Oct. 7, 1952 M. DIDIER 2,613,065

COOLING RADIATOR

Filed March 17, 1948 2 SHEETS—SHEET 1

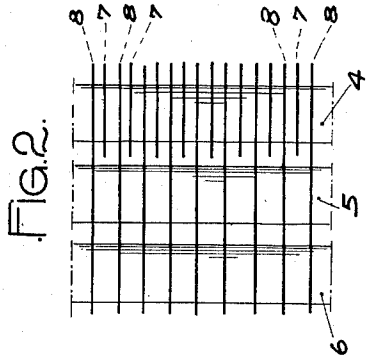


Fig.2.

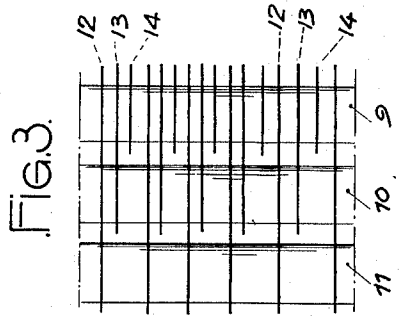


Fig.3.

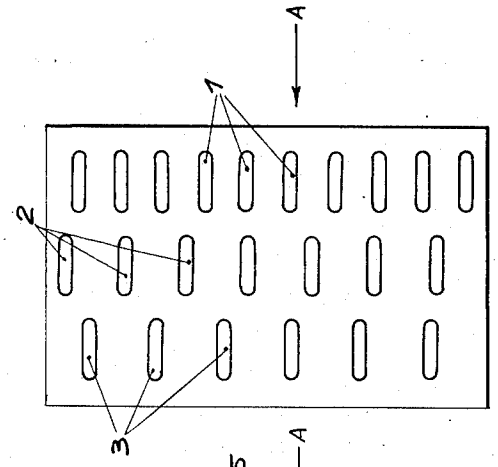


Fig.1.

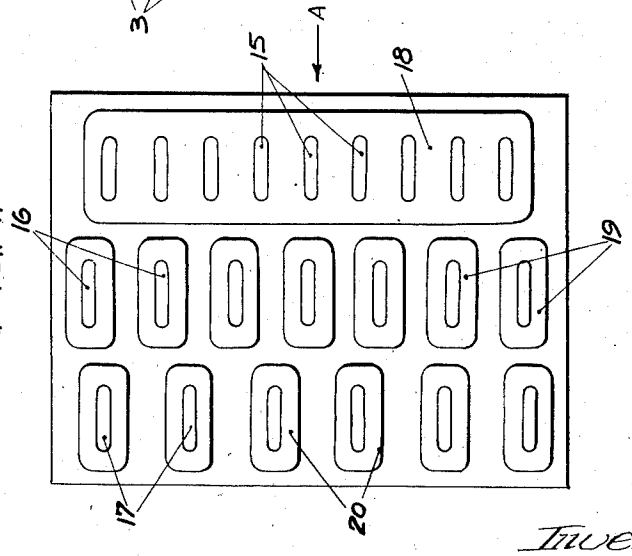


Fig.4.

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Fig.5.

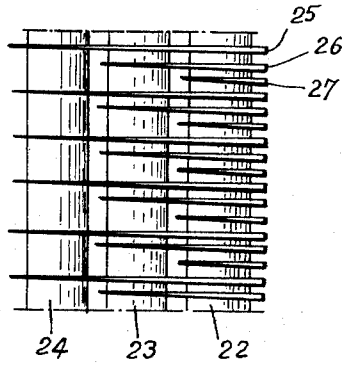


Fig.6.

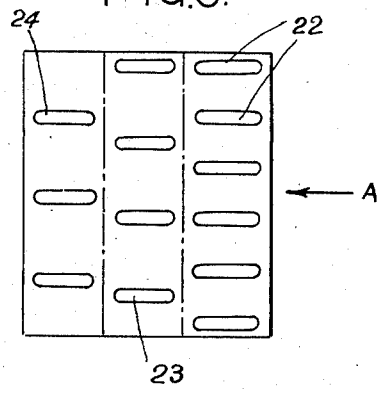


Fig.7.

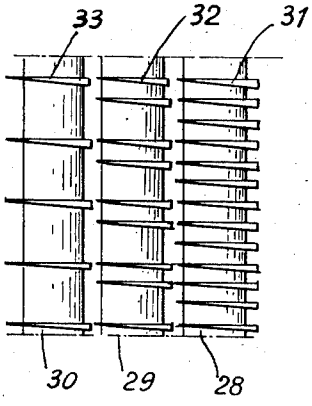
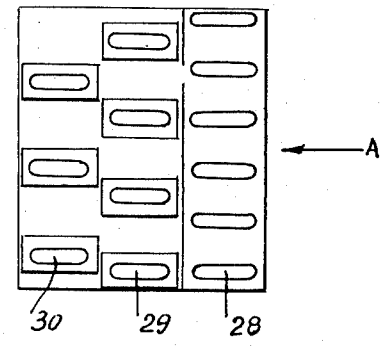


Fig.8.



