July 7, 1936. S. PRZYBOROWSKI 2,046,791

RADIATOR

Original Filed Jan. 17, 1934 2 Sheets-Sheet 1

Fig. 1.

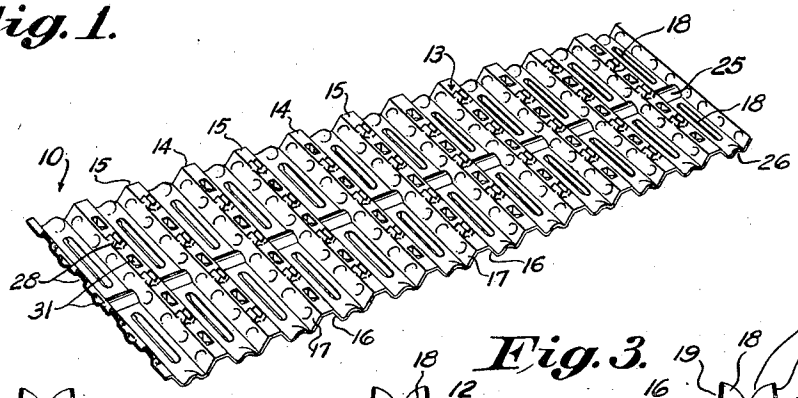


Fig. 3.

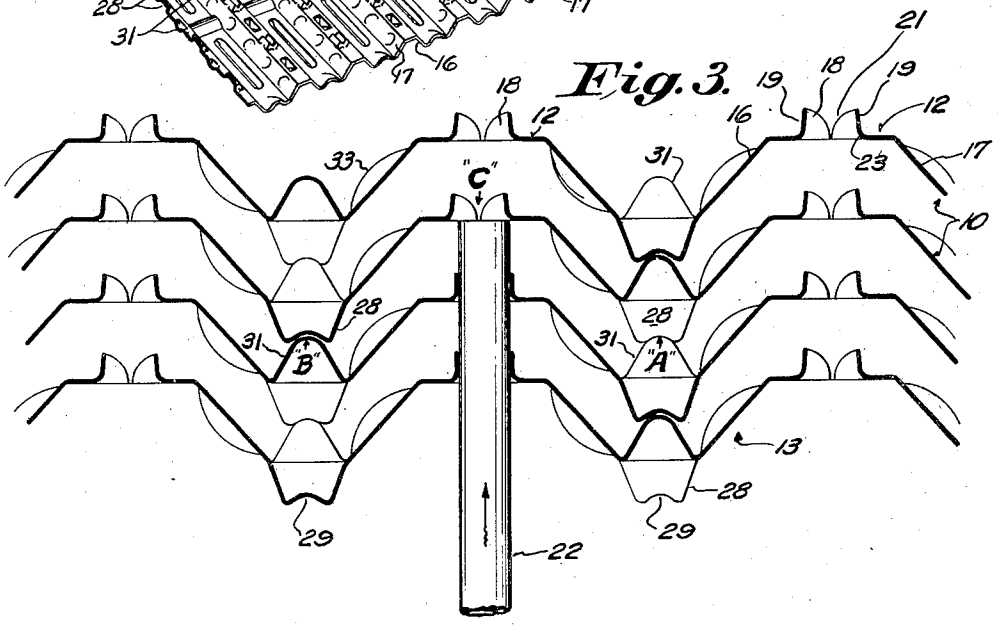
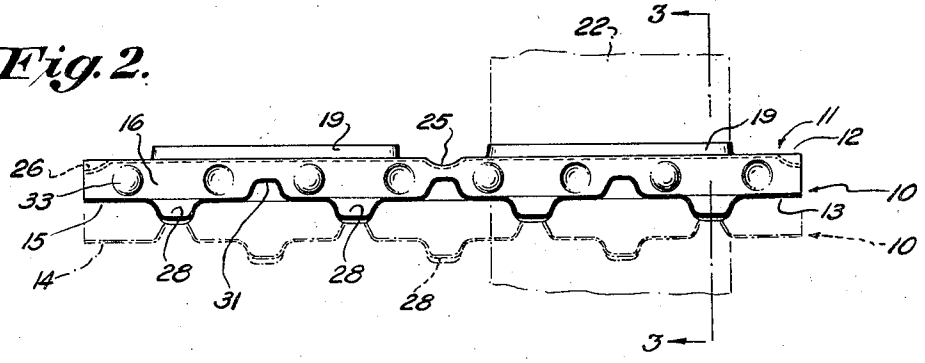


Fig. 2.



