May 27, 1941. J. P. ZALLEA 2,243,593

HEAT EXCHANGER

Filed Aug. 12, 1938 2 Sheets-Sheet 1

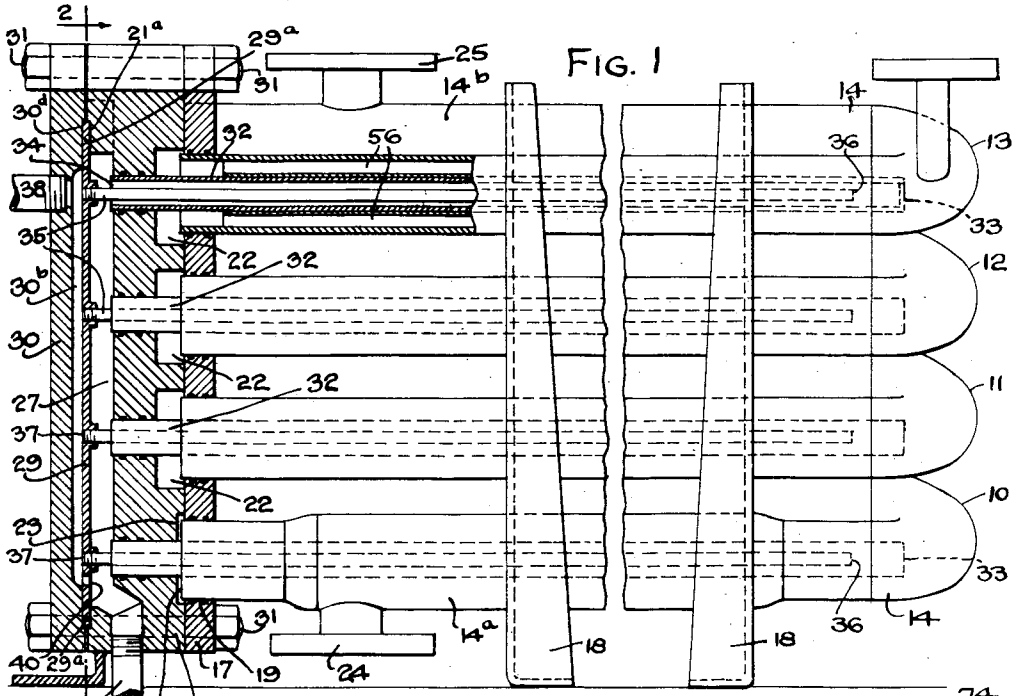


FIG. 1

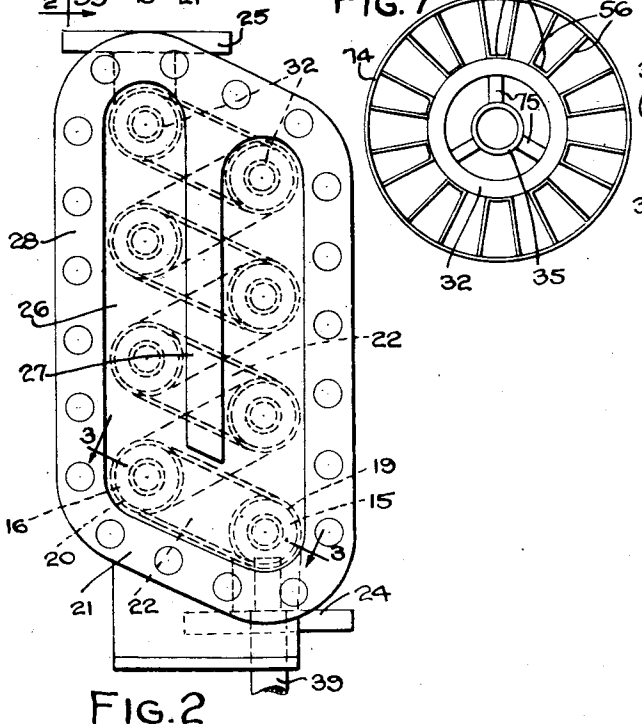


FIG. 2

FIG. 7

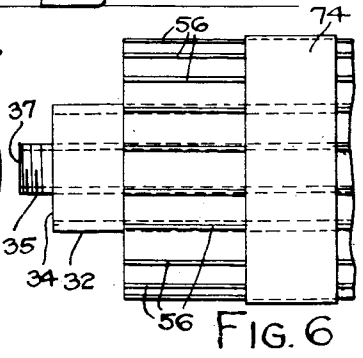


FIG. 6

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HEAT EXCHANGER

Filed Aug. 12, 1938 2 Sheets-Sheet 2

FIG. 4

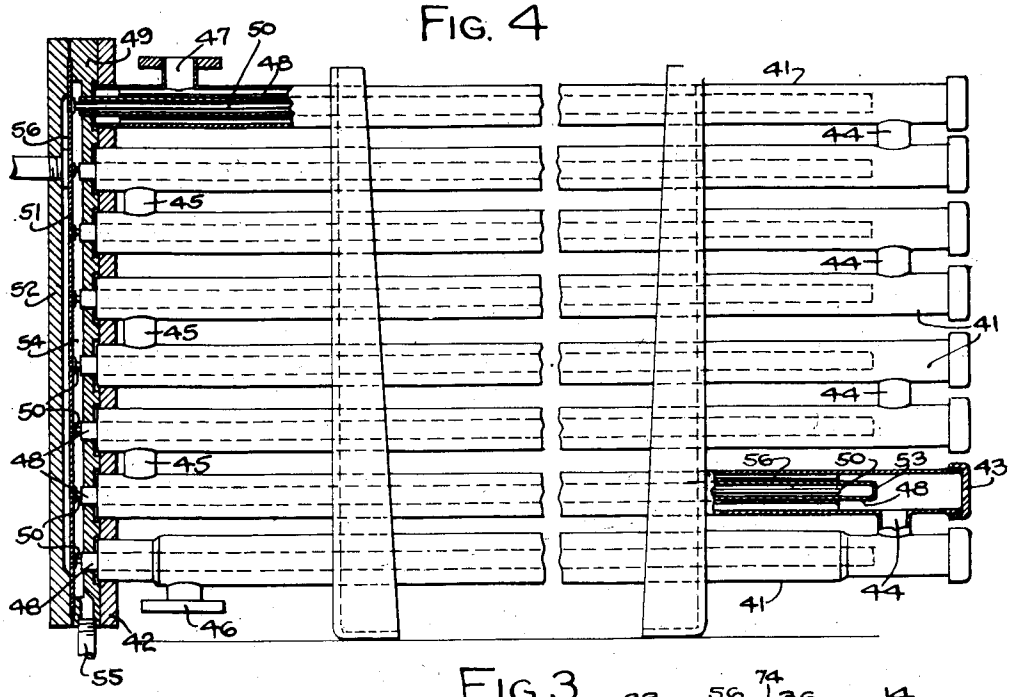
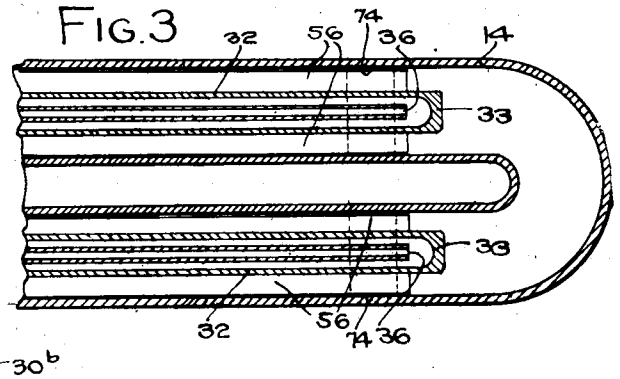


FIG. 3



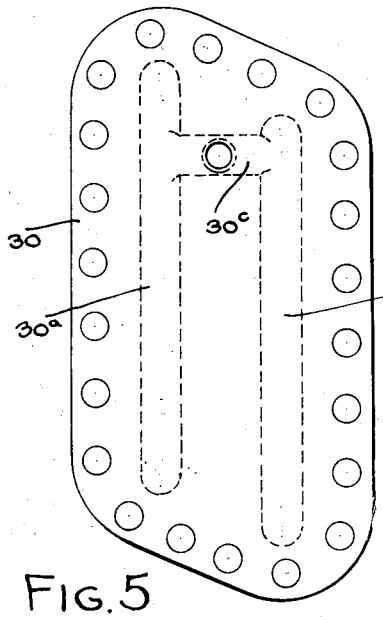


FIG. 5

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HEAT EXCHANGER

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Application August 12, 1938, Serial No. 224,451

3 Claims. (Cl. 257—247)

This invention relates generally to apparatus for heating fluids and more particularly to an improved construction of that type of apparatus in which a heated fluid is employed in such manner that the heat thereof is transferred to a fluid to be heated, the heat so transferred from one fluid to the other being conducted to the latter fluid through the wall or walls of the conduit which separate the fluid to be heated from the heating medium. This type of apparatus is generally termed a heat exchanger and is especially adapted for preheating fluids, such as oil, by the use of a heating medium, such as steam.

Among the principal objects of the present invention is to provide a heat exchanger of high efficiency and in which a rapid transference of heat from the heating medium to the fluid to be heated is effectively secured.

A further object is to provide a heat exchanger of the type referred to which is not only relatively simple and inexpensive to construct and assemble but which is also easy and economical to maintain and operate in service, the several parts of the apparatus being readily adapted for disassembly whenever required for the purpose of making repairs or for cleaning without necessitating a complete disorganization of the entire apparatus.

Heretofore and prior to the present invention heat exchangers have been employed in which concentric tubes were employed, the heating fluid being delivered through one of these tubes in such manner that the heat thereof was transferred by conduction through the wall thereof to the fluid passing through the other of said tubes. During the passage of the heating fluid through its conduit, it naturally loses more and more of its heat in consequence of which such heat exchangers very definitely have a lower rate of heat exchanging efficiency in the discharge or delivery side thereof than in the inlet side thereof. It is among the objects of the present invention to provide a heat exchanger wherein the fluid to be heated is subjected to substantially the same degree of heating temperature throughout its passage through the apparatus, thereby insuring a higher heat exchanging efficiency in the discharge end of the apparatus than has been possible of attainment heretofore.

In addition to the foregoing, it is among the objects of this invention to increase the heat exchanging efficiency of the apparatus by providing the conduits for the heating medium with radially projecting fins of such character and secured to the conduit in such manner that they not only increase the heating surface area but also insure an increased conductivity of the finned conduit so as to facilitate a highly efficient and rapid transfer of heat between the heating medium conveyed within the finned conduit and the fluid to be heated as it is delivered through tubing arranged concentrically about said finned conduit.

Other objects and advantages of the invention will be apparent more fully hereinafter, it being understood that the invention consists substantially in the combination, construction, location and relative arrangement of parts, all as described more fully hereinafter, as is shown in the accompanying drawings and as finally pointed out in the appended claims.

In the accompanying drawings:

Figure 1 is an elevational view of the apparatus constructed in accordance with and embodying the principles of the present invention, a portion thereof being shown in section to illustrate details of construction;

Figure 2 is a vertical sectional view of the apparatus taken on the line 2—2 of Figure 1;

Figure 3 is a horizontal sectional view on an enlarged scale taken along the line 3—3 of Figure 2;

Figure 4 is an elevational view of a somewhat modified construction of the apparatus;

Figure 5 is a front elevational view of the front cover plate of the apparatus;

Figure 6 is an enlarged elevational view of the outer end of the heating fluid finned conduit assembly; and

Figure 7 is an end view of the assembly shown in Figure 6.

Referring now to the drawings and more particularly to Figures 1 to 3 thereof which illustrate one form of the apparatus constructed in accordance with and embodying the principles of the present invention, it will be observed that the apparatus comprises a multiple unit heat exchanger consisting of a plurality of units 10, 11, 12 and 13 of similar construction and arranged substantially in vertically spaced relation. Each of these units includes a U-shaped tube 14, the open ends 15 and 16 of which project through and are secured in any suitable manner within a vertically disposed supporting plate 17, the said U-shaped tubes being further supported in the fixed relation shown by means of one or more supporting elements 18—18. Preferably, in order to obtain as compact a relationship as possible between the several units 10 to 13 of the apparatus, the U-shaped tubes

14 thereof are respectively disposed in vertically spaced, substantially parallel inclined planes. Accordingly, it will be observed that the plate 17 is provided with a plurality of laterally spaced apertures 19 and 20 through which respectively project the laterally spaced open ends of each U-shaped tube 14.

Immediately associated with the plate 17 is a second plate 21, the inner face of which is provided with a plurality of vertically spaced inclined passages 22 affording communication between the outlet end of one of the U-shaped tubes 14 and the inlet end of an immediately adjoining U-shaped tube. The inlet end of the leg 14a of the unit 10 as well as the discharge end of the leg 14b of the unit 13 are each received in shallow seats 23 formed in the inner face of the tube plate 21, said legs 14a and 14b of the tube units 10 and 13 being respectively provided with inlet and outlet connections 24 and 25. The fluid to be heated, which is delivered into the unit 10 by way of the inlet connection 24 and is discharged from the unit 13 by way of the outlet connection 25, is circulated through the units 10, 11, 12 and 13 in the order named, successive pairs of these units being in connection with one another by way of the connecting passages 22 provided in the inner face of the tube plate 21.

As appears most clearly in Figure 2, the outer face of the tube plate 21 is provided with a U-shaped recess 26 the opposite legs of which are separated from each other by a vertically extending rib 27, the outer face of which lies substantially in the plane of the marginal portion 28 of the tube plate 21. The rib 27 is in effect a depending continuation of the upper marginal edge of the tube plate 21 with the lower end thereof terminating short of the lower marginal edge of said plate.

Immediately associated with the tube plate 21 and disposed flatwise against the outer face thereof is a relatively thin diaphragm plate 29, while to the outer side of this diaphragm plate is disposed a cover plate 30 the inner surface of which is provided with a pair of vertically extending laterally spaced channels 30a and 30b (see Figure 5) connected together by a transversely extending channel 30c. The plates 17, 21, 29 and 30 are securely bolted together by a plurality of marginal bolts 31, it being understood, of course, that if desired suitable gaskets may be interposed between the contacting surfaces of the several plates so clamped together. If desired, and in certain instances it is preferable to do so, the diaphragm plate 29 may be formed of a metal sufficiently soft that when its marginal edge 29a is compressed between the plates 21 and 30 it flows and spreads to form a self-sealing gasket between the said plates 21 and 30. In order to provide adequate space between the plates 21 and 30 into which the soft metal of the diaphragm plate may be compressed the contacting faces of the plates 21 and 30 are preferably undercut, as at 21a and 30d.

As has already been mentioned, the plate 17 constitutes the support for the outer ends of the laterally spaced legs of the U-shaped tube units 10, 11, 12 and 13. The intermediate plates 21 and 29 respectively constitute the tube sheets or plates for the conduits through which the heating medium is supplied to and through the apparatus, which latter conduits will now be described. As appears most clearly in Figures 1 and 2, the plate 21 constitutes the support for a plurality of steam tubes 32 which respectively project interiorly of each straight-legged portion of the U-shaped tube units 10, 11, 12 and 13. There being four of these latter units in the apparatus illustrated in Figure 1, it will be understood that the plate 21 constitutes the support for eight of the tubes 32. These latter tubes are respectively disposed concentrically within the straight-legged portions of the U-shaped tubes and are substantially coextensive in length with the latter. As appears most clearly in Figure 3, the outer or rear extremity of each of the tubes 32 is closed, as at 33, while the opposite or inner extremity thereof is open, as at 34, for communication with the U-shaped channel 26 formed in the outer face of the tube plate 21. The tubes 32 are arranged in laterally spaced pairs so that one set of these tubes is arranged in vertically spaced relation and communicates commonly with one leg of the channel 26 while the other set of these tubes 32 is arranged in similar vertically spaced relation and communicates with the opposite leg of the U-shaped channel 26.

Supported by the diaphragm plate 29 are a plurality of tubes 35 which extend interiorly of and are disposed concentrically within the tubes 33, the tubes 35 being open at both ends thereof, as at 36 and 37, the front ends 37 of these tubes being in communication with the channels 30a—30b provided in the inner face of the cover plate 30. From the foregoing description, it will be seen that the apparatus of the present invention comprises a plurality of U-shaped tube units within each straight leg of which is disposed a pair of concentric tubes, the outer ends of these concentric inner tubes being respectively in communication with passages maintained in separated relation by the diaphragm sheet 29.

As appears most clearly in Figure 1, the outer plate 30 is provided with an inlet connection 38 while the tube plate 21 is provided at the bottom thereof with an outlet connection 39. While said outlet connection 39 is shown leading directly from the tube plate 21, it may instead lead outwardly from the bottom of the passage 26 and through the diaphragm and front cover plate 30. In the use of the apparatus as just described, steam employed as the heating medium is introduced to the apparatus by way of the inlet connection 38 while the liquid to be heated, such as oil, is introduced by way of the inlet connection 24, the heat transference from the heating medium to the fluid to be heated being effected by circulating both fluids continuously through the apparatus. The steam which is supplied by way of the inlet 38 enters the steam channels 30a and 30b and is commonly delivered therefrom into the inner steam tubes 35. The steam so delivered into the tubes 36 discharges from the rear open ends 36 thereof against the closed ends 33 of the tubes 32 and is returned by the latter through the annular space provided between the concentric tubes 35 and 32 into the U-shaped channel 26 formed in the outer face of the tube plate 21, the steam being finally discharged from the said channel 26 by way of the steam outlet connection 39. The oil to be heated, which is introduced into the apparatus by way of the annular spaces formed between the steam tubes 32 and the straight-legged portion of the U-shaped tube units 10, 11, 12 and 13, the heat of the steam being transferred to the oil through the walls of the steam tubes 32. Due to the fact that the pressure of the steam is substantially equal on either side of the diaphragm plate 29, the latter need not be any stronger than is necessary to

support the inner steam tubes concentrically within the tubes 32. While any suitable means may be employed for securing the several tubes of the apparatus in their respective tube plates, it is preferable that all of the tubes, except the steam injection tubes 35, be expanded into their respective tube plates 17 and 21. The same procedure may be followed as respects the steam injection tubes but those latter are preferably threaded into the diaphragm plate 29 as shown. It is desirable that the diaphragm plate 29 be provided with an aperture 40 adjacent the bottom thereof to serve as a drain for the escape of any condensate which may accumulate in the steam channels 30*a*—30*b* of the cover plate. It will be appreciated, of course, that should any condensate form within the steam tubes 32, such condensate will be driven therefrom by the pressure of the steam discharging from the open ends 36 of the steam injection tubes 35.

Figure 4 illustrates a somewhat modified construction of apparatus wherein instead of employing U-shaped tube units as in Figure 1, all of the tubes, both steam and oil, are substantially straight from end to end thereof. While in this modified construction, as shown, the oil tubes 41 are arranged in vertically spaced relation, these tubes may be disposed in laterally spaced pairs arranged in vertically spaced relation in the same manner as the straight-legged portions of the corresponding tubes shown in Figure 1. It will be understood, of course, that the general arrangement and relative disposition of the interconnected fluid conduits in either of the forms of apparatus shown may be varied as desired to suit different installation conditions and space limitations. In the form of apparatus shown in Figure 4, the inner ends of the tubes 41 are suitably expanded into a tube plate 42, the outer ends of these tubes being closed, as at 43. Communication between the tubes is effected by means of connections 44 and 45 disposed between successive pairs of the tubes in such manner that a continuous supply of oil or other liquid to be heated may be introduced into the apparatus by way of the inlet connection 46 and discharged therefrom by way of the outlet connection 47, the liquid being circulated successively through all of the tubes 41 of the apparatus.

As in the construction illustrated in Figure 1, in the modified construction the steam tubes 48 are expanded or otherwise secured in a tube plate 49 while the steam injection tubes 50 are screwed or otherwise secured in the diaphragm plate 51, the latter being clamped between the tube plate 49 and the cover 52 by a plurality of marginal bolts (not shown). The steam tubes 48 are closed at their rear ends, as at 53, so that steam supplied thereto by the steam injection tubes 50 is caused to return by way of the annular space provided between the walls of the steam tubes 48 and the steam injection tubes 50 to the channel 54 for ultimate discharge from the apparatus by way of the outlet connection 55. In the apparatus of the construction illustrated in Figure 4, the several tubes 41 are disposed in a substantially common vertical plane in consequence of which the tube plate 49 and the cover plate 52 may each be provided with single vertically disposed channels 54 and 56, the channel 54 serving to deliver the discharged steam and condensate from the steam tubes 48 to the outlet connection 55 while the channel 56 serves to deliver the steam commonly to the steam injection tubes 50. Also, in the arrangement shown in Figure 4, by providing the outer ends of the tubes 41 with removable caps 43, provision is had for the ready removal of the steam tubes 48 by way of said capped ends whenever such removal is necessary for cleaning, repairs or inspection.

It is to be understood that in place of the U-shaped tube units 10—13 of Figure 1, pairs of straight tubes, such as are designated by the reference numeral 41, may be employed, these latter tubes being capped, as at 43, and connected together by the connections 44, as shown in Figure 4. Conversely, the mounting plate assembly for supporting the forward ends of the tubes 41, as in Figure 4, may be employed in lieu of that shown in Figure 1 for supporting the forward ends of the U-shaped units 10—13, in which event the connections 45 would be employed for effecting communication between the inlet and outlet points of adjoining pairs of the units 10—13.

In order to increase the heat conductivity of the steam tubes 32 (Figure 1) or 48 (Figure 4), they are preferably provided with longitudinally extending circumferentially spaced fins 58, these fins being of a depth such that they extend radially from the outer surface of the steam tube to which they are secured into close proximity with the internal surface of the tube through which the oil or other liquid to be heated is circulated. By providing the steam tubes with these radially extending fins, the effective heat transferring surface of each such tube is very materially increased. While finned tubing has been employed prior to the present invention, the type of fin and the manner of securing it to the tube as disclosed herein constitutes an important part of the present invention not only because of the economies effected thereby in the manufacture of such fin tubing but also because of the increased heat conductivity afforded by the fin tubing of the present invention.

Referring now more particularly to Figure 7 it will be observed that the radial fins 58 of the steam tubes 32 (which latter may be the steam tubes 48 of Figure 4) are secured to the outer surface thereof in the form of a multiple number of pairs of fins, each pair of fins constituting the longitudinally extending side walls of a channel having a base 57. The fin-forming channels are secured to the outer surface of the steam tubes by welding the bases thereof to the tubes.

Due to the relatively broad base of the fin-forming channels, a very ample surface contact is had between the steam tube and each of said channels in consequence of which a much higher heat conductivity is obtained between the tube and the fins than would be the case were the fins secured in edgewise relation to the tube. By means of the fins secured to the steam tube in accordance with the present invention, the heat generated in the walls of the tube 32 is quickly radiated therefrom by the fins and transferred to the fluid to be heated which circulates about the outer surfaces of said tubes and between the fins thereof.

If desired, in order to insure maintenance of the radial fins 58 in their proper angular relation, the outer free extremities thereof may be secured together by one or more narrow bands 74 which extend circumferentially about and embrace the fin extremities (see Figures 6 and 7). Also, in order to insure that the steam injection tubes 35 are at all times supported coaxially within the steam tubes 32, the said tubes 35 may be provided at one or more longitudinally spaced

points with radially projecting arms 75 (see Figure 7) which engage the internal walls of the steam tubes 35 and center the steam injection tubes therewithin.

It will be understood, of course, that the invention is susceptible of various changes and modifications from time to time without departing from the real spirit or general principles thereof and it is accordingly intended to claim the same broadly, as well as specifically, as indicated by the appended claims.

What is claimed as new and useful is:

1. A heat exchanging apparatus comprising a plurality of interconnected fluid circulating tubes through which a fluid to be heated may be continuously circulated, a plurality of steam tubes respectively projecting longitudinally into said fluid circulating tubes from corresponding open ends of the latter, the inner extremities of said steam tubes being closed while the outer ends thereof are open, and a plurality of steam injection tubes respectively disposed interiorly of said steam tubes, the inner extremities of said steam injection tubes being open and terminating short of the closed extremities of said steam tubes, and means for distributing steam at substantially equal pressure and temperature into said steam tubes by way of said steam injection tubes, said means comprising a diaphragm carrying the steam injection tubes, and a pair of substantially equal plates having flat faces disposed against the opposite faces of said diaphragm clamping the diaphragm over its marginal and intermediate areas, said plates each having on their diaphragm abutting faces a pair of elongated communicating shallow recesses, one of said plates having a steam inlet in communication with said recesses, and the other of said plates having the open ends of said steam tubes mounted therein in communication with said recesses and also having a steam outlet communicating with its recesses.

2. In a heat exchanging apparatus, a plurality of interconnected fluid circulating conduits having substantially straight portions arranged in parallel relation, a plurality of steam tubes having closed rear ends respectively disposed interiorly of the straight portions of said conduits, means interconnecting adjoining pairs of said conduits adjacent the extremities thereof whereby said conduits are connected in series relation, the fluid to be heated being circulated in said series connected conduits continuously through the space provided between the concentric walls of said conduits and tubes, a mounting plate serving commonly as a support for the outer open ends of said tubes and as a closure for the outer extremities of said conduits, a plurality of steam injection tubes respectively disposed interiorly of said above-mentioned heating tubes and adapted to deliver a heating medium against the closed rear ends of the latter for subsequent discharge therefrom through the space provided between the concentric walls of said tubes, and means for distributing said heating medium commonly into said delivery tubes from a source of supply of said heating medium, said means comprising a diaphragm carrying the steam injection tubes, and a pair of substantially equal plates having flat faces disposed against the opposite faces of said diaphragm clamping the diaphragm over its marginal and intermediate areas, said plates each having on their diaphragm abutting faces a pair of elongated communicating shallow recesses, one of said plates having a steam inlet in communication with said recesses, and the other of said plates having the open ends of said steam tubes mounted therein in communication with said recesses and also having a steam outlet communicating with its recesses.

3. A heat exchanging apparatus comprising a plurality of interconnecting conduits through which a fluid to be heated may be continuously circulated, a mounting plate adapted to receive corresponding ends of said conduits to support the same in spaced relation, a plurality of tubes projecting interiorly of said conduits through the outer ends thereof, a mounting plate for said tubes disposed in flatwise engagement with said conduit mounting plate, said tube mounting plate being provided in its inner face with passages affording communication between adjoining pairs of said conduits and with passages in its outer face affording communication between the outer extremities of said tubes, and means for injecting a heating medium interiorly of said tubes for heating the walls thereof, said heating medium being discharged from said tubes through the forward ends thereof and by way of said passages provided in the outer face of the tube mounting plate, said last-mentioned means including a plurality of relatively small diameter tubes disposed concentrically within said heating tubes to provide an annular space between the walls of said concentric tubes through which the heating medium flows upon its discharge from the inner ends of said small diameter tubes, a diaphragm carrying said small diameter tubes and having a face disposed flat against the outer face of said tube mounting plate, an outer plate disposed flat against the other face of said diaphragm and having a pair of shallow elongated communicating recesses in registry with said small diameter tubes, and a heating fluid inlet in communication with said last named recesses.

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