Dec. 23, 1941. S. G. STRÖM 2,267,619

METHOD OF MANUFACTURING PLATE HEAT EXCHANGERS

Filed June 22, 1938

FIG. 2.

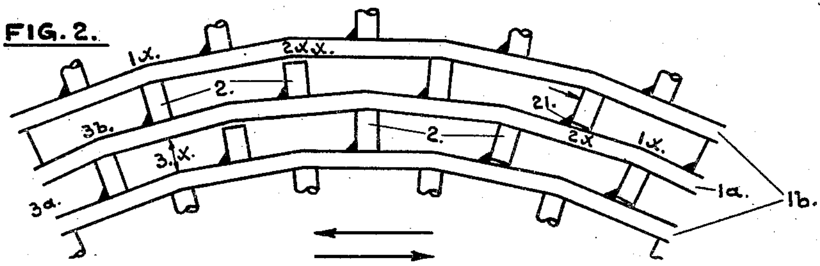


FIG. 4.

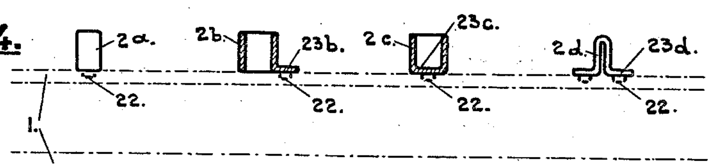


FIG. 5.

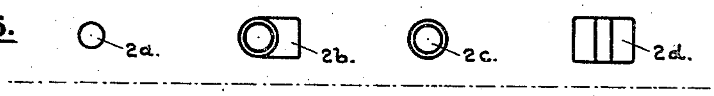
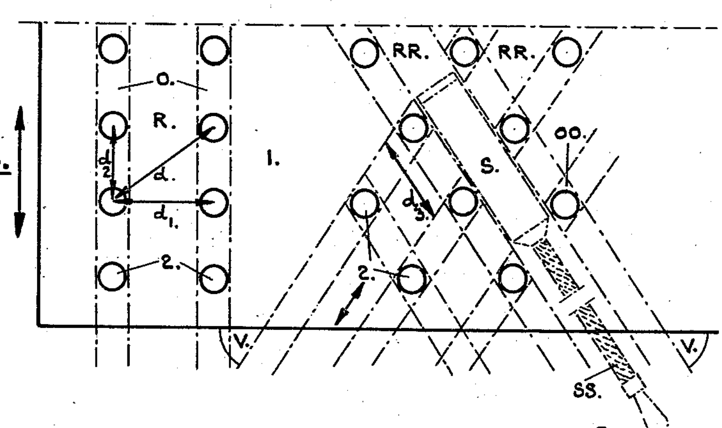


FIG. 3.



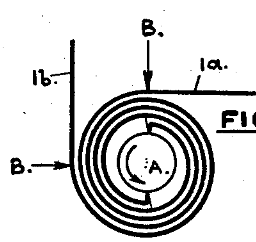


FIG. 6.

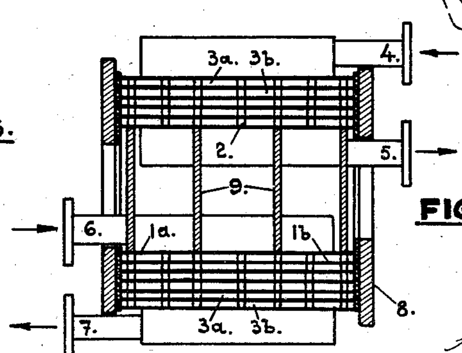


FIG. 1.

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METHOD OF MANUFACTURING PLATE HEAT EXCHANGERS

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2 Claims. (Cl. 29—157.3)

This invention refers to plate heat exchangers for indirect heat transfer between fluids in flow and more particularly to such apparatus of the spiral or a similar type having convolute heat transmitting walls made of sheet metal and in which the wall surfaces extend adjacent and substantially parallel to each other so as to form between them separate channels of a corresponding shape for the different media at opposite sides of a wall, including also small rigid spacing members inserted across the channels for fixing their width and supporting the convolute walls.

