

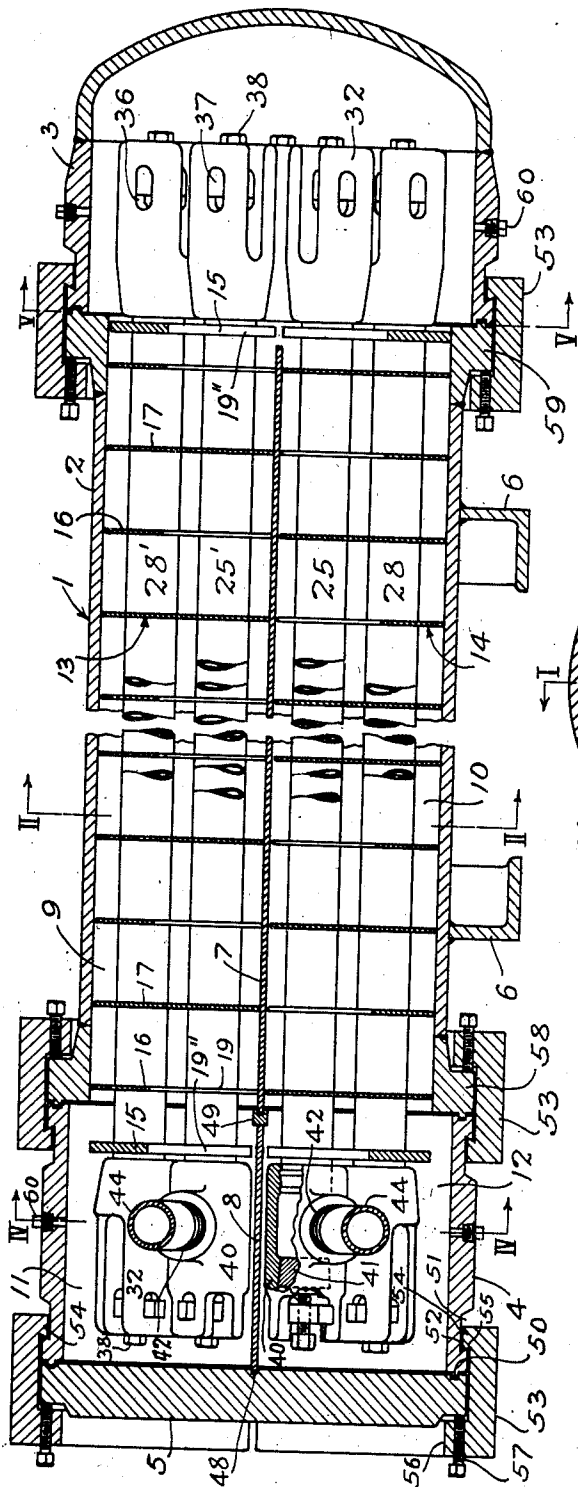
Nov. 3, 1942.

M. ETTINGTON ET AL
HEAT EXCHANGE APPARATUS

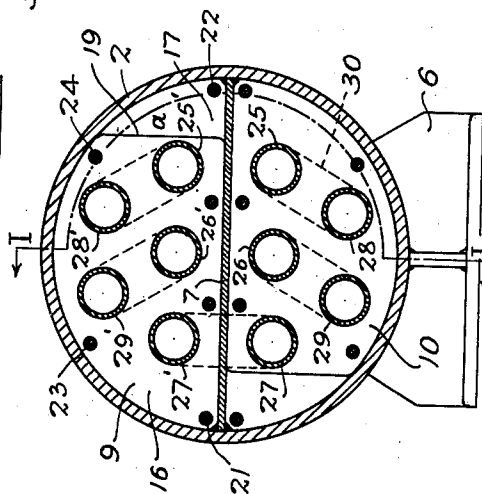
2,301,113

Filed Feb. 25, 1941

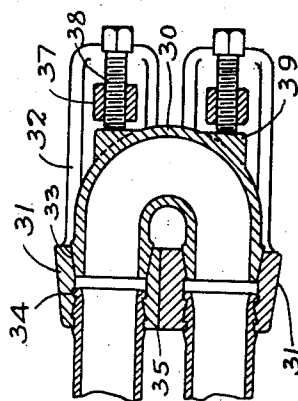
3 Sheets-Sheet 1



- FIG. 1.-



- FIG. 2.-



- FIG. 3.-

INVENTORS
Martin Ettington
John Mac Rae Barclay
BY *E. C. Yeaton*
ATTORNEY

Nov. 3, 1942.

