

April 12, 1966

F. M. YOUNG

3,245,465

HEAT-EXCHANGER CORE-UNIT CONSTRUCTION

Filed Dec. 9, 1964

4 Sheets-Sheet 2

FIG. 4

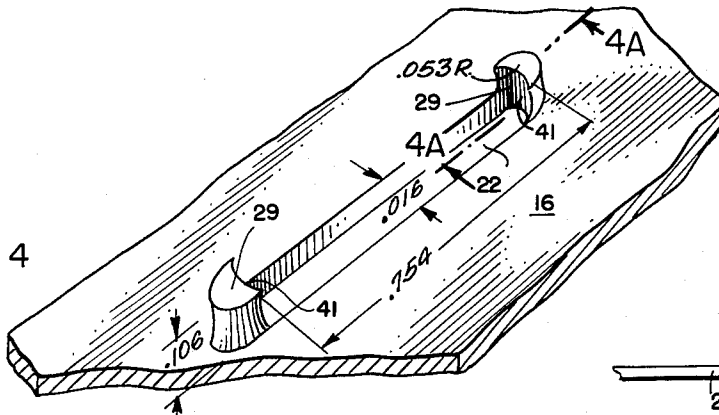


FIG. 4A

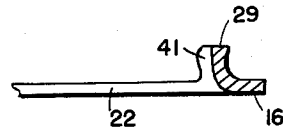


FIG. 5

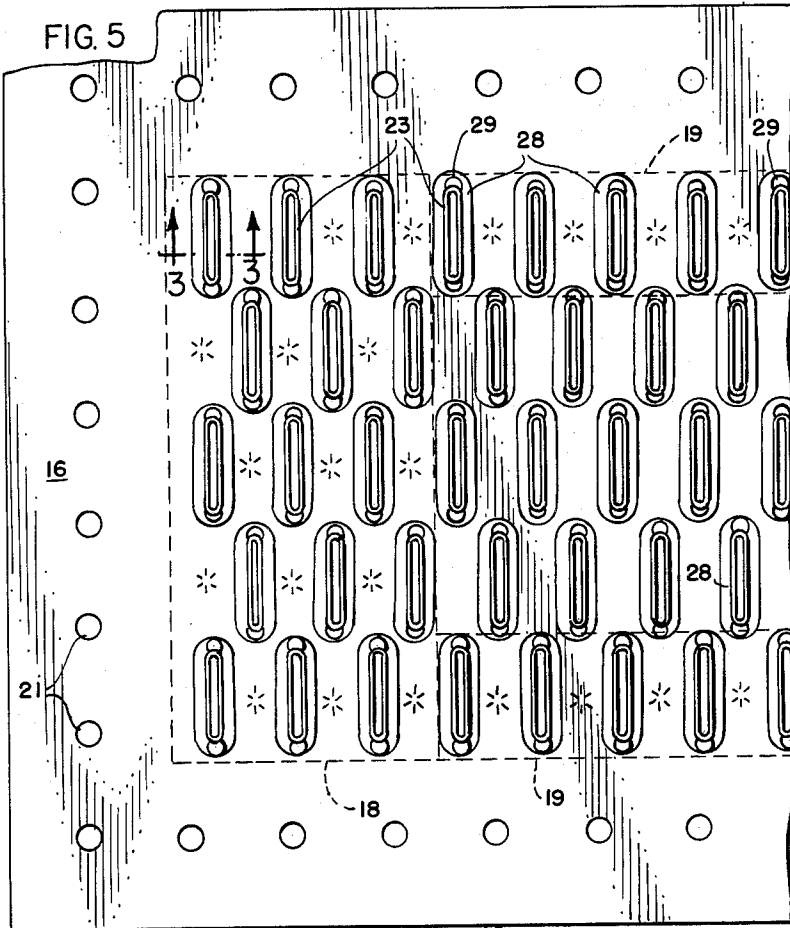


FIG. 6

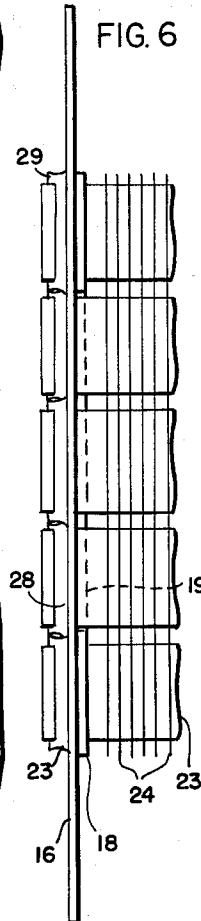
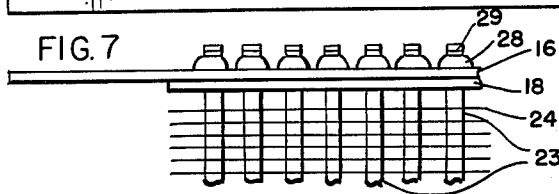


