July 26, 1932. S. BROWN ET AL 1,868,657

HEAT EXCHANGER

Filed Dec. 14, 1931 2 Sheets-Sheet 1

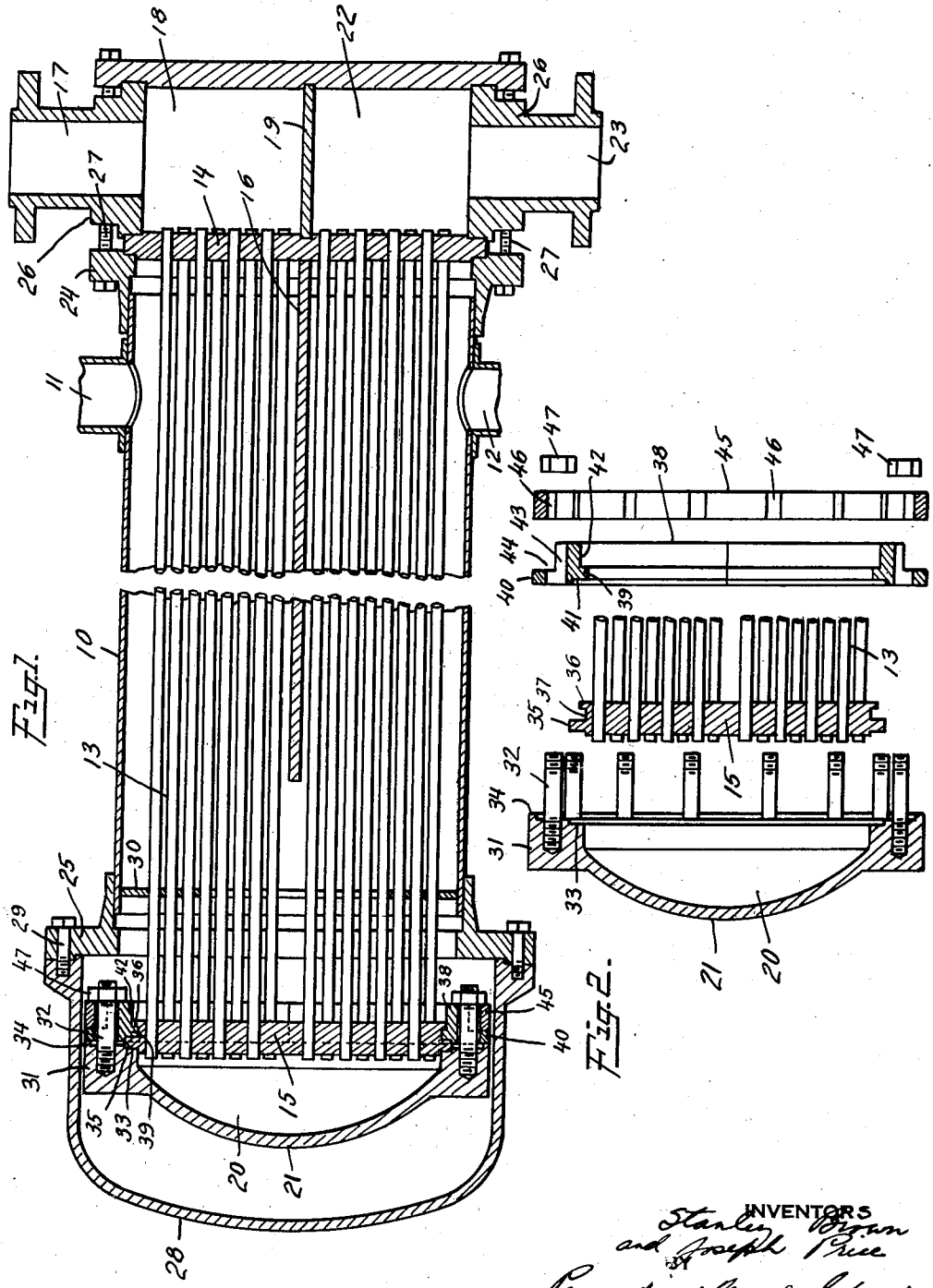

Fig. 1.

Fig. 2.

INVENTORS
Stanley Brown
and Joseph Price
BY
Pennie, Davis, Marvin & Edmonds
ATTORNEYS

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Fig. 3.

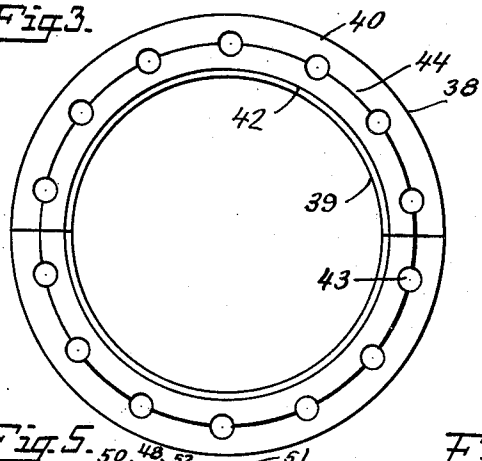


Fig. 4.

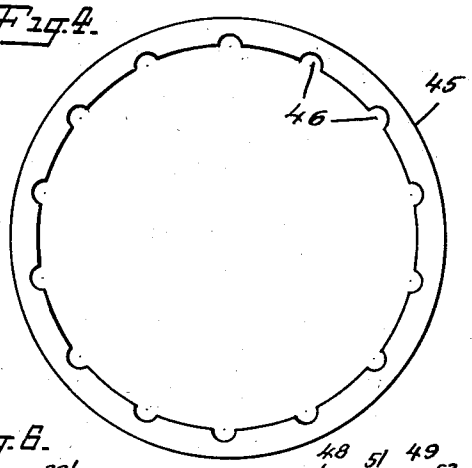


Fig. 5.

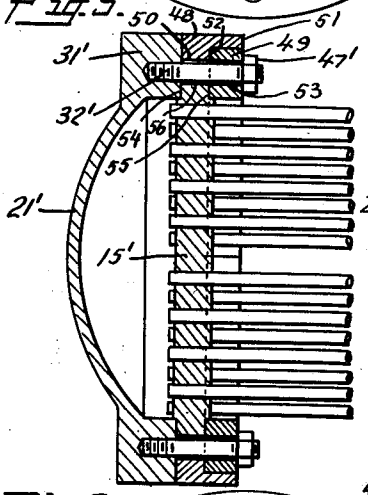


Fig. 6.

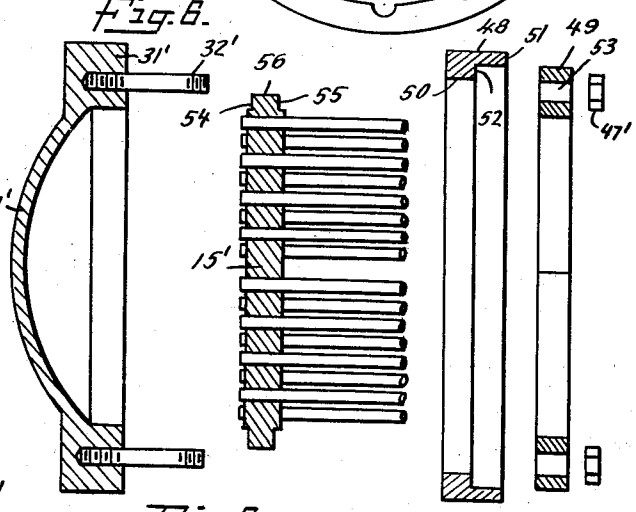


Fig. 7.

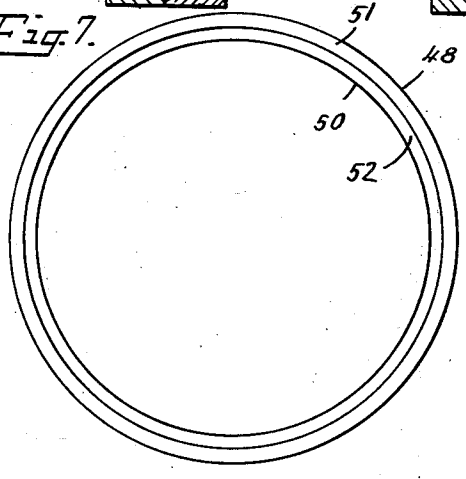
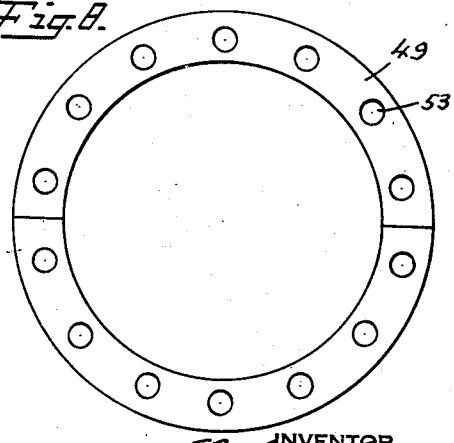


Fig. 8.



INVENTOR
Stanley Brown
and Joseph Price
BY
Cowan, Davis, Irwin & Edwards
ATTORNEYS

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UNITED STATES PATENT OFFICE

STANLEY BROWN, OF GARDEN CITY, AND JOSEPH PRICE, OF WEST NEW BRIGHTON, NEW YORK, ASSIGNORS TO THE GRISCOM-RUSSELL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

HEAT EXCHANGER

Application filed December 14, 1931. Serial No. 580,942.

This invention relates to heat exchangers of the type in which a plurality of tubes are placed in a containing shell and which are commonly known as shell-and-tube or surface type heat exchangers.

This type of heat exchanger is used principally in transferring heat between two liquids, such as in oil refining operations and the like, and in transferring heat between a liquid and a gas as, for example, in steam power plants and industrial establishments. When used for transferring heat between two liquids, one liquid is passed through the shell of the exchanger and comes in contact with the outside surfaces of the tubes and the other liquid is passed through the tubes, and the transfer of heat between the liquids takes place through the walls of the tubes. In transferring heat between a liquid and gas or vapor, the gas or vapor is usually passed into the shell and the liquid forced through the tubes.

In the particular form of shell-and-tube or surface type of heat exchanger with which this invention is concerned, the tube bundle is secured at each end in a tube sheet and means are provided within the shell containing the tube bundle for conducting the fluid so that it makes two or more passes through the tube bundle before being discharged.

Inasmuch as the tubes are usually made of a different metal than the shell and normally operate at a temperature different from that of the shell, the relative thermal expansion between the tubes and the shell must be compensated for. To this end, one end of the tube bundle is anchored at its tube sheet to the shell, while the other end of the tube bundle and its tube sheet is supported so as to allow it to move bodily within the shell in response to thermal expansion or contraction of the tubes relatively to the shell and vice versa.

This floating tube sheet carries a cap which forms with the tube sheet a sealed chamber at the end of the tube bundle for receiving the circulating fluid discharged from one portion of the tubes and redirecting it into another portion of the tubes. This cap moves with the floating tube sheet and the entire organization at that end of the tube bundle is known as the floating head. Also, the tube bundle is of a diameter sufficiently small to permit ready removal of the entire tube bundle as a unit, including the tubes and both tube sheets, for purposes of repair and periodic cleaning, especially when oil and other viscous liquids are used therein.

In order to effectively seal the connection between the floating tube sheet and the cap of the floating head, a very tight joint between them must be provided. It has been common practice heretofore to employ clamping devices which hold the cap and the floating tube sheet securely together and yet may be released readily to enable the heat exchanger to be readily disassembled for cleaning and removing and replacing tubes and the like. These clamping means usually include various kinds of so-called sectional rings to enable ready disassembling of the floating head and these have been found to be generally satisfactory, except that the sectional clamping rings have a tendency to cock, rotate, or cant about the inner periphery of the tube sheet, which they are intended to clamp squarely and securely to the cap, when the clamping means, such as bolts, are tightened down.

It is the principal object of this invention to provide a heat exchanger in which the floating head is so constructed that canting or cocking of the clamping rings is prevented or reduced to an unobjectionable degree, without sacrificing the ready assembling and disassembling of the floating head, which is so necessary to secure easy access to the parts of the heat exchanger for cleaning and repair purposes.

In accordance with this object the heat exchanger includes a tube bundle having tube sheets at each end, one tube sheet being anchored to the shell in the usual way and the other tube sheet being arranged to float in the shell to accommodate relative thermal expansion between the tubes and the shell. The cap, into which one portion of the tubes discharges and which redirects the fluid into another portion of the tubes, engages the outer face of the floating tube sheet and the

floating tube sheet is held against the cap in clamping relation by a sectional ring which is in turn held together by a continuous ring or hoop. Suitable clamping means hold the rings in the clamping relation, and these clamping means preferably comprise bolts passing through at least one of the rings and threaded in or passing through the adjacent portion of the cap.

In this construction, the continuous ring or hoop encircles the periphery and at least partially overlaps one side of the sectional ring in such a way that the cocking or canting of the inner edge of the sectional ring about the periphery of the floating tube sheet is prevented, when the bolts and nuts are screwed down tightly, and the sectional ring and the continuous ring or hoop cooperate to clamp the floating tube sheet squarely and securely to the cap. The tube bundle, including the floating sheet is also of such dimension as to be readily removable as a unit from the shell for repair and cleaning purposes.

For a better understanding of the invention, reference is made to the accompanying drawings, in which

Figure 1 is a longitudinal section of a heat exchanger embodying the construction of the present invention;

Fig. 2 is an expanded view of the floating head consisting of the floating tube sheet, the cap, and the clamping means;

Fig. 3 is a face view of the sectional ring of the clamping means;

Fig. 4 is a face view of the continuous ring or hoop of the clamping means;

Fig. 5 illustrates a modified form of the floating head of this invention;

Fig. 6 is an expanded view of this floating head showing the cap, floating tube sheet, and the clamping means;

Fig. 7 is a face view of the continuous ring or hoop of this clamping means, and

Fig. 8 is a face view of the sectional ring of this clamping means.

In these drawings, the heat exchanger includes the longitudinal cylindrical shell 10 having the inlet 11 at one side and the outlet 12 at the opposite side, whereby a fluid such as steam, water, oil, or the like, may be circulated through the shell. Supported within the shell 10 is a tube bundle 13 made up preferably of a relatively large number of small thin walled tubes. These tubes are expanded at the right-hand end into a fixed tube sheet 14 and at the left-hand end into a movable or floating tube sheet 15. In order to cause the liquid entering at the inlet 11 to pass longitudinally of the shell 10 and the tube bundle 13, a baffle plate 16 extends from the fixed tube sheet 14 centrally of the shell 10 and terminates at a point near the opposite end thereof.

The other fluid, such as oil for example, enters at the right hand end of the exchanger through the inlet 17, which delivers it to a chamber 18 from which it flows into the tubes of the tube bundle 13 lying on the upper side of the dividing partition 19. The liquid passes through these tubes and is discharged into the floating chamber 20 at the left hand end of the exchanger, which is formed between the cap 21 and the floating tube sheet 15, to which it is secured in a manner to be described. This chamber redirects the fluid into the tubes of the lower portion of the tube bundle 13, whereby the liquid is returned to the right hand end of the exchanger and discharged into a chamber 22 on the lower side of the partition 19, from which it passes out of the outlet 23.

The shell 10 is provided at its right hand end with a connecting flange 24 and at its left hand end with a similar connecting flange 25. The fixed tube sheet 14 is clamped rigidly between the flange 24 and the casting 26 containing the inlet 17 and the outlet 23, by means of a plurality of long bolts 27. The shell 10 is closed at its left-hand end by means of a large dome-like cover 28, which is secured to connecting flange 25 by means of bolts 29. The liquid passing through the shell 10 is free to circulate within the dome-like cover 28 around the floating head of the tube bundle formed by the cap 21 and the floating tube sheet 15.

This floating head is supported centrally in the dome-like cover 28 and the tube bundle 13 is supported centrally in the shell 10 by means of an annular disc 30 mounted on the tube bundle 13 near the left hand end of the exchanger. This disc has a large central opening for the free passage of the fluid in the shell and is slidable axially in the shell 10 in response to the relative thermal expansion between the tube bundle 13 and the shell 10 and remaining stationary parts of the exchanger. This relative thermal expansion between the tube bundle 13 and the shell 10 and remaining parts of the exchanger takes place for the reason that the tubes 13 and the shell 10, being made of different materials have different co-efficients of expansion. Also, the temperatures to which the shell 10 and the tubes 13 are subjected are frequently widely different so that the relative expansion of each varies considerably. The floating tube sheet 15 is of slightly smaller diameter than the inside diameter of shell 10 so that it can be withdrawn from the shell 10 in removing the tube bundle.

Cap 21 is provided with a thickened rim 31 having a plurality of tapped holes arranged in equally spaced relation around its inner surface. Screwed into these tapped holes are a series of stud bolts 32 which accordingly project axially from the inner surface of the rim 31 of the cap 21. The inner edge of the cap rim 31 is provided with the

counterbore 33 and the outer edge of the rim 31 is provided with the narrow lip or ridge 34.

The floating tube sheet 15 is provided with a large peripheral flange 35 and a smaller peripheral flange 36, the large peripheral flange 35 being of such dimensions as to fit closely into the counterbore 33 of the cap 31. The two peripheral flanges 35 and 36 of the floating tube sheet 15 define between them a peripheral groove 37.