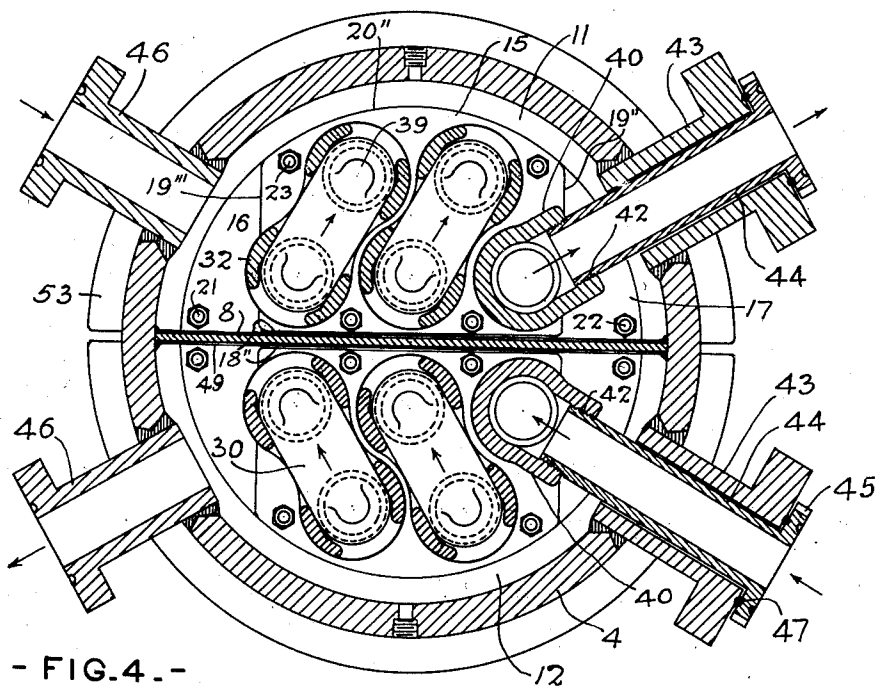
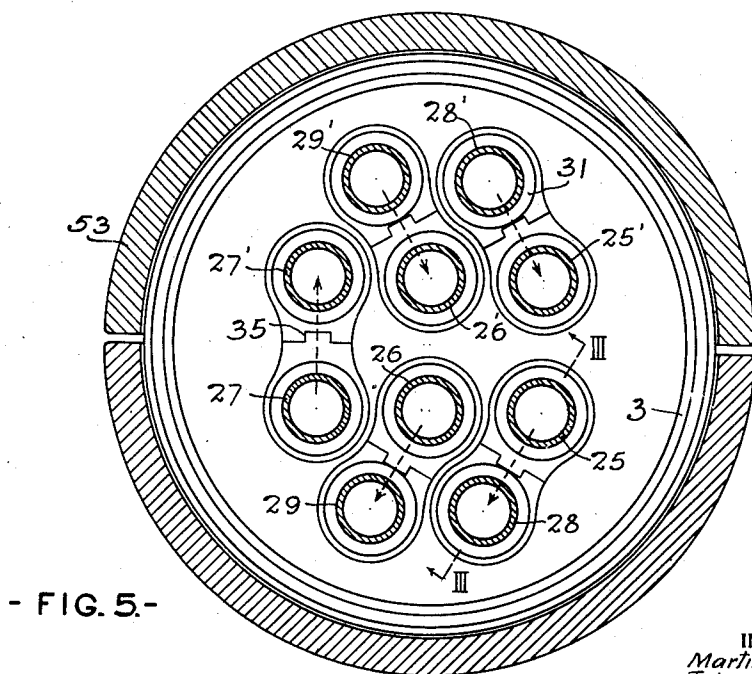
M. ETTINGTON ET AL

2,301,113

HEAT EXCHANGE APPARATUS

Filed Feb. 25, 1941

3 Sheets-Sheet 2



INVENTORS
Martin Ettington
John MacRae Barclay
 BY *S. C. Yeaton*
 ATTORNEY

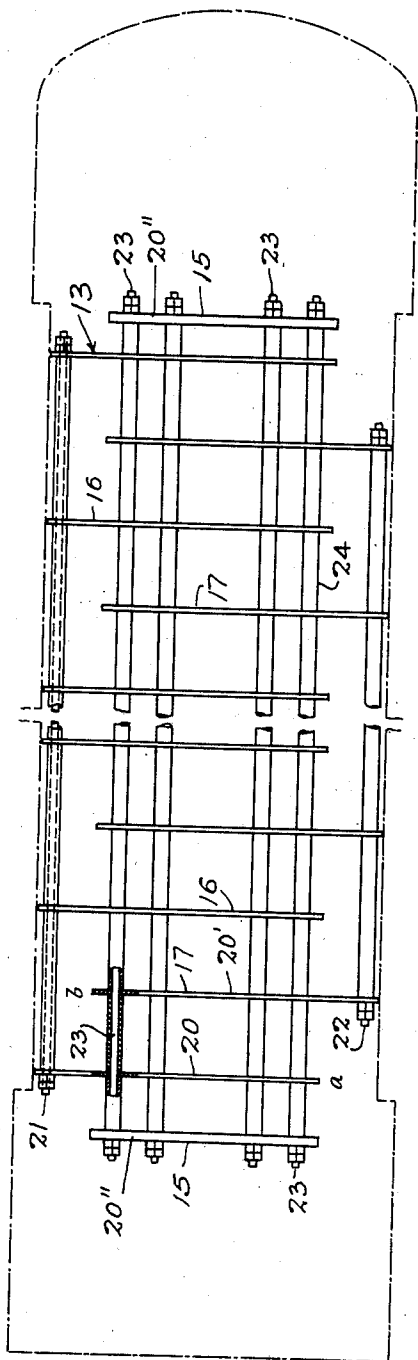
Nov. 3, 1942.

M. ETTINGTON ET AL
HEAT EXCHANGE APPARATUS

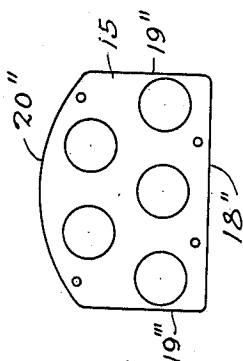
Filed Feb. 25, 1941

2,301,113

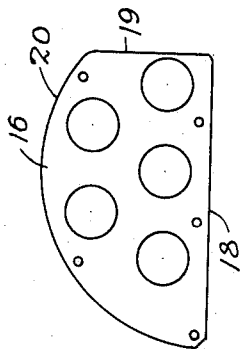
3 Sheets-Sheet 3



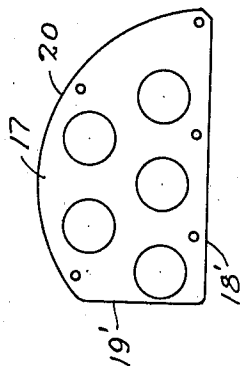
- FIG. 6. -



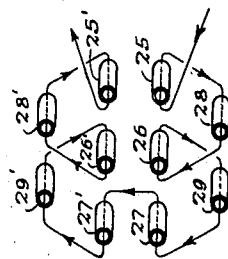
- FIG. 7. -



- FIG. 8. -



- FIG. 9. -



- FIG. 10. -

INVENTORS
Martin Ettington
John MacRae Barclay
BY *S. C. Yeaton*
ATTORNEY

UNITED STATES PATENT OFFICE

2,301,113

HEAT EXCHANGE APPARATUS

Martin Ettington, Pelham, and John MacRae
Barclay, Brooklyn, N. Y., assignors to American
Locomotive Company, New York, N. Y., a corporation of New York

Application February 25, 1941, Serial No. 380,497

1 Claim. (Cl. 257—240)

This invention relates to heat exchange apparatus, and more particularly to apparatus, for indirect heat exchange of fluids, of the type having a plurality of interconnected tubes for the passage therethrough of one of the fluids, and a tube-housing shell for the passage therethrough of the other fluid.

An object of the invention is to employ, in a heat exchanger of the foregoing type, separate return bends for interconnecting tubes instead of the tube sheets usually employed for interconnecting tubes, the sheets having been found unsatisfactory due to their tendency to distort and creep, especially in the case of relatively thick sheets required in high temperature and pressure heat exchangers.

