Oct. 6, 1936. M. W. STOUT 2,056,492

HEAT EXCHANGER

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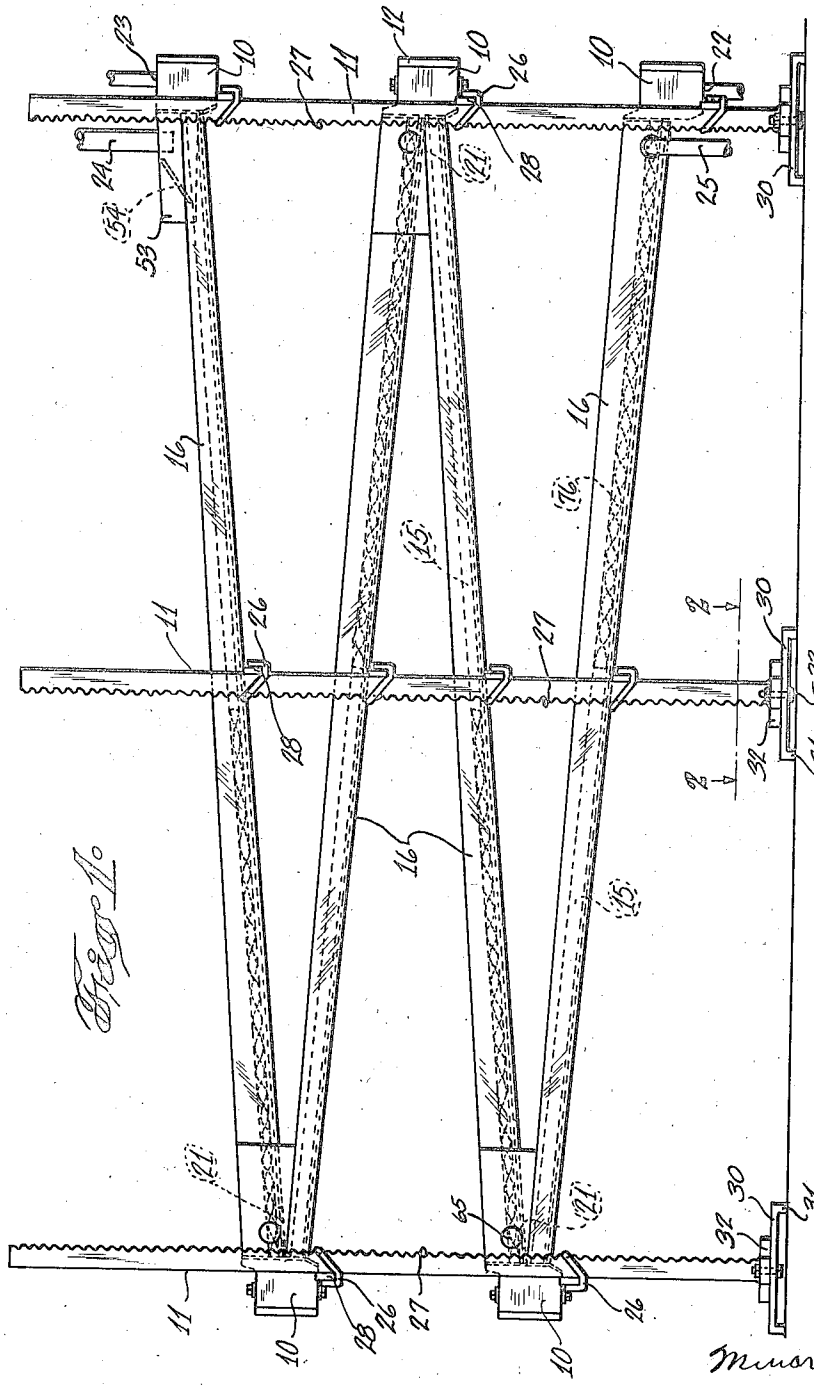


Fig. 1.

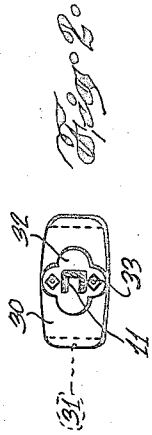


Fig. 2.

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Fig. 3.

