May 16, 1944. S. J. CHUTE ET AL 2,349,143

HEAT EXCHANGER

Filed July 17, 1940 2 Sheets-Sheet 1

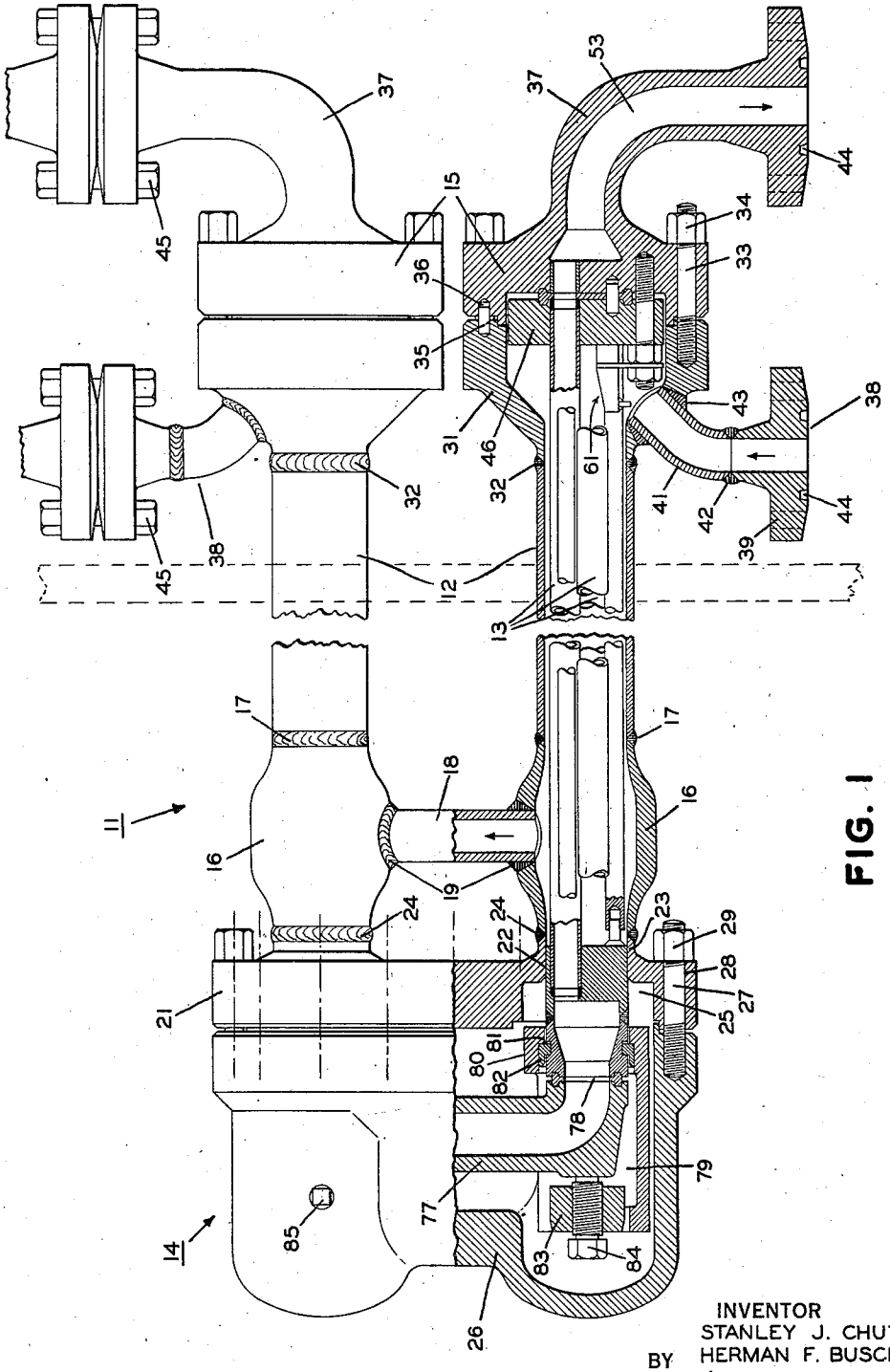


FIG. 1

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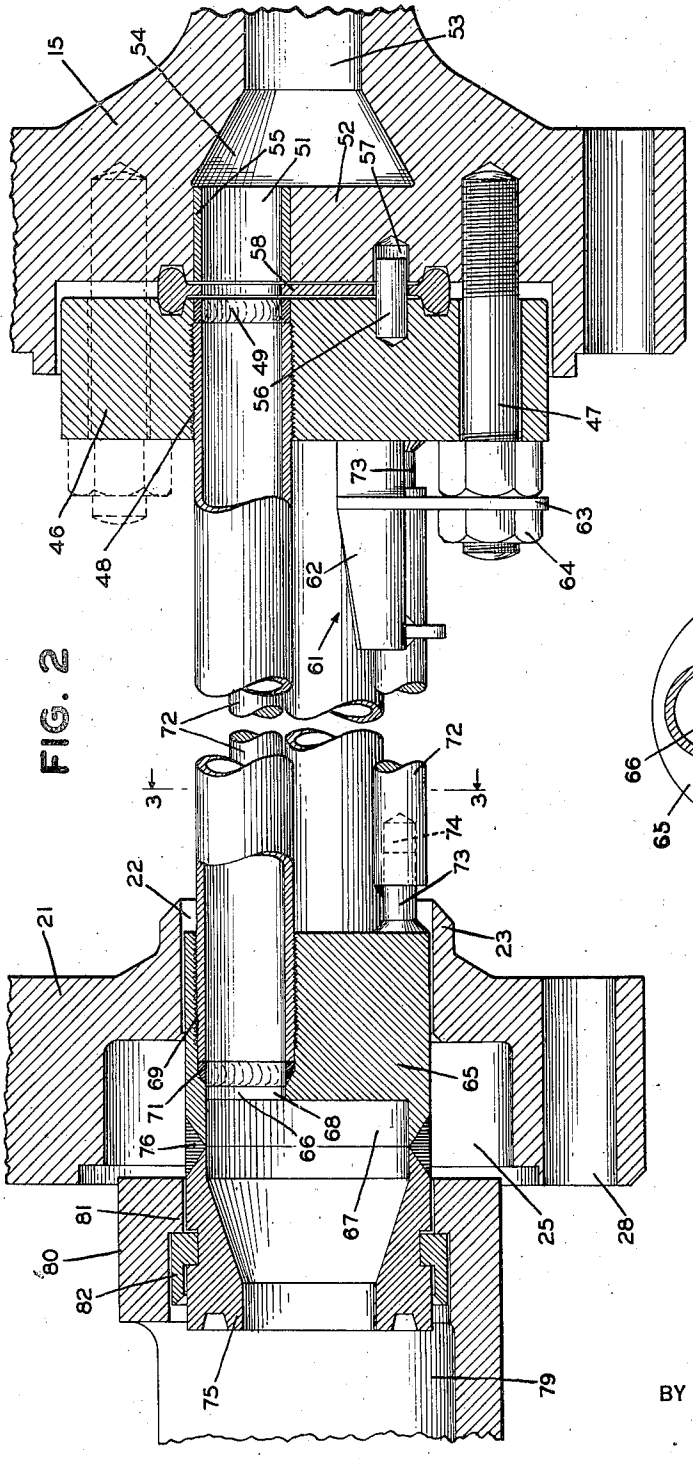


FIG. 2

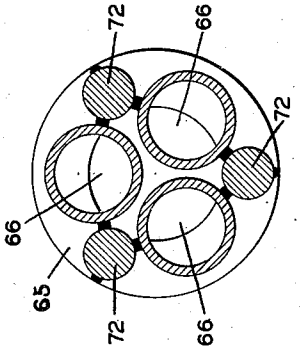


FIG. 3

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HEAT EXCHANGER

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Application July 17, 1940, Serial No. 345,888

3 Claims. (Cl. 257—234)

This invention relates to heat exchangers, and particularly to that type of heat exchanger in which one fluid heat-exchange medium is passed through a tube, or a series of tubes, in which a nest, or nests, of smaller tubes is disposed to provide passage for another fluid heat-exchange medium.

The United States patent to Wilson et al, No. 2,125,972, issued August 9, 1938, discloses a heat exchanger of the type contemplated by this invention. Heat exchangers of this type, because of their rugged and simple construction, their high thermal efficiency, and their high heat-transfer capacity per unit of weight, have gone into successful commercial use in installations where operating conditions are particularly severe or extreme. These heat exchangers have been successfully used as transfer-line heat exchangers in the petroleum refining art and, in such use, have handled fluid media at pressures above 2000 lbs. per square inch and at temperatures higher than 1000° F.

