Sept. 21, 1965 L. J. TRANEL ETAL 3,206,839

FABRICATION OF HEAT EXCHANGERS

Filed May 9, 1961

5 Sheets-Sheet 1

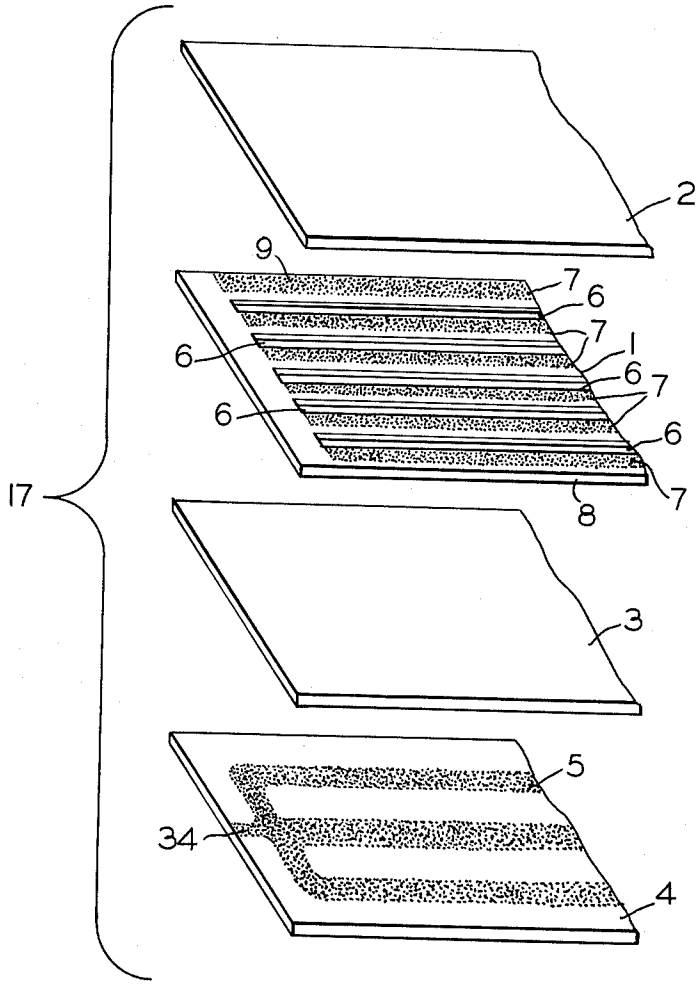


FIG-1

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FABRICATION OF HEAT EXCHANGERS

Filed May 9, 1961 5 Sheets-Sheet 2

FIG-2

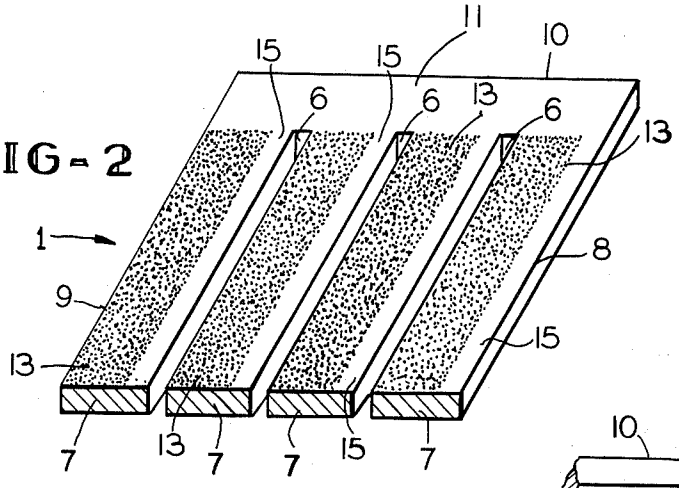
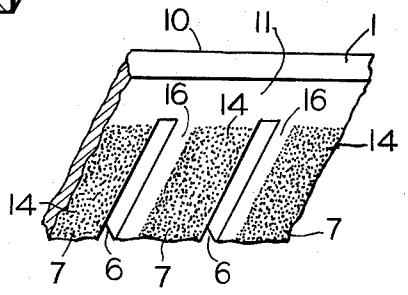


FIG-3



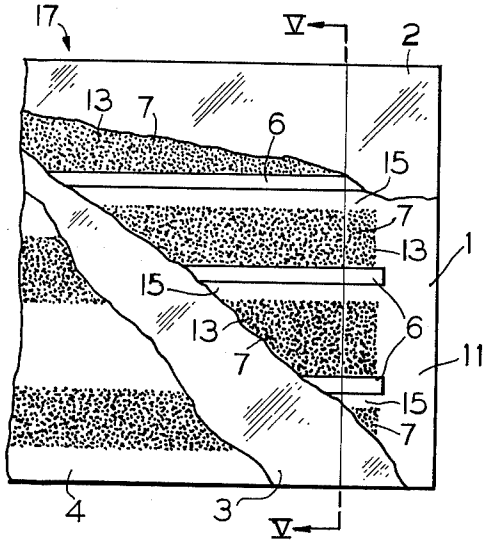


FIG-4

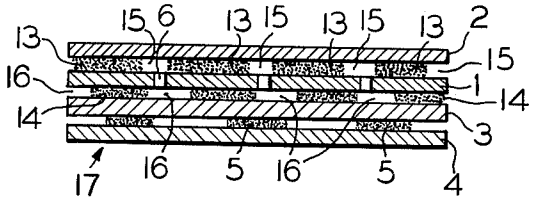


FIG-5

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FABRICATION OF HEAT EXCHANGERS