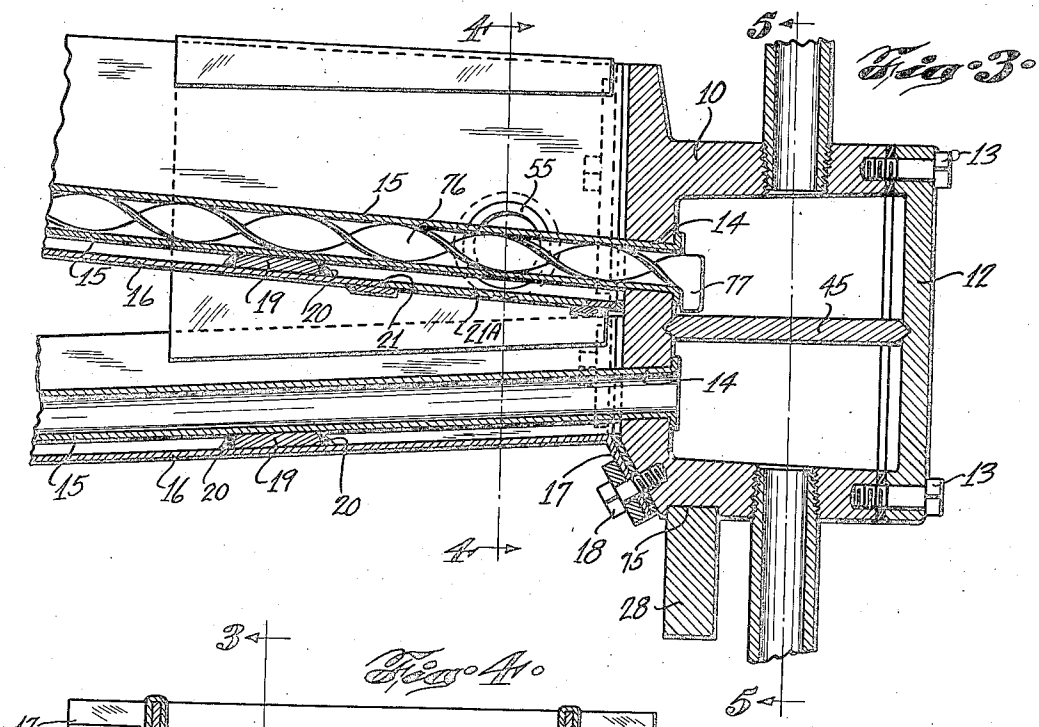


Fig. 4.

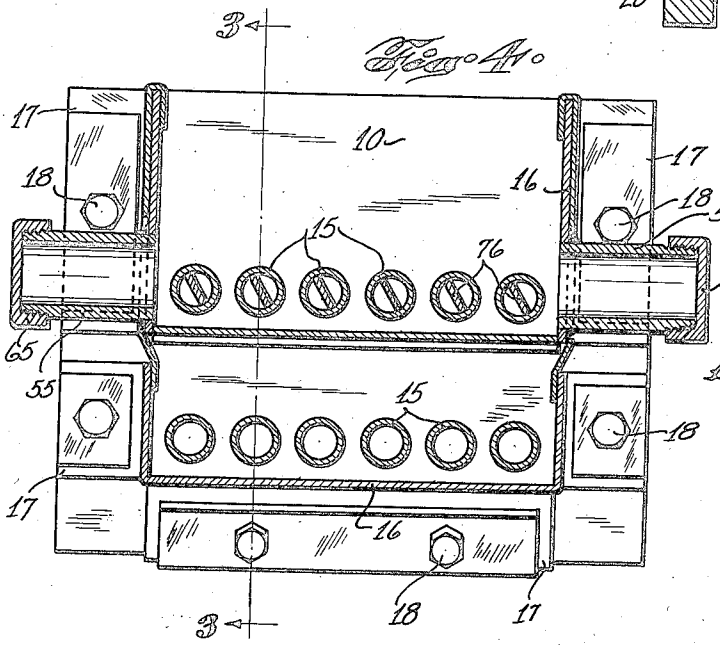
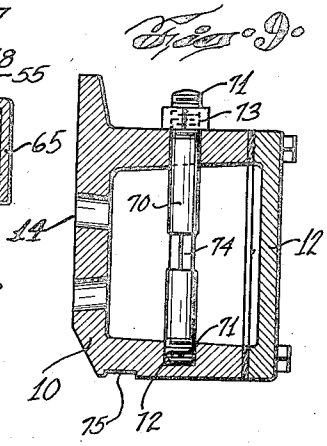


Fig. 9.



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Fig. 5.

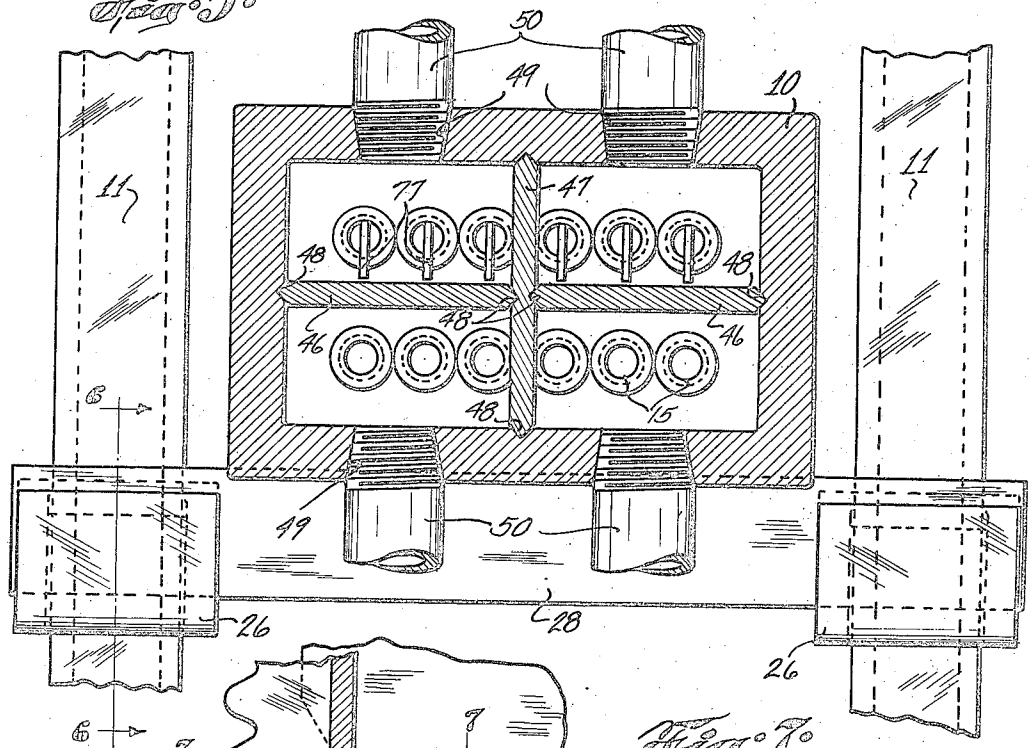


Fig. 6.

