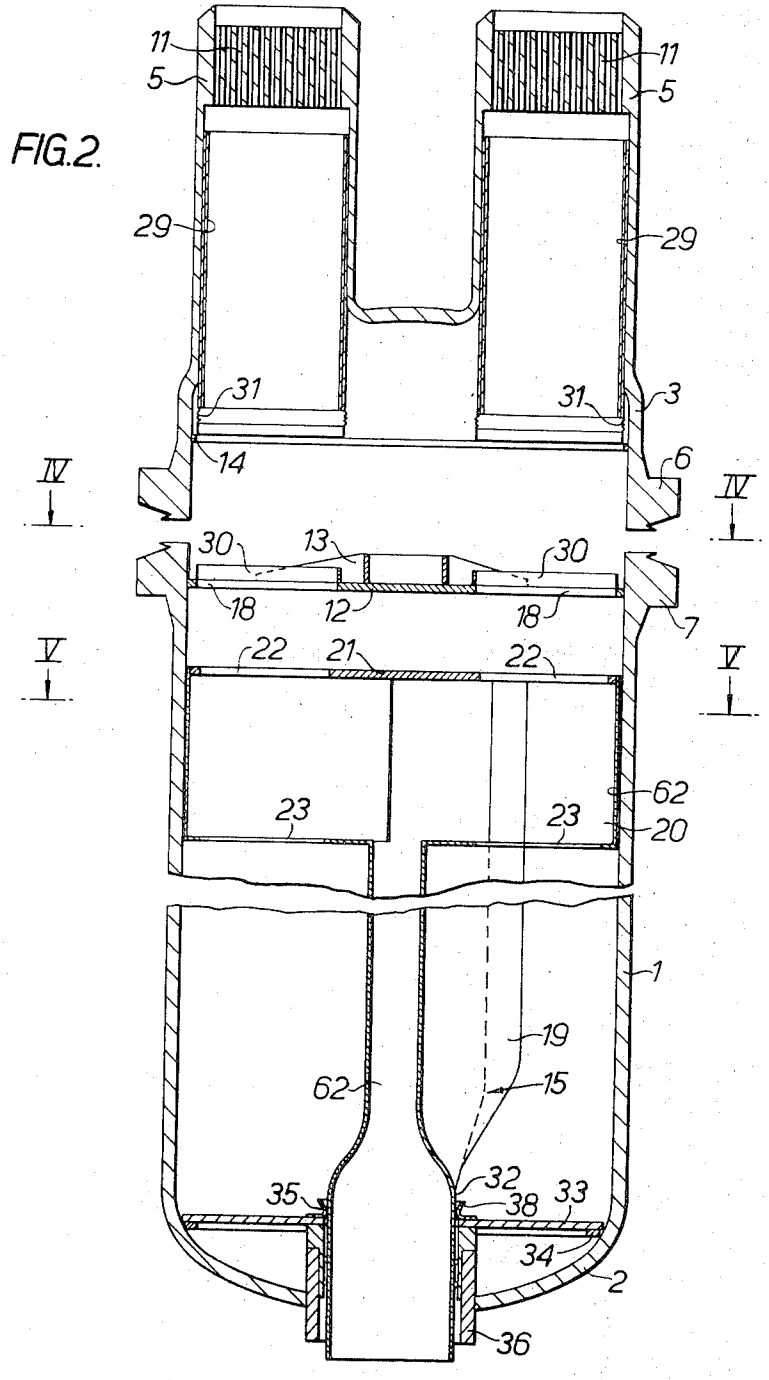
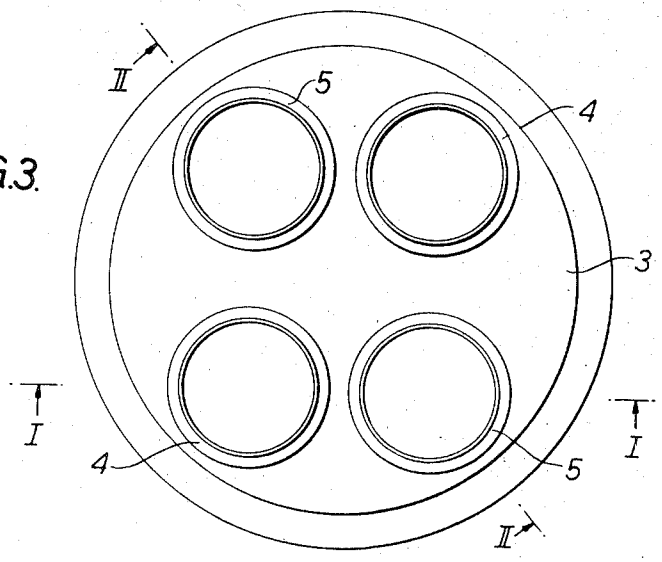

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FIG.3.