Filed May 9, 1961 5 Sheets-Sheet 3

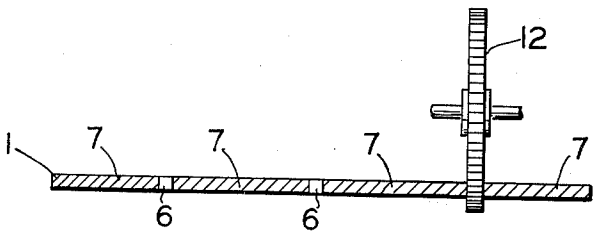


FIG - 6

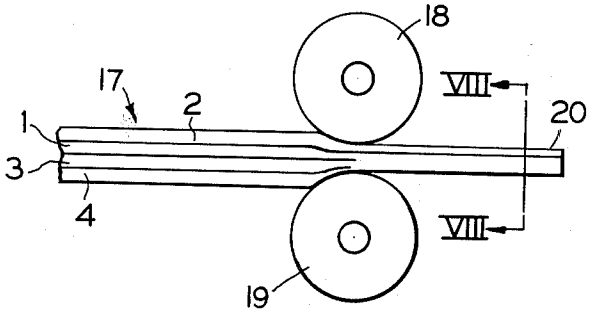


FIG - 7

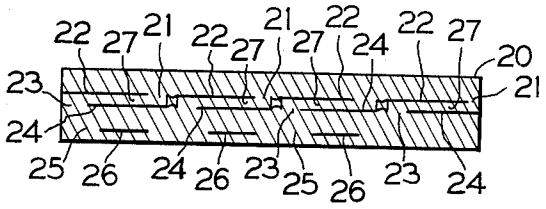


FIG - 8

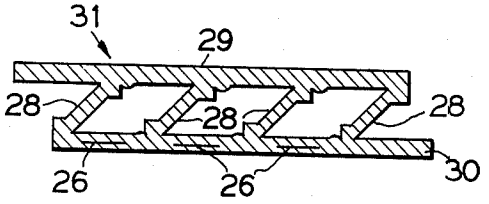


FIG - 9

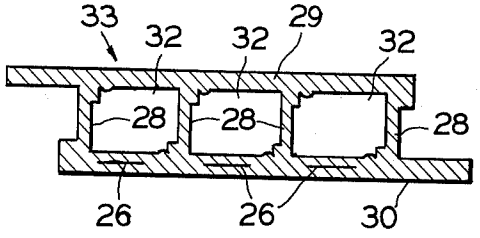


FIG - 10

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FABRICATION OF HEAT EXCHANGERS

Filed May 9, 1961 5 Sheets-Sheet 4

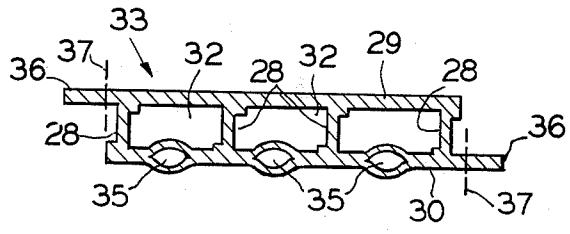


FIG - 11

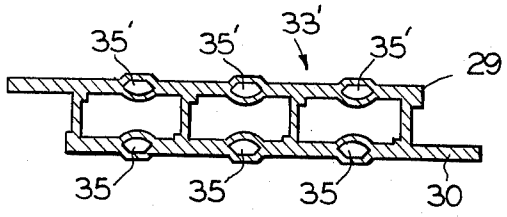


FIG - 12

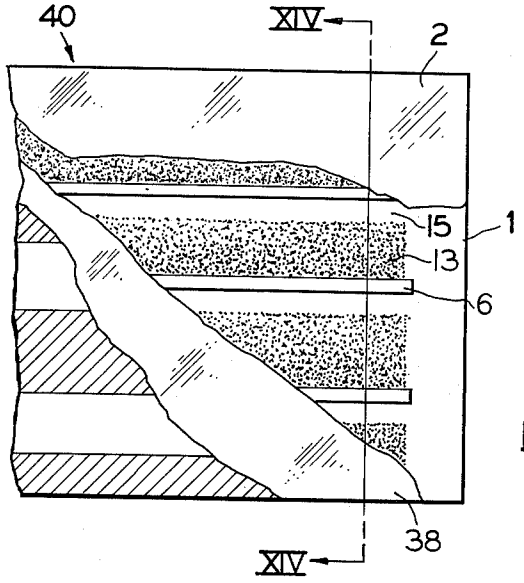


FIG - 13

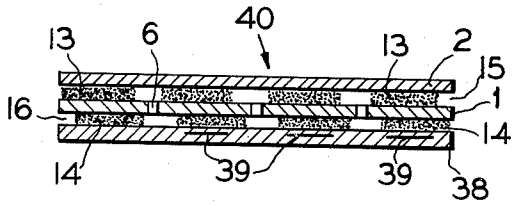


FIG - 14

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FABRICATION OF HEAT EXCHANGERS