Another object is to provide, in an exchanger of the just mentioned characteristics, a system of baffles, associated with the tubes, insuring circuitous or winding passage of the fluid in the shell in one direction and return in the opposite direction, thereby providing ample heat transfer relation thereof with the fluid in the tubes.

A further object is to mount the tubes in association with the baffles and shell to allow free expansion of the tubes in both directions relative to the shell and baffles.

Other and further objects of this invention will appear from the following description, the accompanying drawings and the appended claim.

Referring to the drawings forming part of this application, Figure 1 is a sectional view of the heat exchanger involving the present invention, taken on the line I—I of Fig. 2, being broken away through the central portion and contracted to save space, parts being shown in full and other parts omitted, and a terminal coupling being shown partly in section; Fig. 2 is a sectional view of the heat exchanger taken on the line II—II of Fig. 1; Fig. 3 is a section on the line III—III of Fig. 5, showing the tubes fragmentally; Fig. 4 is an enlarged sectional view of the heat exchanger taken on the line IV—IV of Fig. 1, parts being shown in full; Fig. 5 is a section on the line V—V of Fig. 1, enlarged similar to Fig. 4; Fig. 6 is a plan of a unitary transverse baffle assemblage shown partly in section, and the shell indicated in dot and dash lines, the assemblage and shell being broken away similar to Fig. 1; Figs. 7, 8 and 9 are elevations of three baffles of a transverse baffle assemblage, Fig. 7 being an end baffle, Fig. 8 being an intermediate baffle extending to one side of the assemblage, and Fig. 9 being an adjacent intermediate baffle extending to the other side of the assemblage; and Fig. 10

is a schematic view indicating the direction of travel of the fluid through the tubes.

In the present invention the shell, indicated generally by the reference numeral 1, is formed of a plurality of detachably connected parts, namely an open ended drum 2, a hollow cover 3 closing one end of the drum, an open ended channel 4 extending from the other end of the drum and concentric therewith, and a flat cover 5 closing the outer end of the channel.

The exchanger may be installed in a vertical or any other desired position, but as it is particularly devised to serve as a transfer line exchanger, it is preferably disposed, as shown in Figs. 1 and 2, in a horizontal position and for convenience will be so described. To this end it is supported on two spaced cradles 6 secured to the bottom of the drum.

The baffle system includes a main baffle 7 extending longitudinally of the exchanger through the drum from the channel end thereof to or substantially to the opposite end thereof and, in the horizontal position of the exchanger, is preferably disposed, as shown, horizontally, extending from side to side of the drum to which it is secured at its opposite longitudinal edges preferably by sealing it thereto, as by welding, throughout the entire length of the baffle.

A horizontal baffle 8, which in effect is a continuation of the baffle 7, extends through the channel 4 from the baffle 7 to the cover 5 and from side to side of the channel to which it is welded similar to the welding of the baffle 7. The baffle 7 divides the drum into an upper compartment 9 and a lower compartment 10, and the baffle 8 divides the channel into an upper compartment 11 and a lower compartment 12, which compartments 11 and 12 are in effect respectively continuations of the compartments 9 and 10.

The baffle system further comprises a unitary transverse baffle assemblage, indicated generally by the reference numeral 13, disposed in compartment 9 and extending for a short distance into compartment 11, and another unitary transverse baffle assemblage, indicated generally by the reference numeral 14, disposed in compartment 10 and extending for a short distance into compartment 12.

As these assemblages are similar in all respects a description of one, namely the upper assemblage 13 (shown particularly in Fig. 6), will suffice. It rests upon the baffle 7. The assemblage 13 includes longitudinally spaced transverse baffles, the end baffles or plates 15 being thicker than the other transverse baffles to

add rigidity to the assemblage, and the thinner baffles being preferably equally spaced apart. The thinner baffles do not extend entirely across the full width of the baffle 7, alternate baffles, as the baffles 16, extending from one longitudinal edge of the baffle 7 toward, but not to, the other longitudinal edge, providing open spaces *a*, and the remaining intermediate baffles 17, which are also alternate baffles, extending from the other longitudinal edge of the baffle 7 toward, but not to, the opposite edge, providing other open spaces *b*.

