

June 29, 1937.

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2,085,677

HIGH PRESSURE HEAT EXCHANGER

Filed Aug. 15, 1935

4 Sheets-Sheet 1

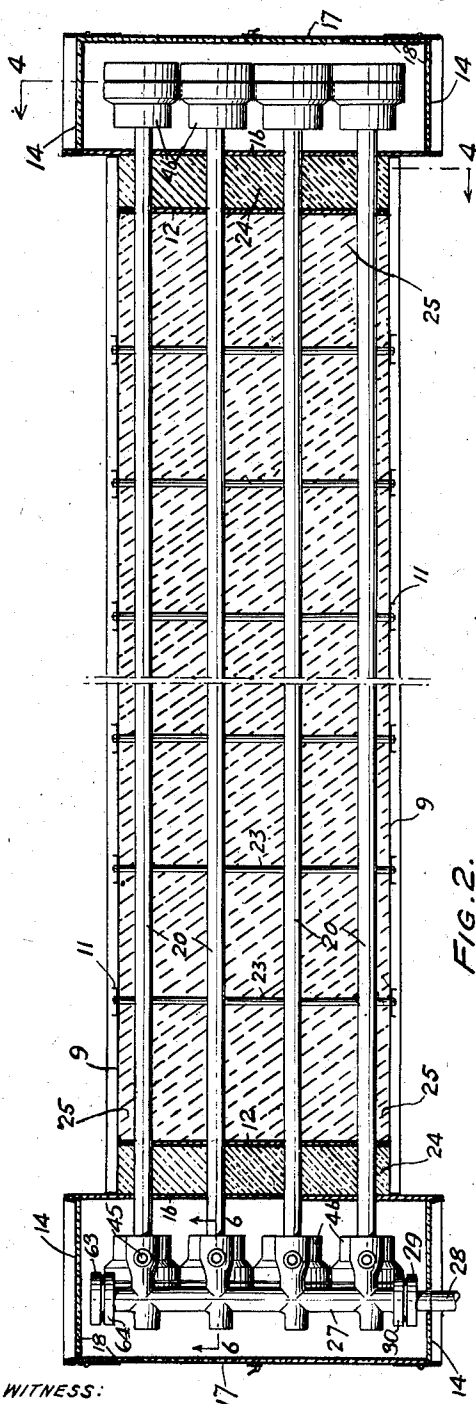


FIG. 2.

WITNESS:

Robt. R. Mitchell

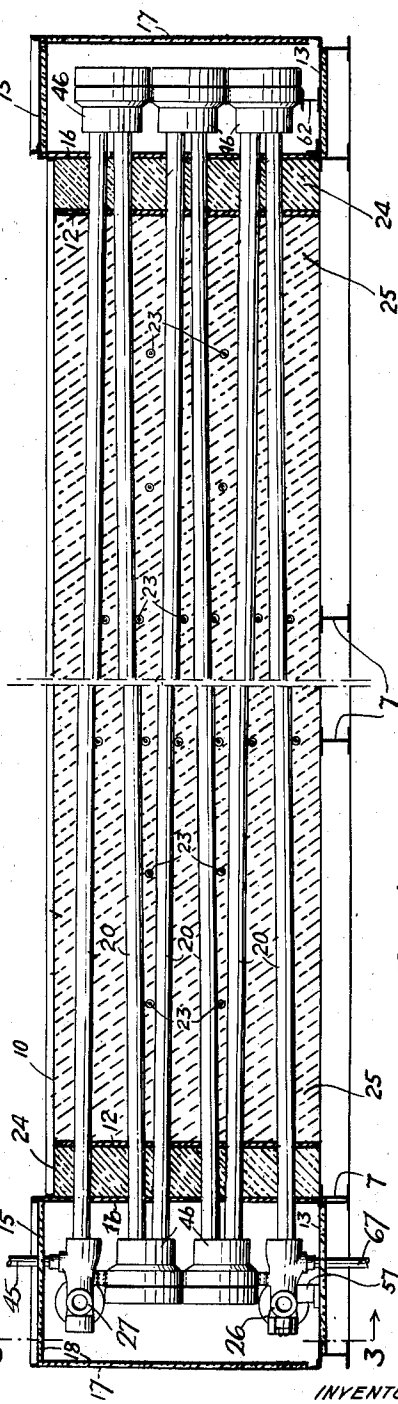


FIG. 1.