Filed May 9, 1961 5 Sheets-Sheet 5

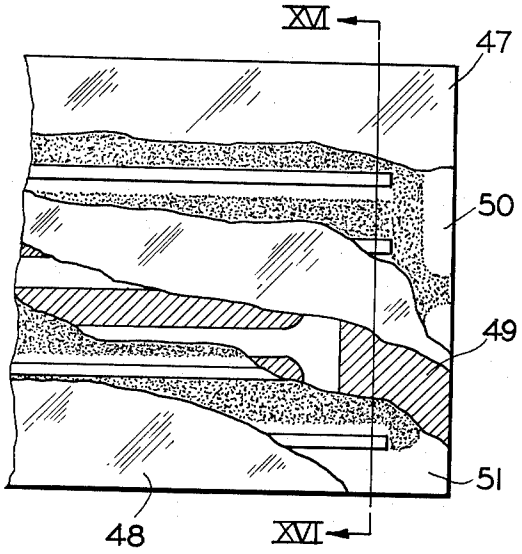


FIG - 15

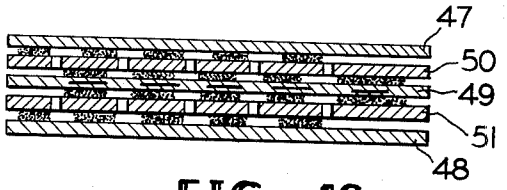


FIG - 16

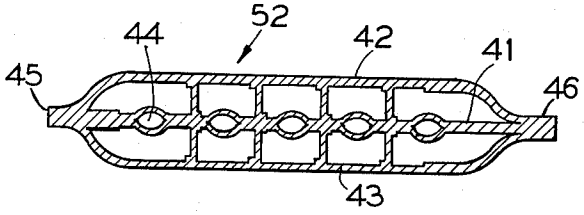


FIG - 17

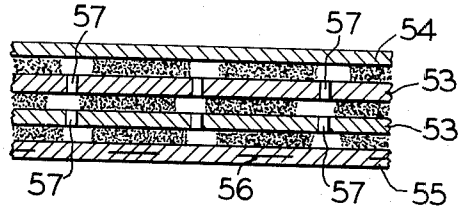


FIG - 18

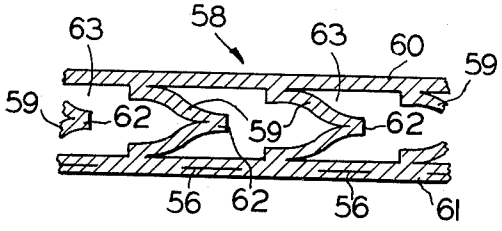


FIG - 19

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United States Patent Office 3,206,839 Patented Sept. 21, 1965

3,206,839

FABRICATION OF HEAT EXCHANGERS

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Filed May 9, 1961, Ser. No. 108,862
3 Claims. (Cl. 29—157.3)

This invention relates to the fabrication of hollow articles, and more particularly to the making of sheet metal heat exchangers.

In the manufacture of metal or plate-like heat exchangers, it is often desirable to utilize said heat exchangers in conjunction with one or more additional sheet metal structures or plates for various applications.

Typical of such applications are those in which it is often found desirable to have the heat exchanger formed with a duct-like structure defining a secondary passage for a heat transfer medium disposal externally of the heat exchanger. An example of such a structure is a duct for transmission and circulation of the air found in the food compartment of conventional refrigerators, with the heat exchanger forming the evaporator panel employed for the cooling of the air.

In other applications, it is often desirable to combine the heat exchanger and the sheet metal structure in the form of structural panels for use as wall separations in which the heat exchanger serves to condition the air adjacent thereto, as, for example, radiant heating of rooms of a home or for cooling the components of various structures, such as the interior of truck bodies.

Heretofore, the adaptation of sheet metal heat exchangers for such uses has involved the cutting, and the like, of a plurality of individual units or components with or without forming, assembling them together and then joining them together by welding, riveting and the like. However, irrespective of the manner in which these components have been assembled, the method involves the disadvantage of requiring the handling of large numbers of components in the assembly of the components and the proper relationship and register with each other. Further, such methods require the use of excess and additional material in the form of welds or rivets which appreciably increase the weight and cost of the desired fabricated unit.

Accordingly, it is an object of this invention to provide a method of making a novel heat exchanger having increased heat transfer capacity.

