July 11, 1950 T. E. BURKHARDT 2,514,469

METHOD OF FABRICATING HEAT EXCHANGERS

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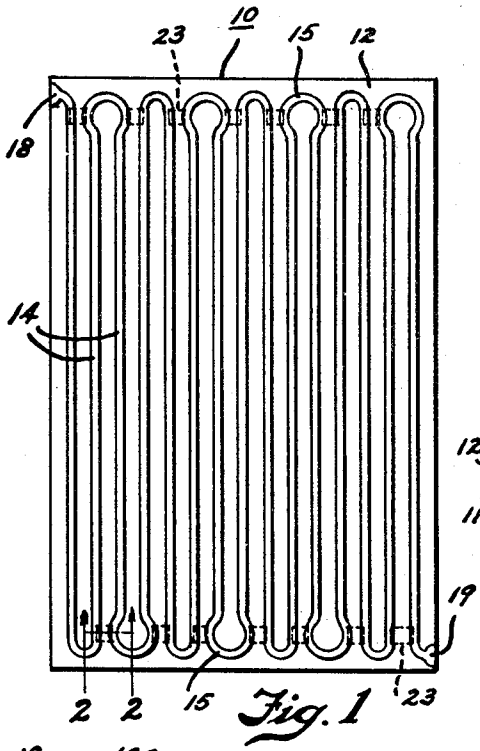


