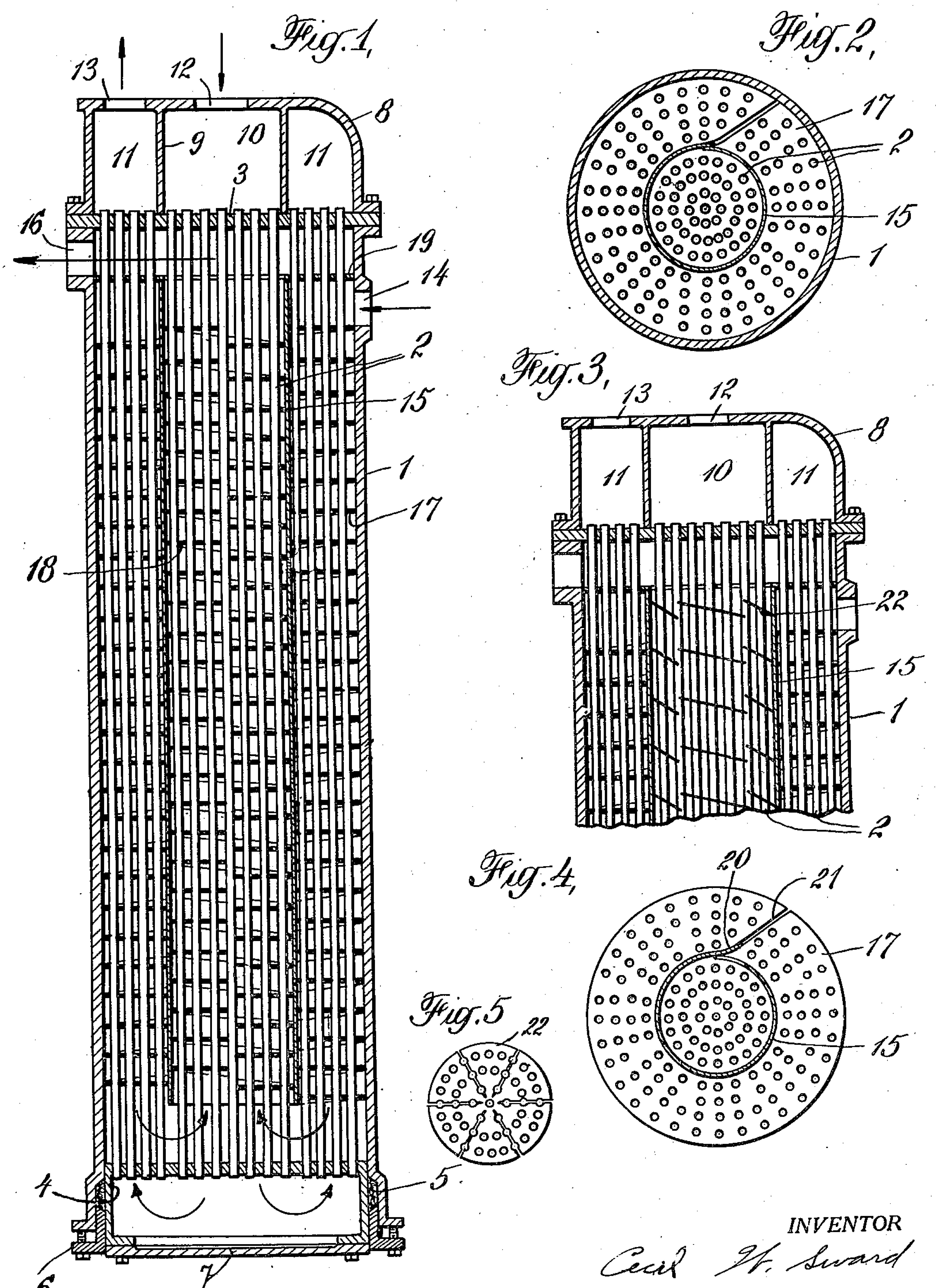
Jan. 27, 1925.

1,524,595

C. W. SWARD

HEAT EXCHANGER

Filed Sept. 18, 1922



INVENTOR

Cecil W. Sward

BY

Pennie, Davis, Marvin & Edmonds

ATTORNEY

Patented Jan. 27, 1925. **1,524,595**

UNITED STATES PATENT OFFICE.

