

Dec. 12, 1939.

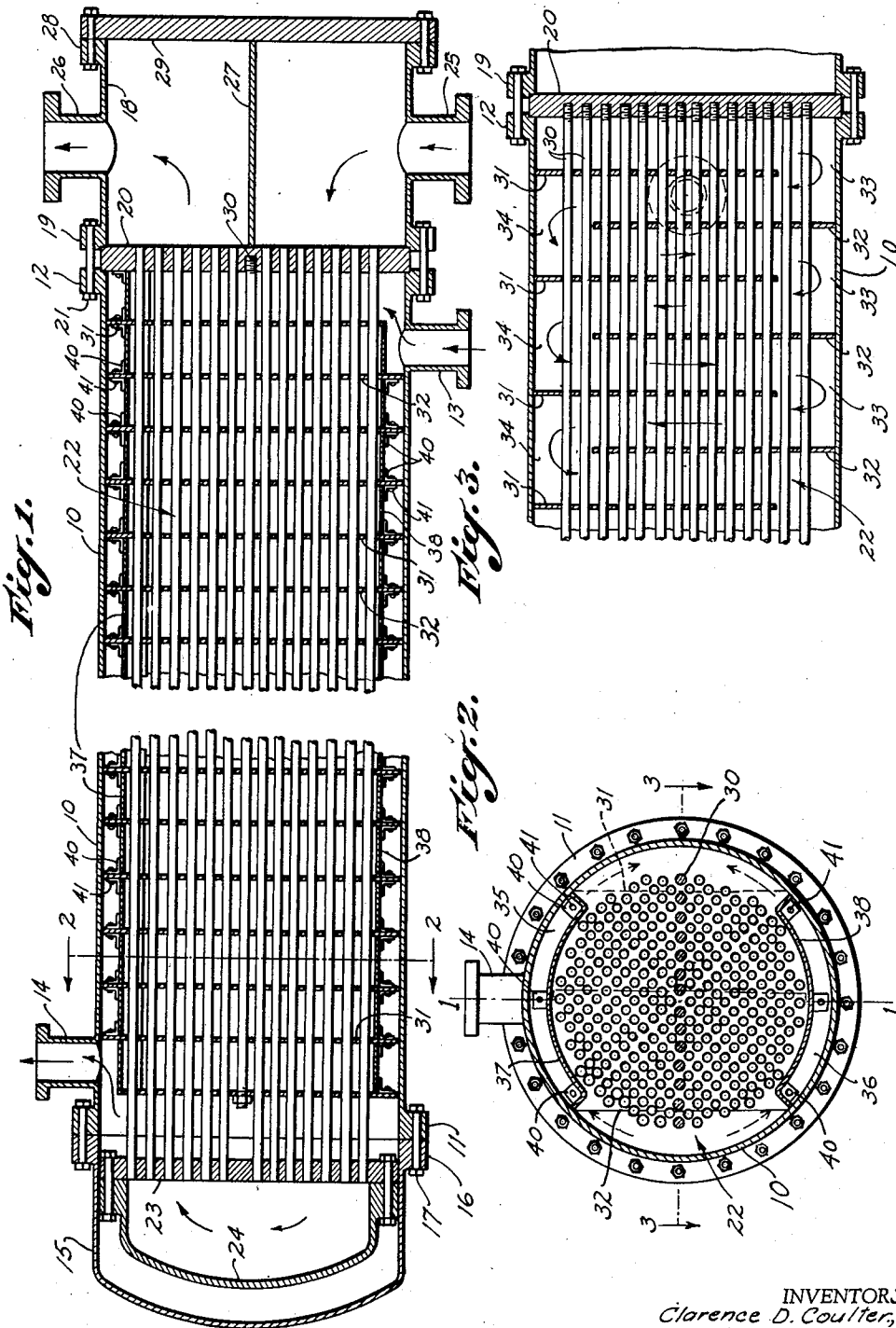
C. D. COULTER ET AL

2,183,160

HEAT EXCHANGER

Filed Jan. 19, 1938

2 Sheets-Sheet 1



BY

INVENTORS
Clarence D. Coulter,
Edwin R. Cox,
Russell M. Otis
ATTORNEY.

