HIGH PRESSURE HIGH TEMPERATURE HEAT EXCHANGER

Filed June 10, 1933 3 Sheets-Sheet 1

Fig. 1.

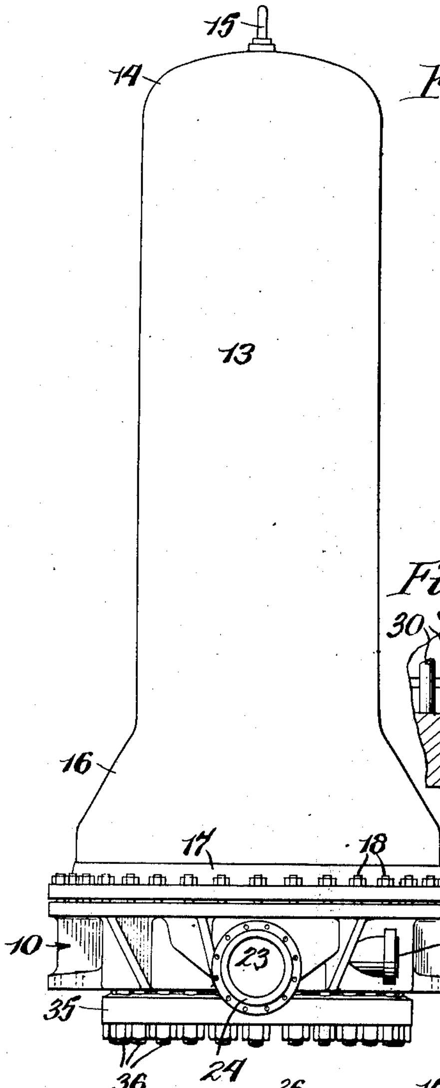


Fig. 2.

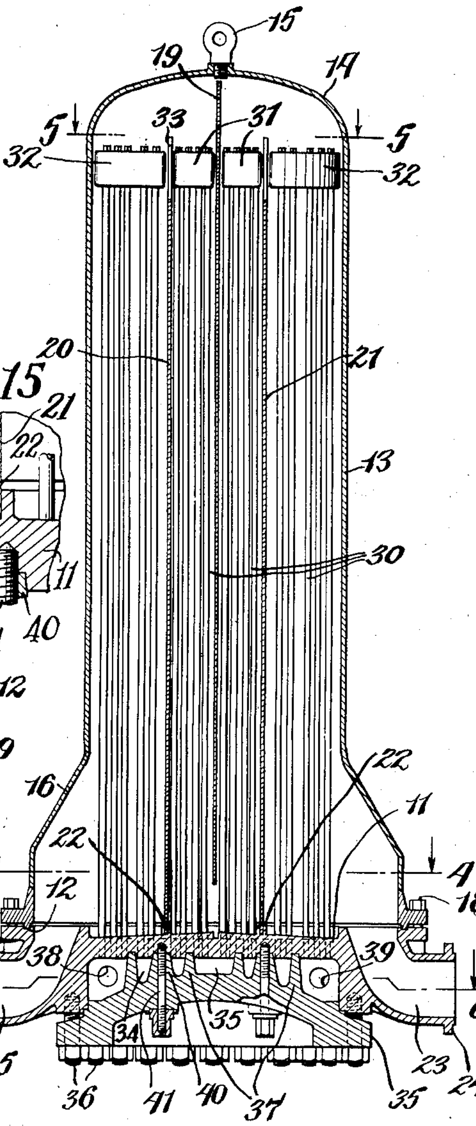
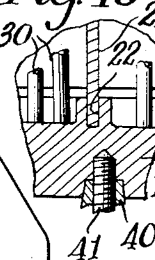


Fig. 15



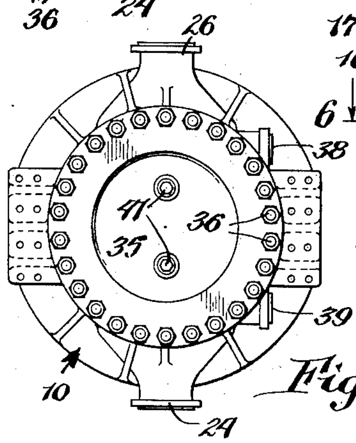


Fig. 3.

