

Jan. 26, 1932.

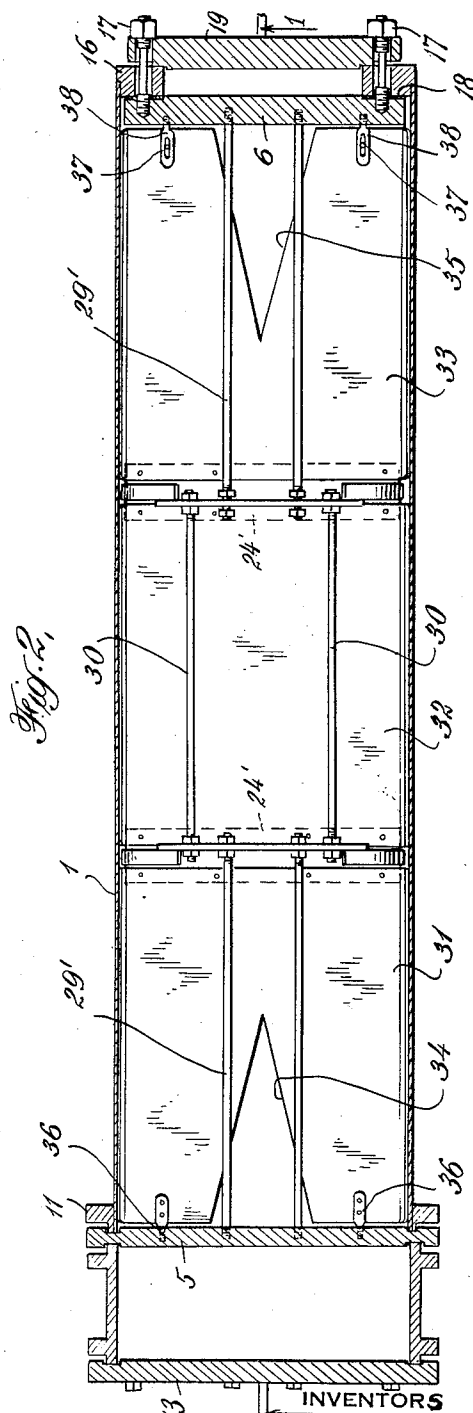
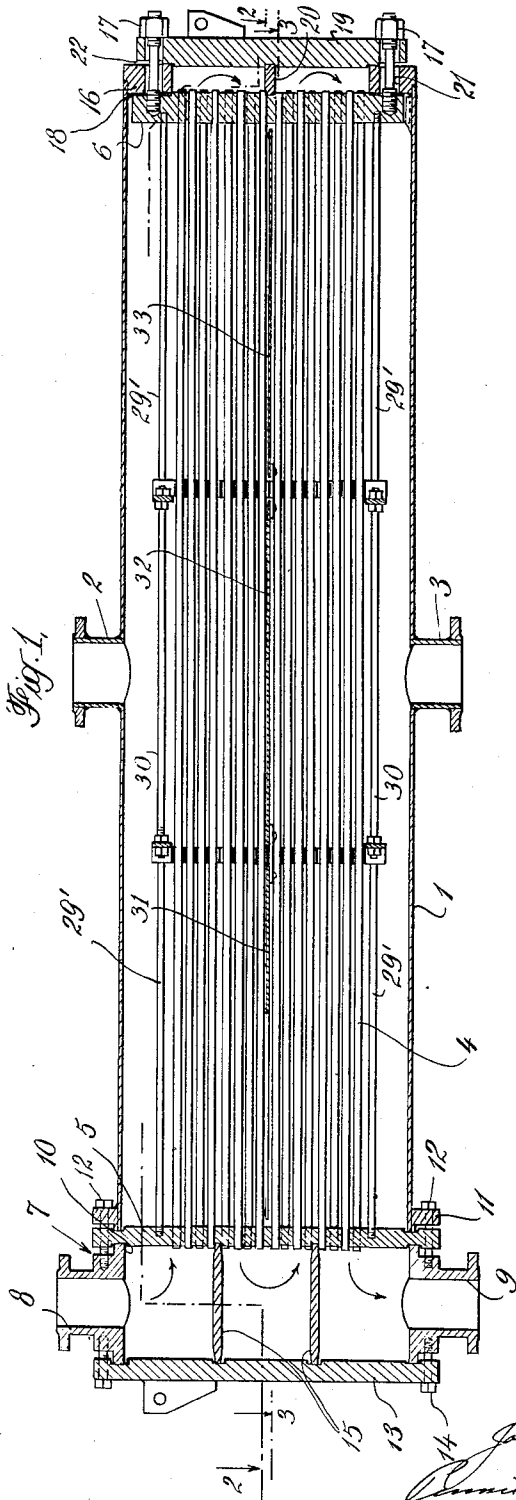
J. PRICE ET AL

