

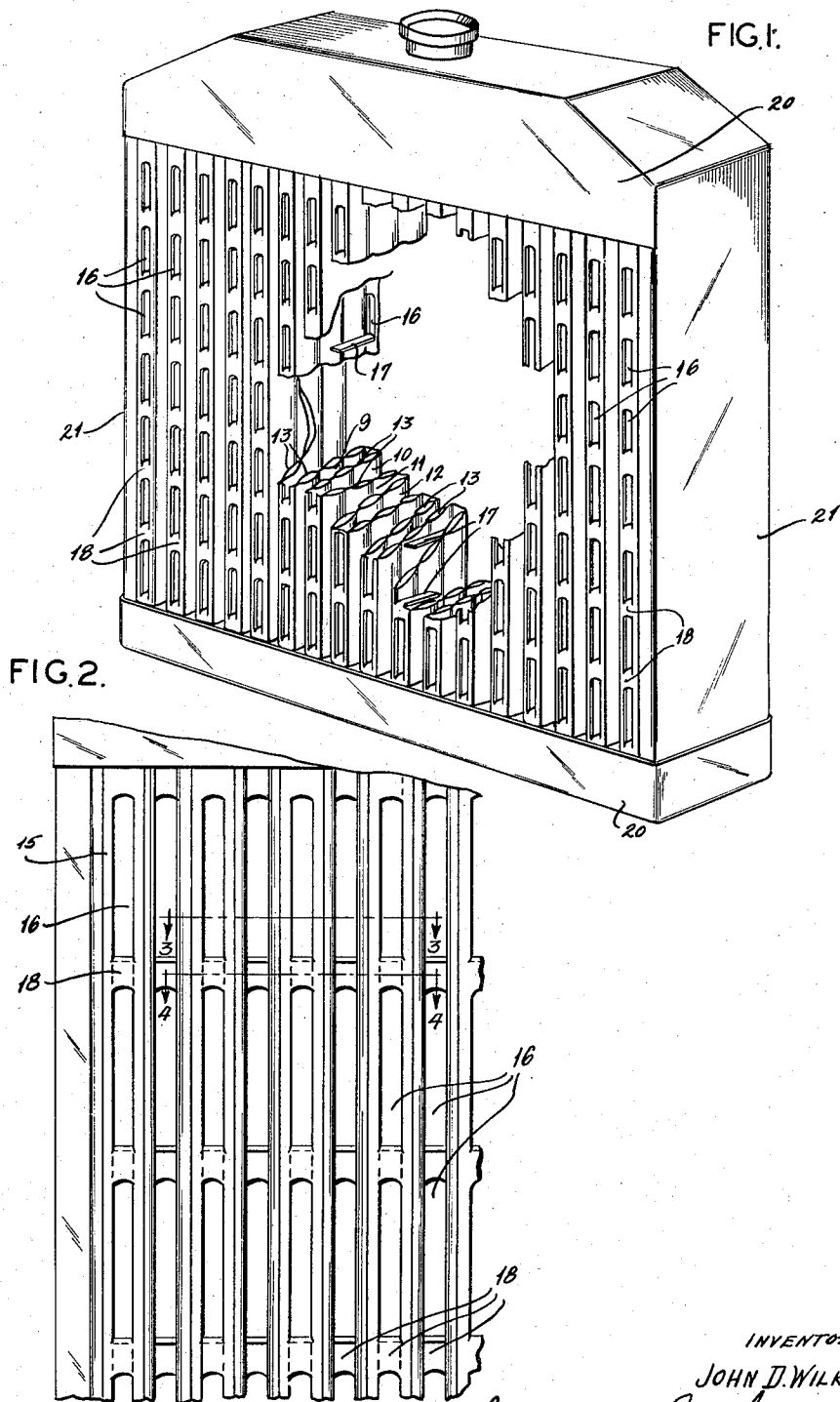
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J. D. WILKINS
HEAT EXCHANGER

2,924,437

Filed March 21, 1955

2 Sheets-Sheet 1



INVENTOR:
JOHN D. WILKINS
By *Bruce and Sutterland*
ATTORNEYS.

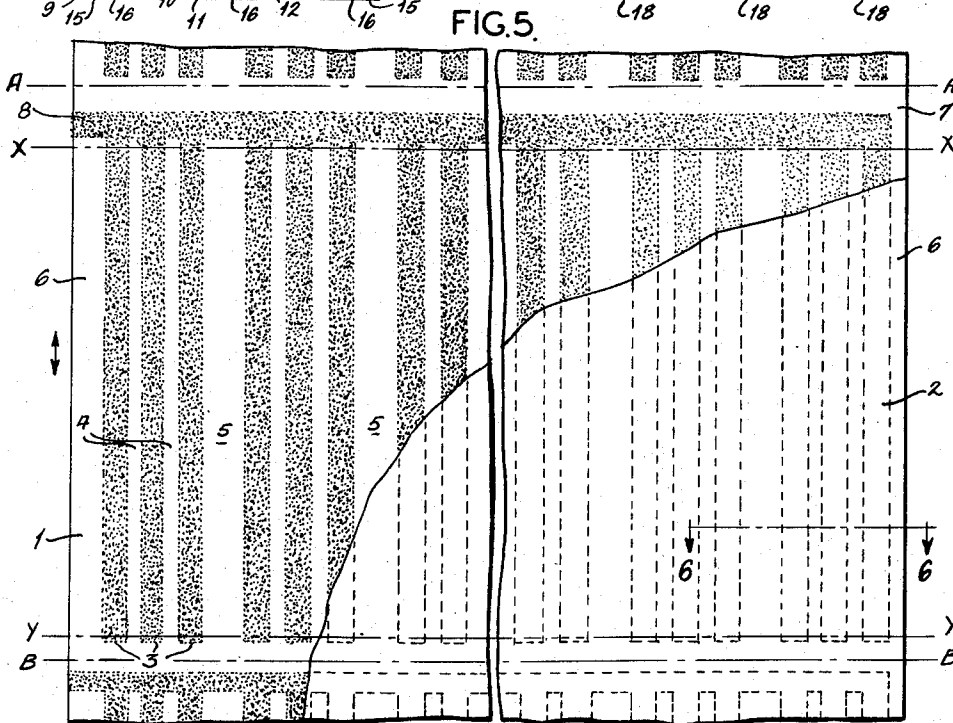
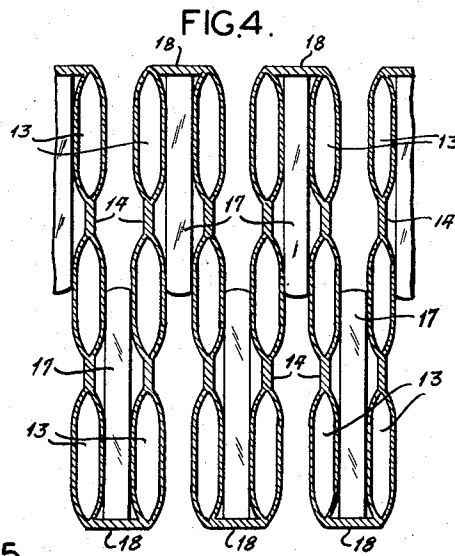
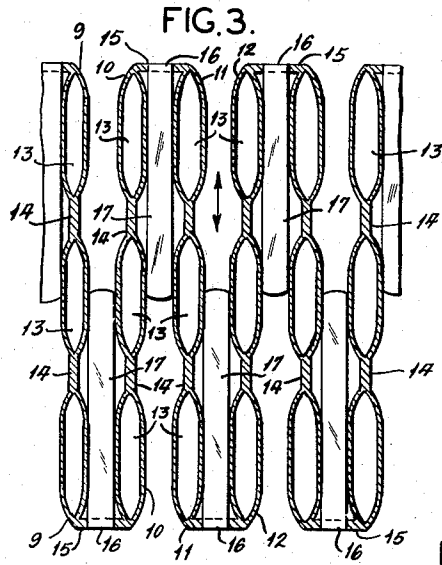
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INVENTOR:
JOHN D. WILKINS
By *Bruninga and Sutterland*
ATTORNEYS.

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2,924,437

HEAT EXCHANGER

John D. Wilkins, St. Louis, Mo., assignor to Olin Mathieson Chemical Corporation, East Alton, Ill., a corporation of Virginia

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1 Claim. (Cl. 257—130)

This invention relates to a heat exchanger construction and more particularly to a multiple parallel tube type radiator of the type exemplified by automobile radiators.

A commonly used and effective type of radiator construction for cooling internal engines or for space heating, and the like, is formed of sheet metal and includes a number of conduits generally in a parallel spaced arrangement extending from a first or intake header to a second or outlet header. The conduits or tubes serve to carry within them a confined heat exchange medium such as water, steam, or the like, in conductive relationship with another medium such as air or other gas passing between the tubes. This type of construction fabricated from sheet metal is typical of automobile radiators, for example, where the heated water, issuing from the cooling block of the engine with the aid of a pump, first enters one of two headers, passes through a great number of thin walled relatively flat closely spaced tubes, between which cooling air is blown and which extend usually vertically from one to the other of the headers, and then, after undergoing cooling in the tubes, is collected in the second header from whence the coolant is returned to the engine block and the pump.

As manufactured presently, this type of heat exchange unit is rather expensive inasmuch as the methods which heretofore achieved any commercial importance usually involved a great multiplicity of brazing or soldering operations, and also involved handling and aligning of numerous parts and joining them together. It will be appreciated that such radiator constructions are not entirely suited for mass production methods, and consequently are quite costly. In radiators of such construction, it is not uncommon for a considerable number of the tubes to have leaks at the joints immediately after fabrication, which requires extensive inspection and testing facilities, together with repair facilities, all of which add to the cost of manufacture. Moreover, during service such units tend to develop leaks at the joints all too soon, and then usually require such intricate and expensive repairing as to make costly replacement of the entire unit often more economical than repair of the joints. Furthermore, the heat exchange units of this type are usually assembled with sheet metal fin stock of one type or another of relatively thin gage as compared to the gage of the tube walls. A well-known type of fin stock consists of thin metal stock such as copper alloy having a thickness of about 0.003 of an inch. Assembly of the tubes and the fins itself involves a rather complicated, additional procedure of stacking a considerable number of separate tubes with a considerable number of separate strips of fin stock. As a result, the core section of heretofore known radiator constructions of this type constitutes the part of the radiator most difficult to manufacture, and the part responsible for the high cost of the completed heat exchange unit.

A principal object of the invention is to provide a novel and improved heat exchange core unit free from the aforementioned disadvantages of construction, and a

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new and improved method of constructing the same. A further object of this invention is to provide a heat exchange unit core structure in which a great multiplicity of fluid conduits are integrated into a single structural member, and hence is admirably suited to mass production methods.

Another object of the invention is the provision of a heat exchanger core structure having closely spaced sheet metal elements integral with each other, and so formed as to improve the rigidity of the core and to eliminate a considerable number of seams and separate fins. Other objects and advantages will be apparent and the invention will be better understood, from the following description when read with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a typical automobile radiator having a core constructed in accordance with the present invention, part being broken away to reveal the internal relationship of the integral parts;

Figure 2 is a view in front elevation of a section of the radiator shown in Figure 1;

Figure 3 is a sectional view taken along line 3—3 of Figure 2;

Figure 4 is a sectional view taken along line 4—4 of Figure 2;

Figure 5 is a plan view of a flat unified sheet structure of which the core shown in Figures 1—4 is made, the upper half of the thickness of said unified sheet structure being in part torn away to reveal the location of bonded and unbonded areas between the upper and lower halves (thickness wise) of the unified sheet; and

Figure 6 is a sectional view at greatly enlarged scale taken along line 6—6 of Figure 5.

The present invention contemplates the manufacture of a self-sustaining core member containing a great multiplicity of integral, but individually distinct, liquid conduits of small cross-section from a pair of flat sheets which, with intervening stop-weld material in a pattern of parallel spaced strips, have been unified by pressure and then distended, as taught in United States Patent No. 2,690,002 to L. H. Grenell; and zig-zag folding the unified sheets so as to provide an aligned series of laps or conduit panels (each containing one or more conduits) with each panel integrally connected to its neighbors on either side thereof. The invention contemplates that the pattern of stop-weld material be so coordinated with the pressure unifying operation, and with the folding to be done, that an air circulation space can be provided on both sides of each conduit panel without severing the integral connection between panels.

More specifically, the invention contemplates that the stop-weld material, which determines the location and magnitude of the fluid conduits, be laid out in a pattern such that the flat unified sheet can be folded at the desired lines after distention of the fluid conduit pattern without interrupting the continuity of the passageway through the conduits, or distended after folding without danger that some passageway, or some part thereof, will not distend because of the stresses due to a fold close-by. In the embodiment to be described in detail, the pattern of stopweld material is such that the welded area between the conduits, or cavitated portions in a given panel is minimized in the interest of providing the greater number of conduits in the panel or laps, but between the endmost conduits of adjacent panels or laps, a welded web of greater extent is provided whereat the fold may be made, but it will be understood that the welded web between all conduits may be made wide enough to permit the folds to be made at any of them, or that the fold may be made part in the web on one side, and part in the web on the other side of a given conduit without interfering with the continuity of passage through the conduits.

In order to provide for the circulation of air between, and transverse to, the direction of the conduit panels, perforations may be provided intermediate the conduits, or cavitated portions, permitting the passage of air between the panels or laps. For example as illustrated in the succeeding example the connecting web, at the front and rear, between panels may be cut away to a large extent; and if the metal cut out be left integral at one edge to form ears of metal cut out of the panels adapted to contact the exterior of the tube walls of adjacent panels, for example, it may be bent in between the panels to act as a spacer and air baffle.

The pattern of stop-weld material contemplated by the present invention is such that the pressure unification and subsequent distending technique, taught by the aforesaid Grenell patent, can be utilized practically without limitation as to size of the integral core being produced. Where the component sheets are to be pressure unified by rolling, as is usual, and the rolling is in the direction of the length of the stop-weld strips which define the respective conduits, the size of the integral core to be produced is limited only by the width of the rolling mill. On the other hand, where the component sheets are rolled in the direction transverse to the length of said stop-weld strips, the magnitude of the integral core to be produced is limited only by the length of the facilities for handling a strip as it is fed into and emerges from the rolling mill.

The pressure unification of the initially separated sheets (with the pattern of stop-weld material intervening) by rolling to a reduction of at least 35% in thickness, with corresponding elongation, produces a single phase weld between the component sheets (at all areas thereof not protected by stop-weld material) without reducing the metal to a fluid body, and consequently the physical characteristics and micro structure of the unified sheet are uniform throughout its thickness and area, as all components thereof have received the same degree of mechanical work and have been subjected to the same degree of heat treatment. Upon the completion of such a pressure unification, no interface between the initial component strips is discernible, and consequently, the resultant sheet may be manipulated in the same manner as a single sheet initially rolled to the same thickness. Copper alloys, aluminum alloys, and steel respond readily to pressure unification about a pattern of stop-weld material as above described. The initial sheets may, for example, be of an alloy composed of 92 to 94% copper, 2.05% to 2.60% iron, phosphorous in an amount up to 0.025%, lead in an amount up to 0.05%, and the balance zinc. Such sheets may initially have a thickness on the order of 0.070 inch so that, after the usual degreasing and cleaning operations, the chosen pattern of stop-weld material (which may consist of a mixture of graphite in water-glass) is applied to one such sheet; and another such sheet then superimposed upon the first sheet so as to produce a pile having a thickness on the order of 0.140 inch. This pile is then subjected to hot rolling to reduce the thickness of the pile, unify the component sheets, and elongate the same. In any such operation, it will be understood that the pattern of stop-weld material elongates to the same extent that the metal elongates, and consequently, allowance must be made for such elongation in the direction of rolling, as the unwelded area, defined by a strip of stop-weld material one unit long (in the direction of rolling), will have grown in length as an incident to the rolling operation.

The accompanying drawings illustrate an embodiment of the invention as exemplified by the core for an automobile radiator. The core, with the great multiplicity of tubes therein, is an integral structure produced from a flat plate resulting from the pressure unification of two sheets of metal (with intervening pattern of stop-weld material) as above described, and which, after being subjected to the necessary reduction and elongation in a rolling mill, is shown in Figure 5. As indicated in Figure 5, a single such unified sheet may provide the stock for the

manufacture of a plurality of cores, and the sheet may be cut up into sections such as the section embraced between the lines A—A and B—B, to provide the stock for a single integral core. The particular sheet shown in Figure 5 has been pressure unified by rolling in the direction indicated by the arrow at the left of the figure. Prior to rolling, there were two component sheets, 1 and 2. On the former, a pattern of stop-weld material was applied such that, after the elongation thereof in rolling, the pattern shown by the stippled section of Figure 5 resulted. In the embodiment shown, the stop-weld material defines a series of three longitudinally extending strips 3 separated by intervening strips 4, which are unprotected by the stop-weld material. The three strips 3, with intervening strips 4, are repeated a number of times transversely of the sheet 1, and each repetition thereof is separated by an unprotected strip 5 of greater width than the unprotected strips 4. Along the outer margins of the sheet, there is an unprotected strip 6, and between the patterns for successive cores, there is an unprotected strip 7. Extending transversely of the sheet, and connecting one end of all stop-weld strips 3, there is a strip of stop-weld material 8 which extends to one margin of the sheet. During the rolling operation, the two sheets 1 and 2 become pressure unified in all of the areas unprotected by stop-weld material, to wit: 4, 5, 6, and 7, while at the areas 3 and 8, which are protected by stop-weld material, there is no welding or unification between the sheets 1 and 2.

Given the portion of the unified flat sheet defined between lines A—A and B—B of Figure 5, the location of the terminus of stop-weld strip 8 at the margin of the sheet is ascertained, and an inflation tool inserted thereat. By the introduction of fluid under pressure, the portions of sheets 1 and 2, which overlie and underlie the strips of stop-weld material 3 and 8, are distended into tubes. The distended structure is then cut off along lines X—X and Y—Y. Either before or after such distention, while still in the flat, such openings as may be desired are punched, sheared, or extruded in areas 5 between the rightmost strip 3 of one series, and the leftmost strip 3 of the next series, it being understood that the edges of such openings are adequately spaced from the adjacent strips 3 to maintain a secure weld between sheets 1 and 2 at the sides of such strips 3.

The sheet may then be zig-zag folded, as shown in Figures 3 and 4, to provide an aligned series of tube panels 9, 10, 11 and 12, until the entire width of the sheet of stock shown in Figure 5 is folded. In other words, the metal which surrounds the tubes resulting from inflation of each series of three strips 3 constitutes a single panel, such as 9, 10, 11, or 12, and there are as many such panels in the zig-zag folded structure as there are series of three strips 3 in the flat sheet shown in Figure 5.

Upon inflation of the unified sheet, a tube 13 is produced at each of the areas delineated by the strips of stop-weld material 3, and between such tubes 13, at the unprotected areas 4, there is produced an interconnecting web 14. Likewise, at the unprotected areas 5 (between the outmost strips 3 of each series), there is produced a wider web 15. In the zig-zag folding of the sheet into the series of aligned panels just described, the fold is made at webs 15, which are of width sufficient not only to accommodate the fold without collapsing the adjacent tubes, but also sufficient to provide an air circulation space between each tube panel and its neighbors.

As previously mentioned, the webs 15 may be perforated or otherwise largely cut away. In the embodiment shown in the drawings, a series of openings 16 is provided in each of the webs 15 both at the front and at the back of the aligned series of tube panels. As shown in the drawings, these openings 16 are formed by three-sided cuts so that the cut-out metal, represented by tabs 17, may be folded inwardly between successive tube panels, and there serve as a spacer and air baffle.

As clearly shown in Figures 1 and 2, the openings 16

may be of such longitudinal extent as to provide almost complete ventilation height-wise of the core, said openings being separated only by relatively narrow bridge piece 18 of dimensions sufficient only to retain the several tube panels 9, 10, 11, 12, and others like them, in integral connection and in proper alignment. As the principal direction of air travel through the core is transverse to the length of tubes 13 (as indicated by the arrow in Figure 3), the relatively large openings 16 in webs 15, at the front and rear of the zig-zag folded structure, provide for the ingress and egress of air into and from the space between successive tube panels 9, 10, etc. As previously stated, the edges of the openings 16 must be spaced from the tubes 13 to leave sufficient residual metal in web 15 that a secure weld is maintained between sheets 1 and 2 at the sides of the tubes (or at the sides of the strips 3, if the holes 16 be formed before the tubes are distended). This residual part of web 15, when bent as shown in Figures 3 and 4, adds stiffness to the panels adjacent the openings 16 at both the leading and trailing edges thereof.

For the sake of clarity in the drawings, the space between adjacent panels 9, 10, etc., as well as the size of the tubes 13, is shown larger than need be in practice. In fact, in actual practice, it is preferred that each tube panel have as many tubes as can be accommodated within the dimensional limits of the panel. Of course, the greater the external area of the panel in proportion to the volumetric content of the tubes, the more efficient will be the heat dissipation, as not only the portion of the panel which forms the exterior walls of the tubes, but also the portion thereof which forms the intervening webs 14, and the webs 15 serve as fins to dissipate heat from the water passing through tubes 13.

The core as thus constructed is appropriately mounted between top and bottom headers 20 of any suitable construction with a fluid-tight connection to the several tubes 13, and is confined sidewise within appropriate members 21. As previously pointed out in connection with Figure 5, the completed core does not include the area of the pressure unified plate which is delineated by the transverse strip 8 of stop-weld material. The strip 8 serves only to delineate a channel through which all of the unwelded areas 3 may be simultaneously inflated and distended; and consequently, where it is more economical to individually inflate the several areas 3 than to waste the metal which is involved in providing such a cross channel, the strip 8 may be eliminated and the metal overlying and underlying the same conserved. Such would be the case in situations where it is desired to assemble the core within

headers 20 before the unwelded areas are distended into tubes.

From the foregoing description, those skilled in the art should readily understand the construction and operation of the radiator core and realize that it accomplishes the objects of the invention. While the invention has been described in detail with respect to its use as the core of an automobile radiator, it will be readily understood that as a heat exchanger it is adapted to diverse other uses; and while reference has been made to the circulation of liquid through tubes 13, and to the transverse passage of air through openings 16 and between the tube panels, it will be readily understood that other coolant fluids will, under various circumstances, be utilized instead of air or water, or both.

While a complete disclosure of one embodiment of the invention has been given to illustrate the construction and operation of the same, it is not to be understood that the invention is limited to the details of the foregoing disclosure. On the other hand, those skilled in the art will readily understand that the essential features of the present invention may be adapted and applied in other forms, and hence such adaptation and application as does not depart from the spirit of the invention is contemplated by and within the scope of the appended claim.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

A heat exchange core comprising a metal sheet having a series of zig-zag folds constituted of a plurality of tube panels in spaced substantially parallel relationship and panel interconnecting bends alternating with said panels, said panels each containing therewithin at least one elongated hollow passageway extending parallel with said bends, the metal at the bends being perforated to permit fluid passageway transversely across the exterior surfaces of the hollow passageways of each of said panels, and fins integral with the bends projecting between said panels.

References Cited in the file of this patent

UNITED STATES PATENTS

965,189	Hyde et al.	July 26, 1910
1,528,461	Woolfe	Mar. 3, 1925
1,542,905	Norrlin	June 23, 1925
2,458,629	Orley	Jan. 11, 1949
2,462,136	Smith	Feb. 22, 1949
2,690,002	Grenell	Sept. 28, 1954

FOREIGN PATENTS

290,868	Great Britain	May 24, 1928
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