Dec. 12, 1939.

C. D. COULTER ET AL

2,183,160

HEAT EXCHANGER

Filed Jan. 19, 1938

2 Sheets-Sheet 2

Fig. 4.

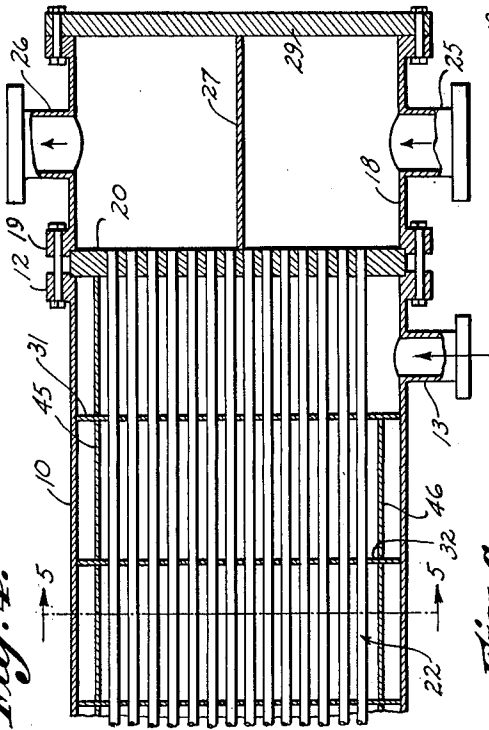


Fig. 6.

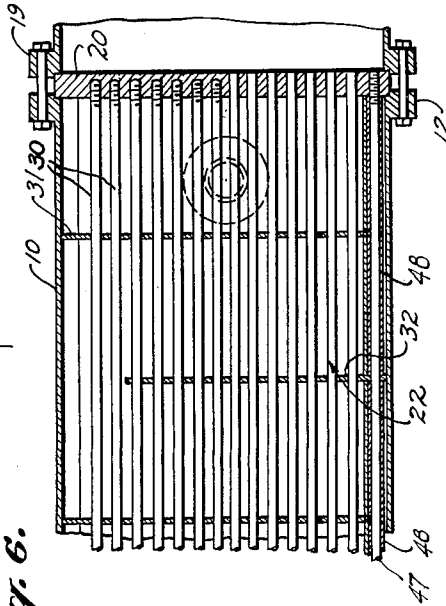


Fig. 7.

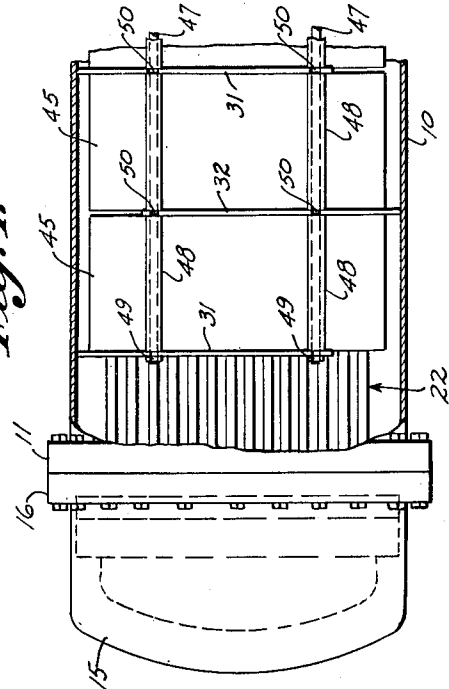
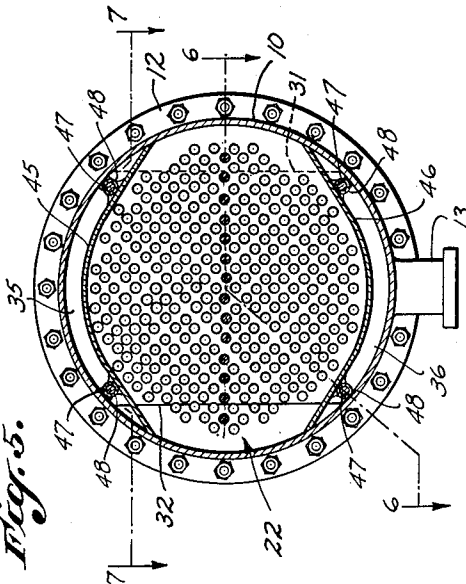


