Nov. 24, 1936. J. PRICE 2,061,980

HEAT EXCHANGER

Filed Dec. 10, 1931 2 Sheets-Sheet 1

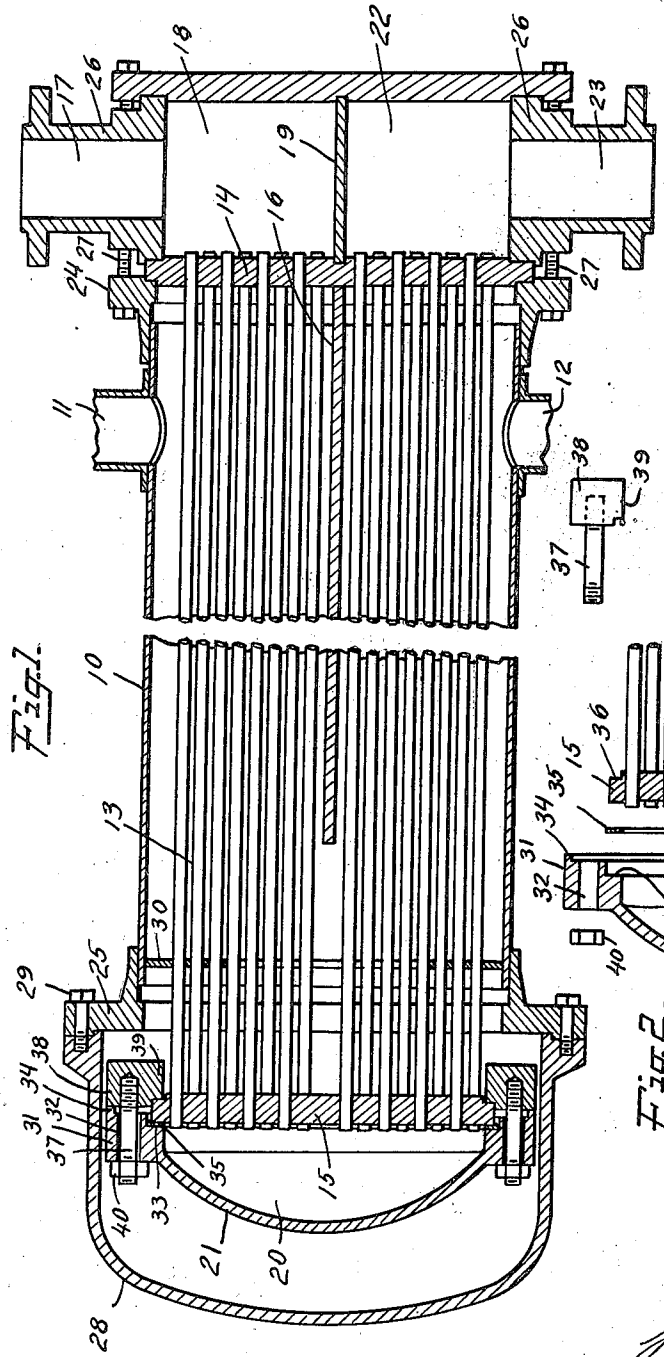


Fig. 1.

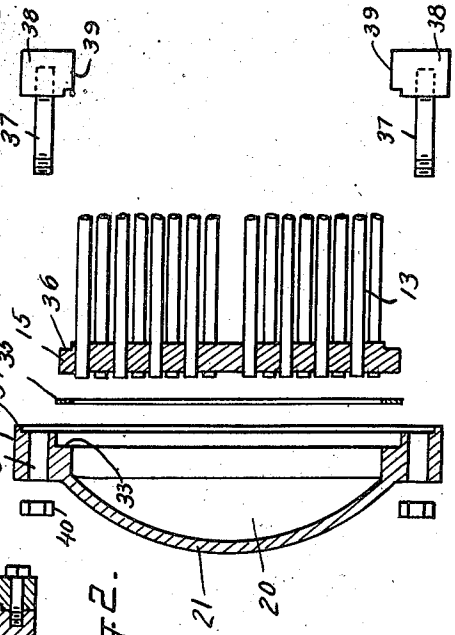


Fig. 2.

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Fig. 3.