Each baffle 16 has a horizontal lower edge 18, supportedly engaging the baffle 7, a vertical edge 19 extending upwardly from one end of the edge 18 providing, with the baffle 7 and drum 2, one of the openings *a*, and a circular edge 20 connecting the opposite end of the edge 18 with the upper end of the edge 19, this edge 20 having the curvature of the drum and being disposed adjacent thereto. These baffles 16 are connected near the point of juncture between the edges 18 and 20 by a tie bolt 21, the baffles having aligned orifices to permit the passage therethrough of this bolt. Each baffle 17 has an edge 18', an edge 19' and an edge 20' similar to the edges 18, 19 and 20 of baffle 16, except that the edge 19' is at the opposite end of the edge 18' and similar remarks apply thereto, except that the edge 19', with the baffle 7 and drum 2, provides one of the openings *b*. These baffles 17 are connected by a tie bolt 22, similar to baffles 16.

The baffles 16 and 17 provide a winding or circuitous passageway for the passage of the fluid through the upper compartment 9 which in the present instance, as will later appear, is from the upper compartment 11 to the hollow cover.

The end plates 15 have relatively little baffling effect and are therefore more strictly strengthening plates. They are similar to each other, each having a lower edge 18'', a vertical edge 19'', and a circular edge 20'' corresponding respectively to the edges 18, 19 and 20 of baffle 16. However plate 15 has another vertical edge 19''' corresponding to the edge 19' of baffle 17. One of the plates 15 is centrally disposed in a transverse direction in compartment 11 with its edges 19'' and 19''' spaced from the respective adjacent portions of the channel 4 to provide openings at each end of this plate 15. The channel 4 is concentric with and of a larger diameter than the drum 2 so that a space is provided between the edge 20'' and the adjacent portion of the channel 4. Thus the fluid freely passes the plate 15 in channel 4 at the edges 19'', 19''' and 20''. The edge 20'' is of the same curvature as and in alignment with the edges 20 and 20' in order that the assemblage may be passed through the compartment 9 when desired, as will later more fully appear.

The other plate 15 is disposed in compartment 9 at the end thereof adjacent the hollow cover. While the edge 18'' may supportedly engage the baffle 7 it is shown slightly spaced from the end of this baffle. The edge 20'' is adjacent the drum 2 but as this plate is disposed centrally similar to the plate 15 in the channel 4, spaces are provided adjacent each edge 19'' and 19'''.

The plates 15 and baffles 16 and 17 are secured together by tie bolts 23, four being employed in the present instance, the plates and baffles being provided with aligned orifices to permit the passage therethrough of these bolts. The bolts 21, 22 and 23 have mounted thereon tubular

spacers 24 of suitable lengths to bear at their ends against the adjacent baffles and plates, and each bolt is provided at each end with a pair of nuts which, when tightened, firmly hold the parts tightly together to provide of the baffles, plates, bolts and spacers a unitary baffle assemblage.

While the assemblages 13 and 14 are separate units, the assemblage 14, as previously remarked, is similar to the assemblage 13 except it is supported upon the drum and, as is obvious, is inverted and consequently it is the curved edges of the baffles in the drum that are supportedly engaged by the drum. Further, while the baffles of the assemblage 14 are in vertical alignment with corresponding baffles of the assemblage 13, the corresponding baffles are reversed in direction providing a reversal in the positions of the spaces *a* and *b*. It follows therefore that the assemblage 14 provides a passage for the fluid similar to that of the assemblage 13 previously described, so that upon entering the hollow cover from the upper compartment, the fluid passes from the hollow cover through the winding or circuitous passageway of the lower compartment 10 into compartment 12.

The system of baffles aforedescribed causes a double flow in the exchanger of the fluid surrounding the tubes, the fluid passing first through the length of the top portion of the exchanger and then returning through the length of the bottom portion of the exchanger. However, if desired, the central horizontal baffles 7 and 8 could be eliminated, making a single flow exchanger of the apparatus. In such a case, as is obvious, a single transverse baffle assemblage of proper design would be employed, and the fluid outlet would be at the opposite end of the exchanger from the fluid inlet, for instance in the wall of the drum adjacent the cover 3. However, the following description will be of a double-flow heat exchanger, by way of illustration, it being understood that the invention has application also to the single-flow type of heat exchanger above mentioned.

The invention is not confined to any particular number of tubes, arrangement thereof, order of connecting, or to the direction of fluid flow through the tubes. However a feature of the invention resides in providing a group of tubes arranged in two banks or sets independently of each other except as to the return bend cross-over coupling connecting a tube of one set with a tube of the other set to provide for the continuous passage of fluid through all the tubes from the inlet end to the outlet end of the group, one set being disposed in the upper compartment 9 and the other set in the lower compartment 10. In the present instance however ten tubes are employed, five in each compartment, and in the preferred embodiment these are arranged and connected as clearly indicated in Fig. 10, the assumed direction of flow through the tubes being indicated in Fig. 10 and also in Figs. 4 and 5 by the arrows. Therefore the following description will be confined to the number of tubes, their arrangement, and the direction of flow as indicated in Fig. 10. Return bends are employed for connecting the tubes, thus avoiding tube sheets which, as before stated, have been found unsatisfactory due to their tendency to distort and creep, especially when made relatively thick as is required in high temperature and pressure exchangers. Such tendency to distort and creep is due in part to the unequal

temperatures between various portions of each tube sheet, which is a condition common in heat exchangers, and further is due to unequal expansion and contraction between the various tubes secured to the tube sheets.

There is a set of five tubes 25, 25', 27, 28 and 29 in the lower compartment 10 and a similar set of five tubes 25', 26', 27', 28' and 29' in the upper compartment 9. The adjacent tubes of each compartment are equally spaced in order that similar return bends may be employed throughout. Although the tubes 27-27' are shown as at slightly a greater space, requiring a larger return bend, they may be of an equal space requiring a return bend similar to the others. The tubes 25, 26 and 27 are arranged in a horizontal row near the baffle 7 and the tubes 28 and 29 are arranged in another horizontal row further from the baffle 7, the tubes of the rows being staggered. The tubes in compartment 9 are similarly arranged. The tubes extend through their respective compartments longitudinally and through all the transverse baffles and plates 15 of their respective compartments, the baffles and plates being provided with aligned orifices to permit this. The tubes extend for a short distance into the hollow cover to provide for their coupling with the return bends which are at this end, and, at their other ends, extend slightly beyond the plates 15 disposed in the compartments 11 and 12 to provide for their coupling with the return bends and outlet and inlet terminal couplings which are at this end, as will presently appear.

The return bends at one end of the apparatus are housed in the hollow cover and at the other end are housed in the channel. The return bends, with their associated parts, are preferably, as shown, separate from each other, all similar, and, as shown, are of a standard type requiring no threaded joints connecting the tubes with their bends, although other types may be employed.

The return bends 30 for coupling the tubes are of U-shape and each is connected to the tubes by two separate ring-shaped couplings 31. A pair of spaced hollow branches 32 extend from one end of each coupling in a direction longitudinally of the axis of the coupling and this end of the coupling is provided with an outwardly flaring inner seat 33. The opposite end is provided with internal grooves 34, and is mounted on the end of a tube, the tube being rolled outwardly to expand it into the grooves 34, providing a sealed, locked joint permitting longitudinally outwardly directed forces to be applied to the coupling and locked tube. The couplings 31 are mounted on the tubes with the spaces between the pairs of branches 32 in alignment. To insure this the couplings, at their adjacent sides, have engaging faces, one being provided with an axially directed groove and the other with a tongue fitting the groove providing the connection 35 which allows for any slight difference in longitudinal positioning of the couplings 31. The return bend 30 is disposed within the aligned spaces with the ends of its legs extending each within the flaring end of a coupling 31, the ends of the legs being oppositely flaring providing a sealed joint when forced tightly into the coupling 31, as will presently appear. The hollow branches 32 of each coupling 31 are provided with aligned orifices 36. A bar 37 is disposed across the space with its ends extending into the aligned orifices. The bar is provided, at its

portion spanning the space, with a threaded opening for a screw 38 which is inserted in the threaded opening after the bar is assembled and which bears at its end against a lug 39 formed on the return bend 30. Upon tightening the screws 38 the return bend, in an obvious manner, is forced tightly into engagement with the couplings 31.

Fig. 5 shows the order of connecting the tubes by the return bends at the hollow cover end of the apparatus, the return bend at the left being the cross-over return bend connecting together one of the tubes in each drum compartment, namely the tubes 27 and 27'.