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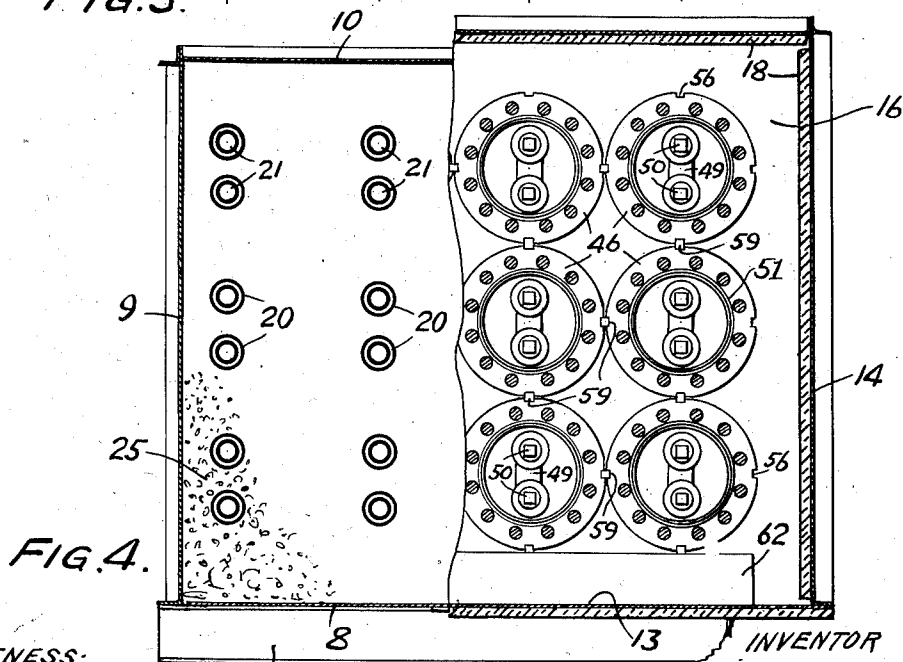
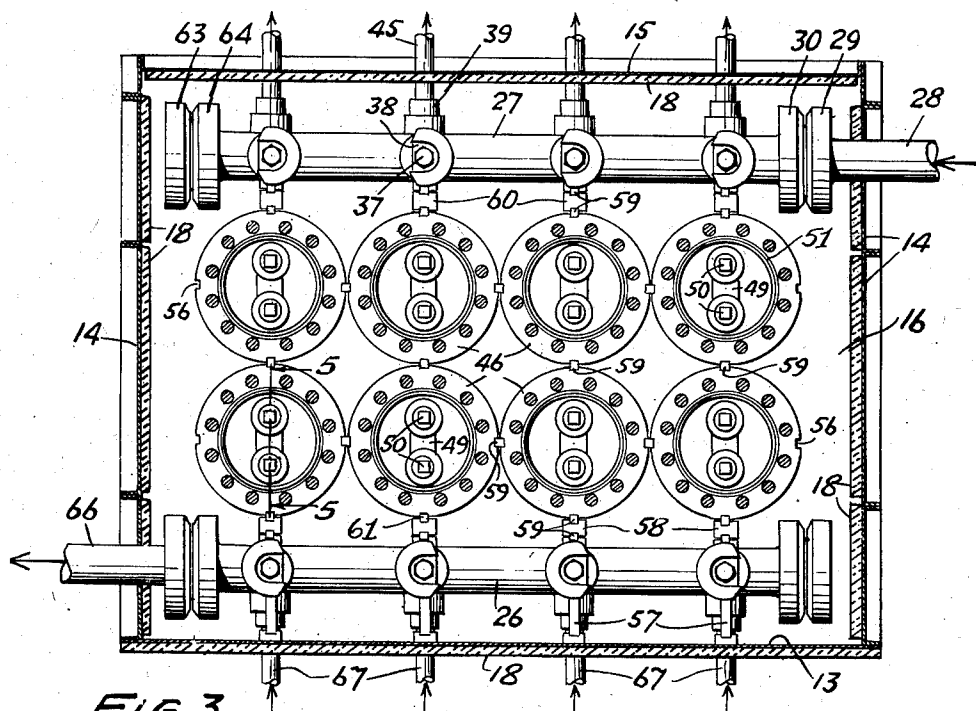
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HIGH PRESSURE HEAT EXCHANGER