Conveniently, this kind of apparatus is manufactured by rolling up pieces of sheet metal simultaneously, one around the other, to a suitable convolute shape, and providing means to keep them spaced apart at the desired distance during the manufacturing process as well as in the completed structure. According to the known methods, the force required for bending the wall plates is obtained by rotating the inner plate ends and guiding the flat plate parts which are to be rolled up through a brake device exerting a sufficient pressure on both sides of the plates. For spacing purposes during the manufacturing there has earlier been used metal strips or the like which are inserted and rolled in between the wall plates at their face edges and afterwards removed, if not needed to close the face ends of the intermediate channel spaces, as may sometimes be the case, or else possibly replaced by a more suitable design. Under all circumstances the completed apparatus must generally have additional spacing means arranged in the central portions of the channels and those which have been found most practical consist of small rigid distance pieces being secured, for instance by means of common welding, at least to one wall of a channel so as to support the opposite one and thus fix the channel width. Such distance pieces may be assembled with the wall plates either before or during the winding process, but anyway it has been impossible to omit the edge strips which serve the important object of imparting a smooth and uniform shape to the wall plates and preventing the same from being creased sharply over the distance pieces as would otherwise occur when using the preferred and cheap winding method. This is due to the fact that the small spacers are disposed with a comparatively long pitch between each other which pitch is determined so that they will be just about sufficient for the spacing duty, and it is obvious that the consequences will be those stated. The kind of apparatus referred to is disclosed, for instance, in the U. S. Patent No. 1,930,879 or 2,060,440 and the co-pending applications Ser. Nos. 15,844 and 79,423.

Thus, it has so far been found most advantageous to use removable edge spacing strips between the wall plates during the manufacturing process, but this involves a considerable additional cost, and also several other drawbacks are caused thereby. The chief difficulty is that the small spacers when secured on their places in the customary manner cannot in practice be mounted accurately enough so that their free ends will coincide exactly with the adjacent wall surface as determined by the spacing strips. This shall, however, be further explained in the following and here shall only be noted that the end surfaces of some spacers may be slanting obliquely in relation to the wall surface which is to be supported, while at some places it may even occur that no contact at all is obtained. The result thereof is that the spacers will not be as effective as supposed, and when subjected to a superpressure from one side only or other heavy stresses and strains, the wall plates will be deformed locally so that the cross area of flow will be throttled and widened irregularly. Thereby the efficiency of the apparatus is considerably lowered, depending also on the lack of contact between the wall surfaces and the spacers in as much as the latter to some extent take part in the heat transfer. In short, the properties and quality of the apparatus will be rather inferior and in many cases not even tolerable and this cannot be remedied at resonable costs when using the old constructions and methods of manufacturing.

It is an object of this invention to remove the above-mentioned drawbacks of the apparatus referred to by providing for small rigid spacing members or the like sufficiently close to each other so as to render it possible to manufacture the same without using any special spacing strips or similar means for this purpose.

Another object of the invention is to manufacture the apparatus in such a manner that the convolute wall plates are firmly pressed against the free ends of all the small spacers so that a satisfactory contact is obtained and they are all thus made more effective.

Still another object of the invention is to mount the small spacers accurately and use such embodiments and methods as are particularly well adapted therefor.

A further object of the invention is to arrange the small spacers in regular rows forming a suitable angle with the wall edges at the face ends of the apparatus and thereby facilitate the accessibility to the central wall portions for cleaning purposes in order to avoid that the condition in this respect will be substantially inferior when increasing the number of spacers.

Other objects of the invention will be evident from the following portion of this specification and the appended claims.

Some embodiments of the invention are illustrated on the accompanying drawing by way of example and also some of the drawbacks which are to be removed thereby. In the drawing:

Fig. 1 is, on a small scale, an axial cross section through a heat exchanger according to the invention.

Fig. 2 shows, in part, a side view of an unsatisfactory convolute structure, as manufactured by means of the methods which were used earlier.

Fig. 3 shows, in part, a plane view of a convolute wall plate having small spacing members arranged, as disclosed by this invention.

Fig. 4 is a side view, partly in elevation and partly in section, of several embodiments of small spacing members particularly suitable for use in apparatus built in accordance with certain principles of the present invention.

Fig. 5 is a plan view of the spacing members shown in Fig. 4; and

Fig. 6 is, on a small scale, a side view of the convolute structure in a phase of its manufacturing, as proposed for carrying out this invention.

