METHOD OF MAKING HEAT EXCHANGERS


Application July 7, 1938, Serial No. 217,532
In Sweden December 16, 1932

4 Claims. (Cl. 113—118)

This application is a continuation-in-part with respect to my co-pending application Serial No. 739,832, filed June 15, 1934, and as to common subject matter embodies subject matter divided therefrom.

The present invention relates to heat exchange and has particular reference to spiral heat exchangers and methods of manufacture thereof.

Spiral heat exchangers of the kind to which the present invention relates are constructed of plate structures curved to provide adjacent and uni-directionally spirally curved channels through which fluid media are adapted to flow in heat exchange relation and out of direct contact with each other.

In order to provide for highly efficient heat transfer and low mechanical loss due to the power required to cause flow of the heat exchange fluids through the apparatus, it is important for the channels to have uniformity of cross-sectional area through the path of flow of the fluids. It is further important in heat exchange apparatus of this kind which is intended for use with fluids which may contain substantial quantities of impurities, that the construction be such as to cause minimum deposition and accumulation of such impurities in the fluid channels. Also, the construction should be such as to permit ready removable of accumulated impurities by any suitable mechanical cleaning operations, this latter requirement, if it is to be fulfilled, making it necessary for the construction to be such as to render the interior portions of the fluid channels readily accessible for cleaning tools and the like from the exterior of the apparatus.

In many instances the desired rate of heat exchange per unit area of surface is such as to make substantially necessary the employment of relatively very thin sheet metal to form the walls of the channels. Such metal has, of course, relatively little resistance to distortion due to difference in internal fluid pressure as between different channels and where very thin walls are used, bracing is required to positively space adjacent walls from each other if undesired distortion and resultant change in cross-sectional area of the channels is to be avoided.

The general object of the present invention is to provide improved heat exchange structure and methods of manufacture thereof which will result in most advantageously and economically meeting the various requirements for heat exchange structures of the type under consideration, some of which requirements have been briefly outlined above. Other and more detailed objects of the invention, the manner in which they are attained, and the advantages to be derived from use of the invention, will all be more clearly apparent from a consideration of the ensuing portion of this specification in which typical apparatus embodying the invention is described by way of example, taken in conjunction with the accompanying drawing illustrative of such apparatus.

In the drawing:

Fig. 1 is a transverse section of a heat exchanger constructed in accordance with the present invention;

Fig. 2 is a longitudinal section taken on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary section on much larger scale of one form of end sealing construction applicable to a heat exchanger of the kind shown in Figs. 1 and 2.

Fig. 4 is a fragmentary transverse section taken on line 4—4 of Fig. 5 illustrating an intermediate stage of manufacture in accordance with the present invention;

Fig. 5 is a longitudinal section of the structure shown in Fig. 6;

Fig. 6 is a developed view showing an arrangement of spaces in accordance with the invention;

Fig. 7 is a view similar to Fig. 6 showing another arrangement; and

Fig. 8 is a fragmentary view showing another form of spacing means.

Referring now more particularly to Figs. 1 and 2 of the drawing, the exchanger illustrated comprises two spirally bent plates 16 and 12 forming between them unidirectionally spirally curved adjacent channels 16 and 18. The inner ends of plates 10 and 12, in the embodiment illustrated, are joined by means of a transverse plate 10 forming a central longitudinally extending partition. As shown, the plates are welded to the side edges of this partition but it will be evident that plates 10 and 12 may if desired be formed from one continuous length of plate material, the central portion of which is bent to form the desired transverse central partition 18. The central partition 18 provides at either side thereof of a chamber extending longitudinally of the structure, the chamber 20 on one side communicating with the spiral channel 14 and the chamber 22 on the other side communicating with the spiral channel 16. Chambers 20 and 22 communicate at their ends, and pref-
erably at their respectively opposite ends, with external connections 24 and 26, for the admission to or outflow of fluid from the channels. At the outer periphery of the apparatus the spiral channels communicate respectively with external connections 28 and 30, also adapted to either admit or discharge fluids from the apparatus. The fluids are preferably passed through the apparatus in counter flow relation, the peripheral connection for one channel constituting an inlet with the peripheral connection for the other channel constituting an outlet and with one of the axially central connections constituting an inlet while the other constitutes an outlet. The ends of the channels 20 and 22 are closed by suitable end plates 32 and 34 at one end of the apparatus and similar plates 36 and 38 at the opposite ends of the apparatus. It will be understood that the desired ones of these end plates will be suitably apertured to provide for the end connections 24 and 26, one of such apertures 40 appearing in Figs. 4 and 5.

