Jan. 12, 1960 H. M. WILLIAMS ET AL 2,920,380

METHOD OF MAKING PLATE-TYPE HEAT EXCHANGER

Filed Aug. 29, 1957

FIG. 1

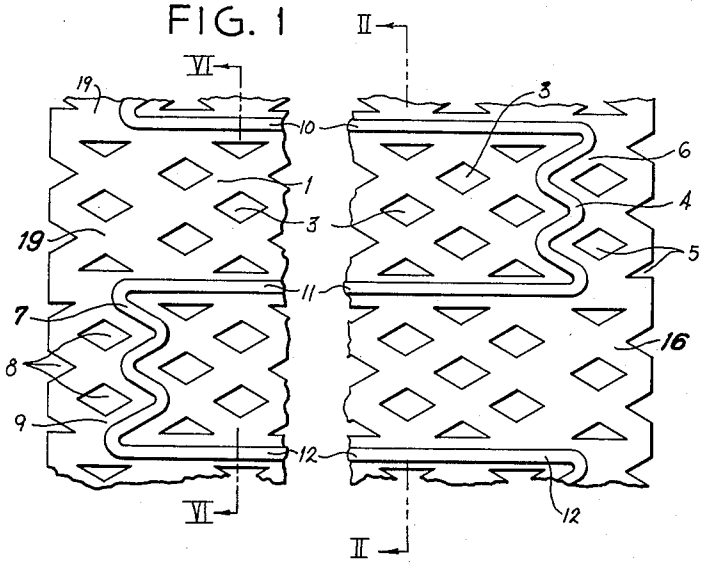



FIG. 2

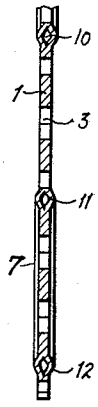



FIG. 3

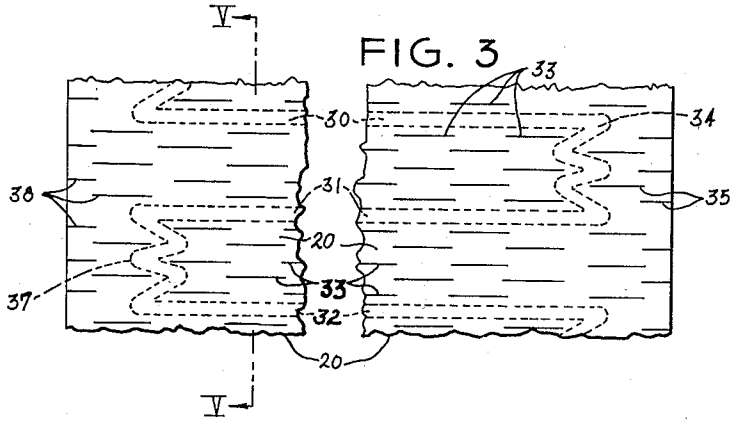



FIG. 4

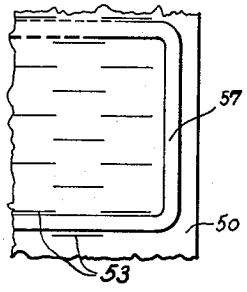



FIG. 5

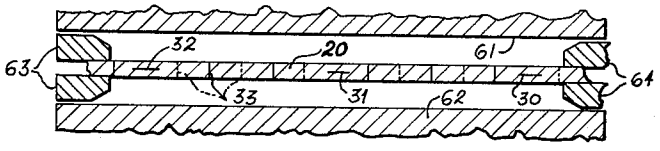
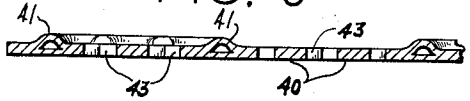



FIG. 6




INVENTORS:
HENRY M. WILLIAMS
BY HUNTLY M. CAMPBELL
Lionel E. Goff
John D. Wilkins
ATTORNEYS

United States Patent Office 2,920,380
Patented Jan. 12, 1960



2,920,380

# METHOD OF MAKING PLATE-TYPE HEAT EXCHANGER

Henry M. Williams, Godfrey, Ill., and Huntly M. Campbell, White Plains, N.Y., assignors to Olin Mathieson Chemical Corporation, East Alton, Ill., a corporation of Virginia

Application August 29, 1957, Serial No. 680,936

7 Claims. (Cl. 29—157.3)

This invention relates to a heat exchanger construction and to the method of manufacture of the same, and particularly relates to a heat exchanger having tubing associated with an open web of the expanded metal type.

