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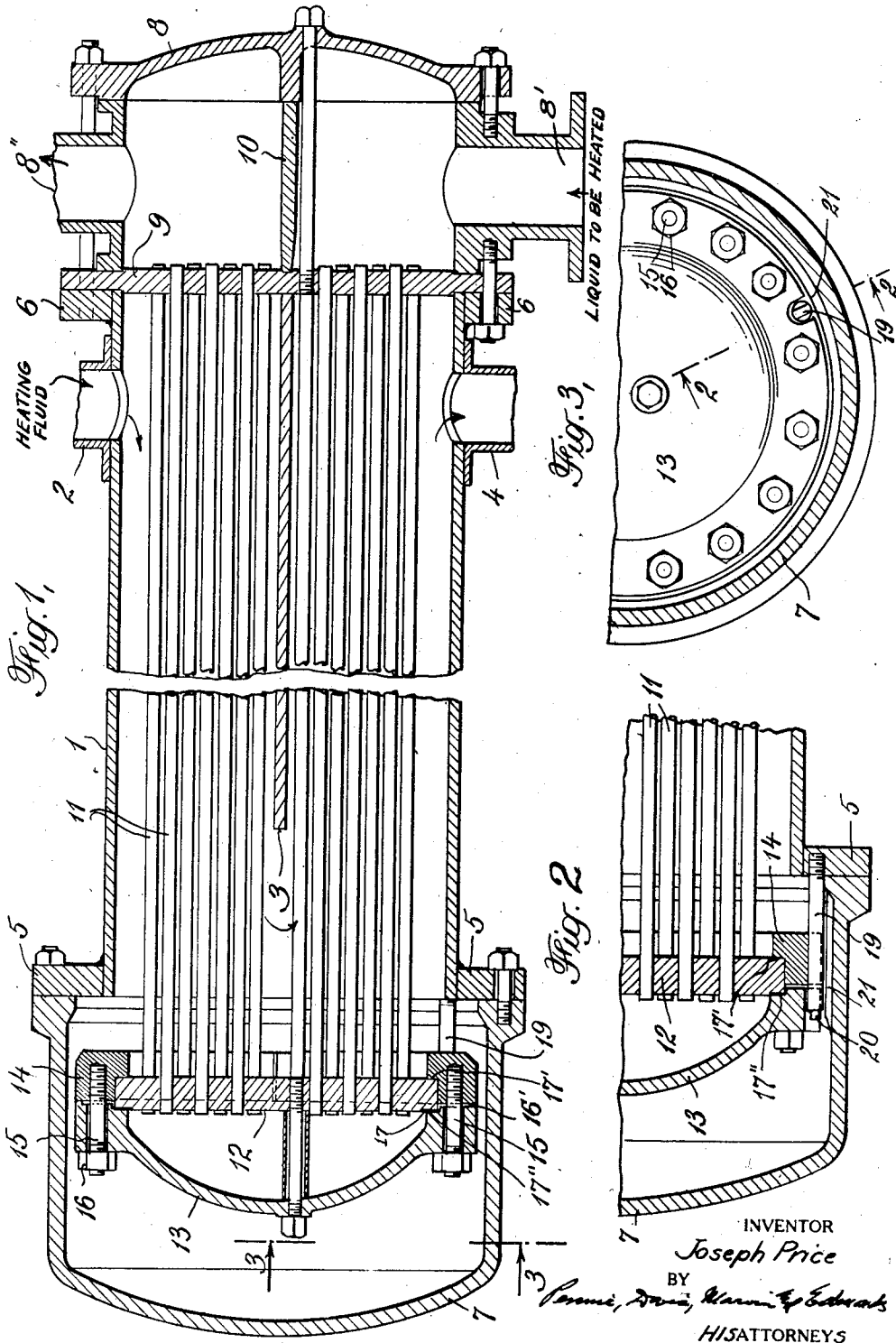
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1,773,199

HEAT EXCHANGER

Filed Jan. 11, 1927

4 Sheets-Sheet 1



Aug. 19, 1930.