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HIGH PRESSURE HIGH TEMPERATURE HEAT EXCHANGER

Filed June 10, 1933 3 Sheets-Sheet 2

Fig. 4.

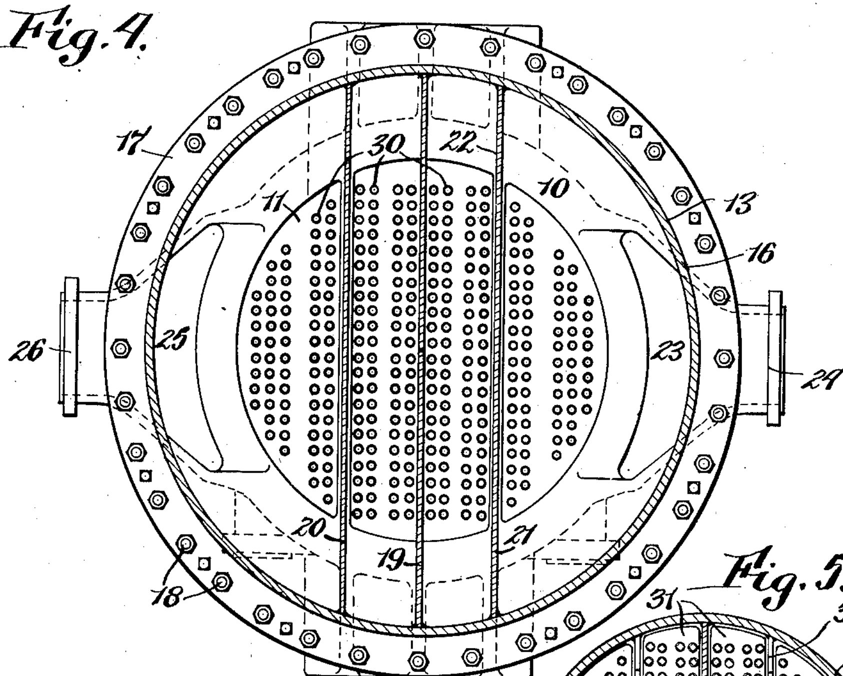


Fig. 5.

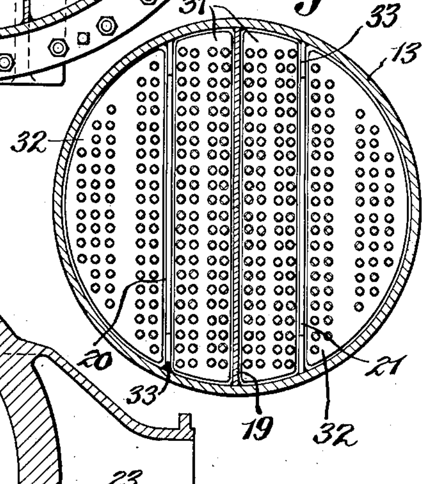
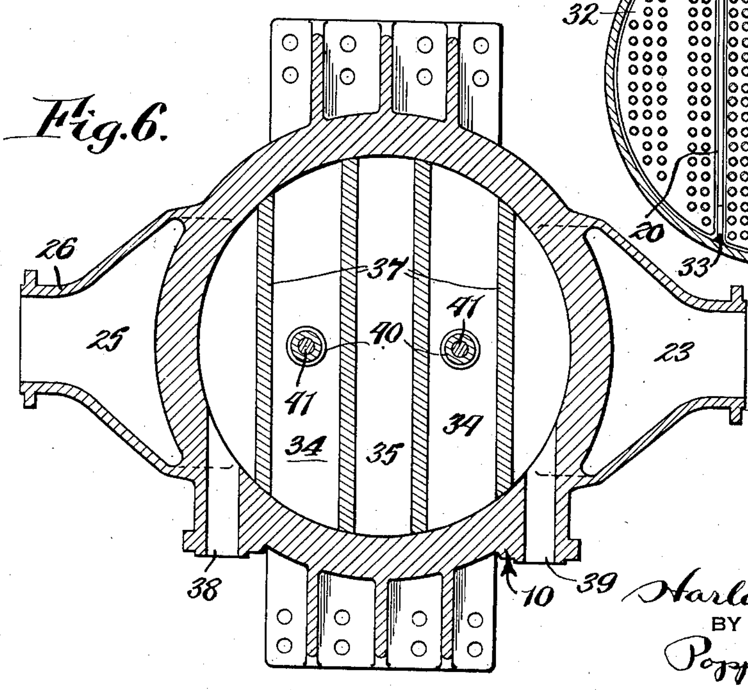