The heat exchanger of the present invention is in the nature of an improvement of the heat exchanger disclosed in the Wilson et al patent above-identified.

It is a principal object of this invention to provide a heat exchanger of the type mentioned, of simple, lightweight, and sturdy construction, having an improved arrangement of units whereby the heat exchanger may readily be disassembled for purposes of cleaning, repairing, or inspection.

A further object of this invention is to provide a heat exchanger of the type mentioned in which the shell system and tube nest system are readily separable.

A still further object is to provide a heat exchanger of the type mentioned, particularly suited for high pressure service, in which each tube nest has novel end arrangements forming therewith a unit removable, as such, from the tubular shell with a minimum of dismantling of the surrounding parts.

Further objects and advantages of this invention will be apparent from the following description and claims taken in connection with the accompanying drawings, in which:

Fig. 1 is a side view, in half-section, of one of a plurality of heat exchanger units arranged in a bank.

Fig. 2 is an enlarged section view of one of the tube nests showing the stationary and the floating end construction; and

Fig. 3 is a section view of the tube nest taken along line 3—3 of Fig. 2.

Heat exchanger unit 11 comprises a pair of comparatively large tubes or shells 12 for conducting one heat-exchange medium; a nest of smaller tubes 13 encased within each of the shells to form a fluid passage therethrough for a second heat-exchange medium; a return-bend, generally indicated at 14, including means for connecting adjacent shell ends and adjacent tube nest ends; and a connecter 15 on the free end of each shell 12, the connecters 15 and portions of the shells adjacent the connecters being adapted to provide an ingress and an egress for the fluid passages formed by the connected shells and the connected nests of tubes.

In a typical heat exchanger installation, a series of such units 11 may be joined together and supported on a framework in a manner similar to that shown and described in the aforementioned patent to Wilson et al. Since the present invention is directed to improvements and modifications in the unit described therein, it is unnecessary, for a complete understanding of this invention, to do more than illustrate and describe a single unit, attention being specifically drawn to the novel departures in design and construction constituting the improvements.

The shells 12, which ordinarily conduct the low pressure medium, are adjacent and parallel. Each of the shells 12 includes at one end, a swaged-out section 16 having an inside diameter larger than the diameter of the shell. The swaging may be performed on portions adjacent the ends of the shells 12 or, as shown in Fig. 1, a separate pipe-section of the desired shape may be joined to the end of a length of tube, as by weld 17, to form the shell 12. A pipe 18 communicates at each end with the adjacent swaged-out sections 16 to form a fluid cross-over between the shells 12. The ends of pipe 18 extend through openings formed in the walls of sections 16, and are joined thereto by welds 19.

A flange plate 21, having two openings 22 spaced center-to-center a distance equal to that between the shells 12, is attached to those ends of shells 12 which are adjacent crossover pipe 18. Each opening 22 aligns with one of the shell passages. The end of each shell is joined, as by weld 24, to a short annular neck 23 formed around each opening 22 of the flange plate 21. The face of flange plate 21 is dished-out around each opening 22 to form rabbeted portions 25. A removable bonnet 26 is secured to flange plate 21. Studs 27, set in the bonnet, extend through holes 28 in

the flange plate and have nuts 29 thereon which hold the bonnet to the flange plate in fluid-tight engagement. Bonnet 26 also forms a fluid cross-over for the shell passageways. Pipe 18, however, forms the main cross-over for the fluid medium in the shell; and bonnet 26 serves to carry over only the fluid seeping past the floating tube sheets, as will be more fully explained hereinafter.

Individual, outwardly flaring flanges 31 are attached, as by welds 32, to the opposite ends of shells 12. Connector 15 is attached in fluid-tight engagement to shell flange 31 by circumferential row of studs 33 and nuts 34 distributed around the flange. Studs 33 are set in the face of flange 31 with their projecting ends extending through holes in the connector 15. A projecting pin 35, set in the face of flange 31, and a recess 36 formed in the connector cooperate as a guide means to maintain a proper relative position between the connector and the shell.

Connector 15 includes a curved tubular portion 37 which forms a 90° elbow on the end of the shell. The tube nest 13 is so arranged within the shell that its tubes connect with the passageway of connector 15 in fluid-tight relation.