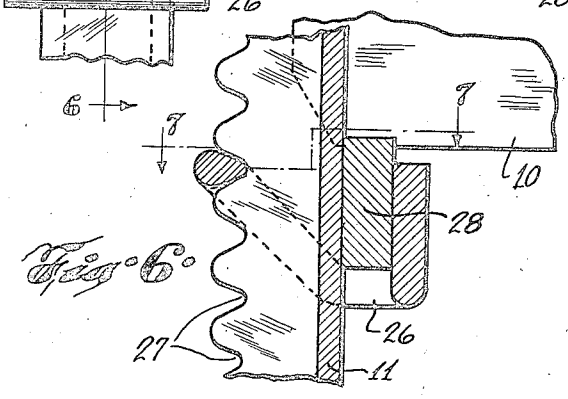
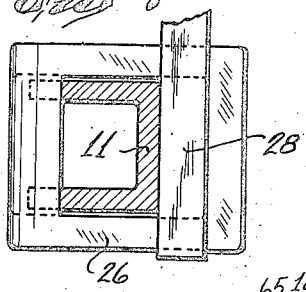


Fig. 7.



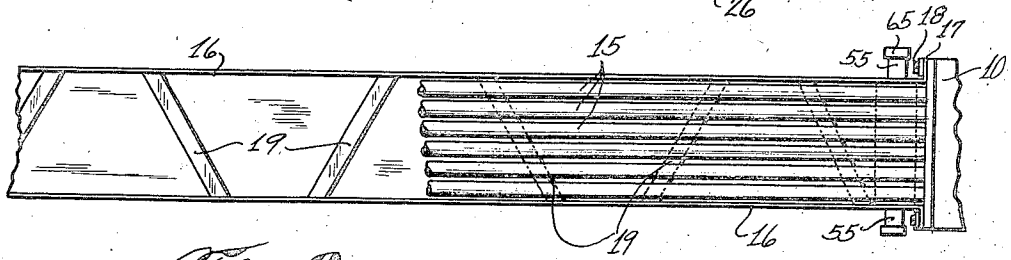


Fig. 8.

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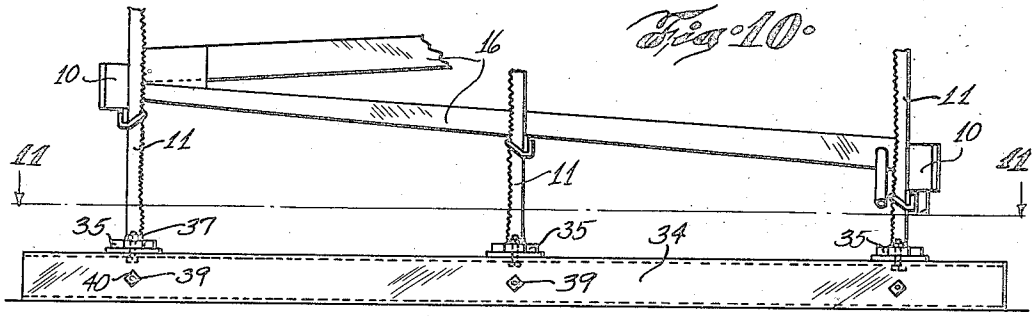
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Fig. 10.



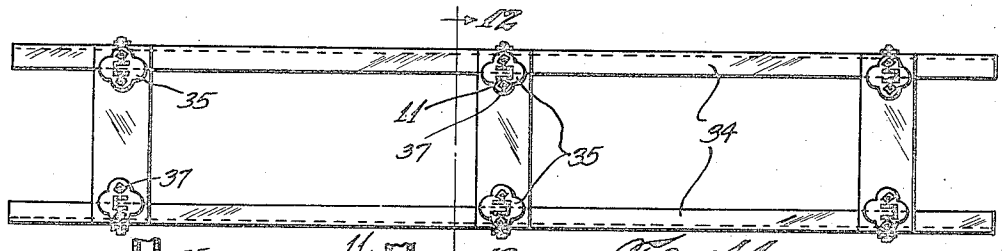


Fig. 11.

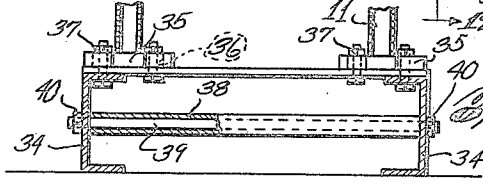


Fig. 12.

Fig. 13.

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Patented Oct. 6, 1936 2,056,492

UNITED STATES PATENT OFFICE

2,056,492

HEAT EXCHANGER

Minor W. Stout, Kansas City, Mo.

Application November 23, 1934, Serial No. 754,411

20 Claims. (Cl. 257—234)

This invention relates to improvements in heat exchangers, and more particularly to a unit for transferring heat from one fluid, through a metal wall to another fluid.

A number of devices are known, for the purpose of effecting transfer of heat between fluids; such heat exchangers have heretofore presented the disadvantages of being difficult to clean, particularly internally; further of being expensive in construction and possessing but a small range of adaptability for handling different quantities of the respective fluids. A further notable disadvantage exists in the short path of travel, in a device of the heretofore prevailing, tubular constructions, of the fluid flowing outside the tubes.

A general object of the invention may be stated as the elimination of the foregoing difficulties by the provision of a heat exchanger so arranged as to facilitate access to the interior of the tubes, at the same time permitting access to the exterior of each of the tubes by the disposition thereof in a layer or layers in each group or pass, the tubes of each pass being supported at the ends and intermediately, but in such a manner that the tubes may be distorted or flexed, within limits, for the purpose of removing foreign matter, such as scale, from both the inside and the outside surfaces of the tubes.