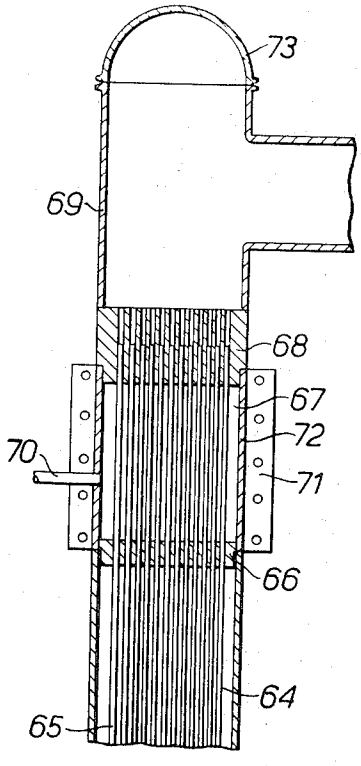


FIG.9.

FIG.4.

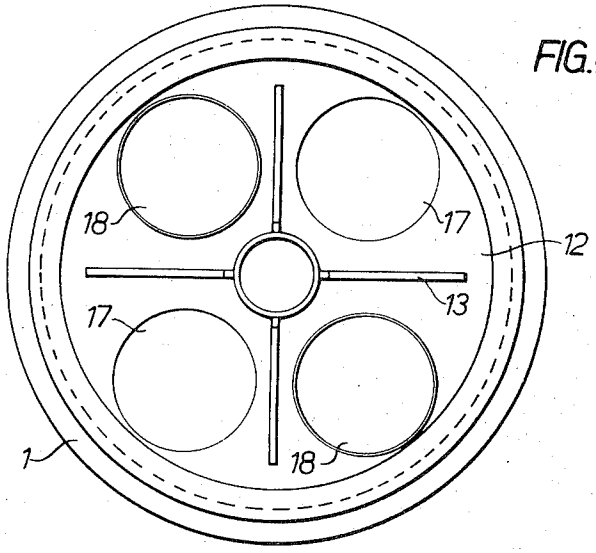


FIG.5.

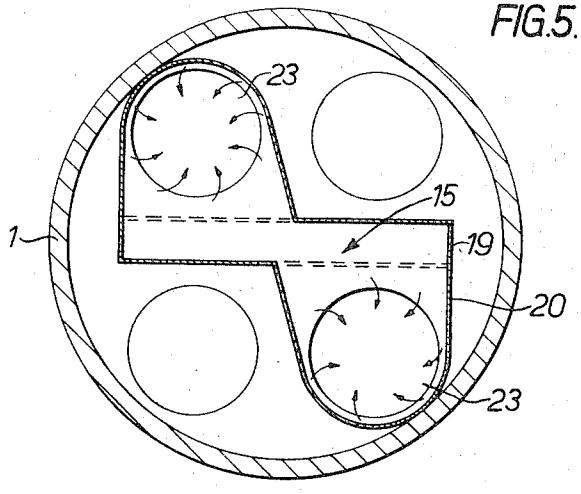


FIG.6.

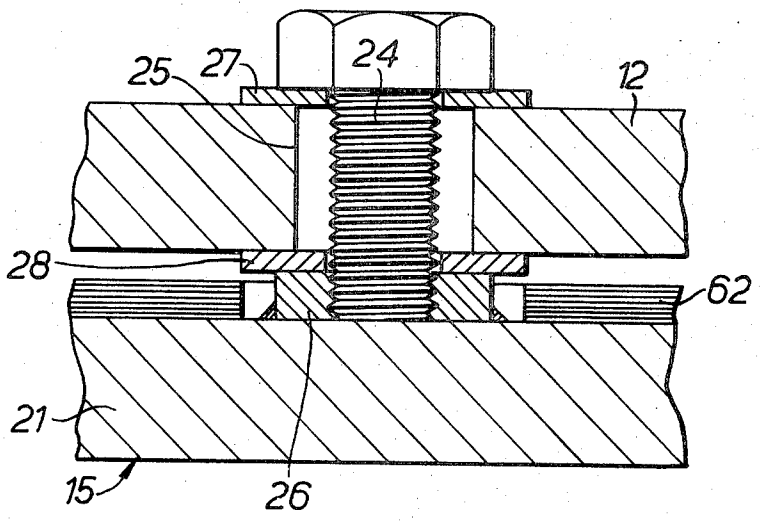


FIG.8.