1,842,945

HEAT EXCHANGER

Filed Dec. 4, 1930

2 Sheets-Sheet 1



INVENTORS

14- Joseph Price & Kenneth B. Price
BY
Dennis Davis Martin & Edwards
ATTORNEYS

Jan. 26, 1932.

J. PRICE ET AL

1,842,945

HEAT EXCHANGER

Filed Dec. 4, 1930

2 Sheets-Sheet 2

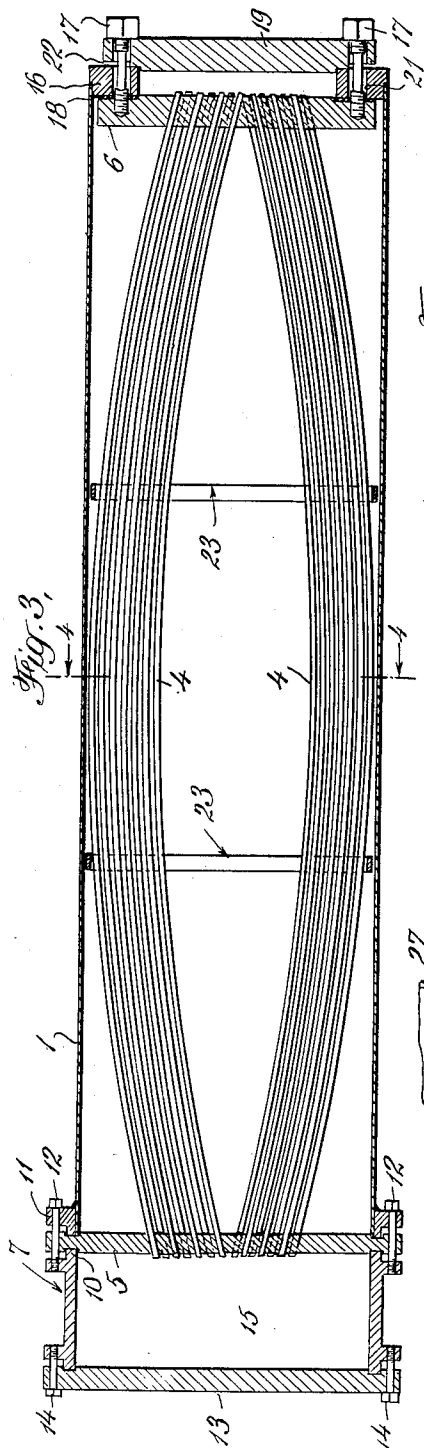


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 19.

Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

Fig. 24.

Fig. 25.

Fig. 26.

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 30.

Fig. 31.

Fig. 32.

Fig. 33.

Fig. 34.

Fig. 35.

Fig. 36.

Fig. 37.

Fig. 38.

Fig. 39.

Fig. 40.

Fig. 41.

Fig. 42.

Fig. 43.

Fig. 44.

Fig. 45.

Fig. 46.

Fig. 47.

Fig. 48.

Fig. 49.

Fig. 50.

Fig. 51.

Fig. 52.

Fig. 53.

Fig. 54.

Fig. 55.

Fig. 56.

Fig. 57.

Fig. 58.

Fig. 59.

Fig. 60.

Fig. 61.

Fig. 62.

Fig. 63.

Fig. 64.

Fig. 65.

Fig. 66.

Fig. 67.

Fig. 68.

Fig. 69.

Fig. 70.

Fig. 71.

Fig. 72.

Fig. 73.

Fig. 74.

Fig. 75.

Fig. 76.

Fig. 77.

Fig. 78.

Fig. 79.

Fig. 80.

Fig. 81.

Fig. 82.

Fig. 83.

Fig. 84.

Fig. 85.

Fig. 86.

Fig. 87.

Fig. 88.

Fig. 89.

Fig. 90.

Fig. 91.

Fig. 92.

Fig. 93.

Fig. 94.

Fig. 95.

Fig. 96.

Fig. 97.

Fig. 98.

Fig. 99.

Fig. 100.

Fig. 101.

Fig. 102.

Fig. 103.

Fig. 104.

Fig. 105.

Fig. 106.

Fig. 107.

Fig. 108.

Fig. 109.

Fig. 110.

Fig. 111.

Fig. 112.

Fig. 113.

Fig. 114.

Fig. 115.

Fig. 116.

Fig. 117.

Fig. 118.

Fig. 119.

Fig. 120.

Fig. 121.

Fig. 122.

Fig. 123.

Fig. 124.

Fig. 125.

Fig. 126.

Fig. 127.

Fig. 128.

Fig. 129.

Fig. 130.

Fig. 131.

Fig. 132.

Fig. 133.

Fig. 134.

Fig. 135.

Fig. 136.

Fig. 137.

Fig. 138.

Fig. 139.

Fig. 140.

Fig. 141.

Fig. 142.

Fig. 143.

Fig. 144.

Fig. 145.

Fig. 146.

Fig. 147.

Fig. 148.

Fig. 149.

Fig. 150.

Fig. 151.

Fig. 152.

Fig. 153.

Fig. 154.

Fig. 155.

Fig. 156.

Fig. 157.

Fig. 158.

Fig. 159.

Fig. 160.

Fig. 161.

Fig. 162.

Fig. 163.

Fig. 164.

Fig. 165.

Fig. 166.

Fig. 167.

Fig. 168.

Fig. 169.

Fig. 170.

Fig. 171.

Fig. 172.

Fig. 173.

Fig. 174.

Fig. 175.

Fig. 176.

Fig. 177.

Fig. 178.

Fig. 179.

Fig. 180.

Fig. 181.

Fig. 182.

Fig. 183.

Fig. 184.

Fig. 185.

Fig. 186.

Fig. 187.

Fig. 188.

Fig. 189.

Fig. 190.

Fig. 191.

Fig. 192.

Fig. 193.

Fig. 194.

Fig. 195.

Fig. 196.

Fig. 197.

Fig. 198.

Fig. 199.

Fig. 200.

Fig. 201.

Fig. 202.

Fig. 203.

Fig. 204.

Fig. 205.

Fig. 206.

Fig. 207.

Fig. 208.

Fig. 209.

Fig. 210.

Fig. 211.

Fig. 212.

Fig. 213.

Fig. 214.

Fig. 215.

Fig. 216.

Fig. 217.

Fig. 218.

Fig. 219.

Fig. 220.

Fig. 221.

Fig. 222.

Fig. 223.

Fig. 224.

Fig. 225.

Fig. 226.

Fig. 227.

Fig. 228.

Fig. 229.

Fig. 230.

Fig. 231.

Fig. 232.

Fig. 233.

Fig. 234.

Fig. 235.

Fig. 236.

Fig. 237.