The sectional or split ring 38, shown especially in Figs. 2 and 3 is provided at its inner periphery with the flange or tongue 39 adapted to fit closely within the groove 37 of the floating tube sheet 15 and is provided at its outer periphery with the flange 40. This sectional or split ring 38 is also provided on one surface with the counterbore 41, which is similar to cap counterbore 33, i. e., it is of such dimension as to fit closely over the peripheral flange 35 of the floating tube sheet 15. The inner surface of sectional or split ring 38 is provided with the counterbore 42 of such dimension as to fit closely over the smaller peripheral flange 36 of floating tube sheet 15. This ring 38 accordingly has an angle cross section as seen especially in Figs. 1 and 2 and one face thereof is adapted to closely engage the lip or ridge 34 on the rim 31 of cap 21 when the split ring 38 is emplaced on floating tube sheet 15 so as to encircle the same with the inner flange 39 thereof by closing in the peripheral grooves thereof in the manner illustrated in Fig. 1. This sectional or split ring 38 is provided with a plurality of spaced holes 43 adapted to receive the studs 32 threaded into the rim 31 of cap 21.

Adapted to fit closely within the peripheral groove 44 formed between flange 40 and the outer periphery of the split ring 38, is a continuous ring or hoop 45, the inner periphery of which is provided with a series of spaced notches or semi-circular grooves 46, adapted to align with holes 43 in sectional or split ring 38 so as to accommodate the studs 32, which project from the inner face of rim 31 of cap 21. In this way, the continuous ring or hoop 45 holds the two sections of split ring 38 together and when the nuts 47 are tightened down on the studs 32, the continuous ring or hoop 45 clamps split or sectional ring 38 between it and the rim 31 of cap 21 and split ring 38 in turn clamps floating tube sheet 15 between it and rim 31 of cap 21.

It will be seen that the only part of the cap rim 31 which is engaged by the split or sectional ring 38 is the narrow lip or ridge 34, so that a tight leak-proof joint is made between the sectional ring 38 and the cap 21. Also, the counterbore 33 in cap 21 and opposite counterbore 41 in sectional ring 38, tightly and firmly receive the peripheral flange 35 of the tube sheet 15, so that the latter is held securely in place when nuts 47 are tightened down on studs 32. Also, the continuous ring or hoop 45, by engaging the radial flange 40 and overlapping the axial surface of sectional ring 38 at groove 44, prevents the latter from spreading radially and also prevents it from rocking, cocking or canting around the inner edge of the outer periphery of floating tube sheet 15, whereby the latter is clamped firmly, squarely and securely onto the cap 21.

In assembling the floating head of the heat exchanger, the two sections of ring 38 are placed around the floating tube sheet 15 and held in place thereon by the bolts 32 of the cap 21 or the continuous ring or hoop 45, or by both bolts and ring or hoop 45, so that the nuts 47 can be tightened down on the bolts 32 without requiring that the rings 38 and 45 be held in place. In disassembling the floating head, after removal of the dome cover 28 and the cap 21, the continuous ring 45 again serves to hold the halves of sectional ring 38 together and in position until it is convenient to remove them.

In the modified form of the tube sheet clamping means illustrated by Figs. 5 to 8, inclusive, rotation of the sectional and continuous rings is reversed, i. e., the continuous ring 48 encircles the tube sheet 15′ and overlaps the sectional ring 49 radially to hold it together, although the sectional ring 49 engages the tube sheet 15 in clamping relation with the cap rim 31′ as before. The radial flange 50 and the axial flange 51 form an angle with the recess 52 between them. The inner diameter of the radial flange 50 of continuous ring or hoop 48 is large enough to clear the ring of studs 32′ projecting from the rim 31′ of cap 21′, and the inner diameter of the axial flange is such as to receive the sectional or split ring 49 within the recess 52. The sectional or split ring 49 is provided with spaced holes 53 adapted to receive the studs 32′ of cap rim 31.

The floating tube sheet 15′ is provided at both edges with the peripheral recesses 54 and 55 which define the peripheral flange 56. The edge of the inner periphery of cap rim 31 is adapted to fit closely in the recess 54 of floating tube sheet 15′ and one edge of sectional ring 49 is adapted to fit closely in the recess 55 thereof, the peripheral flange 56 of the floating tube sheet 15′ and the radial flange 50 of continuous ring 48 being clamped between the flat face of cap rim 31 and the inner face of sectional ring 49, when nuts 47′ are tightened down on bolts 32′. It will be seen therefore, that sectional ring 49, being held flatwise against radial flange 50 of continuous ring 48 and flange 56 of floating tube sheet 15′, and being further held together by the radially overlapping flange 51 of continuous ring 48′, cannot spread radially or de-

flect in any direction and it especially cannot cock, rotate or cant around the inner edge of the outer periphery of floating tube sheet 15′ whereby the latter is clamped firmly, squarely and securely onto the cap 21′.

In assembling the floating head of the heat exchanger, the continuous ring or hoop 48 is slipped over the ring of bolts 32′ which support the ring 48 in encircling relation around the floating tube sheet 15′, whose peripheral groove 54 receives the inner edge of the cap rim 31. The sectional ring 49 is then emplaced within the recess 52 of continuous ring 48 and is held together and in position thereby as the nuts are tightened down on the bolts 32′. In disassembling the floating head, the two parts of the sectional ring are again held together and in position by the continuous ring or hoop 48 until it is convenient to remove them.

Although the invention has been described in connection with a two-pass heat exchanger, it is to be understood that the invention is applicable with equal facility to a single pass heat exchanger or other apparatus requiring a tightly sealed connection of this type.

We claim:

1. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring holding the tube sheet against the cap, a continuous ring encircling the sectional ring, and clamping means securing the tube sheet and rings to the cap.

2. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring in clamping engagement with said tube sheet, a continuous ring holding the sections of said clamping ring together and overlapping the latter radially, and clamping means securing the tube sheet and rings to the cap.

3. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a ring in clamping engagement with said tube sheet, a second ring lying at least partially within the first ring, one of said rings being sectional and the other ring being continuous, and clamping means securing the tube sheet and rings to the cap.

4. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a ring having an annular abutment and encircling the tube sheet and engaging the cap, a second ring engaging the said abutment of the first ring and concentric therewith, one of said rings being sectional and being held together by the other ring, and clamping means securing the tube sheet and rings to the cap.

5. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring engaging the inner face of the tube sheet in clamping engagement therewith, a continuous ring overlapping the sectional ring and holding the latter together, and clamping means securing the tube sheet and rings to the cap.

6. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a ring encircling the tube sheet and engaging the cap, a second ring overlapping said first ring radially, one of said rings being sectional, and clamping means securing the tube sheet and rings to the cap.

7. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring engaging an inner surface of the tube sheet for holding the latter against the cap, a continuous ring concentric with the sectional ring, and bolts passing through the sectional ring and within the inner periphery of the continuous ring for securing the tube sheet and the rings to the cap.

8. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring engaging an inner surface of the tube sheet for holding the latter against the cap, a continuous ring engaging the sectional ring for holding the latter against the tube sheet, and bolts securing the tube sheet and the rings to the cap.

9. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring recessed on one face for receiving a portion of the tube sheet and holding the latter against the cap, a continuous ring engaging the sectional ring for holding the latter against the cap, and clamping means securing the tube sheet and the rings to the cap.

10. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, said tube sheet having a peripheral groove, a sectional ring having a

tongue inserted in the groove of the tube sheet, and a continuous ring engaging the sectional ring for holding it against the cap, and clamping means securing the tube sheet and rings to the cap.

11. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, said tube sheet having a peripheral groove, a sectional ring of angle cross-section having a tongue inserted in the groove of the tube sheet, a continuous ring in the angle of the sectional ring for holding the latter together, and clamping means securing the tube sheet and rings to the cap.

12. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, said tube sheet having a peripheral groove, a sectional ring of angle cross section having a tongue inserted in the groove of the tube sheet, a continuous ring in the angle of the sectional ring, and bolts passing only through the sectional ring and engaging the continuous ring for clamping the tube sheet and rings to the cap.

13. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a continuous ring of angle cross-section encircling the tube sheet and engaging the cap, a sectional ring in the angle of the continuous ring and engaging the tube sheet, and clamping means securing the tube sheet and rings to the cap.

14. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring engaging the tube sheet for holding it against the cap, a continuous ring encircling the tube sheet and spacing the sectional ring from the cap, and clamping means securing the tube sheet and rings to the cap.

15. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for one end of the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a continuous ring encircling the tube sheet and engaging the cap, an axial flange on said continuous ring, a sectional ring engaging the tube sheet and continuous ring and lying within the flange of the latter, and bolts passing through the sectional ring for securing the tube sheet and rings to the cap.

In testimony whereof we affix our signatures.

STANLEY BROWN.
JOSEPH PRICE.