A further object of the invention is the provision of flow directing elements outside of the tubes, resulting in a more desirable flow of fluid adjacent the exterior tube surfaces, whereby to prevent stratification of the fluid about the tubes.

Yet another object of the invention is attained in a provision for adjusting, at will, the flow of the fluids, by gravity, through the unit. This facility for control, in connection with adjustments and changes in the course of the fluid made possible by the use of valves and connections, results in a wide range of possible variations in the unit quantities of either fluid handled by the device, as well as in the rate and extent of heat transfer between fluids.

An additional object is attained in a novel construction of manifold or header elements, such as to permit the use of a standard stock tubing in straight lengths, with plain ends, and without any special fabrication whatever, and such as to permit any desired arrangement of chambers in the headers, with appropriate inlet and outlet connections to and from each of such chambers.

Still a further object is attained by the construction and arrangement of tubing such that not only the fluid within the tubing, but also that on the outside of the tubing is caused to travel in a tortuous path back and forth across the full width of the unit, the arrangement further being such that either or both fluids traverse each pass of tubes in the exchanger in a direction and in a path other than parallel to the axes of the tubes.

An objective attained in present improvements consists in improved facilities for adjusting the elements supporting the several passes of the exchanger, whereby to enable an easy and quick variation in height of the different parts of the system, and thus to facilitate changes in inclination of the conduits, and modification of rate of flow. The realization of full facilities for adjustment also is in part attained in a portable or semi-portable assembly requiring no floor anchorage, and in which the upright supporting elements are or may be adjustably secured to a base structure.

Another object is attained in an improved arrangement of header or manifold elements, provided with removable partitions, so as to be selectively chambered, and provided with connections such that certain or all of the header chambers may be selectively connected among themselves, or the fluid from one circuit of the system directed into the other after passing any selected number of passes of the assembly.

The foregoing and other objects and advantages of the invention will be apparent as the description proceeds and reference is had to the accompanying drawings, in which:

Fig. 1 is a side elevation of a preferred form of exchanger assembly, constructed in accordance with my invention; Fig. 2 is a sectional elevation illustrating the supporting structure, as viewed along line 2—2 of Fig. 1; Fig. 3 is a fragmentary vertical section of a header, trough and tube assembly as viewed along line 3—3 of Fig. 4 the header being of a form shown in Fig. 13; Fig. 4 is a transverse sectional elevation through one end portion of one of the passes of the device, as viewed along line 4—4 of Figs. 3 and 13; Fig. 5 is a sectional elevation taken in a vertical plane transversely of one of the header elements and as viewed along line 5—5 of Fig. 3; Fig. 6 is a fragmentary sectional detail, showing the manner of assembly of the adjustable supporting elements, the section being taken along line 6—6 of Fig. 5; Fig. 7 is a sectional elevation, in a horizontal plane, as viewed along line 7—7 of Fig. 6; Fig. 8 is a fragmentary top or plan view of one of

the passes of the exchanger, showing particularly the preferred location of baffle or deflector members for imparting a tortuous path to the fluid about the tubes; Fig. 9 is a horizontal section taken transversely of one of the header elements, and illustrating a preferred arrangement for reinforcing and strengthening the side walls of the header; Fig. 10 is a fragmentary side elevation of an exchanger unit which is or may be similar to that shown by Fig. 1, except as embodying a unitary base structure common to the several uprights of the supporting frame; Fig. 11 is a sectional elevation taken in a horizontal plane, and as viewed along line 11—11 of Fig. 10, showing a base structure modified somewhat in respect to that shown by Fig. 1; Fig. 12 is a transverse section of the structure shown by Figs. 10 and 11, and as viewed along line 12—12 of the latter figure, and Fig. 13 is a side elevation illustrating diagrammatically the provision of certain valved connections whereby any of the several headers may be selectively interconnected, or connections established between the headers and the trough or conduit elements about the tubes.

As illustrated, a preferred embodiment of my device includes a plurality of superposed headers or manifold elements 10 disposed in vertically aligned relation at the opposite ends of a supporting structure including upright elements 11 hereinafter described. The headers or manifolds 10 are each of box-like shape, being preferably rectangular in horizontal as well as vertical section, and preferably of cast construction. Each of the header elements is provided with a detachable closure 12, constituting the outside wall portion, and which is detachably secured in place as by cap screws 13 or equivalent fastenings. The opposite or rear wall of each of the headers is provided with one or more rows of horizontally aligned openings such as 14, into which are inserted the end portions of tubes 15, my preference being to project the ends, at the time of construction, somewhat inwardly of the headers, the projecting ends then being rolled or expanded into fluid-tight engagement with the inner surface of the manifold, (Fig. 3) whereby to obviate threaded connections at this point. This arrangement is of particular advantage because of my present preference to employ a thin-walled flexible tubing conducing to rapidity and efficiency of heat transfer through the tube wall, the thin wall tubing further resulting in a high degree of flexibility, desirable for purposes hereinafter appearing.

As appears from the drawings, at least certain of the headers 10 are provided with a double row of tube openings, one row being disposed above the other, (Fig. 5).

The preferred arrangement is to dispose the headers or manifold elements 10, at opposite ends of the tubes and of the assembly, in vertically staggered relation, so that a desirable fall is provided, say between the uppermost header 10 on one end, and the uppermost header on the opposite end of the device. The same relation prevails, in turn, between the upper header, say at the left of Fig. 1, and the second highest header disposed, say at the right hand end of the device. The tubes are desirably disposed at an appreciable angle to the horizontal, and thus the openings therefor are inclined, as shown, (Figs. 3 and 9), at a corresponding angle. My preference is to construct each pass, between opposite headers, of a series of laterally adjacent tubes spaced from each other only to a slight extent, but with those of each row of each pass located in a common plane.