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COOLING RADIATOR

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Application March 17, 1948, Serial No. 15,456
In France November 21, 1947

1 Claim. (Cl. 257—124)

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The cooling radiators composed of groups of tubes, which are used on motor vehicles and aircraft comprise rows of equidistant tubes which are arranged behind one another and through which the liquid to be cooled circulates, the cooling liquid flowing successively through said rows.

Since the pitch of the tubes of said rows is the same, the tubes located at the front of the radiator are licked by cold air, whereas the tubes located more to the rear are licked by hot air. The minimum heating of the air is 30° C. in a motor car and 45° C. in an aircraft. Consequently, if it is assumed that the ambient temperature is +30° C. and that the average temperature of the fluid to be cooled is to remain about 90° C., the first row of tubes operates with a difference of 90—30=60° C., whereas the last row operates with a difference of 90—60=30° C. Now, the amount of heat carried away is proportional to the temperature difference, so that the fins welded to the first row of tubes carry away twice as much heat as those welded to the last row, although they are of the same thickness and, the pitch of the tubes being the same, the distance travelled by the heat is identical. Consequently, the radiator has too much metal at the rear and not enough at the front.

The object of the present invention is to vary, together or separately, one or more characteristic parameters inside the radiator, according to a progression which takes into account the condition of the fluids at each point of the depth of the nest. In the above example, it was found that the amount of heat carried away is greater at the front of the radiator than at the rear and the following principle was deduced therefrom: the metal should be used more efficiently at the front than at the rear, its distribution should be calculated according to the differences of temperature.

Another object is to provide a cooling radiator which comprises a group composed of successive rows of tubes through which the liquid to be cooled is to flow, the cooling fluid being adapted to flow between said rows, in which the tubes are spaced apart from one another a distance which, according to the invention, increases in the successive rows from the front to the rear, said tubes being passed through fins, the thickness, the depth and the spacing of which are uniform.

A further object is to mount, on the equidistant tubes of a conventional group, fins of decreasing exchange efficiency, number, area or thickness from the front towards the rear.

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A still further object is to obtain a variation element and to arrange it according to the invention by using materials of different heat conductivity for forming the indirect surfaces, for example copper, aluminium and steel fins, the conductivity of which has been classified herein in decreasing order and may form a parameter similar to the variation of the thickness of the fin hereinbefore considered.

Each of these parameters make it possible, alone or in combination with the others, to obtain according to the invention a distribution which takes into account the difference between the temperatures of the cooling fluid and the fluid to be cooled.

The invention is however not limited to the variation only of the parameters described herein, but includes any relative arrangement of the direct and indirect heat exchange surfaces which may be obtained according to these principles.

Furthermore, in the example of the motor car or aircraft radiator given at the outset, it is observed that the resistance offered by the conventional nest to the flow of the air increases from the front towards the rear as the air is heated, owing to the fact that it increases in volume by expansion and its kinematic viscosity increases, and the following second principle may be deduced therefrom: when the fluid in question is a gas, the passage cross-section which is offered to it in the radiator should vary according to its heating.

By way of example of a radiator applying these two principles, it is possible to arrange successive rows of tubes for the flow of the liquid ot be cooled and between which the cooling air flows, the tubes being spaced apart from one another a distance which increases in the successive rows from the front to the rear of the radiator.

According to another feature, fins or indirect surfaces are mounted on the tubes and, preferably, said fins are closer together and/or of smaller area on the successive rows of tubes from the front towards the rear of the radiator.

A radiator constructed according to the invention provides a substantially equal heat exchange for all the metal parts, thereby decreasing the weight of metal used since all the elements operate under optimum conditions, and it decreases the resistance offered by the radiator to the forward travel of the vehicle owing to the fact that the speed of the air is not accelerated as it passes through the radiator, despite the increase in volume and viscosity produced by the heating of the air.

Further objects and advantages of my invention will be apparent from the description and claim.

In the drawing, in which an embodiment of my invention is illustrated:

Fig. 1 is a diagrammatic cross-sectional view taken transversely of a group of heat exchange tubes.

Fig. 2 is a side view in elevation of the tubes of another group.

Fig. 3 is a similar side view in elevation to Fig. 2 illustrating a modification.

Fig. 4 is a cross-sectional view taken transversely through a group of tubes of another embodiment.

Fig. 5 is a side view in elevation showing another modification.

Fig. 6 is a diagrammatic cross-sectional view corresponding to Fig. 5.

Fig. 7 is a side view in elevation of a further modification.

Fig. 8 is a cross-sectional view corresponding to Fig. 7.

According to Fig. 1, the group comprises a first row of tubes 1 spaced a short distance apart from one another. Behind these tubes is placed a second row of tubes 2 which are spaced further apart from one another than the tubes 1. A third row of tubes 3 is located behind the row 2 and the tubes of said third row are spaced further apart from one another than those of the second row.

In Fig. 2, successive rows of tubes 4, 5, 6 have been shown. In the front row 4, numerous fins or other secondary surfaces 7 are arranged very close together on these tubes. On the other hand, in the rows 5 and 6, the fins 8 are spaced further apart and have a smaller total area.

Fig. 3 shows another construction in which the tubes 9, 10, 11 are alternately provided with fins 12 extending over these three tubes, fins 13 only extending over the tubes 9 and 10 and fins 14 only extend round the front tube 9.

Fig. 4 shows another embodiment in which the group comprises three rows of tubes 15, 16, 17. In the first row 15, the tubes are very close to one another, in the second row 16, the tubes are spaced further apart and in the third row 17 the tubes are spaced still further apart from one another. Fins 18, which are as large as possible, surround the tubes 15 and are located very close together so as to form secondary heat exchange surfaces of very large area. Other fins 19 surround the tubes 16; these fins may be further apart and/or be of smaller area than the fins 18.

The third row of tubes 17 is also provided with fins 20 which are further apart and/or of smaller area than the fins 19. In all these embodiments, the cold air licks the first row of tubes, as indicated by the air flow directional arrows A, Figures 1, 4, 6 and 8. The first row of tubes offers very large primary heat exchange and secondary heat exchange surfaces since not only are the tubes very close together, but the fins are also very close together and of as large an area as possible. The air is heated against this system, it expands and its viscosity increases. When it reaches the second row of tubes, it only encounters primary heat exchange and secondary heat exchange surfaces of smaller area, and there is a larger space between these surfaces which enables it to pass with its expanded volume without increasing its speed. The same effect is produced when the air reaches the third row

of tubes. There also, it encounters smaller primary and secondary heat exchange surfaces than in the previous row, and there are larger spaces for it to pass through which enable it to flow through this third row without increasing its speed despite the increase in its volume and viscosity.

According to Figs. 5 and 6, the rows of tubes 22, 23, 24 are successively spaced further apart from the front to the rear of the nest and the fins 25, 26, 27 surrounding said tubes are progressively spaced further apart and also of smaller area and decreasing thickness from the front to the rear of the radiator.

In the modification of Figs. 7 and 8, the nest comprises rows of tubes 28, 29, 30 which are successively spaced further apart from the front to the rear of said nest and fins 31, 32, 33 surrounding said tubes which are decreasing both in area and thickness from the front to the rear of the radiator.

In all the foregoing embodiments, the device considered is a cooler for a fluid, which may be liquid or even gaseous, the cooling being obtained by the flow of a gas which in so doing is itself heated and therefore increases in volume and viscosity; but the invention is also applicable to the case of the heating of a fluid by an external gas which in so doing is cooled and thus decreases in volume and viscosity. In this latter case, the distance between the fins would of course decrease in the depthwise direction from the front towards the rear, contrary to the previous embodiments, so as to favor the flow of the external gas, but the tubes would remain closer together at the front than at the rear, or, if the distance between the tubes was constant, the thickness of the fins would be greater at the front than at the rear, since according to the invention, these variations are proportional to the differences of temperature.

The construction of a device according to the invention may be effected inside a single group, all the tubes being secured together by the whole or a portion of the fins as hereinbefore described, but it may also be embodied in a composite radiator, the operative element of which comprises a plurality of groups which differ from one another by the pitch and/or the thickness of the fins, the pitch of the tubes, etc., involving the features of the invention together or separately.

The invention is obviously not limited to the embodiments illustrated and described. The radiator may comprise any number of successive rows of tubes and the increase of pitch between the tubes of the rows may be calculated in any manner according to the desired application. The pitch may be increased for each row or only every other row. Similarly, the secondary heat exchange surfaces may be the same on each tube or may be decreased in the rows of tubes from the front towards the rear.

Further modifications will be apparent to those skilled in the art and it is desired, therefore, that the invention be limited only by the prior art and the scope of the appended claim.

I claim:

Cooling radiator comprising a group of these successive rows of tubes which are successively spaced further apart in each row so that the tubes decrease in number and area from the front row to the rear row of said group and a plurality of transverse fins spaced longitudinally along the length of the rows of tubes and ar-

ranged in groups of three, the first fins of each group extending crosswise of and around the front row of tubes, the intermediate fin of each group extending crosswise of and around the front and intermediate rows of tubes and the third fins of each group extending crosswise of and around all three rows of tubes, so that the total fin area decreases from the front to the rear of said group, and the radiator being positioned so that the flow of air is directed normally against the front surfaces of the front row of tubes.

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