

Sept. 20, 1966

T. F. PAULS
HEAT EXCHANGER

3,273,637

Original Filed June 3, 1957

2 Sheets-Sheet 1

FIG. 1

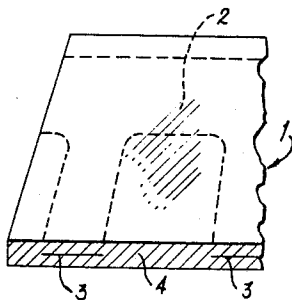


FIG. 2

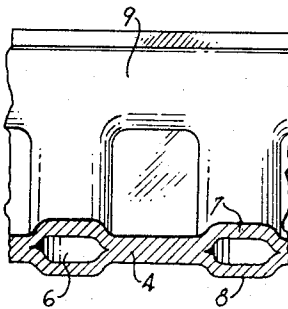


FIG. 3

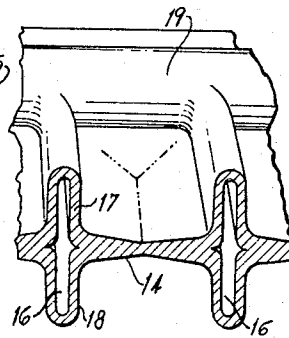


FIG. 4

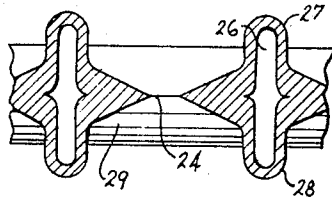


FIG. 5

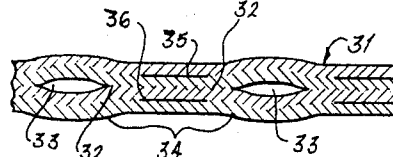


FIG. 7

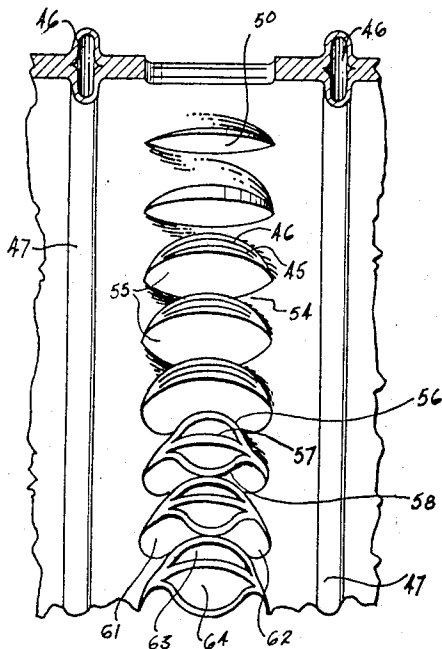
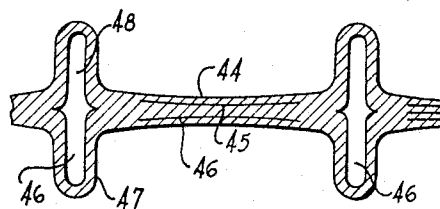


FIG. 6



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FIG. 8

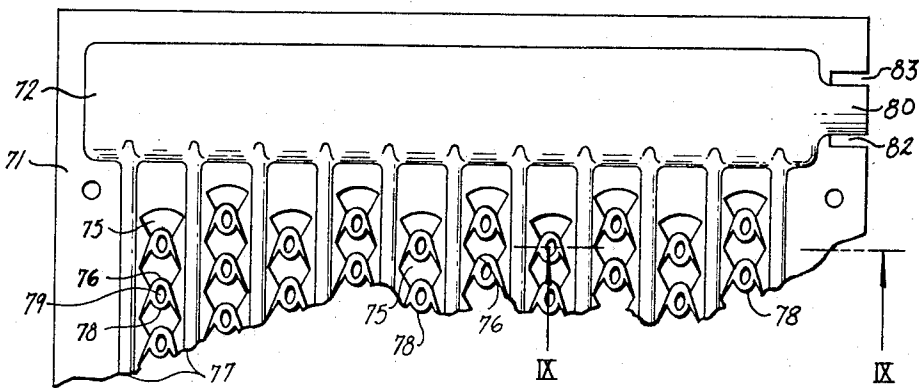
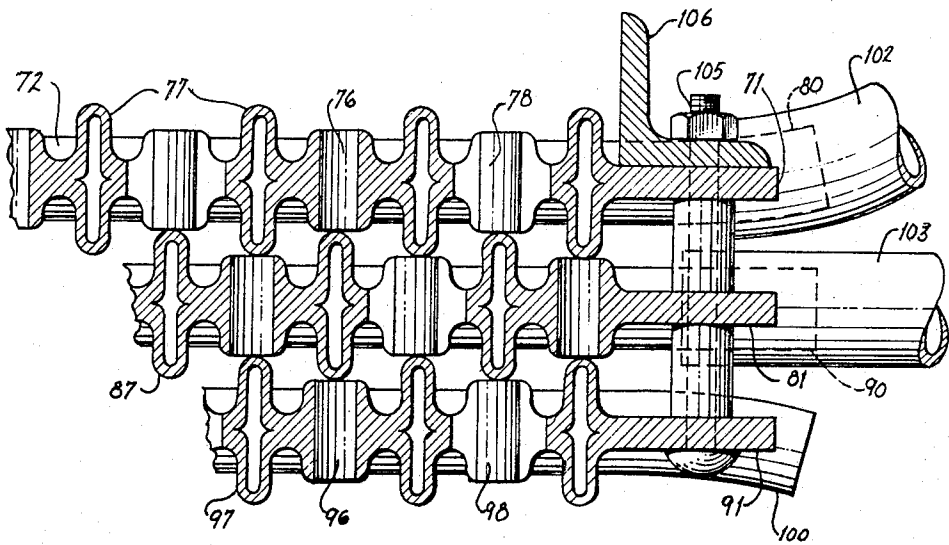