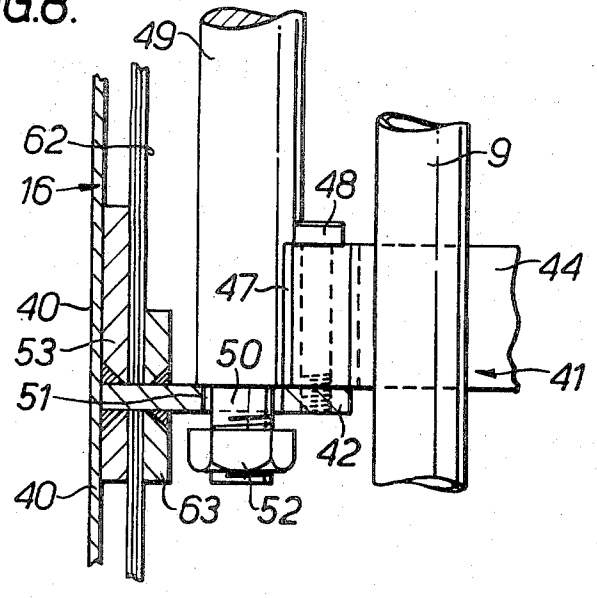
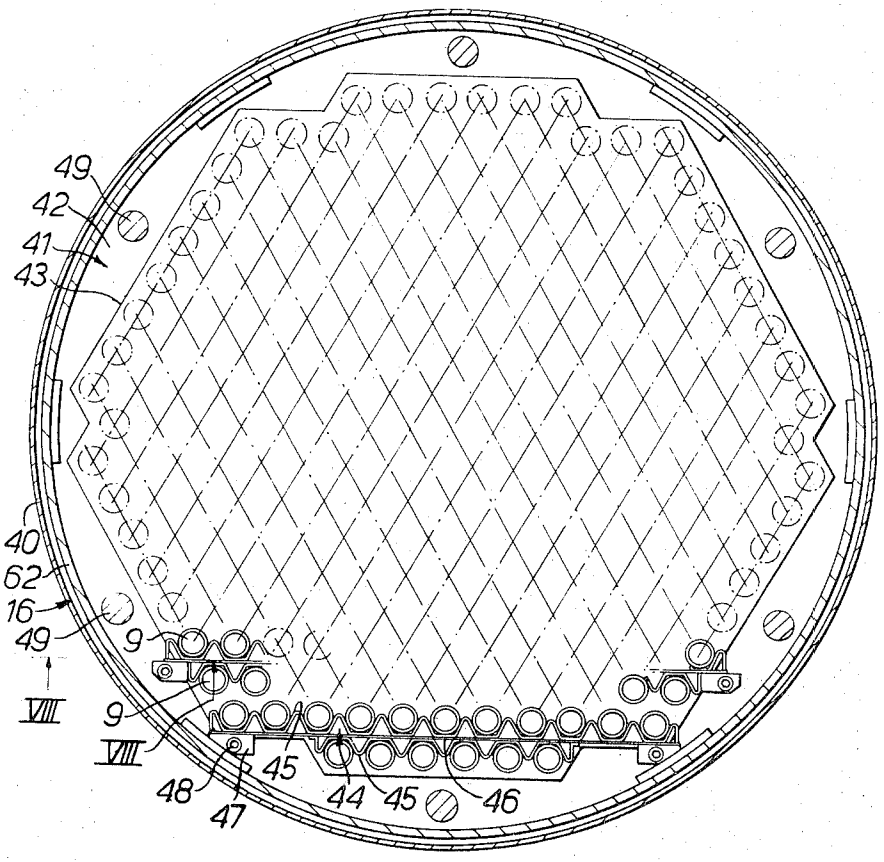


FIG.7



HEAT EXCHANGERS

This is a continuation, of application Ser. No. 179,342 filed Sept. 10, 1971 now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to heat exchangers and in particular to that type of heat exchanger generally referred to as the tube in shell type in which an array of tubes is arranged in a shell, a heat transfer fluid being passed through the shell over the outer surface of the tubes, heat transfer being through the tubes to a second fluid passing through the tubes.

In one such type of heat exchanger the tubes are of U-form arranged longitudinally in the shell being connected at their ends by welding to tube plates in the shell.