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4 Sheets-Sheet 2



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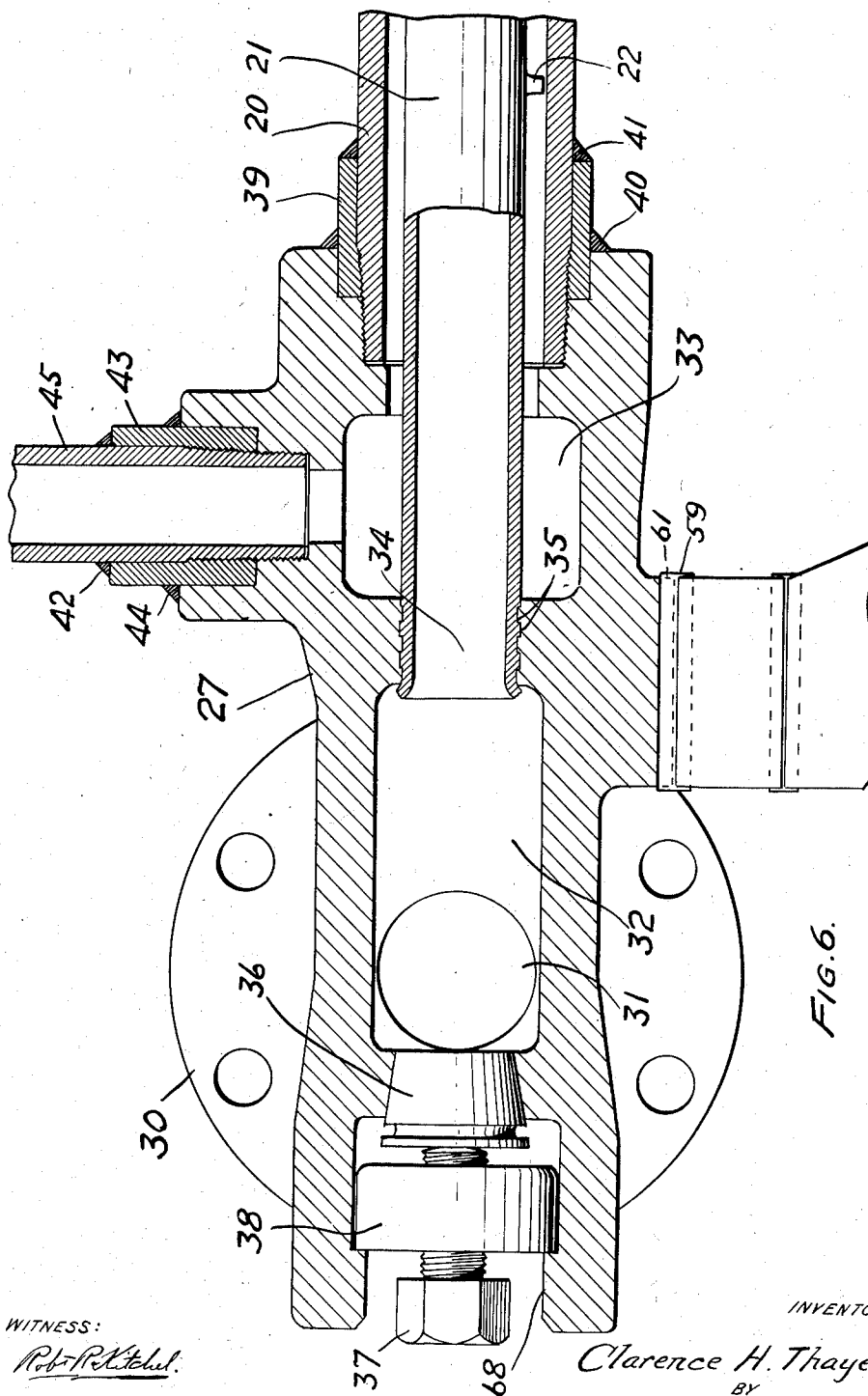
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HIGH PRESSURE HEAT EXCHANGER