FIG. 9



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3,273,637

HEAT EXCHANGER

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Original application June 3, 1957, Ser. No. 663,062, now Patent No. 2,999,308, dated Sept. 12, 1961. Divided and this application Oct. 5, 1960, Ser. No. 67,147

5 Claims. (Cl. 165—171)

This application is a division of co-pending application Serial No. 663,062, filed June 3, 1957, now Patent No. 2,999,308, issued September 12, 1961.

This invention relates to a heat exchanger construction and more particularly to the art of manufacturing a multiple parallel tube type of heat exchanger unit.

A commonly used and effective type of heat exchanger construction for evaporators, air conditioners, condensers, internal engine cooling radiators, such as automobile radiators, or for space heating such as steam radiators, 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. One or more of such sheet metal units may be employed; and the conduits or tubes serve to carry within a confined heat exchange medium such as water, steam, refrigerant coolant, 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 issues from the cooling block of the engine with the aid of a pump, first enters one of two headers, and then thru 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 headers. Condensers are also frequently of this same type of construction.

According to one heretofore known method of manufacture illustrated in U.S. Patent 2,690,002, this type of heat exchanger unit may be readily manufactured to provide a great multiplicity of tubes in a sheet of metal. This method involves emplacement of a suitable predetermined pattern of weld preventive between component sheets, pressure welding in all adjoining areas except at the preventive, and inflation along the preventive to erect tubes integral with the resultant tubed plate. Full advantage heretofore has not been taken of this method inasmuch as the tubes formed are of rather flat or oval shape with the major dimensions lying within or parallel to the metal plate in which the tubes are formed. In many applications it is desired that the tubes extend not only longitudinally but also extend perpendicularly out of the plate to a considerable extent so as to place a greater number of the tubes in spaced parallel relationship rather than a lesser number in the same plane. This design adapts the units to fabrication as single pieces of large size, a lesser number of which may then be put together for installations where the external medium passes through perforations of the plate transversely to it rather than passing parallel to the plate along its surfaces.

Therefore, it is an object of this invention to provide a novel and improved heat exchanger unit free from the aforementioned disadvantages of complex and consuming constructions and a new and improved method of constructing the same. A further object of this invention is to provide a heat exchanger unit in which a great number of fluid conduits are integrated into a single structural member relatively free from seams and joints and hence a unit admirably suited to mass production methods. Another object of this invention is to provide

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an improved heat exchanger core structure having closely spaced sheet metal elements containing both advantageously angled tubes and also integral extended secondary surfaces or fins and all of a construction adapted for the most economical mass production methods of assembling the core. 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 drawing, in which:

FIGURE 1 is a perspective view of a portion of a typical pressure welded blank made according to the aforementioned U.S. Patent 2,690,002 and illustrating a preliminary construction from which the finished units of this invention may be most readily and advantageously fabricated;

FIGURE 2 is a perspective view of an adjoining fragment of the sheet metal unit in a subsequent stage of fabrication still according to the aforementioned prior art patent;

FIGURE 3 is a perspective view of another adjoining fragment of the unit processed in accordance with one embodiment of this invention to provide a new and improved tube shape;

FIGURE 4 is a transverse cross sectional view corresponding to the end view of FIGURE 1 but showing another embodiment in accordance with this invention;

FIGURE 5 is a transverse cross sectional view showing another partially laminated sheet blank at a preliminary stage according to the invention;

FIGURE 6 is another transverse cross sectional view showing a later stage of manufacture of the embodiment of FIGURE 5;

FIGURE 7 is a side elevational view of a portion of the embodiment of FIGURES 5 and 6 shown in still further progressive stages of manufacture showing the full development of one form of fin structure;

FIGURE 8 is a side elevational view of the upper portion of another embodiment of the form of a panel including a header; and

FIGURE 9 is a fragmentary cross sectional plan view taken on line IX—IX of FIGURE 8.