A second connector 38 also communicates with the interior of the shell 12 through the flaring side of flange 31. Connector 38 comprises a flange 39 joined to the end of a curved pipe 41 by weld 42. The other end of pipe 41 extends through an opening in the side of flange 31 and is secured to the latter by weld 43.

As shown, the shell system of the heat exchanger unit 11 is substantially U-shaped, each shell 12 forming one branch of the U. The connecters 15 and 38, associated with each branch of the U, curve outwardly from the end of the unit with their fluid passageways discharging in the same direction, that is, normal to the longitudinal axis of the shell. The flange faces of the connectors 15 and 38 are in a common plane parallel to the shells 12, so that a series of units 11 may readily be connected together in a bank, with all of the shells arranged in parallel fashion. Sealing-ring grooves 44 are provided in the face of each connecter flange, so that, with the use of a sealing ring, a fluid-tight connection may be obtained between the adjacent heat exchanger units. Flange bolts 45, distributed about the flanges, provide a rigid coupling for the units, and enable them to be easily assembled or disassembled.

The tube nest 13 of each shell includes a stationary and a floating tube sheet into which the ends of the tubes are set. The stationary end of the nest is rigidly secured to connector 15, and the floating end thereof extends through flange plate 21 into the bonnet 26. In the particular embodiment illustrated, the tube nest comprises three tubes equi-spaced from each other and from the shell 12, as clearly shown in Fig. 3. The stationery tube sheet 46 is secured to connecter 15 by studs 47 set in the face of the connecter flange.

Stationery tube sheet 46, shown enlarged in Fig. 2, has a plurality of holes, corresponding to the number of tubes in the tube nest, adapted to receive and hold the ends of the tubes. Each hole in the tube sheet is threaded lightly for a portion of its depth, as at 48. Each tube end is inserted into the threaded portion of the hole, and is rolled outwardly therein to cause the threads to bite into the surface of the tube. The remaining portion of the tube sheet hole, that is, the area between the end of the inserted tube and the outer face of the tube sheet, provides a small ledge or recess around which an annulus of weld metal 49 is deposited to rigidly secure the tube to the tube sheet.

Connecter 15 has a plurality of openings 51 corresponding to, and in alignment with, the holes in the tube sheet 46. The openings 51 are in a diaphragm 52 formed across the mouth of the connecter passageway 53. A frusto-conical portion 54 is formed within the connecter passageway adjacent and behind the diaphragm 52. The portion 54 of the connecter passageway tapers from a cross-sectional area at one end large enough to include the openings for the nest of tubes to a cross-section area at the other end approximately equal to the sum of the flow areas of all the tubes in the nest. The openings 51 in the connecter diaphragm 52 are fitted with removable bushings 55 which may be replaced periodically as they become corroded by the flow medium. These bushings serve to materially increase the period of usefulness of the connecter and, since they may be manufactured cheaply and installed easily and rapidly, result in substantially reduced maintenance costs.

To insure proper positioning of tube sheet 46 relative to the connecter 15 which supports it, a projecting pin 56 set in the face of the tube sheet 46 cooperates with a guide recess 57 formed in the outer face of diaphragm 52.

A gasket 58 is positioned between tube sheet 46 and the face of connecter 15 to prevent fluid leakage between the shell and the nest of tubes. Gasket 58 covers diaphragm 52, and has cut-out portions aligning with openings 51 and hole 57.

As illustrated in Fig. 1, the inlet for the medium conducted by the tube shell and the outlet for the medium conducted by the nest of tubes are shown in section. An impingement baffle 61 is placed within the flange member 31 in a position to shield the tubes 13, so that they will not receive the full force of the fluid admitted through connector 38. Baffle 61 comprises a curved shield 62, adjacent and partially surrounding the end of the tube nest, and a lateral brace 63 mounted on the free end of stud 47 and held firmly in position by nut 64.

The opposite end of tube nest 13 is designed to float within the shell, so that the tubes may freely expand and contract longitudinally therein with changing temperatures. The floating end of the tube nest is provided with a tube sheet 65 in the form of a cylindrical block slidably supported and snugly fitted within the opening 22 of thee flange 21. Tube sheet 65 has a plurality of holes 66 adapted to receive and hold the ends of the tubes 13. The outer face of tube sheet 65 has a circular recess 67 encompassing all of the tube sheet holes 66. The tube sheet holes have a stepped bore providing a short zone 68, adjacent recess 67, having a diameter equal to the bore of tubes 13, and a longer zone 69 into which tubes 13 may be inserted. The tube receiving zone 69 is treated to provide a surface of sharp irregularities, as by cutting a screw thread therealong, so that the tube ends, when inserted and rolled outwardly therein, will have their outer surfaces deformed and interlocked with the surfaces of the tube sheet holes.

