Nov. 17, 1959 N. G. BAUERNFEIND ET AL 2,912,749

METHOD OF MAKING A HEAT EXCHANGER

Filed Jan. 13, 1956 2 Sheets-Sheet 1

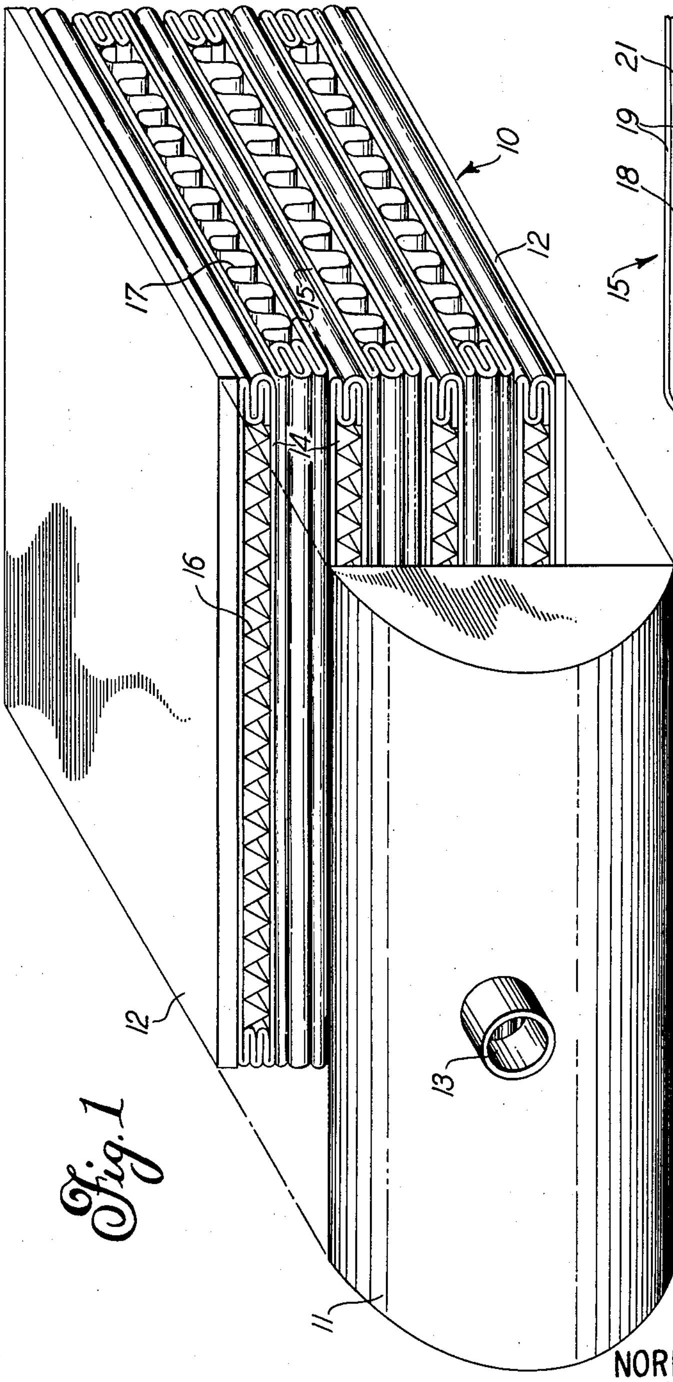

Fig. 1

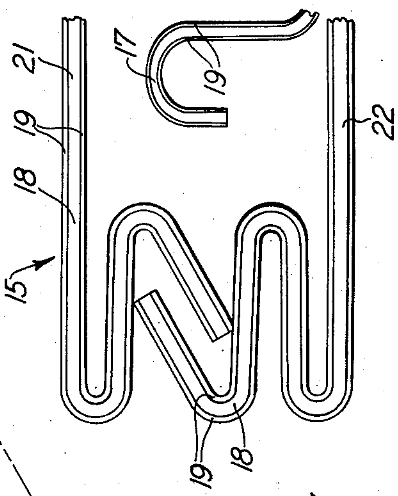

Fig. 7

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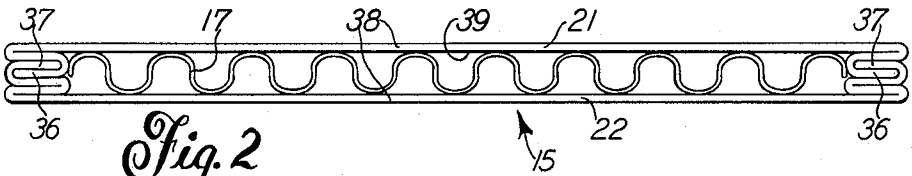