Filed Aug. 15, 1935

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,085,677

HIGH PRESSURE HEAT EXCHANGER

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4 Claims. (Cl. 257-247)

This invention relates to a heat exchanger of the type comprised of an outer tube conveying a fluid, with inner tubes arranged therein, conveying another fluid, flowing in a counter-direction to the fluid in the outer tubes, and wherein one of the fluids gives up part of its heat to the other fluid. More particularly this invention relates to such heat exchangers wherein one or both of the fluids is under a very high pressure.

In order to bring about an efficient heat exchange and to decrease the amount of space occupied by the heat exchanger, it is customary to provide a number of outer tubes connected end to end by return bends and a number of inner tubes connected end to end by return bends. Due to the number of connections necessary at the return bends, and due to the unequal expansion of the tubes, it has been extremely difficult to construct a heat exchanger which will remain tight, especially when the fluids in the exchanger are under a high pressure. This is particularly true with the heat exchangers used at oil refineries, for here all joints should be absolutely tight as the oils in the heat exchangers are generally above their flash point, and any leaks might have disastrous results. Also the tubes in the heat exchangers must be kept clean and therefore the return bends must not only be tight, but must also be readily removable to provide easy access to the tubes for cleaning.

Difficulty has also been experienced at the inlet to the exchanger, since it has been customary to connect the supply line to a relatively large header to which the tubes of the exchanger are connected. The velocity of the fluid necessarily decreases while flowing through the relatively large header and if the fluid is a hot synthetic crude, it has a decidedly increased tendency to deposit carbon. Also erosion has been very great at the inlet and outlet of the exchanger, due to the change in direction of flow of the fluids.

It is therefore an object of this invention to provide a heat exchanger, which is suitable for use with fluids which are under a high pressure, and which will be tight even with the relatively high expansion differences, but at the same time will provide easy access to the tubes for cleaning.

Another object of my invention is to provide an integral manifold for introducing fluid into and withdrawing fluid from a heat exchanger in which the velocity of the fluid will remain substantially the same as in the supply lines, and in which the number of sharp bends will be reduced to a minimum.

Other and further objects will appear as the description progresses.

In the drawings accompanying the specification, and forming a part thereof, and in which like numerals refer to like parts throughout:

Fig. 1 is a side elevation of the heat exchanger embodied in this invention with the one side of the casing removed.

Fig. 2 is a top plan view of the heat exchanger with the top of the casing removed.

Fig. 3 is an end view taken on the line 3-3 of Fig. 1, with the end cover plates on the outer return connections removed.

Fig. 4 is an end elevation partly in section, taken on the line 4-4 of Fig. 2.

Fig. 5 is a detail section of a typical return header taken on the line 5-5 of Fig. 3.

Fig. 6 is a detail section taken on line 6-6 in Fig. 2, of the manifold embodied in this invention.