Extending between, and carried by each pair of opposed headers 10, is a trough member 16. These troughs are constructed by preference of a sheet material of substantial gauge, preferably a metal so selected as to resist any corrosive effect of fluids to be handled thereby. The trough ends are flared outwardly to result in projections or flanges 17, and lie in the planes of the rear walls of the adjacent headers, to which they may be secured as by cap screws 18. The troughs 16 are of such a width as to enclose and embrace the series of tubes 15 constituting the associated pass, and are preferably of such a depth as to extend appreciably above the group of tubes located therein. The metal of the troughs, and the connections to the manifolds or headers are such as to permit a certain flexibility of connection incident to alteration in height and slope of the passes and headers, by means hereinafter described.

It is my preference to employ each of the troughs 16 as an intermediate support for the tubes of the associated pass. To this end there are located, at intervals along the trough, a plurality of elements 19 extending transversely of the several tubes, and serving as supports or rests for the tubes of each pass, between their ends.

The elements 19 are arranged, preferably, as shown by Fig. 8, in zig-zag fashion, and alternately at greater and lesser angles to the tubes, thus imparting a back and forth movement to the fluid in the trough and around the tubes. Besides serving the purposes noted, the members 19 function as deflectors of fluid vertically of the trough, being provided with suitably shaped surfaces 20 which tend to prevent stratification of the fluid flowing through the troughs. Each member 19 thus serves as a baffle, causing that stratum of fluid flowing nearest the bottom of the trough to be deflected upwardly in adjacence to the uppermost or outermost tubes. Obviously, any number of the elements 19 may be employed as desired, and their angles varied according to conditions of flow. The elements 19 may be secured in place as by welding them to the bottom of the trough or outer conduit.

As appears in Fig. 1, each of the troughs 16 is provided with a bottom discharge opening 21, at one end; the discharge openings are, however, staggered in location, so that, proceeding according to the normal line of flow from top to bottom of the device, the uppermost trough will be provided with a discharge opening adjacent the second trough, while the latter trough is provided with an opening at the opposite end, and adjacent the third trough, and so through the series of troughs in the unit. So as to enable selective circulation in the troughs, in a manner and for a purpose later appearing, each opening 21 is provided with a closure 21A, (Fig. 3), which may be considered either as a valve or as a removable door or plate.

As is seen from the drawings, that portion of the device including the tubes, is adapted normally for closed circulation of a fluid usually and preferably introduced to the lowermost header 10 as through an opening 22. Since the header is of a heavy wall construction, one of the end walls thereof may be tapped, as with a standard pipe thread, to which an inlet connection is thus made as by a standard pipe fitting. The same arrangement may conveniently be employed in connection with the uppermost

header 10, into which there is provided a tapped aperture 23 employed as a discharge opening or outlet from the closed circulating system. An inlet for the open circulating portions of the device, including the trough 16, may be disposed as shown, and may include a pipe end 24 directed into the uppermost trough. Drainage for the open circulating fluid is provided for by a suitable drainage fitting 25 which may be directed into a reservoir (not shown), a drain, or piped for return purposes depending upon the nature of the particular installation and intended use of the device.

As a convenient means of supporting the circulating elements upon the frame 11, I have shown a series of adjustable hook elements 26, each engaging one of a series of notches or recessed seats 27 on the upright frame members, the hooks each being provided on one side with a saddle portion in which rest transverse bridge members 28 extending across a pair of the hooks and disposed beneath the headers and between the ends of the troughs. The vertical adjustment provided by the elements 26 enables the headers to be located at selected heights and spacing along the vertical members 11, thus permitting a variation in fall through the troughs, as well as the tubes, and providing a substantial range of adjustment of flow of each of the fluids through the unit. For additional adjustment and regulation of fluid flow, suitable valves, (not shown), may be provided in the inlet 24, the outlet 25, and in the lines connected at the points 22 and 23.

Further facilities for adjustably locating the supporting uprights 11, are found in the structure shown by Fig. 1, and include a base or foot member 30 for each of the vertical uprights. Each element 30 is shown as of modified rectangular shape (Fig. 2) and includes a pair of downturned flange members 31. Supported by the foot 30 is a bolting plate 32, shaped, according to the drawings, as a four leaf clover, and centrally of which is secured, as by welding, the upright 11 with which the piece is associated. The element 32 is detachably secured as by bolts 33 to the associated element 30. It will thus appear that each of the foot elements 30 provides a suitable base of support for the corresponding upright 11, obviating any necessity for the usual fixed anchorage of such uprights to a floor or other subjacent support.

A modified base arrangement appears in Figs. 10, 11, and 12, according to which there are provided a pair of longitudinal sill or base elements 34 preferably consisting of stock channel members, and to the upper flange of each of which is secured, as by bolting, foot members 35 generally resembling or similar to the elements 32 of Figs. 1 and 2. In the case of the modified structure, the elements 35 may be provided with slotted openings 36 to receive securement bolts 37, thus providing for adjustment of the distances between centers of the uprights. The parallel sill members 34 are maintained in spaced assembled relation through the use of tubular spacers 38 (Fig. 12) within each of which extends a tie rod or bolt 39 projecting through and laterally beyond the opposite sill members 34, and exteriorly engaged by assembly nuts 40.

