April 17, 1934. E. F. MILLER 1,955,433

HEAT EXCHANGE APPARATUS

Filed Nov. 23, 1933

Fig. 6.

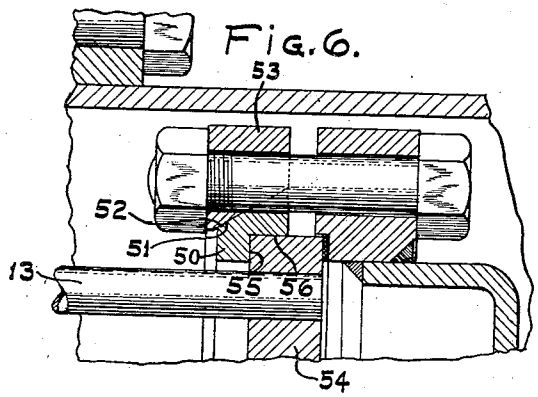


Fig. 3.

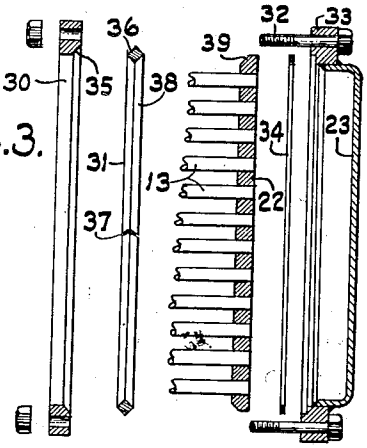


Fig. 4.

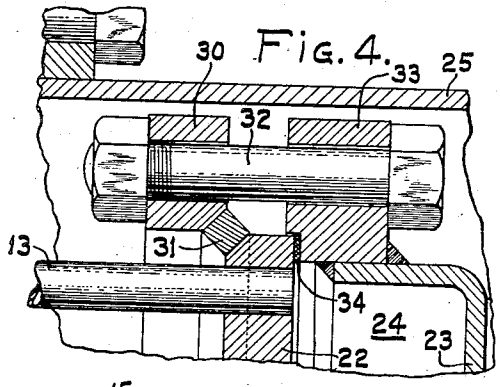
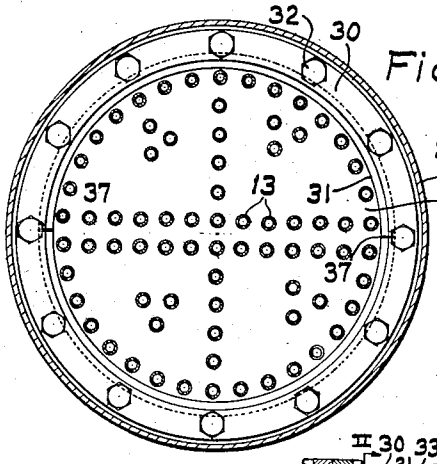


Fig. 2.



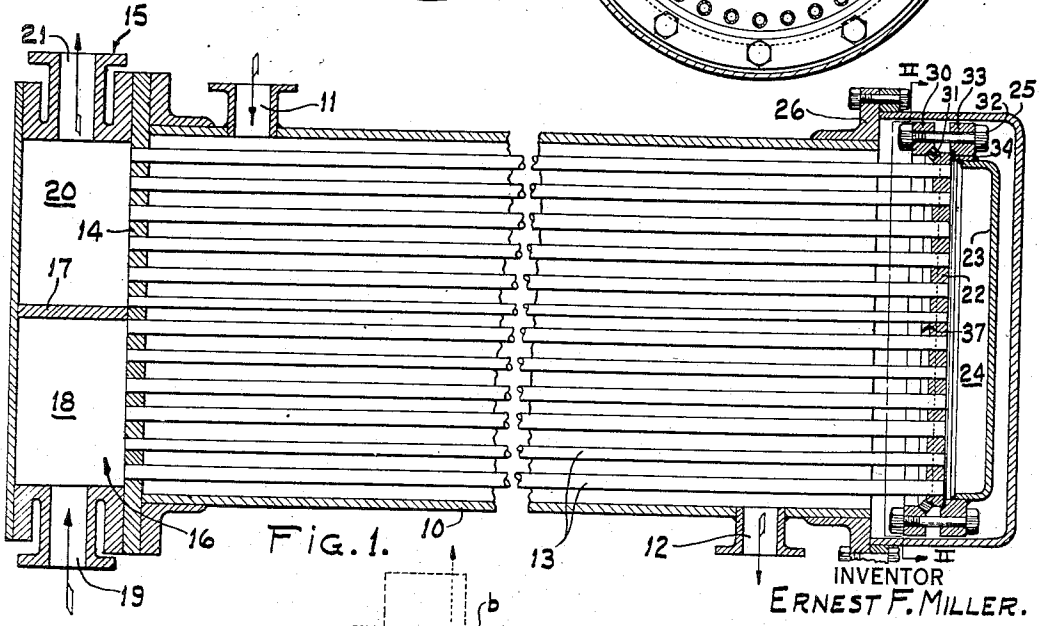


Fig. 1.

