July 26, 1966 G. F. BAIRD 3,262,495

HEAT TRANSFER CORE STRUCTURE

Filed Dec. 21, 1961 2 Sheets-Sheet 1

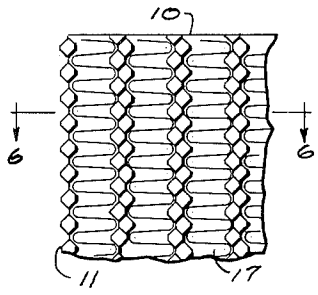


FIG. 1

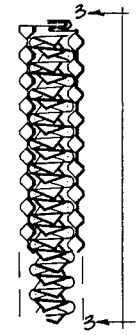


FIG. 2

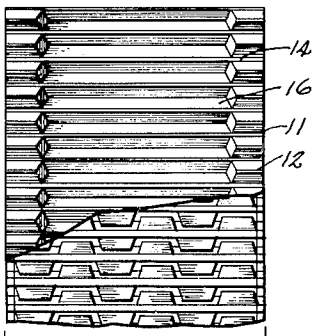


FIG. 3

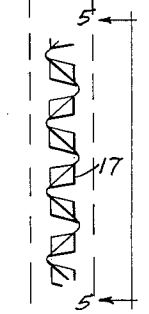


FIG. 4

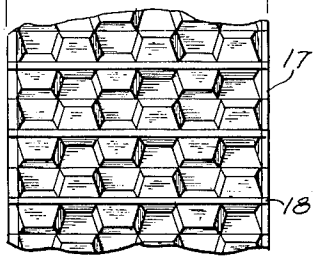


FIG. 5

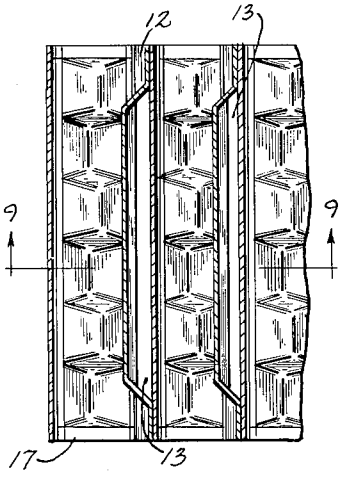


FIG. 6

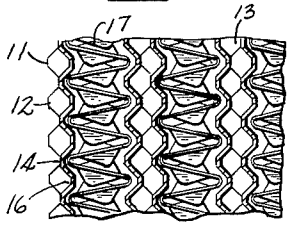


FIG. 9

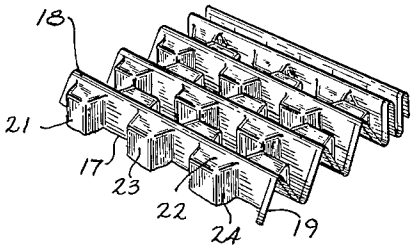


FIG. 7

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July 26, 1966 G. F. BAIRD 3,262,495

HEAT TRANSFER CORE STRUCTURE

Filed Dec. 21, 1961 2 Sheets-Sheet 2

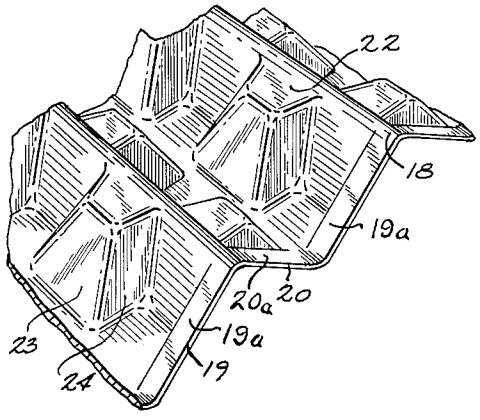


FIG. 8

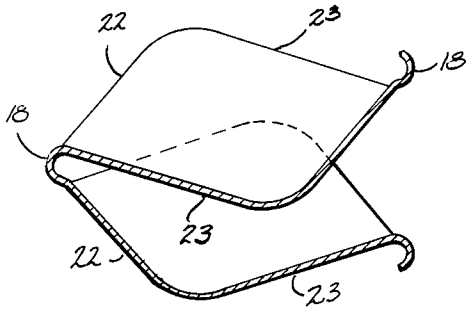


FIG. 11

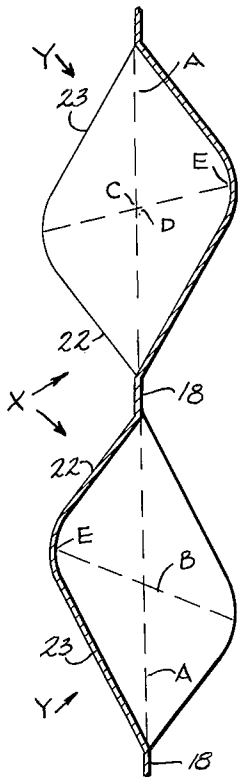


FIG. 10

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3,262,495

HEAT TRANSFER CORE STRUCTURE

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Filed Dec. 21, 1961, Ser. No. 160,976
3 Claims. (Cl. 165—152)

This invention relates to improvements in a core structure for the transfer of heat from liquid to air for the purpose of providing means for heating a given space such, for example, as the interior of an automobile.