In accordance with this invention blank sheet metal panels or plates having relatively shallow passageways and intervening webbing are subjected to a reduction in thickness, such as by swaging, between the passageways in such a manner as to reshape the passageways to more fully extend them out of the plane of the sheet. The resultant tubes are of relatively oblong shape extending at right angles to the heat exchange panel from which the tubes are formed integrally along the panel. Reshaping is accomplished by a swaging, coining or forging operation which thins the metal between the tubes and narrows the dimension of the tubes or passageways in the plane of the panel or sheet while at the same time tending to extend the dimension of the tube protruding beyond or out of the plane of the panel, but without any attendant reduction in the overall width of the initial blank. As a result the major axis of the tube cross section is put at an angle of about 90°.

The panel is preferably of the type obtained in accordance with the teachings of the aforementioned U.S. Patent 2,690,002 wherein the passageways in embryonic form are defined by an included thin layer or stratum of weld preventing material such as graphite or the like. For the purpose of providing integral fins closely and most advantageously associated with the tubes, the pressure welded panels also include preferably an intervening unwelded area defined by weld preventive extending between the tube forming laminated portions but spaced therefrom. This intervening unbonded area is subjected to the aforementioned thinning and may lie in one or

more strata to provide two or more thin fins to give a very large extended secondary heat exchanger surface.

The transverse air duct perforations together with fins are constructed in accordance with this invention by first piercing the sheet in the webbing between the tubes, but preferably in the vicinity of the thinned intervening unwelded portions at spaced intervals up and down in the area between adjacent tube portions of the sheet. Finally, an extrusion piercing and separating step is accomplished along the intervening unwelded stratum in the sections remaining after the first slitting or piercing operation so as to separate and twist the fins to put them in the best heat exchange relationship at an angle to the face of the plate. The swaging, piercing and separating operation of this invention has been found to produce an advantageous disposition of the tubes and also a very thin fin structure between the tubes. The fins are turned so as to be in desired alignment or "feathering" with respect to the airflow. The resultant additional fins are many times thinner and have a greatly multiplied effective area as compared to a single heavy fin.

Where a more greatly extended fin surface is desired a severe extrusion is effected in the piercing operation in the intervening fin area so as to not only thin but also further extend the fins out of the plane of the heat exchanger plate.

Each of the resultant plates or units may be used alone or stacked up with a plurality of like plates to form a heat exchanger core structure of the multiple tube type where the tubes of one plate are staggered with respect to the tubes of an adjacent plate and where the tubes of each plate are juxtaposed opposite the fins of an adjacent plate.

Internal layers of weld preventative such as graphite have been found to facilitate the thinning and tube reshaping.

In FIGURE 1 there is shown a preferred form of blank 1 suitable for practice of this invention. It is characterized by a pattern 2 including certain unjoined portions between the outer faces of the blank 1 whereat the blank is laminated so as to include spaced parallel parted or laminated portions 3 and also intervening and surrounding portions 4 at which the blank remains unparted. As shown in FIGURE 2, the parted portions 3 are adapted for development by fluid inflation of internal passageways 6 forming part of a preliminary conduit system 9 evidenced by corresponding rather shallow bulges 7 and 8 on the surface of the intermediate product 5. Although inflation involving the admission of fluid under pressure to the interior surfaces at the lamina 3 which forces these apart to produce a preliminary distention along the internal passageways 6 is contemplated as a preferred mode of passageway generation, other flat passageway containing blanks are also contemplated. In any event, unparted portions 4 remain undistended and separate the passageways not only from each other but also from any intervening opening in the blank.

FIGURE 3 shows the new finished article resulting when the intermediate product 5 is worked in accordance with the invention to reduce the thickness of the metal at web 14 driving the metal to narrow the original passage 6 in the plane of the blank while elongating it to protrude on one side at 17 and on the opposite side at 18 so that the finished panel contains a finished system of hollows 19 having oblong tube passages 16 disposed transversely to extend out the plane of the panel considerably beyond the preliminary bulges 7 and 8. At the thinned web 14 the panel has been stiffened by work hardening. The swaging operation preferably compresses the metal most severely at the central part of the web 14 so as to force the metal to flow more readily as shown. Accordingly, the thickness of the web is less, in gradations throughout the cross-sectional extent thereof, than the thickness of portions of the panel circumscribing the passages 16.