Fig. 238.

Fig. 239.

Fig. 240.

Fig. 241.

Fig. 242.

Fig. 243.

Fig. 244.

Fig. 245.

Fig. 246.

Fig. 247.

Fig. 248.

Fig. 249.

Fig. 250.

Fig. 251.

Fig. 252.

Fig. 253.

Fig. 254.

Fig. 255.

Fig. 256.

Fig. 257.

Fig. 258.

Fig. 259.

Fig. 260.

Fig. 261.

Fig. 262.

Fig. 263.

Fig. 264.

Fig. 265.

Fig. 266.

Fig. 267.

Fig. 268.

Fig. 269.

Fig. 270.

Fig. 271.

Fig. 272.

Fig. 273.

Fig. 274.

Fig. 275.

Fig. 276.

Fig. 277.

Fig. 278.

Fig. 279.

Fig. 280.

Fig. 281.

Fig. 282.

Fig. 283.

Fig. 284.

Fig. 285.

Fig. 286.

Fig. 287.

Fig. 288.

Fig. 289.

UNITED STATES PATENT OFFICE

JOSEPH PRICE, OF WEST NEW BRIGHTON, NEW YORK, AND KENNETH B. RIS, OF DALLAS, TEXAS, ASSIGNORS TO THE GRISCOM-RUSSELL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

HEAT EXCHANGER

Application filed December 4, 1930. Serial No. 499,930.

This invention relates to condensers and to heat exchangers in general, and is particularly concerned with improvements in heat exchangers of the type comprising a shell enclosing one or more bundles of tubes, the walls of which serve as a medium for conveying heat from one fluid to another. In such apparatus one fluid is caused to flow through the tubes and the other fluid is brought into heat exchanging relation with the exterior surfaces of the tubes, within the shell.

One of the objects of this invention is to provide a heat exchanger which can be manufactured at low cost and which will operate satisfactorily under varying operating conditions and which will require a minimum of attention to keep the apparatus in good working condition. With this object in view we provide apparatus including a relatively small number of inexpensive parts constructed and arranged in a manner hereinafter described whereby an efficient heat exchanger is provided which can be used for a variety of purposes with the assurance that its operation will be satisfactory under all working conditions.

In providing a heat exchanger of the type comprising a plurality of tubes enclosed within a shell, a number of problems are presented the relative importance of which depends upon the type of service for which the apparatus is designed. For example, in the petroleum industry great difficulty has been experienced with what may be termed differential tube expansion strains. In such installations the tubes may contain heavy oils, and due to different degrees of fouling, the individual tubes do not receive the same amounts of oil. Thus tubes carrying lesser amounts of oil are heated to higher temperatures, with consequent differences in tube lengths due to thermal expansions. Thus unequal expansion of the tubes produces abnormal stresses in the tube sheets, and injury may result. The relatively cold tubes may be pulled out of the tube sheets, or if this does not happen, then the relatively hot tubes may elongate to such an extent as to protrude through the tube sheet. With a view to eliminating such disastrous occurrences, our

invention contemplates the provision of tubes which are adapted to accommodate unequal expansion and contraction of the tubes and to accommodate changes in length of the shell, whereby excessive stress at the ends of the tubes is entirely avoided. For example, the tubes may be bowed out of a straight line to such an extent that the distance between the ends of any given tube may change without in any way injuring the bond between the tube ends and the tube sheets. The tubes are sufficiently bowed during normal operation of the apparatus so that in the event the shell elongates more than the tubes, the tubes will merely straighten out to some extent to accommodate the change in length of the shell. On the other hand, whenever the tubes elongate more than the shell, the tubes bend slightly to increase the curvature of the tubes to an extent sufficient to compensate for the change in length and this occurs without producing any undesirable stress in the tube sheets.