Fig. 2

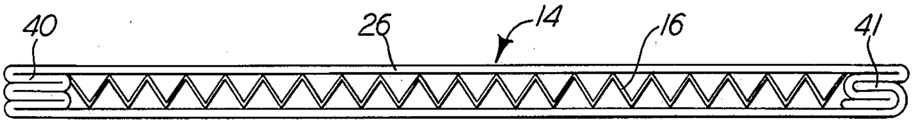

Fig. 3

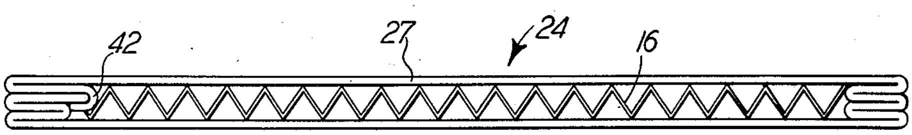

Fig. 4

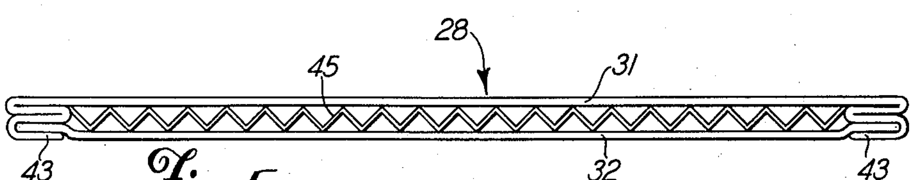

Fig. 5

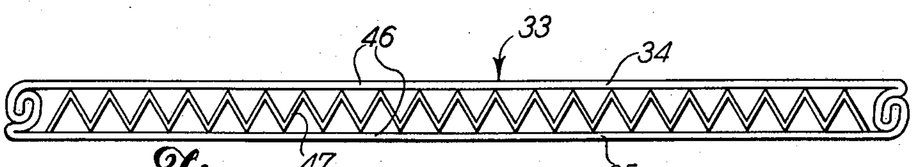

Fig. 6

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METHOD OF MAKING A HEAT EXCHANGER

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Application January 13, 1956, Serial No. 558,942

3 Claims. (Cl. 29—157.3)

This invention relates to a method of making a heat exchanger.

One type of heat exchanger is the type having the usual two separate fluid pass sections with each section divided into small spaced apart fluid pass elements and with the elements of each section alternately disposed within the spacings of the other section. This type of heat exchanger is the conventional plate type having alternate layers of the enclosed elements of the two separate fluid pass sections extending through the heat exchanger. In most of this type of heat exchanger, the enclosed elements are formed of a sheet material having certain physical properties and being sufficiently thin to permit a maximum amount of heat transfer through the material. The thickness of the sheet is partly determined to render the enclosure strong enough to resist the pressure of the fluids as well as pressure from foreign objects which might strike against the enclosure. Also, it has been a problem in the manufacture of heat exchangers to provide a heat exchanger enclosed element with the precision spacing required between the oppositely disposed sheets of an element, and also it is difficult to fluid tightly seal the sides of the element.

In certain previous types of the enclosed elements, either a solid bar or a channel piece of the sheet material has been disposed between the top and bottom sheets of the element to enclose the sides thereof. In both of the foregoing instances, a separate piece is required at each side of the element, and, therefore, four pieces are required to form one complete enclosed element. Further, each side piece must be soldered or welded to the sheet along two seams, and thus a total of four seams must be made fluid tight in each element, and this has been an obvious problem in the construction of heat exchangers. Further, where separate side pieces are employed, there are the additional problems of aligning the pieces with the sides of the sheets, and also the handling of four separate pieces for each element is required. An example of the above-mentioned solid bar type of heat exchanger is disclosed in U.S. Patent No. 2,547,668.