Fig. 6.



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1,954,356

HIGH PRESSURE HIGH TEMPERATURE HEAT EXCHANGER

Filed June 10, 1933

3 Sheets-Sheet 3

Fig. 7.

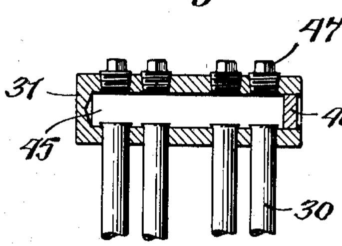


Fig. 8.

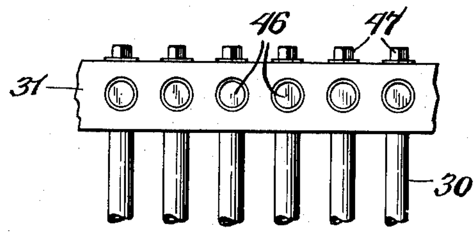


Fig. 9.

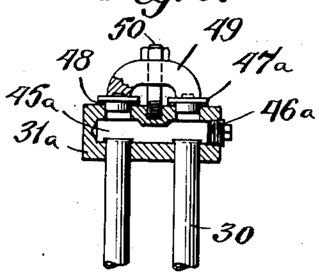


Fig. 10.

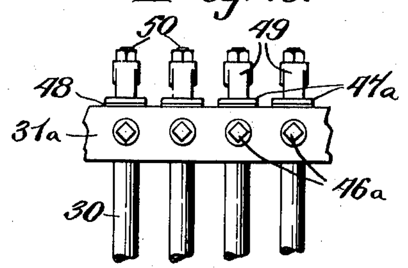


Fig. 11.

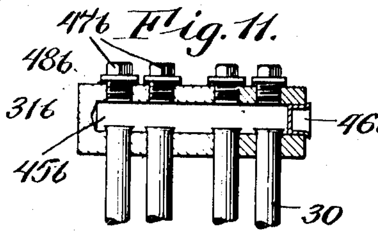


Fig. 12.

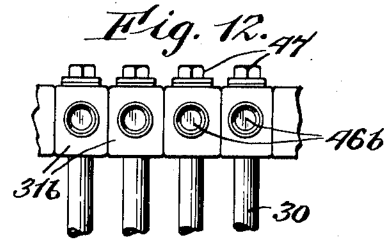


Fig. 13.

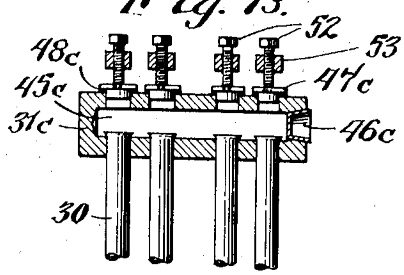
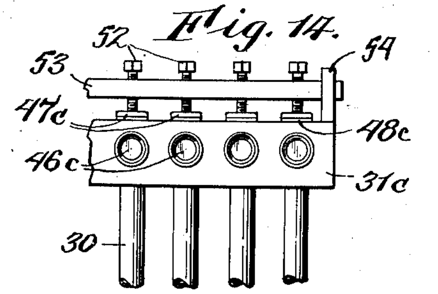


Fig. 14.



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UNITED STATES PATENT OFFICE

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HIGH PRESSURE, HIGH TEMPERATURE HEAT EXCHANGER

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Application June 10, 1933, Serial No. 675,232

10 Claims. (Cl. 257—222)

This invention relates to a high pressure, high temperature heat exchanger, and more particularly to a heat exchanger adapted to be used in the petroleum cracking industry, through which the vapors from the cracking still are passed and employed to preheat the oil delivered to the still or for other purposes. The invention can, however, be advantageously employed in other fields.

The principal difficulty encountered in high pressure, high temperature heat exchangers through which the vapors from a cracking still are passed is the formation of coke deposits around the tubes of the heat exchanger. This deposit can not be avoided and it is essential that the interior of the heat exchanger be readily accessible for cleaning purposes.

It is therefore one of the objects of this invention to provide a high pressure, high temperature heat exchanger in which the tube bundles are rendered completely accessible upon removing an outer shell without breaking any piping connections to the heat exchanger. It has heretofore been proposed to provide a heat exchanger in which the tube bundles were accessible, without breaking piping connections, by removing an enclosing shell, but in such heat exchangers a substantial part of the tube bundles was still required to be housed within that part of the heat exchanger carrying the piping connections, so that the tube bundles were only partly exposed by removing the cover portion, and the cleaning operation rendered difficult.

The present invention proposes a construction in which the tube bundles are completely exposed upon removing the surrounding shell and can be easily cleaned their full length.

Another purpose of the present invention is to provide such a heat exchanger in which the scouring action of the vapors and entrained oil against the pipes of the heat exchanger are reduced to a minimum. For this purpose the inlet passage to the heat exchanger is so arranged that the greater part of the vapor and entrained oil strikes a baffle, thereby avoiding a scouring action of the entrained liquids at high velocity against the tubes. Such of the vapor as does not strike the baffle is arranged to strike the tubes while traveling in a direction substantially parallel with the tubes, so that the scouring action is reduced and also the area of the tube bundles subject to the scouring action is increased to avoid a condition of localized scouring.

A further purpose is to provide such a high pressure, high temperature heat exchanger in which each tube bundle is secured to a floating head, these floating heads being arranged to be supported in and guided by the removable cover portion of the heat exchanger, and these heads being so constructed as to permit of readily cleaning the interior of the tubes. For this purpose each of the floating heads is preferably made of a single cast metal body provided with drilled and plugged passages for cross conducting the oil and also provided with plugs in line with the tubes which are removable to permit direct access to the ends of the tubes for cleaning purposes.

In the accompanying drawings:

Figure 1 is a side elevation of a high pressure, high temperature heat exchanger intended primarily for the transfer of heat from petroleum vapors and oils in cracking duty.

Figure 2 is a vertical section therethrough showing the vapor inlet and vapor outlet connections.

Figure 3 is a bottom plan view.

Figures 4, 5 and 6 are enlarged horizontal sections, taken on the correspondingly numbered lines in Fig. 2.

Fig. 7 is a vertical transverse section through one of the upper headers of the central tube bundles shown in Fig. 2.

Fig. 8 is a fragmentary side elevation of the headers shown in Fig. 7.

Fig. 9 is a view similar to Fig. 7 showing a modified form of header.

Fig. 10 is a view similar to Fig. 8 showing the modified form of the invention illustrated in Fig. 9.

Fig. 11 is a view similar to Fig. 9 showing a still further modified form of floating header.

Fig. 12 is a view similar to Figs. 8 and 10 and showing the form of my invention illustrated in Fig. 11.

Fig. 13 is a view similar to Figs. 7, 9 and 11 and showing another modification of the form of floating header.

Fig. 14 is a fragmentary side elevation of the form of header shown in Fig. 13.

Fig. 15 is an enlarged fragmentary section similar to Fig. 2 and showing the form of the grooves 22 in the tube sheet for supporting the upright partitions 20 and 21.

The numeral 10 represents a header which is shown as being of generally circular form, and is formed to provide a horizontal tube sheet 11 which is arranged in substantially the same plane as the upper face of the marginal portions of the header which face forms a seat 12 for the tubular shell 13 of the heat exchanger. The upper part of the shell 13 is of cylindrical form, and is closed at its upper end by a dome 14 having an eye 15 by means of which the shell can be readily lifted from the header 10. The upper cylindrical part of the shell 13 is of substantially the same diameter as the tube sheet 11, and the lower part 16 of the shell flares outwardly and is welded or otherwise suitably connected to a ring 17 which seats upon the marginal upper face 12 of the header

10 and is secured in position by an annular row of stud bolts 18.

A plurality of internal partitions are welded to the shell 13, the central one 19 of which extends to the dome 14, and at its lower end terminates short of the tube sheet 11 so as to permit vapors to pass thereunder. In addition two vertical partitions 20, 21 are welded to the shell 13, the lower edges of these partitions 20, 21 resting in grooves 22 provided on the upper face of the tube sheet 11 and terminating short of the dome 14 so as to permit of the passage thereover of the vapors, the form of these grooves being best illustrated in Figs. 4 and 15. The vapors are admitted to the heat exchanger through a vapor inlet passage 23 formed in the header 10. This vapor passage is arranged to discharge upwardly against the flaring part 16 of the shell 13, and its other end terminates in a nozzle 24 which is horizontally disposed and is arranged below the horizontal plane of the tube sheet 11. The vapor outlet passage 25 is of the same form as the vapor inlet passage, extending downwardly from the tube sheet 10 and terminating in an outlet nozzle 26 which is arranged below the plane of this tube sheet. The permanent inlet and outlet vapor connections for the heat exchanger are made to the inlet and outlet nozzles 24 and 26.

Within each of the passes formed at the sides of the partitions 19, 20, 21 is arranged a tube bundle 30. Each of the central tube bundles 30 on opposite sides of the central partition 19 connects at its upper end with a floating header 31 and each of the tube bundles on the outer side of the partitions 20 and 21 connects with a floating header 32, these headers 31 and 32 being later described in detail. Each of the headers 31 and 32 is slidably supported in the corresponding pass formed by the adjacent vertical partitions and is guided at one side by the upwardly extending edges 33 of the partitions 20 or 21. The opposite sides of the inner pair of headers 31 are guided by the central partition 19 and the opposite sides of the outermost pair of headers 32 are guided by the cylindrical upper part of the shell 13. The lower ends of the tube bundles are secured to the tube sheet 11 of the header 10 and communicate with an internal chamber 34 formed in the header 10. This chamber is closed by a head 35 which seats against the lower side of the header 10 and is secured in position by an annular row of stud bolts 36. The head 35 is provided on its upper side with ribs 37 which seat in grooves formed on the underside of the tube sheet at the center of each tube bundle 30.

The oil to be heated in the exchanger enters through an oil inlet 38 in the header 10, this oil inlet being arranged on the side of the header 10 adjacent to the vapor outlet passage 25 and the heated oil passes out through the oil outlet 39 also formed in the header 10 on the side adjacent the vapor inlet passage 23.

To secure the necessary strength in the tube sheet 11 bosses 40 are formed on the upper side of the head 35 and the tube sheet is bolted to these bosses by stud bolts 41 which extend through the bosses and head 35 and screw into the tube sheet.

The oil to be heated enters the oil inlet 38 and is forced by the first baffle 37 in the head 35 to pass up through the tubes on one side of the first tube bundle and into the first header 32 in the upper part of the shell 13. From this header the oil passes into the other tubes of the same tube bundle and flows downwardly into the chamber 34 where it is forced by the next succeeding baffle 37 to pass upwardly through part of the tubes of the next bundle into the first header 31 and continues flowing down and up the tubes of each tube bundle until it passes out through the oil outlet 39. The hot vapors from the cracking still enter the nozzle 24 and inlet passage 23 and are discharged upwardly therefrom. The great- and entrained liquids as do not strike the flaring part 16 of the shell 13, and any entrained oil or other substances which so strike the shell 13 are prevented from directly striking the adjacent bundle 30 of tubes, and hence a scouring action of the tubes is prevented. Such oil vapors and entrained liquids as do not strike the flaring part 16 of the shell strike the adjacent bundles of tubes in a glancing manner lengthwise of the tubes so that little scouring action takes place. Moreover, the area of the tubes which are in line with the incoming entering vapors is relatively large so that the scouring action is not localized.

After entering the shell 13 the vapors pass upwardly through the first vapor pass formed by the partition 21, over the top of this partition and down the second vapor pass, thence under the central partition 19, up the third vapor pass, over the top of the partition 21, then down the fourth vapor pass and out through the vapor outlet passage 25.

The present heat exchanger is primarily intended for use with petroleum vapors and oils in cracking duty, both of which form coke deposits, so that the heat exchanger must be frequently cleaned. The present invention renders the tube bundles 30 accessible their full length without breaking either the vapor pipe connections to the nozzles 24 and 26, or the oil piping connections to the oil inlet and outlet 38 and 39. To render the tube bundles accessible, all that is necessary is to remove the nuts on the stud bolts 18 which connect the shell 13 with the header 10, whereupon the shell 13 with its partitions can be lifted freely from the lower header 10 and the tube bundles. When so lifted the tube bundles are exposed their full length from their lower tube sheet 11 to their upper headers 31 and 32, and can be readily cleaned.

This accessibility can only be accomplished by arranging the inlet and outlet vapor nozzles 24 and 26 below the tube sheet 11, and arranging their inlet and outlet vapor passages to enter upwardly into the chamber formed by the shell 13. If the inlet and outlet vapor nozzles 24 and 26 are arranged above the tube sheet 11 and discharge against the sides of the tubes either the vapor piping connections must be broken to permit access to the tubes or the removal of the enclosing shell exposes only a part of the length of the tubes.

In the petroleum cracking industry coke also forms inside of the tubes which carry the oil and it is consequently desirable to be able to readily clean the inside of these tubes. For this purpose the upper floating headers 31 and 32 are preferably so designed that access to the tubes is obtained by means of removable plugs which can be of any of the forms illustrated in Figs. 7–14.

In Fig. 7 is illustrated one form of the upper floating header 31 in which the floating header is made in the form of an integral block of metal provided with drilled passages 45 which connect the upper ends of the adjacent up flow and down flow tubes so as to transfer the oil from one to the other. After being drilled the ends of each of these passages 45 are closed by plugs 46 which can be welded as shown. In line with each of the tubes 30 the header is drilled and tapered and each of these drilled and tapered holes is closed with a removable screw plug 47, these screw plugs preferably having squared extensions permitting them to be readily unscrewed and removed. It is apparent that after being so removed access is obtained to the interior of the tubes 30 for the purpose of cleaning the same.

In the form of the invention illustrated in Figs. 9 and 10 the floating header 31*a* is similarly provided with a plurality of drilled passages 45*a*, the ends of these passages being shown as closed by a screw plug 46*a*. As with the passages 45 in the form of the invention shown in Figs. 7 and 8 the passages 45*a* connect the upper ends of the up flow and down flow tubes 30 so as to effect a transfer of the oil from one to the other. Each of the headers 31*a* is also provided with an opening in line with each of the tubes 30 and these openings are normally closed by a flanged plug 47*a* having gaskets 48 to secure a sealed joint. These plugs are held against the gaskets by a yoke 49 through which a stud bolt 50 passes, these stud bolts 50 screwing into the upper side of the header 31*a*.

In the form of the floating headers shown in Figs. 11 and 12 the headers are composed of a number of transverse header sections 31*b* which are arranged side by side and each of which is provided with a single drilled passage 45*b*, the open end of which is closed by an expanded plug 46*b*. Each of the passages 45*b* connects a single transverse row of the tubes of each bundle 30 and transfers the oil from one to the other. Each of the header sections 31*b* is provided with drilled openings in line with the tubes, these openings preferably being of non-tapering form and each receiving a non-tapering screw plug 47*b*, each of which is flanged and provided with a gasket 48*b* under the flange. It is apparent that upon unscrewing the plugs 47*b* access is obtained, for the purpose of cleaning, to the interior of the tubes 30. It is also apparent that the expanded plugs 46*b* could be substituted for the screw plugs 47*b* to permit of access to the tubes 30.

In the form of the invention shown in Figs. 13 and 14 the floating header 31*c* is made of a single metal body provided with a plurality of transverse drilled passages 45*c* which connect the upper ends of each transverse row of the tubes 30. The end of each of the drilled passages 35*c* is shown as closed by a tapered plug 46*c* which is driven so as to tightly fit in the end of the drilled passage. In line with each of the tubes 30 the header 31*c* is provided with an opening which is closed by a cap or plug 47*c*, these plugs or caps 47*c* being flanged and a sealed joint being obtained by means of gaskets 48*c*. The plugs or caps 47[c] are held in position by screws 52 which pass through and are threaded in jack bars 53. These jack bars 53 extend lengthwise of the floating header and each end of each jack bar is arranged under a bail or yoke 54 which is formed integrally with the header 31*c* and holds the jack bar against upward movement.

From the foregoing it is apparent that the present invention provides a high pressure, high temperature heat exchanger in which the tube bundles can be exposed their full length for the purpose of cleaning without breaking any of the piping connections and also provides such a heat exchanger in which the scouring action of the tubes by the entering vapors is greatly reduced. The present invention also provides a floating header, which, by the removal of the plugs, permits ready access to the interior of the tubes for the purpose of cleaning the same.

I claim as my invention:

1. A heat exchanger comprising a series of bundles of tubes, a transverse header having a tube sheet connected to one end of said bundles of tubes, a floating header connected to the opposite end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said transverse header adjacent its tube sheet, vapor inlet and outlet passages formed in said transverse header, the external end of each of said inlet and outlet passages being arranged in the side of said tube sheet opposite from said shell and the inner end of each of said inlet and outlet passages being directed in the direction in which said tubes extend, and a series of partitions extending longitudinally of the tubes between the floating headers and supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vapor passes extending longitudinally of the tubes in opposite directions, said tubes and headers forming a continuous passage for a liquid.

2. A heat exchanger comprising a series of bundles of tubes, a transverse header having a tube sheet connected to one end of said bundles of tubes, a floating header connected to the opposite end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said transverse header along a plane substantially coplanar with the adjacent face of said tube sheet whereby upon removing said shell substantially the entire length of said tube bundles are exposed from opposite sides, vapor inlet and outlet passages formed in said transverse header, the external end of each of said inlet and outlet passages being arranged on the side of said tube sheet opposite from said shell and the inner end of each of said inlet and outlet passages being directed in the direction in which said tubes extend, and a series of partitions extending longitudinally of the tubes between the floating headers and supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vapor passes extending longitudinally of the tubes in opposite directions, said tubes and headers forming a continuous passage for a liquid.

3. A heat exchanger comprising a series of vertical bundles of tubes, a lower header having a horizontal tube sheet connected to one end of said bundles of tubes, a floating header connected to the upper end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said lower header adjacent the margin of its horizontal tube sheet, vapor inlet and outlet nozzles in said lower header and disposed below said tube sheet, said lower header being provided with vapor inlet and outlet passages extending through said nozzles and upwardly into said shell, and a series of vertical partitions supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vertical vapor passes, said tubes and headers forming a continuous passage for a liquid.

4. A heat exchanger comprising a series of bundles of tubes, a transverse header having a tube sheet connected to one end of said bundles of tubes, a floating header connected to the op-

posite end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said transverse header adjacent its tube sheet, vapor inlet and outlet passages formed in said transverse header, the external end of each of said inlet and outlet passages being arranged on the side of said tube sheet opposite from said shell and the inner end of said inlet and outlet passages being directed in the direction in which said tubes extend and said vapor inlet passage being arranged to discharge alongside and in a direction lengthwise of the adjacent tube bundle, and a series of partitions extending longitudinally of the tubes between the floating headers and supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vapor passes extending longitudinally of the tubes in opposite directions, said tubes and headers forming a continuous passage for a liquid.

5. A heat exchanger comprising a series of bundles of tubes, a transverse header having a tube sheet connected to one end of said bundles of tubes, a floating header connected to the opposite end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said transverse header, vapor inlet and outlet passages formed in said transverse header and communicating with the interior of the shell, the inner end of said vapor inlet passage being arranged to discharge against the adjacent side of the shell, the vapors being deflected thereby through the adjacent tubes, and a series of partitions extending longitudinally of the tubes between the floating headers and supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vapor passes extending longitudinally of the tubes in opposite directions, said tubes and headers forming a continuous passage for a liquid.

6. A heat exchanger comprising a series of bundles of tubes, a transverse header having a tube sheet connected to one end of said bundles of tubes, a floating header connected to the opposite end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said transverse header, vapor inlet and outlet passages formed in said transverse header and communicating with the interior of the shell, the inner end of said vapor inlet passage being arranged to discharge against the adjacent side of the shell, the vapors being deflected thereby through the adjacent tubes in a direction lengthwise of the tubes, and a series of partitions extending longitudinally of the tubes between the floating headers and supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vapor passes extending longitudinally of the tubes in opposite directions, said tubes and headers forming a continuous passage for a liquid.

7. A heat exchanger comprising a series of bundles of tubes, a transverse header having a tube sheet connected to one end of said bundles of tubes, a floating header connected to the opposite end of each bundle of tubes, a shell enclosing the tubes and detachably connected to said transverse header adjacent its tube sheet, vapor inlet and outlet passages formed in said transverse header, the external end of each of said inlet and outlet passages being arranged in the side of said tube sheet opposite from said shell and the inner end of each of said inlet and outlet passages being directed in the direction in which said tubes extend and the inner end of said vapor inlet passage being directed to discharge against the adjacent side of the shell, the vapors being deflected thereby among said tubes, and a series of partitions, extending longitudinally of the tubes between the floating headers and supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vapor passes extending longitudinally of the tubes in opposite directions, said tubes and headers forming a continuous passage for a liquid.

8. A heat exchanger comprising a series of vertical bundles of tubes, a lower header having a horizontal tube sheet connected to one end of said bundles of tubes, a floating header connected to the upper end of each bundles of tubes, a shell enclosing the tubes and detachably connected to said lower header adjacent the margin of its horizontal tube sheet, vapor inlet and outlet nozzles in said lower header and disposed below said tube sheet said lower header being provided with vapor inlet and outlet passages extending through said nozzles and upwardly into said shell, said vapor inlet passage being arranged to discharge alongside of the adjacent tube bundle and against the side of the shell, the vapors being deflected thereby among said tubes.

9. A heat exchanger comprising a series of vertical bundles of tubes, a lower header having a central horizontal tube sheet connected to one end of said bundles, a floating header connected to the upper end of each bundle of tubes, a shell enclosing the tubes and having an upper cylindrical part and a lower outwardly flaring open end, means detachably securing the outwardly flaring lower end of said shell to said lower header adjacent said tube sheet, vapor inlet and outlet passages in said lower header and communicating with the interior of said shell, the inner end of said vapor inlet passage being arranged to discharge upwardly into said shell alongside the adjacent tube bundle and against the flaring lower end of said shell whereby the vapors are deflected by the flaring lower end of said shell through the adjacent tubes, and a series of vertical partitions supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vertical vapor passes, said tubes and headers forming a continuous passage for a liquid.

10. A heat exchanger comprising a series of vertical bundles of tubes, a lower header having a central horizontal tube sheet connected to one end of said bundles, a floating header connected to the upper end of said bundle of tubes, a shell enclosing the tubes and having an upper cylindrical part and a lower outwardly flaring open end, means detachably securing the outwardly flaring lower end of said shell to said lower header adjacent said tube sheet, vapor inlet and outlet passages in said lower header, the inner end of each of said passages being vertically disposed and opening into the interior of said shell at a place below the flaring lower end of said shell, and a series of vertical partitions supported to permit removal of the shell from about the tube bundles and floating headers and providing a series of vertical vapor passes, said tubes and headers forming a continuous passage for a liquid.

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