FIG. 7



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FIG. 8

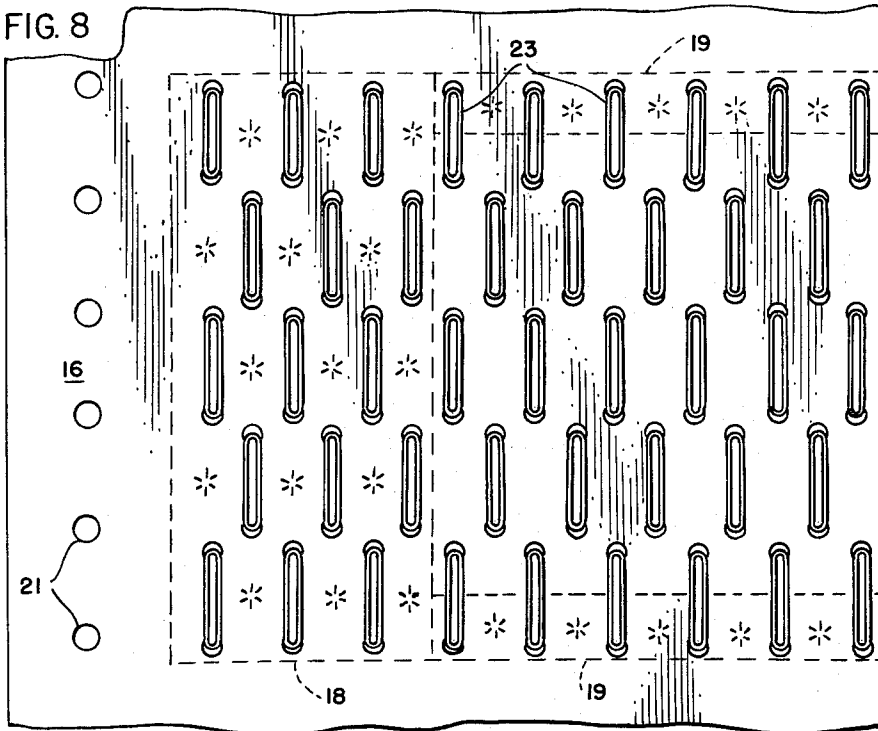
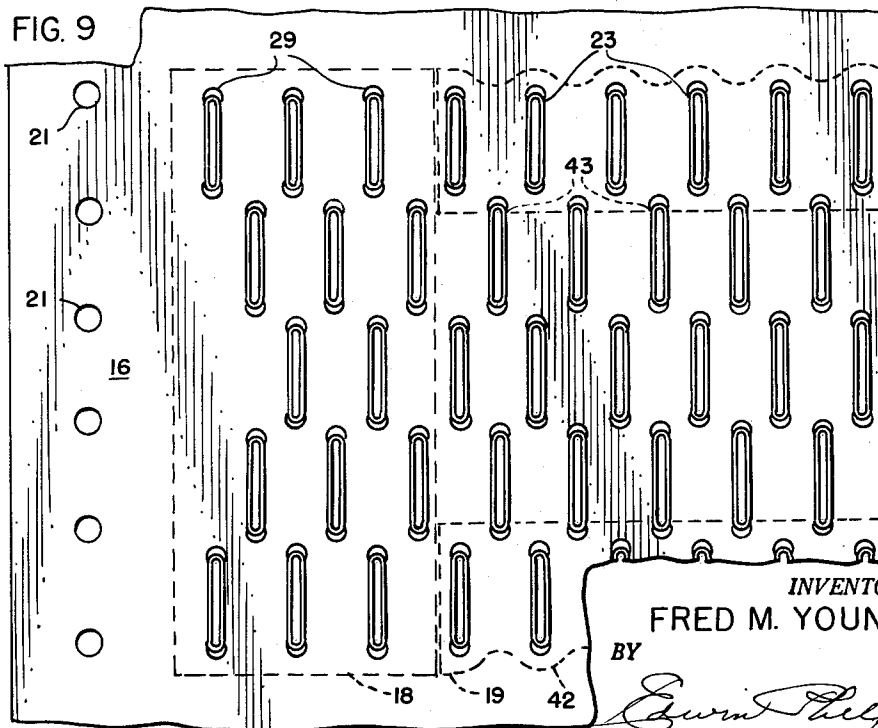