Referring now to the drawings:

A suitable frame work, composed of I beams 7, and uprights 11, is provided. Bottom plates 8 rest on the beams 7 and suitable side plates 9 are secured to the uprights 11. The top of the heat exchanger is covered by top plates 10. Spaced a short distance in from the ends of the body of the heat exchanger are end plates 12, having openings therein through which the outer tubes of the exchanger pass.

At each end of the exchanger there is a box composed of a bottom plate 13 resting on the beams 7, side plates 14, and top plates 15, one end of which box is closed by a plate 16 having opening therein through which the outer tubes of the exchanger pass. The outer end of these boxes is closed by doors 17. All outside plates and doors in these boxes are covered on one side by suitable insulating material 18.

The heat exchanger proper is composed of a number of outer tubes 20, within which are arranged inner tubes 21 of smaller diameter than the outer tubes, and having suitable projections 22 to hold them in spaced relation from the outer tubes. These tubes extend through the entire length of the casing passing through plates 12 and 16, and are supported in the casing by cross bars or tubes 23 extending between the uprights 11. The space between plates 12 and 16 is filled with a refractory or insulating cement 24, poured in place after the tubes are in place. The space around the tubes within the casing is filled with a powdered insulating material 25.

The fluid to be heated and the heating fluid are introduced into and withdrawn from the

tubes 20 and 21 through two manifolds 27 and 28. These manifolds are identical in construction and particular attention is directed to Fig. 6. The heating fluid enters one end of the manifold 27 from flanged pipe 28. The flange 29 on pipe 28 is bolted to flange 30 on the manifold 27. The oil flows through the opening 31, extending the entire length of the manifolds, into spaces 32. The other end of the manifold is closed by plate 63 bolted to flange 64.

The inner tubes 21 communicate with the space 32 in the manifold and pass through the space 33 in the manifold with which the outer tubes 20 are in communication. The inner tubes pass through opening 34, and are rolled into this opening as shown at 35 so as to make a tight joint. The other end of space 32 is closed by a tapered plug 36, which closes an opening through which a cleaning tool may be inserted, and which is held in place by a tap bolt 37 screwed through the plate 38 held in place by semi-annular shoulders 68 in the manifold body. This plate and bolt, 38 and 37 respectively, are of the type ordinarily used to hold U return bends in place.

In order to minimize corrosion, the manifolds 26 and 27 may be constructed of a cast stainless steel such as a chrome molybdenum steel casting. Such material is subject to air hardening and therefore cannot be welded in the field where the weld cannot be properly annealed. In order that the heat exchanger tubes may be welded to the manifold, a collar 39 of plain .10-20 carbon steel may be inserted in the manifold and welded thereto by weld 40. Likewise, the supply lines 45 may be welded to the manifold by inserting a plain carbon steel collar 43 in the manifold and welding it thereto by a weld 44. It is to be understood that the welds 40 and 44 will be made in the shop and will be properly annealed to prevent or overcome embrittlement of the manifold due to air hardening. When the heat exchanger is being assembled the outer tubes 20 may then be attached to the manifold by screwing them into the manifold and welding them to collar 39 by weld 41. Similarly, supply lines 45 may be attached to the manifold by screwing them into the manifold and welding them to collar 43 by weld 42. It is apparent that the welds 41 and 42 may be made in the field without annealing since the collars 39 and 43 are plain carbon steel and therefore are not subject to air hardening. If the manifolds 26 and 27 are of plain cast steel or some other material not subject to air hardening, the collars 39 and 43 may be omitted and the tubes attached to the manifold by screwing them thereto and welding them directly thereto.

At their other end the outer tubes in the top bank are rolled into a return header body 46 (as shown in detail in Fig. 5) and welded thereto as shown at 47. The fluid in one outer tube connected with the return header 46 flows into the space 48 therein, and into the other outer tube connected to the return header.

