HEAT EXCHANGER

Original Filed March 10, 1934 2 Sheets-Sheet 1

Fig. 1

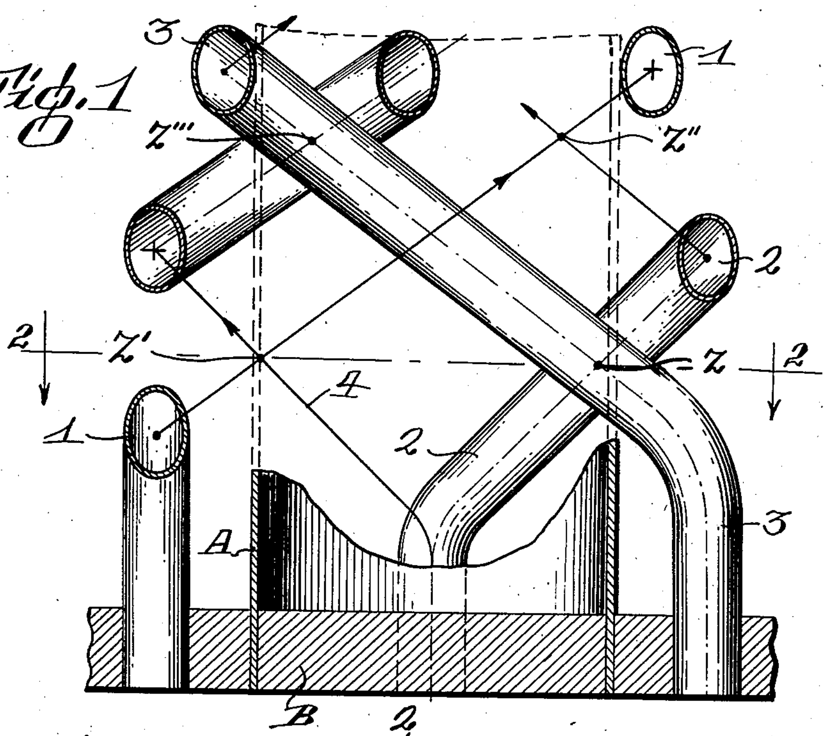
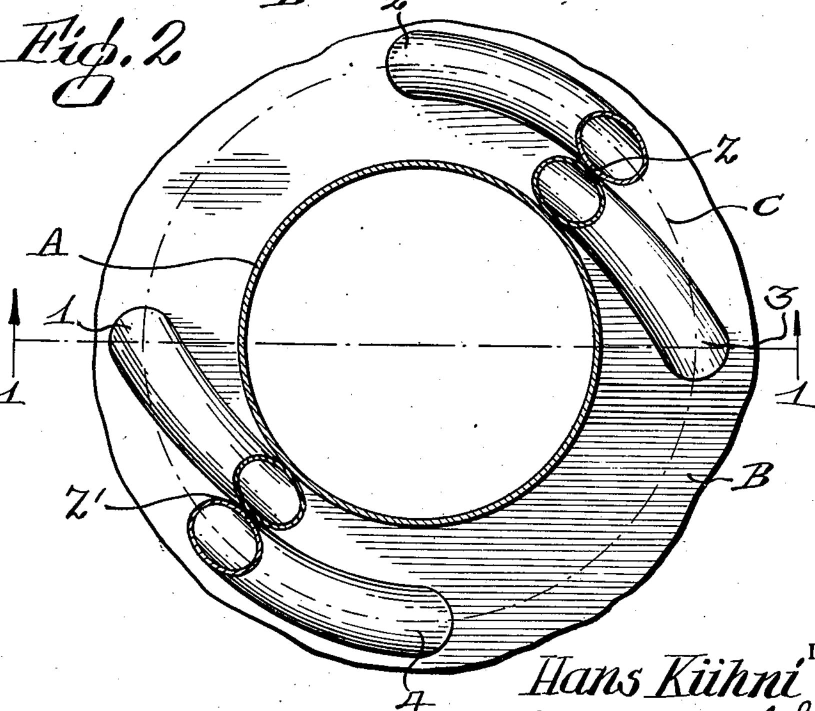