Depending upon the nature and temperature differences between the two or more fluids to be handled through the exchanger, it may, under certain conditions, be desirable to utilize only one or more of the tube passes, or only one or more troughs of the exchanger, excluding the remainder from service, or to employ certain passes of tubes for one fluid and other passes of tubes for another fluid. Optionally, by the provisions embodied in the present structure for realizing such selective circulation, the headers, and hence the tubes, may be selectively interconnected so as to shunt out certain of the passes of tubes while employing a greater number of the troughs or outer conduits. By the present improvements provision is also made for recirculation of fluid, so that a given fluid proceeds, for example, first through one or more passes of tubes and thence into one or more passes of the troughs. To the end of thus selectively circulating or recirculating the fluids, the headers 10 are so cast or otherwise formed as removably to receive, either a single horizontal partition 45 (Fig. 3) or a double horizontal partition structure formed of plate elements 46 (Fig. 5), between which may be disposed a vertical partition 47. The partitions are positioned within the header through the provision of grooves or recesses 48 in the inner walls of the header, and also in the partition 47. Suitable pipe openings 49 are provided, preferably a pair in the top wall and a pair in the bottom wall of each header, and which serve to receive inlet and outlet pipes 50, provided with suitable valves hereinafter described.

An example selected to illustrate the possibilities of regulating or varying the course of fluid through the device as a result of the provisions of the removable partitions and closures, as well as valved connections 50 and 50', is illustrated diagrammatically by Fig. 13. In this example fluid No. 1 is introduced to the lowermost right hand header 10, flowing upwardly through the tubes of the lowermost pass, into the lowermost chamber of the lower left hand header, out through the connection 50, thence through valve 51. This valve, being open, reintroduces this fluid to the uppermost chamber of the same header through connection 50', upwardly through the tubes of the pass above, and into the lower chamber of the second right hand header, and outwardly through connection 50. Upon proceeding upwardly through pipe 52, fluid No. 1 is introduced to the uppermost trough or outer conduit as through connection 24 heretofore referred to in describing Fig. 1.

It may here be noted as my preference, whether the troughs 16 are open or closed at the top, to employ a splash-box 53 about the inlet 24, the box 53 being provided with an internal baffle 54 tending to direct the inflowing stream downwardly and along the axes of the tubes of the uppermost pass. Upon entering the trough 16 of the upper pass, the first fluid proceeds downwardly, to discharge through opening 21 into the trough of the second highest pass. In order to permit either introduction or discharge of fluid to or from the troughs or outer conduits, I provide, preferably, a pair of pipe connections 55 in the side walls of at least one, preferably the lower end of the trough. According to the example outlined in Fig. 13, one or both of the connections 55 extend from the trough of the second highest pass and connect to a common outlet 56, whence the fluid is withdrawn either for drainage or subsequent utilization. Obviously the utilization of connections 55 is dependent upon a closure for opening 21 in the bottom of the corresponding end of trough 16. In the example under discussion, or in any other case, those of the troughs from which the fluid is withdrawn through, or

enters by the connections 55, have their bottom openings closed by the valves or doors 21A.

In the example according to Fig. 13, fluid No. 2 is introduced through a connection 50'; a valve 58 connecting the connections 50 and 50' may be considered as closed, because of which the second fluid proceeds upwardly through the tubes of the first pass into the lowermost chamber of the upper left hand header 10, thence outwardly through a connection 50, through an open valve 60 and connection 50' into the upper chamber of the header last mentioned. From this point the second fluid moves through the tubes of the uppermost pass, and into the uppermost right hand header 10. From the single chamber of this last header the pipe 61 now directs the fluid into the trough of the second pass from the bottom of the assembly, thence into the lowermost trough and out of the system through a pipe 62. For convenience in following the diagram, the course of fluid No. 1 is indicated by the arrows shown in solid lines, while the course of fluid No. 2 is indicated by the arrows shown in broken lines. Fluid No. 2 may, for example, be considered as steam, with or without accompanying condensate, and the counter current fluid may be considered as fresh boiler feed water, for example,

From the foregoing it will appear by the selective chambering of the headers through the provisions of removable partitions 46 and/or 47, and through the selective closure of valves such as 51, 58, 60, etc., any desired circuit of either or both of the fluids may be effected through the different passes of the system. It will of course be understood that the valves and branched connections may be employed ancillary to any selected number of headers in the system.

The pipe connections such as 55 may, when not in use, be conveniently closed by standard pipe caps 65 (Figs. 4 and 8), and such of the threaded openings 49 into the headers, as are not in use, are conveniently closed as by standard threaded plugs (not shown). Other forms of fittings and connections may of course be utilized in lieu of the standard pipe fittings, which are herein suggested as a matter of convenience because of ready availability.

There has heretofore been discussed the possibility of constructing the troughs or outer conduits 16 of either open or closed top construction. According to the latter practice it is of course possible to utilize these elements to conduct fluid under some pressure. In ordinary practice, however, if only one of the fluids be under substantial pressure, such fluid is, at least initially, confined to the tube and header portions of the system. In case such pressures are substantial, I have found it expedient to provide, at least within certain of the headers, an internal tension element to prevent undue deflection of the header walls under the influence of the pressure. A suggested provision of this kind is illustrated by Fig. 9, according to which the upper and lower walls of the header are bridged by a tie rod 70, threaded at its opposite ends as at 71, one end engaging a tapped recess 72 in one of the walls, while the opposite end projects through the wall to receive a nut 73. A polygonal or squared shank portion 74 facilitates threading up the connection 71 and 72 internally of the header. Figs. 3 and 9 illustrate a further provision consisting of a recess or notch 75 utilized as best appears in Fig. 3, to receive the associated bridge piece 28, this interengaging relation of parts serving to prevent any endwise movement of the header and trough assembly.