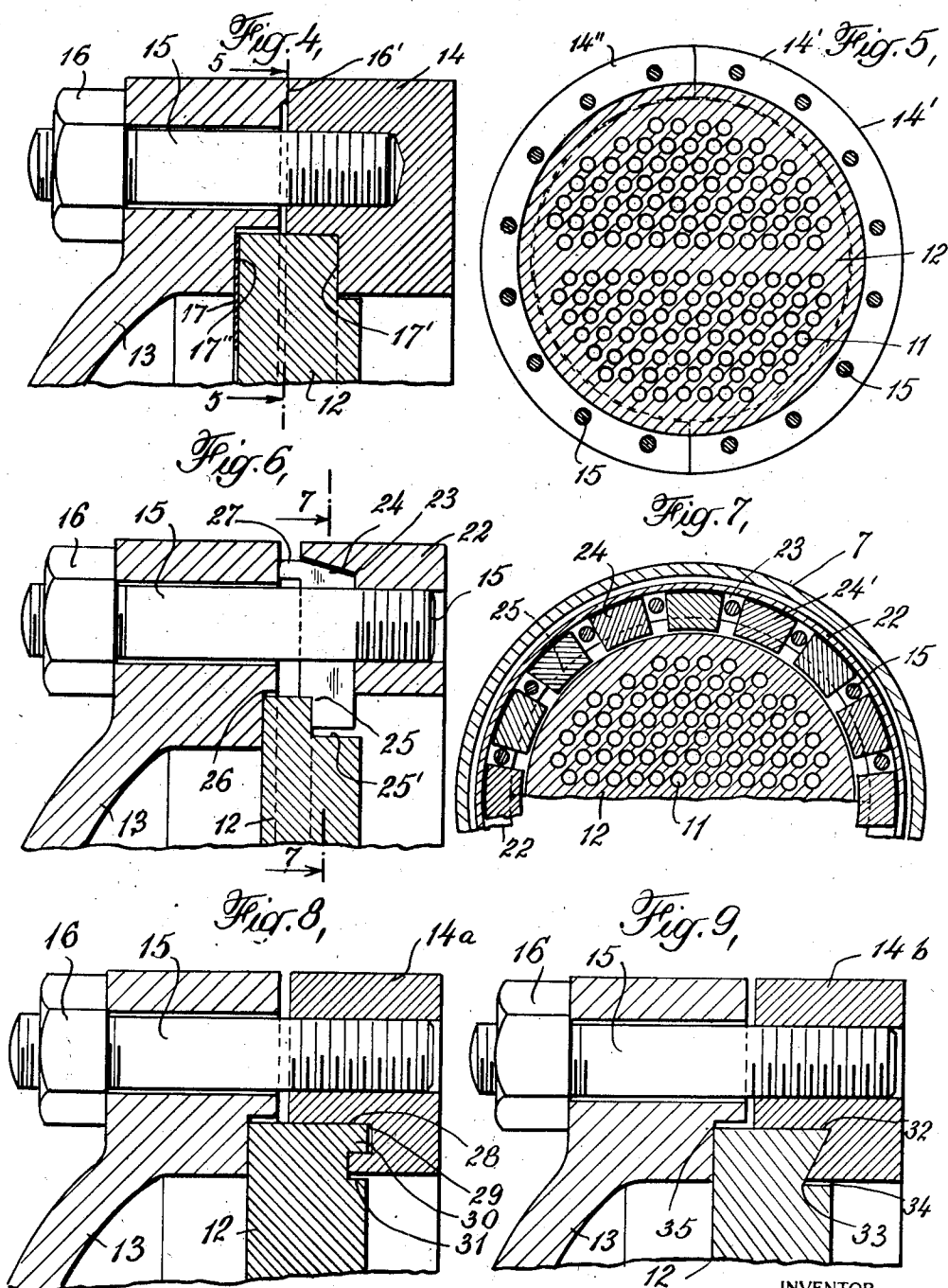
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HEAT EXCHANGER