Fig. 1

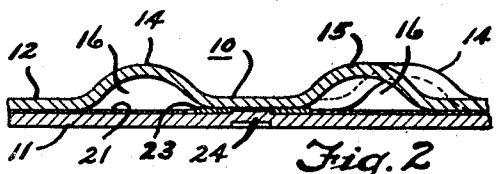


Fig. 2

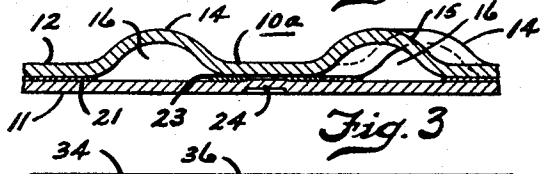


Fig. 3

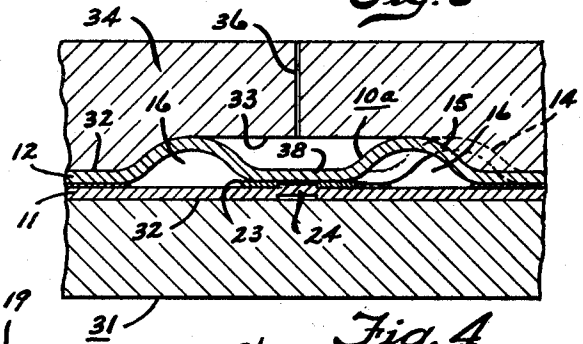


Fig. 4

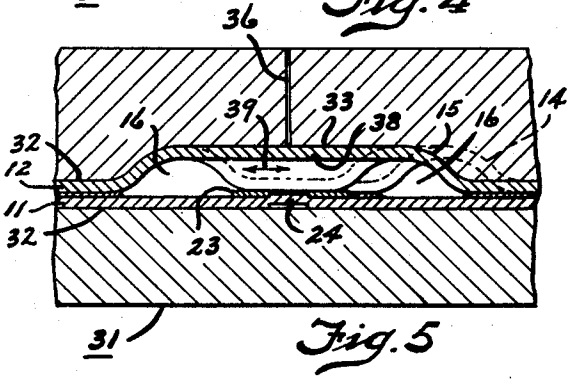


Fig. 5

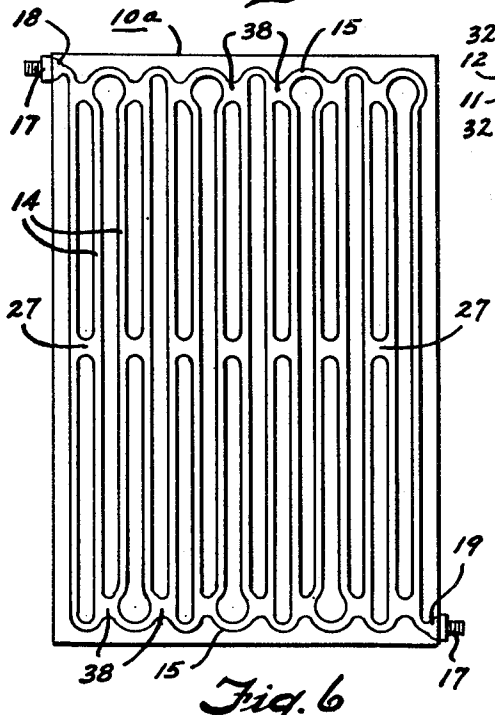


Fig. 6

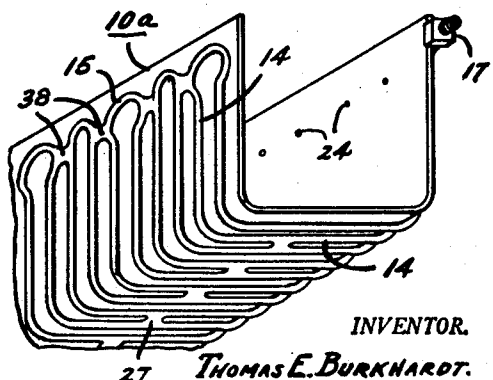


Fig. 7

INVENTOR.
THOMAS E. BURKHARDT.
BY
Spencer Hardman & Fehr.
HIS ATTORNEYS

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METHOD OF FABRICATING HEAT EXCHANGERS

Thomas E. Burkhardt, Dayton, Ohio, assignor to General Motors Corporation, Dayton, Ohio, a corporation of Delaware

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This invention relates to refrigeration and particularly to closed heat exchanger elements employed in refrigerating systems.

An object of my invention is to provide a sheet metal heat exchanger for use in refrigerating systems that will be of improved appearance, more efficient and of lower manufacturing cost.

Another object of my invention is to provide an inexpensive successful method of fabricating a sheet metal heat exchanger from aluminum and/or aluminum alloy sheets whereby the use thereof in a refrigerating system is rendered practical.

A further and more specific object of my invention is to provide a method of fabricating an evaporator for a refrigerating system from metal sheets, one of which is provided with a continuous corrugation to form, when the sheets are heated and bonded together, a series flow passageway between the sheets and to prevent selected or predetermined points of the sheets from being secured to one another, while certain other portions of the sheets are being bonded together, whereby the unsecured or unbonded portions of one of the sheets may be deformed or expanded to provide conduits interconnecting runs of the continuous corrugation in the other sheet and thereby divide the series flow passageway into a plurality of parallel flow passageways.

Further objects and advantages of the invention will be apparent from the following description, reference being had to the accompanying drawing wherein an article fabricated in accordance with the present method is illustrated.

In the drawings:

Fig. 1 discloses a metal sheet having a continuous corrugation formed therein superimposed upon a flat metal sheet with a bonding material therebetween and showing inserts at predetermined points between the sheets.

Fig. 2 is an enlarged fragmentary sectional view taken on the line 2—2 of Fig. 1 showing the superimposed plate-like structure with a bonding shim and one of the inserts between the metal sheets.

Fig. 3 is a view similar to Fig. 2 showing the elements of the double walled plate-like structure after being bonded together.

Fig. 4 is a fragmentary sectional view of the bonded structure showing confinement thereof prior to the application of pressure internally of the double walled structure.

Fig. 5 is a view similar to Fig. 4 and shows the deformation of a part of one wall of the bonded together double walled structure.

Fig. 6 discloses the bonded together double walled structure with the deformed parts of one wall thereof forming conduit connections across the runs of the series or continuous corrugation; and

Fig. 7 is a fragmentary view showing the bonded together structure disclosed in Fig. 6 bent or folded into a substantially U-shaped heat exchanger.

For the purpose of illustrating my invention, I will describe the manufacture of a closed or fluid type heat exchanger such, for example, as an evaporator or cooling element for use in refrigerating systems. Referring to Fig. 1 of the drawing, I have shown a substantially flat plate-like unit 10 comprising superimposed metal sheet portions 11 and 12 (see Fig. 2). The sheet portions 11 and 12 may be two separate metal sheets or the superimposed unit 10 may be formed by bending or folding a part of a single metal sheet over and upon another part of the same sheet. The edge portions of one of the metal sheets may, if desired, be folded over the edge portions of the other metal sheet to better seal the unit 10. A continuous corrugation or embossation is stamped or rolled, in any suitable and well-known manner, in one of the sheet metal portions 12 and extends in spaced apart adjacent runs or convolutions 14 substantially throughout the length of unit 10. The return bends of alternate runs or convolutions may be larger in radius than other of the return bends as indicated at 15 in Fig. 1 so as to position the return bends of the runs 14 closer to one another for facilitating the carrying out of the process to be hereinafter described. The continuous corrugation provided in the one sheet metal portion 12 forms, when this sheet portion is superimposed upon sheet portion 11, a series flow passageway 16 (see Fig. 2) between the sheet portions 11 and 12 and this passageway has an inlet opening 18 and an outlet opening 19 located at the longer edges of the unit 10 (see Fig. 1).