The inner tubes enter the space 48 and enter the return connection 49 placed therein, and are rolled into this return connection as shown. Openings closed by tapered screw plugs 50 are provided in the return connection 49 opposite the inner tubes 21, through which an expanding tool for rolling the inner tubes, or a cleaning tool may be inserted.

An annular packing groove 51 is provided in the return header 46, and the space 48 in the header is closed by cover plate 52 having an annular packing groove and packing 53 and 54

respectively therein. The cover 52 is held to the return header body by tap bolts 55. Four key slots 56, are cut in the return header body as shown.

It is preferred to place both manifolds at one end of the exchanger, and the bottom manifold 26 is supported from the bottom plate 13 by spacers 57, another spacer 58 rests on top of manifold 26 and is keyed thereto by key 59 resting in key slot 61 in the manifold. A return header 46, is keyed to the spacer 58, and to the return headers 46 immediately above and beside it by keys 59 in key slots 56. At the top a spacer 60 is keyed to the top return header and the top manifold 27 is keyed to this spacer and rests thereon. By supporting the return headers on the bottom manifold and each other, and the top manifold on the return headers, a very simple construction is provided. Also, by keying the return headers to each other and to the manifolds, a very rigid construction is provided, so that when the bolts 55 holding the cover 52 on the return header body 46 are turned, the header will be held by the manifold and adjoining headers against turning, and so the tubes will not be twisted and the joints between the tubes and headers weakened.

At the other end (as shown in Fig. 4) the headers 46, in the bottom row, are supported on and keyed to a beam 62, the next row of headers 46, is supported by the row below them and each header is keyed to the headers about it by keys 59 in slots 56. Thus a simple and rigid construction for this end of the heat exchanger is provided.

When the heat exchanger is used to heat up gas oil being charged to a still, by flowing it in heat exchange relation with synthetic crude coming from the still, it is preferred to have the gas oil flow through the outer tubes, and the synthetic crude flow through the inner tubes, since the hot synthetic crude has a tendency to deposit carbon, and it is necessary to clean the tubes through which it flows.

The hot synthetic crude enters through pipe 28 and flows through the central opening 31 in the manifold 27 entering the spaces 32, from here it enters the inner tubes 21 and flows down these tubes to the return connection 49, where it enters space 65 and from here enters the next inner tube and flows back to the top return connection at the manifold end. The oil continues its flow back and forth through the inner tubes until it reaches the space 32 in the bottom manifold 26. Here it flows out through central opening 31 to offtake pipe 66. During its flow through the inner tubes, the hot oil gives up some of its heat to the oil in the outer tubes.

The charging oil to the still enters the spaces 33 in the bottom manifold 26 from pipes 67, and from this space enters the outer tubes 20. The oil flows through the lower bank of outer tubes, and enters the spaces 48 in the lower row of return headers and its flow is reversed, and the fluid flows back through the next bank of outer tubes. The fluid continues this flow back and forth until it flows into the spaces 33 in the top manifold 27, and leaves the heat exchanger through pipes 45. During its travel through the outer tubes, the fluid takes up a great deal of heat from the fluid in the inner tubes.

It is to be noted that the inner tubes 21 are in no way connected to the outer tubes 20, and the return connections 49 of the inner tubes are not connected to the body 46 of the return head-

ers. Thus the inner tubes may be said to float in the outer tubes. This is a most desirable type of construction, since the tubes will expand differently due to the difference in the temperature of the fluids being transmitted. By having the inner tubes and their return connections float in the outer tubes and their return headers, this unequal expansion may take place without placing undue strain on the joints in the exchanger and weakening them to cause leaks. It is also apparent that as the temperature of the fluid in the outer tubes rises as it travels through the exchanger, there will be greater expansion in the upper banks of outer tubes than the lower tubes. Since the return headers are not fixedly connected to each other, this unequal expansion is permitted to take place without unduly straining the joints in the exchanger and causing leaks.

It is apparent that while this heat exchanger has been described as having the heating fluid flow through the inner tubes and the other fluid flow through the outer tubes, this flow may be reversed.