Fig. 2



Hans Kühni, Inventor

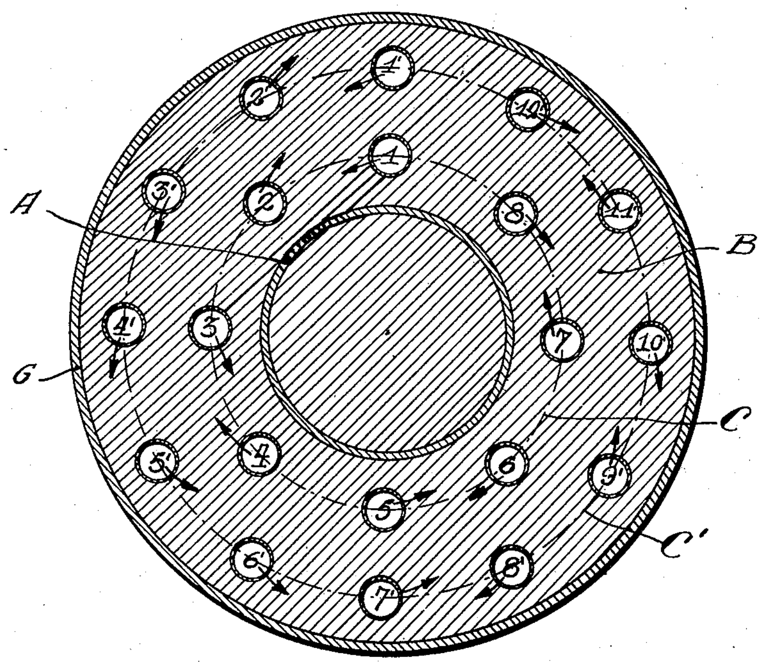
By Raymond A. Robic, Attorney

May 18, 1937. H. KÜHNI 2,081,043

HEAT EXCHANGER

Original Filed March 10, 1934 2 Sheets-Sheet 2

Fig. 3



Hans Kühni Inventor

By Raymond A. Robic Attorney

Patented May 18, 1937

2,081,043

UNITED STATES PATENT OFFICE

2,081,043

HEAT EXCHANGER

Hans Kühni, Basel, Switzerland, assignor to l'Air Liquide, Societe Anonyme pour l'Etude & l'Exploitation des Procedes Georges Claude, Paris, France

Application March 10, 1934, Serial No. 714,967. Renewed October 12, 1936. In Great Britain March 13, 1933

6 Claims. (Cl. 257—229)

The present invention relates to a heat exchanger for fluids in which one of the fluids passes in parallel streams through the tubes of concentric layers of helically wound tubes that are placed in a casing, whilst the other fluid passes through the casing outside the said tubes, for example, in the opposite direction to the first fluid. It is known that it is advantageous to create in the fluids eddies or whirls which favour the thermal exchange between them.

To this end in the exchanger according to the present invention the innermost layer is wound in one direction, say left-hand, and the next layer is wound in the opposite direction (right-hand), the third layer is wound in the same direction as the first and so on. The tubes of each layer touching those of the adjacent layers, or adjacent layer in the cases of the first and last layers, at the points of meeting of their windings. As for the innermost (central) layer No. 1, it can be supported on a cylindrical core placed in the axis of the exchanger; no fluid passes inside this core.

The ends of the tubes of the different layers are, as usual, fixed in tube-plates and may be arranged in a circle for each layer. The ends of the tubes of layers No. 1 and No. 2 may also be fixed in the same circle and then the ends of the layers No. 3 and No. 4 in another common circle, in which case the ends of the tubes of the layer 1 alternate in place on the circle with the ends of the tubes of the layer 2, similarly for layers 3 and 4 and so on.