It will have appeared from the nature and location of the baffle elements 19, that the fluid in proceeding from end to end of each of the troughs 16, is caused to pursue a tortuous course, crossing and recrossing the tubes. I have determined that the rate and efficiency of heat exchange are further increased by imparting a certain tortuous movement or turbulence to the fluid within the tubes. This is accomplished in the illustrated example through the agency of spiral members 76, each of which is required to extend only over a portion of the length of the tube, say from its entrance end. Provision for securement of the spiral element within each tube, consists of a downturned lug or ear 77, which may engage a notch and thus prevent either longitudinal or rotative movement of the thimble.

The possibilities for externally circulating, in selective courses, the several fluids, has been heretofore referred to in connection with Fig. 13. The action of the fluids, when the device is in normal use for effecting exchange of heat between fluids, each circulating entirely through its own system, may be briefly reviewed for sake of completeness as follows:

The first fluid entering, say at a substantial velocity, through the pipe connection 22 (Fig. 1), in the lowest header or manifold, passes back and forth in an upward direction within the several passes or groups of tubes 15, until it leaves the unit through the discharge opening 23 in the uppermost manifold. The second fluid, entering through inlet 24, travels in the troughs and outside of the tubes, back and forth in a downward direction. Due to the preferred use of a thin-wall material in the tubes, the second fluid is thus brought into intimate thermal contact with the first fluid, and a highly efficient transfer of heat is effected between the fluids. A variation in the quantities of either fluid handled in a unit of time by the device, may be made through wide limits, without seriously affecting the efficiency of exchange, and such variation of flow of each fluid handled may, within wide limits, be made independently of the quantity of the other fluid handled.

It will appear from the preceding description that, as compared with older devices intended for heat interchange purposes, the present manifold and tube construction serves materially to increase the length of travel of the fluid flowing outside of the tubes, and minimizes the tendency of such fluid to "short circuit" within the exchanger. There is thus attained a higher degree of heat transfer, due to higher velocities of flow, while at the same time sufficient time is allowed for full transfer to take place, since the outside fluid is compelled to cross and recross the unit over its full length, as such fluid moves from top to bottom of the device. It will appear that the presently described manifold or header construction permits placing the tubes much closer together than is possible according to prevailing practice. This permits the tubes of each pass to be disposed in a common plane, or several such planes, resulting in complete fluid coverage of the outside tube surface, and still permits the high velocity of flow necessary for efficient operation.

The described construction permits a wide choice in selection of materials for the tubes and troughs due to the expedients for fastening the tubes and baffles to the manifolds. Thus any

material which is capable of fabrication, may be employed, and certain metals may thus be utilized, which because of certain natural characteristics, are difficult to bend or weld.

While the invention has been described by making detailed reference to a presently preferred embodiment thereof, it is manifest that such description is to be considered only in an illustrative, and not in a limiting sense, since the various parts may be modified, certain thereof omitted, or others added, without departing from the spirit and full intendment of the invention as defined by the claims hereunto appended.

I claim as my invention:

1. In a heat exchanger, a plurality of flexible tubes of thin wall type, disposed in a series of passes, with adjacent passes of opposite inclination with respect to a horizontal plane therebetween, a conduit about the tubes of each of said passes, headers interconnecting the tubes of adjacent passes, disposed beyond the ends of said conduits, and forming closures therefor, the conduits and tubes being so formed and connected to the headers as to permit of variation in inclination, means for supporting the conduits, tubes and headers, including vertical rack members, and supports adjustably suspended in spaced seats therefor on the rack members.

2. A heat exchanger including a plurality of superposed, inclined conduits, a plurality of tubes disposed in laterally adjacent relation in a common plane transverse of each conduit, a header or manifold, forming a chamber at each end of certain of the conduits, and interconnecting the tubes within adjacent conduits, and means within the conduits, tending to effect a movement of fluid from side to side across the tubes therein.

3. A heat exchanger including a plurality of inclined superposed groups of fluid conducting elements, the conducting elements of each group being disposed parallel to a common axis and adapted for separately handling two fluids, one of said groups including a conduit for one of said fluids, a plurality of tubes in laterally adjacent relation, in said conduit, and adapted to conduct the other of said fluids, headers common to said tubes, disposed at each end of each conduit, and forming the ends of said conduits, the tubes and conduits being formed of a flexible material and so connected to the headers as to permit of variation in inclination, a movable supporting structure for said groups of elements, including upright rack elements having defined supporting seats, and supporting elements selectively engaging said seats.

4. In a heat exchanger, a plurality of groups of inclined fluid conducting elements, those of each group adapted for separately carrying different fluids and including a plurality of laterally adjacent parallel tubes of flexible construction and a trough of rectangular section surrounding said tubes and disposed with its axis parallel thereto, means in the troughs and tubes for imparting a tortuous movement to the several circulating fluids, and manifolds connecting corresponding ends of adjacent tube groups, the troughs and tubes being flexibly constructed and joined to the manifolds, to permit variation in inclination.

5. In a heat exchanging device, a plurality of superposed groups of tubes of flexible, thin wall type, extended lengthwise of the device, the tubes of each group being disposed in a common plane, a conduit of flexible construction, about each group of tubes, a manifold carried by the ends of the conduit at each end of each group of tubes, and having an apertured closed side, the apertures adapted to receive the ends of said tubes, said manifold having an opposite open side, provided with a removable closure, a partition element removably disposed in the manifold, and means other than the tubes for selectively interconnecting the chambers within certain of the manifold.