It is another object of this invention to provide a method of making a novel sheet metal heat exchanger having formed therewith an integrated duct extending along a face of said heat exchanger adapting it for use as a forced-convection-type heat exchanger.

It is still further the object of this invention to provide a method of making a novel sheet metal heat exchanger adapted for use as a structural panel.

Other objects and advantages of this invention will become more apparent from the following description and drawings in which:

FIGURE 1 is a partial view in perspective illustrating an assembly of component sheets in accordance with one embodiment of this invention;

FIGURE 2 is a partial view in perspective of a section illustrating a sheet component treated in accordance with the said embodiment of this invention;

FIGURE 3 is a partial view in perspective illustrating a section of the opposite face of the component depicted in FIGURE 2;

FIGURE 4 is a partial plan view in section illustrating an assembly of said components incorporating the embodiment depicted in FIGURE 2;

FIGURE 5 is a sectional view taken along lines V—V of FIGURE 4;

FIGURE 6 is a plan view, partly in section, illustrating one mode of treating the component depicted in FIGURE 2;

FIGURE 7 is a partial view in elevation illustrating the unification of the assembly of components depicted in FIGURES 4 and 5;

FIGURE 8 is a section view taken along lines VIII—VIII of FIGURE 7;

FIGURE 9 is a section side view of the blank of FIGURE 8 after partial distention thereof;

FIGURE 10 is a section view illustrating the section of FIGURE 9 having the outer components thereof disposed in their desired spaced relationship;

FIGURE 11 is a sectional side view illustrating the section of FIGURE 10 in its fully distended form;

FIGURE 12 is a sectional side view illustrating a modification of the embodiment depicted in FIGURE 11;

FIGURE 13 is a partial plan view in section illustrating a modified assembly of components for obtaining the embodiment depicted in FIGURE 11;

FIGURE 14 is a sectional view taken along lines XIV—XIV of FIGURE 13;

FIGURE 15 is a partial plan view in section illustrating an assembly of said components for obtaining another embodiment of this invention;

FIGURE 16 is a sectional view taken along lines XVI—XVI of FIGURE 15;

FIGURE 17 is a sectional side view illustrating the embodiment of FIGURES 15 and 16 after unification and distention; and

FIGURES 18 and 19 illustrate a still further embodiment of this invention in an assembled form and in a corresponding partially distended form.

Generally speaking, this invention comprehends the use, between a pair of outer sheet metal structures, of at least one inner sheet with at least one of the outer sheets formed or adapted for such forming by selective unification of adjacent portions of two or more superimposed component sheets, so as to define between the component sheets a pattern of unjoined areas corresponding to a desired system of fluid passages. In accordance with this invention, the inner sheet is treated to provide a plurality of appropriate slits by appropriate cutting of this inner sheet along a plurality of special lines extending across this sheet in a direction parallel to a pair of opposite edges thereof, so as to divide the inner sheet into a plurality of sections corresponding to the number of cross-members desired between the outer sheet metal structures.

In accordance with this invention, the cutting or slitting of the inner sheet will terminate sufficiently short of one or more edges, transverse the referred-to opposite edges, to provide an unslit marginal portion on the inner sheet between this edge or edges and the slit portion of the inner sheet. Thereafter, stop-weld or weld-inhibiting material is applied to both slides of these sections and the portions thereof designed to form the desired cross-members between the outer sheet metal structures. Subsequently, the inner sheet is assembled between the two outer sheet metal structures and the entire assembly pressure welded together in the adjacent areas of its components, not separated by stop-weld material, so as to form a unitary structure.

The outer walls or structures of the assembly are then spaced apart into their desired spatial relationship by any suitable means well-known in the art, such as mandrils, vacuum platens and by fluid inflation, under sufficient force to obtain the desired spatial relationship and to erect the sections of the inner sheet, between adjacent

slits, into the desired cross-members extending from and between the opposite walls of the resultant panel.

In accordance with this invention as will be pointed out herein, various shaped integral cross-members can be formed between opposed walls of the resultant panel. For example, the stop-weld material can be applied to each section of the slit inner sheet in a pattern provided so that, in the portions of all sheets adjacent one section of the inner sheet, the band of material between one pair of adjacent surfaces will be in adjacent and overlapping relationship to a band of the weld-inhibiting material between a successive pair of adjacent surfaces. By this pattern, the portions of each section adjacent diagonally opposed edges, defining them, become welded to adjacent sheets with the portions of the sections between the overlapping portions of the applied bands of weld-inhibiting material forming, upon pressure welding and distention, the desired cross-members integrally extending between the opposed walls of the resultant panel.

Referring to the drawings, FIGURE 1 illustrates a metal sheet component **1**, such as AA 1100 type aluminum alloy or AA 6061 type aluminum alloy clad with AA 1100 type aluminum alloy, which is to be assembled between a pair of outer sheet metal structures and from which component sheet **1**, the desired number of cross-members are to be formed to integrally connect with and extend between the walls of the desired panel. In accordance with one embodiment of this invention, one of the outer sheet metal structures is comprised of an outer component sheet **2**, whereas the other outer sheet metal structure is comprised of sheet metal components **3** and **4** between which is interposed a pattern of weld-inhibiting material **5**, which is applied to one of the adjacent faces of this pair of sheets, corresponding to the system of passages desired in the ultimate panel. The means of application of this pattern **5** of weld-inhibiting material may be applied in any conventional manner, as, for example, in accordance with the teachings of U.S. Letters Patent No. 2,690,002 granted on September 28, 1954, to L. H. Grenell.