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4 Sheets-Sheet 2



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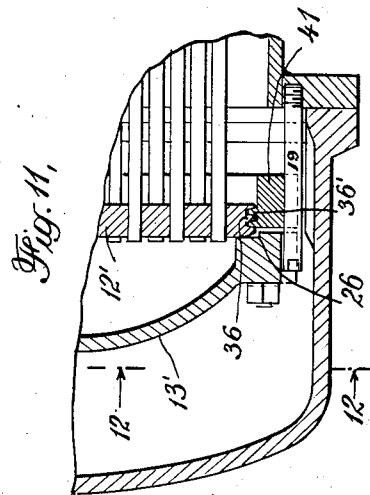
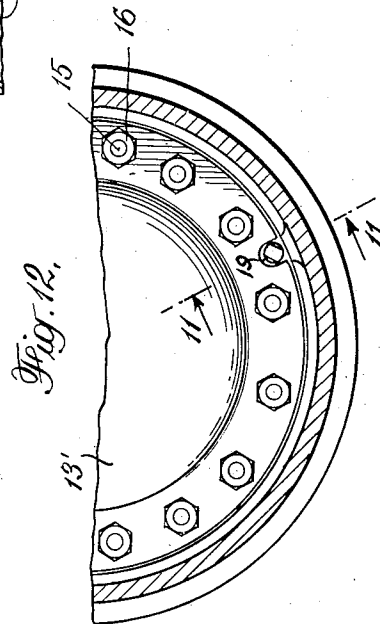
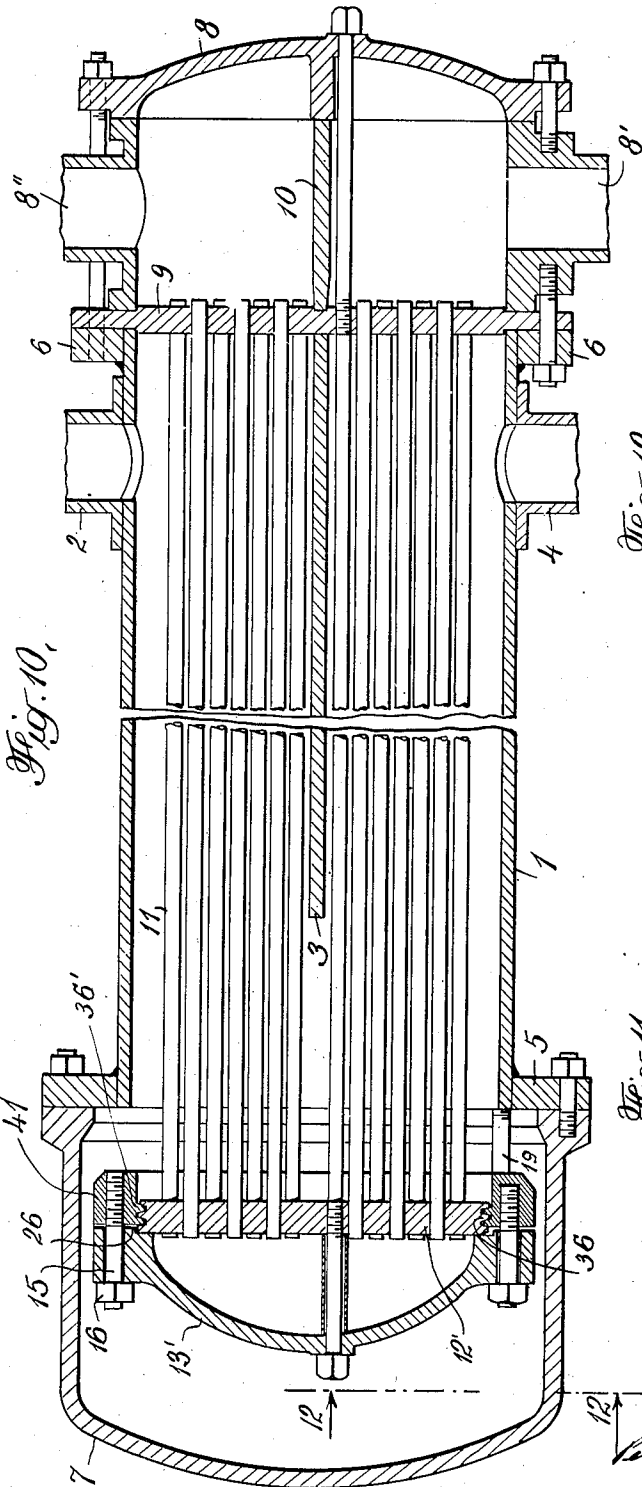
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HEAT EXCHANGER