FIG. 9



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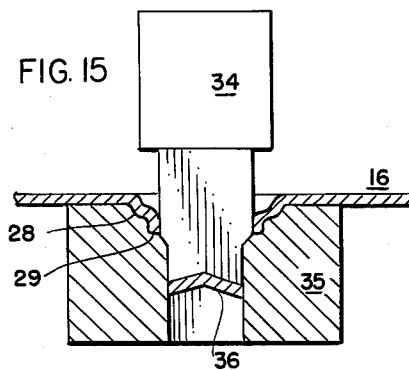
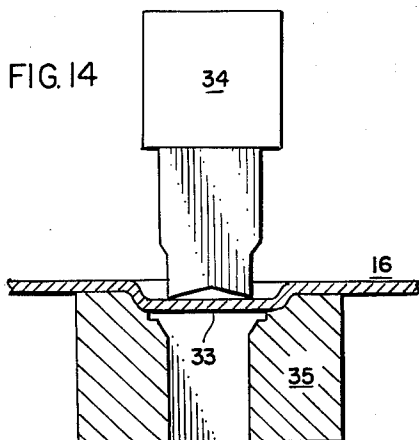
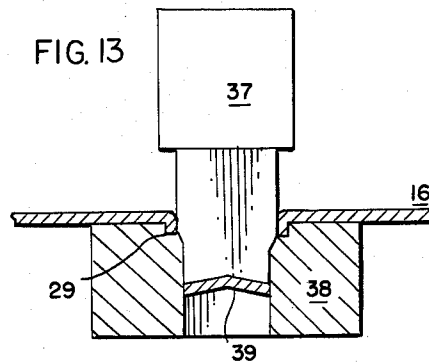
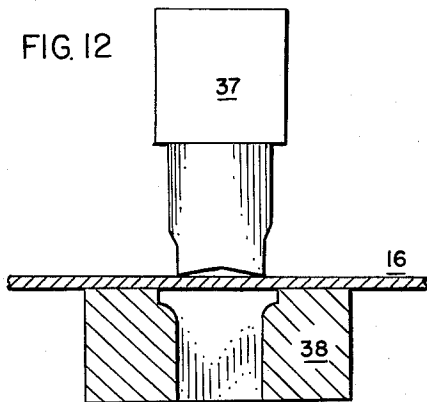
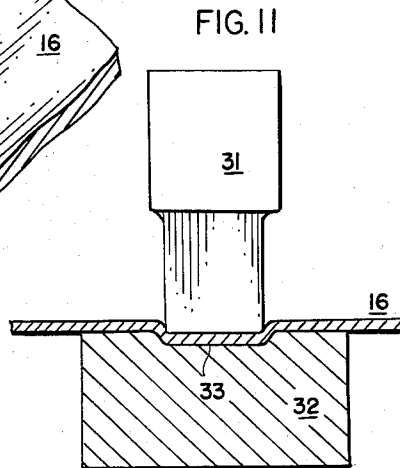
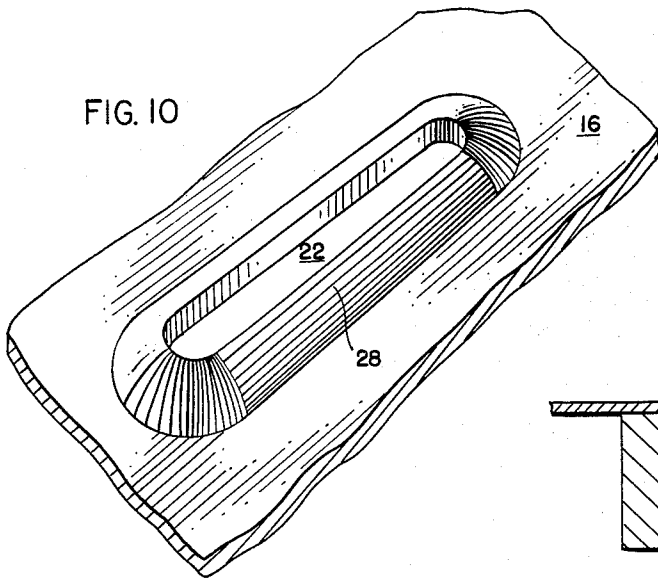
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HEAT-EXCHANGER CORE-UNIT CONSTRUCTION

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4 Sheets-Sheet 4



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3,245,465

HEAT-EXCHANGER CORE-UNIT CONSTRUCTION
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Filed Dec. 9, 1964, Ser. No. 418,594
15 Claims. (Cl. 165-148)

This application is a continuation-in-part of application Serial No. 120,825 filed May 15, 1961, now abandoned.

This invention relates to the structure of core-units for heat-exchangers used in the cooling-systems for heat engines powering motor vehicles.