In addition, the invention contemplates adapting the inner component sheet **1**, see FIGURE 2, for the formation of the desired cross-members by providing by any well-known means a plurality of spaced slits **6** necessary to divide the inner component sheet **1** into sections **7** corresponding to the number of cross-members desired between the walls of the ultimate panel. These sections **7** are obtained by slitting the inner component sheet **1** along a plurality of lines which are spaced from each other and which extend parallel to the pair of opposite edges **8** and **9** of the component sheet **1**. Generally, these slits will extend in a direction which will be longitudinal with the direction of subsequent rolling with the slit parallel to the lateral edges of sheet **1**. However, in accordance with this invention, the slitting will be terminated short of an edge **10** which extends transverse edges **8** and **9** so as to leave an unslit marginal portion **11** on inner sheet **1**, between edge **10** and the slit portions of sheet **1**. It is also contemplated that the slitting may be terminated short of the edge opposite to edge **11**, so as to leave an additional unslit marginal portion on sheet **1** wherein the slits form perforations or slots through this sheet. As will be understood, the selection of the specific manner of slitting will be dependent on a specific application to which the panel is to be put. As will also be understood, the slitting may be accomplished by various means well-known in the art, as, for example, by rotary cutting tool **12**, such as a saw, as depicted in FIGURE 6.

After the provision of slits **6** on sheet **1**, if necessary, the sheet may be given any suitable treatment such as a preliminary cleaning or wire brushing of the fraying surfaces in order to adapt the sheet for unification by welding. Thereafter, each of sections **7** of sheet **1** are coated with a suitable weld-inhibiting material, such as graphite in water glass, on both sides of the sections. As illustrated in FIGURES 2 and 3, duplicated on each of the sections are patterns of the weld-inhibiting material applied as bands **13** and **14** on both sides on each section. As shown, the bands of weld-inhibiting material **13** and **14** are applied so that they will be disposed adjacent diagonally opposed lateral edges defining each of the sections. As can be seen, the coating of weld-inhibiting material is applied to edge of section **7** so as to provide bands **15** and **16** free of weld-inhibiting material on the opposite sides of and disposed adjacent diagonally opposed lateral edges of each of the sections.

In the specific embodiment described, the bands of weld-inhibiting material **13** and **14**, on each of the sections of sheet **1**, are in staggered and overlapping relationship with the parts of each section between the overlapping portions of the weld-inhibiting material corresponding to the cross-members desired between opposed walls of the ultimate panel as depicted in FIGURE 5. In this embodiment, the marginal portion **11** of inner sheet **1** is shown to be uncoated with the stop-weld material. It is to be understood that this marginal portion **11** may be coated with this material if this portion is not desired to be welded during subsequent welding operations particularly where it is desired to utilize mechanical means for distention of the ultimate panel.

Subsequent to the application of the weld-inhibiting material, component sheet **1** is assembled between a pair of inner sheet metal structures, one comprised of component sheet **2** and the other of the pair comprised of component sheets **3** and **4**, to form an assembly of components **17** illustrated in FIGURES 1, 4 and 5. It is to be understood that the spacing and thickness of the various components in FIGURE 5 is illustrated in exaggerated form to denote more clearly the application of weld-inhibiting material between adjacent surfaces of component sheets **1**, **2**, **3**, and **4**, and each of the sections of the component of inner sheet **1**. Generally, the thickness of the weld-inhibiting material employed will be of the order of 0.001 of an inch which will be the distance of the spacing between the various component sheets. However, as will be obvious, smaller or greater thicknesses of weld-inhibiting material may be employed between the various component sheets. In addition, to illustrate the general thicknesses of the component sheets, one unit of this embodiment of the invention was obtained with sheets **1**, **2**, **3**, and **4** having thicknesses, respectively, of 0.169, 0.127, 0.127 and 0.17 of an inch. Also, although in this embodiment each of sections **7** have been illustrated as being equal width, it is to be understood that where a panel of angular dimensions is desired the width of the sections of component sheet **1** would be progressively decreased.

After assembly of the various components as illustrated in FIGURES 1, 4 and 5, they may be suitably secured together against separation in any appropriate manner, not shown, as by spot welding to the corners of the stack, or by any other suitable manner.

Although specific aluminum alloys have been referred to in the foregoing example, it is to be understood that a variety of metals may be employed depending not only upon economic consideration, but particularly upon the specific application to which the ultimate panel is to be put. Thus, the ultimate panel of this invention can be made from other aluminum alloys including heat treatable alloys, copper alloys, titanium, zirconium, steel, or similar alloys. Similarly, any weld-inhibiting material capable of preventing welding of juxtaposed surfaces may be substituted for a specific weld-inhibiting material described above.

Also, the metal sheets employed may be of any combination of metals for any desired application. For example, if the panel is to be employed as a structural panel in the fabrication of walls for buildings, it is generally preferred that the panel be not only lightweight, but, in addition, resistant to the elements. Similarly,

a lightweight panel is also desired where the panel is to be employed, as indicated above, as a forced-convection-type heat exchanger for application in refrigeration systems. In this last application, the cross-members extending between the outer sheet metal structures function to extend the surfaces of the evaporator for heat transmission, and wherein the open areas between the outer surfaces serve as ducting for movement of air within a refrigerator; and as will be understood the system of passageways within one or more of the outer wall structures serves to provide the desired network of passages for the flow of the refrigerant required for cooling the air in a refrigerator. In such applications, it is readily seen that aluminum is not only suitable but preferred since it is both relatively light in weight and resistant to oxidation.

However, if the resultant panel is intended for use as a structural panel in applications which require it to withstand any type of a severe loading force, it is readily seen that the panel will be of heavier gauge or of other metal or of a combination of the two. Thus, if the panel is intended for heavier application such as a floor bed supporting heavy weights, the panel may be formed of steel and the like. In addition, where the panel is intended for application for forming bodies of refrigerated trucks and the like, it will be understood that the panel may be formed of steel, whereas where the panel is employed for the side walls it may be formed of aluminum.

Similar variables also apply with respect to the specific gauges of the metals employed, since the thickness of the metal will vary according to the application intended for the final fabricated unit. Accordingly, the gauges of the components may be selected to give a uniform cross-sectional thickness in all of the components, or any desired variation in thickness between the outer walls and interconnecting webs or legs which the cross-members form extending between the outer walls. In like manner, the components may be selected from various combinations of metals to provide physical properties in the outer surfaces distinguishable from the physical properties in the cross-members between them as, for example, to provide elongation with sufficient retention of hardness in the cross-members.

Subsequent to securing the various sheet components together against separation, the pack **17** is then ready for pressure welding together of the components in accordance with conventional practices. Typical practices by which the panel may be welded together are set forth in the well-known process for fabricating hollow panels such as refrigerator heat exchangers and the like disclosed in the aforesaid U.S. Letters Patent to Grenell, No. 2,690,002.

In accordance with conventional practice, the secured assembly of components may be heated in a suitable furnace to appropriate pressure welding temperatures, for example about 900° F. for components of aluminum alloys. Thereafter, the pack is rolled between a pair of mill rolls **18** and **19**, see FIGURE 7, to effect sufficient reduction, such as about 65% for aluminum alloys, necessary to pressure weld all-adjacent areas in the stack not separated by weld-inhibiting material. This pressure welding results in a substantially complete erasure of the interfaces between the components by inter-dispersion of the grains between adjacent surfaces. The resultant juncture is usually characterized by tensile strength equal to that of other seamless regions of the blank. As will be understood, the amount of reduction required to effect pressure welding will vary with the particular combination and the physical properties of the various combinations of component sheets employed. Generally, a reduction of the order of 35% will accomplish pressure welding of adjacent surfaces not separated by weld-inhibiting material. However, it will be understood that lower or higher percentage reductions may be sufficient or required with different metals and/or different temperatures employed in the pressure welding operation.

By reference to the resultant blank **20** of FIGURES 7 and 8, it can be seen that portions of each of the sections of the inner component sheet **1** are welded to the outer sheet metal structures adjacent to each side of sheet **1** with the areas of the adjacent surfaces separated by weld-inhibiting material remaining unwelded to provide laminations within the blank in accordance with the pattern of weld-inhibiting material utilized. Accordingly, the band **15** devoid of weld-inhibiting material applied on one side of the sections of component sheet **1** results in a pressure welding of this portion of the sections to the outer sheet metal structure, comprised of sheet **2** adjacent thereto, as at **21**, whereas the adjacent surfaces between sheet **1** and sheet **2** separated by weld-inhibiting material, results in laminations **22** between them. Similarly, the sections of inner component sheet **1** are pressure welded at **23** to component sheet **3** adjacent the other side of sheet **1** while leaving unwelded portions defining the laminations **24**. Similarly, portions of the adjacent surfaces between component sheets **3** and **4** of the other outer sheet material structure become welded at **25** in their areas not separated by weld-inhibiting material, whereas those areas separated by the material result in a pattern of laminations **26** extending in a pattern corresponding to the desired system of fluid passages.

As indicated in FIGURE 8, during pressure welding portions of component sheets **2** and **3** may be extruded into the slots formed by the slitting. Where severe reductions are employed in a pressure welding operation, the extruded portions of component sheets **2** and **3** may be lightly tacked or welded to the surfaces defining the slots or perforations provided in inner component sheet **1**. Such tack welding across or within the slots will produce welds of relatively much weaker strength compared to the welds obtained between other adjacent surfaces of the various component sheets. In subsequent separation or spacing apart of the outer sheet metal structures of pressure welded blank **20**, the force employed in such separation will literally tear apart the weak weld formed in the slots without in any manner affecting the desired weld between the various component sheets. If desired, and preferably, the formation of these weak welds across and in the slots can be prevented by the application of a small amount of weld-inhibiting material on the surfaces of the slot or by filling the slots with weld-inhibiting material prior to pressure welding.