A bonding material, indicated at 21 in Fig. 2 of the drawing, is located between the superimposed sheet metal portions 11 and 12. This bonding material may be brushed on the adjacent surfaces of the sheets 11 and 12 or the bonding material may be in the form of a shim or foil placed between the sheet metal portions 11 and 12. In the present method it is desirable to prevent bonding of all portions of the adjacent surfaces of the sheet portions 11 and 12 and various ways of avoiding bonding of selected or predetermined points or parts of the adjacent surfaces of the sheet portions may be employed while the unit 10 is being heated to melt the bonding ma-

terial and cause bonding of the sheet portions 11 and 12 together. In order to carry out the preventing of bonding of selected points of adjacent surfaces of the sheet portions 11 and 12 such points on the surfaces of the sheets may be plated or coated with any desired or suitable substance to render them incapable of being secured together by the bonding material employed. For example, these points may first be plated with copper or zinc and thereafter covered or coated with chromium by plating the chromium over the copper or zinc. However, in the present disclosure I cause these selected points, between the sheets 11 and 12, to remain unbonded during heating of the unit 10 by providing a block or restriction to the flow of the bonding material over the selected adjacent surfaces. These blocks may be in the form of discs or square or rectangular washers 23, as herein illustrated, placed between the sheet portions 11 and 12 (see Fig. 2) at the selected points indicated by the dotted line showing of the washers 23 in Fig. 1. While I have shown the washers 23 as being located at the return bends 15 of the runs 14 of the continuous corrugation, it is to be understood that they may be positioned at any desired points along the runs 14. The washers or inserts 23 may be secured in the desired locations or selected points in any suitable manner such as being spot welded to the one sheet 11 or by staking some of the material of the metal sheet portion 11 into the opening in washers 23 as indicated by the reference character 24 in Fig. 2 of the drawing. In the case of utilizing the bonding material 21 in shim or foil form, the shim 21 will preferably be cut out or provided with holes for straddling the washers 23. The bonding shim or bonding material 21 may have a suitable flux admixed therewith or incorporated therein or the fluxing material may be brushed on or plated upon the surfaces to be bonded together as is common practice in the brazing art.

After the unit 10 is assembled in the manner aforesaid it may be placed in or passed through a suitable or conventional furnace, such as is fully described in the S. M. Schweller Patent No. 2,067,208 or in the C. A. Mann Patent No. 2,093,814 and bodily heated to a temperature sufficient to cause melting of the bonding shim 21, in the presence of the fluxing material by radiant heat. In this manner uniform heating and bonding together of all adjacent surface portions of the sheets 11 and 12 is obtained except at the selected points of location of the washers 23. The bonding material will not flow over or upon a chrome plated surface and will not stick or bond thereto, thus the washers or inserts 23 are preferably plated with chromium. The washers 23 may be tightly pressed between adjacent surfaces of the sheet metal portions 11 and 12 by weights or any other suitable means during heating of unit 10 to effectively prevent flow of the fused bonding material 21 over the flat selected surfaces of sheet portions 11 and 12 contacted by the washers and consequently these selected surfaces or points remain or will be left unbonded or unsecured together while other adjacent surfaces thereof are bonded. Bonding of the sheet portions 11 and 12 together in the manner described provides an integral structure 10*a* (see Fig. 3), having the closed series flow passageway 16 formed therein. After the structure 10*a* has cooled, suitable fittings 17 (see Fig. 6) may be hand brazed in the inlet and outlet