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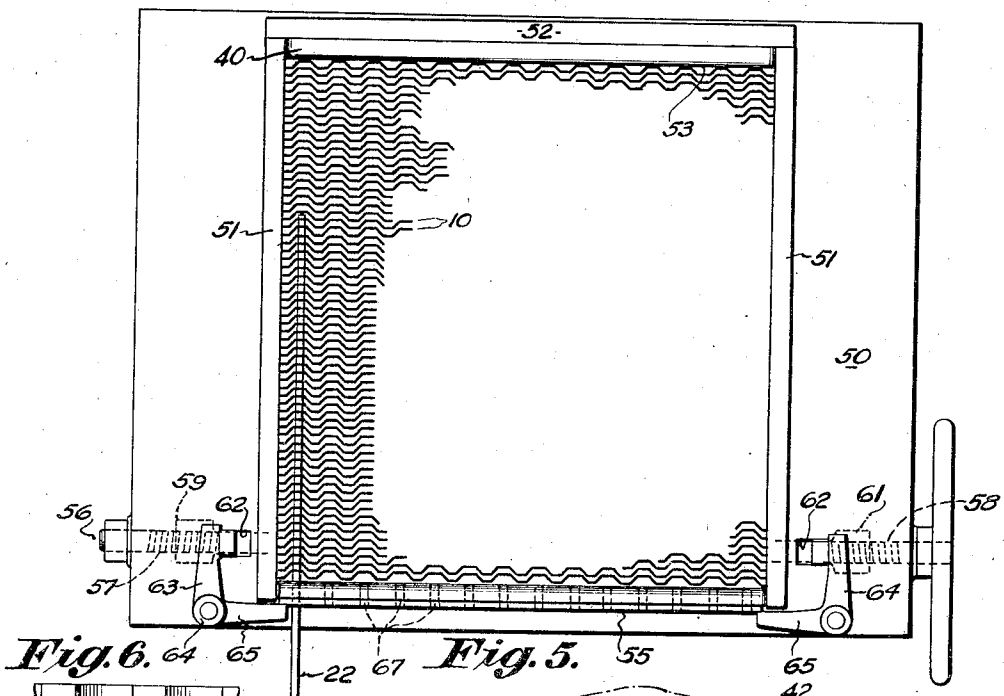


Fig. 6.

Fig. 5.

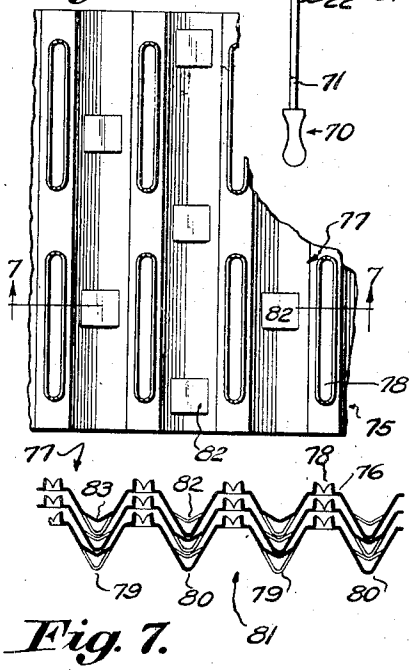


Fig. 7.

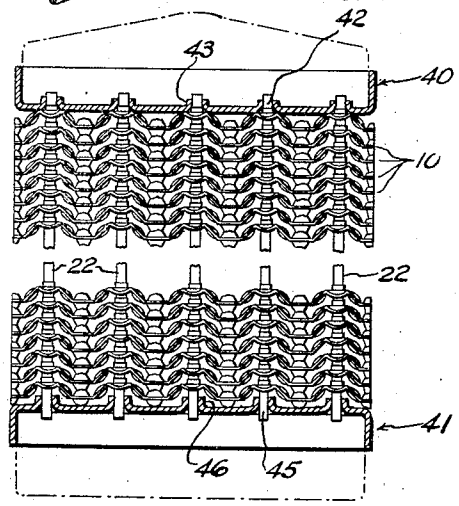


Fig. 4.