By application of the weld-inhibiting material to the inner component sheet **1**, as sectionalized in accordance with this invention, the component sheets of the stack **17** become selectively welded together to form a plait or a plaited portion **27** of an embryonic or undeveloped cross-member **28**, see FIGURE 9, extending between and integral with the outer walls **29** and **30** of the resultant unit **31**. Thus, as can be seen, the particular pattern of weld-inhibiting material employed adjacent the inner component sheet **1** and between component sheets adjacent thereto defines and forms a continuous section of an unwelded portion of metal, comprising the plaited portion **27**, folded over upon itself. During subsequent distention, these plaited portions are caused to unfold to form the desired cross-members **28** extending between and integral with the walls of the structural panel.

After pressure welding, the pressure welded blank **20** is ready for distention to separate the outer sheet metal structures **29** and **30** from each other. However, if desired, prior to distention, the blank **20** may be softened in any appropriate manner as by annealing for removing the effects of mechanical working, and thereafter cold-rolled to provide a more uniform thickness or to final gauge, and again annealed. After treatment to obtain the specific conditions desired in the pressure welded blank, the outer walls **29** and **30** may be separated into the spacing desired between them by driving into

the laminations a suitable mandril, not shown, whose dimensions are graduated from a thin opening edge into a configuration corresponding to the configuration of the openings 32 formed in the resultant panel 33.

Alternately, any other suitable means may be employed within or to the surfaces of the pressure welded blank 20 to separate the outer walls and to unfold the plaited portions of cross-member 28. For example, where the separation of the outer walls is desired to be accomplished with fluid pressure, the assembly of components in stack 17 may be adapted to provide a fluid tight pressure welded blank adapted to contain a fluid under pressure in accordance with the teachings set forth in U.S. Letters Patent No. 2,766,514 granted on October 16, 1956, to R. F. Adams, or in accordance with the teachings set forth in co-pending application Ser. No. 823,960 filed by Wallace C. Johnson on June 30, 1959, now United States Patent 3,111,747, issued November 26, 1963.

Distention of the panel in this latter manner can be utilized to advantage by simultaneous expansion of the pattern of laminations 26 into the desired system of fluid passages 35, see FIGURE 11, simply by insertion of an inflation needle, not shown, into an inlet lamination at an edge of the blank 20, which inlet lamination may be provided by an extension 34 of the pattern of stop-weld material 5 applied to the component sheet 4. Such simultaneous expansion may be readily obtained by simple manifolding of the fluid injecting means utilized in expanding the laminations 26, contained in wall 30 and the fluid injecting means employed for separating the walls 29 and 30 into the desired spatial relationship between them. This expansion of the fluid passages 35 and erection of the cross-members 28 between outer wall structures 29 and 30 of the pressure welded blank 20 may be accomplished without any external restraint against expansion or the blank may be distended between opposed rigid platens or surfaces, with the specific configuration of the embodiment illustrated in FIGURE 11 attained by an expansion without use of any external restraint against it. However, it will be noted that irrespective of use or non-use of restraint against expansion, the passages become distended so that a portion of the walls of said passages which are adjacent to the other outer wall structure are bulged in a convex configuration. In other words, the walls of the fluid passages 35 which remain disposed within the panel have an elliptical configuration.

In addition, it will be understood that the spatial relationship between outer walls 29 and 30 may be such that no elongation is induced in cross-members 28, or to a spatial relationship which will cause the cross-members to elongate. As a result of the manner by which panel 33 is obtained upon separation of the outer walls to the desired spatial relationship, these walls will have in each adjacent pair of laterally extending flanges a portion 36 of one extending beyond and further than the other. In order to provide a uniform panel the extending portion 36 of the overlong flange may be suitably trimmed along line 37.

FIGURE 12 illustrates a modification 33' of the preceding embodiment in which both outer walls 29 and 30 are provided with a system of fluid passages 35 and 35'. This additional system of passageways may be obtained by applying to the external face of said component sheet 2 a duplicate of the pattern of weld-inhibiting material 5 applied to said component sheet 4 or, where desired, a different pattern of the system of fluid passages desired, and then superimposing an additional metal sheet on component sheet 2. In addition, this modification depicts the external configuration of passages 35 and 35' when the pressure welded blank for this modification is expanded between opposed rigid platens or surfaces. In addition, it will be noted that the walls of the passages of 35 and 35' disposed within panel 33 have a convex or elliptical configuration.