openings 18 and 19 respectively of the passageway 16. These fittings 17 permit the connection of the passageway 16 with a suitable pumping apparatus which pumps a cleaning or solvent solution, under pressure, through the series flow passageway 16 to dissolve and remove from the passageway any residue of the flux which may have deposited therein during bonding of the sheet portions 11 and 12 together. The cleaning solution is provided with a positive path of flow through sturcture 10*a* and since there are no traps or pockets in the series flow passageway 16 which are not contacted by the solution, a thorough cleansing of this passageway is insured. The structure 10*a*, after having the series flow passageway 16 extending therethrough thoroughly cleaned out, is placed in a suitable mold or holding tool represented by the reference character 31 (see Fig. 4). The tool 31 is provided with wall portions 32 clamping and confining the bonded together parts of the structure 10*a* in place. Tool 31 is also provided with wall portions 33 extending across the unbonded portions or selected points at which the washers 23 are located. The one part 34 of the holding tool 31 is provided with a bleeder opening 36 extending from the wall 33 to the atmosphere outside the tool for a purpose to be presently described. One one of the series flow passageway is plugged and a suitable or conventional hydraulic or other pressure creating device (not shown) is connected to the other end of the series flow passageway 16. This device establishes a sufficiently high pressure internally of the passageway 16 of structure 10*a* to cause the wall parts of sheet portion 12, indicated at 38 in Figs. 4 and 5 of the drawing, at the unbonded selected points to be forced or deformed outwardly away from the sheet portion 11 against the wall portions 33 of the tool 31 as shown in Fig. 5. The deformation of the wall 38 provides passages, indicated by the double-headed arrow 39 in Fig. 5, interconnecting the passageways 16 of adjacent runs 14 of the continuous corrugation and these interconnecting passages 39 may be formed at any point or at a plurality of points along the length of the corrugated runs 14. For example, washers 23 may be located along the straight runs or ducts 14 intermediate the return bends 15 to provide interconnecting passageways as shown at 27 in Fig. 6. Such intermediate passageways 27 would be disposed along the bottom wall of the evaporator illustrated in Fig. 7 of the drawing to thereby divide the parallelly connected passageways into a plurality of shorter parallel flow passageways. Any air entrapped under the wall portions 33 of tool 31, during the application of pressure internally of structure 10*a*, will escape through the hole 36 to permit the wall parts 38 to be corrugated or forced outwardly of the washers 23 and against the wall portions 33 of the tool. This deformation or corrugation of the wall parts 38 of structure 10*a* occurs at the selected points of location of the washers 23 shown in dotted lines in Fig. 1 of the drawing and transforms or changes the series flow passageway 16, extending through the structure 10*a*, into a plurality of parallelly connected or communicating passageways between the inlet 18 and the outlet 19 of the sheet metal structure as clearly illustrated in Fig. 6. During and after deformation of the wall parts 38 of the bonded structure 10*a*, as described, washers 23 will remain secured to the sheet portion 11 of the structure due to the staking of metal of the sheet 11

into the central opening of the washers and consequently these washers will not interfere with flow of refrigerant in or through the plurality of parallelly connected passageways. The bonded structure 10a shown in Fig. 6 of the drawing may be bent or rolled into any desired shape such, for example, as into a substantially U-shape, as shown in Fig. 7, which is common practice to form an evaporator for household refrigerating cabinets and which U-shaped evaporator provides walls of a sharp freezing chamber, for the reception of trays of water or other substance to be frozen by the refrigerating effect produced by the evaporator. In the form of evaporator shown in Fig. 7 of the drawing the pressure formed corrugations 38 connecting the return bends 15 of the runs 14 of the passageway 16 provide a header at the upper end of each leg of the U-shaped evaporator for the free and unrestricted circulation of refrigerant through the plurality of parallelly connected passageways. After forming the structure into the U-shape illustrated, or into any other desired shape, the appearance of the exterior walls of the evaporator may be enhanced by coating or plating the surfaces thereof in any well known or conventional manner.