For many purposes, it has been found advantageous to use a heat exchanger of the plate-type having included therein a circuit of tubes carrying or mounted upon one or more pieces of foraminous sheeting. A unit of such construction can be used, for example, as the condenser coil of an air conditioning unit or the vertical condenser panel of a refrigerator. Such units have considerable utility also in building construction as radiant cooling and heating panels, serving as a plaster base when of expanded metal or other suitable perforated construction. However, units heretofore available have been rather limited in use because of expensive construction and numerous attendant disadvantages. Most prior art constructions of this type involve the attachment of a separate piece of tubing to a separate panel or expanded web of metal by divers and sundry supporting, stiffening and fastening means including spot welding, brazing, soldering, fastening hardware, and the like. The tubing is shaped to fit the panel which frequently is embossed or otherwise shaped to match the tubing. This construction is not only uneconomical but frequently cumbersome and the resulting structure is susceptible to failure on account of vibration fatigue or corrosion. Furthermore, many prior art constructions of this type have been characterized by a poor appearance, are hard to keep clean, and have a poor heat transfer efficiency for one reason or another and particularly on account of the many joints and connections.

Therefore, an object of this invention is to provide a panel type heat exchanger of open web construction characterized by relative simplicity and economy. Still another object is to provide a heat transfer device having a minimum of heat exchanger conduits together with a maximum of both primary and secondary heat transfer elements so that the unit will operate with a maximum of efficiency. Another object is to provide a plate-like heat exchanger panel of improved construction as well as efficiency characterized by an integral self-sustaining arrangement of parts relatively free from joints and extraneous supports. Another object is to provide a heat exchanger having maximum plate edge area and a relatively rough turbulence generating secondary surface area of integral construction. Still another object is to provide an improved method of making such plate-like units.

Still other objects and advantages will become apparent from the following description in detail when taken together with the accompanying drawing in which:

Figure 1 is an elevational view showing part of a unit according to one preferred embodiment of this invention with a portion broken away;

Figure 2 is a side view in cross section of the embodiment of Figure 1 taken on line II—II;

Figure 3 is an elevational view of a piece of strip material forming the blank from which the unit of Figure 1 is made;



Figure 4 is a similar elevational view showing a modification of the blank adjacent a margin thereof;

Figure 5 is a side elevational view taken in cross section on line V—V of the blank of Figure 3 illustrating details of the blank structure and including typical apparatus for making the unit of Figure 1 according to this invention; and

Figure 6 is a cross sectional view taken on line VI—VI of Figure 1 showing a preferred cross sectional modification of the product.

In general, according to one aspect of this invention, there is provided one or more continuous fluid conducting conduits or tubes bent into serpentine or zigzag form with return bent portions in a multi-perforated web integral with the tubing and extending in surrounding relationship to the tubes generally between spaced portions of the tubing in the web. The tubed web is of the pressure welded or roll forged type distended in certain portions to provide the heat exchanger passageways and expanded in the plane of the web between the distentions to provide a plurality of perforations and their associated edge portions and making on the web rough surfaces.

