

June 9, 1964

H. D. HUGGINS ET AL

3,136,038

METHOD OF MAKING A HEAT EXCHANGER

Filed Oct. 6, 1960

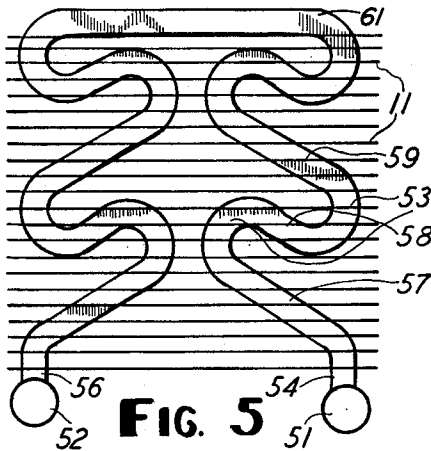


**FIG. 5**

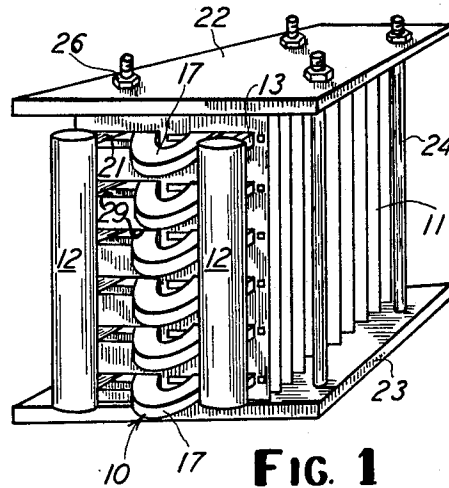


**FIG. 1**

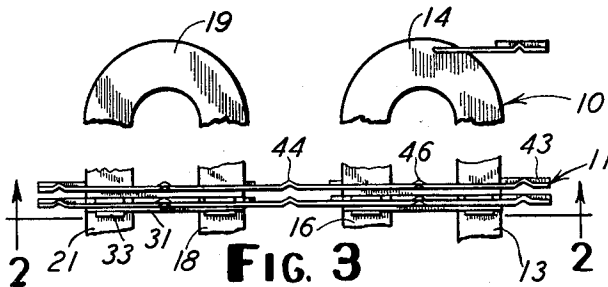


**FIG. 3**

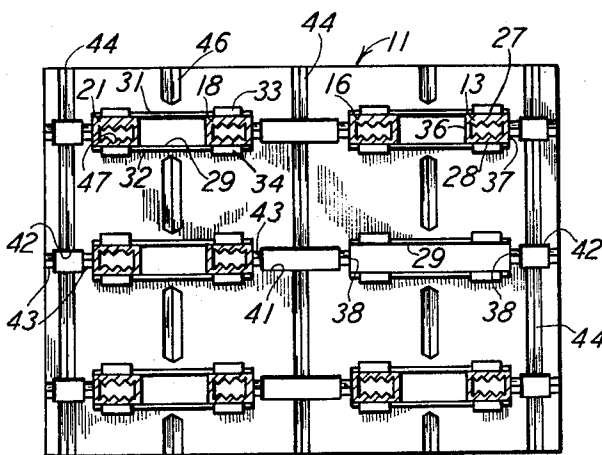


**FIG. 2**

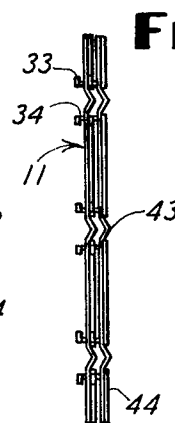


**FIG. 4**

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**METHOD OF MAKING A HEAT EXCHANGER**  
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Filed Oct. 6, 1960, Ser. No. 60,958  
5 Claims. (Cl. 29—157.3)

This invention relates to a heat exchanger, and more particularly, it relates to an evaporator for use in an automobile air conditioning system, and the method of making same.