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2,046,791

UNITED STATES PATENT OFFICE

2,046,791

RADIATOR

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Application January 17, 1934, Serial No. 706,979
Renewed December 2, 1935

11 Claims. (Cl. 257—154)

This invention relates to radiators and radiator cores of the fin and tube type, and contemplates the provision of an improved radiator having a high thermal efficiency and strength and which may be economically manufactured.

One use for which the present radiator is particularly adapted is in the cooling of water for an internal combustion engine in an automobile by heat exchange with air. A large number of such radiators have been heretofore proposed, and they may be generally classified as "cellular" cores, in which corrugated sheet metal ribbons are assembled in a substantially longitudinal relation with respect to each other, to provide water courses spaced by transverse air passages, and "fin and tube" cores, in which a number of parallel tubes are intersected by transversely disposed heat radiating fins more or less spaced to permit the flow of cooling air through the core.

Both types of cores have heretofore been extensively used, and have been made with a relatively high degree of efficiency. Without attempting to discuss here all the factors which may influence the selection of a core of one type in preference to the other, it may be said that, heretofore, the cellular type of core has been more generally employed because of consideration of manufacturing costs and the amount of heat exchange which may be obtained in a unit volume of material, although some cores of the fin and tube type are recognized as advantageous when the heat exchange value is computed in terms of weight of metal employed. In general, the test or criterion for a practical and commercially acceptable radiator core depends on the obtaining of a maximum amount of thermal efficiency or heat exchange capacity in a minimum of space and with a minimum of weight, and at the lowest possible cost, due regard being had at the same time to other factors such as strength, rigidity, and simplicity of design.

It has heretofore been said that a structurally simple form of fin and tube radiator, or one wherein a number of vertical tubes are intersected by plane or slightly corrugated transverse fins, is most effective from the viewpoint of heat exchange capacity per unit of volume and weight. Such cores, however, are lacking in rigidity and resistance to strains developed by the weaving of the core on an automobile during use, and it has heretofore been the practice to strengthen such cores by using relatively heavy tubes at the ends, tie rods, and the like. The manufacture of such cores also introduces a number of serious adverse factors, among which may be mentioned particularly the practical necessity of using carefully made and expensive frames or "nests" for holding the fins in spaced relation during assembly, or complicated machines for placing the fins on a number of tubes. Such equipment or machinery has heretofore been deemed necessary in handling the light sheet metal stock, usually of copper, of which the fins and tubes are formed. The fins, for example, may be of copper sheet having a thickness of only 0.004 inch, or about that of good grade writing paper, and hence are lacking in much strength to withstand manual handling.

The present invention endeavors to devise a radiator which, while of the fin and tube type, is nevertheless susceptible of manufacture without resort to expensive nests or assembling machines, and which, at the same time, may be made to meet satisfactorily the requirements of high strength and thermal efficiency per unit volume and weight. In the practical embodiments of the invention, as hereinafter described, there are provided a plurality of closely but uniformly spaced or parallel undulatory fins of light weight resilient metal, having aligned openings at the crests thereof for receiving the parallel tubes, which openings are advantageously provided with upwardly projecting flanges snugly engaging the tubes over a major portion of the tube perimeter, and having assembled or formed therewith at and along the troughs or offset portions, contacting portions or protuberances or beads, serving to space the fins while the tubes are being assembled therewith, and also imparting to the assembled structure a desirable strength and rigidity and advantageous heat exchange properties.

It will be found that, in radiators made according to this invention, the heat exchange properties, strength and rigidity, and weight and cost factors are favorably comparable with the most efficient of present day or prior art radiators, and that radiators so made may be readily formed and assembled without resorting to expensive tools and equipment or labor. The economies which may be effected in making radiators according to this invention may be attributed to the fact that the extremely light sheet metal of which the fins are formed is undulated to enhance its natural strength and rigidity, and additionally the fins are so devised that they receive

the tube assembly stresses primarily in tension rather than in bending or compression. In such method, expensive assembling machines or jigs or "nests" need not be employed.

In considering the assembled structure, moreover, it will be observed that the relations between the tube volume, surface area, section, and number, and the amount of effective surface area and formation of the fins, are such as to impart to the core a high heat exchange value as measured in heat units exchanged per unit of surface area or volume or weight by any known and acceptable method. The core is also so designed as to permit of the flow of an adequate amount of cooling air between the fins and around the tubes, and to utilize such air in an effective manner. These factors, taken into consideration with the strength and cost of the core, will indicate to those skilled in the art the practical advantages of the article.