While the method herein disclosed may be employed to fabricate evaporators or condensers from various sheet materials, it is especially adaptable to the fabrication of such elements from aluminum or aluminum alloy sheets, whereas such fabricating has heretofore been impractical. In an evaporator wherein the flow of refrigerant is desired through a plurality of parallelly connected passageways, ordinarily preformed in one of the sheets from which the evaporator is fabricated, such passageways could not be properly cleaned out after the bonding operation and flux residue or deposits remaining in the passageways would, upon charging refrigerant into the evaporator, or into the refrigerating system, form with the deposits certain acid compositions or the ike. These acids corroded the aluminum sheets and would cause their decomposition in short time. In practicing my improved method thorough cleansing of flux residue from the interior of the evaporator is, by virtue of the preformed series flow passageway, insured and which passageway is thereafter deformed to provide the desired number of parallelly connected passageways. The present method therefore permits the utilization of relatively inexpensive rolled sheets of aluminum or aluminum alloy in the fabrication of heat exchangers. This material is more desirable than certain other materials, due to its good heat conducting properties and its non-corrosive properties. A neat appearing and lasting finish can be provided on the exterior surfaces of heat exchangers fabricated from aluminum sheets. I may employ aluminum sheets ranging from substantially pure aluminum to aluminum alloy sheets having a chemical composition of .2 to .12% copper, 0 to .5% iron, 0 to .7% silicon, 0 to 1.25% manganese, 0 to .5% zinc, 0 to .35% chromium, 0 to 2.8% magnesium and the remainder pure alumium. Any aluminum sheet composition within the limits specified may be effectively and practically anodized with any of the presently known anodizing apparatuses or processes. Therefore, I anodize the exterior surfaces of the evaporator shown in Fig. 7 of the drawing so as to provide these surfaces with a uniform bright

appearance. In the use of aluminum sheets the discs or washers 23 are preferably made of steel material and chrome plated so as not to be affected by the refrigerant in the evaporator whereby these washers will not cause corrosion or deterioration within a refrigerating system. In order to bond the desired portions of the sheets together by a process involving radiantly heating the entire exposed surfaces of the superimposed aluminum sheets I may employ an aluminum bonding or brazing alloy having the chemical composition of approximately 2.3 to 5% copper, 0.8% iron, 1 to 10% silicon, .15% manganese, .20% zinc, .15% chromium, .15% magnesium and the remainder pure aluminum. It should be understood that these ingredients of the brazing or bonding material may be varied in accordance with the chemical composition of aluminum sheets to be bonded together. One example of a flux suitable for causing bonding of the aluminum sheets together with the bonding material specified may be a compound consisting of eighteen parts lithium chloride, ten parts zinc chloride, four parts stearic acid, thirty parts potassium chloride and eight parts aluminum acetate. Another flux suitable for causing bonding of the aluminum sheets together and which may be in liquid or paste form and when dry has a composition of approximately 32% sodium chloride, 24% potassium chloride, 24% lithium chloride and 20% sodium fluoride. It is also to be understood that the ingredients of the fluxing compound may be varied in accordance with variations in the composition of both the aluminum sheets and the bonding or brazing alloys employed.

In view of the foregoing the objects of my invention become obvious in that I provide a method of fabricating flat aluminum or aluminum alloy sheets into evaporators and/or condensers for use in refrigerating systems, as distinguished from cast or extruded aluminum to greatly reduce manufacturing costs of such heat exchangers.

I claim:

1. The method of making a closed heat exchanger for a refrigerating system which consists in, forming a continuous corrugation having a plurality of spaced apart runs connected in series by return bends in a sheet metal portion and superimposing the corrugated sheet portion upon another sheet metal portion with a bonding material therebetween whereby the corrugation initially provides a series flow passageway between the sheet portions, uniformly applying heat simultaneously over the entire exposed surfaces of the superimposed sheet portions to melt the bonding material and bond surfaces of the sheet metal portions around said continuous corrugation together, preventing surfaces of said sheet metal portions at selected localities intermediate said return bends and extending between certain adjacent spaced apart runs of said series flow passageway from being bonded together, directing a cleaning fluid through said series flow passageway to remove foreign matter from the interior of the exchanger while preventing fluid flow between said certain runs at said selected localities, and thereafter applying pressure internally of said passageway to expand one of said sheet metal portions at said unbonded selected localities whereby said series flow passageway is divided into a plurality of parallel flow passageways.

2. The method of making a closed heat ex-

changer for a refrigerating system which consists in, forming a continuous corrugation having a plurality of spaced apart runs connected in series by return bends in a sheet metal portion and superimposing the corrugated sheet portion upon another sheet metal portion with a bonding material therebetween whereby the corrugation initially provides a series flow passageway between the sheet portions, uniformly applying heat simultaneously over the entire exposed surfaces of the superimposed sheet portions to melt the bonding material and bond surfaces of the sheet metal portions around said continuous corrugation together, preventing surfaces of said sheet metal portions at selected localities extending between adjacent return bends of said series flow passageway from being bonded together, directing a cleaning fluid through said series flow passageway to remove foreign matter from the interior of the exchanger while preventing fluid flow between adjacent return bends at said selected localities, and thereafter confining the bonded together surfaces of the sheet metal portions and applying pressure internally of said passageway to expand one of said sheet metal portions at said unbonded selected localities to provide a header communicating with said return bends.