In the embodiment of FIGURE 4 the panel web is indented and simultaneously cut to form an air duct 24 between the oblong tubes 26 while forming the conduit system 29 of the panel having protuberances 27 on one side as the leading edge of the tubes and protuberances 28 on the opposite side as the trailing edge.

In FIGURE 5, another form of roll forged blank 31 is shown also having internal separations in spaced parallel relationship at 33 at which the passageways 46 are to be erected and reshaped to the perpendicular configuration seen in the intermediate hollow article shown in FIGURE 6 which is ready for finning. The blank 31 differs from the previous blank chiefly by the inclusion of two strata 35 and 36 of separation in the blank portion 34 intervening the separations at 33 and isolated therefrom by the unparted areas 32.

After the blank 31 is forged to the shape shown in FIGURE 6, which is characterized by protruding tube extremities 47 and 48 and by the readily separable zones 45 and 46, it is then provided with a series of slits such as 50 in the web 44 running athwart the tubes 47 and the metal remaining between the slits is twisted and preferably also extruded to form the almond shaped openings 55 and transversely extending crude fin 54 struck up out of the panel to extend at any desired angle with it, such as an angle of 90°. Finally, laminations 45 and 46 of each preliminary fin 54 are opened up to form three finished fins 56, 57 and 58 each very thin and also turned at an angle to the finished panel now having air ducts 61 and 62 and also 63 and 64 in place of each of the single openings 55.

It will be understood that while three very thin fins are shown in this embodiment, each fin portion can remain whole or be subdivided into any number of individual fins such as the two shown for example in the embodiment of FIGURE 8 where the panel 71 has many parallel tubes 77, many sets of fins 76 and 78, and also has main openings 75 together with fin openings 79. One end of the panel has a connecting header 72 and a supply or discharge connection 80 which is preferably cut free at 82 and 83 from the surrounding panel and rounded to permit coupling with a supply or discharge line such as 102 shown in the assembled core of FIGURE 9.

The heat exchange core consists of a series of panels 71, 81 and 91 fastened together and mounted by any suitable means such as fastener 105 mounting the unit on support member 106. The individual tubes 77 of panel 71 are in staggered relationship with the tubes 87 of panel 81; and the tubes 97 of adjacent panel 91 in turn are staggered with respect to tubes 87. Thus fins 76 and 78 of panel 71 and its openings 75 and 79 are aligned with a tube 87 of panel 81 as well as with the openings and fins 96 and 98 of panel 91. Suitable coupling is made between the respective panel connections 80, 90 and 100 and pipes such as 102 and 103, for example.

Since many other embodiments may occur to those skilled in the art it is to be understood the foregoing is intended by way of illustration of an embodiment now believed preferred and not as a limitation of the scope of the present invention except as set forth in the appended claims.

What is claimed is:

1. A hollow sheet metal plate having extending internally therein a system of fluid passages with said passages comprising spaced parallel fluid passageways extending longitudinally in said plate and also distended out of the plane of said plate with the distention of said passageways in a cross-section thereof normal to said plane extending out of said plane an amount greater than the width of said passageways in said cross-section so that said passageways in said cross-section are elongated to have their major axis extending in a direction transverse said plane, the thickness of said plate between said passageways being less, in gradations throughout the cross-sectional extent thereof, than the thickness of said plate

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in portions circumscribing said passageways, a portion of said plate between said passageways having at least one opening through said plate adjacent at least one integral fin extending out of and substantially transverse said plane of said plate.

2. A plate according to claim 1 wherein said portion of said plate between said passageways is provided with a series of openings through said plate in alternation with integral fins extending out of and substantially transverse said plane of said plate.

3. An assembly comprising a plurality of the plates of claim 2 disposed in face-to-face relationship with the passageways of one of said plates opposite to end extending in substantially the same direction as the web portion, between adjacent passageways, of an adjacent similar plate.

4. The assembly of claim 3 wherein each of said plates includes a header extending internally of said plates in a direction transverse to and interconnecting therein said

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passageways, and an interconnection between the headers in the assembly of said plates.

5. The plate of claim 3 including a fluid passage extending internally through said fins in a direction transverse said plane.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,273,637

September 20, 1966

Theron F. Pauls

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 13, for "end" read -- and --.

Signed and sealed this 22nd day of August 1967.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents