May 9, 1933. O. W. HEIMBERGER ET AL 1,908,611

HEAT EXCHANGER

Filed Dec. 10, 1931 2 Sheets-Sheet 1

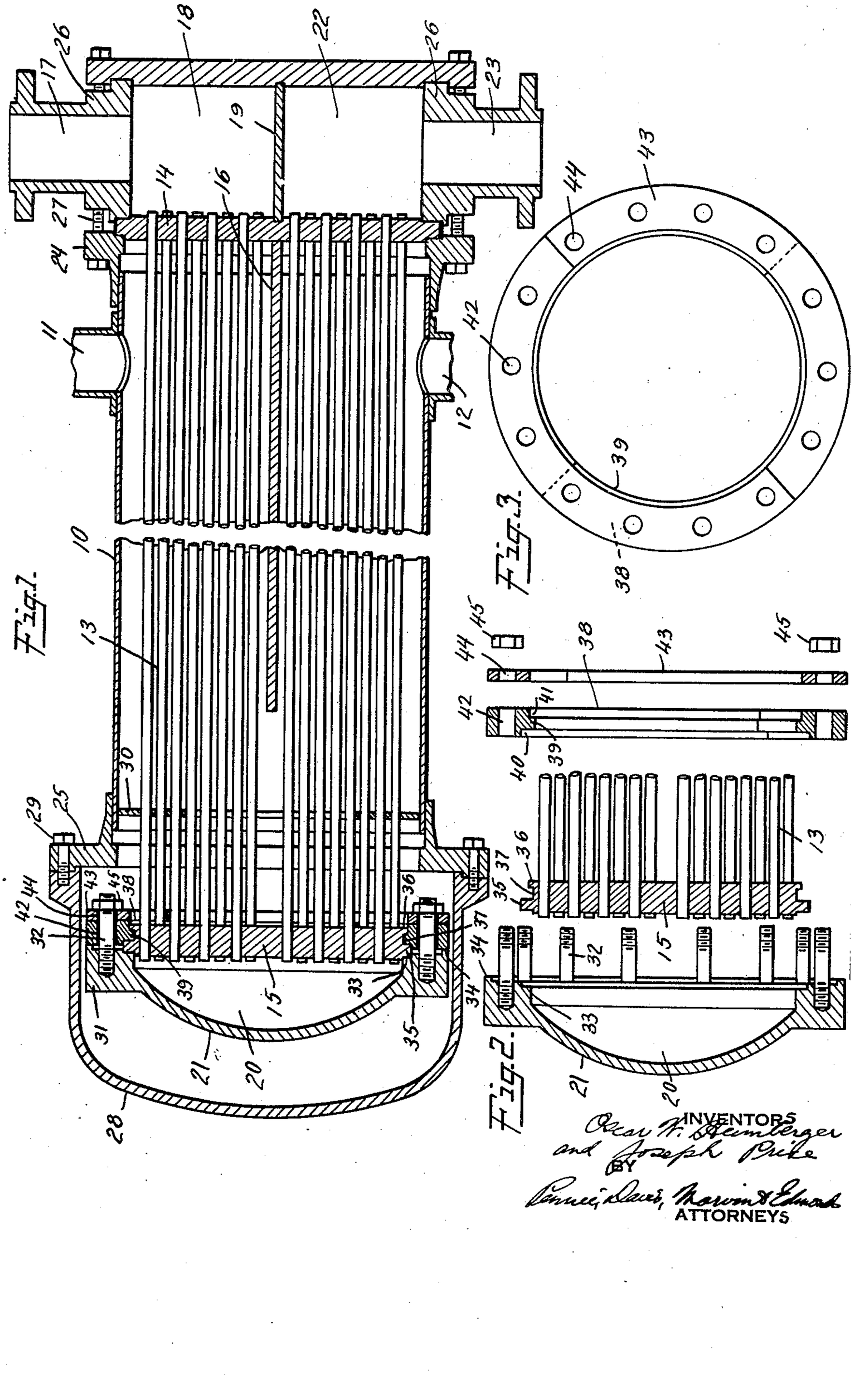

Fig. 1.

Fig. 3.

Fig. 2.

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Fig. 4.

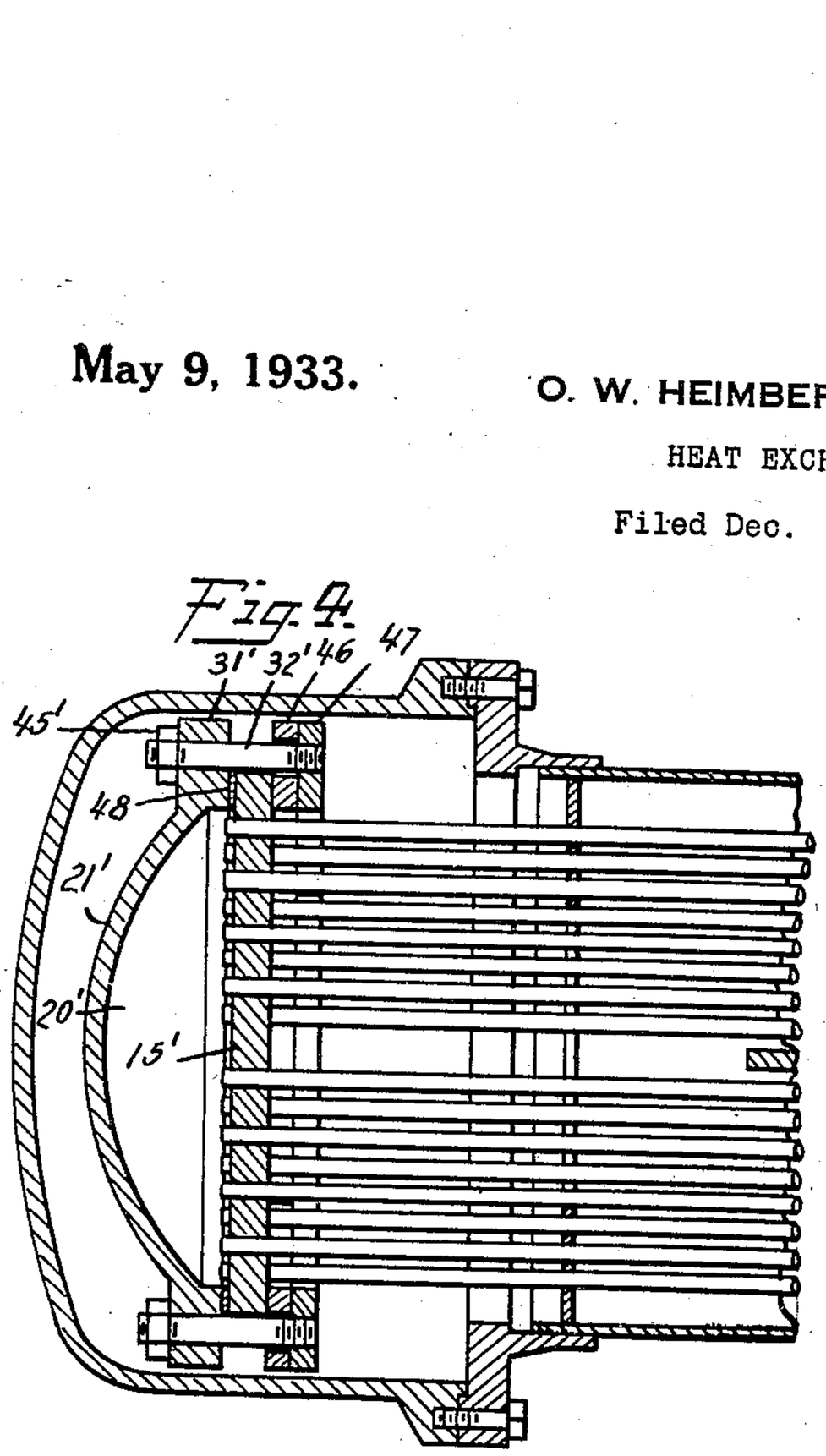


Fig. 5.

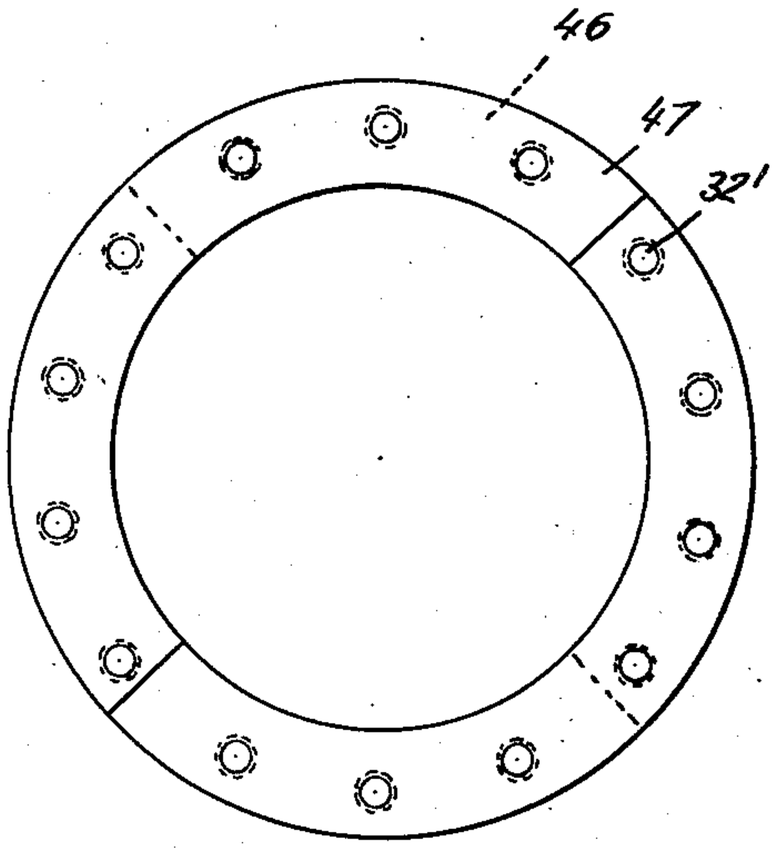


Fig. 6.

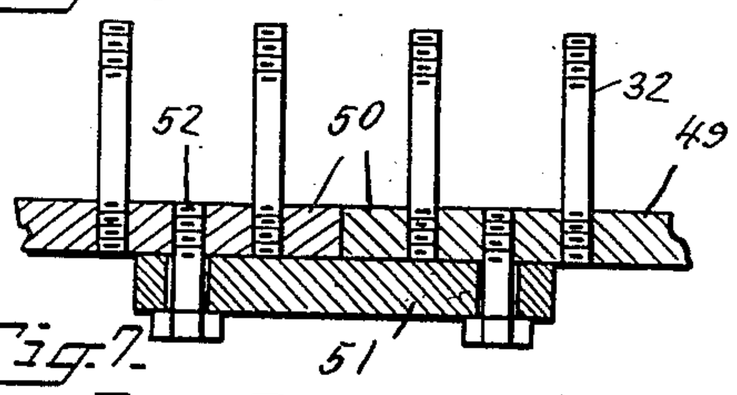


Fig. 7.

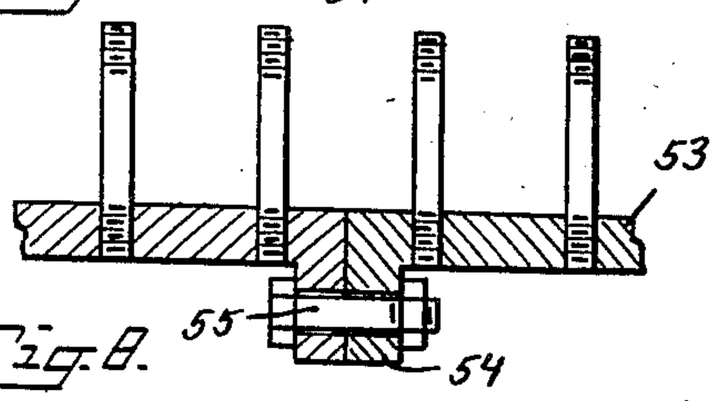


Fig. 8.

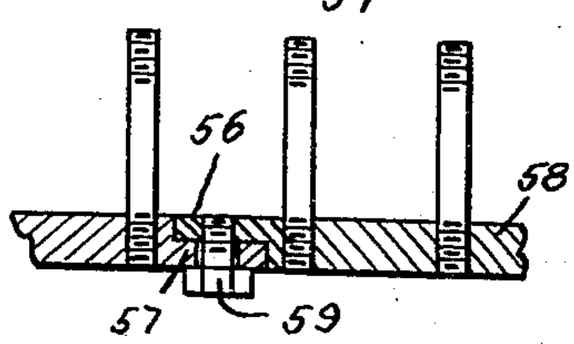


Fig. 9.

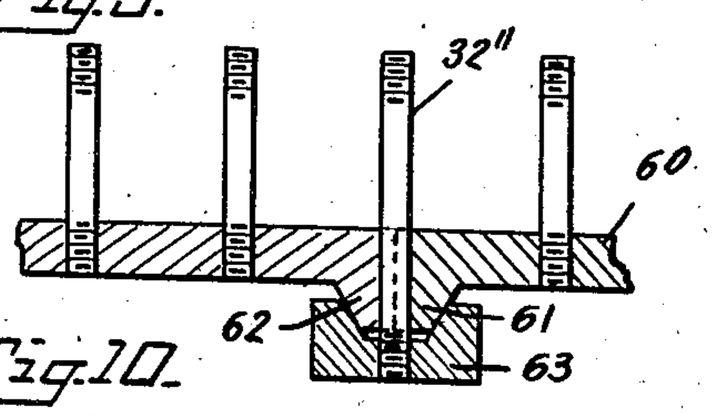


Fig. 10.

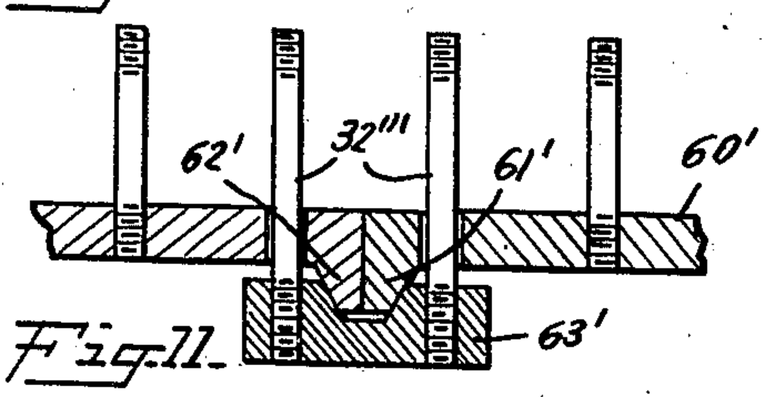
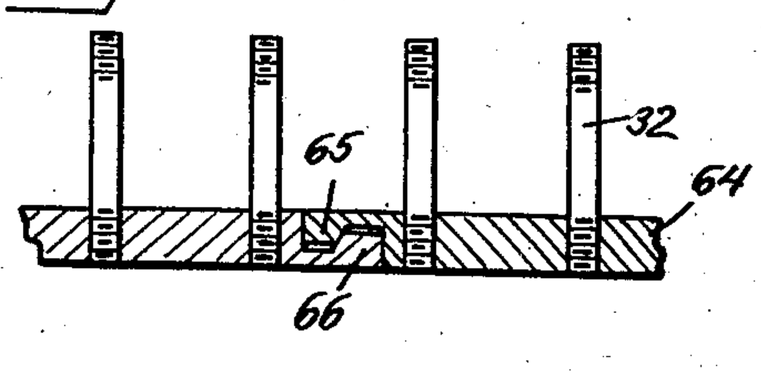


Fig. 11.



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UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

Application filed December 10, 1931. Serial No. 580,073.

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 and 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 discharge 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 the sections or parts of which are in turn tied together at their joints by a special interlocking joint or separate locking means. Suitable securing means such as bolts or studs hold the sectional ring in such a way that the floating tube sheet is clamped securely and squarely to the cap, these bolts or studs also serving to secure the locking means of the sectional ring in position in some instances.

With this construction, the sectional ring is secured against cocking, rocking, or canting about the inner edge of the outer periphery of the floating tube sheet, and light bolts or studs may be employed since the load exerted when the bolts or studs are tightened is applied directly. The tube bundle including the floating tube sheet, is 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 device;

Fig. 3 is a face view of the sectional rings of the clamping device;

Fig. 4 is a partial longitudinal section through the heat exchanger, illustrating a modified form of the clamping device of the floating head;

Fig. 5 is a face view of the sectional rings of the clamping device employed in the arrangement illustrated in Fig. 4; and

Figs. 6 to 11, inclusive, illustrate modified forms of the clamping device, and particularly various arrangements for tying the sections or parts of the sectional ring together.

In this 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 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 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 Fig. 2, is provided at its inner periphery with the radial flange or tongue 39 adapted to fit closely within the peripheral groove 37 of floating tube sheet 15. This sectional or split ring 38 is also provided on its outer face with the counterbore 40, which is similar to counterbore 33 of cap 21 in that it is of such dimension as to accommodate the peripheral flange 35 of the floating tube sheet 15, when the parts of the sectional ring 38 are placed around the periphery of the floating tube sheet 15. The inner face of sectional ring 38 is provided with counterbore 41 of such dimension as to accommodate the smaller peripheral flange 36 of floating tube sheet 15. When the sectional ring 38 is emplaced on the floating tube sheet 15 so as to encircle the latter, and the cap 21 placed over the outer face of the floating tube sheet 15, the lip or ridge 34 of the cap 21 will engage the outer face of the sectional ring 38 and the studs or bolts 32 on the cap 21 will pass through corresponding holes 42 spaced around the sectional ring 38, whereby the sections or parts of the latter are held temporarily together.

Overlying the rear face of the sectional ring 38 is another sectional ring 43 having holes 44 which align with holes 42 in sectional ring 38 for receiving the studs or bolts 32. The sections or parts of the two sectional rings 38 and 43 are staggered axially with respect to each other (preferably 90°) so that the joints of these rings are displaced, i. e. so that the joints of these rings are not in alignment or in juxtaposition, but are overlapped by the sections of the other ring in each case, as illustrated in Fig. 3.

Accordingly, when the nuts 45 are tightened down on the studs or bolts 32, the sections or parts of the sectional ring 43 tie the sections or parts of the sectional ring 38 together and prevent cocking, rocking or canting thereof about the inner edge of the outer periphery of the floating tube sheet 15, and the latter is clamped squarely and securely onto the cap 21, the counterbore 33 of which forms a tight joint with the outer face of the floating tube sheet 15.

The arrangement illustrated in Figs. 4 and 5 is similar in that the sections or parts of the two sectional rings 46 and 47 are displaced radially 90° so that their joints are mutually overlapped by the sections or parts of each other, but the manner of clamping the floating tube sheet 15′ to the cap 21′ is different. In this construction the rim 31′ of the cap 21′ engages the flat outer surface of the floating tube sheet 15′ over the sealing gasket 48 and the sectional ring 46 engages the opposite or inner face of the floating tube sheet 15′ The second sectional ring 47 is tapped for the reception of the inner ends of studs 32′, and the studs pass through aligned holes in the sectional ring 46 and cap rim 31′ and nuts 45′ are tightened down on the studs 32′ over the outer surface of cap rim 31′, as shown in Fig. 4. The studs 32′ do not pass through the floating tube sheet 15′, but support and center it with respect to the cap 21 and the sectional rings 46 and 47.

It will be seen that sectional clamping ring 46 is prevented from cocking, rocking or canting about the inner edge of the outer periphery of the floating tube sheet 15′ by the second sectional ring 47, and that the floating tube sheet 15′ is clamped securely and squarely to the cap 21, the gasket 48 sealing this joint against leakage from the floating chamber 20′. Furthermore, assembling and disassembling of the floating head are readily done, since either before the cap 21′ is emplaced or after it is removed, the studs 32′ support the sectional rings 46 and 47 around the periphery of the floating tube sheet 15′, until it is convenient to complete the assembling or disassembling of the head, and as the studs pass through both sectional rings 46 and 47 they may be handled as a unit.

In the modification illustrated by Fig. 6, the sectional ring 49, which clamps the tube sheet against the cap rim, is tapped at regularly spaced intervals for the reception of the inner ends of the corresponding studs or bolts 32, which are secured at their outer ends on the front face of the cap rim by means of nuts, in the manner illustrated in Fig. 4. The adjacent ends 50 of the sections of ring 49 are tied together by the cleat 51, which overlaps these adjacent ends 50 of the ring sections, and is secured thereto by the tap screws or bolts 52 which pass through holes in the cleat 51 and are threaded in the ring sections. With this arrangement, the sectional ring 49 has all the advantages of the usual section ring and can be as readily applied and dismounted, one section at a time, but ring 49 also has all the advantages of a continuous ring since the cleats 51 tie the adjacent ends 50 of the ring sections together firmly and rigidly, so that the sectional ring 49 with the cleats 51 attached thereto is, in effect, a continuous ring.

In the arrangement shown in Fig. 7 the adjacent ends of the sections of the sectional ring 53 are turned outwardly to form the abutting lugs 54, which are tied together by the bolt 55 passing jointly through these lugs in a manner readily understood. In this arrangement, the ring 53 also has all the advantages of a sectional ring as well as of a continuous ring since the bolt 55 ties the lugs

54 securely together to form the ring 53 into a continuous ring.

In the modification illustrated by Fig. 8, the adjacent ends 56 and 57 of the sections of sectional ring 58 are undercut and overlap each other to form a lap joint. This lapped joint is locked by a tap screw or bolt 59, passing through a hole in one element and threaded into the other element, to form in effect a continuous ring, which, however, may be emplaced and dismounted with the facility of a sectional ring, simply by removing tap screws or bolts 59.

In the modification illustrated in Fig. 9, the adjacent ends of the sections of sectional ring 60 are provided with abutting tapering lugs 61 and 62 and with the semi-circular bores which cooperate to form an opening for the elongated clamping stud or bolt 32″. A cleat 63 of U- or saddle-shape, the inner edges of which are tapered to cooperate with the tapers on lugs 61 and 62, serves to wedge or draw the lugs 61 and 62 together when the clamping stud or bolt 32″ carrying this cleat 63 is tightened down in the usual way. Simply by releasing stud or bolt 32″, or unscrewing it from the cleat 63, the cleat may be released to release the adjacent ends of the sections of sectional ring 60.

The arrangement illustrated in Fig. 10 is similar to that shown in Fig. 9, in that the tapered lugs 61′ and 62′ on the adjacent ends of the sections of sectional ring 60′ are drawn together by a U- or saddle-shaped cleat 63′, but, instead of using one of the clamping studs or bolts to draw the cleat 63′ in wedging relation with the lugs 61′ and 62′, two elongated studs or bolts 32‴ are employed. The inner ends of these elongated studs or bolts 32‴ are inserted through holes in the adjacent ends of the sectional ring 60′ and are threaded into the cleat 63′ in a manner readily understood. The holes in the ring 60′ through which the studs or bolts 32′ pass are enlarged to permit the endwise play of the sections as they are wedged together or released by cleat 63′. This arrangement has all the advantages of the arrangement illustrated in Fig. 10 and may be manipulated in much the same manner.

In Fig. 11 the adjacent ends of the sections of the sectional ring 64 are illustrated as provided with reversely-turned integral hooks 65 and 66, whose cooperating inner surfaces are tapered to draw the adjacent ends of the ring sections together when the clamping studs or bolts 32 are tightened down in the usual way. It is noted that in this arrangement no separate tying or fastening means is employed for tying the ends of the sections of ring 64 together, but that these ends are so shaped as to perform the dual function of tying and drawing themselves together in interlocking relation, so that it is only necessary to release the nuts from the studs or bolts 32, or release the latter from the ring 64 in order to dismount the latter.

With each of the arrangements and modifications illustrated and described herein, the sectional clamping rings are rendered as rigid as a continuous ring or hoop by tying the adjacent ends of the sections thereof together. The sectional clamping ring, therefore, has no tendency to rotate, cock or cant about the inner edge of the outer periphery of the tube sheet when the studs or bolts or other fastening means are tightened down. Also, even though the clamping rings are sectional they clamp the floating tube sheet squarely and securely onto the cap. In each arrangement, assembling and disassembling of the floating head is made easy since it is simply necessary to emplace the tying means to render the sectional ring rigid or release the tying means to render the sectional ring separable in the usual way. Furthermore, light bolts can be used for the reason that all of the load exerted in tightening the bolts is applied to the sectional ring. After the sectional rings and the cap between which the floating tube sheet is clamped have been removed, the entire tube bundle including the floating tube sheet may be withdrawn readily through the shell for cleaning and repair purposes, the diameter of the floating tube sheet being slightly smaller than the inner diameter of the shell.

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 the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap and means overlying the adjacent ends of the ring sections for tying them together.

2. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, and lugs on the adjacent ends of the ring sections for tying them together.

3. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, means overlapping the adjacent ends of the ring sections, and fastening members securing the means to the ring.

4. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, means overlapping the adjacent ends of the ring sections, and fastening members securing the ring and means to the cap rim.

5. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, lugs on the adjacent ends of the ring sections, and means drawing the lugs together for tying the adjacent ends of the ring sections together.

6. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, lugs on the adjacent ends of the ring sections, and a clip engaging adjacent lugs for tying the corresponding ends of the ring sections together.

7. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, tapering lugs on the adjacent ends of the ring sections, and a clip having a tapering recess spanning adjacent lugs for drawing them together.

8. In a heat exchanger, the combination of a shell, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, and a second sectional ring overlying the first sectional ring, the sections of the second ring overlapping the joints between adjacent ends of the first sectional ring for tying the sections of the latter together.

9. In a heat exchanger, a tube bundle therein, a tube sheet for the tube bundle, a cap for said tube sheet having a rim engaging the outer face of the tube sheet, a sectional ring clamping the tube sheet against the cap, and means independent of the cap for preventing separation of the ends of the ring sections.

In testimony whereof we affix our signatures.

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