The conventional type of core-unit for heat-exchangers used in cooling systems for heat-engines, comprises a finned-tube-assembly bonded to, between and supported on axially-spaced header-plates each of which mounts a tank. The tube ends extend through openings in the header-plates and, generally, the bonding of the contacting areas of the tube ends and the header-plates is effected by the use of solder. In some instances, however, brazing might be practiced. The type of bonding may be determined by the use to which the finished heat-exchanger is put.

Where the heat-exchangers are used in motor-vehicles traveling over natural terrain, the tube-header-plate bonds are subject constantly to the severest kind of combination strains resulting from the vibrations of the engine and the movement of the vehicle over the terrain.

To insure optimum light weight of heat-exchangers and minimum production costs the header-plates have to be as thin as is possibly consistent with practical results. Experience has shown that the fracturing of bonds between the tube ends and the header-plates appears first with the tubes adjacent the ends of the header-plates, later with the lateral or outside rows of tubes and still later, if at all, along the inner rows of tubes. Where these core-units are made with tubes of elongated or elliptical cross-section the fractures tend to occur first at the bonds of the lateral edges of the tubes to the plate.

For these reasons the manufacturers of heat-exchangers have sought every possible ingenuity possessed of engineers and mechanics to so structure these bonds as to reduce to a minimum the likelihood of fracturing thereof under whatever may be the conditions to which the heat-exchangers are subject. Obviously, when any of these bonds are fractured the resulting leakage renders the heat-exchanger useless and calls for repair or replacement. Either such result is relatively expensive and often causes financial loss during idle equipment.

The main objects of this invention, therefore, are to provide an improved structuring of the core-units for heat-exchangers used in the cooling systems of heat-engines; to provide an improved structuring of the header-plate for core-units of this kind which makes possible such a strengthening of the bonds between the header-plates and the tubes as to greatly reduce, if not eliminate, likelihood of fracturing of the bonds regardless of the uses to which the heat-exchanger may be subject in normal use; to provide an improved structuring of header-plates of this kind especially adapted for use with tubes of elongated or elliptical cross-section; and to provide an improved structuring of header-plates of such simple form as to make highly economical the manufacture of heat-exchangers for motor-vehicle cooling-systems, and render extremely unlikely the fracturing of header-plate-tube bonds when heat-exchangers are used over long periods of time under the most extreme conditions.

In the structural adaptations shown in the accompanying drawings:

FIG. 1 is an exploded perspective of a portion of a dish-type header-plate and a section of a finned-tube-

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assembly preparatory to their being assembled and bonded together, the header-plate showing one form of upset portions of the header-plate which define the tube-openings therein;

5 FIG. 2 is a much enlarged, fragmentary, perspective of the form of tube-opening upset portions of the header-plate such as shown in FIG. 1;

FIG. 2A is a fragmentary, cross-sectional view taken on the plane of the line 2A-2A of FIG. 2;

10 FIG. 3 is a fragmentary, sectional view taken on the plane of the line 3-3 of FIG. 5;

FIG. 4 is a view similar to FIG. 2 but showing a modification of the tube-opening upset portions of the header-plate;

15 FIG. 4A is a fragmentary cross-sectional view taken on the plane of the line 4A-4A of FIG. 4;

FIG. 5 is a plan view of one end of a flat-type header-plate and bonded tube-assembly with the form of tube-opening header-plate upsets shown in FIG. 1, the header-plate being reinforced with end and lateral auxiliary plates;

FIG. 6 is an end view of the structure shown in FIG. 5;

FIG. 7 is a portion of a side view of the structure shown in FIG. 5;

25 FIG. 8 is a plan view of a section of flat-type header-plate having tube-opening upsets of the form shown in FIG. 4, and illustrating a slightly modified arrangement of the lateral auxiliary plates;

FIG. 9 is a view similar to FIG. 8 but showing a further modified arrangement of the lateral auxiliary plates;

30 FIG. 10 is a view similar to FIG. 2 but showing the upset around the tube opening without the end extrusions;

FIG. 11 is a diagrammatic view of the punch and die block required to form the depressions in the header-plate preparatory to subsequently forming the plate with the upset portions as shown in FIGS. 2 and 10;

35 FIGS. 12 and 13 are diagrammatic views of the punch and die block in the successive positions for initiating and completing the formation of the end extrusions shown in FIG. 4; and

40 FIGS. 14 and 15 are diagrammatic views of the punch and die block in the successive positions for initiating and completing the formation of the side and end extrusions in FIG. 2.

45 The essential concept of this invention involves effecting the reinforcement of the solder bonds of tube ends with header-plate, for the core-units of heat-exchangers required for motor-vehicles, by reformed of the header-plate which define the tube openings therein to increase the areas of plate and tube contact whereat bonding is effected and by bonded super-imposed auxiliary plates embracing rows of tubes at the ends and along the lateral portions of the header-plate.