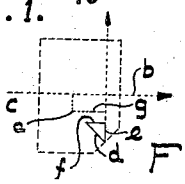


Fig. 5.

INVENTOR
ERNEST F. MILLER.

BY A. B. Rivis
ATTORNEY

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HEAT EXCHANGE APPARATUS

Ernest F. Miller, Prospect Park, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application November 23, 1933, Serial No. 699,441

8 Claims. (Cl. 257—239)

My invention relates to tubular heat exchange apparatus and more particularly to those of the floating-head type and it has for a broad object to provide apparatus of this character which is extremely simple and low in manufacturing cost.

Prior apparatus of this character usually comprises a tubular shell, a nest of tubes extending longitudinally through the shell, a tube sheet for one end of the tubes fixed to one end of the shell, and a floating tube sheet for the other end of the shell slightly smaller in diameter than the shell to permit its longitudinal withdrawal therethrough. An end cover is fixed to the shell and the fixed tube sheet and provides with the tube sheet two or more chambers for the fluid passing through the tubes, which fluid may be either heating fluid or fluid to be heated. At the floating tube sheet end, a floating head is secured to the floating tube sheet to define a return chamber for the fluid flowing through the tubes. A removable end cover surrounds the floating tube sheet and floating head and is fixed to a flange on the end of the shell.

In apparatus of this character heretofore known to me wherein it is desired that the maximum number of tubes be used, the floating head has been secured to the floating tube sheet by clamping means engaging the tube sheet at its periphery and removable for permitting the withdrawal of the tube nest and sheet through the shell. Usually some form of clamping ring is provided which has an inner rim portion engaging the side of the floating tube sheet opposite to the head. Bolts connect the clamping ring and head and serve to draw together the head, tube sheet and clamping ring and thereby exert the desired sealing pressure between the engaging surfaces of the head and tube sheet.

In order that the clamping ring may be readily removed to permit withdrawal of the tube sheet, the ring is made in sections; but sectionalizing of this ring seriously impairs its resistance to bending or twisting stresses resulting from the application of the bolt force to the outer portions of the ring with its inner rim being held by its engagement with the tube sheet. In order to resist effectively these twisting or bending stresses in the clamping ring, some form of heel or strut connection has been used between the peripheral portions of the ring and the head which in some cases is a peripheral flange on the clamping ring. The strut construction has the disadvantage that the bolt effort is divided between the strut connection and the engaging surfaces of head, tube sheet and inner rim of the ring; and it is apparent that in order to exert the proper sealing pressure, the bolts have to be relatively large, which also necessitates a larger clamping ring and flange on the floating head so as to accommodate the bolts and provide for the strut connection. The strut construction had the added disadvantage of requiring extremely accurate dimensions so that when completely assembled and tightened, all surfaces would remain true and square. It is, therefore, a more specific object of the present invention to provide an improved form of clamping means for the floating head and tube sheet of heat exchangers in which effective sealing pressures are provided on the engaging surfaces of tube sheet and head with a relatively small bolt effort and with a relatively small clamping ring and securing flange on the head.

These and other objects are effected by my invention, as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

Fig. 1 is a longitudinal sectional view through a heat exchanger of the floating head type constructed in accordance with the present invention;

Fig. 2 is a transverse, vertical section taken on the line II—II of Fig. 1;

Fig. 3 is an exploded sectional view of the floating tube sheet, head and the clamping means and illustrates more clearly the detail structure thereof.

Fig. 4 is an enlarged fragmentary, transverse section illustrating more in detail my improved means of clamping the head cover to the floating tube sheet;

Fig. 5 is a diagram illustrating the principle of moment opposition involved in the present invention;

Fig. 6 is a view similar to Fig. 4 illustrating a slightly modified form of construction.

According to one preferred embodiment of my invention, an effective sealing pressure is maintained on the engaging surfaces of a floating head and tube sheet by the use of a solid clamping ring having a slightly larger diameter than the tube sheet, a sectional filler or key ring between the clamping ring and tube sheet and bolts connecting the clamping ring and head. The engaging surfaces of the clamping ring and filler ring and the filler ring and tube sheet are chamfered or beveled.