The present invention is concerned with problems which can arise in the use of such a heat exchanger for example as a steam generator or steam superheater employing a liquid metal heat transfer medium such as sodium which is passed through the shell over the tube bundles and water, for steam generation, or steam for superheating, being passed through the tubes. The heat exchange is thus between fluids which will react violently if they come into direct contact and it must be particularly ensured that the welds between the tubes and the tube plates are of high integrity and are easily accessible for inspection and repair during service of the heat exchanger.

Also provision must be made for accommodating flexing of the tubes due to thermal expansion during service of the heat exchanger and for containing and mitigating the effects of a reaction between the heat transfer fluids should they come into contact for example by failure of a tube.

SUMMARY OF THE INVENTION

According to the invention a heat exchanger of the type comprising a shell containing an array of U-shaped tubes arranged longitudinally in the shell has the tubes assembled in a number of separate tube bundles with the ends of the tubes connected with individual tube plates in separate inlet and outlet header pipes in an end closure head for the shell. In this arrangement access for making the welds between the tube ends and the tube plates is readily available during manufacture of the heat exchanger and for subsequent repair or inspection of tube welds in service. Also the tube bundles are removable with the end closure head from the shell during service of the heat exchanger for inspection of the shell and repair of any defective tube/tube plate welds.

In an alternative arrangement of a heat exchanger according to the invention the ends of the tube bundles extend through a lower tube plate and connect with an upper tube plate in each of the inelt and outlet header pipes in the end closure head for the shell, the upper and lower tube plates in each inlet or outlet header pipe being separated by a sealed interspace in the header pipe which is monitored to detect any leakage at the tube/tube plate joints.

According to another feature of the invention each tube bundle is contained within an individual tubular shroud, ducting being provided for passing heat transfer fluid from outside the shell into one end of each shroud so that the heat transfer fluid passes through the

shrouds over the surface of the tubes in the tube bundles and enters the shell of the heat exchanger from the other end of the shrouds. In this arrangement each tube bundle is separated from the other tube bundles by its individual shroud so that damage due to the occurrence of a reaction between the heat exchange fluid passing over the tubes and the fluid passing through the tubes is confined to the tube bundle in which the reaction occurs. The shrouds for the tube bundles may be made of sufficient strength to withstand the shock wave energy release of the reaction and means including a pressure relief device may be provided for venting the gaseous products of such a reaction from the shrouds to the outside of the shell.

According to a further feature of the invention the tubes in the individual tube bundles are spaced and located at intervals along their length by transverse grids which are supported one from another in an articulated manner so that flexing of the tubes due to thermal expansion can be accommodated. The shrouds for the tube bundles may comprise individual tubular sleeves extending between adjacent grids so that the shrouds can also flex with flexing of the tubes of the tube bundles.

A heat exchange fluid inlet manifold may be provided extending longitudinally through the shell between the tube bundles, the manifold leading from an inlet branch at the lower end of the shell and having a header box at its upper end in the shell, the header box having apertures in its base and top for passage of the legs of the tube bundles leading to the outlet branches in the top closure head of the shell, sleeves being provided connecting the outlet branches in the top closure head of the shell with the corresponding apertures in the top of the header box, the parts of the shrouds for the legs of the tube bundles leading to the outlet branches in the closure head of the shell connecting at their upper ends with the apertures in the base of the header box, the parts of the shrouds surrounding the legs of the tube bundles leading from the inlet branches in the closure head of the shell being open at their upper ends to the interior of the shell.

A strongback plate may be provided mounted inside the end closure head of the shell, the strongback plate supporting the inlet manifold and the grid system and thereby the shrouds for the tube bundles, so that the assembly of the closure head the tube bundles and their shrouds and the inlet manifold is removalbe as a whole from the shell.

The grids for spacing and locating the tubes of the tube bundles may be connected by tie bars extending between adjacent grids, the tie bars being connected in an articulated manner with outer frame members of the grids. The upper grid on each leg of the tube bundles may be connected by tie bars, in a similar manner, with the strong-back plate in the end closure head of the shell.

The individual tubular sleeves of the shrouds for the tube bundles may extend between cylindrical flanges on the frame members of adjacent grids, each sleeve being welded at one end to the flange on one grid and being a sliding fit at its other end about the flange on the adjacent grid.

The lower end of each shroud for the tube bundles may be formed by a U-shaped sleeve surrounding the lower U-shaped ends of the tubes, the ends of the U-shaped sleeve connecting with the ends of the lower-

most tubular sleeves which are part of the shroud on the straight legs of the tube bundles. A baffle plate may be provided extending across the lower end of the shell and outlet branches may be provided in the U-shaped sleeves forming the lower ends of the shrouds for the tube bundles, connecting through apertures in the baffle plate with the space in the shell below the baffle plate and an outlet branch with a pressure relief device (for example a bursting disc) being provided in the shell connecting with the space below the baffle plate.

A heat exchanger in accordance with the invention will now be described by way of example with reference to the accompanying drawings in which:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional elevation, the section being along the line I—I in FIg. 3.

FIG. 2 is a longitudinal sectional elevation partially in "exploded" form showing the main components of the heat exchanger the section being along the line II—II in FIG. 1.

FIG. 3 is a plan view of the heat exchanger shown in FIG. 1.

FIG. 4 is a section along the line IV—IV in FIG. 2.

FIG. 5 is a section along the line V—V in FIG. 2.

FIG. 6 is a detail.

FIG. 7 is a plan view of a grid structure employed in the heat exchanger of FIG. 1.

FIG. 8 is a detailed cross sectional elevation along the line VIII—VIII in FIG. 7, and

FIG. 9 shows in section an alternative form of inlet and outlet headers for the heat exchanger shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The heat exchanger shown in the drawings is particularly applicable as a steam generator using a liquid metal such as sodium as the heat transfer medium and comprises a cylindrical shell 1 having a domed lower end 2. The shell 1 is fitted with a domed closure head 3 having two water inlet headers 4 and two longer steam outlet headers 5. The closure head 3 has an external end flange 6 at which it is bolted and seal welded to an external end flange 7 on the shell 1. A gasket is fitted between the contacting faces of the flanges 6 and 7. The shell 1 contains two U-shaped tube bundles 8 which extend side by side longitudinally through the shell 1.

As shown in FIGS. 1 and 2 each tube bundle 8 comprises an assembly of U-shaped tubes 9. FIG. 1 shows one of the tube bundles 8 and the associated water inlet header 4 and steam outlet header 5 on the closure head 3. The tubes 9 in the tube bundle 8 are connected at one end to a tube plate 10 in the water inlet header 4 and are connected at their other end to a tube plate 11 in the steam outlet header 5. Similarly the tubes 9 in the other tube bundle 8 are connected to tube plates 10 and 11 in the second water inlet header 4 and steam outlet header 5 of the closure head 3.

A circular strongback plate 12 having radial stiffening webs 13 is bolted to an annular flange 14 inside the closure head 3. The strongback plate 12 provides support for a sodium inlet manifold 15 and for shrouding 16 surrounding the tube bundles 8. As shown in FIG. 4 the strongback plate 12 has openings 17 for passage of the water inlet logs of the tube bundles 8 from the inlet headers 4 and openings 18 for passage of the steam outlet legs of the tube bundles 9 to the outlet headers 5.

As shown in FIGS. 1, 2 and 5 the inlet manifold 15 comprises a duct 19 of rectangular cross section extending longitudinally through the shell 1 between the tube bundles 8. At the upper end of the inlet manifold 15 the duct 19 opens out into a header box 20. The manifold 15 is bolted to the strongback plate 12 at the header box 20 which has a top closure plate 21 with openings 22 corresponding to the openings 18 in the strongback plate 12. Openings 23 in the base of the header box 20 correspond to the openings 22 in the top closure plate 21 of the header box 20 so that the steam outlet legs of the tube bundles 9 pass through the header box 20. FIG. 6 shows the method of securing the manifold 15 to the strongback plate 12. Bolts 24 extending through oversize apertures 25 in the strongback plate 12 are screwed into threaded bosses 26 welded to the top closure plate 21 of the header box 20. Washers 27 are fitted between the heads of the bolts 24 and the strongback plate 12 and Stellite (Registered Trade Mark) washers 28 are fitted on the bolts 24 between the strongback plate 12 and the bosses 26. As the apertures 25 are oversize with: respect to the bolts 24 this allows for radial thermal expansion of the header box 20 relative to the strongback plate 12.

Each of the steam outlet headers 5 on the closure head 3 is fitted with a thermal sleeve 29. The thermal sleeves 29 extend downwards to the openings 18 in the strongback plate 12. A flange 30 is fitted around each of the openings 18 in the strongback plate 12 and the lower end of each thermal sleeve 29 is connected with the flange 30 around the corresponding opening 18 in the strongback plate 12 by a bellows 31.

As shown in FIGS. 1 and 2 the duct 19 of the inlet manifold 15 is of cylindrical form at its lower end 32. A circular baffle plate 33 is bolted to a flange 34 inside the lower end of the shell 1. The cylindrical lower end 32 of the inlet manifold 15 extends through a central opening 35 in the baffle plate 33 into a sodium inlet branch 36 at the lower end 3 of the shell 1. The cylindrical lower end 32 of the inlet manifold 15 is sealed in a slidable manner within the inlet branch 36 by piston ring seals 37. A bell shaped sealing ring 38 is fitted around the opening 35 in the baffle plate 33. The sealing ring 38 seals around the cylindrical lower end 32 of the inlet manifold 15.

