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N. S. DIAMANT

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RADIATOR

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2 Sheets-Sheet 2

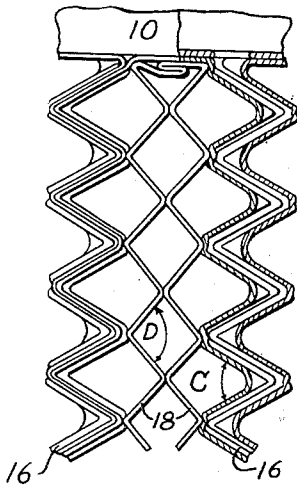


Fig. 4.

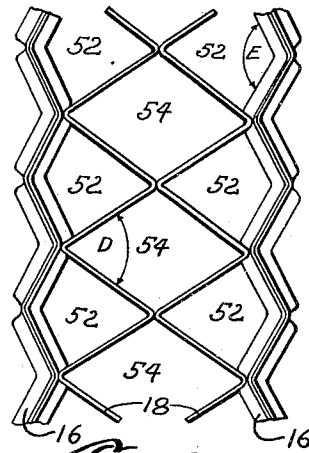


Fig. 5.

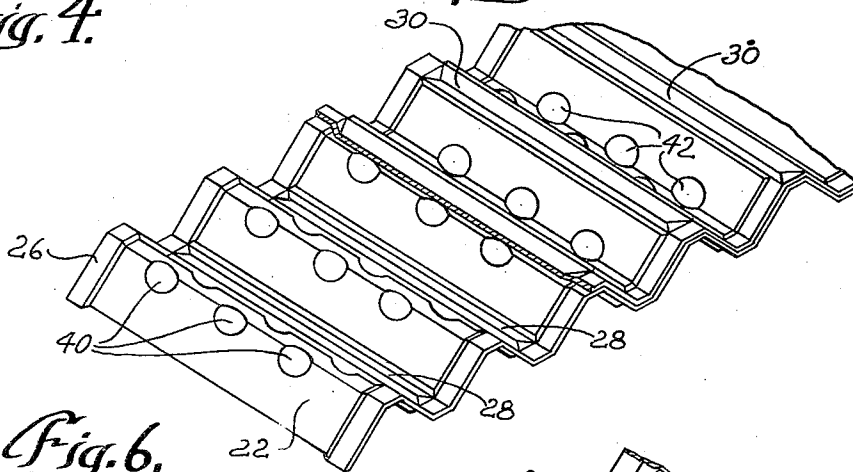


Fig. 6.

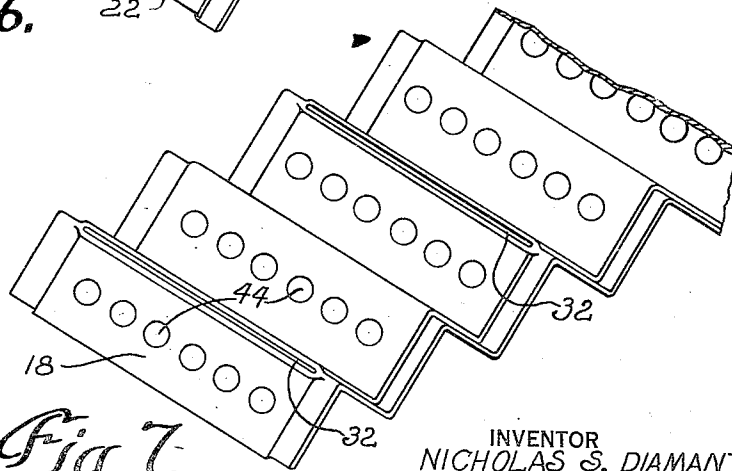


Fig. 7.

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RADIATOR

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This invention relates to improvements in cellular radiator construction for motor vehicles and the like and more particularly to a radiator construction in which the liquid passages are separated by spacer plates forming one group of cells bounded by the spaces and another group of cells bounded on one side by liquid passages and bounded on the opposite side by the spacers.

to have the outer face of the radiator present openings or air passages of substantially uniform size so as to give a pleasing and symmetrical appearance to the finished radiator. When this is done in the ordinary construction, the interior passageways of liquid spacer bound cells will not have an equal geometrical area to that of the spacer bound cells by reason of the fact that the walls of the liquid spacer bound cells are bulged inwardly to provide the liquid passageways.

The aim of modern radiator construction is toward securing the maximum transfer of heat with the use of a minimum amount of material, that is to say, that on a certain engine a definite amount of cooling is required. Brass, solder and copper, from which radiators are commonly made, are among the most costly of the metals generally used in radiator manufacture. If a radiator is designed which will effectively accomplish this cooling which is two or three pounds or even one pound lighter in weight than radiators heretofore required, then a very substantial advancement has been made in the art. In the construction of radiators of the cellular type, the cells are customarily of diamond shape and are of two classes; those in which two sides of the cell are formed by walls of the liquid passageway, the other two sides being formed by the spacer member, and those cells in which all four sides are formed by the spacer member. The cells of the first mentioned class will hereinafter be referred to as liquid-spacer bound cells and those of the second mentioned class as spacer bound cells.

Thus, a second inherent unbalanced condition arises, which necessitates the provision of some means to aero-dynamically balance the air flow of the cells. It is, therefore, a further object of my invention to balance the unequal cells by projecting the body portions of the spacer plates so as to compensate for their geometrical unbalance just referred to while presenting a substantially symmetrical appearance at the front of the core.

A still further object of my invention is to provide a multiplicity of re-entrant channels or grooves in the plates from the liquid passages so that a truss action is obtained in the assembling of the core. This is of utmost importance in view of the fact that the cores are made of long zig-zag ribbons of about five-thousandths of an inch in thickness. The truss action referred to gives the assembled structures a mechanical strength, particularly transversely, which is very desirable. Further, these grooves assist in securing a more uniform and efficient transfer of heat from the liquid passage plates to the spacing plates disposed in the air channels between the liquid passages by increasing the contacting surfaces between spacer and liquid plates and by offering a more positive contact than can be obtained by means of one flat surface bearing upon another flat surface.

In order to accomplish the advancement in the art referred to above, it is necessary to secure such a turbulent flow of liquid and such a turbulent flow of air as will yield the maximum cooling for a given amount of space exposed to the liquid and to the air. But the securing of a turbulent flow of air becomes an extremely difficult matter because of the inherent unbalance which exists between liquid spacer bound cells and spacer bound cells. Therefore, an important object of the invention is to make the two groups of air cells, spacer bound and liquid spacer bound cells, thermally balanced, as will be fully explained later.

The two spacer plates between the liquid passages and the two opposite side plates of the adjacent liquid passages are preferably made from a continuous strip of sheet metal having an overall length of slightly more than twice the height of the core so that each single strip may be folded transversely at its center to have the two sections of the folded

It is highly desirable for appearance sake

strip connected at one end of the strip. The spacer sections of the one strip are received between the sections of the other strip and all four sections constituting the two pieces are assembled as a unit. A plurality of such units are then assembled to form a radiator core.

Other objects and advantages of the invention will be more apparent from the following description and claims taken in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a radiator core, parts being broken away and sections of the core shown in the process of assembling.

Fig. 2 is an enlarged view of a portion of the core shown in elevation.

Fig. 3 is a sectional view of a portion of the core as shown in Fig. 2, but showing a further enlargement.

Fig. 4 is a diagrammatic view, partly in section, illustrating an extreme design in which the spacer bound cells have a much smaller area than the liquid spacer bound cells.

Fig. 5 is a diagrammatic view illustrating the other extreme in which the spacer bound cells are larger in area than the liquid spacer bound cells.

Fig. 6 is a perspective view of a portion of the liquid passage plates, one plate being broken away and in section.

Fig. 7 is a perspective view of a portion of one of the spacer plates.

Referring to the drawings wherein I have illustrated one adaptation of my invention and particularly to Fig. 1, the radiator comprises generally an upper liquid tank 10, lower tank 12 and an interposed core structure which is made in accordance with my invention. The core structure has a multiplicity of liquid passages 16, better shown in Figs. 2 and 3, extending between and communicating with the upper and lower tanks. Spacer plates 18 are interposed between adjacent water passages.

Each spacer plate and each plate forming the opposite sides of the adjacent water passages is formed from a strip of metal approximately twice the height of the core and of a width corresponding to the thickness of the radiator core. A zig zag spacer plate 18 is folded back upon itself adjacent its center to form two spacer sections closed at the upper end, as at 20. A zig zag plate 22 is also formed slightly longer than twice the height of the core and it is folded adjacent its center with a straight portion 24 folded in such a manner that the apex of each folded portion comes directly opposite the apex of the folded portion on the spacer plates. The folded strip 18 is received in the folded strip 22 and these two strips form a single unit consisting of a pair of spacer ribbons and

the opposite walls of the adjacent water passages. In assembling a radiator core a plurality of such units are secured together, such as by dipping into a molten vat of solder. The one side of each unit forms one side of the liquid passage and the opposite side of the unit forms the opposite side of another adjacent liquid passage.

Considering one section of the liquid passage strip 22, the sheet metal is formed zig zag with its outer longitudinal edge 26, Fig. 6, offset inwardly and secured together to close the front and rear faces of the spaced walls of the liquid passage. Between the joined marginal edge portions 26 are intermediate panels which are outwardly offset with respect to the edge portions 26 and which form the side walls of the liquid passages. Every other crown of the zig zag strip, preferably the lower crowns of the strip 22, as shown in Fig. 6, are provided with re-entrant grooves or channels 28, terminating just inside the offset edges, which provide the water channels. The complementary strip which makes up the other wall of the liquid passage is also provided with re-entrant grooves, as shown at 30, Fig. 6, at the other crowns of the zig zag liquid passages. These re-entrant grooves receive the crowns of zig zag spacer plates.

The crowns of the zig zag spacer plates adjacent the water passage plates are received in the re-entrant grooves 28 and 30. The adjacent crowns of the spacer plates are alternatively provided with re-entrant grooves 32 so that at one point the crown of the spacer plate is received in a groove of the other plate and the adjacent inner crown of the second mentioned plate is received in a groove of the first mentioned plate. By this arrangement the durability and the transverse mechanical strength of the core has been secured, because of the positive interlocking at the apex of each cell. Thus, in spite of the very thin material commonly used in the manufacture of the ribbons, the complete core structure is extremely strong; it will withstand constant shock, vibration and wearing and it can be bent through 90 degree angle before breaking. It will be more immune to leaks or cracks in the liquid passages than conventional core structures which lack this positive interlocking and self-tightening feature. Further, the stresses and strains are inherently distributed uniformly throughout the core structure, which is obviously extremely desirable.

Referring to Fig. 3, it will be seen that the re-entrant grooves reduce the area of the liquid bound cells 34. The spacer bound cells 36 have no re-entrant grooves and are consequently larger in area than the liquid bound cells 34. Comparing any pair of water spacer bound cells, such as 34 and 38, Fig. 3, it will be clear that there is geometrical

inequality in their areas by reason of the groove 32 which extends into the cell 34. These further inherent inequalities in the geometrical areas of the cells, in addition to those mentioned above, produce a necessary inequality in the amount of air flow between liquid spacer bound cells and spacer bound cells and a small degree of inequality in air flow between each pair of adjacent liquid bound cells. It is obvious that a smaller amount of air will flow through the liquid bound cells than through the spacer bound cells and a further slightly smaller amount of air through the liquid bound cells into which the grooves 32 project.

I have discovered that for maximum efficiency a substantially equal amount of air should flow through each cell. Further, I have discovered that mere substantial equalities in air flow in each cell is not sufficient, but the turbulence of air in each cell should be substantially equal. Therefore, it is an object of this invention to secure what I have termed an aero-dynamically balanced condition under which the amount of air flow as well as the amount of turbulence will be substantially equal in each cell and if necessary to favor the liquid bound cell. Consider, for example, a substantially straight and unobstructed passageway, from front to rear, of a given cross sectional area, air passing through this passageway will contact with the side walls around the peripheral portion of the air stream, but the central part or core of this air stream will travel through the passageway without contacting with the side walls. Therefore, only a portion of the air stream is effective. In order to get the greatest efficiency from a given sized air stream, it is necessary to cause the air stream to have a turbulent flow in each cell, which will cause substantially all of the air passing through each cell to come in contact with the side walls of the cells and attain optimum turbulence in each cell. The turbulence in one cell should not be secured at the expense or the lack of turbulence in another cell.

The general aim of my present construction is to create a turbulence in the different air streams in such a manner that the effective heat transfer capacity of each cell in a radiator will be equalized, thereby producing what I have termed herein an aero-dynamically balanced radiator, as well as a thermally balanced core, the total effective result of which is greater than has been heretofore attained.

To produce a thermal balance and to make the cells aero-dynamically balanced, I have provided depressions 40 in the plates 22 extending into the cells 38. These depressions reduce the area of the cells 38 as well as increase the turbulent flow of air and liquid through the core. If it is desired to have

further means for producing turbulence in the cells 34 and liquid passageways, smaller depressions 42 may be formed in the plates 22 extending into the cells 34 having the re-entrant grooves. These depressions may be closed, as shown. Depressions 44 and 44' are formed in the spacer plates 18 extending into the cells 38 and 36 to further balance the cells 38 with respect to the cells 36 and secure the desired amount of turbulence.

One of the main factors contributing to what I have termed aero-dynamically balanced construction are offsets in the spacer toward the spacer bound cells and the provision of suitably sized and positioned protuberances or projections which will first balance unequal geometrical areas and then produce the desired amount of turbulence in the air stream.

In Fig. 3 the sides of the spacer bound cells 36 have been offset or depressed inwardly between their edges so as to form intermediate panels which extend into the spacer bound cells in order to equalize the areas of the spacer bound cells 36 with those of the liquid bound cells 34 and 38. Further, to balance the liquid bound cells 34 and 38 the protuberances or projections 42 in cells 34 are made smaller than the indentations 40 in the cells 38. Further, by means of the indentations or projections 40, 42, 44 and 44', the liquid bound cells 34 and 38 and the spacer bound cells 36 are thermally and aero-dynamically balanced. Further, the projections 40 and 42 produce a turbulent flow in the liquid passages themselves, thus further improving and increasing the efficiency of the metal used in the construction.

In Fig. 3 the included angles A between the zig zag sides of the spacer are substantially equal to the included angles B between the zig zag sides of the water ribbons.

Referring to Figs. 4 and 5, wherein I have diagrammatically shown exaggerated conditions of the extreme formations, and more particularly to Fig. 4, the angles C are considerably smaller than the angles D. Thus, the inside geometrical area of the liquid bound cells is somewhat larger than the inside area of the spacer bound cells. Therefore, in this case no offsets or depressions are necessary in the spacer. This construction gives nearly balanced cells and, therefore, a suitable number of projections, suitably positioned and sized can easily be made to produce the necessary amount of turbulence to complete the inherent aero-dynamical and thermal balance. The construction disclosed in Fig. 4, although somewhat non-uniform and unsymmetrical in appearance, is fairly pleasing since the larger liquid bound cells do appear smaller on account of their thick liquid passages. This construction has the further advantage in that it affords inherently a very simple

and convenient means for reducing the number of liquid passages by reducing the height of the cell, but increasing the average width of cell while keeping the total surface constant, or increasing it slightly for a given frontal area; further, it will be apparent that by reducing the number of liquid passages the weight of the core can be reduced materially while the heat transfer capacity can be maintained by increasing slightly the total amount of heat transfer surface, as already noted. This feature of reducing the weight while keeping the heat transfer capacity constant is not, of course, an inherent but not an exclusive feature of the construction shown in Fig. 4, since obviously as a matter of deliberate design it can be incorporated in the other forms by reducing the height of their cells, but increasing the width of the same said cells.

It will be noted that, as compared with Fig. 4, in Fig. 5 the other extreme condition exists, in which the spacer bound cells 54 are larger than the liquid bound cells 52, due to the fact that the included angle E is obtuse or larger than the angle D. This construction has the further advantage of larger water flow than that shown in Fig. 4 and consequently freedom from plugging with sedimentary solid materials suspended in the system. Further, though more difficult to secure an aero-dynamic and thermal balance, according to my invention, when properly balanced it will be lighter and, therefore, more efficient than that shown in Fig. 4, because the amount of material required to form a given length of water course unit is less than the amount of material required to form a water course unit of equal length, but of the form shown in Fig. 4. Further, it is apparent that due to the acute angles C, as compared with the obtuse angles E, the ribbon material of the liquid passages of Fig. 5 will be stretched less than the ribbon material of the liquid passages of Fig. 4. Finally, though the size and shape of the cells in Fig. 5 is slightly unsymmetrical when properly designed and manufactured, it can be made nearly as pleasing in appearance as if the cells were geometrically symmetrical and perfectly equal in size and shape; this is accomplished with comparative ease on account of the small size of the cells and the extremely large number found in a given frontal area.

It will be understood that a radiator core may be thermally and aero-dynamically balanced by the suitable provision of protuberances, such as shown in Fig. 3, or it may be balanced by the angle of the water course, as illustrated in Figs. 4 and 5.

It will be understood that various changes, including the size, shape and arrangement of parts, may be made without departing from the spirit of my invention. The num-

ber of depressions may be varied in the cells to increase or decrease the turbulence of the unequal cells as well as their sizes varied. It is not my intention to limit the scope of this invention other than by the terms of the appended claims.

What I claim is:

1. In a core, spaced pairs of corrugated plates forming liquid passages and having adjacent joined edge portions at the front and rear of the core, the intermediate portions of each pair of plates being offset with respect to said edge portions, and a pair of corrugated spacer plates forming with each other a series of vertically aligned air passages through said core and forming a pair of vertically aligned air passages with the adjacent plates of said liquid passages, the edge portions of said spacer plates being so located with respect to the joined edge portions of the plates of said liquid passages so as to form substantially geometrically identical cells on the front and rear sides of said core and the intermediate portions of said spacer plates being offset inwardly towards each other between their edge portions and sufficiently to substantially balance the volumes of the air passages between said spacer plates with the volumes of the air passages between each spacer plate and the adjacent plates of said liquid passages.

2. In a radiator core, a pair of corrugated plates having joined edge portions and offset medial portions forming a liquid passage, a pair of corrugated spacer plates having alternate corners abutting each other and the remaining corners of one plate abutting the alternate corners of the adjacent plate of said passage, so as to form separated air passages between the spacer plates and between one plate of said liquid passage and one of said spacer plates, the edges of said spacer plates forming with the joined edges of the plates of said water passage a plurality of geometrically identical cells at the front and rear sides of said core, and depressed panels in the intermediate portions of said spacer plates extending from the front to the rear marginal edge portions thereof increasing the volume of the air passages adjacent the liquid passage and decreasing the volume of the air passage between said spacer plates so as to compensate for the offset medial portions of the plates of said water passage and to substantially equalize the volumes of all of said air passages.

3. In a core, spaced pairs of corrugated plates forming liquid passages and having joined edge portions and offset intermediate portions, a pair of corrugated spacer plates forming with each other a series of air cells and forming series of air cells with the adjacent plates of said liquid passages, and depressed panels formed in said spacer plates extending substantially from one edge por-

tion to the other edge portion thereof and protruding into the cells between the latter for creating a turbulence in said cells substantially equal in effect to the turbulence created in the cells between adjacent plates of said liquid passages and said spacer plates by the offset intermediate portions of the plates of said liquid passages.

4. In a core, spaced pairs of corrugated plates forming liquid passages and having adjacent joined edge portions at the front and rear of the core, the intermediate portions of each pair of plates being offset with respect to said edge portions, and a pair of corrugated spacer plates forming with each other a series of vertically aligned air passages through said core and forming a pair of series of vertically aligned air passages with the adjacent plates of said liquid passages, the edge portions of said spacer plates being so located with respect to the joined edge portions of the plates of said liquid passages as to form substantially geometrically identical cells on the front and rear sides of said core, the intermediate portions of said spacer plates being offset inwardly towards each other sufficiently to substantially balance the volumes of the air passages between said spacer plates with the volumes of the air passages between each spacer plate and the adjacent plates of said liquid passages, and closed depressions in said spacer plates extending into the passages therebetween for balancing the turbulation of air in all of the said passages.

5. In a radiator core, spaced pairs of corrugated plates having joined edge portions and offset medial portions forming a liquid passage, a pair of spacer plates forming between each other a series of air passages and forming other series of air passages with the plates of said water passages, substantially the entire intermediate portions of said spacer plates being offset into the air passages between the latter plates and rendering the projected thickness of the spacer plates greater than the actual thickness thereof.

6. In a radiator, a core having spaced corrugated liquid passages each including a pair of corrugated plates having joined marginal edge portions and outwardly offset intermediate panels, and corrugated spacing plates between the passages forming air cells between each other and between each spacing plate and the plates of the adjacent liquid passages, said spacing plates having offset panels extending between their marginal edge portions and extending into the air cells between said spacing plates substantially as far as the intermediate panels of the plates of said liquid passages extend into the air cells adjacent thereto to compensate in the cells between said spacing plates for the volume displaced in the other cells by the inter-

mediate panels of the plates of said liquid passages.

7. In a cellular radiator core having liquid passages including joined plates having protruding side portions, a pair of corrugated spacing means between the passages extending from front to rear of the core and forming with each other a multiplicity of vertically aligned air passages through the core and forming with the liquid passages pairs of horizontally aligned air passages through the core, said spacer plates having their entire intermediate portion between the front and rear marginal edges thereof offset into the cells between said spacer plates.

8. In a radiator core including spaced corrugated liquid passages and corrugated spacing means between the passages together forming aligned pairs of spacer bound air cells and transversely aligned pairs of liquid bound air cells, inwardly extending corner portions forming grooves at some of the crowns of each of the spacing means to receive the apexes of the crowns of the other spacing means, said corner portions being extended into one cell of each pair of liquid bound cells, and substantially closed depressed portions in said liquid passages extending into the other cell of each pair of liquid bound cells at the corner thereof corresponding in location to the position the inwardly extending corner portion occupies in the adjacent liquid bound cell for creating a turbulence substantially equivalent to the turbulence produced by said inwardly extending corner portions.

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