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4 Sheets-Sheet 3



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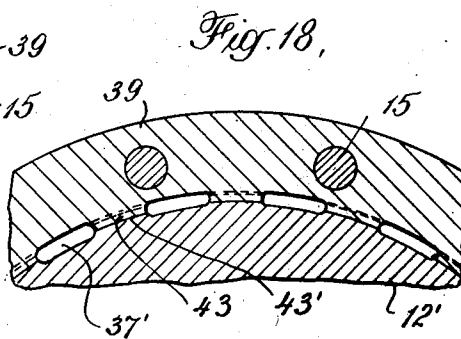
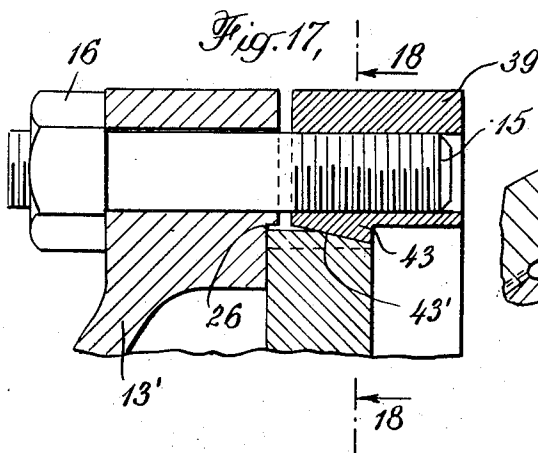
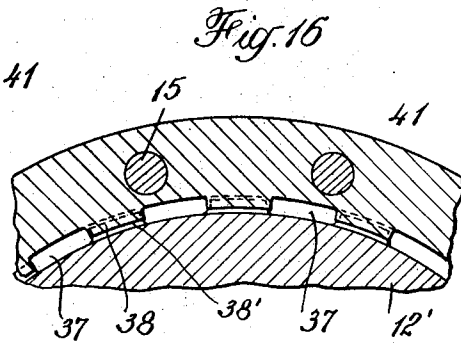
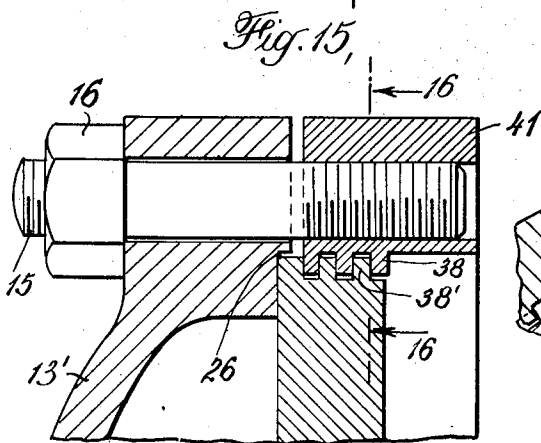
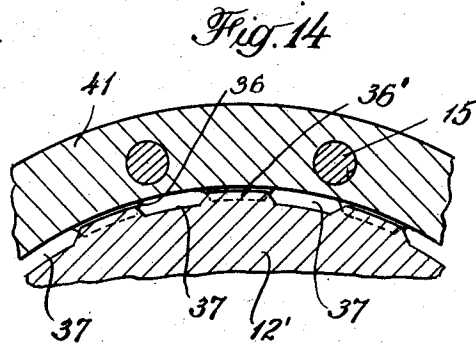
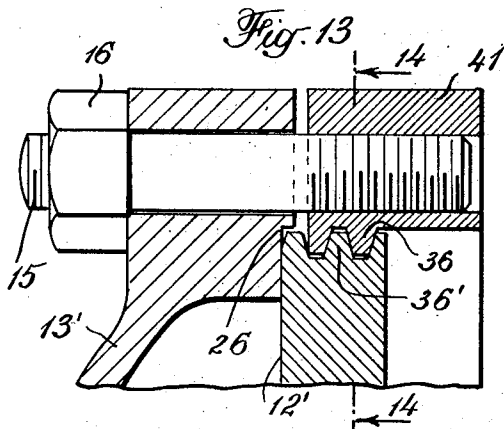
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HEAT EXCHANGER

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4 Sheets-Sheet 4



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HEAT EXCHANGER

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

Such heat exchangers are used chiefly in transferring heat between two liquids, such for example as in oil refining operations, and in transferring heat between a liquid and a vapor or gas, as for example in steam power plants and industrial establishments. When used for transferring heat between two liquids, one liquid, for example oil, is passed through the shell of the exchanger and comes into contact with the exterior surfaces of the heating tubes, while the other liquid, for example water, is sent through the interior of the tubes. In transferring heat between a liquid and a gas or vapor, the gas or vapor such, for example, as steam, is usually passed into the shell, and the liquid forced through the tubes.

The particular form of shell-and-tube heat exchanger which this invention concerns is that form in which the tubes are secured at each end to a pair of spaced tube sheets, and suitable chambers are provided at each tube sheet to conduct the water first through a portion of the tubes and then return it through a different portion thereof before allowing it to leave the apparatus. The water therefore makes two or more passes through the tube bundle before being discharged.

Provision must be made for relative expansion between the shell and the tubes in as much as it is frequently desirable to make the tubes of different metal from that of the shell. Thus the tubes might be made of copper and the shell of steel, and these metals having different coefficients of expansion, a greater lengthening or shortening of the tubes as compared with the shell will take place for a given temperature change. Moreover, even when the tubes and shell are made of the same metal, there is not infrequently a difference in temperature between the interior of the tube bundle and the surface of the shell which will set up expansion strains.

One very practical way of taking care of this question of expansion is found in the floating head construction which has come into quite general use. In this form of construction only one of the tube sheets is secured fast to the shell, while the other tube sheet, i. e. the "floating" tube sheet, is so supported as to allow it to move bodily within the shell when expansion or contraction takes place. The cap or other element which forms the chamber or chambers for receiving the fluid from one portion of the tube and redirecting it into another portion of the tubes is secured to the floating tube sheet and moves with it.

