Nov. 25, 1930. S. J. CHUTE 1,782,409

HEAT EXCHANGER

Filed Dec. 19, 1927 2 Sheets-Sheet 1

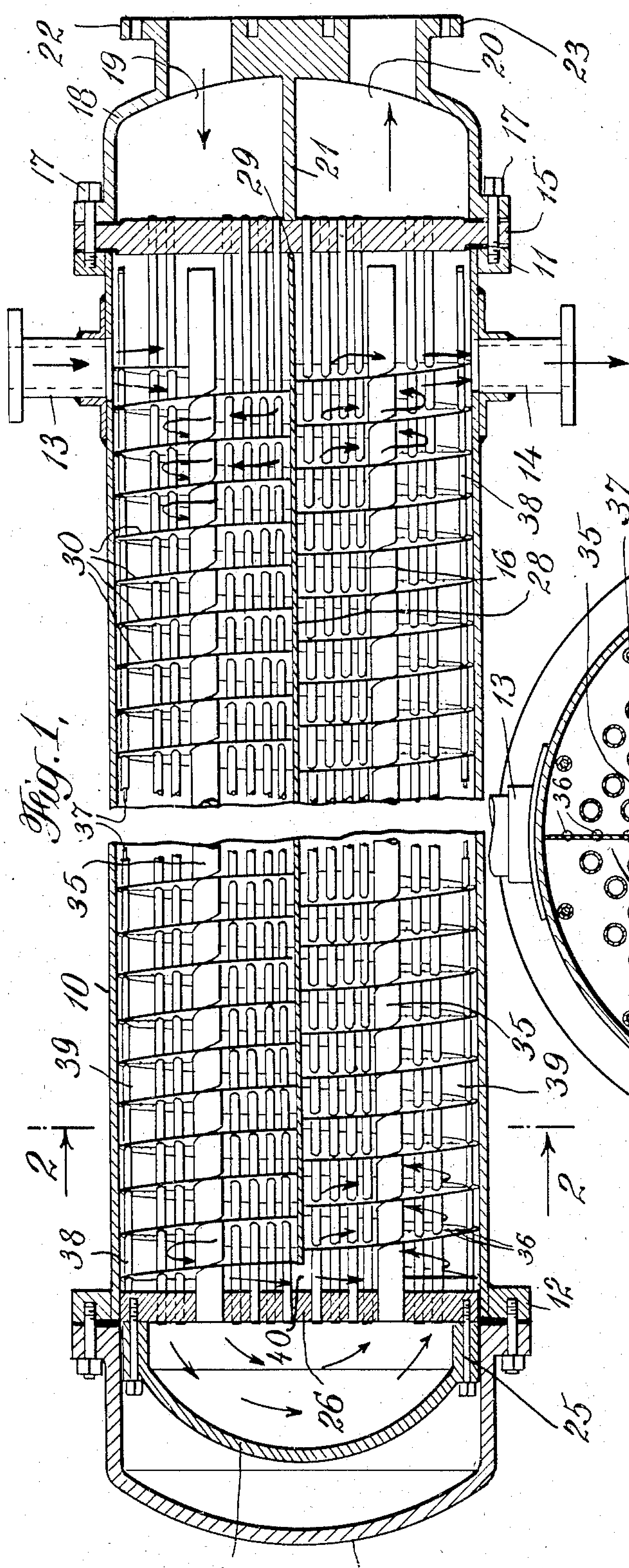

Fig. 1.

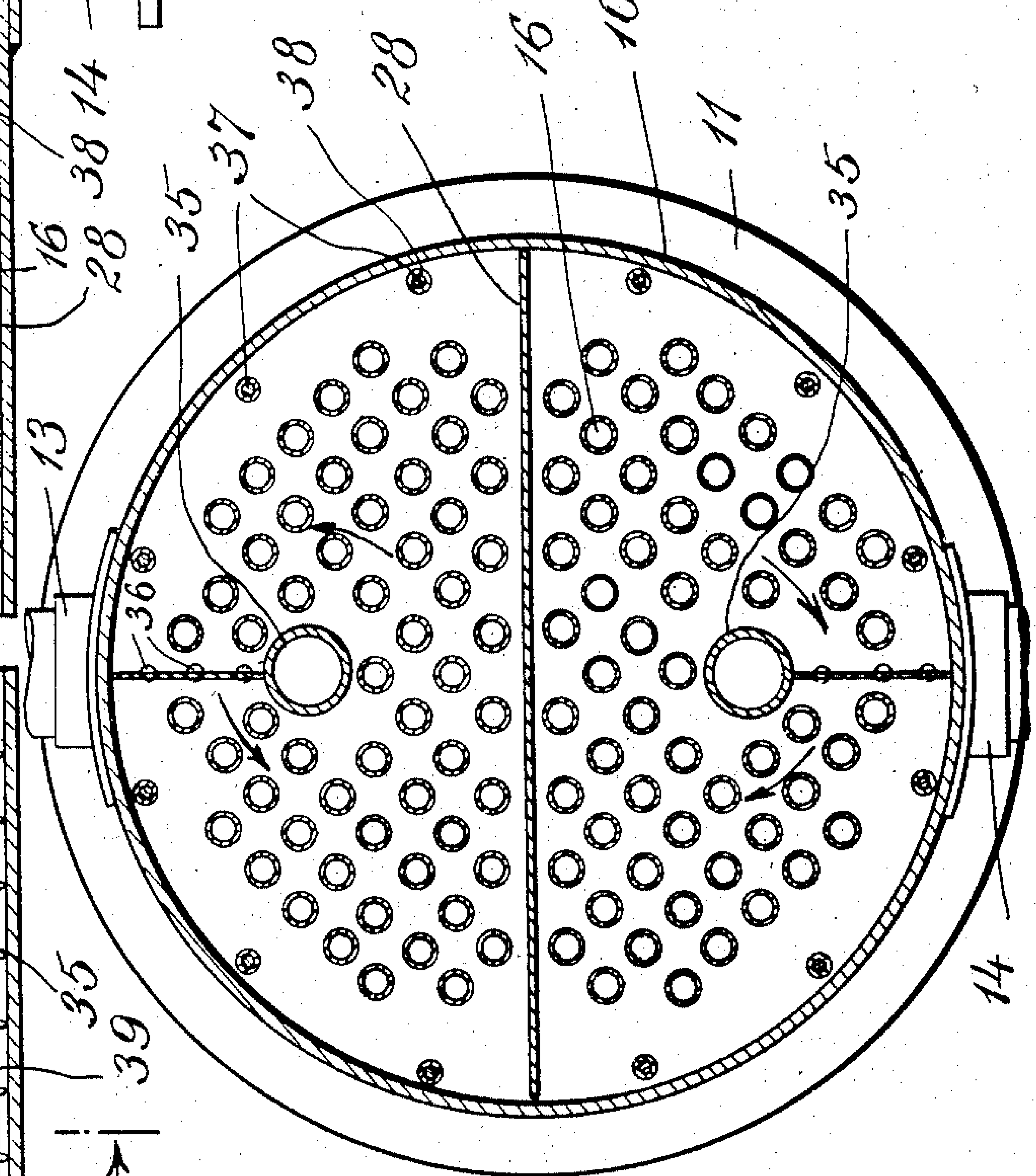

Fig. 2.

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Fig. 3,

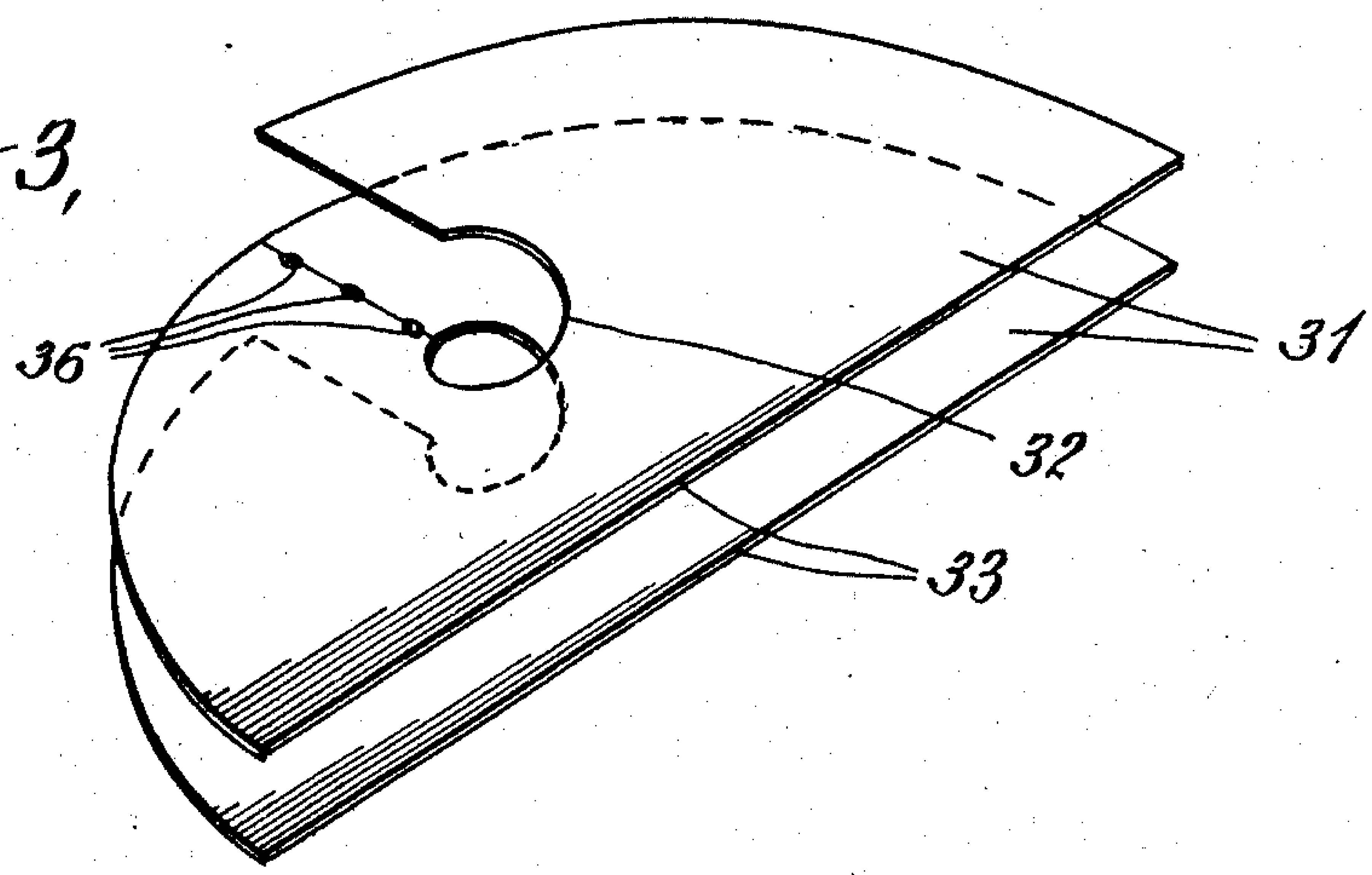


Fig. 5,

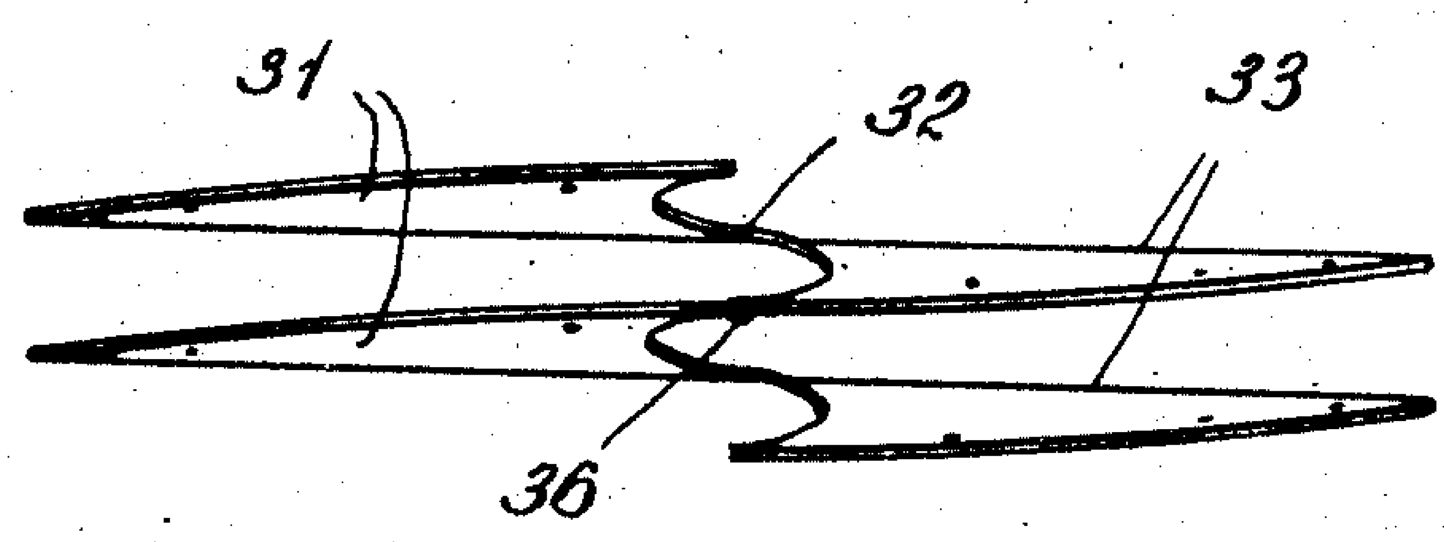


Fig. 4,

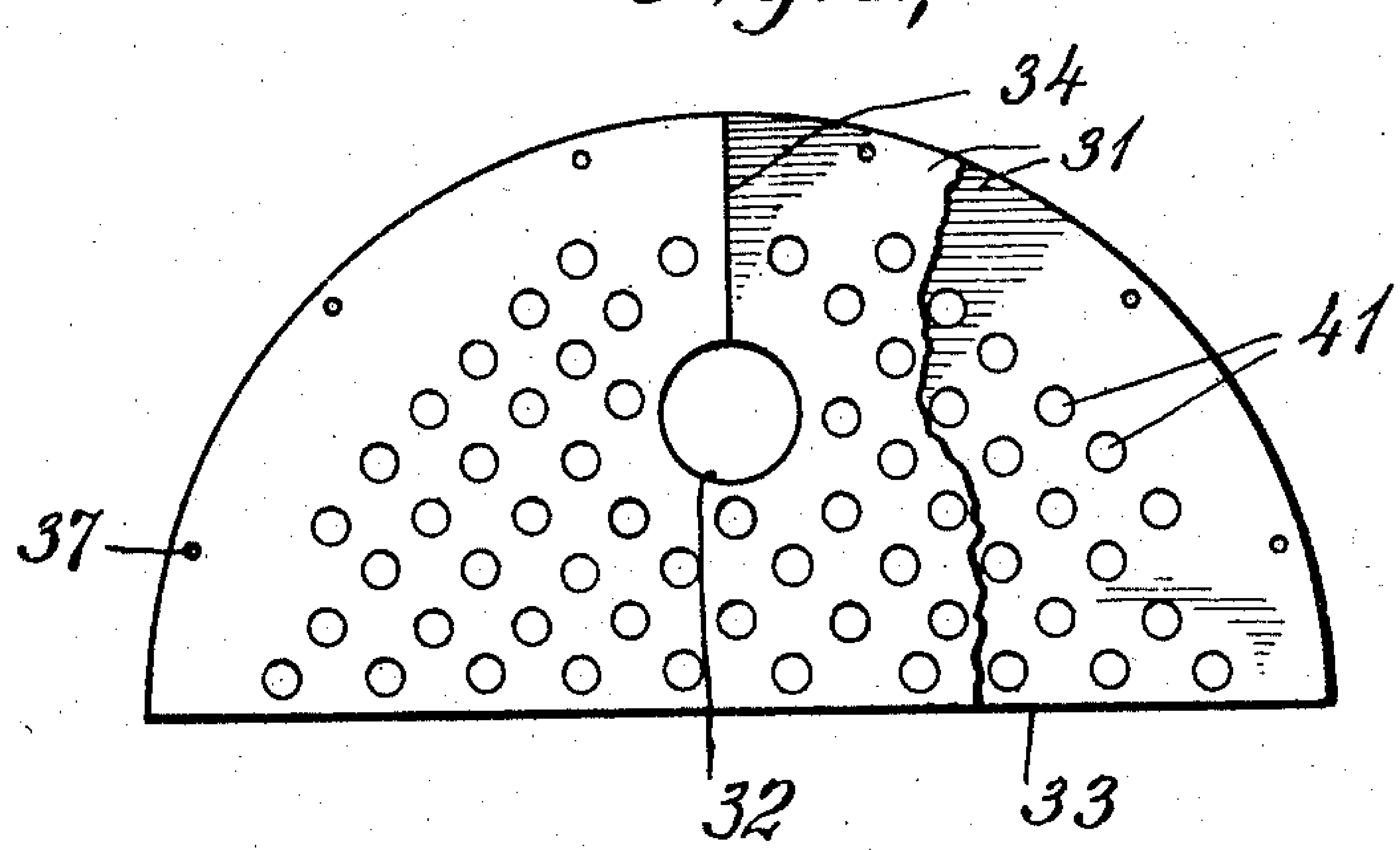
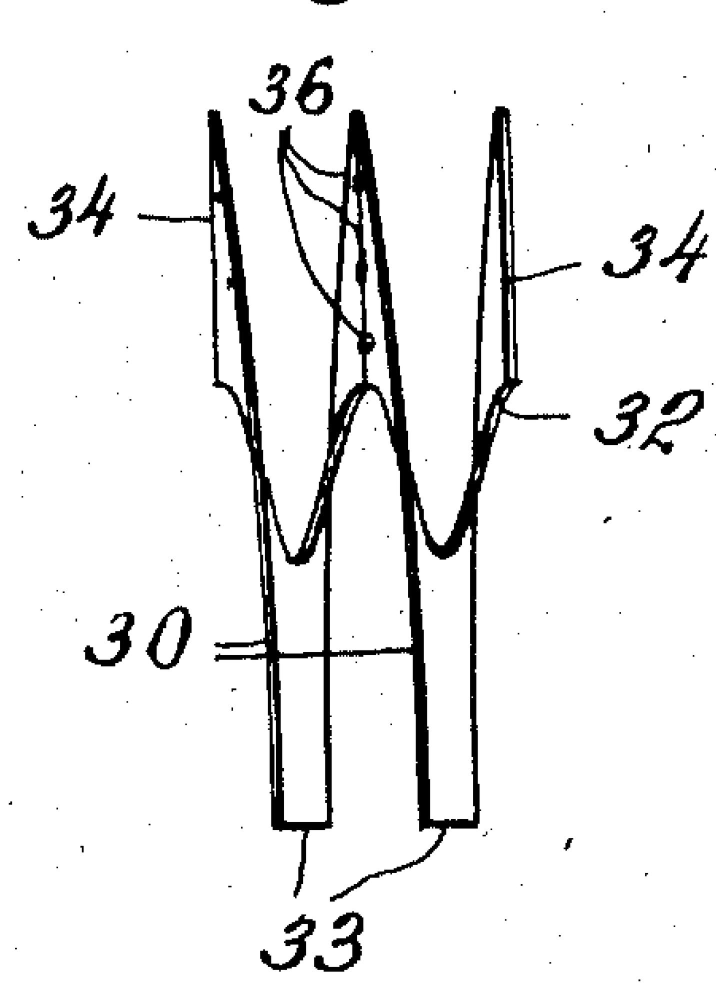


Fig. 6,



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1,782,409

UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

Application filed December 19, 1927. Serial No. 240,957.

This invention relates to apparatus for heating or cooling fluids in which the heat is transferred from one fluid to another. The apparatus is particularly applicable to the transfer of heat unaccompanied by condensation or vaporization of either fluid, but it may be used also as either a condenser or a boiler. The apparatus is of that type in which one of the fluids, for example, the fluid to be cooled, is passed through a tubular shell and the other fluid, which may be termed the working fluid, is passed through a plurality of tubes, that is, a tube bundle or tube nest positioned within the shell.

One object of the invention is to provide an apparatus of this character of small exterior dimensions but having a relatively long path of movement for the fluid in the shell, whereby the fluid to be cooled in its passage through the apparatus is kept in continuous motion at a sufficiently rapid rate to most effectively utilize the cooling surface and at the same time obtain the desired drop in temperature of the fluid to be cooled.

A further object of the invention is to construct an apparatus of this character providing a plurality of passes for the fluid in the shell in which that fluid in its travel throughout the length of a given pass is maintained in continuous motion in the same direction instead of in a zig-zag direction with a reversing motion as heretofore practiced, thereby avoiding the fluid friction and loss of pressure which result when the rate of flow is sufficiently rapid to efficiently utilize the heat transferring surface.

Another object of the invention is to provide a heat exchanger having a shell that is divided into passes of semi-circular cross section, with a baffle structure for causing the fluid in the shell to flow continuously in the same direction instead of in a zig-zag direction as heretofore customary, particularly in heat exchangers having passes of this shape.

A further object of the invention is to provide a heat exchanger which is of simple construction and low in cost of manufacture, the long walls of the passages for the fluid in the shell being formed of thin metal shaped to form a baffle of approximately helical shape extending from end to end of each pass through the shell or casing.

A further object of the invention is to provide a heat exchanger having a plurality of passes for the fluid in the shell in which provision is made throughout the length of each pass for maintaining the fluid in continuous motion in the same direction, and in which the bundle or nest of tubes for the entire tubular shell, including both the baffles for dividing the shell into parallel passes, and the baffles for causing continuous rotary motion, may be removed from the shell as a unit.

A further object of the invention is to provide a heat exchanger having a plurality of passes for the fluid in the shell in which the tubes and other parts of the apparatus can freely expand and contract without straining the apparatus or loosening the joints between the several parts.

In the accompanying drawings I have illustrated an embodiment of my invention which has been found highly satisfactory in actual use.

In these drawings:

Fig. 1 is a longitudinal section taken vertically through the heat exchanger;

Fig. 2 is a somewhat enlarged transverse vertical section taken on line 2—2 of Fig. 1;

Fig. 3 is a perspective view of two adjacent baffle plates for one of the passes, the tube holes in these plates being omitted for the sake of clearness;

Fig. 4 is a front view of two adjacent baffle plates joined together as in the heat exchanger;

Fig. 5 is a plan or top view of these two baffles showing the joining of the upper portion of one baffle to the next; and

Fig. 6 is a side view of these baffles.

My improved heat exchanger will be described in its application to the cooling of oil, the coil passing through the shell, as referred to above, and the working fluid being passed through the interior of the tubes. It will be understood, however, that the oil may be passed through the tubes, and the working fluid through the shell if desired. It will be assumed that water is employed as the working fluid.

Referring now to the accompanying drawings, the shell 10 in the embodiment illustrated in cylindrical in cross section and is made of steel of suitable thickness to withstand the pressure under which the oil to be cooled is circulated. At each end of the shell is provided with flanges 11 and 12 respectively, which can conveniently be annular rings cut from thick steel plates and secured to their respective ends of the shell by welding. Near the right hand end of the shell, as viewed in Fig. 1, is a flanged inlet 13 for the passage of the oil to be cooled, and diametrically opposite the inlet 13 is a flanged outlet 14 by which the cooled oil is discharged.

The tube supporting plate 15 for the bundle or nest of tubes 16 is clamped accordingly against the flange 11 at that end of the shell which is near the inlet and outlet for the oil to be cooled, this clamping being effected by the bolts 17 which also serve to secure a water head 18 to the outside of the tube sheet 15. The water head is divided into an inlet chamber 19 and an outlet chamber 20 by means of a partition wall 21. This partition terminates in the same plane as the flanges of the water head so that when the head is secured in place a fluid-tight joint will be made between the partition and the surface of the tube sheet 15. A flanged inlet 22 communicates with the admission chamber 19, and a similar flanged outlet 23 is provided for the discharge chamber 20, and by means of these connections the working fluid is supplied to and discharged from the apparatus.

The tubes of the tube bundle 16 supported in tube sheet 15 are arranged in concentric rows, with the tubes in alternate rows staggered as shown particularly in Fig. 2. All of the tubes are expanded in the tube plate 15 after the manner of boiler tubes to produce rigid and fluid-tight joints.

At the opposite end of the shell an end cap 24 is bolted to the flange 12. Fluid-tight joints are provided between the end cap 24 and the flange 12, as well as in securing the water head 18 and tube sheet 15 to the flange 11.

The water tubes of the tube bundle 16 at the left hand end of the heat exchanger are all connected to a floating head or return drum 25 whose cylindrical walls fit loosely in the shell and end cap 24 to permit free expansion and contraction of the water tubes. The return drum is composed of a tube sheet 26 and a cap 27 which is bolted thereto and which forms with the tube sheet a chamber connecting the open ends of all of the tubes so that the water entering the chamber from one portion of the tubes, is returned through the other portion of the tubes. The tubes are expanded into the tube sheet 26 of the floating head in the same manner as in the stationary tube sheet 15.

To cause the oil in passing through the cooler to follow a path sufficiently long to be cooled to the desired degree by its passage through the shell at a relatively rapid rate of flow, the shell is provided with a system of baffles for causing the oil to travel twice throughout the length of the apparatus, and to assume during each of these longitudinal passes a continuous rotary motion in the same direction. This baffle structure also comprises a longitudinal baffle 28 which extends from the inner surface of tube sheet 15 and terminates just short of the tube sheet 26 of the return drum. This baffle is a relatively thin metal sheet extending in the horizontal direction diametrically across the shell 10 and dividing the interior of the shell into two parallel passageways of equal area. The baffle may conveniently be made of sheet steel and is welded across its right hand end 29 where it meets the stationary tube sheet 15 so as to prevent the passage of the oil being cooled and so as to firmly secure the baffle to the tube sheet for a purpose which will appear hereafter.

The passageway on the upper side of the longitudinal baffle is provided with a continuous winding helical baffle 30 which extends from a point adjacent the inlet 13 to a point adjacent the end of the longitudinal baffle 28 at the opposite end of the apparatus. Instead of making this helical baffle as a single unitary structure, each turn or vane is made of a separate sheet of metal of the shape shown in Figs. 3 to 6 inclusive. Each of these elements 31 consists of a semi-circular sheet or plate of thin sheet metal, such for example, as sheet steel. Each of the vanes has a circular aperture 32 located approximately mid-way between the center of its straight base 33 and the outer edge of its semi-circular periphery. The vanes are each slitted or cut along a straight line 34 extending outwardly from the aperture 32.

The vanes 30 are mounted in uniformly spaced relation upon a core tube 35 which extends longitudinally of the upper passageway above the longitudinal baffle 28. The vanes 30 are arranged with their bases 33 at an angle to the axis of the core tube 35, depending upon the pitch which it is desired to give to the helical channel formed between the vanes. The bases 33 are then tack-welded to the surface of the longitudinal baffle 28 so as to form a fairly close fit therewith. The upper portions of the vanes which have been previously severed by the cut or slit 34 are now offset so that a portion of one vane is brought into alignment with the opposite portion of the adjacent vane, and the edges of these two vanes are spot-welded together, as indicated at 36 in Figs. 1, 3 and 5.

By thus positioning and joining the individual vanes a continuous helical baffle is produced extending from a point adjacent the inlet 13 to a point adjacent the end of longitudinal baffle 28 at the opposite end of the apparatus. A substantially helical channel is produced about the core tube 35 and between the vanes and extending throughout the pass above the longitudinal baffle 28. In order to maintain the vanes in the desired uniform spaced relationship a plurality of stay rods 37 pass through the vanes near their peripheries as may be seen in Fig. 4 and extend substantially from tube sheet 15 to the return drum 25. Spacing sleeves 38 are placed upon these rods between the vanes. A relatively large number of stay rods are used for the sake of strength and to serve as oil deflectors.

The baffles on the lower side of the longitudinal baffle 28 are arranged substantially as described above in connection with the passageway on the upper side thereof, except that the direction of rotation of the oil channel 39 is reversed. The helical channel between the vanes 30 and the upper pass is joined to the helical channel 39 of the lower passageway by the space 40 between the tube sheet 26 of the floating head and the end of the longitudinal baffle 28.

In operation the oil or other fluid to be cooled is pumped into the inlet opening 13 under sufficient pressure to force the oil through the helical passage at a good rate of flow. Although the passage is long, there is little friction loss for the reason that the direction of flow is continuous throughout the length of the helical channels both in the upper and lower passageways, and except for the water tubes and spacing rods is free from obstructions. The rapid circulation causes all particles of the oil to be brought rapidly and repeatedly against the cooling surface under the circulating pressure without dependence upon convection so that the heating surface is maintained at its maximum efficiency of operation. This is a feature of particular importance in oil coolers for the reason that there is not a great difference in temperature between the oil to be cooled and the circulating water, as the water usually available for the purpose is seldom at a temperature below 60 or 70° F.

It will be understood that the water tubes of the tube bundle 16 pass through the apertures 41 in the vanes of the helical baffle members. These apertures may be made to fit the tubes closely, or they may be made somewhat larger than the outside diameter of the tubes for the purpose of securing an automatic scouring action lengthwise of the tubes as disclosed in Letters Patent of the United States No. 1,454,053, granted May 8, 1923, to Russell C. Jones and assigned to the same assignee as the present application.

The core tube 35 and the corresponding core tube for the lower passageway are secured at their left hand ends to the tube sheet of the floating head 25, and at their right hand ends they are spaced slightly from the stationary tube sheet 15. By reason of this, if there happens to be any difference in the coefficients of expansion of the metal of the core tube, and of the metal of the tubes of the tube bundle, the possibility of strain on the tube joints is avoided.

The longitudinal baffle 28, as mentioned above, is firmly secured to the stationary tube sheet 15, and the individual vanes forming the helical baffles in both the upper and lower oil passageways are individually welded to the continuous longitudinal baffle 28 along their base lines. The spacing stay rods 37 which support the outer edges of the helical baffle members are not attached to either tube sheet, thus avoiding the possibility of stresses due to unequal expansion and contraction, but because the peripheries of the vanes are rigidly spaced by means of these rods, and because the bases of the vanes are secured to the longitudinal baffle, the entire baffle system possesses a remarkable degree of rigidity and strength.

It will thus be understood that the entire baffle system is made an integral part of the tube bundle and can be removed with the tube bundle and replaced in the shell without fear of damaging the vanes forming the helical baffle members. At the same time because semi-circular baffle members are secured to the longitudinal plate 29 along straight edges, the individual baffle members are permitted to flex slightly to the temperature stresses without exerting stresses upon the tubes.

This removal of the tube nest from the shell 10 can be effected in the customary manner, by removing the water head 18. The entire unit, including the return drum 25, can then be removed from the shell with the stationary tube sheet 15.

It is to be noted that the spacing rods 37 are arranged in close proximity to the inner surface of the shell, in which position they serve the additional function of baffles for impeding the circulation of the oil at the outer edge of the helical channel, thereby causing the greater flow of the oil through the portions of the channel occupied by the tubes. This is an important feature of the construction for it would be impractical to arrange the tubes close to the outer edge of the tube sheet 15 on account of the employment of the floating head construction. Without the rods located adjacent the shell wall, there would be less resistance to the flow of the oil at the outer edge of the helical channels with the result that some of the cooling surface would be short-circuited.

It is to be understood that my invention includes all modifications of my improved apparatus which fall within the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an apparatus of the character described, a tubular shell forming a chamber for the fluid to be acted upon and having inlet and outlet passages for said fluid at one end of the shell, a plurality of tubes within the shell for the circulation of the working fluid, means for delivering and discharging the working fluid to and from said tubes, a flat longitudinal plate arranged diametrically across the interior of the shell and extending substantially from one end thereof to the other so as to cause the fluid to be acted upon to travel from the inlet to the opposite end of the shell and thence to return within the shell to the outlet, an elongated core member extending substantially centrally of the semi-circular chamber above said longitudinal plate, and a second similar core member positioned in the semi-circular chamber below the plate, a plurality of semi-circular sheets of thin metal each perforated centrally and arranged in spaced relation upon the core members in each of said semi-circular chambers, the bases of said baffle elements being placed against the flat surface of said longitudinal plate and arranged in substantially parallel relation at an angle to the axes of the core members, the baffle elements each being severed radially from the core member to their respective semi-circular edges, and the severed portions of each element being offset with respect to one another, the severed edge of one element being secured to the oppositely directed severed edge of its adjacent element thereby forming a continuous substantially helical passageway throughout the length of each of said semi-circular chambers.

2. In an apparatus of the character described, a shell having a plurality of tubes extending therethrough, a tube sheet at one end of the shell for supporting said tubes, a longitudinal plate arranged diametrically across the shell and extending lengthwise thereof and secured to the tube sheet at one end, a return drum freely movable at the opposite end of the shell including a tube sheet for supporting the tubes at that end, and supporting a core member extending longitudinally of the shell above said plate and a similar core member below said plate, and a plurality of half-circular baffle elements threaded in spaced relation transversely upon said core members, said baffle elements being each severed radially from the core member to their respective curved edges, the severed portions of each element being offset with respect to one another and the severed edge of one element being secured to the oppositely directed severed edge of its adjacent element, and the bases of said elements secured to the surfaces of said longitudinal plate, thereby forming a continuous substantially helical passageway within the shell from one end thereof to the other both above and below said longitudinal plate, inlet and outlet connections at one end of the shell, and means for connecting said helical passageways at the opposite end of the shell.

3. In a heat exchanger having a shell with a bundle of tubes therein, a return drum freely mounted in one end of the shell for connecting the tubes of the bundle, and a tube sheet at the opposite end of the shell for supporting the tubes, a baffle structure for the fluid in the shell comprising a longitudinal plate secured to said tube sheet and extending lengthwise of the shell and dividing the interior thereof into two semi-circular chambers, an elongated core member extending centrally lengthwise of each of said chambers, a plurality of semi-circular baffle elements perforated to receive the tubes of the tube bundle and said core member, said elements being arranged in spaced parallel relation lengthwise of each of said semi-circular chambers at an angle to the axes of the core members and having their bases secured to said longitudinal plate, each of said baffle elements being slit radially from the core member to the arcuate edge of the baffle, and the thus severed portions being offset into alignment with similar portions of adjacent baffles and secured thereto so as to form a substantially helical channel about the core member in each of said semi-circular chambers, inlet and outlet connections for the shell at one end thereof, and means for connecting said helical passageways at the opposite end of the shell so as to form a continuous fluid path through the shell, and a plurality of stay rods extending longitudinally between the baffle members and arranged in spaced relation around the periphery thereof to support the edges of said members.

4. In an apparatus of the character described, a shell having a plurality of tubes extending therethrough, a tube sheet at one end of the shell, a longitudinal baffle arranged diametrically across the shell and extending lengthwise thereof and secured at one end to the said tube sheet, a plurality of semi-circular baffle elements mounted in spaced relation upon both sides of the longitudinal baffle and secured thereto at their straight bases, a movable tube sheet at the opposite end of the shell, two core members secured to said tube sheet and extending lengthwise of the shell on the respective sides of the longitudinal baffle through central perforations in the semi-circular baffle ele-

ments, the said baffle elements being severed radially from the core member to their respective curved edges and the severed portions of each element being offset with respect to one another and the severed edge of one element being secured to the oppositely directed severed edge of its adjacent element, thereby forming continuous helical passageways within the shell on both sides of the longitudinal baffle.

In testimony whereof I affix my signature.

STANLEY J. CHUTE.