If it is desired to increase the capacity of the exchanger, its size may be doubled by removing plate 63 and pipe 66 from manifolds 27 and 26 respectively, and bolting another manifold to each of manifolds 26 and 27, and thus building another similar unit beside the one described. By this means a heat exchanger of any desired capacity may be constructed.

Although the heat exchanger has been described as having both manifolds at one end of the exchanger casing, it is apparent that the inlet manifold may be placed at one end of the casing and the outlet manifold at the other end.

What I claim and desire to protect by Letters Patent is as follows:

1. A heat exchanger comprising a multiplicity of series of tubes of relatively large diameter, a multiplicity of series of tubes of relatively small diameter, return headers joining adjacent pairs of said tubes of relatively large diameter, return connections arranged within said return headers and joining adjacent pairs of said tubes of relatively small diameter, an integral manifold at each end of said multiplicity of series of tubes for introducing fluid into one of said series of tubes and withdrawing fluid from the other of said series of tubes, each of said manifolds comprising a longitudinal chamber with which said tubes of relatively small diameter communicate, and chambers surrounding the ends of said tubes of relatively large diameter and with which said tubes of relatively large diameter communicate, means for interlocking adjacent return headers, and means for interlocking said manifolds and the return headers adjoining the same.

2. A heat exchanger comprising a multiplicity of series of tubes of relatively large diameter, a multiplicity of series of tubes of relatively small diameter, return headers joining adjacent pairs of said tubes of relatively large diameter, return connections arranged within said return headers and joining adjacent pairs of said tubes of relatively small diameter, an integral manifold at

each end of said multiplicity of series of tubes for introducing fluid into one of said series of tubes and withdrawing fluid from the other of said series of tubes, each of said manifolds comprising a longitudinal chamber with which said tubes of relatively small diameter communicate and chambers surrounding the ends of said tubes of relatively small diameter and with which said tubes of relatively large diameter communicate, keys interlocking the headers by means of which headers on a lower level support headers on a higher level, and spacing devices interposed between said manifolds and the adjacent headers by means of which the headers are supported by one manifold and support the other manifold.

3. A heat exchanger comprising a multiplicity of series of tubes of relatively large diameter, a multiplicity of series of tubes of relatively small diameter, return headers joining adjacent pairs of said tubes of relatively large diameter, return connections arranged within said return headers and joining adjacent pairs of said tubes of relatively small diameter, an integral manifold at each end of said multiplicity of series of tubes for introducing fluid into one of said series of tubes and withdrawing fluid from the other of said series of tubes, each of said manifolds comprising a longitudinal chamber with which said tubes of relatively small diameter communicate and chambers surrounding the ends of said tubes of relatively small diameter and with which said tubes of relatively large diameter communicate, keys interlocking the headers by means of which headers on a lower level support headers on a higher level, and spacing devices interposed between said manifolds and the adjacent headers by means of which the headers are supported by one manifold and support the other manifold, keys interposed between said spacing devices and their adjacent manifold and other keys interposed between said spacing devices and their adjacent headers.

4. A heat exchanger comprising a multiplicity of series of tubes of relatively large diameter, a multiplicity of series of tubes of relatively small diameter, return headers joining adjacent pairs of said tubes of relatively large diameter, return connections arranged within said return headers and joining adjacent pairs of said tubes of relatively small diameter, an integral manifold at each end of said multiplicity of series of tubes for introducing fluid into one of said series of tubes and withdrawing fluid from the other of said series of tubes, each of said manifolds comprising a longitudinal chamber with which said tubes of relatively small diameter communicate, openings in said longitudinal chamber opposite the ends of said tubes of relatively small diameter, removable plugs closing said openings, and chambers surrounding the ends of said tubes of relatively small diameter and with which said tubes of relatively large diameter communicate, means for interlocking adjacent return headers, and means for interlocking said manifolds and the return headers adjoining the same.

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