As shown in FIGS. 1, 7 and 8 the shrouding 16 surrounding each of the tube bundles 8 comprises a series of cylindrical sleeves 40 extending between transverse grids 41 which space and locate the tubes 9 of the tube bundles 8 at intervals along their length. As shown in FIGS. 7 and 8 the grids 41 comprise a circular plate 42 having a substantially hexagonal aperture 43. Locating members 44 for the tubes 9 of the tube bundles 8 extend across the aperture 43 in the plate 42. The tube locating members 44 comprise zig-zag strip members 45 attached, for example by spot welding, to the faces of straight strip members 46. Lugs 47 at the ends of the straight strip members 46 provide for mounting of the tube locating members 44 on the plate 42 by socket headed screws 48. The tubes 8 of the tube bundles 9 lie in the troughs of the zig-zag strip members 45.

In general each grid 41 is supported from the grid 41 immediately above by tie bars 49. As shown in FIG. 8 the tie bars 49 have shouldered ends 50 which pass through holes 51 in the plate 42 of each grid 41. The shouldered ends of the tie bars 49 are fitted with nuts 52 which have a clearance with the plates 42 of the grids 41, so that the grids 41 are connected together in an articulated manner by the tie bars 49.

As shown in FIG. 1 the upper grids 41 on both the water inlet and steam outlet legs of the tube bundles 8 are suspended from the strongback plate 12 by similar tie bars 49.

The cylindrical sleeves 40 of the shrouding 16 of the tube bundles 8 each extend between two of the grids 41. As shown in FIG. 8 a cylindrical flange 53 is welded around the edge of the plate 42 of each grid 41. Each sleeve 40 has its upper end fitting around and welded to the flange 53 of the upper of the two grids 41. The lower end of the sleeve 40 fits about and is free to slide on the flange 53 of the lower of the two grids 41.

As shown in FIG. 1 the lower end of the shrouding 16 for each tube bundle 8 is formed by a U-shaped sleeve 54 having its upper ends fitting around and welded to the flanges 53 of the lowermost grids 41 on both the water inlet and steam outlet legs of the tube bundle 8.

Both the U-shaped sleeves 54 forming the lower end of the shrouding 16 for the tube bundles 8 have an outlet branch 55. The outlet branches 55 of the U-shaped sleeves 54 are connected with apertures 56 in the baffle plate 33 at the lower end of the shell 1. A flange 57 is fitted around each of the apertures 56 in the baffle plate 33 and each flange 57 is connected with the outlet branch 55 of the corresponding sleeve 54 by a bellows 58. The lower domed end 2 of the shell 1 below the baffle plate 33 is fitted with a nozzle 59 including a pressure relief device such as a bursting disc.

On the water inlet log of each tube bundle 8 the shrouding 16 terminates at the upper grid 41 below the strongback plate 12. On the steam outlet leg of each tube bundle 8 the shrounding 16 is extended above the upper grid 41 to the base of the sodium header box 20 of the sodium inlet manifold 15 by a sleeve 60. The sleeve 60 is welded at its upper end around the corresponding opening 23 in the base of the header box 20 and the lower end of the sleeve 60 fits about and is free to slide on the flange 53 of the adjacent upper grid 41. Sodium outlet branches 61 are provided at the upper end of the shell 1.

Thermal insulation 62 is fitted inside the shrouding 16 of the tube bundles 8. The thermal insulation may be of the form disclosed in our British Pat. No. 1,098,485. This type of thermal insulation comprises two closely spaced metal sheets which are welded together along intersecting seams to divide the space between the sheets into a number of separate gas filled compartments. The thermal insulation 62 comprises several layers of this form of insulation mounted inside the sleeves 40 of the shrouding 16 of the tube bundles 8. The thermal insulation 62 extends inside the sleeves 40 between the plates 42 of adjacent grid 41, being located as shown in FIG. 8 by pads 63 welded to the plates 42 of the grids 41. Similar thermal insulation may be provided on the thermal sleeves 29 and on the duct 19 and on the header box 20 of the sodium inlet manifold 15.

FIG. 9 shows an alternative form of the headers 4 and 5 of the heat exchanger 1 shown in FIG. 1, in which a tube bundle 64 has the ends of its tubes 65 extending through a lower tube plate 66, and an interspace 67 to connect with an upper tube plate 68 forming part of a header 69. The interspace 67 is filled with argon and is provided with a sampling line 70 which connects the interspace with a monitoring system which detects the presence of any water vapour or sodium which may have leaked through a defective tube/tube plate joint. Preferably the tube/tube plate sealing joints in the lower tube plate 66 are brazed, whilst in the upper tube plate 68 the connecting joints may be formed by explosive welding, fusion welding or brazing. The interspace 67 may be enclosed by an annular removable inspection cover 71 sealed by a gasket 72 and the top of the header 69 may be provided with a removable dome 73. This arrangement allows access for inspection and repair purposes to both sides of the upper tube plate 68 and the upper side of lower tube plate 66.

If the gas pressure in the interspect 67 rises to an unacceptable level (eg in the case of a sodium/water reaction due to leakage at the tube/tube plate joints) it activates a pressure relief device such as a bursting disc which releases the gaseous by products of the reaction into the effluent system.

In use of the heat exchanger described above hot sodium is passed through the sodium inlet branch 36 at the lower end 2 of the shell 1 and passes upwards through the duct 19 of the sodium inlet manifold 15. The hot sodium enters the header box 20 of the manifold 15 from the duct 19. From the header box 20 the hot sodium passes through the openings 23 in the base of the header box 20 and passes downwards through the shrouding 16 surrounding the steam outlet legs of the tube bundles 8. The hot sodium thus passes in heat exchange relationship over the surface of the tubes 9 forming the tube bundles 8. At the base of the tube bundles 9 the sodium flow reverses through the U-shaped sleeves 54 forming the lower ends of the shrouding 16 on the tube bundles 8. The sodium then passes upwards through the shrouding 16 surrounding the water inlet legs of the tube bundles 8 and spills out of the open upper end of this side of the shrouding 16 into the shell 1 of the heat exchanger. The cool sodium leaves the shell 1 through the sodium outlet branches 61, although a bypass arrangement may be provided so that the cool sodium washes over the inside surface of the shell 1 before leaving the shell 1 through the outlet branches 61.

Water is passed into the tubes 8 of the tube bundles 9 through the water inlet headers 4. In passing through the tubes 8 the water is converted into steam by heat exchange with the hot sodiu flowing over the tubes 8 through the shrouding 16 of the tube bundles 9. The steam thus generated leaves the tubes 8 through the steam outlet header 5.

The arrangement is considered to have the following advantages as compared with known forms of sodium/-water heat exchangers.

The provision of individual water inlet headers 4 and steam outlet headers 5 in the closure head 3 provides for easy access to the tube plates 10 and 11 in the headers 4 and 5. Thus the welds between the tubes 8 of the tube bundles 9 and the tube plates 10 and 11 can readily be inspected or repaired on site.

The whole assembly of the closure head **3**, the tube bundles **9** and the inlet manifold **15** can be removed from the shell **1** and replaced when necessary after a designed length of use or should damage due to mechanical falilure have occurred during use.

As the grids **41** for the tube bundles **9** are supported in an articulated manner this allows unrestrained thermal expansion of the tube bundles **9** to take place. In particular the longitudinal thermal expansion of the steam outlet legs of the tube bundles **9** will be greater than the longitudinal thermal expansion of the water inlet legs of the tube bundles **9** because the steam outlet legs of the tube bundles **9** are first contacted by the hot sodium entering the tube bundles **9** from the header box **20.** Thus the tube bundles **9** will tend to take up a "hockey stick" or J shaped configuration and the flexible grid support system allows this to occur.

One of the most difficult problems which can occur in such a sodium/steam generator form of heat exchanger is to cater for a sodium/water or sodium/steam reaction incident which occur if a defect arising in one of the heat exchanger tubes allows escape of a jet of water or steam into the surrounding sodium. The sodium/water or sodium/steam reaction thus occurring can be violent with release of large amounts of energy and the generation of large volumes of high pressure gas to hydrogen. In the design of the present invention the individual containment of each tube bundle **9** by the shrouding **16** contains the effects of the reaction to that tube bundle **9** having the defective tube **8.** The individual sleeves **40** of the shrouding **16** for each tube bundle **9** can be made of sufficient strength to contain the energy release so that the gases generated in the reaction are channelled through the shrouding **16** of the defective tube bundle **9** and pass through the outlet branch **55** at the bottom of the shrouding **16** into the lower domed end **2** of the shell **1** below the baffle plate **33.** The reaction gases are released to an effluent system through the nozzle **59** at the lower end **2** of the shell **1** by failure of the bursting disc in the nozzle **59.** In this context the thermal insulation **62** fitted inside the shrouding **16** of the tube bundles **9** can also assist in shock wave energy absorption by collapse of the individual compartments of the insulation under the shock wave loading.