For the most lucid description of this invention, these comments will now be made regarding the state of the art relating to heat exchangers having the features under consideration herein. Heretofore, heat exchangers have been known and made to consist of an extended tube of a serpentine or reversed loop shape for the usual passage of a liquid through one end of the tube and out the other end of the tube. Of course the usual plate type of fins are disposed transverse to the axis of the tube and in contact with the tube in order to give the usual heat transfer characteristics to the exchanger. In this known construction, it is also common to make the tube circular in cross section and the fins thus have either circular or oblong shaped openings therein so that the tube can be passed through the openings in the fins. The tubes can then be hydraulically expanded in order to make physical contact with the edges defining the fin openings if a snug fit is not already obtained through the original dimensioning of the outer diameter of the tube and the size of the openings. Also, the desired contact between tube and fin can be by a metallurgical process such as soldering or brazing in the heretofore known exchangers. Certain disadvantages exist in this conventional type of exchanger, and the disadvantages include the fact that the openings in the fins and the diameters of the tubes must be precisely made in the type of core where there is no expansion of tube to fit snugly with the fin openings. Also, where the tube is expanded to fit snugly with the fin openings, the fin bond is generally not tight since the fin does not have sufficient strength to resist the expansion and therefore an inferior heat transfer relation exists in this type of mechanical bonding. Further, the maximum contact between the fin and tube is limited to the internal circumference of the fin opening or collar. Still further, and an important point, is the fact that the return bends of the tube cannot be utilized in their maximum capacity for heat transfer since fins cannot be placed over the return bends in snug contact therewith as desired. Also, these return bends are frequently separate pieces which must be attached to the intermediate straight length of the tube, and these seams or points of attachment of course are potential sources of tube leakage. In the tube design where the return bends are not separately attached to pieces, the tubes must be flattened or deformed to where again they are not available for maximum heat transfer function since the fins cannot be placed over these return bends.

It is a general object of the present invention to provide a method of making a heat exchanger which will retain all of the advantageous features of the extended surface or serpentine type of exchanger, but yet which will over-

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come the disadvantages such as those mentioned heretofore.

It is accordingly an object of this invention to provide a method of making a heat exchanger of the type wherein serpentine-shaped tubes are disposed within openings in fins extending transverse to the direction of the tubes, wherein the full length of the tubes have fins applied thereto for maximum heat transfer efficiency.

Another object of this invention is to provide a method of making a heat exchanger wherein the area of contact between fin and tube is at a maximum although no expensive or intricate manufacturing is required in order to obtain the maximum contact area.

Another object of this invention, and one which is in conjunction with the foregoing object, is to provide a method of manufacturing a heat exchanger having the desirable features expressed heretofore so that the exchanger is relatively inexpensive but yet of a maximum efficiency and easy to manufacture. Further, the exchanger of this invention can be metallurgically bonded between tube and fin and thus this more desirable form of bonding for the instant purpose is available.

Still another object of this invention is to provide a method of making a heat exchanger core which permits the use of rectangular extruded tubing and particularly the type which contains internal finning which can more easily provide an optimum ratio from heat transfer areas. Further, the rectangular tube permits the tube to be formed into a serpentine shape so that special treatment or brazing or soldering of return bends is not required. Still further, with the use of the rectangular tube, the maximum area of contact between tube and fin can be achieved by disposing the fins oblique to the axis of the tube rather than directly transverse thereto and thus a longer length or area of contact can be achieved.

Other objects and advantages will become apparent upon reading the following description in light of the accompanying drawings wherein:

FIG. 1 is a perspective view of a preferred exchanger of this invention and showing the exchanger in a fixture so that it is ready for metallurgical bonding.

FIG. 2 is an end elevational view of the exchanger of this invention and it is a sectional view taken on the line 2—2 of FIG. 3 and has one end of a tube thereof removed for purposes of clarity of drawing.

FIG. 3 is a top view of a fragment of the exchanger shown in FIG. 2 and having the tube thereof broken away and having certain fins eliminated and the upper fin broken away all for the purpose of clarity of drawing.

FIG. 4 is a side elevational view of the exchanger shown in FIG. 2 but with the tubes thereof removed.

FIG. 5 is a top plan view of the exchanger of this general type, but showing a different form of the exchanger tube.

The same reference numerals refer to the same parts throughout the several views.