Fig. 4 shows the order of connecting the tubes by the return bends at the channel end of the apparatus. Here the two tubes at the right, (one in each drum compartment, namely tubes 25 and 25'), are not connected to a return bend but instead each of these tubes is connected to a terminal coupling 40, these couplings being disposed one in each of the compartments 11 and 12. The coupling 40 is connected to the tube in a manner similar to the manner of connecting a coupling 31 as aforescribed, and a plug 41 for closing the coupling 40 is connected thereto similar to the manner of connecting a leg of the return bend as aforescribed, as clearly shown in section in Fig. 1.

Each terminal coupling 40 is provided with a threaded lateral opening 42. The channel is provided with openings in which are welded flanged couplings 43, one in line with each of the threaded openings 42. A flanged fitting 44, threaded at the end opposite its flange, extends through each of the couplings 43 with a loose fit, providing thereby a limited degree of flexibility, especially as to the expansion and contraction of the terminal tubes, and is screwed tightly into the threaded opening 42 in alignment therewith, the flange of the fitting 44 being provided with peripheral grooves 45 for the application of a wrench for turning the fitting 44. The fittings 44, due to their extending through the exchanger side wall, do not interfere with removal of the cover 5 for inspection and cleaning of the parts.

The channel 4 is further provided with two other couplings 46 similar to the couplings 43, one provided for and opening into each of the compartments 11 and 12.

Between the flanges of the couplings 43 and fittings 44 are sealing rings 47, grooves being formed in these flanges for receiving the rings. Other sealing ring grooves are provided in the opposite faces of the flange of each of the fittings 44 and in the outer faces of the flanges of the couplings 46, it being understood that the flanges of the couplings 43 and 46 are for securing thereto, by means of bolts, the flanges of other pipe couplings (not shown) similarly provided with sealing ring grooves, a sealing ring being disposed in each pair of these grooves and the flanges of the couplings 43 and 46 being provided with bolt holes (not shown).

The cover 5 is provided with a groove 48 in which is seated the adjacent end of the baffle 8, and an enlarged bar 49, which is provided with a similar groove in which is seated the adjacent end of the baffle 7, is disposed at the opposite end of the baffle 8 and secured thereto and to the channel as by welding (not shown).

The channel 4 and cover 5 are connected by a circular tongue and groove joint 50, the groove being in the cover and connecting with the

groove 48. A circular sealing gasket is disposed in the bottom of the tongue and groove joint and has a diametrically disposed cross rib seating in the bottom of the groove 48. A similar tongue and groove joint and gasket are provided between the channel 4 and the drum 2, the groove being in the channel and connecting with the groove of bar 49. A similar tongue and groove joint and gasket are provided between the hollow cover and the drum except that the gasket has no cross rib.

A groove 51 is formed in the outer face of the channel providing a circular shoulder 52 flaring outwardly toward the opposite side of the groove. A clamping ring 53, which is made in two sections to enable it to be assembled, secures the cover 5 to the channel 4. It has an interior flange 54 disposed in the groove 51 providing a shoulder 55 corresponding with and engaging the shoulder 52. The ring, at its opposite end, has another interior flange 56 extending over the peripheral margin of the outer face of the cover 5 and spaced therefrom sufficiently to permit the ring to be moved axially to clear its shoulder 55 from the shoulder 52 when assembling and disassembling, the groove 51 being of a sufficient length to permit this. The flange 56 has a series of threaded orifices formed therein for screws 57 which, in an obvious manner, when tightened, firmly hold and seal the cover 5 to the channel 4 and baffle 8. The drum and channel are secured together in a similar manner, the channel being provided with a flaring shoulder, and an outwardly extending flange 58 being formed on the drum for receiving the ends of the screws. Thus the drum is firmly held and sealed to the channel, and the baffle 7 to the bar 49. The drum and hollow cover are secured together in a similar manner, the hollow cover being provided with the flaring shoulder, and an outwardly extending flange 59 being formed on the drum for receiving the ends of the screws. The tongue of the tongue and groove joints between the drum and channel, and between the drum and hollow cover, project respectively from the outer end faces of the flanges 58 and 59. Drain orifices provided with screw plugs 60 are provided in the bottom and top of the channel, and in the bottom and top of the hollow cover.

From the foregoing it will be seen that the tubes are series connected, producing a continuous flow of fluid therethrough. The fluid enters the tube 25 from the fitting 44 connected thereto, this being considered the inlet fitting in the present set-up, as already stated. The fluid passes through all the tubes in the lower compartment 10 in the manner indicated in Fig. 10, crosses over through the cross-over return bend disposed in the hollow cover from the tube 27 to the tube 27', and then passes through all the tubes in the upper compartment 9 in the manner indicated in Fig. 10, and from the tube 25' passes to the outlet fitting 44 connected therewith. The fluid surrounding the tubes exteriorly initially enters the compartment 11 through the coupling 45 connected therewith, this being considered the inlet coupling in the present set-up, as already stated, and finally discharges from the compartment 12 through the outlet coupling 46 connected therewith. The fluid in the tubes is brought into most effective heat exchange relation with the fluid surrounding the tubes during the latter fluid's circuitous passage from the compartment 11 through the compartment 9 to

the hollow cover and during its return circuitous passage from the hollow cover through the compartment 10 to the compartment 12.

The fittings 44, which extend through the side wall of the exchanger, provide the only connection that the group of tubes has with the shell. The tubes thereby are free to expand and contract longitudinally responsive to temperature changes.

The chief advantage of the heat exchanger is this longitudinal freedom of expansion and contraction of the pairs of tubes, thereby avoiding the setting up of strains and stresses so prevalent in constructions employing one or more tube sheets. This freedom of expansion and contraction is aided by providing sufficient tolerances between the transverse baffles and the shell and longitudinal baffle and also between the tubes and the transverse baffles, which tolerances permit slight lateral movement of the tubes, giving them sufficient flexibility, when it is required, to minimize the aforesaid strains and stresses when the tubes expand and contract. This is especially important for the reason that the various tubes will have different temperatures due to the manner of heat exchange between the fluid in the tubes and that exterior thereto, which produces variable expansion. This result is not obtainable where a tube sheet is employed at either or both ends of the tubes.

It will be seen from the foregoing description that the parts of the exchanger are easily assembled and disassembled, facilitating cleaning, repairing and replacement of the parts.

By removal of the clamping rings, the various parts of the shell may be separated. By removal of the fittings 44 the entire tube group with both entire transverse baffle assemblies may be removed from the shell through the hollow cover end after the hollow cover has been removed, or, if desired, either set of tubes, with its transverse baffle assembly, may be removed from the shell in like manner after the cross-over return bend has been removed. The return bends are easily removed and the separate tubes may then be removed from their engaging transverse baffles and plates. Wherever there is a plurality of like parts they are made similar in all respects, thereby minimizing maintenance.

While there has been hereinbefore described an approved embodiment of this invention, it will be understood that many and various changes and modifications in form, arrangement of parts, and details of construction thereof may be made without departing from the spirit of the invention and that all such changes and modifications as fall within the scope of the appended claim are contemplated as a part of this invention.

The invention claimed and desired to be secured by Letters Patent is:

In a heat exchanger, the combination of a horizontal cylindrical shell open at one end and having a horizontal baffling and supporting partition providing an upper compartment and a lower compartment for series passes of fluid therethrough; a removable cover for said open end, said shell at its opposite end having two orifices, one for each compartment, one serving as an inlet and the other as an outlet for said fluid; a unitary structure in each compartment, each structure being removable as a unit through said open end and comprising a row of transverse, longitudinally spaced, baffles provided with horizontal rows of orifices, means rigidly securing

the baffles together to form an assemblage thereof, and a bundle of tubes arranged in horizontal rows and supported by said baffles, the tubes extending through said baffle orifices, and return bends interconnecting said tubes at adjacent ends to form a single passageway; a removable coupling combining said compartment passageways together at the shell end adjacent said cover providing thereby a continuous passageway for series flow of fluid through the tubes thereof in heat exchange relation with said fluid

in said shell; and a removable coupling for each said compartment passageway connected to its opposite end and extending through said shell at its orificed end, said opposite end couplings serving one as an inlet and the other as an outlet for said continuous passageway, said upper unit being slidably supported on said partition and said lower unit being slidably supported on said shell.

MARTIN ETTINGTON.
JOHN MacRAE BARCLAY.