Nov. 22, 1966 G. A. ANDERSON 3,286,328

METHOD OF MAKING HEAT EXCHANGERS

Original Filed June 24, 1963

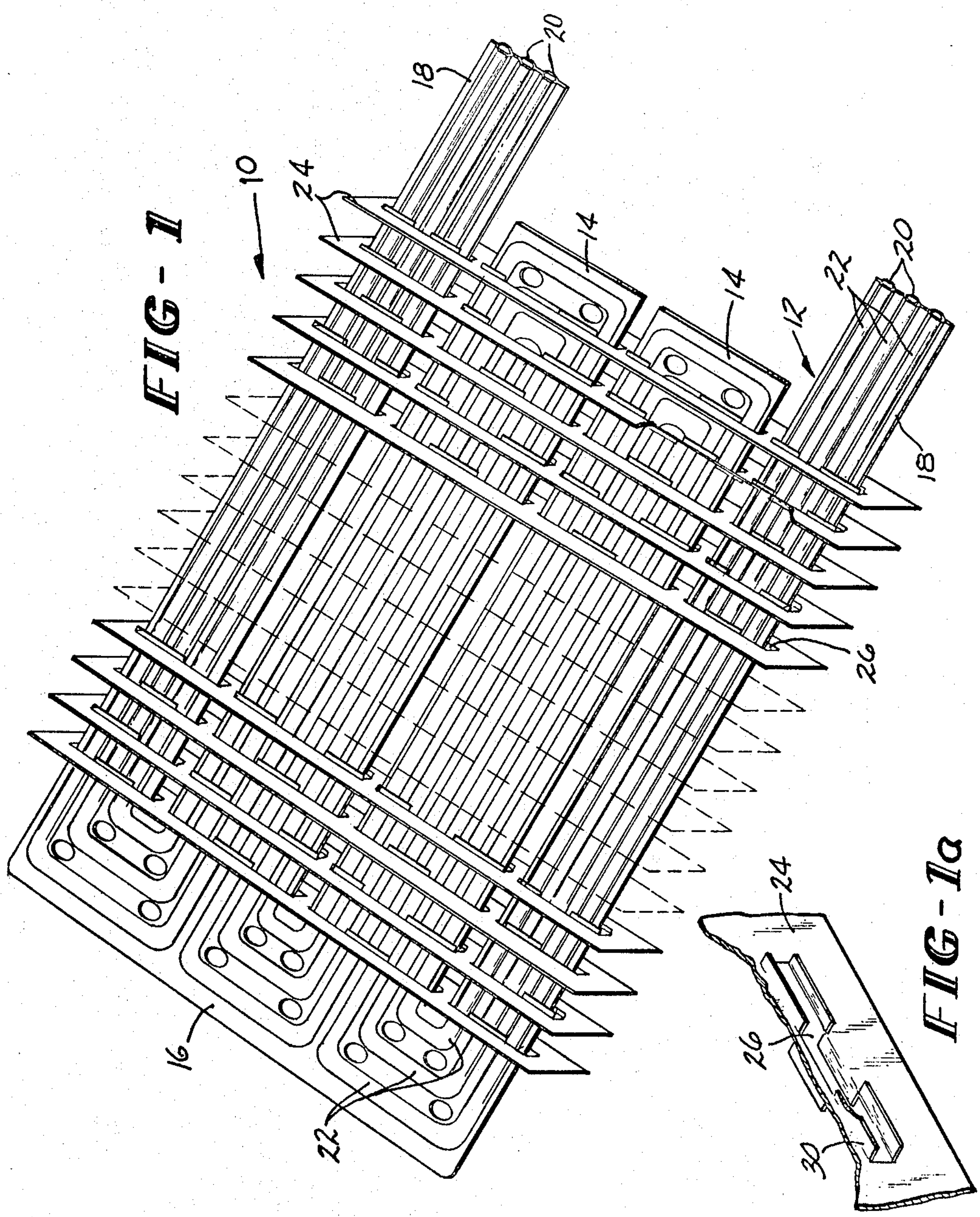

FIG - 1

FIG - 1a

INVENTOR
GEORGE A. ANDERSON
BY Robert H. Bachman
ATTORNEY

Nov. 22, 1966 G. A. ANDERSON 3,286,328

METHOD OF MAKING HEAT EXCHANGERS

Original Filed June 24, 1963 2 Sheets-Sheet 2

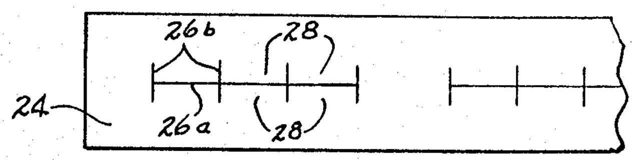

FIG-1b

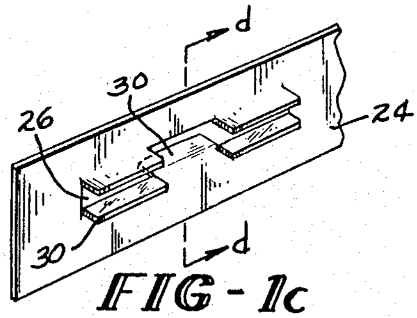

FIG-1c

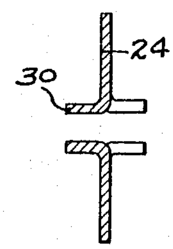

FIG-1d

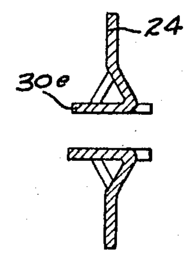

FIG-1e

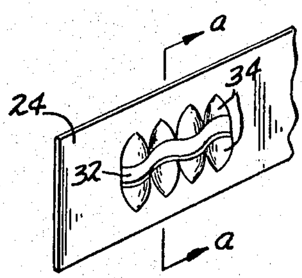

FIG-2

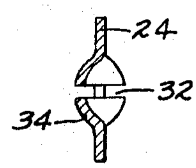

FIG-2a

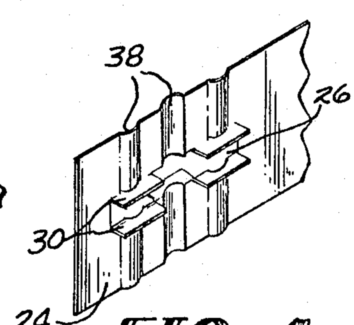

FIG-4

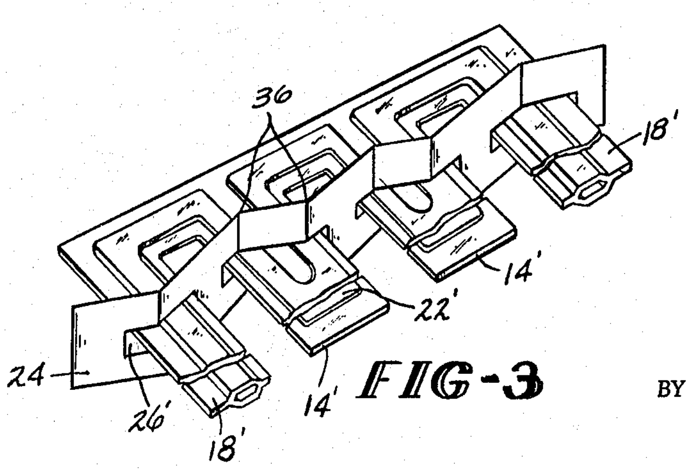

FIG-3

INVENTOR.
GEORGE A. ANDERSON

BY

ATTORNEY

United States Patent Office

3,286,328
Patented Nov. 22, 1966

3,286,328

METHOD OF MAKING HEAT EXCHANGERS

George A. Anderson, Northford, Conn., assignor to Olin Mathieson Chemical Corporation, a corporation of Virginia

Original application June 24, 1963, Ser. No. 290,052. Divided and this application Feb. 13, 1964, Ser. No. 353,013

3 Claims. (Cl. 29—157.3)

This application is a division of copending application Serial No. 290,052, filed June 24, 1963.

This invention relates generally to a method of making heat exchangers. More particularly it relates to a method of making heat exchangers having fins integrally attached to a heat transfer panel and to a method of securing the fins on the panel in such a manner so as to constrain them to remain erect.

Finned heat exchangers find a wide variety of applications in the heating and cooling arts, among which are such examples as radiator panels for use with internal combustion engines, radiant heaters for home use, refrigeration and air conditioning condensers and forced air evaporators. Within these fields there is an ever growing demand for a wide variety of heat exchange devices incorporating the use of heat dissipating fins to increase the efficiency and reduce the cost of prior heat exchange devices.

In the past, designers and manufacturers of finned heat exchange devices have encountered three major obstacles to the development of an efficient low cost unit. One is the problem of providing a satisfactory means of attaching the fins to the heat exchange panel or core in such a way that a sturdy and durable structure is obtained which will withstand at least the normal handling and wear and tear to which it may be subjected with minimum damage to the article. Another is the problem of providing a suitable heat transfer contact area between the fin and the heat transfer panel so as to transfer the maximum amount of heat from the panel to be dissipated to the surrounding atmosphere from the fin. Still another major problem is that of the cost involved in the often complicated and numerous steps in the assembly procedure for a finned heat exchanger which usually requires the association together of a great many individual components to fabricate the finished article. Much effort has been devoted to overcoming these obstacles and past solutions have not met with great commercial success.

For example, one method of fabricating such devices has involved forming openings in a plurality of fins, maintaining the fins in spaced relationship to each other, and inserting individual tubes or sections of a heat exchange core or panel through the openings in the fins. Frequently, breakage occurred if the fins and tube stock were not of sufficient strength to withstand the assembly operations. Heat transfer contact area was often insufficient to produce an efficient and economical device. Connecting the fins by welding or soldering was expensive and often faulty to the point of obtaining poor heat transfer contact area. Various methods have been proposed for expanding the tubes or cores after the fins and cores have been assembled together, but these methods have met with considerable economic unfeasibility due to the number and nature of processing steps and material wastage.

A more recent proposal for an economic and efficient finned heat exchanger is to assemble a plurality of slotted fins over an unexpanded heat transfer panel formed of a plurality of flat sheets which have been treated with a pattern of stop-weld material corresponding to the tube pattern desired in the finished article and which have been pressure welded together, then expanding the unwelded portions of the sheets by known methods to bring

the outer tube walls into contact with the edges of the fin slots. It was found, however, that when the tube walls pressed against the edges of the fin slots with sufficient pressure to lock the fins in place and to establish good heat transfer contact between the tube walls and fins, undesirable twisting forces were set up in the fins which caused them to bend over and lie flat on the panel wall rather than remain erect and perpendicular thereto.

Accordingly, the need arises for a finned heat exchange device which overcomes the aforementioned obstacles encountered in the heat exchange arts and more particularly overcomes the deficiencies and shortcomings of the prior art devices.

To this end there is herein presented a novel method of making a heat exchange device. Generally, the invention comprises forming a heat transfer panel from a plurality of relatively thin flat sheets which are coated with a weld-resist material over a sinuous pattern which corresponds to the pattern of fluid passageways desired in the finished article. The pattern is a matter of choice, and may take the form of a waffle design, be convoluted, or have straight tubes entering a main pattern at intermediate points. The sheets are then pressure welded together to form a unified stack, the portions of the sheets coated with the weld-resist material remaining unjoined. The panel desirably takes the form of a plurality of parallel, spaced apart longitudinal sections connected by a lateral section along adjacent ends of the longitudinal sections.

A plurality of thin sheet metal fins having slots cut therein and spaced in correspondence to the spacing of the longitudinal sections of the panel are assembled over the panel by means more fully described hereinbelow, and the panel is then expanded by the application of fluid pressure to the unwelded portions thereof. This causes the outer walls of the fluid passageways to forcibly contact the edges of the fin slots.

Each fin is provided, integrally herewith, with an anti-twist means which acts, together with spacer bars, to prevent the fin from bending over and lying flat on the face of the panel when the latter is expanded to form the fluid passageways. The anti-twist means may take several forms as more fully described hereinafter, but all are directed to the provision of alternate moments acting equally and in opposite directions over the length of the fin with the result that the fin remains in upright position relative to the panel.

Having thus generally described the invention, it is a principal object thereof to provide a method of making a heat exchange device which is durable, efficient and economical to manufacture.

It is another object of the present invention to provide a method of making a heat exchange device having a plurality of heat dissipating fins mounted on a heat transfer panel for more efficient transfer of heat to or from the panel and the surrounding atmosphere.

Still another object of the present invention is to provide a method of making a heat exchange device having a plurality of heat dissipating fins mounted on a heat transfer panel in a rigid and permanent manner and having a maximum amount of heat transfer contact area between the panel and the fins.

Yet another object of the present invention is the provision of a method of making a heat exchange device having a plurality of heat dissipating fins mounted on a heat transfer panel with means integral with the fins and associated with the panel for securely and permanently maintaining the fins in vertical and upright relationship with the panel.

Further objects and advantages of the present invention will become apparent from the following detailed description when considered in conjunction with the accompanying drawings in which:

FIGURE 1 is a perspective view of the heat exchange device of this invention illustrating one embodiment of the heat dissipating fins mounted in place on the heat transfer panel;

FIGURE 1A is a fragmentary, partially sectional view of the mounting means incorporated with the fin illustrated in FIGURE 1;

FIGURE 1B is a fragmentary view of the fin stock illusrtating the slit pattern for forming the mounting means for the fin of FIGURE 1;

FIGURE 1C is a fragmentary perspective view of the fin illustrated in FIGURE 1;

FIGURE 1D is a sectional view taken on line D—D of FIGURE 1C;

FIGURE 1E is a view similar to FIGURE 1D illustrating a slightly modified form of tab;

FIGURE 2 is a fragmentary perspective view illustrating another form of mounting means,

FIGURE 2A is a sectional view taken on line A—A of FIGURE 2;

FIGURE 3 is a view similar to FIGURE 1 illustrating a modified form of fin mounted on a slightly altered heat transfer panel, and

FIGURE 4 is a view similar to FIGURE 2 of still another form of the present invention.

Referring now to the drawings and more particularly to FIGURE 1 thereof there is seen a fin-on-panel heat exchange device generally designated by the reference numeral **10** which comprises generally a heat transfer panel **12** formed by the process disclosed in the patent to Grenell et al., No. 2,690,002, issued September 28, 1954. In accordance with the teachings of this patent, a pair of flat metal sheets are superposed one upon the other after having been treated with a weld preventing material, such as graphite. The weld preventing material is applied to one or the other of the aforementioned sheets in a foreshortened pattern which is similar to the pattern of tubular passageways desired in the finished heat transfer panel. The individual sheets are then secured together in any suitable manner, heated to a required temperature, and fed through pressure rolls to firmly bond the sheets together in the areas uncoated with the weld preventing material. After suitable cold working and annealing, a hydraulic pressure device is attached to the panel and the panel is inflated by the application of pressure in the unwelded portions defined by the pattern of weld preventing material.

As more fully described hereinafter, the heat dissipating fins are assembled on the panel **12** prior to complete inflation so as to lock them firmly in place. Subsequent to inflation, suitable connections are made to the panel for communication therewith of a heat transfer medium and thereafter the panel is incorporated into any desirable system involving the transfer of heat.

Referring again to FIGURE 1, one embodiment resulting from this invention is seen to comprise the aforementioned heat transfer panel **12** which takes the form of a generally rectangular planar sheet material unit which is divided longitudinally into a plurality of longitudinally extending fingers **14**, the latter projecting outwardly from a transverse portion **16** extending across and connecting all of the fingers **14** along adjacent ends thereof. The two outermost fingers **18** incorporate the terminal ends **20** of a system of passageways **22** which is internally disposed within, and sinuously traverses, the panel **12** between the two ends **20**, although the ends may be located elsewhere as desired. The fingers **14** and **18** are most expeditiously generated by forming a plurality of elongated apertures through the panel **12**, the apertures extending from one lateral edge thereof to a point spaced from the opposite lateral edge thereof. As will be evident, each of such apertures lies wholly within an area of panel **12** devoid of weld-preventing material, such that the passageways **22** are restricted to the fingers **14** and **18**, as is depicted in FIGURE 1. It will be noted that in the panel illustrated in FIGURE 1 there are three parallel internal passageways **22** which traverse the panel **12** in the aforementioned pattern between the respective terminal portions **20**; however, it is to be understood that any number of passageways desired may be formed in the panel, that these passageways may take a pattern other than that shown, and that the passageways are not limited to use as fluid passageways. For example, it is contemplated that a heater wire may be inserted into one of the passageways so that the finished product will have a defrosting capability in addition to that of refrigeration. Also any desired number of fingers **14** may be placed parallel to each other in the plane of the panel intermediate the outermost fingers **18**.

In order to increase the heat dissipating efficiency of the panel **12**, a plurality of heat dissipating fins **24** are mounted on the panel **12** and extend generally in a direction perpendicular to that of the individual panel fingers **14** and **18**. The fins extend continuously from one outer edge of an outermost finger **18** to the opposite outer edge of the other outermost finger **18**, and are disposed on both sides of the panel as best seen in FIGURES 1 and 3. Each fin **24** has a plurality of slots **26** cut therein and spaced longitudinally along the fin in a manner corresponding to the spacing of the intermediate fingers **14** of panel **12** to facilitate the mounting of the fins over the panel **12** in the manner illustrated in FIGURE 1.

In accordance with the practice of this invention each fin is provided with a means for applying anti-twist forces to the body of the fin to prevent the fin from bending over and lying flat or substantially so upon the opposite surfaces of the expanded panel tubes subsequent to the aforementioned panel inflation process. Generally, this means takes the form of a structural configuration formed on the fin adajcent the fin slot which, when the outer passageway walls contact the opposed edges of the slots **26** cut in the fin, applies substantially equal and oppositely directed moments to various portions of the fin so as to constrain the fin to remain erect on the panel and in generally perpendicular relationship thereto.

The embodiment illustrated in FIGURE 1 is shown in embryonic form in FIGURE 1*b*. Specifically, the fin **24** is slit longitudinally as indicated by the line **26*a***, and slit laterally in a number of places along the longitudinal slit, as indicated by the lines **26*b***. The line **26*a*** and lines **26*b*** define integrated fin portions **28** of generally rectangular configuration which are the embryonic form of the mounting tabs **30** best seen in FIGURES 1*a*, 1*c* and 1*d*.

Alternatively, the slits **26*b*** could be eliminated by simply providing the longitudinal slit **26*a*** and then punching the fin to form the mounting means.

The fin portions **28** are bent outwardly to form the tabs **30** which extend outwardly from the plane of the fin and in substantially perpendicular relationship thereto. Each longitudinally adjacent set of fin portions **28** are bent in opposite directions so that the resulting tabs **30** will be disposed on opposite sides of the fin in an alternate pattern corresponding to the manner in which the fin portions **28** are bent.

This procedure for forming the mounting tabs **30** is continued across the length of the fin thereby resulting in an approximately equal number of mounting tabs extending in each of the opposite directions. From this structure it will be apparent that when the panel passageways are inflated to expand the walls thereof, the walls are pressed firmly against the tabs to secure the fins in place on the panel and provide an efficient heat contact transfer area.

The pressure of the passageway walls on a set of tabs extending in corresponding directions produces equal and opposite moments in these tabs tending to twist the upper and lower portions of the fin in opposite directions, or in other words tending to fold the fin in half. However, corespondingly oppositely directed moments are set up in an adjacent oppositely directed set of tabs which tends to fold the fin in half in a direction opposite to that mentioned above. The net result of these forces is to constrain the fin to remain erect and in substantially perpendicular relationship to the panel on which it is mounted.

FIGURE 1*e* illustrates embodiment similar to that illustrated in FIGURE 1*d*, the essential difference being that the transverse slits **26***b* are made somewhat longer than is necessary to form the tabs **30** shown in FIGURE 1*d* resulting in an elongated tab **30***e*, so that after the tabs **30***e* are bent outwardly perpendicular to the plane of the fin **24**, a portion of the tab is bent out of the plane of the fin on the side thereof opposite the side or face on which the end of the tab is disposed. Thereby approximately one half of the perpendicular portion of the tab is disposed on each side of the fin **24**. Alternatively, as mentioned above, this form of tab may be formed as shown during punching without the use of the transverse slits **26***b*. In this embodiment the forces imposed upon the tabs **30***e* by contact therewith of the walls of the panel passageways are distributed substantially equally over the area of the tabs **30***e* thereby providing a better distribution of pressure over the tab to improve the heat transfer characteristics of the tab.

FIGURES 2 and 2*a* illustrate still another embodiment resulting from the invention in which the fin **24** is slotted as by cutting or punching to form the slot **32**, and is then formed by any suitable means to provide alternately oppositely directed substantially semi-conical protrusions **34** extending out of the normal plane of the fin. This structure imparts a generally scalloped appearance to the opposite longitudinal edges of the fin slot. Alternatively the above forming steps may be carried out simultaneously.

When the fin is assembled on the heat exchange panel, and the panel subsequently inflated to force the outer passageway walls into firm engagement with the slot edges, counter bending moments are set up in the oppositely directed conical sections **34** to constrain the fin to remain in the desired erect relationship.

Referring now to FIGURE 3, another embodiment resulting from the invention takes the form of a fin **24** which has been alternately bent or corrugated in the transverse direction of the fin so as to form creases or folds **36** transversely across the fin and located within the outer edges of the intermediate fingers **14′** and outermost fingers **18′** of panel **12′**. It will be noted from FIGURE 3 that within the limits of each of the intermediate fingers **14′** two such creases or folds have been provided, each lying approximately over the center of the single hollow passageway **22′** provided within this panel. This is illustrative of a desirable manner of corrugating the fin, but other suitable fold patterns may be substituted for the particular pattern shown.

Due to the convoluted or folded configuration of the fin **24′** as illustrated in FIGURE 3, it will be apparent that upon inflation of the passageway **22′** within the panel the outer walls of the passageway contact and firmly press against the inner edge of the slots **26′**, thus securing the fin on the panel and also providing a firm heat transfer contact area. It will also be apparent that the force imposed upon alternate portions of the fin in the region of the folds **36** produces equal and opposite moments tending to twist the fin in alternately opposite directions with substanially equal force. The net result of the stresses thus created internally within the fin is that the fin will remain erect and in substantially perpendicular relationship with respect to the plane of the panel.

It should be noted that any of the foregoing tab designs may be incorporated with the fin of this embodiment to provide additional anti-twist effect.

The panel of the embodiment illustrated in FIGURE 3 contemplates that a plurality of fins are slotted and then creased and folded in a corresponding manner and then applied to the panel with folds of a given direction arranged in a corresponding manner so that a large number of fins may be mounted on the panel in parallel closely adjacent relationship.

FIGURE 4 illustrates the embodiment shown in FIGURE 1 and incorporates the added feature of a strength impressioning means in the fin adjacent oppositely disposed edges of the slots **26**. This impressioning takes the form of oppositely directed transverse spaced apart ridges and grooves **38** which add transverse rigidity to the fin and tend to provide more rigidity to the fin in the tab area thereby providing better tab to panel contact pressure distribution and further aiding to resist damage from handling. The impressioning also serves as flow disturbances for improving heat transfer at high air flow rates.

It will now be apparent that three major steps are required for fabrication and assembly of the device. The first of these is the formation, by the procedure of the Grenell et al. patent generally outlined above, of the heat transfer panel in its embryonic state as a flat sheet of metal; the second is the formation of the fins by any desirable means to produce the panel mounting slots and anti-twist means; the third is the assembling together of the heat transfer panel and the fins, and the ultimate expansion of the fluid passageways within the heat transfer panel to firmly lock the fins thereon in the desired perpendicular relationship.

The heat transfer panel is generally fabricated in the manner described above and as illustrated in the patent to Grenell et al. to which patent reference may be made for a detailed description of this process. The panel may then be crack inflated to reveal the passageway pattern and then punched to provide the slots defining the fingers. The heat dissipating fins are formed by and desirable means to provide the various modifications of anti-twist means described hereinabove, and are then assembled on the heat transfer panel and temporarily secured in place by suitable jigs or fixtures for subsequent processing. In assembling the panel and fins together, it is usually necessary to first assemble the fins in a jig. The jig consists of spacer bars which space the fins apart in the longitudinal direction and provide constraint for the panel tubes during the inflation process; the bars are spacers between the inflation press platens and the tubes. The entire assembly is then placed in a press which applies restraining pressure to the outer passageway walls while the passageways are being inflated by hydraulic pressure so as to limit the expansion of the walls to a desired extent and also to impart a desired shape to the walls, this being generally flat. It should be noted that care must be exercised in determining the extent to which the passageways are inflated to avoid cracking or rupturing the heat dissipating fins in the area of the slots by the application of too great a pressure on the slot edges.

As the tubular passageways expand during inflation, the outer surfaces of the passageway walls engage and press firmly against the various anti-twist means formed in the fins, thereby applying to the fins the forces necessary to securely lock them in place and to provide the moments necessary to maintain the fins erect. Thus, the outer passageway walls operatively co-act with the structural conformations of the fin slots to effectuate the desired result. If additional holding power is necessary, the heat transfer panel may be treated with a soldering material prior to the final assembly, and the assembly subjected to a heat treating process whereby the fins will be soldered directly to the outer walls of the tubular passageways. This in some cases may even serve to improve the heat transfer characteristics of the fin and panel heat transfer contact area.

It will be apparent from the foregoing description and accompanying drawings that there has been provided a method of making a heat exchange device which is believed to provide a solution to the foregoing problems and achieve the aforementioned objects. It is to be understood that the invention is not limited to the illustrations described and shown herein which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are susceptible of modification of form, size, arrangement of parts and detail of operation, but rather is intended to encompass all such modifications which are within the spirit and scope of the invention as set forth in the appended claims.

What I claim and desire to secure by Letters Patent is:

1. The method of making a heat exchange device which comprises the steps of:

(A) providing a heat exchange panel having a pattern of internal unjoined portions disposed between solid portions of said panel with the unjoined portions forming opposed walls integrally joined to said solid portions,

(B) forming a plurality of elongated apertures in said panel, each of said apertures extending from one lateral edge of said panel to a point spaced from the opposite edge thereof, each of said apertures lying wholly within one of said solid portions and being of a length to define a plurality of spaced fingers containing said unjoined portions and projecting out from a lateral marginal portion of said panel adjacent said opposite lateral edge,

(C) providing at least one sheet metal fin having a plurality of slots corresponding in spacing and number to the spacing and number of said fingers, each of said slots being at least equal in length to the width of said fingers and greater in width than the unexpanded thickness of said panel,

(D) forming on said fin adjacent the slots thereof means for supporting said fin on said panel,

(E) assembling said fin on said panel in a substantially perpendicular relationship to said panel by inserting the fingers thereof into the corresponding slots of said fin, and

(F) expanding said walls into contact with said means of paragraph (D) by the application of a fluid pressure into said unjoined portions, whereby said walls exert substantially equal and opposite moments on said fin to constrain said fin in said perpendicular relationship.

2. A method according to claim 1 wherein said plurality of slots in said fin are formed by

(A) slitting said fin along a plurality of longitudinal spaced-apart lines equal in length to the length of said slots, and

(B) bending the portions of said fin bounded by said slits out of the normal plane of said fin, adjacent alternate pairs of said portions being bent in opposite directions and defining said means for supporting said fin on said panel.

3. A method according to claim 1 wherein the step of paragraph (D) comprises corrugating said fin laterally along a plurality of spaced-apart lines disposed intermediate the lateral edges of said slots.

References Cited by the Examiner

UNITED STATES PATENTS

Re. 20,016	6/1936	Hopkins	165—151 X
1,920,313	8/1933	Mautsch	165—151
2,414,159	1/1947	Modine	165—151
2,747,258	5/1956	Kramer	29—157.3
2,759,247	8/1956	Grenell et al.	29—157.3
2,894,731	7/1959	Wurtz	29—157.3 X
2,994,123	8/1961	Kritzer	29—157.3
2,998,639	9/1961	Forst et al.	29—157.3
3,011,466	12/1961	Simpelaar	29—157.3 X

JOHN F. CAMPBELL, *Primary Examiner.*

J. D. HOBART, *Assistant Examiner.*