The drawings show the exchanger to consist generally of a serpentine and rectangular cross section tube 10 and fins 11 disposed thereacross. Headers 12 are suitably attached to the several tubes 10 in the usual manner, and as customary, fluid can then flow into one header 12 and through the first length 13 of the tube 10 and around the return bend 14 of the tube 10 and then through the straight length 15 of the tube 10. The serpentine shaped

tube then continues through the other return bend 17 and into the next straight length 18 and around the next return bend 19 and through the last straight length 21 and into the outlet header 12 on the left in FIG. 1. Thus the usual general arrangement of a serpentine shaped tube and cross fins is shown in the drawings, and of course it will be understood that a plurality of tubes 10 can be employed such as the six layers thereof as shown in FIG. 1 or the three tubes or layers thereof as shown in FIG. 2. FIG. 1 further shows an upper plate 22 and a lower plate 23 connected by posts 24 which are suitably attached to the plates 22 and 23 and which may have adjustable means such as the nut 26 on the post 24 to permit the plates 22 and 23 to be drawn together and thereby compress the fins 11 to place them into snug contact with the upper and lower surfaces 27 and 28 respectively of the tubes 10 in a manner made more apparent hereinafter.

FIG. 2 shows the front elevational view of a preferred fin 11, and it will here be noted that the fin is provided with rectangular openings 29 which are also defined by an upper flange 31 and a lower flange 32 extending transverse to the plane of the body of the fin 11. It will here also be noted that the straight or parallel length of the tubes 10 are disposed at opposite ends of the rectangular openings 29 and it will thus be understood that the tubes can be inserted into the openings, or the fins of course can be slid over the tubes when the latter are in their completed serpentine shape as shown and even when the headers 12 are attached to the tubes. The fins 11 also have tabs or spacers 33 and 34 formed thereon so that they project forwardly of the plane of the fins 11 and thus about the fin disposed in front thereof to provide for automatic spacing between the fins, as shown in FIGS. 3 and 4.

It will also be noted that the opposite sides 36 and 37 of the tubes 10 are defined on the tube, and the side 37 is shown to be in contact with the outer edge 38 of the opening 29. Thus, the three sides 27, 28, and 37 of the rectangular tube 10 are in contact with the edges defining the opposite ends of the fin openings 29.

The method of manufacturing the exchanger core to achieve the object of placing the fin and tube in the desired contact described, is that of compressing the fins between top and bottom thereof so that the upper edges or collars 31 and the lower edges or collars 32 come into abutment with the respective upper and lower surfaces of the tube. Thus, the opening 29 can be stamped or otherwise formed in the fin 11 at any desirable oversize dimension which does not require precise tolerance and thus is inexpensive and simple to provide. With opening 29 being slightly oversize, the fins can then be compressed so that each fin is snug on the tube as desired. To accomplish this, it is preferred that the fins 11 be formed with central cutouts 41 and end cutouts 42 which are shown in alignment with the fin openings 29 so that upon compressing the fin 11 in the plane thereof, the fin will collapse so that, in the area of the opening 29, it becomes snug with the tube 10 as shown. To further facilitate the shortening or collapsing of the fin 11, it is shown that indentations 43 are provided in the fin and are also disposed in line with the openings 29, 41, and 42 so that this entire transverse line of the fins is weakened and will readily collapse down to where the fin is snug on the tube 10 as desired.

Further, to stiffen the fin 11 in the direction of its height or the force which is being applied thereto by the fixture shown in FIG. 1, it is shown that folds or indentations 44 extend from top to bottom in the fin 11 so that the fin will not buckle or collapse off the plane thereof, but instead it will simply collapse within its original plane to be shortened as desired. Additional indentations or creases 46 are provided in the fins for this purpose. For purposes of simplicity and also clarity, these creases or indentations 43, 44, and 46 are not shown in FIG. 1, but

it will of course be understood that they would be included in the fins 11 as fully shown and described in conjunction with FIGS. 2, 3, and 4 in order that the fins will collapse vertically or along their height as described.

FIG. 3 further shows that the fins 11 can be disposed over the return bends 14 and 19 of the tube 10 and thus the upper and lower surfaces 27 and 28 of the tube will be in contact with the respective adjacent edges or collars 31 and 32 of the openings 29 so that even the return bends of the core serve as part of the prime surface of the exchanger to increase the efficiency of the exchanger and this is made possible by the provision of the rectangular cross section of the tubes. FIG. 2 further shows that the interior of the tube 10 is provided with the fins 47 so that the interior surface of the tubes is increased by the provision of the fins and thus the tube efficiency as a heat exchanger is accordingly increased.