3. The method of making a closed heat exchanger which consists in, forming a continuous corrugation having a plurality of spaced apart runs connected in series by return bends in an aluminum sheet portion and superimposing the corrugated aluminum sheet portion upon another aluminum sheet portion with a bonding material therebetween whereby the corrugation initially provides a series flow passageway between the sheet portions, uniformly applying heat simultaneously over the entire exposed surfaces of the superimposed aluminum sheet portions to melt the bonding material and bond surfaces of the sheet portions around said continuous corrugation together, preventing surfaces of said aluminum sheet portions at selected localities intermediate said return bends and extending between certain adjacent spaced apart runs of said series flow passageway from being bonded together, directing a cleaning fluid through said series flow passageway to remove foreign matter from the interior of the exchanger while preventing fluid flow between said certain runs at said selected localities, and thereafter applying pressure internally of said passageway to expand one of said aluminum sheet portions at said unbonded selected localities whereby said series flow passageway is divided into a plurality of parallel flow passageways.

4. The method of making a closed heat exchanger which consists in, forming a continuous corrugation having a plurality of spaced apart runs connected in series by return bends in an aluminum sheet portion and superimposing the corrugated aluminum sheet portion upon another aluminum sheet portion with a bonding material therebetween whereby the corrugation initially provides a series flow passageway between the sheet portions, uniformly applying heat simultaneously over the entire exposed surfaces of the superimposed aluminum sheet portions to melt the bonding material and bond surfaces of the sheet portions around said continuous corrugation together, preventing surfaces of said aluminum sheet portions at selected localities extending between adjacent return bends of said series flow passageway from being bonded together, directing a cleaning fluid through said series flow passageway to remove foreign matter from the interior of the exchanger while preventing fluid flow between adjacent return bends at said selected localities, and thereafter confining the bonded together surfaces of the aluminum sheet portions and applying pressure internally of said passageway to expand one of said aluminum sheet portions at said unbonded selected localities to provide a header communicating with said return bends.

5. The method of making a closed heat exchanger which consists in, forming a continuous corrugation having a plurality of spaced apart runs connected in series by return bends in a sheet metal portion and superimposing the corrugated sheet portion upon another sheet metal portion with a bonding material therebetween and with inserts of a material that will not bond to said sheet metal portions or to said bonding material between and in contact with the sheet portions and extending from one of said runs to an adjacent run of said corrugation intermediate said return bends, securing said inserts to one of said sheet metal portions, uniformly applying heat simultaneously over the entire exposed surfaces of the superimposed sheet portions to melt the bonding material and bond surfaces of the sheet metal portions around said inserts and said corrugation together whereby the surfaces of the sheet portions contacted by said inserts remain unbonded and the corrugation initially provides an open series flow passageway between the sheet metal portions, directing a cleaning fluid through said open series flow passageway to remove foreign matter from the interior of the exchanger while preventing fluid flow from said one run to said adjacent run at the point of location of said inserts, and thereafter applying pressure internally of said passageway to expand the unbonded portions of one of the sheet portions at said inserts whereby said series flow passageway is divided into a plurality of parallel flow passageways.

6. The method of making a closed heat exchanger which consists in, forming a continuous corrugation having a plurality of spaced apart runs connected in series by return bends in a sheet metal portion and superimposing the corrugated sheet portion upon another sheet metal portion with a bonding material therebetween and with inserts of a material that will not bond to said sheet metal portions or to said bonding material between and in contact with the sheet portions and extending from one return bend to another adjacent return bend of said corrugation, securing said inserts to one of said sheet metal portions, uniformly applying heat simultaneously over the entire exposed surfaces of the superimposed sheet portions to melt the bonding material and bond surfaces of the sheet metal portions around said inserts and said corrugation together whereby the surfaces of the sheet portions contacted by said inserts remain unbonded and the corrugation initially provides an open series flow passageway between the sheet metal portions, directing a cleaning fluid through said open series flow passageway to remove foreign matter from the interior of the exchanger while preventing fluid flow from said one return bend to said another adjacent return bend at the points of location of said inserts, and thereafter applying pressure internally of said passageway to expand the unbonded portions of one

of the sheet portions at said inserts to form a header interconnecting said corrugated return bends.

THOMAS E. BURKHARDT.

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