CECIL WILLIAM SWARD, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE GRISCOM-RUSSELL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

HEAT EXCHANGER.

Application filed September 18, 1922. Serial No. 588,929.

To all whom it may concern:

Be it known that I, Cecil William Sward, a citizen of the United States, residing at Chicago, in the county of Cook, State of Illinois, have invented certain new and useful Improvements in Heat Exchangers; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to heat interchangers and has to do particularly with that type of heat interchanger in which the heat interchange fluids are both liquids, although the apparatus may be used as a condenser, or the like, if desired.

Apparatus at present employed as heat interchangers of the character referred to, usually comprises an outer shell and a plurality of metallic tubes extending through the shell. One of the heat interchanging liquids is passed from one end of the shell to the other through the metallic tubes while the other liquid is circulated about in the space within the shell so that it comes in contact with the outer walls of the tubes, the heat interchange occurring through the metal of the tubes. Suitable inlet and outlet openings are, of course, provided at the respective ends of the apparatus. One objection to apparatus of this nature is the stresses which result from expansion and contraction of the tubes and other parts with changes in temperature.

The general direction of the two liquids through the shell is usually opposite, inasmuch as by thus employing the counter current principle a better heat transfer results. For instance, if the incoming fluid is, say, a hot liquid, and the cooling liquid is passed through the shell in a direction counter to the flow of the hot liquid, the hot liquid immediately as it enters the apparatus will come into heat transferring relation with that portion of the cooling liquid which has already traversed the length of the shell and which has consequently been warmed considerably by the heat derived from the hot walls of the tubes. As the hot liquid passes on through the shell it gradually becomes cooler, but near the outlet end of the shell it is in contact with the freshly admitted cooling fluid whose temperature is relatively low. In this manner the hot fluid as it is discharged from the apparatus may be at a temperature considerably lower than that of the cooling fluid which has become heated in its passage through the shell.

It is always an aim in a heat interchanger of this general type to effect a repeated contact between the heat interchanging liquids and the heat transferring surfaces of the tubes. For this purpose baffles are generally provided to cause the fluid in the space within the shell to follow a circuitous path so that the entire volume of the fluid will be brought repeatedly into direct contact with the tube surfaces. This is particularly true when one or more of the heat interchanging fluids are viscous in character or are of such nature that their viscosity changes with changes in temperature, such as oils. It is furthermore desirable to maintain at all points as great a temperature difference between the heat interchanging fluids as is possible and also to produce as high a velocity of the fluid along the heat transferring surfaces as is practicable without unduly increasing the total pressure difference required across the apparatus to maintain a continuous flow. In order to provide for sufficiently high velocities the diameter of the apparatus is more or less restricted between certain limits. That is, according to the best theoretical conditions the apparatus is usually relatively long and slender, the diameter being greatly less than the total length of the apparatus which must be sufficient to maintain the heat interchanging liquids in heat transferring relation for such a length of time as will insure proper temperature results, and which frequently proves to be inconvenient from the standpoint of manufacture or installation.

It is an object of the present invention to provide a heat interchange apparatus particularly adapted for effecting heat transfer between two liquids in which the liquids are directed repeatedly into contact with the heat transferring surfaces so that a complete heat transfer is assured, and in which the fluid passages may be made sufficiently long to obtain the desired temperature results under all conditions without necessitating a total length of apparatus greater than the length of tubes which can be satisfactorily obtained on a commercial scale or increasing the length of the apparatus to such an extent as to render it inconvenient for installation.

It is also an object to provide a single unitary apparatus of this type in which the passages for conveying each of the heat transferring fluids are materially longer than the total length of the apparatus itself and in which there is afforded ample opportunity for expansion and contraction of the heat transferring surfaces or tubes without danger of excessively straining the parts of the apparatus, loosening the end connections of the tubes, or the like.

It is a still further object to provide a heat interchanging apparatus of the above general type in which counter flow of the heat interchanging fluids is obtained throughout and which at the same time permits of a wide variation in design as to the type of baffle which may be used for directing the flow of the liquid, and the like, whereby the apparatus is readily adaptable to the varying operating conditions encountered in practice.

In an apparatus embodying my invention one of the heat transferring liquids is preferably conveyed by means of metallic tubes extending longitudinaly of the apparatus, suitable heads being provided at the ends of the apparatus for admitting and discharging the liquid. The entire body of tubes is constructed as a single unitary bundle, and the tube ends at one extremity of the bundle are secured in a rigidly supported tube sheet while the tube ends at the other extremity of the bundle are supported in such manner as to permit of longitudinal expansion and contraction of the tubes under the influence of temperature changes and thus avoid stresses which would normally result. Although the tube bundle is thus formed as a single unit, I may nevertheless arrange a plurality of fluid circuits through the tubes of the unit. For instance, I may divide the tubes into two sections, one of which conveys fluid in one direction through the shell and the other of which conveys the fluid on its return passage in the opposite direction. The circulating liquid is contained in the space surrounding the tubes and suitable passages and guiding walls are provided to direct its flow in a circuitous fashion about the tubes so that adequate heat interchange will be insured, the general direction of flow of the cooling fluid following the flow of fluid through the passages formed by the groups of tubes but in a reverse direction so that the advantages of the counter flow method may be obtained. In this manner I am able to secure a fluid passage through the heat transferring tubes of length which is a multiple of the length of the apparatus and also a passage for the working fluid many times the length of the shell and of such nature as to repeatedly bring the entire volume of the working fluid into intimate contact with the heat transferring surfaces of the tubes.

I have illustrated a preferred embodiment of my invention in the accompanying drawings in which Figure 1 is a longitudinal sectional view illustrating an apparatus embodying my invention. Fig. 2 is a transverse sectional view of the apparatus shown in Fig. 1; Fig. 3 is a partial sectional view similar to Fig. 1 illustrating a modification; Fig. 4 is a transverse sectional view illustrating a detail of the apparatus; and Fig. 5 is a plan view of a special type of baffle.

Referring to the drawings, 1 indicates the containing shell of the apparatus, and 2 indicates the plurality of longitudinal heat transferring tubes which extend lengthwise of the shell and whose walls constitute the heat transferring surfaces of the apparatus. The upper ends of the entire group of tubes 2 are expanded or otherwise secured in a tube sheet 3 fitting upon the upper end of the shell 1. At their lower ends the tubes 2 are secured in one wall of a head or chamber 4, which chamber is of outside diameter substantially equal to the inner diameter of the shell so that the entire head 4 is free to move longitudinally of the shell under the influence of the expansion or contraction of the tubes. A ring of packing 5 and a retaining flange 6 serve to keep the joint between the head 4 and the adjacent shell walls fluid-tight. By this arrangement strains on the tubes or other parts of the apparatus due to sudden temperature changes are avoided. The head 4 may be a closed chamber fitted with a cover plate 7, as shown, in order to render it fluid-tight. It is particularly to be noted that the entire construction of the apparatus is essentially unitary in nature, and the entire group of tubes is assembled and built as a single bundle which is free to move as a unit under the influence of temperature changes.

At the upper end of the shell is a hollow head 8 having in addition to its outer walls a downwardly extending cylindrical partition or wall 9, the lower edge of which rests snugly against the upper face of the tube sheet 3 and serves to divide the upper ends of the tubes into two groups, one being the central cylindrical column of tubes opening into the chamber 10 formed within the cylindrical wall 9 and the other being the annular group of tubes surrounding the central tube column and opening at their upper ends into the annular space 11 immediately surrounding the cylindrical partition 9. An opening in the upper face of the head 8 and directly above the cylindrical chamber 10 may serve as an inlet for one of the heat transferring liquids, say, the hot liquid, and the opening 13 communicating with the annular chamber 11 may serve as the outlet for the same liquid after its passage through the shell. As the liquid enters through the inlet 12 it gathers within the chamber 10 and from thence finds its way downwardly through the central group of tubes until it is discharged into the floating head 4. This head is in communication with all of the tubes 2, so that the outflowing liquid from the central group of tubes enters the remaining tubes and, after passing up along the entire length of the shell, discharges into the annular chamber 11 and from thence through outlet 13, from whence it is conveyed away as desired. With this construction the fluid passage and consequently the length of time during which the two fluids are maintained in heat interchanging relation is twice that in a single passage apparatus having the same overall length. Furthermore, the total pressure difference required to maintain a flow through the apparatus is no greater than would be required were the same length of passage provided in a single pass type of apparatus. However, this additional length of fluid passage is obtained without increasing the length of the shell, the diameter and cross sectional area of the shell being increased to accommodate the double passage. Such increase in diameter is not undesirable inasmuch as the working pressures in installations of this type are normally very low and no difficulty will be encountered in casting a shell of sufficient strength. This is in contrast to the situation as presented when the length of the shell must be increased, for in that case the length often exceeds that of tubing which may be commercially obtained as well as exceeding convenient dimensions for installation.

The working fluid, for instance the cooling liquid, enters the shell through an inlet 14 into the space surrounding the tubes 2. For the purpose of confining the circulation of this entering liquid to the space surrounding the annular group of tubes discharging into chamber 11, a cylindrical core tube 15 is provided to incase the central group of tubes and in effect divide the space within the shell into two chambers. The lower end of the core tube 15 stops short of the bottom of the apparatus, so that the cooling liquid admitted at the opening 14 may find its way down the length of the shell and from thence up inside the core tube 15 until it is discharged at the outlet opening 16. With this situation a complete counter flow of the two heat interchanging fluids is accomplished throughout the entire length of the apparatus.

For the purpose of properly directly the flow of the working fluid into heat transferring relation with the tubes 2 the space within the shell is provided with baffles 17 and 18. These baffles may be of generally helical conformation so that the cooling liquid will be directed during its passage through the shell across the length of the heat transferring tubes and will be brought into repeated and intimate contact with them. The baffles here shown are of the general type illustrated in the patent to Russell C. Jones No. 1,335,506, and the baffle blades may be conveniently formed by stamping them out of sheet metal and so cutting them that the central portion of the sheet can be used for the baffles 18 inside the core tube 15 while the outer portion of the stamped sheet may be used to constitute the baffle 17 in the annular space adjacent the walls of the shell. Near the upper end of the shell is a perforated annular disc 19 which fits snugly over tubes 2 and is of such dimensions as to fit snugly within the interior of the shell 1. The perforations in the disc 19 are so arranged as to block off the space between the tubes constituting the outer annular group, with the result that the liquid entering the annular space through the inlet 14 will not be permitted to rise into that part of the shell above the disc 19. After descending to the bottom of the shell and again ascending the central core tube 15 the liquid may find its way through the central opening provided in the disc 19 so that it may enter the space above the disc and be discharged at the outlet 16.

I have shown a slightly different modification in Fig. 3 in which the continuous helical baffle is provided only in the annular space surrounding the central core tube 15. Within the core tube I have provided a baffle consisting of a plurality of elements each having a number of radial blades or vanes so that the liquid in passing through the space surrounding the tubes impinges upon co-adjacent blades or vanes and is thus kept in thorough agitation and is brought repeatedly into contact with the heat transferring surfaces of the tubes. This particular type of baffle is disclosed in co-pending application of Russell C. Jones, Serial No. 449,678, assigned to the company which is assignee of the present application. With this type of baffle the liquid is directed in a circuitous path through the length of the apparatus and in addition is maintained in thorough agitation. It is to be understood that the specific types of baffles shown need not be employed, it being possible to utilize any desired system of baffling which will direct the working fluid in such manner as to effect an efficient heat interchange. For instance, the baffle may consist of a series of horizontally positioned baffle elements whose alternate blades extend out from opposite sides of the retaining shell or tube so that the liquid in passing along the length of the shell will be directed in a circuitous path around the ends of the successive baffle blades. Baffle blades of all descriptions may even be omitted under certain conditions, if desired, and the liquid allowed to flow longitudinally along the tubes. Furthermore, the space surrounding the annular group of tubes may be equipped with a baffle similar to that shown within the core tube in Fig. 3, or the structure of Fig. 3 may be reversed so that the helical baffle is within the core tube and the horizontally positioned baffle sheets are placed in the annular chamber surrounding the central core. In general, any appropriate system of baffles may be employed. The central core tube 15 may simply be a continuous sheet of metal, but for the purpose of removal I prefer to constitute it as shown in Fig. 4 of a longitudinally split cylinder having its free end 20 engaging in slots 21 provided in the baffle sheets so that when it is desired to remove the central tube for cleaning or other purposes it may be fed out through the slots 21 in the baffles to the outside of the tube bundle. This operation is, of course, performed after the tube bundle is removed from its shell.