Conventional practice calls for a structure made up of two types of metal strips. One type, designated as a primary strip, consists of a thin metal sheet with the edges offset along the long dimension thereof in such manner that when a pair of these strips are bonded together along these edges, a lengthwise water passage is created. The other type, designated as the secondary strip, is formed from thin sheet metal that is folded on lines across its long dimension to form substantially parallel pleats. The structure is assembled by first pairing primary strips to form parallel water passages and interposing one or two secondary strips between such passages, after which all are bonded together by any of several well known means. The secondary strips serve to space apart the water passages and add stiffness to the flat side of such passages. Also, the extent of heat transfer may be altered by a change in the area of the surfaces of the secondary strip to exposure to any given air flow.

Since it is desired to heat air, it will of course be understood that the water temperature is necessarily higher than that of the air to be heated and that heat is conducted from the inner to the outer surfaces of the primary strips and picked up by the air flow across these surfaces. Heat also flows from the outer surfaces of the primary strip through the bond to one or more secondary strips and is picked up by air flowing across these surfaces. It is customary to form the secondary strips in such a manner that discontinuities or projections therein cause turbulence in the air flow and thus increase the rate of heat transfer from the water passages to the air. To some extent, bumps or projections have been formed in the primary strips to increase the rate of heat transfer, or they may be located in the folds of the secondary strips, or both. Of course, the resulting turbulence in the flow of air increases the resistance to air flow and a practical compromise must be reached between the advantages and disadvantages of increased turbulence as against a somewhat choked flow of air.

With the increased use of cooling systems operating above atmospheric pressure, the mechanical strength and rigidity of heat transfer cores has become increasingly important. Pressure on the inside of the water passages may easily cause them to swell, resulting in failure of the joints between the primary and secondary strips. In those designs where two secondary strips have been provided between each pair of water strips, a permanent and virtually integral joint between the secondary strips is difficult to make and failure at this point is frequent. It is also pointed out that since the pressure in the cooling system with which the present core is intended to be associated is not constant, pressure fluctuations may cause repeated bending of the strips defining the water passages, resulting in fractures and leaks.

It is a principal object of the invention to provide a core in which the primary and secondary strips, when combined, produce a structure of great rigidity and mechanical strength.

It is another important object of the invention to so design the primary and secondary strips of a core that, when assembled, a high rate of heat transfer is obtained.

A further object of the invention lies in the provision of secondary strips which, when assembled with primary strips to form a core, create a resistance to air flow which is within a practical range.

Other objects and advantages of the invention will be more fully understood and appreciated from a consideration of the following specification, taken in conjunction with the accompanying drawing; and in which

FIG. 1 is a front elevation of a portion of a core embodying the invention;

FIG. 2 is a fragmentary vertical end outline of one secondary strip enclosed by primary strips;

FIG. 3 is a view of the structure shown in FIG. 2, being taken as suggested by the line 3—3 of that figure;

FIG. 4 is a fragmentary vertical end outline of the secondary strip in expanded form;

FIG. 5 is a face view of the expanded strip shown in FIG. 4, being taken as suggested by the line 5—5 of that figure;

FIG. 6 is an enlarged fragmentary horizontal sectional view, taken substantially as indicated by the line 6—6 of FIG. 1;

FIG. 7 is a perspective view of a portion of the secondary strip showing certain of the folds in expanded relation and others in compacted relation, as when assembled;

FIG. 8 is a greatly enlarged expanded portion of the secondary strip, being shown in perspective;

FIG. 9 is an enlarged vertical sectional view taken as suggested by the line 9—9 of FIG. 6;

FIG. 10 is an enlarged longitudinal sectional view of two segments of the secondary strip; and

FIG. 11 is an enlarged fragmentary vertical sectional view and illustrates the appearance of the nested bumps of adjacent folded pleats of the secondary strip.

Referring to the drawing, the reference numeral 10 is employed to generally designate a portion of a heat exchange core embodying the invention. As is common practice, the core consists of alternate vertical water passages and horizontal air passages. As above mentioned, each water passage is formed from a pair of primary strips, generally designated by the reference numeral 11. These strips have laterally offset margins 12 of zigzag pattern in order that a pair of them, when assembled, will create a water passage 13. That portion of each strip between these margins consists of transverse angular ribs 14, with intervening valleys 16. The ribs and valleys are spaced apart the same distance as desired for the pleats of the secondary strip hereinafter described. As may be noted, the laterally outwardly extending portions of the margins 12 are in the plane of the valleys 16, thus providing a continuous surface from one edge to the other of the primary strip. This, as may be seen, provides full width contact with appropriate portions of the pleats of the secondary strip. Each valley and the in-plane portions of the margins 12 may be selectively V-shaped with a cylindrical radius or a narrow flat.

A secondary strip 17 is intended to be located between each pair of water passage primary strips 11. Each of these strips is formed from a thin metal sheet folded transversely of its length to produce a series of pleats. Each pleat consists of two parts that are integrally joined along their meeting edges as well as to the adjacent edges of the parts of corresponding pleats. The parts are of equal width and their lines of jointure take the form of straight, narrow bends 18 which extend from one side edge to the other of the strip. For convenience of description the two parts of each pleat are indicated by the numerals 19 and 20. And to further designate these parts, they have, as viewed from one side, faces 19*a* and 20*a*.

Each of the parts 19 and 20 of any given pleat is

formed with bumps or projections which are alternately above and below the general plane of the faces **19***a* and **20***a*. The bumps on corresponding parts of the pleats extend in the same direction and arrangement and thus appear in lengthwise rows, as may be seen in several of the views. In the drawing, the bumps on any one part of a pleat, as viewed from said one side, appear as outwardly projecting bumps between which are inwardly projecting depressions that, on the opposite face, show up as outwardly projecting bumps. In the present illustration of the invention, one of the faces of a given part of the strip shows three bumps, whereas the opposite face shows only two bumps. This arrangement is carried out throughout the strip length. Since that face of a part that has only two outward bumps also includes three inward bumps, it follows that the opposite face of the part will have the same arrangement and pattern of bumps as above described.

Attention is now particularly directed to FIGS. 7 to 11, wherein the structure of the bumps and their relationship to each other are shown both in expanded and compacted form. Referring particularly to FIG. 8, it is to be noted that each bump **21** appears as two sides of a triangular prism with the plane of the surface from which the bump projects forming the third side. When viewing the strip from one margin (see FIGS. 4 and 10), the bumps on opposite surfaces combine to outline a parallelogram wherein the strip is shown as it appears after forming the bumps but prior to completing bending into final pleated shape. To more clearly disclose the structure of strip **17**, a diagonal dash line "A" of each parallelogram represents the general line or level of the strip and is the full length of the distance between the bends **18** and at least ninety percent of the distance between the water passages when the core is assembled (see FIG. 11). The shorter diagonal "B" of each parallelogram is at least sixty percent of the length of the longer diagonal "A" and the two diagonals, at their intersection, form angles "C" and "D" of approximately eighty-five and seventy-five degrees, respectively. The angle "E" at the crest of each bump, between the two faces of the prism, is rounded to preclude cracking crosswise of the strip during forming the bumps.

As viewed in the direction of the arrows "X" (FIG. 10), the smaller face **22** is substantially flat and trapezoidal in outline. The width of the face **22**, where it blends with the bend **18**, is seventy-five to one hundred ten percent of the diagonal "A" described above. The width of this face, at the crest of the bump, however, is fifty to sixty percent of the diagonal "A." The larger face **23**, as viewed in the direction of the arrows "Y," is substantially flat and trapezoidal with the width of the face, where it joins the bend **18**, at least equal to or greater than the width at the crest of the bump. The sides **24** of the bump, at their line of meeting with faces **22** and **23**, as well as at their line of meeting with the pleat surfaces, are slightly rounded to prevent cracking of the metal during forming.

From the description above, it will be seen that, measured in a direction across the width of the strip, the length of the crests of the bumps is considerably less than the center line spacing of the bumps. Since successive bumps are alternately above and below the general plane of the strip surfaces, the metal between successive bump crests and bump faces may form a slightly wrinkled surface at varying angles to the average direction of the air flow across the strip. When the strip is bent alternately upwardly and downwardly to form the bends **18** and the angle of these bends is adjusted to give the desired spacing between the pleats, the bump face **22** will approach the bump face **23** of the next adjacent surface. Similarly, the face **23** of each bump will approach the face **22** of the next adjacent bump located on the adjoining pleat. Due to the geometry of the bumps, these pairs of faces will not be parallel, but will form the walls of air passages of

wedge-shaped cross section with the passages interconnected where the crest between these faces approaches the under face of the adjacent face **23**. The portions of each surface between successive bumps also approach each other, forming a sloping passage between oppositely disposed wedge-shaped passages over successive bumps.

In assembling the primary and secondary strips into a core, certain details of their structure should be noted. As indicated above, these strips are joined in conventional manner, which, in the present instance, is by the use of molten solder. The sloping sides of ribs **14** of the strips **11** are approximatelly parallel to the small faces **22** of the bumps and are spaced therefrom by a gap of .01 to .03 of an inch. This spacing is great enough to confine and control the spread of solder during a bonding operation. Also, this spacing is such that it limits the straight flow of air across the width of the primary strip **11** along the sloping sides of the ribs **14**. If desirable, when bonding the strips of a core structure by face dipping, the gap may be increased where the first row of bumps approaches the ends of the ribs **14**.

As above stated, the structure of the present core is intended to provide a heat exchange device that combines maximum efficiency with ruggedness. To this end, the transverse ribs **14** in the primary strips serve to greatly strengthen and stiffen the walls of the water passage and, in so doing, reduce the stress on the solder bond and distortion of the strips **11** when pressure is applied from within the water passages. The compactness of the pleats of the secondary strip **17** also serve to prevent distortion of the walls of the water passages because, regardless of their slight incline, the bends **18** thereof seat or nest in the valleys **16** between the ribs **14** and thus cannot shift, open up, or otherwise change their assembled relationship with respect to the primary strip. Further, the in-plane surface, consisting of the valleys **16** and a part of the margin **12** of strip **11**, provides not only a seat for each bend **18**, but an excellent area for solder bonding. The inter-action of the ribs **14** with the bumps of the strip **17** force air flowing adjacent the strips **11** to be repeatedly deflected back and forth across the crests of the ribs, thus insuring high turbulence and, in effect, creating a scrubbing action by which to obtain a most satisfactory degree of the transfer of heat from the water in the passages to the air passing through the air spaces between such passages.

Although applicant has shown and described only one form of his invention for an improvement in heat exchange cores, it will be apparent that certain modifications of structure may be made in adapting the core for use involving different conditions than those presently contemplated and it is, therefore, considered that such modifications are within the spirit and scope of the present invention insofar as they are within the meaning of the attached claims.

Having thus set forth my invention, what I claim as new and for which I desire protection by Letters Patent is:

1. In a heat exchange core, at least two pairs of primary strips, laterally offset opposed zigzag margins on said strips interengageable to create in each pair a lengthwise water passage therebetween when suitably bonded together, the walls forming said passage being parallel and forming a zig-zag water course between said primary strips including parallel uniformly spaced outwardly extending transverse ribs, the valleys between said ribs being co-planer with the lateraly outwardly extending portions of said margins whereby to provide an edge to edge seat for suitable edge to edge bends of a secondary spacer strip and a secondary spacer strip between the two pairs of primary strips seated on said edge to edge seat of said primary strips and defining an air passage therebetween.

2. In a heat exchange core having alternate vertically extending water passages spaced by transverse air passages, said water passages consisting of pairs of parallel primary strips of zig-zag configuration having inwardly offset margins engageable to create said water passages when suitably bonded together, outwardly extending transverse ribs in the portions of said strips forming the sides of said passages, said ribs being parallel and uniformly spaced to provide valleys therebetween, a secondary strip interposed between adjacent pairs of said primary strips and cooperating therewith to create said air passages, transverse pleats of zigzag formation throughout the length of said secondary strip, the bumps projecting outwardly from one surface being alternated with bumps projecting outwardly from the other surface, the bend formed between the surfaces of each pleat being seated in the valley between adjacent ribs of said primary strip.

3. In a heat exchange core, at least two adjacent pairs of primary strips, laterally offset opposed zigzag margins on said strips interengageable to create in each pair a lengthwise zig-zag water passage therebetween when suitably bonded together, the walls forming said passage

including parallel uniformly spaced outwardly extending transverse ribs, a secondary strip interposed between said adjacent pairs of said primary strips and cooperating therewith to create and define air passages, transverse pleats of zigzag formation throughout the length of said secondary strip, angularly disposed surfaces of said pleats being connected by bends adapted to seat in the valleys formed between the ribs of said primary strip, a series of identically positioned bumps on corresponding surfaces of said pleats, said bumps, transversely of said secondary strip, being alternated with areas depressed out of the plane of said surface in a direction opposite to said bumps, the depressed areas of each pleat surface accommodating the aligned bumps of the next adjacent surface whereby to create high air turbulence.

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ROBERT A. O'LEARY, *Primary Examiner.*

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