Nov. 8, 1960 J. C. BURTON 2,959,401

PLATE-FIN TYPE HEAT EXCHANGER AND METHOD OF MAKING THE SAME

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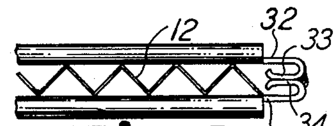
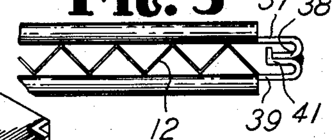


Fig. 4

Fig. 5



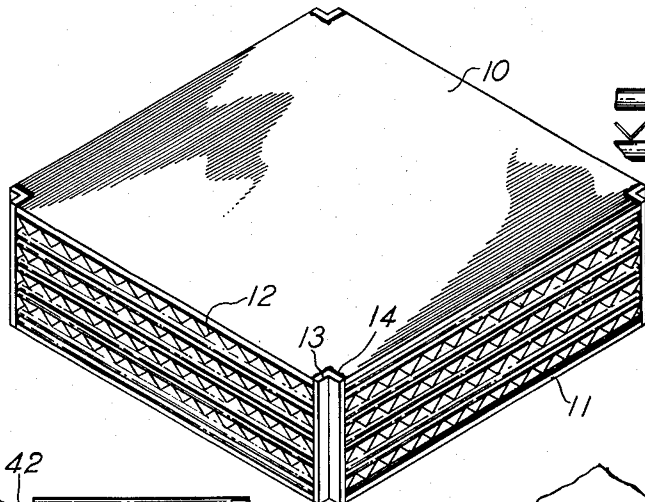


Fig. 1

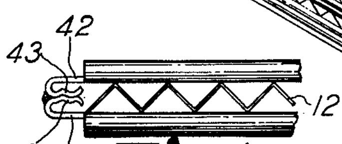


Fig. 6

Fig. 7

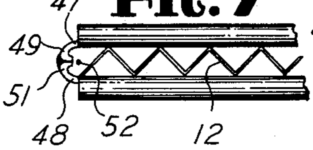


Fig. 2

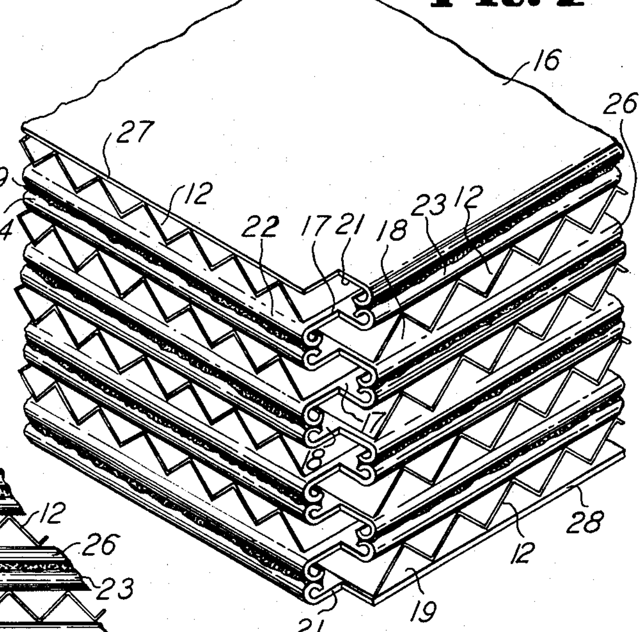


Fig. 3

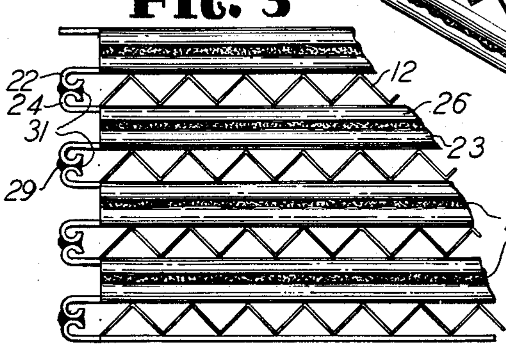


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PLATE-FIN TYPE HEAT EXCHANGER AND METHOD OF MAKING THE SAME

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This invention relates to heat exchangers and, more particularly, it relates to the side closure for the plate and fin type heat exchanger and the method of making the same.