Fig. 5.



BY

INVENTORS
Clarence D. Coulter,
Edwin R. Cox,
Russell M. Otis
ATTORNEY.

UNITED STATES PATENT OFFICE

2,183,160

HEAT EXCHANGER

Clarence D. Coulter, Los Angeles, and Edwin R. Cox, Huntington Park, Calif., assignors to Southwestern Engineering Company, Los Angeles, Calif., a corporation of California

Application January 19, 1938, Serial No. 185,710

4 Claims. (Cl. 257—239)

This invention relates to heat exchangers and to means for improving their efficiency.

It is a principal object of the invention to provide a heat exchanger of high efficiency.

5 An object of our invention is to provide means in a heat exchanger for directing the flow of fluid therethrough so as to result in an improved heat transfer.

10 Another object is to provide a heat exchanger having means for confining the flow of fluid therethrough to paths in which heat exchange may take place.

15 Still another object of the invention is to provide convenient means for mounting the fluid confining means in a heat exchanger.

20 These and other apparent objects we attain in a manner which will be clear from consideration of the following description taken in connection with the accompanying drawings, of which:

Fig. 1 is a cross-sectional view of one form of our improved heat exchanger taken along a vertical diameter of the shell.

25 Fig. 2 is a sectional view of the heat exchanger of Fig. 1 taken along the line 2—2.

Fig. 3 is a cross-sectional view of our improved heat exchanger taken along the horizontal diameter 3—3 of the shell.

30 Fig. 4 is a cross-sectional view of an alternative form of heat exchanger employing the principles of our invention, taken along a vertical diameter of the shell.

Fig. 5 is a sectional view of the heat exchanger of Fig. 4 taken along the line 5—5.

35 Fig. 6 is a sectional view of the heat exchanger of Figs. 4 and 5, taken along the broken line 6—6.

40 Fig. 7 is a view of the heat exchanger of Figs. 4 and 5 with the shell partially cut away along the line 7—7.

45 The heat exchanger in which our invention is herein illustrated as being employed includes an elongated cylindrical shell 10 with outwardly directed flanges 11 and 12 at the ends, a radially directed inlet 13 at one end, and a radially and oppositely directed outlet 14 at the other end. One end of the shell 10 is closed by shell cover 15 having a flange 16 which is bolted tightly against the flange 11 by bolts 17. At the other end of the shell is located a relatively short cylindrical member 18, called a channel, and providing at its ends the flanges 19 and 28. Between the flanges 12 and 19 is securely clamped a tube sheet 20 by action of the bolts 21. The tube sheet 20 is a circular plate forming the ter-

50 minal support for the bundle of tubes 22. The tubes 22 pass through holes bored in the tube sheet 20 and are expanded at their ends to retain them in the tube sheet. The tubes extend longitudinally of the shell for nearly its full length and terminate in a similar manner in a second tube sheet 23 forming part of a floating head. A cover 24 is bolted to the tube sheet 23 to make the tube bundle fluid tight at this end. It will be observed that the tube bundle is longitudinally fixed at only one end which permits it to freely expand and contract within the shell 10 in response to temperature changes without placing stress upon the shell.

55 The channel 18 is provided with an inlet 25 at the bottom, and an outlet 26 at the top. A partition 27, welded to channel 18, extends across the full diameter of the tube sheet and separates the inlet from the outlet within the channel 18. A cover plate 29 is bolted to the flange 28 to make this end of the channel fluid-tight. As a result of this construction, fluid enters through inlet 25, passes through the tubes comprising the lower half of the tube bundle 22 in the direction of the arrows shown, turns within the space between the tube sheet 23 and the cover 24, returns through the tubes comprising the upper half of the tube bundle and passes out through the outlet 26.

60 The function of the heat exchanger is to transfer heat from one fluid to another, and to this end a fluid is caused to enter the shell 10 through inlet 13, pass around and between the tubes 22 and leave through outlet 14, so that heat may be exchanged between this fluid and that inside the tubes 22. In order to assure uniform transverse circulation of the fluid around the tubes and a better contact of all the tubes with the body of fluid, the baffles 31 and 32 are alternately located at intervals longitudinally along the tube bundle. The baffles 31 and 32 are circular sheets of about the same diameter as the shell 10 and through which the tubes 22 pass, the baffles fitting the outsides of the tubes closely to prevent flow of fluid through the baffles. Each of the baffles 31 has a segment cut away at one side to provide a fluid passage 33, and each of the alternately disposed baffles 32 has a segment cut away at the opposite side to provide a fluid passage 34. As a result of this construction, the fluid entering inlet 13 passes horizontally back and forth between the tubes in the transverse passages defined by baffles 31 and 32, and through passages 33 and 34, as indicated by the arrows, and finally leaves the shell through out-

let 14. The baffle nearest the tube sheet at each end of the tube bundle may, if necessary, be cut away nearest the adjacent inlet or outlet passage to afford communication between the inlet and outlet passages and the spaces adjacent the respective tube sheets.

Since the row of tubes which would ordinarily be present in the diametric position directly facing the end of partition 27 would be blocked by the partition so that fluid could not pass there-through, we prefer to substitute solid rods 30 in this row in place of tubes. The rods are preferably screwed into threaded holes in tube sheet 20 which extend only part way through the tube sheet, and at their opposite ends terminate in threaded portions extending somewhat beyond the baffle farthest from tube sheet 20. Nuts are screwed on these threaded ends tightly against this baffle. By this construction a smooth surface on the tube sheet 20 is presented to abut the end of partition 27. The rods 30 are made of suitable diameter with respect to the spacing and diameter of tubes 22 to prevent excessive bypass of fluid through the tube bundle along the horizontal diameter of the shell, which would otherwise occur if the tubes in this row are simply omitted to leave an uninterrupted passage through the tube bundle. In place of the row of rods 30 we may substitute a plate in the same plane as the partition 27, suitably mounted, and of a thickness such that excessive bypass of fluid through the tube bundle does not take place in the space opposite the partition 27.

In order to secure a comparatively large heat transfer area in a limited space, it is desirable to employ a very large number of relatively small tubes in the tube bundle and to locate them close together. Another result following from the use of small, closely spaced tubes is that tortuous paths are provided for all the fluid from one side of the shell 10 to the other, resulting in a turbulent condition of flow in which all parts of the fluid contact the tube surfaces and may readily transfer heat to or from these surfaces. In order to still further increase the turbulence of the flow of fluid around the tubes 20, they are preferably located with their centers at the corners of adjoining squares or triangles and the tube bundle is oriented so that the sides of the squares or triangles lie at angles to the horizontal.

The condition of a large number of small, closely spaced tubes, staggered to provide tortuous paths between, while being advantageous from the standpoint of heat exchange, provides a problem by offering a high frictional resistance to the flow of fluid from one side of the shell to the other. If, therefore, a path other than that between the tubes and of lower resistance is offered the fluid, it will flow through this path of less resistance rather than past the tubes, and the advantage of closely spaced, staggered tubes may be partially or completely lost. Such an alternative path, we find, is ordinarily provided in heat exchangers of the general type illustrated because of the fact that a space must necessarily exist between the tube bundle and the inside of the shell. This space designated at the top by numeral 35 and at the bottom by numeral 36 must exist in order that the tube sheet 23 with its outwardly extending rim, to which cover 24 is bolted, may be withdrawn through the shell. Unless means are provided, as according to our present invention, to prevent it, a considerable quantity of fluid, which should for best results flow between the tubes 22 from one side of the

shell 10 to the other side, will rather flow up over the tube bundle through the space 35, and down under the tube bundle through the space 36, to the other side, as shown by the dotted arrows, and thus completely avoid contact with the tubes 22. This detrimental action takes place to some extent at the open end of each of the baffles 31 and 32 in a heat exchanger not provided with means to prevent it, and is, we find, a very important cause of inefficiency in heat exchangers. The inefficiency due to this cause is, moreover, particularly great in the case of viscous fluids moving through the shell of the exchanger, and this condition exists in many important industrial processes.

According to our invention, shrouds 37 and 38 are placed in the passages between the baffles 31 and 32, and above and below the tube bundle, so as to substantially block off the spaces 35 and 36 to the transverse flow of fluid and force all of the fluid to flow through the spaces between the tubes. The shrouds 37 and 38 preferably consist of arcuate sheets closely fitting the outside of the tube bundle, of a width substantially the same as the distance between baffles 31 and 32, and terminating at each end in a portion which may be bent out radially to meet the shell 10 at points near where baffles 31 and 32 are cut away. Right angular lugs 40 may be welded to the outside of each shroud adjacent each baffle at the ends and middle of the shroud. The shrouds are supported by bolting to the intervening baffle by means of bolts 41 the lugs of adjacent shrouds. By means of this construction, fluid tending to flow into the spaces 35 and 36, as indicated by the dotted arrows in Fig. 2, is diverted into the tube bundle where heat exchange may take place. The result is that, following this construction, we have been able to construct heat exchangers with considerably higher heat transfer rates than have been common in the industry.

An alternative form of shroud and manner of supporting it is shown in the heat exchanger of Figs. 4, 5, 6, and 7, in which all other parts are similar to those of the heat exchanger above described and are designated by the same numerals. In this form also, the shrouds 45 and 46 are placed at the top and bottom, respectively, between each two baffles 31 and 32, fitting closely the outside of the tube bundle over most of the length of the shroud. At each side the shrouds leave the tube bundle and continue in nearly a straight line over to the shell 10 to substantially block off flow of fluid into the spaces 35 and 36. By making the shrouds approach the shell at a small angle, eddying of the fluid at the juncture of shroud and shell is avoided.

In order to support the shrouds, long rods 47 may be screwed into the tube sheet 20 at one end and pass through all the baffles 31 and 32. Spacing tubes 48, of suitable inside diameter to slip over rods 47, and of a width equal to that of the shrouds, are welded to the outsides of shrouds 45 and 46, and are supported on rods 47 between the baffles 31 and 32. The nuts 49 screwed onto the threaded ends of the rods 47 beyond the baffle farthest from tube sheet 20 are employed to tighten the entire structure of baffles, rods 47, and spacers 48. The rods 47 may pass through holes in the baffles 31 and 32, but preferably slots 50 are formed in the outer edges of the baffles of suitable width and depth to accommodate the rods 47 in their operative position, but of less width than the outside diameter of spacers 48.

The rods 47, then, are simply slipped into these slots, with the supported spacers and shrouds located between the baffles, and the whole structure is tightened. In this manner the shrouds 45 and 46 are firmly supported in a way that permits of their being easily and quickly removed for cleaning of the equipment.