It is highly desirable to construct such heat exchangers so that the tube bundle, including the two tube sheets, can be removed as a unit from the shell for the purposes of occasional repair and the periodical cleaning which the use of oil and other viscous liquids entails. It is also important that the tube bundle, as nearly as possible, fill the interior of the shell so as to prevent short circuiting, i. e., the tendency of the fluid within the shell to pass along the space between the outer layer of tubes and the shell instead of passing into the interior of the tube bundle into contact with the surface of the tubes.

The principal object of the present invention, however, is to provide a heat exchanger of the floating head type of improved construction in which the outside diameter of the tube bundle is only slightly smaller than the inside diameter of the shell, the tube bundle therefore substantially filling the interior of the shell, the floating head being of an improved construction, whereby, among other advantages, the cap forming the floating chamber may be readily removed from the tube sheet, and the tube bundle then removed as a unit from the shell.

A further object of the invention is to provide an improved form of clamping device for securing the cap to the floating tube sheet, through the use of which the cap member can be readily removed from the tube sheet in an improved manner in disassembling the heat exchanger.

It is also an object of the present invention

to provide such a clamping device as will permit the removal of the device either in easy stages, as by sections, or as a single unit, when it is desired to take the tube bundle unit out of the shell.

While it has been proposed to engage tube-sheets with cap-members by means other than bolting the caps directly to the tube-sheet, as by means of certain particular kinds of so-called sectional clamping rings, these proposed structures fail to accomplish the above objects in a satisfactory manner. The chief difficulty encountered with those structures employing such means as divided clamping rings is the tendency of the split clamping-ring sections, to rotate about the inner edge of the outer periphery of the tube sheet. This occurs when the clamping bolts and nuts are set up.

A particular object of the present invention is to provide a heat exchanger having a clamping device which will prevent binding, springing, or "cocking", when stress is put on the device to cause it to perform its clamping functions.

Another particular object of the present invention is to provide improved means for carrying the weight of the tube bundle and tube sheet when the shell cover and floating head cap are removed for the withdrawal of the tube bundle.

A still further particular object of the present invention is to make possible such an interchangeable construction at the floating head end of the tube bundle that greatly varying temperatures of refinery work may be carried out by merely substituting a different composition of clamping device to coact with the cap member and tube sheet, which therefore can be made of different materials, or the cover can be made of that special composition which is the best for the high temperature work in question though this material may not be hard or tough enough to hold alone the necessary tap-bolts, which can by the present invention, be tapped into the clamping device itself.

The invention will be better understood by referring to the accompanying drawings, in which there is illustrated by way of example a heat exchanger intended chiefly for the purpose of transferring heat between water and oil, in oil refining operations. In these drawings,

Fig. 1 is a longitudinal section of a heat exchanger embodying the preferred form of floating head construction;

Fig. 2 is a detail sectional view of the floating head construction shown in Fig. 1, sighting from behind the stud 19 therein;

Fig. 3 is a fragmentary transverse section taken on line 3—3 of Fig. 1, illustrating the manner of supporting the floating head for expansion and contraction, and for removal of the tube bundle;

Fig. 4 is a fragmentary, detail section illustrating a modification of the floating head construction illustrated in Fig. 1;

Fig. 5 is a view on reduced scale of the floating head construction of Fig. 4, along line 5—5 of Fig. 4;

Fig. 6 is a detail view of another modification of the floating-head construction shown in Fig. 1;

Fig. 7 is a view on a reduced scale of the floating head construction of Fig. 6, along line 7—7;

Fig. 8 is a detail view of a further modification of the floating head construction shown in Fig. 1;

Fig. 9 is a detail view of a still further modification of the floating head construction shown in Fig. 1;

Fig. 10 is a longitudinal section of a heat exchanger embodying a still further modification of the floating head construction of Fig. 1;

Fig. 11 is a detail view of the floating-header end of Fig. 10;

Fig. 12 is a fragmentary transverse section taken on line 12—12 of Fig. 11;

Fig. 13 is an enlarged view of a portion of Fig. 10;

Fig. 14 is a detail view of the structure shown in Fig. 13, along line 14—14;

Fig. 15 is a detail view of a modification of the floating-head construction shown in Fig. 10;

Fig. 16 is a detail view of the structure shown in Fig. 15, along line 16—16;

Fig. 17 is a detail view of a further modification of the floating-head structure of Fig. 10; and

Fig. 18 is a detail view of the structure of Fig. 17 along line 18—18.