The tubed web is of one-piece sheet metal construction made by the roll forging and fluid inflation process disclosed in Grenell, U.S. Patent 2,690,002. Since this process is fully disclosed in the Grenell patent and is now well known to those skilled in the art, it will not be described in great detail. By that process, there is provided a sheet metal blank having internally a separation material in a pattern according to this invention. After roll forging, the blank embraces this separation material in a special zigzag pattern including laterally extending substantially straight portions adjacent ones of which are connected together by a return bend portion adjacent alternately one and then the other of the marginal edge portions of the blank. In accordance with this invention, the blank is specially further modified with a series of laterally extending cuts or perforations in a laterally extending series arranged in rows spaced longitudinally with respect to each other and arranged between adjacent straight portions of the separation material. These cuts or perforations may advantageously extend to adjacent the lateral margins except at the return bend portions of the separation material and may intersect with the margins. According to one embodiment, the staggered array of cuts or perforations at the margin is more widely separated laterally to provide a longitudinally extending solid area of serpentine configuration wherein the return bend, correspondingly of curved or sinusoidal shape, extends. The perforations may be provided in some instances prior to forging of the component pieces by rolling so as to accomplish both stretching and rolling in one step.

According to another aspect of this invention, a process is provided whereby this special distendable cut blank is made and then worked in such a way as to elongate the blank longitudinally to more greatly separate the straight portions of the separation material and to expand the cut webbing between these straight portions sufficiently to develop a multiplicity of perforations such as those of the expanded metal type. At some stage in the operation, fluid pressure is applied internally along the separation material so as to distend the blank in these portions to provide a zigzag conduit or tube including the return bend portions. The resultant product is of perforated and internally cavitated one-piece construction.

The cut portions of the blank may comprise slits extending parallel to the straight tube portions and arranged in staggered or overlapping relationship to each other and having contiguous edge portions or may include

or consist of perforations made by punching or sawing, round or slotted.

It is contemplated that development of the expanded structure can be made either by stretching before or after development of the fully distended passageways or by a rolling process before the development of the passageways by fluid pressure inflation. According to the latter procedure, rolling may occur across the entire sheet or only marginally at the lateral edge portions. With edge rolling, preferably under tension, elongation of the return bend occurs together with increased separation of the straight portions of the tubing. In this instance, the expanded metal portion intermediate the edges is merely stretched and suffers no reduction in thickness. This has the advantage of improved rigidity.

According to one embodiment, distention of the tube or passageway portions occurs from both sides with respect to the web portions. According to another embodiment, distention occurs only on one side leaving the other flat except for the openings in the webbing. The latter embodiment is particularly advantageous where the heat exchanger unit is to serve as a shelf with a flat upper surface providing no interference to articles slid on or off the shelf. This construction also has the advantage of improved appearance and easy maintenance of cleanliness where the flat surface forms the outer surface of a unit such as the vertical plate condenser mounted on the back of a refrigerator or on an air conditioner.

In the finished product of this invention, the tube winds sinusoidally across the unit and it will be appreciated that it has the advantage of a continuous conduit free from joints and supporting connections, which would not only increase the cost of manufacture and the task of maintenance but also increase the danger of development of leaks.

In the embodiment of Figures 1 and 2, the heat exchanger device has a perforated web 1 having openings 3 therethrough and a series of laterally extending tube runs of which 10, 11 and 12 are shown interconnected by return-bend passageways such as 4 and 7. As shown in Figure 2, the web 1 is of integral construction with the passageways 10, 11 and 12 and the various return-bend passageways. The web is located on a medial plane with respect to the passageways so that the tubes 10, 11 and 12 project from both sides of the web 1.

The return-bends between the lateral passageway runs of the tube portion of the heat exchanger are sinusoidal and extend through suitable otherwise solid portions of the webbing intermediate the lateral runs. Thus, sinuous return bend 4 is disposed in a solid piece 6 of the webbing likewise of sinuous configuration. Similarly, return bend portion 7 traverses the solid section 9 between the ends of the tube runs 11 and 12. In addition to the main interior perforations 3 of the web 1, there are marginal perforations such as 5 and 8 associated with the return bend portions of the tubing 4 and 7, respectively. The inter-connecting solid portions 6 and 9 of the webbing, forming the traversal between return bends, are each preferably somewhat wider than the remaining solid portions of the webbing surrounding the main perforations 3. Uniformly this design of webbing and return-bends adjacent the marginal portion thereof continues throughout the length of the heat exchanger plate of this invention constituting this embodiment. Thus, the enlarged interconnecting portion 6 containing return bend 4 is continued again at 16. Similarly, the enlarged expanded portion 9 containing the other return bend 7 is continued as at 19.

Blank 20 of Figures 3 and 5 is a pressure welded piece of sheet metal suitable for making the finished structure of Figures 1 and 2 and contains unjoined internal areas in a predetermined pattern of embryonic lateral separation runs 30, 31 and 32 and also the embryonic return separation 34 between runs 30 and 31 and the embryonic return separation 37 between separation runs 31 and 32.



Such partially laminated internal construction, obtained in part in accordance with the process disclosed in the aforementioned Grenell patent, U.S. 2,690,002, is further characterized by incisions 33, 35 and 38 from which the openings 3, 5 and 8 of the finished product are generated by any suitable process of expansion of the sheet metal blank 20 by stretching.

In accordance with a further process aspect of this invention, the blank 20 is subjected to internal fluid pressure which develops the final finished sinusoidal passageway, including tube runs 10, 11 and 12 and the various return runs 4 and 7 of the finished product either before, simultaneously with or after stretching, but preferably the distended blank is first stretched longitudinally to expand the metal at the incisions 33, 35 and 38 to produce the perforations 3, 5 and 8. The incisions adjacent the sinuous return bends cooperate with this shape of the bends in order to produce elongated but unrestricted return bend connections. At least one secondary or expansion bend, or reentrant loop with laterally extending legs, is included in the return bend of the tube to minimize rupture of the tube when stretch is applied. Thus, the incisions 33 adjacent the return run 34 cooperate with the marginal incisions 35 to produce the finished return passageway 4. Similarly, adjacent incisions 33 cooperate with marginal incisions 38 during the stretching operation so that the return pattern 37 under full distention produces a satisfactory return bend 7. In order to obtain still further modification, it is to be understood that the expansion of the internal unjoined areas of the blank 20 can take place in different ways without departing from the spirit and scope of this invention. It may be desirable to first partially expand the tube pattern prior to the web cutting operation and after such web cutting operation and lateral stretch operation, a final expansion of the tube would be carried out, but with the knowledge of the location of the pattern within the sheet, it is believed possible to eliminate the initial expansion of the tube pattern. The stretching operation can advantageously occur before a single fluid pressure distention of the tube passageway portions. This procedure has the advantage of maintaining the tube passageways more nearly flat especially at the return bends and of maintaining the tube passageway unrestricted.

Expansion can be accomplished so as to obtain distention of the pasageways on both sides of the webbing as shown in Figure 2 or for certain purposes on one side of the webbing as shown in Figure 6. With expansion maintained on one side only, the resultant webbing 40 presents a smooth protective surface on one side for the pasageways 41 which extend on the opposite protected side.

In Figure 4, the modified blank 50 has a different type of return separation 57, adapted for expanding the blank by a method including rolling marginally so as to elongate the return separation 57 to form a finished return bend in the pasageway at an unslit marginal portion. In this embodiment slits 53 are confined intramarginally of the edges of blank 50. Accordingly since none of the slits 53 extend to the edges of the blank, the edges of the expanded sheet will be free of any indentations or edge recesses present in Figure 1. In other words, the edges of the expanded sheet will be continuous and uninterrupted. It is to be noted that from the blank 50, the final finished product produced will be elongated at the lateral margins with concomitant reduction in thickness while the intra-marginal portion is elongated by stretching alone leaving this portion thicker than the marginal portion. The resulting product is more rigid.

In Figure 5, blank 20 of Figure 3 is shown positioned between platens 61 and 62 of a press with the ends of the blank grasped by suitable jaws 63 and 64 of a stretching or metal expanding mechanism of any suitable type. Jaws 63 and 64 put into operation stretch

the blank **20** to open it at the cuts **33, 35** and **38** thereby further spacing the separation runs **30, 31** and **32** from each other, leaving an expanded metal web structure therebetween.