We claim:

1. A shell and tube heat exchanger in which the shell is an elongate vessel with a detachable closure head and the tubes are single-walled and U-shaped to extend from the head into the vessel and back to the head, the tube ends being disposed within headers upstanding from the head, and in which the tubes are arranged in at least two independent bundles which are suspended from the closure head, a U-shaped shroud for each tube bundle to cause heat transfer fluid to flow longitudinally along the outside of the tubes in the bundle and successively over each leg of the bundle while confined by the shroud, means including ducting defining a flow passage from the outside of the vessel and thence to one end of the shrouds and from the other end of the shrouds to the inside of the vessel, an outlet connection from said vessel, an outer tube plate at each end of each bundle between tubes and header, said plates being located in said header so as to present the tube ends accessible from outside the head, and an inner tube plate at each end of each bundle within the header and between tubes and shroud and spaced from said outer tube plate, enclosing means defining with said plates an interspace, and means for testing the contents of said interspace to test for leakage between tubes and both tube plates.

2. Apparatus as claimed in claim **1** wherein said enclosing means is openable to present the tubes, emerging from the inner tube plate, accessible from outside the removable head.

3. Apparatus as claimed in claim **1** having a chamber into which the tubes discharge, said chamber having a removable dome to render the tube ends accessible from outside the head.

4. A heat exchanger as claimed in claim **1** having a pressure release device for said shroud in the region of its U-bend arranged to vent the shroud to a location outside the shell of the heat exchanger.

5. A heat exchanger as claimed in claim **1** wherein the ducting for passing heat transfer fluid from outside the shell into one end of each shroud comprises an inlet manifold extending longitudinally through the shell between the tube bundles, the manifold leading from an inlet branch at the lower end of the shell and having a header box at its upper end in the shell, the header box having apertures in its base and top for passage of the legs of the tube bundles leading to the outlet branches in the top closure head of the shell, sleeves being provided connecting the outlet branches in the top closure head of the shell with the corresponding apertures in the top of the header box, the parts of the shrouds surrounding the legs of the tube bundles leading to the outlet branches in the closure head of the shell connecting at their upper ends with the apertures in the base of the header box, the parts of the shrouds surrounding the legs of the tube bundles leading from the inlet branches in the closure head of the shell being open at their upper ends to the interior of the shell.

6. A heat exchanger as claimed in claim **5** wherein a strongback plate is mounted inside the end closure head of the shell, the strongback plate supporting the inlet manifold and the shrouds for the tube bundles whereby the assembly of the closure head, the tube bundles, their shrouds and the inlet manifold is removable as a whole from the shell.

7. A heat exchanger as claimed in claim **1** wherein the tubes in the individual tube bundles are spaced and located at intervals along their length by transverse grids which are supported from one another in an articulated manner so that flexing of the tubes due to thermal expansion can be accommodated.

8. A heat exchanger as claimed in claim **7** wherein the shrouds for the tube bundles comprise individual tubular sleeves extending between adjacent grids so that the shrouds can flex with flexing of the tubes of the tube bundles.

9. A heat exchanger as claimed in claim **7** wherein the grids are connected by tie bars extending between adjacent grids the tie bars being connected in an articulated manner with outer frame members of the grids.

10. A heat exchanger as claimed in claim **7** wherein the upper grid on each leg of the tube bundles is connected by tie bars in an articulated manner with a strongback plate mounted inside the end closure head of the shell.

11. A heat exchanger as claimed in claim **7** wherein individual tubular sleeves forming the shrouds for the tube bundles extend between cylindrical flanges on outer frame members of adjacent grids, each sleeve

being welded at one end to the flange on one grid and being a sliding fit at its outer end about the flange on the adjacent grid.

12. A heat exchanger as claimed in claim **11** wherein the lower end of each shroud for the tube bundles is formed by a U-shaped sleeve surrounding the lower U-shaped ends of the tubes, the ends of the U-shaped sleeve connecting with the ends of the lower-most tubular sleeves which are part of the shroud on the straight legs of the tube bundles.

13. A heat exchanger as claimed in claim **12** wherein a baffle plate is provided extending across the lower end of the shell and outlet branches are provided in the U-shaped sleeves forming the lower ends of the shrouds for the tube bundles, connecting through apertures in the baffle plate with the space in the shell below the baffle plate, an outlet branch with a pressure relief device being provided in the shell connecting with the space below the baffle plate.

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