Another previously known type of enclosed element of a heat exchanger is that type where the opposite sides of one of the sheets are bent to meet with the other sheet and lap therewith and thus present only one seam where the sides must and can be soldered or welded together. A variation of this type is that where both sheets have their sides bent toward the side of the other sheet to have the bent sides overlap, and this is, therefore, the well-known type of construction. The known problems in this lap type construction include the fact that an element of only a low strength results since the thin sheets themselves form the sides of the element, and these sides are thus vulnerable in the heat exchanger. Also, one seam on each side of the element must be welded or soldered to render the element fluid tight.

Still another disadvantage of the above-mentioned type and other types is a problem of spacing the top and bottom sheets of an element a precise distance apart and thus requiring a side enclosure of the element to be disposed between the sheets to occupy exactly the precise distance.

It is a general object of this invention to make a fluid pass element which is an improvement over the above-mentioned types of elements and, particularly, overcomes the disadvantages mentioned with respect to those elements.

It is a specific object of this invention to make a fluid pass element wherein each element requires not more than two pieces for the formation of the complete element. Thus, the problem of aligning the heretofore employed separate side pieces with the sheets of the element is overcome, and the handling of extra side pieces is eliminated.

Another object of this invention is to make a fluid pass element which is sufficiently strong to resist the pressure of the fluid as well as forces created by external foreign objects which might strike against the exposed sides of the heat exchanger.

Still another object of this invention is to make a fluid pass element which eliminates a separate welding or soldering step, such as that required in the above-mentioned previous type of fluid pass elements.

Still a further object of this invention is to make a fluid pass element wherein the spacing between the portions defining the passage of the element is precisely attained, as required.

Another further object of this invention is to make a fluid pass element wherein the element is less susceptible to permitting leakage of the fluid. This object is attained in part by the fact that the sides of the element are interlocked and pressed in the final condition of the element.

A further object of this invention is to provide a method of making a fluid pass element having the advantages referred to in the foregoing and the characteristics mentioned in the following description.

Similar reference numerals refer to similar parts throughout the several views wherein:

Fig. 1 is an exploded perspective view of a heat exchanger incorporating preferred embodiments of the fluid pass elements of this invention.

Fig. 2 is an enlarged end view of one of the fluid pass elements incorporated in Fig. 1.

Fig. 3 is an enlarged end view of the other element shown in Fig. 1.

Fig. 4 is an enlarged end view of another embodiment of the element shown in Fig. 2.

Fig. 5 is an enlarged end view of still another embodiment of the element shown in Fig. 2.

Fig. 6 is an enlarged end view of still another embodiment of the element shown in Fig. 2.

Fig. 7 is an enlarged end view of a fragment of the side of the element shown in Fig. 2 but prior to final compression of the element and with the coating substance shown.

Fig. 1 shows a heat exchanger in an exploded view with a core **10** and the usual header **11** shown separated from the core for the purpose of clearly showing the invention. Of course, different sizes of the core could be made and the number of plates or elements disposed between the top and the bottom plates **12** could also be changed from that shown. The header **11** includes a nipple **13** which serves to conduct fluid into or out of the exchanger. Assuming that fluid would flow into the exchange through the header **11**, the fluid flows to the core **10** where it enters the alternate layers of the heat exchanger elements **14**. In the usual manner, the fluid continues to flow through the elements **14** and out the opposite side of the exchanger core where it is suitably conducted away from the core. Similarly, the second fluid passes through the interspersed elements 15 of the heat exchanger core in a path transverse to the path of the first fluid, and the second fluid is also suitably conducted away from the core, in any well-known manner, on the side opposite the side of its entry into the core. Thus, the usual cross flow of two fluids is conducted in the core 10 and the desired exchange of heat between the fluids is accomplished.

The important feature of this invention is the fluid pass element and its method of manufacture. The elements or tubes 14 and 15 are made of a thin metal, of high heat transfer characteristics, and a fin or diverter 16 and 17 is diagrammatically shown disposed within the passageway of each element. In one instance the fin 16 is shown to be pleated and formed of straight sections while the fin 17 is shown to be formed of curved sections. In both instances the fins are of a serpentine shape with their crests in contact with the opposite walls of the tube to conduct heat to or from the walls, as the case may be, and thereby increase the efficiency of the exchanger. Also, the fins are bonded to the walls, in a manner explained later, and thus support the walls of the element against fluid pressures and other forces.

The thickness of the sheet metal forming the elements generally varies from .010 of an inch to .125 of an inch depending upon the application of the heat exchanger. Also, aluminum, steel, copper, and brass sheets are known to be acceptable materials for the sheet but any metal of sheet form can be employed. Further, the sheet is coated with a coating substance of, for example, an aluminum brazing alloy or solder for the aluminum sheet, and solder or copper for the steel sheet. It is, therefore, preferred that the sheet base substance 18, as shown in Fig. 7, have a coating metal 19 applied thereto in any well-known manner. The melting point of the coating is lower than that of the base metal for a reason mentioned later.

Figs. 2 through 6 show embodiments of the elements all formed with interlocking side or sides by folding or pleating the two sides of each element, as shown. In all embodiments the folded sides present a spacer between the intermediate parallel or planular portions of the element and the folded sides are sufficiently thick to resist the formation of leaks such as those caused by foreign objects striking the sides. Fig. 2 shows the element 15 composed of two sheets 21 and 22 folded into different forms while Figs. 3 and 4 show elements 14 and 24 composed of single sheets 26 and 27. Fig. 5 shows an element 28 composed of sheets 31 and 32 folded or formed in two different shapes, and Fig. 6 shows element 33 composed of sheets 34 and 35 folded into the same form but with the two ends of each sheet folded differently.

Fig. 2 shows the element 15 formed of the sheets 21 and 22 with the respective ends 36 and 37 of the sheets interlocked by each being disposed within the folds of the opposite sheet. The folded portions of the sheets form the sides of the element while the remainder of the sheets form parallel intermediate portions 38. Thus the folded sides and the portions 38 define the fluid passageway 39 in which the fin 17 is preferably disposed. The folds form a solid mass at both sides of the element and the number of the folds determine the height of the passageway which can, therefore, be the selected desired dimension.

In the preferred formation of the elements, the sheets of the element 15, for example, are folded by rolling substantially into the form shown in Fig. 7, and they are interlocked as shown. The fin 17 is also disposed as shown and it should be noted that the original height of the fin is preferably slightly greater than the final height of the passageway 39 when the element is in the Fig. 2 condition. The element is then compressed together until the folded sides form compact masses and are fluid tight, and, at that point, the fin is in contact with both of the sheets. Subsequently, the element is heated to cause the

coating material to bond the folded sides fluid tightly together and to bond the sheets and the fin together. In this manner, a sturdy and efficient element is made out of only two pieces of material and no final welding or soldering is required such as that required in the U.S. Patent No. 1,945,287 to L. M. Monroe. Also, the interlock results in a joint which requires that the fluid flow through the bonded sides for a length three times the length of the abutting folds of the Monroe type if the fluid is to leak, and no direct or single path of flow is possible for any leaking, and no free end of the sheet is exposed.

Fig. 3 shows the element 14 having one side 40 formed of a continuous portion of the single sheet 26 with the opposite side 41 interlocked at the free ends of the sheet. The element can otherwise be formed in the manner described in connection with the element 15. Here also the fluid must flow past three layers of the folded side if there is any fluid leaking at the seam of the folds, and only one seam is present in the entire element.

Fig. 4 is similar to Fig. 3 except that the fold is formed in the different manner shown and the end 42 is folded around the opposite free end of the sheet 27. Since both the elements 14 and 24 have four layers of fold at each side, the height of their passageway will be the same and the fin 16 can also be employed in the element 24.

The element 28 of Fig. 5 has the multi-folded sheet 31 while the sheet 32 is substantially a flat sheet disposed within the folds of the sheet 31. It is preferred that the ends 43 of the sheet 31 do not project beyond the plane of the intermediate portion of the sheet 32, and, therefore, the latter can be formed to receive the free ends 43 of the sheet 31. A shallower fin 45 is disposed in the element 28.

Fig. 6 shows the element 33 with most of the layers of the folded sides disposed transverse to the intermediate portions 46 of the sheets 34 and 35. Of course, the sides are interlocked, and they are in abutting contact with the parallel intermediate portions. The folds form spacers between the sheets and, if a leak is to develop, it is obvious from the drawing that the leaking fluid must flow the extended length along the seam. This element is also compressed to achieve its final form and a fin 47 is shown disposed in the passageway formed.

It should also be obvious that the precise form of the folds of the elements could vary from those forms shown; therefore, the scope of this invention should be limited only by the scope of the appended claims.

We claim:

1. In a method of making a fluid pass element for a heat exchanger, the steps comprising folding the opposite edges of two flat heat transfer sheets having a coating metal and a base metal with the melting point of said coating metal being lower than the melting point of said base metal, the folding of said sheets being suitable for disposing the layers of the folds in planes parallel to the planes of said sheets and within the limits of the portions intermediate said edges and being suitable for interlocking said sheets together and being of sufficient number of layers to present a total thickness equal to the desired final height of the pass when said layers are fully compressed together, interlocking said sheets together at said folds, folding a sheet into a serpentine shaped fin of a height slightly larger than the desired final height of said element, disposing said fin between said sheets, pressing said sheets toward each other to press said layers of said folds together, and heating said element to melt said coating metal for bonding said folds together to fluid tightly seal said sides.

2. In a method of making a heat exchanger fluid pass element of the type having fluid tight sides and open ends and an intermediate passageway defined by said sides and parallel portions of the sheets of said element with said passageway being a certain height, the steps comprising folding the two sides of each of two thin metal heat trans-

fer sheets having a coating of a bonding metal with a melting point lower than the melting point of the base metal of said sheets, the folding of the sides of said sheets being suitable for disposing the layers of the folds in extents parallel to and between the planes of said parallel portions of said sheets defining said passageway, and the number of the folds being a certain amount dependent upon the final thickness of each of said layers of said sheets at said folds and said certain height of said passageway so that the total of said final thicknesses equals said certain height when said layers are compressed together, the folding of said sides of said sheets being further suitable for interlocking said sheets together, interlocking said sheets together at said folds, forming a sheet into a serpentine shaped fin of a height slightly greater than said certain height, disposing said fin between said sheets within the limits of said sides, pressing said sheets toward each other to compress said folds of said sides and to press said sheets against said fin to reduce said height of said fin until the distance between said parallel portions of said sheets is equal to said certain height, and heating said element to melt said bonding metal for fluid tightly sealing said folds together and for cohering said sheets with said fin.

3. In a method of making a heat exchanger fluid pass element of the type having fluid tight sides and open ends and an intermediate passageway defined by said sides and parallel portions of said element with said passageway being a certain height, the steps comprising folding a side portion of a thin metal heat transfer sheet a certain number of times to form one of said sides of said element,

the folding of said side portion being suitable for disposing a plurality of layers of said sheet within the lateral limits of the unfolded portion of said sheet, said plurality being a number sufficient to provide a total compressed thickness of said layers equal to said certain height, said folding being further suitable for defining the interior of said element and for interlocking one of said sides of said element, forming a sheet into a serpentine shape of a height greater than said certain height to provide a fin, disposing said fin in the interior of said element, interlocking one of said sides together, and pressing said element together to reduce the height of said sides until the final height of said passageway is said certain height.

References Cited in the file of this patent

UNITED STATES PATENTS

583,683	Gersant	June 1, 1897
811,853	Lamplough	Feb. 6, 1906
1,142,711	Isaacs	June 8, 1915
1,276,197	Fedders	Aug. 20, 1918
1,613,306	Bell	Jan. 4, 1927
1,796,114	Meadowcroft	Mar. 10, 1931
1,825,498	Wogan	Sept. 29, 1931
1,840,318	Horvath	Jan. 12, 1932
1,945,287	Monroe	Jan. 30, 1934
2,170,639	Hopkins	Aug. 22, 1939
2,339,284	Modine	Jan. 18, 1944
2,360,123	Gerstung et al.	Sept. 10, 1944
2,566,310	Burns	Sept. 4, 1951
2,576,213	Chausson	Nov. 27, 1951
2,784,947	Peterson	Mar. 12, 1957