Referring to the accompanying drawings, and particularly to Figs. 1 to 5 inclusive, the invention comprises a heat-exchanger having a casing or shell 1 of any suitable form to handle a fluid such as oil, and provided with an oil inlet 2 on its upper surface, a baffle plate 3 extending horizontally through its middle, an outlet 4 on its lower surface, flanges 5 and 6 at opposite ends of the shell, a shell cover 7 rigidly secured to the flange 5 at one end, a rigid plate or tube-sheet 9 at the other end, and a partitioned header 8 secured to the flange 6 over the tube-plate 9. A partition 10 in the header 8 engages with the tube-sheet in any suitable manner, and the header has a water inlet 8' and outlet 8'', and extending longitudinally of the shell therefrom, and projecting into the shell-cover 7, are a series of liquid-type tubes 11 forming a unitary rigid tube-bundle. The shell-cover ends of these tubes are anchored in the specially constructed floating-tube-sheet 12, which is made of a diameter only slightly larger than the perimeter of the tube-bundle, and just enough smaller in di-

ameter than the shell to permit it to readily slide therethrough towards the other end of the shell, carrying one end of the tube bundle, and supported on the interior of the shell.

The floating-head cover or cap-member 13 is of a considerably larger diameter than the shell itself, and is securely attached to the tube-sheet 12 over a gasket 17 by a clamping device comprising the ring 14 and the stud bolts 15 and nuts 16. This clamping ring 14 is made in two or more arcuate sections, shown as 14' and 14'' in Fig. 5, in order to permit the removal of the ring 14 and floating chamber head 13 when it is desired to remove the tube bundle from the shell. Thus the floating chamber header 13 need not be bolted to the tube-sheet, which would then have to be of the same composition as the chamber header, but is clamped thereto with a three-point contact, comprising the riding lip 16', bearing against the split ring 14, annular groove 17'' in the header 13, bearing against the outer flat or gasketed side of tube sheet 12, and the annular groove 17' on the outer internal edge of the split ring bearing against the flat plane inner side of the tube-sheet 12.

The chief purpose of the above described three-point contact is to positively obviate any possibility of the sections of the split clamping ring springing or cocking, or canting by rotation about the corner of the tube-sheet under the stresses set up by tightening the nuts 16. If the ring attempts to cant around the inner corner of the tube-sheet, then bearing will occur on the anti-cocking lip 16', and also on the outer circumferential surfaces of the tube sheet. It will hence be seen that the annular formation 16' referred to as a "riding lip", "anti-cocking lip", or "lug" can, without departing from the essence of this invention, satisfactorily be formed either on the split-ring, or on the cap-member, and it is contemplated by the present invention to place it wherever it can be most conveniently or economically placed.

In order to provide a riding support for the complete floating head to allow it to move under action of expansion and contraction of the tubes, and to support the tube-sheet and clamping ring while the rest of the tube bundle is being disassembled, a stud bolt 19 is tapped into the flange 5 as shown in Fig. 2, and may have its head shaped as at 20 to engage with a wrench or other removing tool. There may also be provided on the shell-cover 7, a guideway 21, shown in Figs. 2 and 3.

Removal of the tube bundle is effected by removing the shell cover 7, then removing the floating head cover 13, removing the upper sections of the split ring 14, jacking up the floating tube sheet 12 to a height equal to the gasket-bearing 17, removing the lower sec-

tions of the split ring and then readily withdrawing the entire tube bundle from the stationary end.

In Figs. 6 and 7, there is shown a variation of the structure for effecting the improved engagement hereinbefore described between the floating tube-sheet and floating cap member. This structure accomplishes the objects of the invention by means of a solid ring 22, larger in diameter than the tube-sheet, and hence removable thereover as a unit, and having therein an annular groove or socket 23 encircling the upper inner edge of the ring and having a series of studs 15 tapped at proper intervals around its periphery. Between each two of these studs is inserted a section 24 of the clamping ring proper 24'. Each section of the ring 24' fits into and against the socket 23 by its outer edge and has its inner edge overhanging the inner edge of the solid ring 22. These ring sections are recessed at 25 for the reception of the tube-plate, which itself has a complementary recess 25', and the tube-sheet engages with the header 13 by means of an annular groove 26 therein, its outer face being flat and without any grooves, recesses or other formations. To prevent springing or cocking of the ring sections 24 when the nut 16 is set up, there is provided an annular lip or lug 27 on the outer upper periphery of each one of the sections 24, which constitutes the second member of an improved and advantageous three-point contact system, the other members of which are the groove 25 and the bolt 15 middling between them. It is also contemplated by the present invention to locate the anti-cocking formations on the contact periphery of the cap-member 13, and in this case, the sections of the split ring 24' can advantageously be made perfectly flat and plane.

In all of the foregoing modifications of that typical form of the present invention which is completely disclosed in Fig. 1, there has been employed a three-point contact between the various elements of the clamping devices, chiefly for the purpose of preventing cocking, that is, the stud bolts have been "middling" between the reaction-stresses it creates upon being tightened. It is also contemplated by the present invention to prevent cocking, canting, springing or binding, by moving the points of contact interiorly of the stud-bolts, and thus reducing the number of contact points to two only, without departing from the spirit of the invention.

In Fig. 8 there is shown a variation of the preferred form of engagement between the header, tube-sheet and split clamping ring which has an annular groove 26 in the inner edge of the flange of the header to receive the flat, square edge of the tube-plate, while the inner upper edge of the clamping ring 14' has a recess 28 and groove 29, as shown, to engage with a complementary tongue 30 and groove 130

31 on the inner periphery of the tube-sheet. Cocking is entirely obviated by this structure.

This structure thus makes it possible to employ the heat-exchanger of the present invention in many industries by substantially lowering the cost of the improved heat-exchangers of the present invention, as they can, by the use of this form, be produced at a much more economical figure, and yet this variation, for certain work, is entirely satisfactory.

In Fig. 9 there is disclosed another structure which is capable of accomplishing the objects of the invention in the same manner, and this variation comprises an undercut or dovetailed annular groove 32 in the upper edge of the inner periphery of the split clamping ring 14^b, a complementary groove 33 in the inner face of the tube-sheet, with a slight clearance 34 between the dovetailing surfaces to allow for expansion, and an annular recess 35 in the lower edge of the header for receiving the outer upper edge of the tube-sheet, the outer face of which is perfectly flat and without grooves or other formations. Thus the anti-cocking tit is eliminated altogether, and the number of contact points reduced to two.

This particular formation of the parts of the present invention is especially susceptible of quick and inexpensive quantity production, and hence meets the demand for large quantities of small, cheap heat exchangers of the present novel and improved type.

In order to adapt the inventive idea to heat exchangers for certain particular types of work, such as very high temperature work, the present invention also contemplates the use of a single, solid ring to carry the studs for clamping the cap-member to the tube sheet in such a manner that the ring may be removed from the stripped tube-bundle with the minimum number of motions, in fact, with a single slight rotation and a pull, and no repetition of motion, or separate parts. Also, since it is sometimes desirable that the clamping stress be applied directly and solely upon the joint itself, the present invention contemplates a form of solid ring engagement with the tube-sheet which reduces the number of contact points of the clamp to two, at the same time applying the clamping pressure to the joint itself, and increasing this pressure, since the tightening up stress is not divided between an anti-cocking lug and the tube-sheet joint.

Referring first to Figs. 10 to 14 inclusive, the header 13' is held against the tube sheet 12' by means of a ring 41, bolts 15 and nuts 16. Ring 41 is a solid or continuous ring instead of being made in sections. This ring however is readily removable from the tube sheet for the purpose of removing header 13' so as to permit the tube bundle to be removed from the shell.

To provide a sturdy means of connection

between the ring 41 and tube sheet 12', and at the same time arrange for the quick removal of the ring, the following construction is used. On the internal periphery of ring 41 and the external periphery of tube sheet 12' coacting interlocking members are provided these being distributed in a plurality of groups 36 and 36' separated by spaces or slots 37.

The interlocking members of each group consist of a plurality of similar arcuate tongues or projections equally spaced from side to side of the tube sheet. As shown in Fig. 13 the tongues on ring 41 fit into the spaces between the tongues on the tube sheet with a sort of mortise and tenon interlock. The cross section of the tongues here shown is approximately that of the Acme screw thread, but the tongues are parallel to the faces of the tube sheet and not helical.

As shown in Fig. 14 the groups of tongues 36 on ring 41 are opposite and in engagement with the corresponding groups of tongues 36' on tube sheet 12'. With the parts in this position nuts 16 can be tightened and the gasket face 26 of the header 13' will be firmly pressed against the outer face of the tube sheet 12'. Upon loosening nuts 16, however, the header and ring may be slipped around, i. e. rotated slightly and the groups 36 of tongues on the ring will thus be angularly displaced and brought opposite the spaces or slots 37 between the groups 36' of tongues on the tube sheet. Now the ring 41 may be pulled longitudinally off of the tube sheet.

All the other elements described in connection with Fig. 1 may be incorporated in this modification without change, or with any changes which do not interfere with the proper location and functioning of the foregoing structures, and in Figs. 11 and 12 is shown the riding stud and guideway of Fig. 1 incorporated in this modification.

This particular modification gives rise to many advantageous results, outstanding among which may be mentioned the increased ease of manipulation, positiveness of engagement, and reduction of the three-point clamping contact to a two-point contact, and increased pressure because the stress of the bolt is not divided.

In Figs. 15 and 16 is shown a variation in the shape of some of the parts of the structure of Figs. 13 and 14, differing therefrom principally in having the interlocking members 38 on the clamping ring and tube sheet of a square shape, retaining the same slots 37, at the same time also increasing the strength of the joint by increasing the number of mortises and tenons in each group 38, 38'. This modification functions in accomplishing the objects of the invention in substantially the same way as the preceding modification, and is engaged and disengaged in exactly the same way.

In Figs. 17 and 18 is shown another form of the floating head structure of Fig. 10. This formation and arrangement of parts embodies the inventive idea of a floating tube sheet disengageably clamped to a floating header, by employing a solid clamping ring 39 provided around its inner periphery with a series of equi-distant wedge-members 43, alternating with clear spaces or slots 37', and the floating tube sheet is provided on its periphery with complementary wedge shaped members 43', likewise alternating with clear spaces or slots 37. The outer face of the tube sheet fits into an annular recess 26 in the lower inner periphery of the cap member. For fluid tightness, a ring gasket may be fitted therein in the well known manner.

This modification functions in a manner similar to the preceding forms. The floating header structure is disassembled by merely removing the header, rotating the solid ring until the wedge members register with an opening 37 or 37', and then slipping the ring outwardly off the tube sheet.

I claim:

1. A heat exchanger of the class described having a shell, a tube bundle therein, a floating tube-sheet slidably supporting one end of said tube bundle within the shell, a flange on said shell at the floating tube sheet end thereof, a cap member for said tube sheet, means for securing said cap member to said tube sheet including a sectional ring associated with said tube sheet and with the cap member, and a stud bolt tapped into the lower arc of said flange and slidably engaging one of said ring sections whereby said floating tube sheet is slidably supported to permit expansion and contraction of the tubes.

2. A heat exchanger of the class described having a shell, a tube bundle therein, a floating tube sheet for slidably supporting one end of said tube bundle within the shell, a flange on said shell at the floating tube sheet end thereof, a cap member for said tube sheet, means for securing said cap member to said tube sheet including a sectional ring associated with said tube sheet and with the cap member, and a support secured to the lower arc of said flange for slidably engaging one of said ring sections whereby said floating tube sheet is slidably supported to permit expansion and contraction of the tubes.

3. A heat exchanger of the class described having a shell, a tube bundle therein, a floating head for one end of said tube bundle comprising a movable tube sheet for supporting one end of the tube bundle within the shell, and a cap for said tube sheet and removably secured thereto, a flange on said shell at the floating tube sheet end thereof, and a stud bolt tapped into the lower arc of said flange and slidably engaging said floating head whereby said floating tube sheet is slidably

supported to permit expansion and contraction of the tubes.

4. In a heat exchanger having a shell, a tube bundle substantially filling the interior thereof, a stationary tube sheet for one end of the tube bundle removably secured to the shell, a movable tube sheet for the opposite end of the tube bundle comprising a disc sufficiently smaller than said shell to be easily removable therethrough, a cap for said movable tube sheet of a larger diameter than the shell having a rim engaging the outer face of said disc, a sectional ring engaging the outer periphery of the rim of said cap and having a lip engaging the inner face of said disc, and a plurality of loosely fitting bolts for fastening said ring sections to said cap and thereby clamping the cap to the disc.

5. In a heat exchanger having a shell, a tube bundle substantially filling the interior thereof, a tube sheet for one end of the tube bundle removably secured to the shell, a movable tube sheet for the opposite end of the tube bundle comprising a disc sufficiently smaller than said shell to be easily removable therethrough, a cap for said movable tube sheet of a larger diameter than the shell having a rim engaging the outer face of said disc and a ridge extending around the periphery of said rim, a sectional ring having a lip engaging the inner face of said disc and said peripheral ridge on the rim of the cap, and a plurality of loosely fitting bolts for fastening said ring sections to said cap and thereby clamping the cap to the disc.

6. In a heat exchanger having a shell, a tube bundle substantially filling the interior thereof, a tube sheet for one end of the tube bundle removably secured to the shell, a movable tube sheet for the opposite end of the tube bundle comprising a disc sufficiently smaller than said shell to be easily removable therethrough, a cap for said movable tube sheet of a larger diameter than the shell having a rim engaging the outer face of said disc, a sectional ring having a lip engaging the inner face of said disc, a narrow spacing ridge interposed between said sectional ring and the rim of the cap at the periphery of said sectional ring, and a plurality of loosely fitting bolts for fastening said ring section to said cap and thereby clamping the cap to the disc.

In testimony whereof I affix my signature.

JOSEPH PRICE.