For closing the ends of the spiral channels, various different specific arrangements may be resorted to. Depending upon the relative amount and character of impurities carried by either one or both of the fluids to be passed through the heat exchanger, the channels may be closed by their edges by removable closure means for both spiral edge portions of both channels or at only one edge portion of one or both channels. In the latter case it will be understood that the remaining edge portions of the channels are closed by permanent closure means. For convenience of illustration, the exchanger illustrated is of the type in which the axial edge portions of both channels at both ends of the apparatus are adapted to be closed by removable end cover structures which may advantageously be of the kind illustrated on enlarged scale in Fig. 3. With this type of structure a plurality of rigid spiral closure strips 42 are attached to a series of radially extending clamping bars 44 which at their ends are secured, as by means of bolts 46, to suitable brackets 48 fixed to the outer peripheral wall of the exchanger. It will be understood that the curvature of the strips 42 conforms to the curvature of the spiral openings at the edges of the channels, and these spiral strips may advantageously be tapered as shown in Fig. 3 for ease of entrance into the edge portions of the channels. Axially inwardly of the strips 42, the spiral channels may advantageously be provided with seals against fluid leakage, which seals may be in the form of strips 50 of flexible material, of suitable nature in view of the fluids to be passed through the exchanger. As illustrated, the sealing strips may advantageously be U-shaped in cross-section so as to tend to be forced against the channel walls by internal fluid pressure to provide a fluid tight seal.

Obviously, the specific nature of the removable edge sealing means may be wide varied, but in accordance with one phase of the present invention it is to be noted that the rigid strips 42 act as spacing members for rigidly holding the spiral wall plates in radially fixed position relative to each other.

In addition to the spacing of the wall plates effected by the spiral strips 42, the plates are further maintained in desired radially spaced relationship and braced against distortion due to differential internal pressure between the adjacent channels by means of fixed spacing means which in accordance with the invention is constituted of a plurality of small spacing members which advantageously are in the form of separate distance pieces rigidly fixed, at least at one end, to the plate structure. Advantageously, these distance pieces may be of the general form indicated at 52 in Figs. 4 and 5, each welded at one of its ends to one of the spiral plates as indicated by welds 54.

The specific arrangement of the distance pieces 52 on the plates may be varied as indicated in the developed views of Figs. 6 and 7, but it is particularly to be noted that in accordance with the present invention these distance pieces are confined in their location to the axially central portion or zone of the channels, indicated at a, in order to leave the edge portions or zones b of at least those of the channels which are closed by removable spiral strips, free from any fixed obstruction. Preferably, all of the spaced distance pieces are confined to the central portions or zones of the channels.

Instead of employing separate distance pieces welded to the plate structure, the plates may in some instances be indented to provide spacing members 52' integral with the plates as illustrated in Fig. 8. The location of these spacing members 52' is, in accordance with the invention, governed by the same principles as those governing the location of the spacing members which are in the form of separate distance pieces as shown at 52. The spacing members 52' have, like the separate distance pieces 52, small lateral dimensions, particularly in the lateral direction transverse with respect to the direction of fluid flow through the channel.

In constructing a heat exchanger in accordance with the present invention, the plates 10 and 12 are secured, as by welding, to the central partition plate if a separate plate is employed, or if a continuous sheet is employed, the sheet is bent to provide a central transverse partition. The portions of the plates adjacent to the central partition are then bent around the end plates 32-36, which plates, as appears more clearly from Fig. 3, project respectively as at 32a and 34a somewhat beyond the longitudinal edges of the central partition at the opposite sides thereof. The projecting portions of these end plates serve to space the respective spiral walls from each other to form the desired spiral channels. The plates 10 and 12 are then progressively bent around each other but before this bending operation is performed the fixed spacing members are provided on the plates. Preferably the spacing members for one channel are provided on one plate and the spacing members for the other channel are provided on the other plate. It will be understood, however, that the spacing members for both channels may alternatively be provided on one of the plates, on the opposite surfaces thereof, the remaining plate not being provided with any fixed distance members.