My invention does not contemplate broadly the provision of a heat interchange in which the heat interchange fluids are passed twice along the length of the shell, nor is it strictly confined to the provision of any particular type of baffle construction. The invention resides primarily in the particular construction illustrated and described, whereby the advantages of freedom from strains due to temperature changes, and the like, are obtained, yet in which fluid passages of great length relative to the length of the shell, as well as other advantages, are obtained. The scope of the invention is defined in the appended claims.

I claim:

1. Apparatus of the class described, comprising tubes for conveying one of the heat interchange fluids, said tubes being divided into a centrally disposed group for conveying fluid in one direction and a surrounding group of annular conformation for conveying fluid in the opposite direction, a shell surrounding said tubes for containing the other heat interchange fluid, a cylindrical core tube surrounding said centrally disposed group of tubes for dividing the space within the shell into two portions, said core tube consisting of a sheet of flexible material wound into substantially cylindrical form and adapted to be unwound upon disassembling of the apparatus, and means disposed within said respective portions for bringing the fluid therein into intimate heat transferring relation with said tubes.

2. Apparatus of the class described, comprising tubes for conveying one of the heat interchange fluids, said tubes being divided into a centrally disposed group for conveying fluid in one direction and a surrounding group of annular conformation for conveying fluid in the opposite direction, a shell surrounding said tubes for containing the other heat interchange fluid, a cylindrical core tube surrounding said centrally disposed group of tubes for dividing the space within the shell into two portions, said core tube consisting of a sheet of flexible material wound into substantially cylindrical form and adapted to be unwound upon withdrawal and baffles disposed within said respective portions for directing the fluid in a circuitous path across the tubes of one of said groups throughout the length of the shell and returning it similarly along the other of said groups of tubes on its return passage through the shell, said baffles being provided with slots thru which said sheet of flexible material passes upon disassembling of the apparatus.

3. Apparatus of the class described, comprising tubes for conveying one of the heat interchange fluids, said tubes being divided into a centrally disposed group for conveying fluid in one direction and a surrounding group of annular conformation for conveying fluid in the opposite direction, a shell surrounding said tubes for containing the other heat interchange fluid, a cylindrical core tube surrounding said centrally disposed group of tubes for dividing the space within the shell into an inner cylindrical portion and an outer annular portion, and baffles disposed within said respective portions for directing the fluid therein in a substantially continuous helical path across the tubes of one of said groups, and then passing it similarly across the tubes of the other group, said baffles comprising a plurality of independent cooperating units arranged one above the other in the shell, each of said baffle units in the outer annular portion of the space within the shell and the corresponding baffle unit arranged at the same height in the inner cylindrical portion of the space within the shell constituting a single disc of material of diameter equal to the inner diameter of the shell, said disc being cut to admit said central core tube and having portions deformed to constitute the baffle units.

4. Apparatus of the class described, comprising tubes for conveying one of the heat interchanging fluids, said tubes being divided into a centrally disposed group for conveying fluid in one direction and a surrounding group of annular conformation for conveying fluid in the opposite direction, a shell surrounding said tubes for containing the other heat interchange fluid, a transversely disposed disc adapted to fit around said tubes and block the spaces between the tubes of said annular group, a cylindrical core tube surrounding said centrally dis-

posed group of tubes for dividing the space within the shell into two portions, an inlet for admitting fluid to the portions surrounding said annular group of tubes at a point farther from the end of the shell than said disc, whereby the space above said disc constitutes a chamber in communication with the space within said cylindrical core tube for receiving fluid issuing from said space.

In testimony whereof I affix my signature.

CECIL WILLIAM SWARD