Having thus outlined the art to which the invention most nearly pertains, and the problems presented therein and the mode in which it is proposed to meet such problems, there will now be described certain embodiments of the invention, which represent the best ways known to apply the same in practice, reference being had to the accompanying drawings, wherein:

Fig. 1 is an inverted perspective view of a fin;

Fig. 2 is a transverse section through a fin, also showing, in dotted lines, its cooperation with a second fin;

Fig. 3 is a section on the line 3—3 of Fig. 2 on an enlarged scale;

Fig. 4 is a front elevation of an assembled core, the header plates being shown in section;

Fig. 5 is a diagrammatic plan of an assembly table with a core clamped in position therein;

Fig. 6 is a fragmentary plan of a fin forming another embodiment of the invention; and

Fig. 7 is a section on the line 7—7 of Fig. 6.

Referring momentarily to Fig. 4, it will be understood that the radiator or radiator core, when assembled, comprises upper and lower water tanks or headers, the plates of which are respectively designated by the numerals 40 and 41, between which extend a plurality of water tubes 22, which are intersected by a plurality of transversely disposed heat radiating fins, here designated generally by the numeral 10. It will also be understood that the tubes and fins are to be assembled with the tubes extending through apertures formed in the fins, and that the tubes are tinned or coated with solder so that, upon a subsequent heating operation, the parts will be bonded or integrated to each other.

Referring now to Figs. 1, 2, and 3, each fin 10 is formed of light gauge copper ribbon, which, through the applications of suitable dies, is provided with undulations or offset portions so that the ribbon is no longer plane, but is in a form suitable for the purposes hereinabove described and hereinafter explained in detail.

For convenience of reference, one side of the fin 10 is designated as a face 11 and the elevated portions viewed on this face are termed crests 12. Similarly, the opposite face 13 of the fin, as most advantageously shown in Fig. 1, discloses uniformly disposed undulations, differing alternately in specific formation, to form troughs or offset portions 14 and 15. The crests and troughs on the opposite faces 11 and 12 are connected by diagonally disposed walls 16 and 17.

Considering first the upper face 11 of the fin, it will be observed that each crest 12 thereof is formed with elongated tube openings 18, extending transversely of the fin and being uniformly spaced on opposite sides of the medial line. Each longitudinal side of each opening 18 is bordered by a protruding flange 19 formed out of the fin stock and having a slight taper toward the center or apex of the crest 12 (Fig. 2). In actual practice, the flanges 19 are drawn as a peripheral flange with fractured ends, as indicated by the numeral 21. The flanged holes provide for the assembly of the fin with tubes 22, as hereinafter described, and the bases of the flanges are formed with a relatively generous radius 23 to facilitate assembly.

Each crest 12 may be reinforced transversely by a central rib or depression 25 extending between adjacent walls 16 and 17 and by inwardly fluted edge beads 26.

On its opposite face 13, the fin 10 presents the two groups of trough structures 14 and 15 disposed in alternate relation (Fig. 1), the troughs 14 being each formed with a plurality of spaced projecting beads or saddle portions 28 having lateral depressions or sockets 29. Depressions are formed in the troughs 14 between the saddle portions 28 and they appear as similar beads 31 when viewed from the opposite side of the fin. Each alternate trough 15 is also formed with similar saddle portions 28, but they are located in a position corresponding to the beads 31 of the trough 14. Intermediate these formations each trough 15 is formed with depressed beads 31 which correspond in lateral spacing to the saddle portions of the troughs 14.

The connecting walls 16 and 17 are each formed with a plurality of alternately concave and convex deformations 33 which serve as air diverting means.

The described fins 10 are assembled in superimposed relation with the faces 11 all disposed in a common direction, as shown in Fig. 3. Furthermore, the troughs 14 of the faces 13 are disposed so that they align with the depressions formed by the troughs 15 of an adjacent fin. The saddle portions 28 of the troughs 14, therefore, will engage the corresponding beads 31 in the troughs 15; similarly, the saddle portions 28 of the troughs 15 will engage the beads 31 of the troughs 14. The troughs 14 and 15 will accordingly be staggered in alternate disposal, while the crests 12 of the upper faces 11 will be in alignment, and, as a result, all the tube openings 18 and the flanges 19 thereof will be in aligned relation preparatory to the insertion of the tubes 22.