Particularly when forming an exchanger of very thin metal, great care must be exercised in shaping the plates to their spiral form in order to prevent their being distorted during the fabricating operation and to avoid forming channels of varying cross-section due to such distortion. Preferably, in accordance with the present invention, the plates, provided with the fixing spacing members distributed over their axially central portion, are bent around spiral forming members 56 which serve as rigid guides between the portions of the plates at each end of the apparatus for bending them to smoothly curved form.
Even with such spiral members between the edge portions of the plates, the intermediate portions of plates of thin material may tend to distort from smooth curved form during the bending operation, and experience in practical manufacture with thin plate structures has shown that if the height of the fixed spacing members centrally of the structure is the same as that of the spiral forming members, the fixed spacing members may in some instances produce dents or local distortions in the plates. In accordance with one phase of the present method, this difficulty is overcome by making the height of the spiral forming members, which act as the primary bending guides, slightly greater than that of the intermediate fixed spacing members. This difference in height is very small, preferably being less in proportion to the depth of the channels than shown on the accompanying drawing, in which the difference in height has been exaggerated somewhat, proportionally, for the sake of clearness in the drawing.

As will be clearly evident from Figs. 4 and 5, the difference in height between the spiral end pieces and the distance pieces 88 provides a very small clearance c between one member of each distance piece and the adjacent plate, which clearance is sufficient to insure prevention of the distance piece from denting the plate as the plates are bent into shape.

Apparatus of the character under consideration is ordinarily subjected to variations in temperature in normal operation and the difference between the temperature of the apparatus under normal working conditions and when the apparatus is not in use is frequently of substantial value. These temperature differences naturally result in expansion and contraction of the parts and by having the spacing members rigidly fixed to the plate structure at only one of their ends so that a certain freedom of movement is permitted between the free ends of the distance pieces and the plate structure, the structure as a whole is relieved of internal stress caused by expansion and contraction which stress might be sufficient to be of a damaging nature. This freedom of relative movement of various parts of the internal structure relative to each other is also aided in a desirable fashion by the provision on the slight clearance between the distance pieces and the plates if this clearance is maintained after fabrication is completed.

In order to accomplish the principal object of the clearance provided during the fabrication, it is not essential that this clearance be maintained in the completed structure, since experience has shown that if the spiral forming members are withdrawn after the bending operation has been completed, the completed spiral structure may thereafter be subjected to a slight additional torque of a nature causing the bent plates to wrap themselves firmly against the distance pieces, and that this additional wrapping of the structure to take up the clearance can be accomplished without causing the distance pieces to dent the plate structure. The reason for this will be readily apparent since when this method of procedure is followed, the distance pieces come into contact with the plates only after the plates have been shaped to their proper form and the distance pieces do not act as fulcrum points around which plates are bent from their original plane state to their spiral shape.

As previously pointed out, some of the edges of the spiral channels may in some instances be permanently closed, as for example, when it is known that the exchanger is to be utilized to effect heat exchange between fluids at least one of which is clean, for instance, steam, when heated water is heated by a vapor which does not carry impurities. In such instances, one or more of the spiral forming members 88 used as guides for bending the spiral plates may be retained in their organization and permanently fixed to the plates as by welding, such members being used in conjunction with the removable strips 42 providing access to those channels which in normal service would require periodic cleaning.

In a spiral heat exchanger of the type to which the present invention relates, the spiral flow of the fluids results in the application of centrifugal force to any impurities carried thereby, tending to cause the impurities to concentrate in the outer portions of the channels. Consequently, in this type of device, cleaning of the channels when certain types of impurities are carried by the fluid or fluids is highly important. Any deposits of impurities will obviously adversely affect the heat transfer per unit area of the apparatus, and since in most applications the apparatus may be placed with the longitudinal axis in a vertical position, it is highly important that the edge zones, particularly the lower or bottom edge zone of a channel carrying a fluid with a high percentage of impurities, be readily accessible and free from obstruction in order to permit both rapid and effective cleaning. This is accomplished in the present structure by confining the distance pieces to the axially central zone of the apparatus so that when such spiral end strips as may be made removable are removed, the adjacent end zone is free from any fixed obstruction and through this free and unobstructed end zone comparatively ready access is obtained for cleaning not only such adjacent end zone but also the central zone in which the spacing members are located, where this central zone is further more readily cleanable because of its relative small area as compared with the total area of the channel.

Where fluids carrying impurities are passed through the apparatus, it is further obviously desirable to reduce as far as possible the deposition and adhesion of such impurities to the surfaces of the plates and the distance pieces contribute to this end by introducing a certain amount of disturbance or turbulence in the flow of fluid, sufficient to break up the so-called "lazing" of the fluid which if undisturbed would tend to increase the rapidity of deposit of impurities and which would further tend to reduce the rate of heat transfer through the spiral walls as compared with that effected by slightly turbulent flow operating to bring different portions of the fluid body into direct contact with the walls of the channels. With spacing members having small lateral dimensions, particularly transverse to the direction of flow through the channels, sufficient turbulence to break up the undesirable lazing of the fluids may be effected without introducing sufficient resistance to flow of fluid to materially increase the pressure drop through the apparatus due to such resistance.

While for purposes of illustrating the invention, only one kind of spiral heat exchanger organization has been shown by way of example, it will be evident that the principles of the invention are equally applicable to other kinds of spiral exchangers in which fluids are passed
through the apparatus in different flow relation from that illustrated, and that many changes in detail of design and arrangement may be made within the scope of the invention as defined by the appended claims.

What is claimed is:

1. In the manufacture of spiral heat exchangers, that improvement which consists in providing spacing members on a plate section at spaced places distributed through the axially central zone of the section and thereafter bending said section and another plate section around spiral forming members located between the edge portions of the sections, whereby to form spiral convolutions having a spiral channel therebetween in which said spacing members are located, the height of said spiral forming members being slightly greater than the height of said spacing members whereby to insure sufficient clearance between the ends of the spacing members and the adjacent plate section to prevent distortion of the plate sections as they are bent because of bending contact with the ends of the spacing members during the forming operation.

2. In the manufacture of spiral heat exchangers, that improvement which includes the steps of welding distance pieces having small lateral dimensions at spaced places distributed over the axially central zone of a plate section and thereafter bending said plate section and another plate section over spiral forming members located between the edges of the plate sections to form from said sections adjacent spiral convolutions providing a spiral channel therebetween, said spiral forming members having slightly greater height than said distance pieces whereby to prevent the distance pieces from distorting the plate sections during the bending operation.

3. In the manufacture of a spiral heat exchanger, that improvement which includes the steps of welding distance pieces having small lateral dimensions to the axially central zone of one surface of each of two plate sections, thereafter bending said sections around spiral shaping members located between the edges of the adjacent plate sections to form from said sections spiral convolutions having spiral channels therebetween with said distance pieces located in said channels, the height of said forming members being somewhat greater than the height of said distance piece to prevent distortion of the plate section by the distance pieces during the bending operation.

4. In the manufacture of spiral heat exchangers, that improvement which includes the steps of providing a plate section with a plurality of spacing members located in the axially central zone of the section, bending said section and another plate section over spiral forming members located between the edge portions of the sections to form from said sections spiral convolutions having a spiral channel therebetween in which said spacing members are located, said spiral forming members having somewhat greater height than said spacing members whereby to provide a slight clearance between the tops of the spacing members and the adjacent plate as the plates are bent, removing the spiral forming members from between the edge portions of the plate sections after they have been bent substantially to final shape and thereafter subjecting the spiral plates to torque to induce a final wrapping action of the plates relative to each other to eliminate the clearance between the tops of the spacing members and the adjacent plate.

CURT FREDRIK ROSENBLÅD.