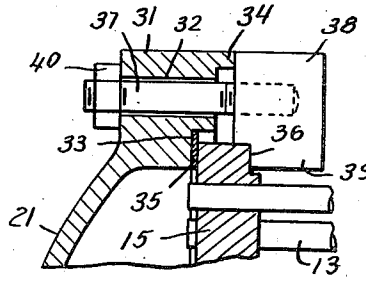


Fig. 4.

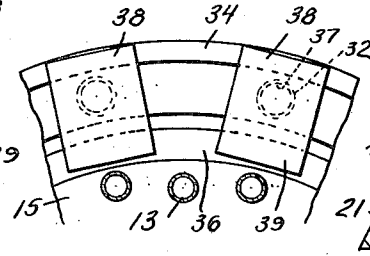


Fig. 5.

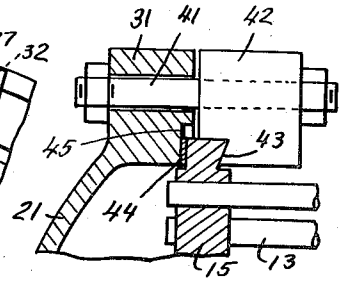


Fig. 6.

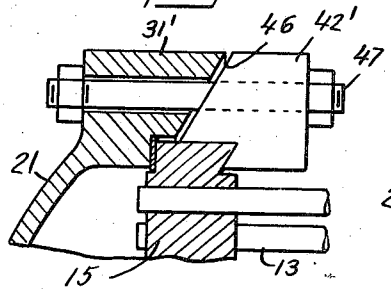


Fig. 7.

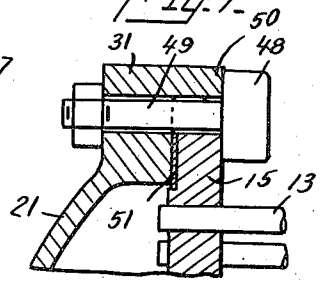


Fig. 8.

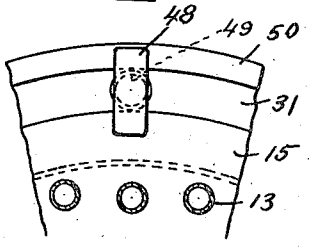


Fig. 9.

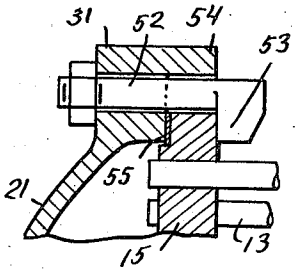


Fig. 10.

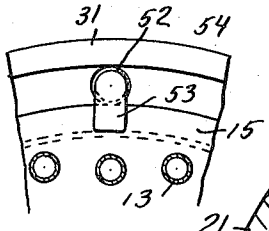


Fig. 11.

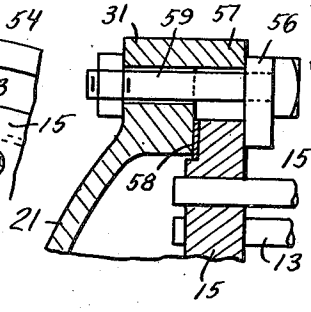


Fig. 12.

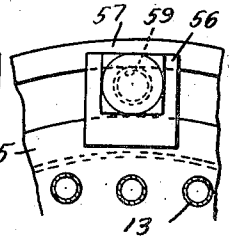


Fig. 13.

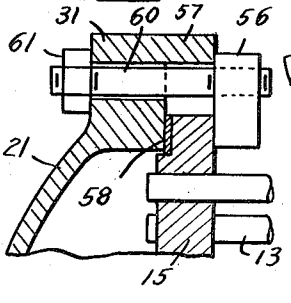
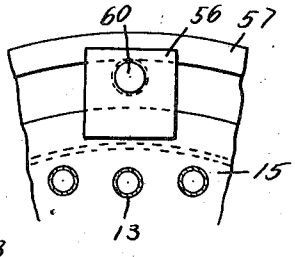


Fig. 14.



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UNITED STATES PATENT OFFICE

2,061,980

HEAT EXCHANGER

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Application December 10, 1931, Serial No. 580,071

2 Claims. (Cl. 257—239)

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 then 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 floating head 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 devices 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 tube sheet is clamped securely and squarely to the cap of the floating head without the use of sectional rings or other clamping means which are subject to misalignment caused by cocking or canting with respect to the floating tube sheet.

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 shell. The cap, into which one portion of the tubes discharges and which redirects the fluid into another portion of the tubes, engages with its rim the outer face of the floating tube sheet and the floating tube sheet is held against the cap rim in clamping relation by a plurality of separate spaced clamping elements anchored to the cap and having a head or other lateral extension or hook overlying the edge of the floating tube sheet for clamping it to the cap rim.

In this construction, the clamping members, when drawn tightly at spaced intervals over the edge of the floating tube sheet, secure the latter squarely and securely to the cap rim over a gasket, so that there is no tendency toward looseness or leakage. The clamping members may take various forms such as hook-headed bolts, studs with separate heads of different shapes, and the like. The tube bundle including the floating tube sheet is of such dimension as to be readily removable as a unit from the shell for repairing and cleaning purposes.

For a better understanding of the invention,

reference is made to the accompanying drawings, in which

Fig. 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 members;

Figs. 3 and 4 are, respectively, a partial section and a partial face view of the edge of the floating head, showing the clamping members employed in the arrangement of Figs. 1 and 2, and

Figs. 5 to 14, inclusive, are views of modified forms of clamping members applied to the floating head.

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 passing through these tubes is discharged into the floating chamber **20** at the left hand end of the exchanger, this chamber being formed between the cap **21** and the floating tube sheet **15**, to which the cap **21** 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 castings **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 stationary parts of the exchanger takes place for the reason that the tubes **13** and the shell **10**, being made of different materials have different coefficients 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** when the tube bundle **13** is removed.

Cap **21** is provided with a thickened rim **31** having a plurality of holes **32** arranged in equally spaced relation around its periphery. The inner face of cap rim **31** is provided with the counterbore **33**, shown especially in Figs. 2 and 3 and with the narrow lip or ridge **34** at its outer periphery. The floating tube sheet **15** is adapted to seat in the counterbore **33** of cap **21** over a sealing gasket **35**, and the inner edge of the floating tube sheet **15** is provided with the recess **36**.

As shown in Figs. 1 to 4, inclusive, studs **37**, threaded at each end, are inserted through the peripheral holes **32** so that their inner ends project inwardly around the periphery of the floating tube sheet **15**, when the latter is seated in the counterbore **33** of the cap **21**. The inner ends of these studs **37** are threaded into blocks **38**, which have a lateral extension **39** overlying the edge of the floating tube sheet **15**, as shown especially in Figs. 1 and 3, these extensions **39** of the block **38** being seated in the recess **36** of the floating tube sheet **15**.

When the nuts **40** are tightened down on the studs **37** over the outer face of the cap rim **31**, the blocks **38** are drawn tightly against the inner face of the tube sheet **15** and against the peripheral lip or ridge **34** of the cap rim **31**. It will be seen that the ridge or lip **34** of the cap rim **31** holds the spaced blocks **38** against rocking or canting in a counter-clockwise direction about the periphery of the floating tube sheet **15**, and that the extension **39** which overlaps the floating tube sheet **15** lies locked in the recess **36** thereof in such a way that any movement of the block **38** about the lip or ridge **34** as a fulcrum would only tend to clamp the tube sheet **15** more securely in the counterbore **33** of cap **21** and compress gasket **35** further.

Accordingly, by means of these spaced clamping members **38—39**, which overlap the floating tube sheet **15** at spaced intervals around its periphery, the floating tube sheet **15** is clamped squarely and securely to the cap **21**. Also, simply by relieving these clamping members by loosening nuts **40**, they may be rotated so as to withdraw extension **39** from out of contact with floating tube sheet **15**, whereby the floating head may be disassembled without actually removing the clamping members **38—39**.

In the modification of the clamping means illustrated in Fig. 5, the bolt **41** passes through both the cap rim **31** and the clamping block **42**. The abutting surfaces of the cap rim **31** and the block **42** are made perfectly flat, but the inner face of the floating tube sheet **15** is provided with a radially inwardly sloping or tapered annular recess, into which the correspondingly shaped extension **43** on the block **42** fits closely. The gasket **44** is clamped between the outer face of the floating tube sheet **15** and the counterbore **45** in the cap rim **31** in which the floating tube sheet **15** lies. It will be seen that as the bolt **41** is tightened down, the tapered extension **43** is so shaped as to seat more tightly into the corresponding annular recess of floating tube sheet

15. In this way the block 42 is locked against rotating or canting in a counter-clockwise direction about the periphery of floating tube sheet 15, while at the same time this arrangement provides a very simple and inexpensive joint which may be readily assembled and disassembled.