50 A reinforced core-unit, for motor-vehicle heat-exchangers, embodying the foregoing concept comprises a pair of header-plates 16 (only one being shown herein) and a finned-tube assembly 17 and auxiliary reinforcing plates 18 and 19.

55 The header-plate 16 may be the dish-type, as shown in FIG. 1, or the flat-type, as shown in FIGS. 5-9. Generally, either of these types of header-plate 16 is made of copper or brass. The thickness for either type depends somewhat upon the required size and use of the heat-exchanger. In a more or less standard size heat-exchanger the dish-type header-plate would be formed of metal approximately .100" thick, whereas, the flat-type header-plate would be formed of metal approximately .035-.125" thick. In either type of plate this is sufficient to provide plates with a renitency sufficient to resist distortion under severe strains. The length and width of the header-plate 16 would depend upon the heat exchange capacity re-

quired for the equipment with which the heat-exchanger is to be used. Either type of header-plate may be solder bonded or bolted to a conventional tank. In the structures herein shown a series of bolt holes 21 are formed therein around the perimeter for the attachment of the conventional tanks (not shown) to complete the heat-exchanger.

Either type of header-plate 16 has rows of elongated openings 22 formed therein for the reception of the tubes 23 of the finned-tube-assembly 17. The formation of the header-plate 16 to define the tube openings 22, which is one of the essential features of this invention, will be explained presently.

The finned-tube-assembly 17 preferably is of the construction shown and described in Patent No. 2,932,489, issued April 12, 1960. In this construction the tubes 23 are of flat elongated form arranged in parallel rows extending through a stack of perforate fin sheets 24 and mounting protective side members 26 (FIG. 1). The tube ends 27 extend above the outermost fin sheet 24 for telescopic contact insertion into the openings 22 in the header-plate 16.

The tubes 23 may be either the conventional extruded form or the seamed form. The opposite tube walls preferably are parallel with the opposite lateral edges rounded. Generally, the tubes are formed of a copper alloy. In a more or less standard heat-exchanger of this construction, the tubes 23 would be approximately .748" in transverse external width and .096" in transverse thickness. When these dimensions are compared with those of the herein-after-explained form of openings 22 in the header-plate 16, it will be noted that the tube ends 27 will easily but snugly telescope into the openings 22 to extend the requisite distance above the exposed face of the header-plate 16. It will be understood, of course, that the differentials in the dimensions of the tubes 23 and between the opposed faces of the upset rims 28 and the extruded knobs 29 is such as to insure the requisite capillary action to draw the molten solder into all the opposed areas of the tubes 23 and the portions of the header-plate 16 which have been formed into the rims 28 and knobs 29.

Returning, now, to a further explanation of the header-plate 16, portions of the header-plate 16, which define the respective openings 22, are formed to provide the parallel and opposed side upset rims 28 and/or opposed end extruded knobs 29. The purpose of this formation is two-fold; to enlarge the bonding areas of the tube ends 27 to the header-plate 16 and disposed portions of these bonding areas above the exposed face of the header-plate 16. As is indicated in the drawings, such a header-plate 16 may be formed only with the end extruded knobs 29 (FIGS. 4, 8, and 9) or in combination with the parallel upset rims 28 (FIGS. 1, 2, 5-7), or the header plates 16 may be formed with only the upset rims 28 (FIG. 10).

The forming of these upset rims 28 and/or 29 requires tools and a procedure quite different from that conventionally used in the formation of header-plates where the tube openings 22, which provide the bonding areas with the tubes, are disposed within the plane of the header-plate as shown in the aforesaid patent.

To make provision for the upset side rims 28, defining the tube openings 22, for either of the header-plates 16 shown in FIGS. 2 and 11, a punch 31 and die-block 32 of the general character shown in FIG. 11 is used to preform depressions 33 in a header-plate 16. When a header-plate 16 is to have the final form shown in FIG. 10, a conventional punch and die block (not here shown) is used to punch out the metal for the opening 22 and form the rims 28 around each tube opening 22. This, it will be understood, is without the addition of the extruded end knobs 29.

When the final form of the header-plate 16 is to be as shown in FIG. 2, then a special punch 34 and die-block 35 such as illustrated in FIGS. 14 and 15 would be used to punch out the slugs 36 to provide for the opposed up-

set rims 28 and the extruded end knobs 29. When the final form of the header-plate 16 is to be as shown in FIG. 4 a special punch 37 and die-block 38 such as illustrated in FIGS. 12 and 13 are used to punch out the slug 39 and extrude the end knobs 29.

It will be understood that the requisite number of such special punches and die-blocks, as identified for the respective forms of header-plate 16 are provided and arranged in the presses conventionally used for the structuring of header-plates for heat-exchangers of the type herein described.

The parallel upset rims 28 dispose bonding areas for the tubes 23 and the header-plate 16 above one face of the header-plate. Such upset rims 28 can be so formed as to increase, slightly perhaps, the thickness of the portions thereof which contact the sides of the tubes 23 over the normal thickness of the header-plate 16. However, the very fact that these upset rims 28 extend above the face of the header-plate 16 serve to strengthen the header-plate 16 per se over what it would be without such upset rims. That condition, in and of itself, tends to reduce the incident of bond fracturing resulting from the strains directed against the header-plate 16. The height of these upset rims 28, for a heat-exchanger of the above-noted construction, is approximately .093".

As the drawings clearly confirm (especially FIGS. 2 and 4) these rims 28, which define the openings 22, are so formed by the above-described tools and procedures as to present opposed, flat and continuous parallel surfaces substantially equal to the thickness of the header-plate 16. Such rims 28 are disposed above one face of the header-plate and these flat surfaces of the rims 28 are substantially normal to the plane of the header-plate 16. Thus, whether these rims 28 are formed in a header-plate 16 as indicated in FIG. 2 or in FIG. 10, there is a firm bonded contact established with the tubes 23 throughout the entire areas of contact between the tubes and the header-plate 16.

The extruded knobs 29 are formed of portions of the header-plate 16 that, in currently conventional procedures, is punched out and discarded. In this development those extruded end portions of the plate are formed into the crescent-like knobs 29 with the opposed faces 41 of each pair of knobs 29 contoured with an arc substantially the same as that of the lateral rounded edges of the tubes 23. For a core-unit of the structure hereinbefore explained the radius of these inner knob faces would be approximately .053". The distance between the curved faces 41 of each pair of opposed knobs would be approximately .754". The height of the knobs 29 above the face of the header-plate 16 is approximately .106".

The extension of the extruded knobs 29 above the face of the header-plate 16 (as shown in FIG. 4) disposes the bonding areas of the header-plate 16 and the tubes 23 above the face of the plate to supplement that of the flat, continuous, parallel surfaces of the header plate 16 which define these elongated tube openings 22. Hence, these knobs more than double the bonding areas along the lateral edges of the tubes 23 with the header-plate 16 and supplements the bonding of the parallel sides of the tubes 23 to those parallel bonding areas of the header-plate. All of this enhances greatly the durability and resistance of the core-unit to the fracturing of the solder bonds of the tubes and the plate.

Obviously, the combining of the upset rims 28 and the extruded knobs 29 serves to more than double the strength of the bonds which these two facilities would effect when used separately. Thus, the joint use of these two facilities ensures a durability of bond never before attained in the conventional practices heretofore employed.

The auxiliary plates 18 and 19 serve to further strengthen the bonding of the header-plate 16 to the tubes 23 over that which is obtained with these perimetrical upsets of the header-plate 16. For reasons hereinbefore explained, these auxiliary plates 18 and 19 are located

respectively at the ends of the header-plate 16 and inwardly along the opposite lateral portions of the header-plate 16 intermediate the end plates.

These auxiliary plates 18 and 19 may be the same metal as that of the header-plate 16 and of a thickness nearly, if not actually, the same as that of the header-plate 16. For some types of header-plates the auxiliary plates may exceed the thickness of the header-plate. The plates 18 and 19 are stamped with the openings in size and position to register with the openings 22 in the header-plate 16. The end plates 18 here are shown to span four transverse rows of tubes 23. In FIG. 5 the auxiliary plates 19 are shown to embrace single outside lateral rows of tubes 23. In FIG. 8 the auxiliary plates 19 are shown partially embracing single outside lateral rows of tubes 23. In FIG. 9 the supplemental plates 19 are notched along their edges to seat over one edge of the next innermost row of tubes 23.

These auxiliary plates 18 and 19 preferably are spot welded to the header-plate 16, as indicated in the figures. However, other forms of bonding could be employed.

It is well known that flat objects with rectilinear perimeters, subject to severe strains, are more likely to fracture than are the same objects with non-rectilinear or sinuate perimeters. Hence, the side plate 19 may be formed with undulating perimeters as shown at 42 in FIG. 9. Even the notches 43 (FIG. 9) formed to fit around the lateral edges of the tubes, will have a tendency to reduce the incident of fracture over that of a rectilinear perimeter.

These auxiliary plates 18 and 19 also become bonded to the tubes 23 along these areas where the tubes and the auxiliary plates abut. Thus the auxiliary plates 18 and 19 and the upset flanges 28 and/or the extruded knobs 29 form a continuous bonding area of tubes 23 and header-plate 16 equal to or more than the thickness of the header-plate 16. Such a bond possesses a strength much greater than is possible with the structures that heretofore have been produced in the heat-exchanger equipment industry.

Where these side-plates 19 are used with the header-plates 16 having the upset flanges 28 a pocket 44 is formed between the header-plate 16 and the auxiliary plate 18 (see FIG. 3). Almost inevitably, during the soldering operation, molten solder will tend to accumulate in this pocket 44. This well serves to further enlarge the area of the bonding along the intermediate edges of the tubes 23.

Obviously, if header-plates 16 were formed of metal equal to the combined thickness of the header-plate 16 and auxiliary plates 18 and 19 the bonding areas of the tubes and such thicker header-plates might be more than double that of the header-plates conventionally employed in the heat-exchanger industry. However, thicker header-plates would present problems in header-plate formations that never would compensate for the gained tube-and-plate bonding areas by that means.

Following the formation of the header-plates 16, of any of the above-described forms and with the above-described tools and procedures, a pair of such header-plates 16 are pressed on the tube ends 27, of a finned-tube-assembly 17 and placed in a conventional jig preparatory to effecting the bonding of the tubes to the header-plates 16. The jig-supported assembly is first dipped in a flux bath and then into a solder tank. The sequence and the timing of these operations are more or less as now practiced with the conventional form of core-units for heat-exchangers of the type herein explained. However, the resulting core-units, obtained with these forms of header-plates 16 possess a rigidity and durability far beyond what has heretofore been obtained with the currently conventional structures.

Variations and modifications of these structures and arrangements of parts may be resorted to within the spirit and coverage of the appended claims.

I claim:

1. A renitent, tube-supporting header-plate for core-units for heat-exchangers of the type wherein a pair of the header-plates are adapted to be spanned by and supported on an assembly of finned flat tubes with rounded lateral edges and which heat-exchangers are used in the cooling systems of heat-engines powering motor vehicles, the header-plate having a series of elongated openings formed within the opposite faces thereof and presenting continuous flat parallel surfaces with rounded ends disposed normal to the plate and approximating the exterior cross-sectional contour of the above-defined tubes, the plate also having portions thereof at the opposite ends of the openings extruded above one face of the plate to form knobs with the opposed inner faces thereof curved to approximate the contour of the rounded lateral edges of the tubes, the plate being adapted for bonding to the tube ends throughout the entire areas of contact thereof with the respective flat parallel and rounded end surfaces of the plate and the curved inner faces of the respective knobs.

2. A renitent, tube-supporting header-plate for core-units for heat-exchangers of the type wherein a pair of header-plates are spanned by a battery of finned flat tubes with rounded lateral edges and which heat-exchangers are used in the cooling systems for heat-engines powering motor vehicles, the header-plate having a series of elongated openings defined by portions of the plate upset above one face of the plate substantially equal to the thickness of the plate and each opening presenting opposed continuous flat parallel surfaces with rounded ends disposed normal to the plane of the plate and approximating the cross-sectional contour of the above-defined tubes, the plate being adapted for bonding to the tube ends through the entire areas of contact with the aforesaid upset flat parallel and rounded end surfaces of the respective plate openings.

3. A renitent, tube-supporting header plate for core units for heat-exchangers of the type wherein a pair of header-plates are adapted to be spanned by and supported on a battery of finned flat tubes with rounded lateral edges and which heat-exchangers are used in the cooling systems for heat-engines powering motor vehicles, the header-plate having a series of elongated openings defined by portions of the plate upset above one face of the plate substantially equal to the thickness of the plate and each opening presenting opposed continuous flat parallel surfaces with rounded ends disposed normal to the plane of the plate and approximating the cross-sectional contour of the above-defined tubes, the plate also having portions thereof at the opposite ends of each upset portion extruded above the respective upset portions to form knobs with the opposed inner faces thereof curved to approximate the contour of the rounded lateral edges of the above-defined tubes, the plate so formed being adapted for bonding to the tube ends throughout the entire areas of contact thereof with the aforesaid flat parallel and rounded end surfaces of the upset portions and the curved inner faces of the respective knobs.