It will be observed that the inter-engaging beads 31 and saddle portions 28 provide spacing means between adjacent fins and centering means for determining the alignment of the flanged tube holes 18. In practical effect, the bead and saddle portion connections provide parallel and substantially solid supporting columns in the assembled fin bank, between which the aligned flanged hole structures are disposed, and are supported from each column by the diagonal members 16 and 17.

The fin assembly or bank, when placed in a suitable frame, is thus self-spacing and self-supporting, and does not require spacing and supporting jigs for each fin, as is necessary in prior structures of this nature. In this connection, it will be appreciated that the thickness of the fins may be as low as three-thousandths (.003) of an inch, and the fins will therefore not be capable of withstanding bending loads of any

consequence. It may be mentioned here that when a tube is projected through the aligned holes of a self-supporting assembly, irregularities on the tube itself, coupled with the possibility of slight misalignment of the hole due to mechanical imperfection, would cause disruptive stresses unless provision were made for absorbing the loads or avoiding such possibilities.

The present fin, therefore, is constructed with a view of resisting such adventitious loads in tension and of also providing a resilient tube receiving portion which may either move laterally to off-center positions or expand to meet irregularities on the tube. Referring to Fig. 3, it will be observed that this is accomplished by supporting each flanged opening below its plane by the spaced saddle and bead engaging portions so that, in effect, a resilient truss is formed, the truss being secured at its ends A and B and having its load receiving portion C (the crest 12) connected thereto on each side by diagonally disposed tension members or the walls 16 and 17. The particular fin portion, thus enumerated, is shown as slightly bent to an off-center position. The tube 22 which is about to enter the opening 18, will therefore strike the right hand edge of the opening and exert a centering pressure on the section. The section will accordingly be sprung or moved to its proper position by the tube without distortion or damage, because of its resilient characteristics, to permit passage of the tube through the opening.

It will be further observed that the base of the opening 18 (between the flange radii 23) offers a generous clearance for the tube end; in fact, it provides a guide throat or funnel for the tube. The opposite ends of the opposed opening flanges 19, however, are spaced to engage the tube resiliently. This structural feature provides what may be termed a self-enlarging opening, since if the tube is slightly oversize at any point (due to a solder lump or the like) it will first engage the throat and the force thus transmitted to the crest 12 will tend to move it and its associated structures transversely, thus causing the opening flanges to spread to permit easier passage of the tube.

Provision is also made for the assembly of upper and lower header plates 40 and 41 with the described tube and fin structure, so that the complete assembly will appear as shown in Fig. 4. These plates form part of the usual headers, as indicated in dotted lines in this figure, and since their completion is a matter of a further and separate assembly, the dotted indication of Fig. 4 will suffice for the present description.

The header plates 40 and 41 may bear a structural relation to the fin and tube bank to form a rigid part thereof. The upper header plate 40 is formed with rows of flanged openings 42 corresponding to the openings in the fin bank, the flanges 43 thereof projecting into the plate, so that the crests 12 of the first fin abut the plate, and the flanges 19 of this fin enter the throat of the plate openings 42.

The lower header plate 41 is formed with flanged openings 45, the flanges 46 thereof projecting from the plate 41 and being received between the crests 12 of the adjacent fin. The saddle portions 28 of this fin, therefore, abut the body of the plate 41 to provide a uniform contact between these members.

In actual practice, the tubes 22 may be inserted through and finally integrated with the combined fin and header plate assembly in a single operation by means of a relatively simple assembly method. As diagrammatically shown in Fig. 5, an assembly table 50 serves as a base to which an open frame is secured, consisting of side walls 51 and a back wall 52. The upper tube plate 40 is first inserted on edge against the back wall 52 of the frame and a solder ribbon 53, suitably perforated to match the tube openings, is placed against its exposed surface. The fins 10 are then placed in the frame in the manner shown in Fig. 2, until the fin bank is complete; whereupon, the plate 41 of the lower header of the radiator is placed against the last fin.

Succeeding this preliminary assembly, a compressor block 55 is inserted in the lower plate 41 preparatory to clamping the fins together. The clamping means, herein shown, consists of a shaft 56, mounted transversely of the table 50 and below the sufrace thereof. The shaft 56 is formed with right and left hand threaded sections 57 and 58 engaging slidable blocks 59 and 61 respectively, which protrude through guide slots 62 in the table 50. The protruding portions of the blocks each engage the arm 63 of a bell crank 64, while the remaining arm 65 of each crank is engageable with the ends of the compressor block 55. By turning the shaft 56 the arms 65 are swung into engagement with the block, which thus forces the plate 55 into the frame. This compressing movement is relatively slight and it serves to insure contact between the bead and saddle portions of the fins 10 and the header plates. The compressor block is pierced with guide holes 67 proportioned to permit the entry of tubes to the fin bank.

After the fins and header plates are properly positioned and clamped, the tubes are inserted in position with the aid, if desired, of a steel push rod 70. The tube 22 is slipped over the blade 71 of the rod, and the tube, thus reinforced, is first inserted through a compressor block guide hole 67 and then through the aligned apertures in the plate 41, the described fin bank, and the plate 40. After all the tubes are inserted, the compressor block is released and the assembled core removed from the frame for the final operations of heating the core to fuse the solder on the tubes and thus effect the connection between the fins, tubes and header plates.

Prior to heating the core, a ribbon of solder is placed within the lower header plate 41, the assembly is then placed in a suitable heating furnace in inverted position (that is, with the plate 41 uppermost) so that the solder within the plate 41 may melt and flow into the flanges 46. This also permits the solder insert 53 to melt and flow into the flanges 43 of the upper heater plate 40. These extra quantities of solder provide a rigid connection between the tube ends and header plates and between the first and last fins and the plates at their contacting portions. During the process, the solder on the tubes is fused to connect the fins and tubes, the previously described resilient engagement of the fin flanges with the tubes greatly aiding in obtaining positive integration therebetween.

The product resulting from the described structures and process offers a structural advantage over the usual cross-fin tubular radiator, in that its fins are adequately supported and connected, and as a result the radiator is reinforced against diagonal strains and vibration, which ordinarily would demand heavier tubes or auxiliary reinforcement. The radiator is also devised to obtain maximum thermal efficiency, since the beads

which are located between the tubes divert the air stream toward the tubes. Consequently, the warmest fin areas, adjacent the tubes, are supplied with the greater volumes of air. It will also be observed that, due to the location of the beads and the deformations **33**, the air stream through a particular cell diverges toward the tubes, whereby, despite its aligned disposal, the rear tube is adequately cooled.

It will be apparent that supporting means or connections between the troughs **14** may be formed in various manners. In Fig. 6, for example, there is shown an undulatory fin **75**, the crests **76** on the upper face **77** thereof being truncated and formed with flanged tube openings **78** of similar character to the tube openings **18** of the first embodiment. The alternate troughs **79** and **80** on the lower face **81**, however, remain relatively angular and they are provided with depressed lugs **82**, which, when viewed from the face **77**, appear as supporting strips each having a central depression or saddle **83**. The lugs **82** are staggered in the alternate troughs **79** and **80**.

Upon assembly (Fig. 7) the crests **76** are all placed uppermost, as in the first embodiment, while the troughs **79** and **80** engage in the troughs **80** and **79**, respectively. The lugs **82** will accordingly receive the troughs **79** and **80** and both space the fins from each other and center the fins for a subsequent tube assembly, as previously described.

While the invention has been described in detail with reference to certain specific structural forms and a preferred method of assembly, and has been stated to be particularly applicable for use in automobiles, it will, of course, be understood that it is not intended to restrict the invention to such use, nor to limit the same to such embodiments or method or by the terms employed in describing or explaining the same, but that the invention should be considered as including all such variations and applications of its principles as are encompassed by the following claims.

I claim:

1. A radiator core comprising a plurality of spaced parallel fins of metallic ribbon formed with a plurality of spaced aligned openings, water tubes engaged through the aligned openings of the fins, said fins being formed intermediate the openings therein with transversely extending offset portions all projecting in a common direction, said offset portions being each formed with projections for engaging the offset portion of an adjacent fin to space said fins.

2. A radiator core comprising a plurality of parallel water tubes, a plurality of spaced fins of metallic ribbon formed with transverse undulations having crests on one face formed with flanged openings and troughs alternately disposed with respect to said crests, said fins being disposed in parallel arrangement and with said faces all similarly disposed, the openings in the crests thereof being in alignment and receiving said tubes, the troughs on the opposite face of the fins being formed with means engageable with the similar trough of an adjacent fin to space said fins.