The accompanying drawings show diagrammatically and by way of example the principle of construction of a vertical exchanger according to the present invention. Figure 2 is a plan view of a part of the lower terminal tube-plate, Figure 1 is a partial section on a plane passing through the line 1—1 of Figure 2, and Figure 3 is a transverse section of the exchanger at the tube plate. Figs. 1 and 2 show only some of the tubes in the innermost circle of tubes.

A denotes the inner-core or axial tube which connects the two parallel tube-plates in which the ends of the tubes are fixed. B (Figure 1) denotes the lower one of these plates, part of which is shown by Figure 2. C indicates the common circle in which are fixed the ends of the first and second of innermost layers. In order to facilitate the description, it will be supposed that the first layer is composed only of two tubes 1 and 3 and the second layer similarly composed of two tubes 2 and 4 and there has only been shown in Figure 1 the commencement of the tubes as seen when, viewed from the front of the plane 1—1, the exchanger is seen with the core A partially removed. The course of each of the tubes is indicated by an arrowed line when it is in front of the plane 1—1; again, in accordance with a system of representation employed in electricity for windings, the centre of each section of tube cut by the plane 1—1 has a point allotted to it when the tube passes to the front of the said plane, and by a cross allotted to it when it passes behind the same plane.

In Figure 2 there is indicated only the first circle C of the four tubes 1, 3—2, 4 and the horizontal projection of these tubes has been shown only up to the first crossing of 1 with 4 and of 3 with 2.

The construction of the exchanger is as follows:— the tubes 1 and 3 forming the first (innermost) layer are coiled in the same direction around the core A so as to form two helices; the winding is effected, for example, as shown, from right to left (Figure 2). Thus the tube 3 rises out of the plate B, passes from the right to the left—that is behind the plane 1—1—and continues until it again cuts this plane at the end of a half turn, the projection of this half turn being shown on Figure 1, the tube then passes in front of the plane. The tube 1 rises in the same way, but first of all passes in front of the plane 1—1 and then returns to the back of this plane at the end of a half turn, the projection of this half-turn being diagrammatically indicated on Figure 1 by an arrowed line.

The tubes 1 and 3 being thus coiled and fixed into the tube-plates the tubes 2 and 4 are mounted by winding them round the helices formed by the tubes 1 and 3 along other helices which are parallel to each other and are of the same pitch as the tubes 1 and 3, but in the opposite direction, so as to create round the core A two superposed concentric crossing layers of helicoidal tubes. Consequently, the tube 2 first of all meets the tube 3 at Z and then meets the tube 1 at Z'', whilst the tube 4 meets the tube 1 at Z' and the tube 3 at Z''' and so on until the top tube-plate is reached in which the two tubes 2, 4 are fixed.

Under these conditions, by arranging on the same circle C several series of tubes alternately odd (1, 3) and even (2, 4) and disposing similarly on a larger circle C', distant from circle C by double the diameter of a tube, further series of tubes alternately odd and even, the next series of odd tubes being wound on the external surface of tubes 2—4 and the next series of even tubes being wound on the external surface of the preceding odd tubes and so on, so that there are produced a number of helicoidal layers which are superposed one on the other but the helices of which are successively in the opposite sense to each other.

In the working of the exchanger the fluid passing along the external surface of the tubes is divided by these numerous tubes placed close one to another into a plurality of streams which flow parallel to the two series of helices and which, at the points of contact of the tubes Z′, Z″ and Z, Z‴ meet one another and thus create eddies and whirls which facilitate the exchange of heat between the fluids passing inside and outside the tubes.

Inasmuch as the ends of the tubes are disposed in a common circle on the tube plates, it is advantageous to use a number of said tubes the ratio of which, to the radius of the said circle, is a constant for the successive circles. As previously noted, the meeting points of tubes have been given a reference character Z; such a meeting or contact point, for example Z′, occurs for successive layers of tubes on a same line and at right angles to the central core axis (see line extended between points Z′Z in Fig. 2). Consequently, the tubes can be arranged to meet at definite points, to create eddies as defined before, these contacting areas being further supported by the central core to impart rigidity to the system.

The above will be illustrated on referring to Figure 3 wherein a horizontal section through the lower tubular plate of the exchanger is schematically depicted. The exchanger shown comprises four superposed layers of tubes spirally wound, the reference character B showing the tube plate, A the tube constituting the central core, around which the first layer is wound, as from the axis of the exchanger, G is the outside casing or envelope of the exchanger. The extremities of the tubes connected to the tube plate are distributed according to concentric circles C and C′: the tubes 1, 3, 5, 7 issue from the circle C and, upon winding on the core A, constitute a first layer of spiral tubes wound from right to left when seen at the axis and as shown by the arrow of Figure 3. The tubes 2, 4, 6, 8 also issue from circle C and winding over the first layer of tubes, constitute a second layer thereof, the winding of which is in a reverse direction to that of the first layer, as shown by the other arrow of Figure 3. A third layer of tube is constituted by tubes 1′, 3′, 5′, 7′, 9′, 11′, starting from the circle C′ and the winding is reverse to that of the tubes of the second layer and, finally, the fourth layer is constituted by the tubes 2′, 4′, 6′, 8′, 10′, 12′, also issuing from circle C′ and wound in a direction reverse to that of the tube of the third layer. Thus, it will be seen that the ratio of the number of tubes on the circle C to the radius of this circle is equal to the ratio of the number of tubes on the circle C′ to the radius of this last circle.

On the other hand, it is advantageous to have all the lengths of the tubes from which the coils are formed as nearly equal as possible, so that the drop of pressure of the fluid passing through each tube will be nearly the same for all the tubes and that therefore this fluid will pass in the same quantity through all the tubes; for this purpose the pitch of the windings of the different layers is so much the greater as the respective layer is far from the axis of the heat exchanger.

A further improvement to the present heat exchanger is accomplished during its construction by pressing each tube of each layer against the tubes of the next inner layer at the places where the said tube touches the tubes of the said layer, with a sufficient strength as to force back at those places towards the interior of the tube the metal of said tube which is for example made of copper more or less annealed.

By referring to the apparatus shown in the drawings, this can be executed at the time of winding a tube on a layer already in place, by pulling said tube towards the interior of the layer so as to crush more or less deeply the metal of the tube at the places where it touches the tubes of the layer.

The driving or forcing back thus obtained of the metal at certain places of the tube results in lessening the section of said tube at those places and this improves, as is well known, the transmission of heat between the fluid passing through the interior of the tube and the fluid passing over the exterior on account of the succession of drops in pressure which is produced in the flow of the fluid in the tube.

The present exchanger especially enables a very thorough exchange of heat to be obtained between two fluids—*e. g.*, between two gases or vapours.

I claim:

1. In a heat exchanger a casing, a core concentrically mounted in said casing, helically wound tubes arranged inside the casing in layers the successive layers being wound in opposite directions and their tubes touching one another at the points of meeting of their opposite windings.

2. Heat exchanger according to claim 1, in which the innermost layer of tubes is wound round a cylindrical core through which no fluid passes.

3. In a heat exchanger, a casing for one of the fluids, helically wound tubes arranged inside the casing in concentric circles on tube plates, the odd tubes on each circle being wound in one direction and the even tubes on same circle being wound in the opposite direction, said tubes touching one another at the points of meeting of their opposite windings and similarly touching the tubes of the immediately next layers.

4. In apparatus for heat exchange between fluids, a casing adapted to hold one fluid, and helically wound tubes disposed in concentric circles inside said casing and within which another fluid circulates in parallel streams, odd tubes of each circle being wound in one direction while even tubes run in opposite directions, said tubes contacting at the meeting points of opposite windings and with tubes of immediately next layers, the ratio of the number of tubes to the radius of said tube ends circle is constant for all circles of tubes.

5. Apparatus as claimed in claim 4, wherein the individual pitch of the tube windings varies in direct ratio to the spacing of each winding from the axis of the casing.

6. Apparatus as claimed in claim 4, wherein the tubes are flattened at the contacting points thereof.

HANS KÜHNI.