Plate and fin type of heat exchangers are well known in the art, and it is old in the art to fabricate such exchangers with either a solid bar, brazed or otherwise bonded to the plate edges to form side closures such as shown in U.S. Patent No. 2,547,668, or to fabricate these exchangers with channel-shaped pieces which are utilized in place of the solid bars to form the side closures when the pieces are bonded to the edges of the sheets or plates. It is also old to have the adjacent sides or edges of the exchanger plate bent in opposite directions such as shown in U.S. Patent No. Re. 16,807. Mention is made of these prior art structures to facilitate defining the instant invention which is an improvement over the prior art.

An object of this invention is to provide a plate and fin type heat exchanger wherein the overall height of the plurality of the exchanger passes can be brought to the desired dimension with a minimum of effort and without damage to the parts of the exchanger.

Another object of this invention is to provide a heat exchanger of the plate type wherein the side closures are readily and easily made fluid tight, and when the closures are subjected to pressures, they will actually become self-sealing in response to the internal pressure in the exchanger.

Another object of this invention is to provide a plate and fin type of heat exchanger which has the foregoing advantages and which can be readily and accurately assembled, and when thus assembled, the side closures of the exchanger hold the entrance losses of the incoming fluid to a minimum.

Still another object of this invention is to provide a plate and fin type of heat exchanger wherein the inherent variables of dimensions and tolerances of the prior art structures are held to a minimum or are even entirely eliminated in some instances of manufacture of the exchanger material and in fabrications and assembly of the same. Thus, for instance, in the channel type of prior art closure mentioned above, the gage of the channel material and the height of the material introduce dimension variations which must be considered to obtain the final overall height of the exchanger and, of course, the same is true where the bar type of prior art side closure is employed as mentioned above. In the instant invention, the dimension variations mentioned are of no final consequence, and thus the prior art tolerances need not be mentioned.

Still another object of this invention is to provide a side closure for a plate type heat exchanger wherein only one joint seam is formed, and the closure provides excellent facilities for filleting on both sides of the joint.

Another object is to provide an exchanger of a minimum weight but of high strength as the side closures are formed by the ends of the thin sheets.

Fig. 1 is a perspective view of a plate-fin type of heat exchanger incorporating a preferred embodiment of this invention.

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Fig. 2 is an enlarged perspective view of a fragment of that shown in Fig. 1 and with the corner piece removed.

Fig. 3 is a side elevational view of a fragment of the exchanger shown in Fig. 2.

Figs. 4, 5 and 6 and 7 are side elevational views of a fragment of one pass of the exchanger and showing other embodiments of the side closures of the passes.

The same reference numerals refer to the same parts throughout the several views.

Fig. 1 shows the plate-fin type of heat exchanger with a top plate **10** and a bottom plate **11** and with intermediate sheets or plates disposed parallel to the top and bottom plates **10** and **11** and with serpentine fins **12** extending through the length and width of the exchanger as shown. Corner pieces **13** are nested in cut-outs in the plates **10** and **11** and also cut-outs in the intermediate sheets so that the angled corner pieces **13** can be bonded at **14** to the plates and the sheets as shown. Fig. 2 shows the intermediate sheets or plates **16**, **17**, **18** and **19** which are all formed with right angle corner cut-outs **21** for reception of the corner pieces **13**, and the corner pieces **13** are bonded along all of the sheet edges defining the cut-outs **21**, on both sides of the latter, to make a complete fluid tight bond along the height and width of the pieces **13**. Here, also, it will be seen that the serpentine fins **12** are disposed between the sheets to be at perpendicular orientation in alternate layers such that the fluid flow through the exchanger is also in a perpendicular direction as the exchanger is of the cross-flow type.

It will further be seen that the sheets or plates **17** and **18** form pairs which together define the exchanger passes in the alternate layers mentioned. A top sheet **16** is shown at the top of the exchanger, and the bottom sheet **19** is at the lower or bottom end of the exchanger. The sides of the sheets **17** and **18** are arcuately formed such that one side of the sheets **17** is curved downward as at **22** while the ajdacent side of the sheets **17** is curled or curved upward as at **23**. Similarly, one side of the sheets **18** is curled or curved upward at **24** while the adjacent side of the sheets **18** is curled or curved downward as at **26**. Thus, the sides **22** and **24** and the sides **23** and **26** are both paired and are formed of an arcuate or circular shape to be in aligned and abutting relation as shown in Figs. 2 and 3 so that the sides form fluid tight closures for the passes of the exchanger. The remaining side **27** of the top sheet **16** and the side **28** of the bottom sheet **19** are respectively bonded to the top plate **10** and the bottom plate **11** so that the fluid tight closures are formed in the heat exchanger as desired.

It will, of course, be understood that the unshown sides of the exchanger are the same as those sides shown. It has been found that with the curled sides which are circular information and in abutment as shown, the exchanger can be easily fabricated and assembled to a desired overall accurate height, and a final compressing of the exchanger places the fins **12** in tight contact with their respective adjacent sheets at the apex or crests of the fins, and also the arcuate sides of the closure, are thus placed in tight contact. Fig. 2 shows that the fin **12** extends into the vertical plane of the curls **22** and **24**. Subsequent bonding by the well-known heat processes cause the contact lines referred to to become fluid tightly sealed, as desired. The seams thus formed can be brazed along the lines **29**, and the curved sides make a desirable channel for the brazing, and the brazing material will also flow, by virtue of capillary attraction, to the inner apex of the two arcuate sides along the line **31** so that the joint is brazed on both the inside and the outside to make a strong fluid tight joint. Internal exchanger pressure which would tend to cause the closures to open up actually will cause the closures to uncurl one against the other and thereby form a tighter joint as the curls are of the pressure sealing type as pressure on the beads **31**, for instance, will force outwardly on the curls tending to straighten them and thereby roll them toward each other.

Figs. 4, 5, 6 and 7 show modifications of the side closure, and Fig. 4 shows the sheet **32** to have a long and flat side **33** which abuts the side **34** of the sheet **36** such that the sides **33** and **34** are in full abutting contact, and such abutting arrangement simplifies assembly of the sheets **32** and **36** as the wider sides **33** and **34** can more easily be placed in full physical contact for subsequent bonding as desired. Fig. 5 shows another configuration of the side for simplification of assembly, and in this instance a sheet **37** is formed with a straight flat side **38** while the mating sheet **39** is formed with a right angle bend in the sheet side **41** such that the side **38** of one sheet is within the right angle bend of the side **41** of the other sheet, and this also simplifies assembly of the sheets **37** and **39**. Fig. 6 shows another form of the sheet side for simplifying assembly, and in this instance a sheet **42** is provided with a side **43** which side has indentations, as shown, and the mating sheet **44** and its side **46** has indentations, as shown, which mate with the indentations on the side **43** and thus the two sheets can be readily aligned in assembly. The contacting surfaces between the sides in Figs. 4, 5 and 6 constitute alignment means. Fig. 7 shows still another arrangement of sheets **47** and **48** and their respective sides **49** and **51**. In this instance, the sides **49** and **51** are curved inwardly toward each other in such a curvature so that in final mating assembly, a center point **52** is formed by the two curved sides **49** and **51**, which center point **52** becomes the center of the pair of curving sides, and this is particularly desirable in reducing entrance losses of the flowing fluids as the sides **49** and **51** present a continuously curved or streamlined surface to the incoming fluids. The sides are also provided with alignment means consisting of the line of contact between the two curvatures.

In the process of making each of the side closures referred to, each curve **22**, **23**, **24** and **26** is of a size such that the initial total height of the two mating curves are of a height which is slightly greater than the final fin height. Then, upon assembling and fixturing under pressure, the mating curves are compressed, as the entire exchanger is compressed between the plates **10** and **11**, and the serpentine fins then come into contact with the sheets above and below each fin, and the curves of the side closures are placed in good physical contact. Because of this process, the tolerances and variations in fabrication of the parts are not as important as they are in the prior art referred to in that the final height of the exchanger can be achieved by compressing the assembled exchanger so that the parts will not only come into good contact but will present the desired final overall height. Fig. 3 particularly shows the side closure to consist of the two curvatures which are greater than one-half of a circle, and this particular curvature lends itself to the compressing referred to as the two curves will always be in mating contact since they are more than one-half of a circle, and the line of contact between curves or bends is an alignment means.

It is also significant that the sheets are formed of a material with a gauge as low as .002 inch. Since the edges of the sheets are utilized in forming the side closures, the latter are also of light gauge and, therefore, light weight. Weight is very critical in an exchanger of this type. It is difficult, if at all feasible, to form an exchanger with separate channel members for the side closures with the channel gauge as light as .002 inch. Such gauge in a small channel piece is impractical to handle in assembly of the exchanger. Further, the curled shape of the side closures described give the desired strength to the side closures as this shape is actually a good sheet stiffener.

The sheets are thus paper thin but where internal pressures require it, the plates **10** and **11** are provided to give support to the sheets through the fins **12**, and the corner pieces secure the plates. The plates **10** and **11** are also available for the attachment of duct work or other connections desired.

While specific embodiments of this invention have been shown and described, it should be obvious that certain changes could be made therein, and the invention should, therefore, be limited only by the scope of the appended claims.

What is claimed is:

1. A method of making a plate and fin type of heat exchanger, the steps comprising arcuately forming the sides of every two plates in curvatures directed back toward said plates and being so formed that when said plates are placed one above the other pairs of said sides will be in contact at their surfaces on the outside of said curvatures while the remainders of said plates are planular and spaced apart and in parallel portions, forming a serpentine fin to a height less than the spacing between said plates and disposing said fin between said parallel portions of said plates, compressing said plates and each said fin together in the direction normal to said remainders until the crests of each said fin contact said plates, and bonding said pairs of said sides together and said fin and said plates together along the resulting lines of contact.

2. A method of making a plate and fin type of cross-flow heat exchanger, the steps comprising forming the sides of the plates of the exchanger in circular bends directed back toward the plates in curves greater than that of a semi-circle and with adjacent sides of each plate bent in opposite directions, forming surfaces on the outer radii of said bends and along the entire lengths thereof for mating with each other and aligning said plates, arranging said plates in layers with adjacent ones of said bends on the same sides of said exchanger disposed in opposite directions for said surfaces to be in contact with each other to form a seam and for spacing said plates apart at least a minimum distance, forming a serpentine fin to a height less than said minimum distance between said plates and disposing said fin between every two said plates in alternating orientation and parallel with said bends which are in the plane of each said fin, compressing said plates and each said fin together in the direction normal to said plates until each said fin contacts said plates on opposite sides, and brazing said bends along said seams.

3. A plate-fin type of heat exchanger comprising a plurality of plates disposed in parallel relation with the two edges thereof along the same side of the exchanger being formed of a pair of smooth curves directed back toward said plate and in bonded contact with each other and spaced from the remainders of said plates, said pair of smooth curves terminating with one edge thereof including an angled end directed toward the other edge and with the latter abutting said angled end for alignment of said plates, and a fin disposed between said every two plates and in bonded contact therewith.

4. A plate-fin type of heat exchanger comprising a plurality of plates disposed in parallel relation with the two edges thereof along the same side of the exchanger being formed of a pair of smooth curves directed back toward said plate and in bonded contact with each other and spaced from the remainders of said plates, said pair of smooth curves terminating in interengaged indentations mated for alignment of said plates, and a fin disposed between said every two plates and in bonded contact therewith.

5. A plate-fin type of heat exchanger comprising a

plurality of plates disposed in parallel relation with the two edges thereof along the same side of the exchanger being formed of a pair of smooth curves directed back toward said plates and in contact with each other and spaced from the remainders of said plates, said pair of smooth curves terminating in flat parallel portions matched in abutting contact for alignment of said plates and provide an area of abutment for fluid sealing over said area, and a fin disposed between said every two plates and in bonded contact therewith.

6. A method of making a plate and fin type of cross-flow heat exchanger which has layers of passes secured together in a fixed overall height through one pass on one side and through the pass on the opposite side of the exchanger, the steps comprising forming the sides of the plates of the exchanger by bending the same into arcuate bends directed back toward the plates and by bending adjacent sides of each plate into arcuate bends in opposite directions, arranging said plates in layers with adjacent ones of said sides of said exchanger disposed in opposite directions for being in contact with each other to form a seam and for spacing said plates apart, said bends being of a sufficiently large curvature to space the remainders of said plates apart at least a minimum dimension, forming a serpentine fin to a height less than said minimum dimension between said plates and disposing said fin between every two said plates in alternating orientation and parallel with said bends which are in the plane of each said fin and with said fin placed to extend into the projected area between the latter said bends for physically supporting the same through said plates, compressing said plates and each said fin together in the direction normal to said plates until each said fin contacts said plates on opposite sides, and brazing said bends along said seams.

7. A plate-fin type of heat exchanger of a plurality of tubes comprising a plurality of plates disposed in parallel relation through the central body thereof and with every two sides thereof along the same side of the exchanger arcuately curved in fractional circular bends and in contact with each other on the outside surfaces of said bends and bonded together along the lines of contact and disposed with ends directed back toward said body of said plates and being spaced therefrom for the entrance of fluid pressure to the interior of said bends and with the remainder of said plates spaced apart, a serpentine fin disposed between every two of said plates and oriented with the crests of said fin parallel to said lines of contact on the sides of each said fin and bonded to said plates at said crests of each said fin, the length of said fins being sufficient to extend through the projected areas between said bends and being in supporting contact with said plates at said sides for preventing uncurling of said bends toward said fins from internal fluid pressure, and means connected between the two oppositely located said tubes for restricting the height of said exchanger and thereby prevent height increase of each of said tubes.

8. A plate-fin type of heat exchanger comprising a plurality of plates disposed in parallel relation with the two edges thereof along the same side of the exchanger being formed of a pair of smooth and arcuate curves directed back toward said plate and with said edges being in brazed contact with each other on the outer convex surfaces of said curves and with the ends of said edges forming said curves being free and spaced from the parallel remainders of said plates to allow for expansion and contraction of said curves in response to external mechanical force and internal fluid pressure on said curves, alignment means along said edges on the surfaces thereof disposed outwardly with respect to said curves with said means on said every two sides of said plates being brazed and being mated for alignment of said plates and for spacing said plates apart, and a fin disposed between said every two plates and in bonded contact therewith.

9. A plate-fin type of heat exchanger comprising a plurality of plates disposed in parallel relation with every two plates having every two sides along one side of the exchanger arcuately curved toward each other to contact each other and terminate in ends directed back toward and spaced from the remainders of said two plates and form a seam at the line of contact, said sides and said remainders having a space therebetween to admit fluid pressure to the interior of the arcs of said sides for urging said arcs into expansion and thereby enhance the seal at said seam, each said seam being brazed and including a brazing bead on the convex sides of said arcs at said line of contact and on both sides thereof for fluid tightly sealing said seam and with the outer one of said beads filling in between said arcs for reducing entrance losses of fluid flowing into said exchanger past said sides, and a fin disposed between said every two plates and in contact therewith.

References Cited in the file of this patent

UNITED STATES PATENTS

660,292	Durr	Oct. 23, 1900
708,712	Hill	Sept. 9, 1902
811,853	Lamplough	Feb. 23, 1906
849,878	Zivi	Apr. 9, 1907
2,344,588	Blauvelt	Mar. 21, 1944
2,368,814	Fagan	Feb. 6, 1945
2,378,646	Manning	June 19, 1945
2,380,002	Wetherby-Williams	July 10, 1945
2,539,870	Simpelaar	Jan. 30, 1951
2,576,213	Chausson	Nov. 27, 1951
2,614,517	Peterson	Oct. 21, 1952
2,869,835	Butt	Jan. 20, 1959

FOREIGN PATENTS

4,441	Great Britain	Feb. 23, 1909
788,309	France	July 29, 1935