With such a construction warping or twisting stresses in the clamping ring resulting from the

bolt force are resisted effectively, since the reaction to the bolt force is a force at right angles to the chamfered engaging surfaces of the clamping ring and filler ring and this latter force has two components, one radial with respect to the axis of the shell and the other parallel thereto or horizontal. The radial component acts to partially neutralize the moments about the center of gravity of the ring set up by the bolt force; thus converting some of the moments into tension stresses on the clamping ring, but, as the ring is in one piece, the tension stresses are taken care of effectively.

Referring now in detail to the construction illustrated and to the embodiment shown in Figs. 1 to 5, inclusive, the reference numeral 10 designates a tubular shell having an opening 11; which, by way of example, may be for the introduction of fluid to be cooled; and having an outlet opening 12 serving as an exhaust for such fluid. Disposed longitudinally within the shell 10 is a nest or bundle of tubes 13 through which the cooling fluid may flow. Rigidly connected to one end of the tubes and to the shell is a fixed tube sheet 14 having openings therethrough within which the ends of the tubes are secured. A cover or head 15 is disposed at the outside of the tube sheet 14 and is rigidly secured to the tube sheet and shell and defines with the tube sheet a box or chamber 16 for the cooling fluid. A baffle plate 17 is fixed within the box and divides the latter into an inlet chamber 18 having an inlet connection 19 and an outlet chamber 20 having an outlet connection 21.

Secured to the other end of the tubes is a floating tube sheet 22 having a removable head 23 defining therewith a return chamber 24 for the cooling fluid. The floating tube sheet is of a diameter slightly smaller than that of the shell to permit its withdrawal through the shell. An end cover 25 is secured to an end flange 26 on the shell and serves to close the end of the shell.

The structure just described in detail is well known in the art and is susceptible of a variety of changes and uses without departing from the spirit of the present invention. For example, either fluid to be heated or to be cooled may flow through either the shell or the tubes, additional baffle plates 17 may be provided in the chamber 16 and one or more baffle plates in the chamber 24 so as to cause the fluid in the chambers to pass back and forth through the tubes any desired number of times before passing out of the shell. The present invention is not limited to any particular type of construction, use or operation of the conventional elements of heat exchangers, it having to do particularly with an improved means for securing the floating head to the floating tube sheet, as will presently appear.

My improved clamping means comprises a solid clamping ring 30, a filler or key ring 31 and bolts 32 connecting the clamping ring 30 and an end flange 33 fixed to the floating head 23. A gasket 34 is interposed between the end flange 33 and tube sheet 22 to aid in sealing.

The inside diameter of the clamping ring 30 is slightly larger than the outside diameter of the tube sheet 22 to permit its withdrawal over the tube sheet. The inner peripheral portions of the clamping ring are chamfered or beveled to provide an inclined surface 35 which engages a correspondingly chamfered surface 36 on the filler rings 31. (See Figs. 3 and 4.)

The filler ring 31 is of smaller inside diameter than the tube sheet 22 and is sectionalized as indicated at 37 to permit its removal when it is desired to remove the tube sheet 22 through the shell. The filler ring 31 is provided with a second chamfered surface indicated at 38 which engages a correspondingly chamfered surface 39 on the tube sheet 22.

With this construction, a relatively large sealing pressure is exerted on the sealing gasket with a relatively small bolt effort and consequently a relatively small size of clamping ring 30 and head flange 33 is required. With the parts in the position shown in Figs. 1 and 4, the reaction to forces applied by bolts 32 will be at right angles to the chamfered surface 35 which reaction has two components one radial and the other horizontal. The radial component serves to partially neutralize moments about the center of gravity of ring 30 which are set up by the bolt force.

Diagrammatic Fig. 5 indicates the principle of moment opposition involved in connection with the clamping ring. In the diagram, the center of gravity of the clamping ring section is indicated at "*a*". The dotted line "*b*" indicates the direction of the bolt force and "*c*" is the moment arm thereof with respect to the center of gravity of the ring, the effect being a clockwise moment about the center of gravity. The reaction at the chamfered surface is represented by the normal resultant vector "*d*" having the radial and axial components "*e*" and "*f*". The radial component of the reactive force acts with the moment arm "*g*" about the center of gravity, thereby producing a counterclockwise moment with respect thereto. It will be seen that the moments are in opposition, thereby making it possible to use a clamping ring of lighter section and to use smaller bolts than would be the case if the construction were such that the principle of opposed moments could not be utilized.

As the ring 30 is solid in construction the remaining moments will be effectively neutralized by twisting stresses in the ring. In my construction the element 31 which is the one sectionalized, serves only as a compression member and therefore is not called upon to resist bending stresses as was the case of the prior art structures heretofore described. By reason of the fact that the element 30 is solid and the bolt force is resisted through surfaces inclined to the axis of the shell, no heel or strut connection is necessary, consequently small bolts and small rings may be used.