By using tubes that are slightly bowed as explained above it is entirely feasible to support the ends of the tubes rigidly at the ends of the shell and our invention contemplates improved means for securing the tube sheets at the ends of the shell. This can be accomplished in such a way as to make it possible to insert the tube bundle in the shell, and remove the same from the shell whenever necessary, with a minimum of effort. Furthermore, our invention involves a method of mounting the tube sheets which greatly facilitates inspection of the apparatus to determine whether it is in proper operating condition. In general we prefer to employ an annular flange on the interior of one end of the shell, and to secure one of the tube sheets directly to this flange, a gasket being provided to insure proper sealing of the tube sheet against the flange. A cover plate may be secured to the outer face of the flange and we prefer to employ a flange of sufficient thickness to provide a tube manifold chamber between the tube sheets and the cover plate. The tube sheet and cover plate may be secured to the flange by a plurality of studs and the studs are preferably of smaller

diameter than the stud holes in the flange whereby drip passages are provided along the studs, and these passages may communicate with an open channel formed in the cover plate. Thus any leakage of fluid through or around the gasket is readily detected and the studs may be tightened to stop the leakage, or the studs may be removed and a new gasket inserted.

Our invention may include improved means for supporting or spacing apart the tubes within the shell. Where a relatively long shell is employed, enclosing tubes of corresponding length, it is desirable to provide some means for maintaining the tubes in proper position at one or more points intermediate the ends thereof. According to our invention such spacing means are preferably connected to the tube sheets by tie rods, or the like, whereby the spacing members, the tubes and the tube sheets constitute a unitary structure which can be inserted into the shell, or removed therefrom, as the case may be, with a minimum of effort.

The various objects of our invention will be more apparent upon considering the following detailed description which is to be taken in conjunction with the accompanying drawings in which

Fig. 1 is a longitudinal sectional view of a heat exchanger embodying our invention;

Fig. 2 is a horizontal sectional view taken on line 2—2 of Fig. 1 showing details of construction;

Fig. 3 is a sectional view similar to Fig. 2 except that it is taken on line 3—3 of Fig. 1;

Fig. 4 is an enlarged transverse sectional view taken on line 4—4 of Fig. 3 showing details of construction;

Figs. 5 and 6 are, respectively, a side elevation and a front elevation of a portion of the apparatus shown in Figs. 1 to 4 inclusive.

The embodiment of our invention illustrated in the accompanying drawings comprises a heat exchanger shell 1 which may be supported in a horizontal position, or in a vertical position as may be desired. The shell 1 is provided with ports 2 and 3 for the admission and discharge of fluid to and from the interior of the shell, and the shell encloses a plurality of tubes 4 extending lengthwise thereof with the ends of the tubes suitably mounted in tube sheets 5 and 6. An annular housing 7 provided with an inlet 8 and an outlet 9 forms a manifold chamber communicating with the ends of the tubes mounted in the tube sheet 5. The housing 7 is provided with an annular flange 10 engaging a corresponding recess near the periphery of the tube sheet 5, and the housing 7 and the tube sheet 5 are both clamped firmly to the annular supporting ring or flange 11 on the exterior of the adjacent end of the shell 1. Stud 12 serve to clamp these parts together. The outer end

of the housing 7 is closed by a suitable cover plate 13 which may be detachably secured to the housing by any suitable means, such as the studs 14. One or more baffles 15 may be provided within the housing to direct the flow of fluid through the apparatus as indicated by the arrows.

The tube sheet 6 at the end of the shell remote from the housing 7, is detachably secured to an annular flange 16 by any suitable means, such as the studs 17. The flange 16, carried by the shell 1, is disposed within the end of the shell and the tube sheet 6 engages the inner face of this flange, a suitable gasket 18 being interposed between these parts to provide a seal. The studs 17 may serve to hold a cover plate 19 against the outer face of the annular flange 16, and the flange 16 is preferably of sufficient width to provide a manifold chamber between the tube sheet 6 and the cover plate 19. A baffle 20 may be arranged between the cover plate 19 and the tube sheet 6 to direct the flow of fluid through the apparatus.

The annular flange 16 is provided with stud holes 21 to accommodate the studs 17, and these stud holes are substantially larger in diameter than the studs, thus forming passages extending through the flange 16. Accordingly, any fluid leaking through or around the gasket 18 from the interior of the shell is permitted to escape through the drip passages extending along the studs, and to further facilitate detections of leakage the cover plate 19 is provided with an annular recess or channel 22 in direct communication with the drip passages through the flange 16. Accordingly fluid leaking through the gasket may be at once detected in the open channel in the cover plate and the studs 17 may be tightened to stop the leakage. This attention can be given to the apparatus without the necessity for removing any shell cover, for the heads of the studs are exposed at all times.

As explained above, the tube bundle comprising the tubes 4 and the tube sheets 5 and 6, is rigidly secured at its ends to the shell 1. The tube sheet 5 is rigidly clamped against the annular ring or flange 11 and the other tube sheet 6 is clamped against the annular flange 16. Such being the construction, destructive stresses would be developed at the ends of the tubes where they are mounted in the tube sheets, unless some provision were made for making due allowance for changes in length of the shell with respect to the length of the tubes, such changes being caused by unequal expansion or contraction of the tubes and the shell. In accordance with the preferred embodiment of our invention, this is taken care of by providing tubes of such length that during normal operation they are bowed to some extent. This is best illustrated in Fig. 3 in which the bowing of the tubes has been considerably exaggerated for

purposes of illustration. Where the shell is to be installed in a horizontal position the tubes are preferably initially bowed in a horizontal direction, the tubes being supported at one or more points intermediate their ends by tube supporting or spacing devices. Two such devices are shown at 23 in Figs. 1 to 4 and in greater detail in Figs. 5 and 6.

It will be understood that under some conditions, for example where relatively short tubes are employed, it is not necessary to provide any supports or spacers such as those illustrated at 23.

With respect to the feature of providing bowed tubes, it will be understood that the tubes are preferably initially bowed to such an extent that during normal operation there is sufficient "slack" in the tubes to take care of all changes in length of the shell relative to the length of the tubes and to take care of differential expansion of the tubes. The tubes are sufficiently bowed so that whenever the shell elongates more than the tubes, the tubes straighten out to some extent, but do not become perfectly straight for in such event abnormal stresses would be developed at the ends of the tubes.

The use of bowed tubes involves the use of tube sheets and a shell of such dimensions that ample space is provided for the end flange 16, and a gasket joint of satisfactory dimensions can be provided between the tube sheet 6 and the adjacent flange 16.

The tube spacers or intermediate supports illustrated at 23 each comprise a plurality of metal strips 24 secured at their ends to curved frame members 25 and 26. These frame members are interconnected by metal strips 27 and 28 each having a plurality of bolt holes 29 therein. It will be understood that the tubes pass between the strips 24 as best illustrated in Fig. 4 and are thereby maintained in proper alignment. Expansion or contraction of the tubes causes them to slide lengthwise of the strips 24 and these strips are spaced apart a distance sufficient to provide ample freedom of movement of the tubes during the expansion and contraction thereof. As illustrated in Figs. 1 and 2, tie rods 29' serve to connect the spacer frames with the tube sheets, and similar tie rods 30 serve to interconnect adjacent spacer frames. Each set of spacer strips 24 and the supporting frame members therefor may be regarded as a cage and it will be noted that these cages are connected to the tube sheets at the extremities of the apparatus and are not fastened to the shell directly. Accordingly the cages constitute part of the unitary removable bundle comprising the tubes and tube sheets, and accordingly the spacer cages can be assembled in place on the tubes before the tube bundle is inserted in the shell.

The apparatus illustrated in the accompanying drawings includes a plurality of

baffle plates 31, 32 and 33, the end baffle plates 31 and 33 having V-shaped notches 34 and 35 respectively through which fluid within the shell may pass from one section of the shell to another section thereof. The baffle plate 31 is provided with lugs 36 engaging corresponding recesses in the tube sheet 5 and the other end of this baffle plate is secured to one of the spacer strips designated as 24' (see Fig. 5). This strip is wider than the other strips and provides a flange support for the baffle plate which is riveted or otherwise fixed thereto. In like manner the central baffle plate 32 is secured to the spacer strips 24' of the adjacent spacer cages and the inner end of the baffle plate 33 is supported in similar manner. The outer end of baffle plate 33 is provided with projections 37 engaging slots in pins 38 carried by the tube sheet 6. This slotted connection permits relative movements of the parts which occurs whenever there is unequal expansion or contraction of the shell and the baffle plates.

It is to be understood that our invention is not limited to the details of construction of the apparatus illustrated in the accompanying drawings but includes such modifications thereof as fall within the scope of the appended claims. For example, as indicated by the appended claims, certain features of the invention may be used to advantage without employing other features which may be included in the specific embodiment of the invention herein described in detail. The construction and arrangement of the tube supporting or spacing cages may be modified and in fact the use of such devices for causing the tubes to bow in parallel planes may be eliminated if desired. The tubes can be made of material similar to that of the shell, or they may be made of metal possessing physical characteristics different from those of the shell. If the tube metal has a materially higher coefficient of expansion than the shell metal, it is merely necessary to provide a slightly larger shell to accommodate greater bowing of the tubes whenever there is a tendency for the tubes to elongate more than the shell. The arrangement of the tubes may be varied as desired, for example, alternate rows of tubes may be bowed in opposite directions, or alternate banks or passes may be bowed in opposite directions. Furthermore the construction and arrangement of the baffles within the tube manifold chambers and within the shell may be altered as desired to control the flow of fluids through the apparatus.

We claim:—

1. A heat exchanger comprising a shell, a plurality of tubes therein, a tube sheet secured to said tubes, an annular flange secured to one end of the shell and having a plurality of stud holes therein, a cover plate,

and a plurality of studs for securing the cover plate and said tube sheet to opposite sides of said flange, at least one of said studs being of smaller diameter than the corresponding flange stud hole whereby a drip passage is formed along the stud, and said cover plate having an open channel communicating with said drip passage.

2. A heat exchanger comprising a shell, a plurality of tubes therein, a tube sheet secured to said tubes, an annular flange secured to one end of said shell and having a plurality of stud holes therein, a cover plate and a plurality of studs for securing the cover plate and said tube sheet to opposite sides of said flange, said studs being of smaller diameter than the flange stud holes whereby drip passages are formed along the studs, and said cover plate having an annular open channel communicating with said drip passages.

3. A heat exchanger comprising a shell, a plurality of tubes therein, a tube sheet secured to said tubes, an annular flange secured to one end of the shell and having a plurality of stud holes therein, a cover plate, a plurality of studs for securing the cover plate and said tube sheet to opposite sides of said flange, and a gasket interposed between said tube sheet and said flange, said studs being of smaller diameter than the flange stud holes whereby drip passages are formed along the studs, and said cover plate having an open annular channel communicating with said drip passages.

4. A heat exchanger comprising a shell, a plurality of tubes therein, tube sheets to which the opposite ends of said tube are secured, a plurality of tube spacing strips, a frame for supporting said strips, and means for securing said frame to at least one of said tube sheets.

5. A heat exchanger comprising a shell, a plurality of tubes therein, tube sheets to which the opposite ends of said tubes are secured, a plurality of tube spacing strips, a frame for supporting said strips whereby the strips and frame constitute a unitary cage, means for securing said frame to at least one of said tube sheets, and a baffle supported by said cage and one of said tube sheets.

In testimony whereof we affix our signatures.

KENNETH B. RIS.
JOSEPH PRICE.