Zone 69 is only partially occupied by tube 13, sufficient space being left between the end there-

of and zone 68 to provide a channel into which weld metal 71 may be deposited to rigidly secure the tubes to the tube sheet.

Tubes 13 are arranged on the shortest center-to-center distances possible with the type of tube sheet construction shown, so that a one-to-one ratio may be closely approximated between the volumes of the media passed in each flow path per unit of time. Due to structural limitations, however, the close spacing of the tubes does not alone provide a close approximation of the one-to-one ratio between the available cross-section flow area of the shell 12 and the combined cross-section flow areas of the tubes 13, as will be apparent from a consideration of Fig. 3. To compensate for this, filler rods 72 are placed in the tube nest to decrease the flow area of shell 12, so that it closely approximates the flow area of the tube nest.

The rods 72 are shorter than the distance between the tube sheets, and are supported at their ends by dowels 73 firmly set in the tube sheets. The projecting ends of dowels 73 are received in holes 74 drilled longitudinally in the ends of the rods. The dowel length and the depth of holes 74 are such that the rods may easily be inserted and removed independently of the tubes. In assembling the tube nest, the rods are slipped onto the dowels and then centered between the tube sheets. In this position, the rods are rigidly secured at one end to the dowels, as by a small deposit of weld metal; the other end is left unconnected to allow free longitudinal expansion of the rods.

A reducing nipple 75, having an outside diameter equal to that of the tube sheet 65, is joined to the latter by weld 76. The bore of nipple 75 tapers from a diameter, adjacent the tube sheet, equal to the bore of recess 67 to a diameter, at its outer end, sufficient to provide a flow area substantially equal to the total flow area of the nest of tubes.

A return bend 77 within the bonnet 26 connects the ends of the tube nests in the adjacent shells 12. The ends of the return bend 77 and the outer ends of the reducing nipples 75 are suitably grooved to receive a sealing ring 78.

A yoke 79 is provided at each end of return bend 77 to hold the latter in fluid-tight engagement with the floating end of the tube nest. One end of yoke 79 is formed into a ring 80 adapted to encircle the reducing nipple 75. Ring 80 has an annular shoulder 81 extending inwardly which engages the projecting edge of a split-ring 82. Split-ring 82 has a shoulder extending inwardly which fits into a circumferential groove on the surface of the nipple 75.

The remaining portion of yoke 79 partially encases the end of the return bend 77. A cross-member 83 at the open end of the yoke is drilled and tapped to receive a screw 84 which may be made to press against the end of the return bend 77 to maintain a fluid-tight connection between the latter and the tube nest. The entire floating end of the tube nest, including the tube sheet 65, nipple 75, return bend 77, and yoke 79, may thus move longitudinally with changing temperatures within the shell and the bonnet.

The flow path thus formed by the nests of tubes and the return bend is completely sealed from the shell and the bonnet. Although some of the fluid in the shell, instead of passing through the cross-over pipe 18 may leak between the tube sheet 65 and the flange plate opening 22 into the bonnet 26, no harm can be done, since the escaped fluid may cross over through the bonnet and pass into the shell on the opposite side. Drain plugs 85 are provided in the bonnet 26 for the evacuation of the accumulated fluid therein when the bonnet is to be removed from the flange plate 21.