It is recognized that the shrouds herein disclosed may be made in various shapes and may be attached to the associated parts in various ways, and that the shrouds may be applied to heat exchangers of other design, while still operating in accordance with our invention. While we have shown a heat exchanger in which fluid passes one way through part of the tubes of the tube bundle and returns through the remaining tubes, the invention may also be applied to a single-pass exchanger in which fluid passes only once through the tubes of the tube bundle, or to a multiple-pass exchanger in which the fluid flows any desired number of times through the tubes of the tube bundle. We have illustrated our invention in connection with a heat exchanger in which fluid within the shell, but outside the tubes, traverses the length of the unit only once; but our invention may also be applied to heat exchangers in which this fluid traverses the unit more than once. Such an exchanger, for example, may be constructed with a partition on the shell diameter and with fluid passages causing fluid to be directed back and forth down the exchanger between the baffles on one side of the partition, then to be returned in a similar manner between the baffles on the other side of the partition, making a double pass through the shell.

When we have spoken of the vertical and horizontal directions and of the sides of the apparatus, it is understood that we were in no way limiting the apparatus to use in the particular orientation disclosed, but that the heat exchangers shown and described may be oriented in any desired direction.

It is understood that in the light of this disclosure various other changes and modifications in design and construction may be made by those skilled in the art without departing from the spirit of the invention defined in the appended claims.

We claim as our invention:

1. In a heat exchanger, the combination of: a plurality of tubes for passage of fluid therethrough and forming a tube bundle, a shell surrounding said tube bundle and spaced therefrom, a plurality of baffles transverse to said tube bundle and disposed at intervals longitudinally thereof, alternate baffles having openings at opposite sides for longitudinal passage of fluid within said shell, said baffles having slots in their outside edges, longitudinally extending rods residing in said slots outside of said tube bundle, spacers on said rods between said baffles and of a length sub-

stantially equal to the distance between baffles, and shrouds located between said baffles and adapted to substantially prevent transverse flow of said fluid in the space between said tube bundle and said shell, said shrouds being attached to said spacers for support of said shrouds.

2. In a heat exchanger, the combination of: a plurality of tubes for passage of fluid therethrough and forming a tube bundle, a shell surrounding said tube bundle and spaced therefrom, a plurality of baffles transverse to said tube bundle and disposed at intervals longitudinally thereof, alternate baffles having openings at opposite sides for longitudinal passage of fluid within said shell, said baffles having slots in their outside edges, longitudinally extending rods residing in said slots outside of said tube bundle, shrouds located between said baffles and adapted to substantially prevent transverse flow of said fluid in the space between said tube bundle and said shell, and means for supporting said shrouds on said rods.

3. In a heat exchanger, the combination of: a plurality of tubes for passage of fluid therethrough and forming a tube bundle, a tube sheet supporting said tubes at one end thereof, a partition abutting said tube sheet, a shell surrounding said tube bundle, a plurality of transverse baffles arranged to cause fluid to pass transversely back and forth across said tube bundle, means longitudinally spacing said baffles from one another and from said tube sheet, solid rods taking the place of tubes opposite said partition, said rods being of such diameter as to prevent excessive bypass through said tube bundle in the space opposite said partition, and means on the ends of said rods retaining said baffles and said tube sheet in assembled relation.

4. In a heat exchanger, the combination of: a plurality of tubes for passage of fluid therethrough and forming a tube bundle in which the tubes occupy positions characterizing a regular geometrical pattern, a tube sheet supporting said tubes at one end thereof, a partition abutting said tube sheet, a shell surrounding said tube bundle, a plurality of transverse baffles arranged to cause fluid to pass transversely back and forth across said tube bundle, means longitudinally spacing said baffles from one another and from said tube sheet, members occupying the tube positions opposite said partition and supported in said tube sheet in holes therein extending only partially therethrough, said members being of such diameter as to prevent excessive bypass through said tube bundle in the space opposite said partition, and means on said members in engagement with one of said baffles for retaining said baffles and said tube sheet in assembled relation.

CLARENCE D. COULTER.
EDWIN R. COX.