6. In a heat exchanger consisting of a plurality of tubes of a thin-wall type arranged in superposed inclined passes, a manifold connecting the tubes of the adjacent pass, said manifold having a plane wall portion apertured to receive the tube-ends of a given pass, the tube ends being deformed into fluid-tight connection with said wall portion, a conduit of flexible material about the tubes of each pass, tube-supporting elements within said conduits, formed to provide a tortuous path of fluid flow laterally across the tubes therein, and vertically adjustable means supporting the conduits near their opposite ends and adapted to permit a variation in inclination of the tubes and conduits of each pass.

7. In a heat exchanging device, a plurality of tubes arranged in groups extending lengthwise of the device, adjacent groups being of opposite inclination, a header element constituting a chamber at each end of each group of tubes, a conduit closed at its ends by, and forming a support for opposite headers, and extending therebetween, and a baffle member disposed within said conduit at an angle to the line of flow therein, the baffle supportingly engaging the tubes between their ends and adapted to direct the fluid in the conduit from one side to the other, and across the tubes therein.

8. In a heat exchanging device, a plurality of tubes disposed in superposed groups or passes, those of each pass being arranged in laterally adjacent, parallel relation, a conduit surrounding the tubes of each pass, and a plurality of baffles in the lower portion of said conduit, arranged at an angle to each other and to the axes of the tubes, whereby to direct a flow of liquid in a direction at an angle to the axes of said tubes, and to oppose stratification of liquid within the conduit.

9. In a heat exchanger, a group of tubes of relatively thin flexible material arranged in a plane transverse of the structure and having relatively rigid end connections, a liquid-receiving conduit disposed around said tubes and an element disposed between said tubes and the adjacent wall of said conduit, said element constituting a combined deflector or baffle for liquid flow within said conduit, and an intermediate support for said tubes, being arranged to oppose stratification of liquid within the conduit, in either horizontal or vertical planes.

10. In a heat exchanging device, a plurality of tubes arranged with their axes parallel, a conduit about said tubes, a manifold at each end of the tubes and a tube support within said conduit, intermediate the ends of said tubes, said support having a surface adapted and disposed to deflect a fluid stream both horizontally and vertically from an axial course through said conduit.

11. In a heat exchanging device, a plurality of tubes arranged with their axes parallel to each other, manifolds at the opposite ends of said tubes, each of said manifolds having a wall portion apertured to receive the tube ends, a conduit extending along the said tubes, and a pair of baffle members disposed along the lower por-

tion of said conduit, and arranged to direct a flow of fluid therein, toward opposite sides of the conduit.

12. In a heat exchanging device including a plurality of tubes arranged in superposed groups, a trough extended along each group of tubes, and a pair of flow control elements in each trough, presented at different angles to the flow therein, and adapted to prevent stratification of liquid flow in vertical planes, adjacent said tubes.

13. In a heat exchanging device arranged for concurrent movement of two fluids in opposite directions, a support including vertical members provided with notches, a plurality of troughs extending crosswise of the device and between said vertical members, the troughs being supported near their opposite ends by said vertical members, means selectively engaging the notches for separately adjusting the height of the ends of each trough with respect to said vertical members, a header at each end of each trough, and forming the end walls of the troughs, each of said headers being of relatively rigid, box-like construction and detachably secured to the troughs, the inner wall of each header being provided with at least one horizontal row of apertures, a plurality of circulating tubes in each trough, and disposed in laterally adjacent spaced relation along the lower part thereof with the tube ends inserted in the apertures in opposite headers and rolled into fluid-tight engagement therewith, each of the headers having a removable outer wall portion adapted, upon removal, to provide access to the end connections of the tubes connected into the header.

14. A heat exchanger including an inclined conduit, a plurality of tubes within the conduit, means for separately circulating fluids through the conduit and tubes, means within the tubes for causing a turbulence of fluid in proceeding therethrough, and means within the conduit tending to cause a flow therethrough in a direction other than parallel to the tubes.

15. In a heat exchanger, an inclined conduit, a plurality of tubes within the conduit, means for supplying separate circulating fluids to the conduit and tubes, a spiral element within each of certain of the tubes, and baffle elements within the conduit, adapted to direct a fluid flow in crossing and re-crossing relation to the tubes.

16. A heat exchanger including a plurality of inclined conduits, tubes within the conduits, chambered headers connecting certain of the tubes at their corresponding ends, but normally out of communication with the conduits, and means for connecting at least one of the header chambers selectively to the conduits or to another header chamber.

17. A heat exchanger including a plurality of inclined conduit elements, a tube element in each conduit element, a header element connected to each end of each tube element, and valved connections for selectively interconnecting said elements.

18. In a heat exchanger assembly, a plurality of oppositely inclined outer conduits, headers at the ends thereof, tubes within the outer conduits interconnecting the headers, a plurality of upright members provided with vertical rows of recessed seats, a suspension element on each upright member, selectively engaging the seats thereon, bridge pieces carried by the suspension elements, supporting the conduits headers and tubes, and supports at the bottom of the upright members, with respect to which said members are adjustable.

19. In a heat exchanger assembly, a plurality of oppositely inclined passes, each including an outer conduit, tubes interiorly thereof and headers connected to the opposite ends of the tubes, a plurality of upright supports related in pair on opposite sides of the passes, and provided with vertically spaced notches, a hook member on each upright selectively engageable with the notches thereon, a bridge piece between opposite hook members, by which the passes are supported, longitudinal sill pieces forming a base, and adjustable connections between the uprights and sill pieces.

20. In a heat exchanger of a type including a plurality of inclined passes, each comprising tubes and a conduit, headers at the ends of each pass, the headers being connected to the tubes, a removable partition in one of the headers for selectively dividing it into a plurality of chambered portions, and connections other than the said tubes, to each of the chambers of the header.

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