3. A radiator core comprising a plurality of spaced parallel fins of metallic ribbon formed with a plurality of spaced aligned openings, water tubes engaged through the aligned openings of the fins, said fins being formed intermediate the openings therein with transversely extending offset portions all projecting in a common direction, said offset portions of adjacent fins being formed with abutting projections to space said fins, said projections being formed with inter-engaging portions.

4. A radiator core comprising a plurality of parallel fins of metallic ribbon formed with a plurality of spaced aligned openings, water tubes engaged through the aligned openings of the fins, said fins being formed intermediate the openings therein with transversely extending offset portions all extending in a common direction, each offset portion being formed with a plurality of beads projecting alternately from each face of the fin, the beads on one face of the fin being adapted to engage the beads of the opposite face of an adjacent fin, whereby said fins are spaced from each other.

5. A radiator core comprising a plurality of parallel fins of metallic ribbon formed with a plurality of spaced aligned openings, water tubes engaged through the aligned openings of the fins, said fins being formed intermediate the openings therein with transversely extending offset portions all extending in a common direction, each offset portion being formed with a plurality of centering beads on one face each having a depressed saddle portion therein, and other beads intermediate thereto and projecting from the opposite face of the fin, the saddle portions of said centering beads on one fin receiving the apices of said other beads of an adjacent fin, whereby the fins are spaced from each other and connected against longitudinal movement.

6. A radiator core comprising a plurality of fins of metallic ribbon each formed with transverse undulations having crests on one face each formed with a spaced pair of projecting flanges defining elongated openings therebetween, said flanges tapering toward each other from the said face of the fin, said fins being disposed in parallel arrangement with said flanged openings in alignment and all extending in a common direction, said fins being further formed with troughs disposed alternately with respect to said crests, the troughs on the opposite face of each fin being formed with projections engageable with similar troughs of an adjacent fin to space said fins, and water tubes insertable through the aligned flanged openings of the fins, said flanges resiliently engaging the tubes inserted therebetween, and said first named crests being resilient and capable of self-adjustment for alignment under the influence of the tubes during assembly.

7. A radiator core comprising a plurality of spaced parallel fins of metallic ribbon formed with a plurality of spaced aligned openings, water tubes engaged through the aligned openings of the fins, said fins being formed intermediate the openings therein with transversely extending offset portions terminating in troughs all projecting in a common direction, and lugs struck from each trough and adapted to receive the trough of an adjacent fin to space said fins.

8. A radiator core comprising a plurality of parallel fins of metallic ribbon formed with a plurality of spaced aligned openings, water tubes engaged through the aligned openings of the fins, said fins being formed intermediate the openings therein with transversely extending offset portions terminating in troughs all projecting in a common direction, and lugs struck from each trough and forming depressions therein, said lugs being of angular formation to receive the trough of an adjacent fin to space and center said fins.

9. A radiator core comprising a plurality of fins

of metallic ribbon each formed with transverse undulations having crests on one face each formed with a spaced pair of projecting flanges defining elongated openings therebetween, said fins being disposed in parallel arrangement with said flanged openings in alignment and all extending in a common direction to form a fin bank, water tubes insertable through the aligned flanged openings of the fins, a header plate on each end of the fin bank and parallel to said fins, one plate having openings defined by flanges extending in the same direction as the fin flanges and telescopically receiving the flanges of the adjacent fin, the remaining plate having openings defined by flanges protruding between the undulations of the adjacent fin.

10. A radiator core comprising a plurality of substantially parallel water tubes and a plurality of fins intersecting said tubes, said fins being formed with transverse undulations presenting crests, aligned apertures formed in said crests and having marginal flanges projecting upwardly therefrom, said tubes being positioned in and through said apertures and being snugly contacted by said flanges, the portions of the fins remote from said crests being formed with mutually contacting portions disposed between said tubes, said fins being spaced at other portions thereof to provide passages for the flow of air.

11. A radiator core comprising a plurality of substantially parallel water tubes and a plurality of fins intersecting said tubes, said fins being formed with spaced apertures through which said tubes extend in contacting relation, said fins being formed with offset portions provided with a plurality of contacting points between the tubes, adjacent fins being spaced between aligned apertures and contacting points to permit the passage of air through the core, the portions of the fins between said apertures and points being deformed to create turbulence in the air passing through said core.

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