In providing chamfered surfaces 36 and 38 on a ring such as 31 which can be readily made from bar stock, the cheapest way is to make the angle of chamfer at 45° to the axis of the shell. However, my invention in its broader aspects is not limited to any particular angle, for example, if the chamfered surface be provided by machining, such as is disclosed in the modified construction shown in Fig. 6, the angle may be at 30° to the axis of the shell or at any angle so long as the beneficial results of the present invention are accomplished.

In Fig. 6, I have shown a modified form of sectional filler or key ring 50, having a chamfered surface 51 engaging a correspondingly chamfered surface 52 on a solid clamping ring 53. In this construction the filler ring has no chamfered surface engaging the floating tube sheet 54, the engagement being effected by right angle surfaces 55 and 56 engaging respectively the vertical face and peripheral face of the tube sheet. However, the effect of the forces applied

by the bolts 32 is the same as in the previously described modification and the benefits derived from the use of this construction are the same, the difference being that the ring 31 is slightly cheaper to manufacture.

An additional advantage of the use of a solid clamping ring and chamfered engaging surfaces, is that more tolerance is permitted in the manufacture of the parts. As before stated, in the prior art constructions, the engaging surfaces had to be extremely accurate. However, in the present construction, adequate engagement of the chamfered surfaces can be effected even though there be slight inaccuracies, the surfaces merely sliding on one another until a firm engagement is effected.

While I have shown my invention in two forms, it will be obvious to those skilled in the art that they are not so limited, but are susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In a heat exchanger of the floating-head type, the combination of a shell; a tube bundle therein; a floating tube sheet for the tube bundle of a diameter smaller than the shell to permit withdrawal through the latter; a floating head cover for the tube sheet having a rim portion engaging the outer face of the tube sheet; and means for clamping the head cover against the tube sheet comprising a clamping ring disposed at the side of the tube sheet opposite the cover and being of a diameter slightly larger than the tube sheet, the inner edge of the clamping ring adjacent the tube sheet being chamfered, spacing means abutting the tube plate in opposition to the cover rim portion and being chamfered for engagement with the chamfered surface of the clamping ring, and connecting means between the head cover and clamping ring for drawing the parts firmly together.

2. Apparatus according to claim 1 wherein the clamping ring is formed in one piece.

3. Apparatus according to claim 1 wherein the engaging surfaces of the spacing means and tube sheet are also chamfered.

4. Apparatus according to claim 1 wherein the connecting means between the clamping ring and head cover comprises bolts passing through the clamping ring and an end flange provided on the head cover.

5. In a heat exchanger of the floating-head type, the combination of a shell; a tube bundle therein; a floating tube sheet for the tube bundle of a diameter smaller than the shell to permit withdrawal through the latter; a floating head cover for the tube sheet having a rim portion engaging the outer face of the tube sheet; and means for clamping the head cover against the tube sheet comprising a clamping ring disposed at the side of the tube sheet opposite the cover and being of a diameter slightly larger than the tube sheet, the inner edge of the clamping ring adjacent the tube sheet being chamfered, a sectional ring having one side engaging the inner surface of the tube sheet and having its other side chamfered and in engagement with the chamfered surface of the clamping ring, and connecting means between the head cover and clamping ring for drawing the parts firmly together.

6. Apparatus according to claim 5 wherein the angle of chamfer of the engaging surfaces of both the clamping ring and sectional ring is approximately 45° with respect to the longitudinal axis of the shell.

7. Apparatus according to claim 5 wherein both the engaging surfaces of the clamping ring and sectional ring and the engaging surfaces of the sectional ring and tube sheet are chamfered, and the angle of chamfer of both sets of surfaces is approximately 45° with respect to the longitudinal axis of the shell.

8. In a heat exchanger of the floating head type, the combination of a shell; a tube bundle therein; a floating tube sheet for the tube bundle having an outside diameter smaller than the inside diameter of the shell to permit withdrawal through the latter; a floating head cover for the tube sheet having a rim portion engaging the outer face of the tube sheet; and means for clamping the head cover against the tube sheet comprising a clamping ring disposed at the side of the tube sheet opposite the cover and having an inside diameter slightly larger than the outside diameter of the tube sheet, spacing means abutting at one side thereof the tube sheet in opposition to the cover rim portion and abutting at the other side thereof the clamping ring, the engaging surfaces of the tube sheet and spacing means being chamfered, and connecting means between the head cover and clamping ring for drawing the parts firmly together.

ERNEST F. MILLER.