FIG. 5 shows a modification of the exchanger in that the tube 10 is not only of a serpentine shape in extending from say an inlet header 51 to an outlet header 52, but also the tube has reverse bends 53 along the length thereof within the interior of the core covered by the fin 11. Thus it will be understood that the fin 11 as described in the other drawings will also be utilized in FIG. 5 so that the rectangular openings 29 are provided in the fins 11 and the tube 10 can be assembled with the fins by say inserting the tube ends 54 and 56 into the fin openings 29. There are at least two advantages to the arrangement shown in FIG. 5 and it will here of course be understood that a rectangular tube 10 also is employed so that the tube has the ends 54 and 56 described and it also has the straight portion 57 and the curves 53 and the intermediate portion 58 and 59 and the return portion 61. In this particular arrangement, the advantages are that the fin contact with the tube is of increased length since the fin extends diagonally over the tube lengths 57, 58, 59, as well as diagonally over the return bends 53. This, therefore increases the length as mentioned, and it accordingly increases the exchanger efficiency. Also, the overall length of the tube 10 is greater though actually only two passes are made through the exchanger, rather than the four passes as described in the other figures. This particular modification points up the versatility and advantage of the rectangular tube as compared to the round tube described in the foregoing of this description.

It should also be understood that the tube 10 has the loop or serpentine shape of the tube shown in FIG. 1 of U.S. Patent No. 2,838,830. The tube therefore has parallel legs 13, 16, 18 and 21 with curved portions 14, 17, and 19; and parallel legs 58, 59 and curved portions 53 are shown in FIG. 5.

In summary, the exchanger consists of a rectangular tube 10 and fins 11 with an opening 29 therein for receiving and thus surrounding the tube 10 to provide a large contact area between the tube 10 and the edges of the fin opening. In the method of making this exchanger, the fin openings 29 are formed initially larger than the cross section of the tube in the height of the latter between top 27 and bottom 28. The dimension between the diametrically opposite surfaces or sides 27 and 28 is thus a selected dimension. Also, the fins can be scored or creased at the lines 43, and additional openings 41 and 42 can be provided in alignment with the tube openings 29. The fin is thus weakened across the width thereof, and pressure applied to the fin height by the fixture of plates 22 and 23 and rods 24 will cause the fins 11 to collapse along those transverse lines 43 so the openings 29 become snug on the tubes 10, as desired. The exchanger is then ready for metallurgical bonding. Also, the tubes 10 and the fin openings 29 can be so dimensioned that the spacing between tube lengths 13, 16 and 18, 21 are slightly oversized with respect to the widths of the openings between edges 38, and the tubes 10 can be sprung inwardly by a force so that the lengths 13, 16 and 18, 21 are moved together within the elastic limit of their material so they are suf-

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ficiently clear of the opening edges 38 when the fins 11 are placed over the openings 29. Then, upon release of the tubes, or upon the outward expansion thereof by an outwardly directed force, the tubes 10 will come into snug contact at their sides 37 with the edges 38.

The advantage of this method is the elimination of the manufacturing precision heretofore required, and an even better and more efficient heat exchanger results since three-sided contact is assured, and the return bends 14 and 19 are utilized as prime surface at least on the tube tops 27 and bottoms 28.

While two specific embodiments and a method have been shown and described, it will be understood that certain changes could be made therein and the invention therefore should be limited only by the scope of the appended claims.

What is claimed is:

1. A method of manufacturing a heat exchanger of the tube and sheet fin type, comprising the steps of forming a tube into a cross-sectional shape and having diametrically opposite exterior surfaces spaced apart a selected dimension, forming an opening in the sheet of the fin for receiving the tube co-axially of said opening and with said opening being larger than said selected dimension of said tube along the line of orientation of said selected dimension, scoring said fin along a line oriented to be both transverse to said line of orientation of said selected dimension and in intersection with said opening, assembling said tube and said fin with said tube being disposed in said opening and across the plane of said fin, forcing inwardly on the opposite peripheral edges of said fin for collapsing said fin in said plane thereof and in the direction along said line of said selected dimension until opposite edges of said fin defining said opening are snug on respectively said opposite exterior surfaces of said tube and in abutment therewith, and metallurgically bonding said tube and said fin together at the areas of abutment therebetween.