4. A reinforced core-unit for heat-exchangers used in the cooling systems for heat-engines powering motor vehicles, the core-unit comprising, a pair of renitent header-plates, an assembly of finned flat tubes with parallel sides and rounded lateral edges, each header-plate having a series of elongated openings formed within the opposite faces thereof and presenting continuous flat parallel surfaces with rounded ends approximating the cross-sectional exterior contour of the flat tubes and disposed normal to the plane of the plate, each header-plate also having portions thereof at the opposite ends of each opening extruded above one face of the header-plate to form a pair of knobs at the ends of each opening with the opposed inner faces thereof curved to approximate the contour of the rounded lateral edges of the above-defined tubes, the finned-tube

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assembly having the opposite ends of the tubes contactively inserted into the respective header-plate openings and bonded to the header-plates throughout the entire areas of contact of the tubes with the aforesaid flat parallel and rounded end surfaces of the plate and with the opposed inner curved faces of the respective knobs.

5. A reinforced core-unit for heat-exchanges as set forth in claim 4 wherein a pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate and embrative of opposite perimetrical rows of tubes.

6. A reinforced core-unit for heat-exchanges as set forth in claim 4 wherein a pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate and embrative of a row of tubes inwardly along the opposite lateral perimeters of each header-plate, and another pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate embrative of a plurality of rows of tubes inwardly along each of the ends of the header plates.

7. A reinforced core-unit for heat-exchanges as set forth in claim 6 wherein the auxiliary plates along the lateral rows of tubes have the inner edges thereof sinuate in contour.

8. A reinforced core-unit for heat-exchanges used in the cooling systems of heat-engines powering motor vehicles, the core-unit comprising, a pair of renitent header-plates, an assembly of finned flat tubes with parallel sides and rounded lateral edges, each header-plate having a series of elongated openings formed therein by portions of the plate upset above one face of the plate substantially equal to the thickness of the plate and presenting opposed continuous flat parallel surfaces and rounded ends approximating the cross-sectional exterior contour of the flat tubes and disposed normal to the plane of the plate, the finned-tube assembly having the opposite ends of the flat tubes contactively inserted into the respective header-plate openings and bonded to the header-plates throughout the entire areas of contact of the tubes with the aforesaid flat parallel and rounded end surfaces of the upset portions of the respective plates.

9. A reinforced core-unit for heat-exchanges as set forth in claim 8, wherein a pair of auxiliary plates with opening conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate and embrative of opposite perimetrical rows of tubes.

10. A reinforced core-unit for heat-exchanges as set forth in claim 8 wherein a pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate and embrative of a row of tubes inwardly along the opposite lateral perimeters of each header-plate, and another pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate embrative of a plurality of rows of tubes inwardly along each of the ends of the header-plates.

11. A reinforced core-unit for heat-exchanges as set forth in claim 10 wherein the auxiliary plates along the

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lateral rows of tubes have the inner edges thereof sinuate in contour.

12. A reinforced core-unit for heat-exchanges used in the cooling systems of heat-engines powering motor vehicles, the core-unit comprising, a pair of renitent, tube-supporting header-plates, an assembly of finned flat tubes with parallel sides and rounded lateral edges, each header-plate having a series of elongated openings formed therein defined by portions of the plate upset above one face of the plate substantially equal to the thickness of the plate and presenting opposed flat continuous parallel surfaces with rounded ends approximating the cross-sectional exterior contour of the flat tubes and disposed normal to the plane of the plate, and each header-plate also having the portions thereof at opposite ends of each of the aforesaid upset portions of the plate extruded above the upset portions to form a pair of knobs at the ends of each opening with the opposed inner faces thereof curved to approximate the contour of the rounded lateral edges of the above-defined tubes, the finned-tube assembly having the opposite ends of the flat tubes contactively inserted into the respective header-plate openings and bonded to the header-plates throughout the entire areas of contact of the tubes with the flat parallel and rounded end surfaces of the upset portions of the plate and with the opposed inner-curved faces of the respective knobs.

13. A reinforced core-unit for heat-exchanges as set forth in claim 12 wherein a pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate and embrative of opposite perimetrical rows of tubes.

14. A reinforced core-unit for heat-exchanges as set forth in claim 12 wherein a pair of auxiliary plates with openings conforming with openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate embrative of a row of tubes inwardly along the opposite lateral perimeters of each header-plate, and another pair of auxiliary plates with openings conforming with the openings in the header-plates are bonded in superimposed contactive relationship with the other face of each header-plate embrative of a plurality of rows of tubes inwardly along each of the ends of the header-plates.

15. A reinforced core-unit for heat-exchanges as set forth in claim 14 wherein the auxiliary plates along the lateral rows of tubes have the inner edges thereof of sinuate contour.

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CHARLES SUKALO, *Examiner*.

T. W. STREULE, *Assistant Examiner*.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,245,465

April 12, 1966

Fred Matthew Young

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 2, line 48, after "reformed" insert -- portion --.

Signed and sealed this 6th day of December 1966.

SEAL)

test:

ERNEST W. SWIDER

Testing Officer

EDWARD J. BRENNER

Commissioner of Patents