Thus elongated by stretching, blank **20** is ready for the next operation of distention produced by fluid pressure injected along the separation runs **30, 31** and **32** to form the finished passageways including lateral runs **10, 11** and **12** in the finished article between the sizing and confining platens **61** and **62**. In another modification the inflation can occur without confinement between spaced flat press platens.

By this invention, a highly efficient self-sustaining unit with a minimum number of parts is obtained by a minimum number of manufacturing steps. Moreover, each unit being of integral construction enables most efficient heat trasmission throughout it between the tube and the fin, or web portions and also between it and the surrounding heat exchange medium, be it liquid, air, or plaster.

While the foregoing is a description of what is now believed to be the most practical and preferred embodiment, it will be understood that numerous modifications and various changes in detail can be made and will occur to those skilled in the art without departing from the principles set forth therein. Therefore, the purpose of this disclosure is not to put a limitation on the spirit and scope of this invention except as set forth in the appended claims.

What is claimed is:

1. In the method of making a one-piece heat exchanger plate of pressure welded construction having distended tube passageways including substantially parallel lateral runs and integral expanded web portions adjacent said passageways, the improvement comprising prior to distention of said tube passageways, slitting said web portions laterally intermediate said runs to form a series of parallel rows of slits therein, the slits of each row being separated by unslit areas and being in staggered, overlapping relationship with the slits of an adjacent row and thereafter elongating said slit web portions longitudinally to expand said portions thereby forming an integral expanded web in heat exchange relationship with said tube passageways.

2. In the method of making a one-piece heat exchanger plate of pressure welded construction having distended tube passageways and integral expanded web portions adjacent said pasageways, the steps of forging a pair of component sheets together except in areas of separation including substantially parallel laterally extending sections terminating short of the lateral margins of said web portions and interconnecting sections between adjacent laterally extending sections and disposed alternately adjacent opposite margins thereby providing a zig-zag area of separation with return bends, slitting said web portions in a lateral direction to form a series of parallel rows of slits therein between said laterally extending sections, the slits of each row being separated by unslitted areas and being in staggered overlapping relationship with the slits of an adjacent row, elongating said slit web portion longitudinally to expand said portion to form an expanded web, and applying fluid pressure along said sections internally of said plate thereby distending said plate along said sections to form said tube passageways in heat exchange relationship with said expanded web.

3. The method of claim 2 wherein the interconnecting sections include at least one reentrant loop having laterally extending legs and wherein slits are provided in alternation with said legs thereby adapting said return sections to longitudinal extension during elongation of the web portion.

4. The method of claim 2 including edge rolling under tension for elongating the web portion.

5. The method of claim 4 wherein slitting of the web portion is confined intramarginally thereby providing continuous marginal areas of the plate free from foramina and edge recesses.

6. In the method of making a one-piece heat exchanger plate of pressure welded construction having distended tube passageways and integral expanded web portions adjacent said passageways including the step of distending the tubes, the improvement comprising providing a pair of component sheets with longitudinally spaced groups of perforations each extending at least laterally of said sheets, superposing said sheets upon each other with the perforation of adjacent sheets in communicating relationship with each other to provide a perforated web portion, forging said pair of sheets together to weld said sheets across their adjacent surfaces except in areas of separation including substantially parallel laterally extending longitudinally spaced sections terminating short of the lateral margins of said superposed sheets and interconnecting sections of separation between adjacent laterally extending sections and disposed alternately adjacent opposite margins thereby providing a zigzag area of separation with return bends, said forging being accomplished by rolling across the entire width of said sheets to produce simultaneously with said forging an elongation of said perforated web portion to expand said portion to increase the final finished size of said perforations.

7. The method of claim 2 including a partial distention of said plate along said sections by preliminary fluid pressure prior to slitting.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,471,960 | Johnson | May 31, 1949 |
| 2,585,736 | Burr | Feb. 12, 1952 |
| 2,676,001 | Polad | Apr. 20, 1954 |
| 2,690,002 | Grenell | Sept. 28, 1954 |
| 2,703,702 | Meinel | Mar. 8, 1955 |
| 2,759,247 | Grenell et al. | Aug. 21, 1956 |