Referring now to Fig. 1 on the drawing the apparatus may comprise two convolute wall plates 1a and 1b with surfaces which extend adjacent and parallel to each other and conveniently have a true spiral shape, as shown by Fig. 6. These wall plates are spaced apart by means of small rigid spacing members 2 which consist of solid cylinders, for instance, being preferably welded to one of the wall plates only and distributed uniformly over the entire wall surfaces. Thereby there are formed separate spiral channels 3a and 3b for the different fluids at opposite sides of the wall plates in the spaces between the same so that heat transfer is effected through the common channel walls when passing the fluids through the apparatus in counter-current or otherwise. In this case one fluid enters the channel 3a through the inlet 4 at the periphery and is discharged at the centre through the outlet 5, while the other fluid flows in counter-current through the channel 3b which it enters at the centre through the inlet 6 and leaves through the outlet 7 at the periphery. With such apparatus the face ends of both the channels must be covered during operation and this may be effected by means of flat and removable covers 8, for instance, with which conveniently a rubber packing or the like is used to ensure a tight sealing. Located centrally in the spiral structure and embraced closely by the central spiral plate windings there are further shown a plurality of substantially circular discs or rings 9 which are disposed at right angles to the axis of the apparatus and serve to brace the innermost wall parts. Also the shape of said wall parts may be determined by the central discs in as much as the spirals are conveniently manufactured by rolling up pieces of flat sheet metal around the discs, but it is obvious that many other means can be used for this purpose.

Fig. 2 illustrates, on a larger scale, a similar spiral structure having the drawbacks stated in the introductory part of the specification. Thus, there are shown spacers 2 which are secured to the wall plates in the old manner by means of common welding with fusing electrodes whereby the joining is effected by a small lump of metal 21 being added locally at one place only. When using this method a considerable side pressure is exerted upon the spacers, as indicated by the small arrow, and this pressure tends to overturn the distance pieces. In fact, such a dislocation happens so easily that in practice it cannot possibly be avoided that a great number of spacers will be standing obliquely towards the plate surface as shown at 2x, whereby the free edges of such individual spacers will at some place rise more or less above the plane that coincides with the free ends of those spacers which remain in a correct position. In view of the old manufacturing method described it follows that the plates will obtain sharp creases indicated by 1x wherever a dislocation of the spacers occurs and obviously the contact at such places is very unsatisfactory, while even no contact at all may be obtained at other places, when a crease is formed over a correctly positioned spacer, as shown at 2xx. Further, it can be seen that the channel width 3x will vary quite irregularly and the whole structure will be rather flexible which cannot very well be allowed. All these drawbacks are rather severe, when the spacers are comparatively scattered and their distribution determined only with respect to the strength of the structure, as has been the practice before.

According to this invention, however, it is advantageous to increase the number of small spacing members irrespective of the requirements for strength so that the pitch between adjacent spacers or from the outermost ones to the adjacent wall edge never exceeds a certain length which is determined so as to render it possible to form the convolute windings by exerting a pressure upon the outer wall plate right over the spacers located underneath the same. It has been found that the pitch referred to should in no direction more than equal a measure which has a maximum projection d of 90 mm. in the tangential direction of the spirals and a maximum projection d_2 of 180 mm. or two times the former in the axial direction, as illustrated on Fig. 3, to the left. When using this arrangement the effect of the above mentioned drawbacks is to a great extent eliminated even if applying the old methods of manufacturing, but in addition the result may be considerably improved and the manufacturing costs lowered in as much as they may be replaced by new methods which will be described below.

As shown on Fig. 3 the spacing members are conveniently disposed in regular rows and the left part of the figure also illustrates the usual manner of cleaning the wall surfaces. Thus, when the spacers are comparatively scattered it is sufficient to move some kind of cleaning tool, for instance a flat bar with a small width, over the free surfaces R between the rows of spacers substantially in the axial direction of the apparatus, indicated by the left hand arrow, from one face end to the other and thereby turn it a little sideways as required to reach the intermediate portions O located within the dotted lines, as well. However, in case of a very dense distribution of spacers this method will obviously be ineffective in as much as the areas O will be practically inaccessible to the cleaning tool and, moreover, the method will be too laborius. As a matter of fact in such apparatus the inaccessible areas would be very much increased, but according to the present invention this may be overcome by arranging the rows of spacers in a special manner so that a suitable cleaning tool while being guided by the spacing members can be moved over the free surfaces in two different directions which form an angle with the spiral axis and cross each other. Thereby it is easily attained that practically the entire surfaces may be reached by the cleaning tool as shown on the right hand part of the figure wherein the accessible areas are indicated by RR and the remaining portions by OO. The angle between the rows of distance members and the spiral axis is equal to the angle V and should preferably be kept between 30° and 60° so as to minimize the inaccesible portions as much as possible, whereas the pitch d_3 between adjacent individual spacers should under no circumstances exceed 200 mm. in order that said tool may be guided satisfactory by means of the same. Conveniently, the pitch d_3 which also corresponds to the distance between adjacent rows of spacers is made about half as long as the cleaning tool proper S which must be rigid and have comparatively small dimensions being dependent on the data referred to, while being moved by means of a flexible member SS.

It is important that the accessibility to the wall surfaces for cleaning purposes is not unnecessarily hampered when increasing the number of small spacers in the apparatus and for this reason as well as in order to lower the manufacturing cost and ensure that the spacing members are mounted accurately so that the advantages of the invention will be still more accentuated, it is preferred to secure the spacers to the wall plates without using any additional welding material, for instance, by means of electrical welding according to the resistance fusing method. Therefore, it is proposed to use a special design of spacing members particularly adapted for this purpose and some embodiments of such spacers are shown in Figs. 4 and 5. Thus, they may consist of a solid and conveniently cylindrical piece 2a having one or more small projections 22 at one end whereby these projections are fused down by an electric current in order to secure the pieces to the wall plate, 1. Further, a hollow piece 2b can be used which has one or more thin flanges 23b extending laterally from one end, such flanges conveniently being provided with projections 22 to be fused down as described. Instead of flanges the hollow piece 2c may have a thin bottom part 23c. Another modification 2d consists of a metal strip or the like which is bent in a suitable fashion, as shown, for instance T-shaped, so as to obtain one or more flanges 23d extending adjacent and close to one of the wall plates, laterally from a spacing body which supports the opposite wall, the flanges being secured in the manner described. Obviously, these types of spacers are particularly well adapted for being welded automatically according to the method referred to, and this will also be economical when a sufficiently great number of spacers is used. Moreover, in this manner the spacers may without difficulty be mounted very accurately in as much as the method comprises pressing a movable contact member against the pieces in a direction towards the plates to which they are to be secured. A valuable advantage is that the spacers according to the invention will obstruct the accessibility much less than does the old type on account of the bulky lumps of welding material which are added in that case, since this would be intolerable in apparatus having a dense disposition of spacers.

Fig. 6 illustrates the new method of forming the plate spirals without using any special supporting means between the plate edges, while rolling up the flat plates around a suitable central body A which is rotated. According to the invention there is exerted a pressure B upon the outer sides of the plates at the portions thereof which are about to be bent, successively as they are passing the points where they change into completed spirals. This pressure is directed perpendicularly to the spiral axis and may be distributed uniformly over the entire breadth of the plates or work only on a few points between the plate edges to the effect that one plate portion after the other is bent spirally in parallel with the completed windings whereby the shapes of the portions during formation are determined by the small spacers which are located underneath such portions in as much as the same are moved against the preceding winding until the free ends of the spacers engage the adjacent wall surface closely. In this case, therefore, the plates are subjected to very little tension because the bending force is applied directly against the small spacers, and thus there is further obtained a better contact between the same and the wall surfaces, while the plates will obtain a smooth and regular convolute shape, provided that they have a sufficient number of spacers disposed in close proximity, as proposed. Under all circumstances the quality of the apparatus is very much improved when using this method of manufacturing.

It is obvious that a great many changes can be made in various details of the apparatus described including those elements which form the subject matter of this invention in particular without departing from its scope and spirit, and it is to be understood that the invention shall not be limited otherwise than by the appended claims.

Thus, what I claim is:

1. The process of fabricating a convolute plate heat exchanger comprising permanently securing a plurality of rigid spacing elements of small cross section and uniform height in close proximity to each other in spaced relation on one surface of each of two plates of good heat conductivity so that when the plates are rolled up upon each other the spacers on one plate will engage the adjacent plate and maintain the plates in spaced relation, securing one end of each of the plates to a central body at circumferentially spaced points, rolling up said plates about said body to form convolute walls spaced apart by said spacing elements, and during the rolling operation exerting radial pressure across the outer side of the outer one of said plates successively as it is passing the place where it changes into convolute form to successively bend the outer plate in accordance with the subjacent convolute turn as determined by said spacing elements when brought into engagement with the adjacent convolute wall and to secure positive contact between said spacing elements and the adjacent wall.

2. The process of fabricating a heat exchanger from a plurality of plates of good thermal conductivity which includes the steps of providing a plurality of rigid raised spacing elements of

small cross section and of substantially uniform height extending from one surface of each of two plates so that when the plates are rolled up upon each other the spacers on one plate will engage the adjacent plate and maintain the plates in spaced relation, said spacers being sufficiently close together to ensure rigid spacing of said plates, each of said plates and spacing elements carried thereby constituting a unitary structure, securing an end portion of each of the plates to a central body at circumferentially spaced points, spirally rolling said plates about said central body to form convolute walls held apart by said spacers, and during the rolling operation exerting force substantially radially inward across the outer surface of the outer of said plates successively as it is passing the place where it changes into convolute form to successively bend the outer plate in accordance with the subjacent convolute turn as determined by said spacers when brought into engagement with the adjacent convolute wall and to secure positive contact between said spacers and the adjacent wall.

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