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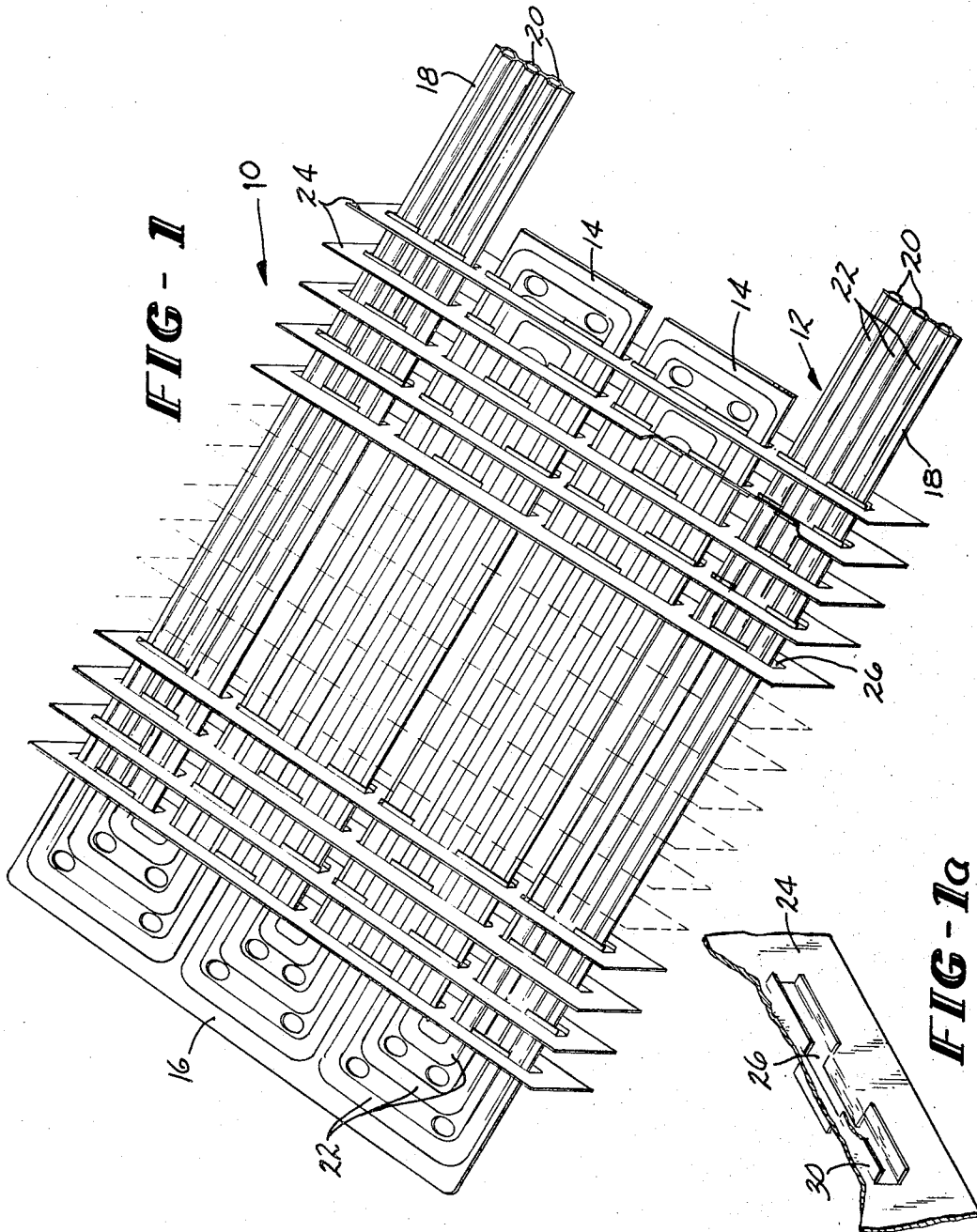
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3,368,614

HEAT EXCHANGER

Filed June 24, 1963

2 Sheets-Sheet 1



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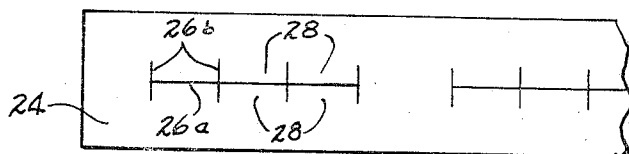
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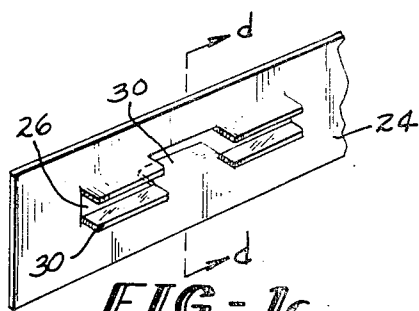
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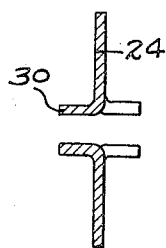
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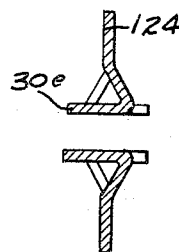
**FIG-1b**



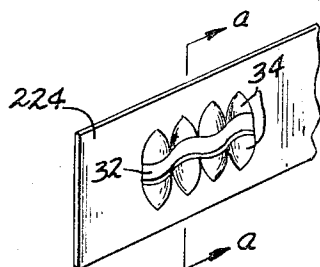
**FIG-1c**



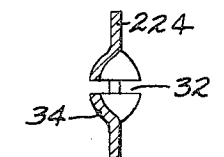
**FIG-1d**



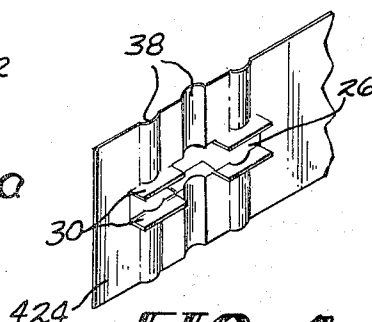
**FIG-1e**



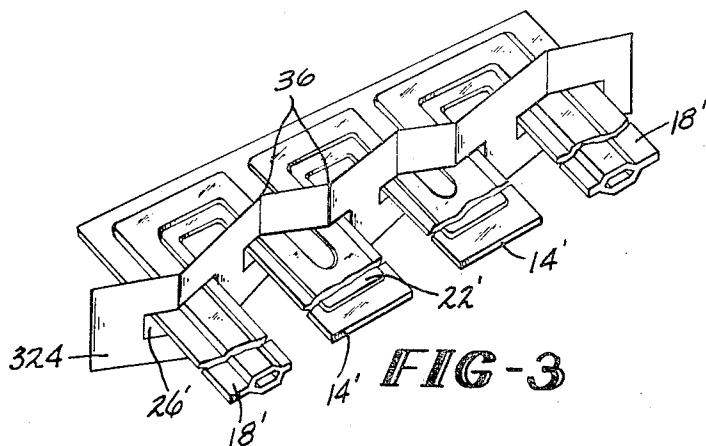
**FIG-2**



**FIG-2a**



**FIG-4**



**FIG-3**

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## HEAT EXCHANGER

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Filed June 24, 1963, Ser. No. 290,052

10 Claims. (Cl. 165—82)

This invention relates generally to improvements in heat exchangers. More particularly it relates to heat exchangers having fins integrally attached to a heat transfer 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 exchanger 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

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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 exchanger 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 heat exchange device. Generally, the invention comprises a heat transfer panel formed 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 heat exchange device which is durable, efficient and economical to manufacture.

It is another object of the present invention to provide 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 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 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 illustrating 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 Sept. 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 of 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 sinusously traverses, the panel 12 between the two ends 20, although the ends may be located elsewhere as desired. 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 can be seen in FIGURE 1, or in the modification of FIGURE 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 adjacent 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 of the invention illustrated in FIGURE 1 is shown in embryonic form in FIGURE 1b. Specifically, the fin 24 is slit longitudinally as indicated by the line 26a, and slit laterally in a number of places along the longitudinal slit, as indicated by the lines 26b. The line 26a and lines 26b define integrated fin portions 28 of generally rectangular configuration which are the embryonic form of the mounting tabs 30 best seen in FIGURES 1a, 1c and 1d.

Alternatively, the slits 26b could be eliminated by simply providing the longitudinal slit 26a 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, correspondingly 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 1e illustrates a form of the invention similar to that illustrated in FIGURE 1d, the essential difference being that the transverse slits 26b are made somewhat longer than is necessary to form the tabs 30 shown in FIGURE 1d resulting in an elongated tab 30e, so

that after the tabs 30e are bent outwardly perpendicular to the plane of fin 124 analogous to 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 26b. In this embodiment the forces imposed upon the tabs 30e by contact therewith of the walls of the panel passageways are distributed substantially equally over the area of the tabs 30e thereby providing a better distribution of pressure over a tab to improve the heat transfer characteristics of the tab.

FIGURES 2 and 2a illustrate still another embodiment of the invention in which a fin 224 analogous to 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 of the invention takes the form of a fin 324 analogous to 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 324 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 substantially 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 a fourth embodiment of the invention shown in FIGURE 1 and incorporates the added feature of a strength impressing means in the fin adjacent oppositely disposed edges of the slots 26 of a fin 424 analogous to fin 24. This impressing 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 impressing also serves as flow disturbances for improving heat transfer at high air flow rates.

Considering now the method of forming the apparatus of the invention, it will become 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 any 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 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. A heat exchange device comprising:

(A) a substantially flat, seamless, integral sheet metal structure having

- (1) a plurality of parallel elongate spaced apart sheet elements lying in a common plane,
- (2) an elongate sheet element formed integrally with said plurality of sheet elements along adjacent ends thereof, said later sheet element lying in said common plane and extending in a direction transverse to that of said plurality of sheet elements,

(B) at least one tubular passageway internally disposed within said structure and traversing said structure in a sinuous pattern over all said sheet elements,

- (1) said passageway being defined by opposed portions of the thickness of said structure bulged out of the planes of opposing surfaces of said structure over said sinuous pattern thereby forming opposed spaced apart walls,
- (2) said passageway having open terminal portions, and

(C) a plurality of heat dissipating fins mounted on said structure in parallel spaced apart relationship and in intimate contact with said spaced apart walls of said passageway,

- (1) said fins extending transversely across said plurality of sheet elements for substantially the full width thereof and lying in planes disposed substantially perpendicularly to said common plane,

- (2) each said fin having a plurality of slots formed therein and spaced apart in correspondence to said spaced apart sheet elements, said slots being at least equal in length to the width of one of said plurality of sheet elements but being greater in width than the unexpanded thickness of said plurality of sheet elements,
- (3) each said fin further having means formed integrally therewith adjacent opposite longitudinal edges of said slots and operatively associated with said spaced apart walls for applying substantially equal and opposite moments to said fin whereby said fin remains erect and substantially perpendicular to said common plane.

2. A device as set forth in claim 1 wherein said means comprises a plurality of pairs of alternately oppositely directed tabs bent out of the normal plane of said fin at substantially right angles thereto, said tabs being in firm engagement with said spaced apart walls of said passageway.

3. A device as set forth in claim 2 wherein each of said tabs is disposed substantially entirely on one side of said fin whereby the forces exerted on said tabs by contact therewith of said spaced apart walls produce maximal moments in said fin.

4. A device as set forth in claim 2 wherein each of said tabs is disposed substantially intermediate the plane of said fin with a portion of said fin adjacent said tabs

being bent out of the plane of said fin in a direction opposite to the direction in which said tabs are bent whereby the forces exerted on said tabs by contact therewith of said spaced apart walls are distributed substantially uniformly over said tabs.

5. A device as set forth in claim 1 wherein said means comprises a plurality of pairs of alternately oppositely directed semiconical protrusions formed in said fin and extending out of the normal plane thereof, said protrusions being in firm engagement with said spaced apart walls of said passageway.

6. A device as set forth in claim 5 wherein said pairs of protrusions are adjacent to one another and impart a generally scalloped appearance to the longitudinal edges of said slots.

7. A device as set forth in claim 1 wherein each of said fins is corrugated laterally along the length thereof to form a series of transverse creases extending between opposite edges of said fin.

8. A device as set forth in claim 7 wherein said creases are intermediate the lateral ends of said slots.

9. A device as set forth in claim 8 wherein at least two creases are disposed intermediate the ends of a single slot.

10. A device as set forth in claim 2 further including stiffening means for said fin in the form of a plurality of pairs of alternately oppositely directed transverse ridges extending out of the normal plane of said fin.

#### References Cited

##### UNITED STATES PATENTS

Re. 20,016	6/1936	Hopkins	165—151 X
440,671	11/1890	Wiesel.	
780,565	1/1905	Humphrey	122—367 X
1,795,055	3/1931	Taylor et al.	165—81 X
1,854,278	4/1932	Smith	165—151 X
1,887,036	11/1932	Modine	165—181
1,903,125	3/1933	Modine	165—81
1,920,313	8/1933	Mautsch	165—151
1,921,278	8/1933	Young	165—81
1,940,152	12/1933	Steele	165—82
2,032,065	2/1936	Modine	165—151
2,072,975	3/1937	Winsborough et al.	165—82
2,118,206	5/1938	Kritzer et al.	165—151
2,145,244	1/1939	Berg et al.	
2,173,666	9/1939	Sibley	165—151 X
2,256,993	9/1941	Van Vleet	165—184 X
2,462,511	2/1949	Kramer	29—157.3
2,558,952	7/1951	Hayward	29—157.3
2,804,286	8/1957	Pintarelli	165—182
2,827,774	3/1958	Dunkelman	62—523 X
2,894,731	7/1959	Wurtz.	
2,759,247	8/1956	Grenell et al.	29—157.3

##### FOREIGN PATENTS

469,367	12/1928	Germany.
696,380	8/1953	Great Britain.

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