The heat exchanger unit 11 is assembled in the following manner: The tubes 13 are set in the tube sheets 46 and 65, and the tube ends then are rolled outwardly. Welds 49 and 71 are then made to join the ends of the tubes to the tube sheets. The filler rods are inserted and tack-welded, or otherwise secured, at one end to the dowels projecting from the tube sheets. The reducing nipple 75 is welded to tube sheet 65. Stationary tube sheet 46 is joined to connecter 15 by studs 47, gasket 58 being placed therebetween to provide a fluid-tight joint. Baffle 61 is mounted on the projecting end of stud 47. The assembled tube nest is then pushed through the shell until the flanged connecter 15 engages flange 31. Nuts 34, on the ends of the studs 33 which project through the connecter, are used to hold the shell and the connecter tightly together. As thus assembled, the stationary end of the heat exchanger unit is complete, and the reducing nipple 75 and part of the tube sheet 65 extend through opening 22 in the flange 21. Yoke 79 is slipped over the end of nipple 75 and slid inwardly into the rabbeted portion 25 of the flange 21 until the tube-sheet encircling ring 80 of the yoke 79 clears the groove which accommodates the split-ring. The split-ring 82, which is in three parts, is then inserted piece-by-piece into the groove at the most accessible point, each piece being slide around to make room for the next piece. The yoke 79 is then pulled outwardly until shoulder 81 engages the projecting edge of the split-ring. With the yokes of both tube nests in this position, the return bend 77 is slipped in place. Sealing rings 78 are placed between the return bend and the reducing nipples 75, and screws 84 are advanced until sufficient pressure is exerted against the return-bend 77 to provide a fluid-tight connection between the latter and the tube nest. Bonnet 26 is then secured to the flange 21.

The construction of unit 11 is such that it has the advantage of being easily and quickly disassembled for the purpose of cleaning or repairing. To disassemble the unit, bonnet 26 is removed and screws 84 are backed up to release return-bend 77, which is also removed. Yokes 79 are slid forward on the tube sheet 65, permitting the split-rings 82 to be removed. The yokes 79 are then removed from the end of the tube nest. At the stationary end of the unit, nuts 34 are removed from their studs 33 to release connecter 15 from flange 31. The entire tube nest, being attached to connecter 15 by the studs 47, is then removed as a unit with the connecter.

The parts of the apparatus most easily affected by the corrosive action of the fluids are thus made easily accessible for the purpose of replacement or repair. Although bushings 55 are fitted into the openings 51 of diaphragm 52 to decrease corrosion therein, periodic replacement may be necessary. While the tube nest is removed from the shell 12, the connecter 15 may be separated from the tube sheet 46 by removing the nuts from studs 47. New bushings may then be placed, if required, in the diaphragm of connecter 15.

A particular advantage of the novel arrangement shown and described is that the various

nozzles, flanges, tube sheets, etc. may be of lighter construction than has heretofore been possible. A considerable saving in weight is thus effected, which applies not only to the various parts of the heat exchanger unit, but also to its supporting structure. The compact and sturdy construction of the unit permits the use of shorter and lighter bolts for connecting the various parts. These weight-saving features of the unit appreciably affect the cost of construction, and serve to maintain it at a minimum. A further advantage to be gained by the use of lighter and smaller parts is that the heat exchanger as a whole is given greater flexibility.

We claim:

1. In a heat exchanger, a nest of tubes; a shell encasing said nest of tubes; a connecter attached to the end of said shell, said connecter having a diaphragm integral therewith extending across the end adjacent said shell provided with a plurality of passages corresponding to said tubes and replaceable linings within said plurality of passages; a tube-sheet having partly threaded tube holes, the ends of said tubes being expanded within the threaded portions thereof; and annuli of deposited weld metal uniting the ends of said tubes to said tube-sheet and lining the remaining portions of said tube holes; said tube-sheet being secured within said shell to said connecter with said tube-nest passages and said diaphragm passages joined in fluid-tight connection.

2. In a heat exchanger of the character described, a nest of tubes; a shell encasing said nest of tubes; a flanged connecter attached to the end of said shell, said connecter having a central passage closed at the end adjacent said shell by a substantially thick perforate diaphragm integral with the body of the connecter, the flange face and diaphragm closing the end of said shell; a tube-sheet for said tubes having openings corresponding to and aligning with the perforations of said diaphragm, said tube-sheet being removably attached in fluid-tight relation to said flange face; and replaceable tubular linings within said perforations; said tubes, said lined perforations, and said central passage providing a substantially uniform flow area for the tube nest fluid.

3. In a heat exchanger, a nest of tubes; a tubular shell encasing said nest of tubes; a connecter attached to the end of said shell, said connecter having a diaphragm integral therewith extending across the end adjacent said shell provided with a plurality of passages and replaceable linings therein; and a tube-sheet for said tube nest secured within said shell to said connecter, said tubes and said lined passages having substantially equal flow areas and being connected in fluid-tight relation.

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