2. A method of manufacturing a heat exchanger of the tube and sheet fin type, comprising the steps of forming a tube into a rectangular cross-sectional shape and a serpentine shape along the longitudinal axis of said tube and in one plane to have parallel legs and an interconnecting curved portion, forming an elongated rectangular opening in each of a plurality of the fins for receiving the tube co-axially of said opening and with the smaller dimension of said opening being larger than the corresponding dimension between the opposite sides of the cross-section of one of said parallel legs of said tube for receiving said tube with clearance and with the larger dimension of said opening being sufficiently long for receiving two of said parallel legs, creasing said fins along a line coaxial with the longer axis of said rectangular opening, forming a spacer on each of said fins at the edges defining said openings, assembling said tube and said fins with said two parallel legs of said tube being disposed in each said opening and across the plane of said fins and with each said spacer abutting the adjacent said fin, compressing said fins in said plane thereof in direction of said smaller dimension of said opening and transverse to said line on said fin by forcing inwardly at the opposite peripheral edges of said fins until said opening is snug on said tube and in abutment therewith on the fin surfaces defining said opening, and bonding said tube and said fin together at the areas of abutment therebetween.

3. A method of manufacturing a heat exchanger of the tube and sheet fin type, comprising the steps of forming a tube into a rectangular cross-sectional shape, with a selected dimension across opposite sides, and into a serpentine shape along the axis of said tube to have spaced-apart parallel legs and an interconnecting curved portion, forming an elongated rectangular opening in each of a plurality of planular fins for receiving said tube transverse to the plane of said fins and with said opening being larger than said selected dimension of said tube in one

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direction of said opening along the line of said selected dimension, for receiving the latter with clearance, and said opening being sufficiently long in the other direction for receiving two of said parallel legs, forming said fins along a first line coaxial with the longer axis of said rectangular opening for weakening said fins along said first line relative to a force directed transverse to said first line, and forming said fins along a second line transverse to and offset from said first line for stiffening said fins along said second line relative to said force, assembling said tube and said fins with said tube being disposed in said opening and across the plane of each of said fins and with said two parallel legs in each said opening, and with each of said fins spaced from the adjacent one of said fins, forcing inwardly on the peripheral edges of said fins in the direction of said second line until each said opening is reduced in dimension in said one direction to where said fins are in abutment with said tube on the fin surfaces defining said opening, and bonding said tube and said fin together at the areas of abutment therebetween.

4. A method of manufacturing a heat exchanger of the tube and sheet fin type, comprising the steps of forming a tube into a cross-sectional shape of a selected dimension across diametrically opposite exterior surfaces, and forming the length of said tube into a serpentine shape along the axis of said tube and in one plane to have spaced-apart parallel legs and an interconnecting curved portion, forming an elongated first opening in each of a plurality of planular fins for receiving the tube and with said first opening being larger than said selected dimension of said tube in one direction along the line of said selected dimension, and said first opening being sufficiently long in another direction for receiving two of said parallel legs, forming additional openings in each said fin on opposite sides of and on a first line along the larger axis of each said first opening, creasing said fin along each said first line coaxial with each said larger axis and along a second line transverse to each said first line, assembling said tube and said fins with said tube being disposed in said first openings and across the planes of said fins with said two parallel legs in each said first opening, and with each said fin spaced from the adjacent said fin, compressing said fins on the opposite peripheral edges thereof in the direction of each said second line until said first opening is reduced to said selected dimension to have said fins snug on said tube and in abutment therewith on the fin surfaces defining said first opening, and bonding said tube and said fins together at the areas of abutment therebetween.

5. A method of manufacturing a heat exchanger of the tube and sheet fin type, comprising the steps of forming a tube into a cross-sectional shape with a first selected dimension across opposite sides, and forming said tube into a serpentine shape along the axis of said tube to have pairs of parallel legs spaced apart and to have an interconnecting curved portion, forming an elongated opening in each of a plurality of fins for receiving the tube and with said opening being larger in one direction than said first selected dimension of said tube, and said opening being smaller than the spacing between the furthest spaced-apart portions on said spaced-apart parallel legs in another direction along said opening and transverse to said one direction, displacing and holding said pairs of legs toward each other and then assembling said tube and said fins with said two parallel legs being disposed in said opening and across the plane of said fins, releasing said legs for movement of said portions to opposite ends of said opening to abut the edges of said fins defining said openings, forcing inwardly on the peripheral edges of said fins in said planes thereof and collapsing said fins until opposite edges of said fins defining said opening are snug on said opposite sides of said tube and in abutment therewith, and bonding said tube and said fin together at the areas of abutment therebetween.

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