The arrangement shown in Fig. 6 is similar to that just described in connection with Fig. 5, except that the abutting faces 46 of the block 42' and the cap rim 31' are conical and dished together, so that when the bolt 47 is tightened down, the block 42' is not only locked more securely to the floating tube sheet, but the conical connection 46 between each block 42' and the cap rim 31' serves as an additional preventative against rocking or canting of the blocks 42' about the outer periphery of the floating tube sheet 15, since additional tightening of the bolt 47 will cause the block 42' to be wedged more securely into contact with the outer periphery of the floating tube sheet 15 and into its conical seat.

Fig. 7 illustrates an arrangement wherein the laterally extending head 48 of the T-bolt 49 jointly engages the lip 50 of the cap rim 31 and the inner face of the floating tube sheet 15. The gasket 51 lies between the cap rim 31 and the floating tube sheet 15. It will be seen that, as the T-bolt 49 is tightened down, any tendency of the head 48 to rock takes place about lip 50 of cap rim 31 as a fulcrum, so that the opposite or inner end of the head 48 of the T-bolt 49 serves to force the floating tube sheet into more intimate contact with the gasket 51 and the cap rim 31, whereby no rotating or canting of the T-bolts 49 can take place in a counter-clockwise direction.

Fig. 8 is a face view illustrating the arrangement of the T-bolt in this construction.

Figs. 9 and 10 illustrate a bolt 52 having a hook head 53, which overlaps the inner face of the floating tube sheet 15, the lip 54 of the cap rim 31 preventing the hook-headed bolt 52 from moving outwardly or canting away from the outer periphery of the floating tube sheet 15. With this arrangement, it is only necessary to remove or loosen the T-bolt 52 to release the cap 21 from the floating tube sheet 15, and the floating tube sheet and the cap 21 may be as readily assembled simply by inserting and tightening down the bolts 52. The gasket 55 between the floating tube sheet 15 and the cap rim 31 serves to seal the connection between them.

The modifications illustrated in Figs. 11 and 12 and in Figs. 13 and 14 are similar, in that the block 56 overlaps both the lip 57 of the cap rim 31 and the outer face of the floating tube sheet 15, to hold the latter in place against the cap 21 over the gasket 58. Instead of being passed entirely through the block 56, as is the bolt 59 in the arrangement of Figs. 11 and 12, the stud 60 is threaded through the block 56 and is tightened down on its opposite end by means of the nut 61, in the arrangement illustrated by Figs. 13 and 14. In each of these modifications, it is only necessary to release bolt 59 or the stud 60 to release the floating tube sheet 15 from the cap 21 and the cap 21 and floating tube sheet 15 may be as readily assembled by replacing and tightening down the blocks 56 by means of the corresponding bolts 59 or studs 60.

It will be seen that in each of the modifications of the floating head clamping means illustrated and described herein in connection with the invention, the usual sectional or split ring is eliminated and separate spaced clamping members are employed instead, and that these clamping members may take various forms, so long as they individually clamp the floating tube sheet to the cap rim and are so locked to the cap rim and floating tube sheet as to prevent canting or cocking around the outer periphery of the tube sheet. In fact, in the various modifications of the invention illustrated and described herein, the more these clamping members are tightened the less is their tendency to cant or rotate away from or about the periphery of the floating tube sheet. Also, in each case the clamping members may be readily removed separately or with the cap so that the entire tube bundle including the floating tube sheet may be withdrawn through the shell of the heat exchanger, the tube sheet being made of such diameter as to permit its withdrawal through the heat exchanger shell.

Although the invention has been described in conection 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.

I 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, said cap rim having a conical seat in its inner face, and a clamping member having a tapered surface cooperating with the conical seat of the cap rim secured to the latter and overlapping the inner face of the tube sheet.

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, said cap rim having a conical seat in its inner face and said tube sheet having a tapered annular recess in its inner face, and a clamping member having a tapered surface cooperating with the conical cap rim seat and a tapered extension overlapping the inner face of the tube sheet and cooperating with the tapered annular recess thereof.

JOSEPH PRICE.