Although the preceding embodiments included the fabrication of a system of fluid passages in one or more of the outer wall structures simultaneously with the fabrication of the desired panel itself, FIGURE 13 illustrates an additional modification wherein one of the outer sheet metal components 38 is initially formed by unification of two or more component sheets together about a fluid passageway pattern of weld-inhibiting material 39 prior to placement in the assembly or stack 40. The fabrication of the internally laminated outer wall structure 30 may be obtained by any of the well-known methods and particularly by the teachings set forth in the aforesaid U.S. Letters Patent to L. H. Grenell.

FIGURES 15 through 17 illustrate a further modification of this invention by which is obtained a three walled structure with each wall interconnected by integral cross-members with the inner metal wall 41, see FIGURE 17, disposed between two outer walls 42 and 43 with only the inner wall 41 provided with a system of fluid passages 44. Further, this modification is obtained with the marginal portions of the sheet metal components abutting the pair of common edges 45 and 46 integrated together as by welding. As will be observed in FIGURES 15 and 16, this modification is attained by superimposing a sheet metal component 47 and 48 adjacent and opposite each face of an internally laminated wall component 49 with an inner sheet 50 interposed between component sheets 47 and 49 and an inner sheet 51 interposed between component sheets 48 and 49. As discussed above, each of the inner sheets 50 and 51 are suitably slit and coated with stop-weld material in accordance with the preceding embodiments. Unification of the marginal portions adjacent to common edges 45 and 46 may be obtained as discussed above in accordance with the aforesaid U.S. Letters Patent granted to R. F. Adams or by the teachings set forth in the aforesaid co-pending application of Wallace C. Johnson, now United States Patent 3,111,747. Unification of the various components and distention of the resultant blank between opposed rigid surfaces results in a resultant blank such as 52 illustrated in FIG. 17.

FIGURES 18 and 19 illustrate still another modification of the preceding embodiments in which two identical inner component sheets 53 are employed between two outer sheet metal structures 54 and 55 with one of the structures being internally laminated at 56 in accordance with the system of fluid passages desired in the ultimate panel. As will be observed, each of the inner component sheets are divided into a plurality of sections by slitting at 57 with a pattern of weld-inhibiting material applied to provide bands of it at each successive pair of adjacent surfaces at successive alternate edges defining the sections of the inner component sheets. This modification results in a panel 58 having interconnecting cross-members 59 between outer walls 60 and 61, with the system of laminations 56 in the wall 61 remaining in their undistended form. The panel is shown in partially distended form as panel 33' in FIGURE 11 to illustrate the unfolding of the plaited portions formed as a result of this modification, and to illustrate the attainment of flanges 62 which are projected from the sides of the cross-members 59. The provision of the flanges 62 provides additional advantage when the unit is desired to be employed as a heat exchanger, since these flanges can be made to extend the surfaces of the heat exchanger so as to serve as fins for the transmission of heat from and into heat exchanger mediums employed in the tubular cross-sections 63 which are formed between the outer walls 60 and 61 and the tubular cross-sections which will be formed upon distention of the laminations 56.

Although the invention has been described with reference to specific embodiments, materials and details, various modifications and changes within the scope of the invention will be apparent to one skilled in the art and are contemplated to be embraced within the invention.

What is claimed is:

1. The method of making a hollow article of the character described, comprising,

(A) forming a first outer sheet by

(1) superposing a first component sheet upon a second component sheet, and

(2) interposing a weld-inhibiting material between said first and second component sheets in a pattern corresponding to a desired system of fluid passages,

(B) forming at least one inner sheet with a plurality of spaced-apart sections by slitting said inner sheet along a plurality of lines,

(1) said lines being spaced from each other across the width of said inner sheet,

(2) said lines extending along the length of said inner sheet for substantially the full extent thereof,

(3) said lines terminating sufficiently short of an edge of said inner sheet to provide an unslit marginal portion along the width of said inner sheet joining one end of each of said sections,

(C) partially coating said sections with weld-inhibiting material, with said coating applied to each of said sections in a pattern providing on each side of said section a band of said material along the length of said section and a band free of said material along the length of said section, said bands of material at successively alternate lateral edges defining said sections on one side of said section with like bands on the opposite side thereof in staggered and overlapping relationship,

(D) superposing said first outer sheet and said inner sheet upon a second outer sheet,

(E) pressure welding said superposed first outer sheet, inner sheet, and second outer sheet to unify the portions thereof not coated by weld-inhibiting material,

(F) spacing apart said first and second outer sheets into the desired spaced relationship, and

(G) expanding said first outer sheet to form the desired system of fluid passages,

whereby said sections of said inner sheet will form integral cross-members extending transversely between said first and second outer sheets.

2. The method of claim 1 wherein at least two inner sheets are interposed between said outer sheets, with the spaced-apart sections of one inner sheet being in juxtaposed relationship to the corresponding spaced-apart sections of the inner sheet adjacent thereto.

3. The method of claim 1 wherein said first and second component sheets are unified together prior to superposition on said inner sheet and second outer sheet.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,206,839 September 21, 1965

Lester J. Tranel et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 59, for "slides" read -- sides --; column 4, line 49, after "being" insert -- of --; column 6, line 23, for "material" read -- metal --.

Signed and sealed this 17th day of May 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents