June 7, 1966 K. F. FERGUSON 3,254,707

HEAT EXCHANGER AND COOLING APPARATUS

Filed March 19, 1964 2 Sheets-Sheet 1

Fig. 1.

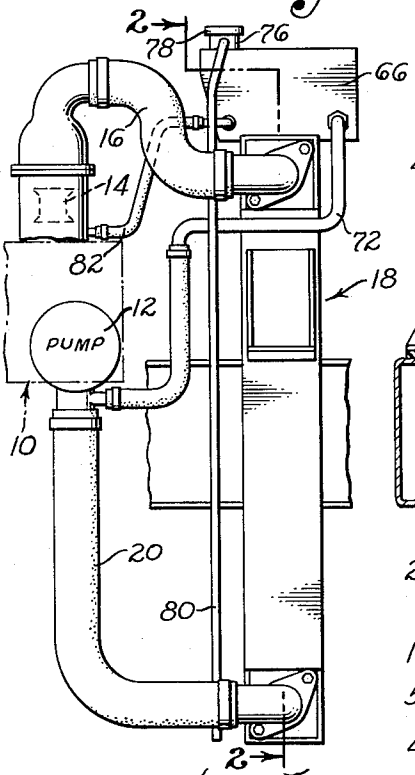


Fig. 2.

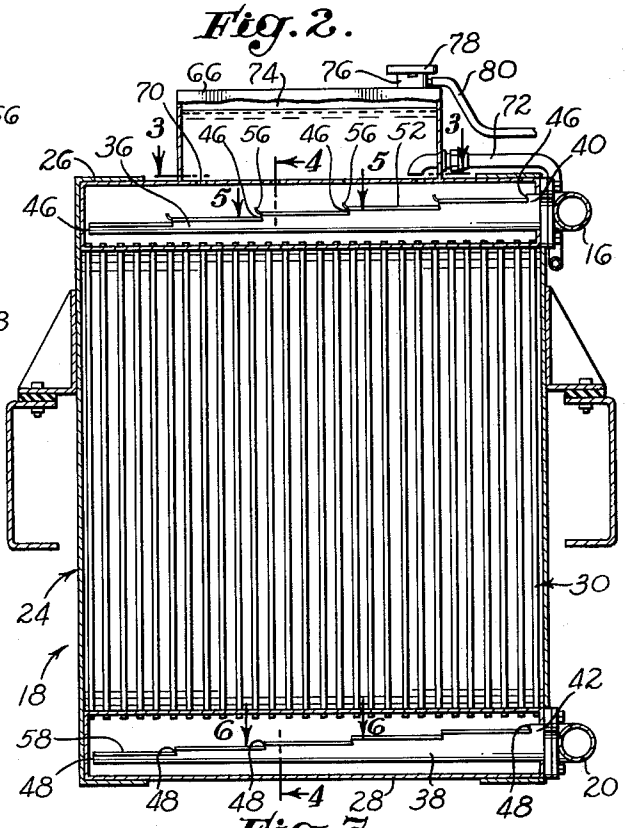


Fig. 4.

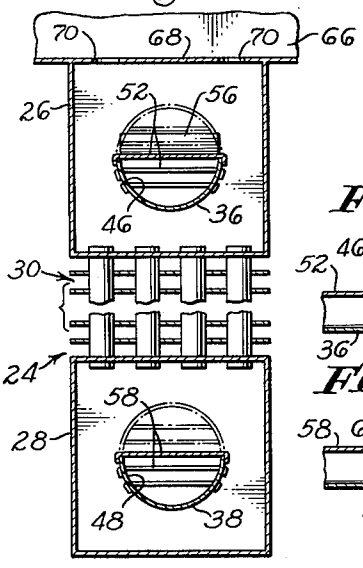


Fig. 3.

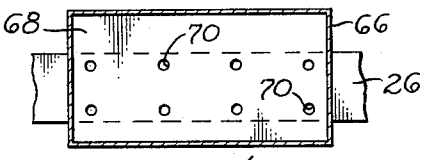


Fig. 7.

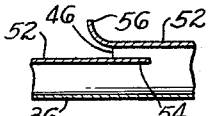


Fig. 5.

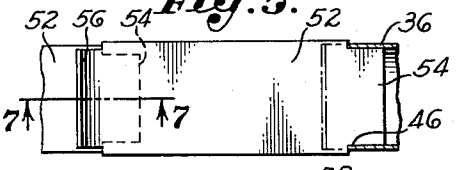


Fig. 8.

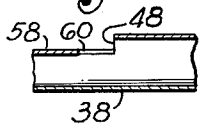
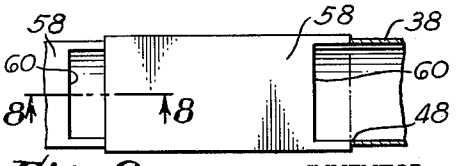


Fig. 6.



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HEAT EXCHANGER AND COOLING APPARATUS

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Fig. 9.

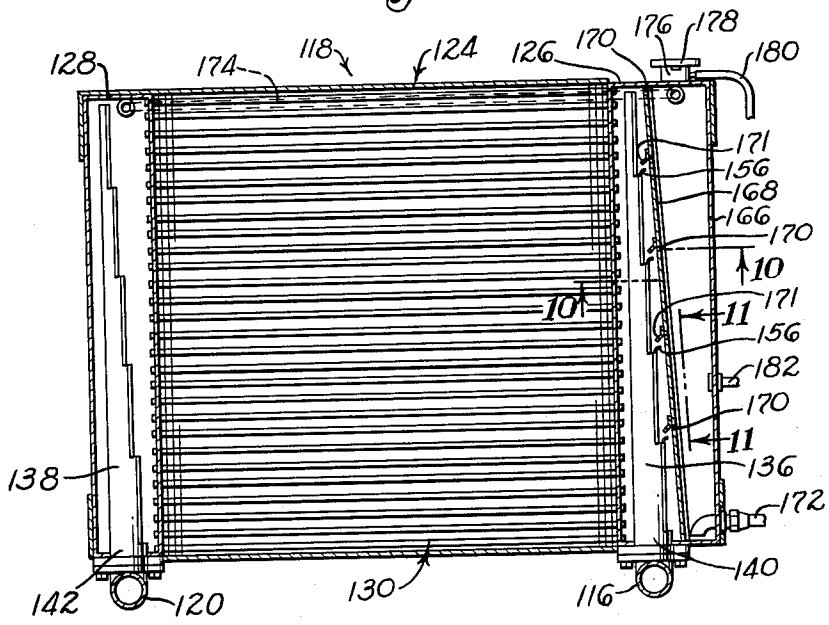


Fig. 10.

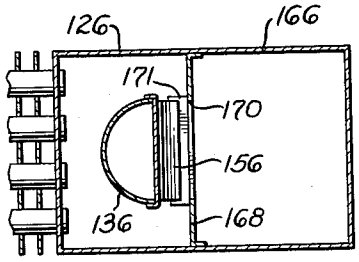
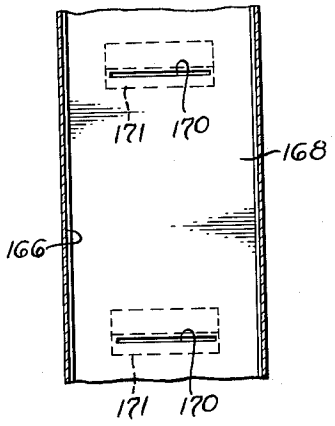


Fig. 11.



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3,254,707

HEAT EXCHANGER AND COOLING APPARATUS

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Filed Mar. 19, 1964, Ser. No. 353,066
14 Claims. (Cl. 165—110)

Primary objects of the invention are to provide a cooling apparatus for use with an internal combustion engine which is extremely effective in extracting heat from the water, or other coolant, used to cool the engine, and which efficiently removes air, or other gases, and vapors from the water so that these will not interfere with effective cooling of the engine.

Considering the manner in which the invention achieves the foregoing basic goals, an important object is to provide a heat exchanger, serving as a radiator in this instance, which achieves extremely uniform distribution of the water, or other coolant.

More particularly, an important object of the invention is to provide means in the inlet and outlet headers of the heat exchanger for achieving uniform flow distribution throughout the core of the heat exchanger, which core may be of any suitable construction.

Still more particularly, an important object is to provide flow distribution means comprising inlet and outlet ducts, disposed in the inlet and outlet headers, respectively, which are of stepped construction transversely of the heat exchanger and which decrease uniformly in area in a step-by-step manner from one side of the heat exchanger to the other, the inlet duct having inlet openings of substantially equal size at the respective steps therein and the outlet duct similarly having outlet openings of substantially equal size at the respective steps therein. With this construction, water is introduced into the inlet header at a plurality of transversely spaced points and is withdrawn from the outlet header at a plurality of transversely spaced points, the rates of water introduction and withdrawal at the respective points being substantially equal. The result is uniform flow of water through all parts of the heat exchanging core of the heat exchanger, this result being further enhanced by providing relatively large clearances around the inlet and outlet ducts within the inlet and outlet headers.

Considering the manner in which gases and vapors are removed from the water to promote more effective engine cooling, an important object of the invention is to continuously circulate a fraction of the cooling water through a reservoir adjacent and in fluid communication with the inlet header of the heat exchanger.

Another object is to achieve the foregoing by providing interconnecting ports between the inlet header and the adjacent reservoir, and by connecting the reservoir to the cooling water system of the engine on the inlet side of the water pump thereof, the flow capacity of this connection being such as to constantly circulate a small fraction of the total cooling water flow from the inlet header through the adjacent reservoir to the water pump.

Another object in the foregoing connection is to provide baffle means at the ends of certain of the steps of the inlet duct in the inlet header for directing the water introduced into the inlet header toward the ports connecting the inlet header to the reservoir thereadjacent.

The foregoing construction provides an extremely effective deaerating means for continuously bleeding off air, or other gases, and vapors into the reservoir adjacent the inlet header. Such gases and vapors accumulate in the reservoir so that they cannot interfere with efficient cooling of the engine, which is an important feature of the invention.

Other objects are to provide a heat exchanger having

headers which are oriented horizontally with the inlet header above the outlet header and with the reservoir surmounting the inlet header, and to provide a heat exchanger having horizontally spaced, preferably vertical, headers with the reservoir alongside the inlet header.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results thereof which will be evident to those skilled in the art to which the invention relates in the light of this disclosure, may be achieved with the exemplary embodiments of the invention described in detail hereinafter and illustrated in the accompanying drawings, in which:

FIG. 1 is a semidiagrammatic side elevational view showing one embodiment of the cooling apparatus of the invention connected to the cooling water system or cooling means of an internal combustion engine;

FIG. 2 is a vertical sectional view taken as indicated by the arrowed line 2—2 of FIG. 1;

FIGS. 3, 4, 5 and 6 are enlarged, fragmentary sectional views respectively taken along the arrowed lines 3—3, 4—4, 5—5 and 6—6 of FIG. 2;

FIGS. 7 and 8 are fragmentary sectional views respectively taken along the arrowed lines 7—7 and 8—8 of FIGS. 5 and 6;

FIG. 9 is a vertical sectional view of another embodiment of the cooling apparatus of the invention; and

FIGS. 10 and 11 are enlarged, fragmentary sectional views respectively taken along the arrowed lines 10—10 and 11—11 of FIG. 9 of the drawings.

Embodiment of FIGS. 1 to 8

Referring initially to FIG. 1, designated diagrammatically therein is an internal combustion engine **10** having the usual cooling water jacket through which water is circulated by a water pump **12**. As is conventional, as long as the water temperature is below a predetermined value, circulation by the pump **12** is confined to the water jacket of the engine **10** by a thermostat **14**. When the water temperature reaches the value for which the thermostat **14** is designed, the water may flow from the water jacket of the engine through a line **16** to a cooling apparatus **18** of the invention, returning through a line **20**. As is conventional, the lines **16** and **20** are connected into the cooling water system of the engine **10** on the outlet and inlet sides, respectively, of the pump **12**. Since the foregoing structure, except for the cooling apparatus **18** of the invention, is conventional, further illustration and description are not necessary.

The cooling apparatus **18** includes a heat exchanger **24** which serves as a radiator in this instance. As is conventional, the radiator **24** is mounted in front of the engine **10** in a position to have air forced therethrough by the forward motion of a vehicle, not shown, in which the engine may be mounted and/or by an engine-driven fan, not shown, located rearwardly of the radiator.

Considering the radiator **24** in more detail, it includes upper and lower transverse horizontal headers **26** and **28** interconnected by a heat exchanging vertically oriented, vertically extending core **30** of any suitable construction, which may comprise the finned tubes shown. As thus far described, the radiator **24**, with its combination of headers **26** and **28** and core **30**, is more or less conventional. The invention embodied in the radiator **24** will now be considered.

Disposed in the upper and lower headers **26** and **28**, and extending transversely of the radiator **24** therein, are inlet and outlet ducts **36** and **38**, respectively. The inlet and outlet ducts **36** and **38**, which extend substantially from one side of the radiator **24** to the other in the respective headers **26** and **28**, are proveded with ends **40** and

42 respectively connected to the lines 16 and 20 leading to the cooling water system of the engine 10.

As best shown in FIG. 4, the headers 26 and 28 are relatively large in cross section compared to the ducts 36 and 38 therein, thereby providing substantial clearances around the ducts. Such clearances contribute to uniform water flow through the core 30 and to the removal of gases and vapors from the water. More particularly, the sizeable clearance around the inlet duct 36 insures that the water entering the radiator 24 can reach all portions of the core 30. The substantial clearance between the outlet duct 38 and the bottom of the lower header 28 also serves as a sediment trap. If desired, access to the sediment trap may be provided in a manner not specifically shown to permit sediment removal.

As best shown in FIG. 2 of the drawings, the inlet duct 36 is of stepped construction and decreases in cross sectional area step by step from the inlet end 40 thereof to its opposite end. Similarly, the outlet duct 38 is of stepped construction transversely of the radiator 24 and decreases in cross sectional area step by step from the outlet end 42 thereof to its other end. The steps of each of the ducts 36 and 38 are substantially uniformly distributed across the width of the radiator 24, and the area reductions at the respective steps are substantially equal. (As viewed in FIG. 2 of the drawings, the left end of each duct 36 and 38 may be regarded as a step which reduces the area to zero.)

The inlet duct 36 is provided with inlet openings 46 at the respective steps therein (including the last step defined by the left end of the duct 36, as viewed in FIG. 2). Similarly, the outlet duct 38 is provided with outlet openings 48 at the respective steps therein (again including the last step defined by the left end of the duct 38, as viewed in FIG. 2 of the drawings). The inlet openings 46 leading from the inlet duct 36 into the upper header 26 are all substantially the same size, as are the outlet openings 48 leading from the lower header 28 into the outlet duct 38. This insures uniform distribution of the water introduced into the upper header 26, and uniform withdrawal of water from the lower header 28. Consequently, the flow of water through the core 30 from the upper header 26 to the lower header 28 is also uniform.

Thus, the heat exchanging core 30 operates with maximum effectiveness, as compared to prior radiators which permit channeling of the water through only a portion or portions of the core. The end result is ample cooling capacity for the engine 10 without an excessively large radiator, excessive fan power losses, and the like.

The inlet duct 36 comprises simply a circular tube having the desired steps cut therein and covered with plates 52 welded to the tube. As best shown in FIGS. 5 and 7, the plates 52 are provided at their upstream ends with tongues 54 which project into the tube in the upstream direction. As will be apparent from FIG. 7, each tongue 54 cleanly divides the corresponding portion of the water flow from the main stream coursing through the inlet duct 36, and delivers it to the corresponding inlet opening 46.

All but the last plate 52 in the series are provided at their downstream ends with upturned baffles 56, subtending arcs of substantially 90°, for deflecting upwardly the streams of water emanating from the respective inlet openings 46 upstream therefrom. The last plate 52 in the series is not provided with one of the baffles 56 since the adjacent end wall of the upper header 26 performs the same function. The upward motion imparted to the water by the baffles 56, and by the end wall of the upper header 26 at the downstream end of the inlet duct 36, serves a purpose which will be discussed hereinafter.

The construction of the outlet duct 38 is similar to that of the inlet duct 36, the outlet duct comprising a circular tube having steps cut therein which are covered by plates 58 welded to the tube. The plates 58 are provided at their downstream ends with notches 60 which form parts of the outlet openings 48 leading from the outlet header 28 into the outlet duct 38, thus providing these openings with relatively large areas to minimize flow resistance.

Turning now to a consideration of the hereinbeforementioned means of the invention for removing gases and vapors from the water circulated through the radiator 24 by the pump 12, the upper header 26 is surmounted by a reservoir 66 which is separated from the upper header by a wall 68 common to both. This common wall is provided therethrough with ports 70 establishing fluid communication between the upper header 26 and the reservoir 66.

The reservoir 66 is connected to the cooling water system of the engine 10 on the inlet side of the pump 12 by a line 72 having a capacity of the order of, for example, ten percent of the capacity of the pump. Consequently, a small fraction of the water introduced into the upper header 26 is continuously drawn upwardly into the reservoir 66 and thence back in to the cooling water system of the engine 10 through the line 72.

The foregoing construction provides very effective separation of gases and vapors from the water circulating through the cooling water system of the engine 10 and through the cooling apparatus 18. Gases and vapors tend to become separated from the heated water entering the upper header 26, and are drawn upwardly into the reservoir 66 as the result of the bleeding of water from the reservoir through the line 72. Such separating out of the gases and vapors, and such withdrawal thereof upwardly into the reservoir 66, are enhanced by the action of the baffles 56 in directing the heated water upwardly toward the top of the upper header 26 as it is introduced thereinto through the inlet openings 46 in the inlet duct 36. The gases and vapors then accumulate in a layer 74 at the top of the reservoir 66, where they cannot interfere with efficient cooling of the engine 10.

The reservoir 66 serves additional functions, one being to provide a way of filling the entire system with water. For this purpose, the reservoir 66 is provided with a filler neck 76 which is closed by a cap 78, preferably a conventional pressure cap. As is conventional, an overflow line 80 leads from the filler neck. The reservoir 66 is located at an elevation such that the water level therein is above the highest point in the cooling water jacket of the engine 10. Thus, the reservoir 66 insures that the cooling water jacket of the engine 10 is always completely full to prevent hot spots.

As shown in FIG. 1 of the drawings, the reservoir 66 is also connected to the cooling water system of the engine 10 below the thermostat 14 by a line 82 having a relatively small capacity. With this construction, a small quantity of water can flow from the cooling water system of the engine, from a point below the thermostat 14, at all times, being replenished by water drawn through the line 72. The purpose of this arrangement is to permit accumulations of gases or vapors below the thermostat 14, when the thermostat is closed, to be discharged into the reservoir 66. Thus, such accumulations of the gases or vapors cannot interfere with efficient engine cooling.

In the foregoing embodiment of FIGS. 1 to 8 of the drawings, the flow is vertical from the upper, inlet header 26 to the lower, outlet header 28. However, the invention may be embodied in a heat exchanger which is so oriented that the flow from the inlet header to the outlet header is horizontal, with the heat exchanger oriented either horizontally or vertically. The latter orientation is embodied in the species of the invention which is illustrated in FIGS. 9 and 11 and which will now be considered.

Embodiment of FIGS. 9 to 11

Referring to FIG. 9, illustrated therein is a cooling apparatus 118 of the invention which is similar to the apparatus 18 and which may be regarded as corresponding approximately to the apparatus 18 rotated 90°, in the clockwise direction as the apparatus 18 is viewed in FIG. 2 of the drawings. In view of the fact that the cooling

apparatus **118** is similar to the apparatus **18**, the various components of the apparatus **118** will be identified by reference numerals higher by one hundred than the corresponding components of the apparatus **18**.

Thus, the cooling apparatus **118** includes a heat exchanger **124** having vertical inlet and outlet headers **126** and **128** connected by a vertically oriented, horizontally extending core **130**. Extending upwardly within the inlet and outlet headers **126** and **128** are stepped inlet and outlet ducts **136** and **138**, these having inlet and return lines **116** and **120** connected to their respective lower ends **140** and **142**. Except for their vertical orientations, the inlet and outlet ducts **136** and **138** are identical to the inlet and outlet ducts **36** and **38**, the relationships to the inlet and outlet headers **126** and **128** also being substantially identical. Thus, a further description is not necessary, except to point out that the inlet duct **136** is provided with baffles **156** corresponding to the baffles **56**, but directed horizontally toward a reservoir **166** alongside the inlet header **126**, instead of being directed upwardly as in the previous embodiment.

The reservoir **166** is separated from the inlet header **126** by an upright wall **168** which is inclined toward the core **130**. This inclined wall is provided with a plurality of vertically spaced, horizontal slots **170** therethrough, including one which interconnects the extreme upper ends of the inlet header **126** and the reservoir **166**. The slots **170** below the uppermost one are provided thereabove with baffles **171** which slope downwardly toward the inlet duct **36** above the respective baffles **156** thereon.

It will be apparent that, with the foregoing construction, any gases or vapors discharged into the inlet header **126** through the openings in the inlet duct **136** tend to rise along the inclined wall **168** and to pass through the ports **170** into the reservoir **166**. Such migration of the gases and vapors into the reservoir **166** is aided by the interaction between the baffles **171** and the baffles **156**, and also by the fact that the wall **168** slopes toward the core **130** in the manner shown. Furthermore, a fraction of the total flow into the inlet header **126** is constantly drawn off through a line **172** corresponding to the line **72**, thereby insuring migration of most of the gases and vapors from the inlet header **126** into the reservoir **166**. Such gases and vapors thus accumulate in the upper end of the reservoir **166** to prevent interference with effective heat exchange. Any gases and vapors tending to accumulate in the upper end of the outlet header **128** may pass to the upper end of the reservoir **166** through a connecting line **174**.

The reservoir **166** is provided at its upper end with a filler neck **176** adapted to be closed by a cap **178** and equipped with an overflow line **180**. A line **182**, corresponding to the line **82**, is also connected to the reservoir **166** for the same purpose as the line **82**.

Although exemplary embodiments of the invention have been disclosed herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the spirit of the invention as defined by the claims which follow.

I claim:

1. In combination:
(a) a heat exchanger having spaced headers which extend transversely of said heat exchanger;
(b) inlet and outlet ducts which are disposed in said headers, respectively, and which extend transversely of said heat exchanger therein;
(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other; and
(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction.

2. In combination:
(a) a heat exchanger having horizontal upper and lower headers which extend transversely of said heat exchanger;
(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said heat exchanger therein;
(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other; and
(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction.

3. In combination:
(a) a heat exchanger having vertical inlet and outlet headers which extend transversely of said heat exchanger;
(b) inlet and outlet ducts which are disposed in said inlet and outlet headers, respectively, and which extend transversely of said heat exchanger therein;
(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other; and
(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction.

4. In combination:
(a) a heat exchanger having horizontal upper and lower headers which extend transversely of said heat exchanger;
(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said heat exchanger therein;
(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;
(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction; and
(e) baffle means for directing upwardly in said upper header fluid discharged from at least some of said openings in said inlet duct.

5. In combination:
(a) a heat exchanger having horizontal upper and lower headers which extend transversely of said heat exchanger;
(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said heat exchanger therein;
(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;
(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction; and
(e) baffle means at the ends of certain of said steps of said inlet duct for directing upwardly in said upper header fluid discharged from at least some of said openings in said inlet duct.

6. In combination:
(a) a heat exchanger having inlet and outlet headers which extend transversely of said heat exchanger;
(b) inlet and outlet ducts which are disposed in said inlet and outlet headers, respectively, and which extend transversely of said heat exchanger therein;
(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;
(d) each of said ducts having openings of uniform size

at the ends of the respective steps therein and facing in the same direction;

(f) a reservoir adjacent said inlet header; and

(f) port means interconnecting said reservoir and said inlet header in fluid communication.

7. In combination:

(a) a heat exchanger having inlet and outlet headers which extend transversely of said heat exchanger;

(b) inlet and outlet ducts which are disposed in said inlet and outlet headers, respectively, and which extend transversely of said heat exchanger therein;

(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;

(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction;

(e) baffle means for directing upwardly in said upper header fluid discharged from at least some of said openings in said inlet duct;

(f) a reservoir adjacent said inlet header; and

(g) port means interconnecting said reservoir and said inlet header in fluid communication.

8. In combination:

(a) a heat exchanger having upper and lower headers which extend transversely of said heat exchanger;

(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said heat exchanger therein;

(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;

(d) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction;

(e) a reservoir surmounting said upper header; and

(f) port means interconnecting said reservoir and said upper header in fluid communication.

9. In combination:

(a) a heat exchanger having upper and lower headers which extend transversely of said heat exchanger;

(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said heat exchanger therein;

(c) each of said ducts being of stepped construction transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;

(d) each of said ducts having openings of uniform size at the ends of the steps therein and facing in the same direction;

(e) baffle means for directing upwardly in said upper header fluid discharged from at least some of said openings in said inlet duct;

(f) a reservoir surmounting said upper header; and

(g) port means interconnecting said reservoir and said upper header in fluid communication.

10. In an apparatus for removing heat from an internal combustion engine having cooling means which includes a coolant jacket and a pump for circulating a coolant through said jacket, the combination of:

(a) a radiator having upper and lower headers which extend transversely of the radiator;

(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said radiator therein;

(c) means for connecting said inlet and outlet ducts to said engine cooling means on the outlet and inlet sides, respectively, of said pump;

(d) said connecting means being connectible to said inlet and outlet ducts at one side of said radiator;

(e) each of said ducts being of stepped construction transversely of said radiator and decreasing uniformly in area step by step from said one side of said radiator to the other;

(f) each of said ducts having openings of uniform size at the ends of the respective steps therein and facing in the same direction;

(g) baffle means for deflecting upwardly in said upper header coolant discharged from at least some of said openings in said inlet duct;

(h) a reservoir surmounting said upper header;

(i) port means interconnecting said reservoir and said upper header in coolant communication; and

(j) means for connecting said reservoir to said engine cooling means on the inlet side of said pump.

11. In an apparatus for removing heat from an internal combustion engine having cooling means which includes a coolant jacket and a pump for circulating a coolant through said jacket, the combination of:

(a) a radiator having inlet and outlet headers which extend transversely of said radiator;

(b) inlet and outlet ducts which are disposed in said inlet and outlet headers, respectively, and which extend transversely of said radiator therein;

(c) means for connecting said inlet and outlet ducts to said engine cooling means on the outlet and inlet sides, respectively, of said pump;

(d) said connecting means being connectible to said inlet and outlet ducts at one side of said radiator;

(e) each of said ducts decreasing in area from said one side of said radiator to the other;

(f) each of said ducts having openings therein at points spaced apart transversely of said radiator, which openings are of uniform size and face in the same direction;

(g) a reservoir adjacent said inlet header;

(h) port means interconnecting said reservoir and said inlet header in coolant communication; and

(i) means for connecting said reservoir to said engine cooling means on the inlet side of said pump.

12. In an apparatus for removing heat from an internal combustion engine having cooling means which includes a coolant jacket and a pump for circulating a coolant through said jacket, the combination of:

(a) a radiator having upper and lower headers which extend transversely of said radiator;

(b) inlet and outlet ducts which are disposed in said upper and lower headers, respectively, and which extend transversely of said radiator therein;

(c) means for connecting said inlet and outlet ducts to said engine cooling means on the outlet and inlet sides, respectively, of said pump;

(d) said connecting means being connectible to said inlet and outlet ducts at one side of said radiator;

(e) each of said ducts decreasing in area from said one side of said radiator to the other;

(f) each of said ducts having openings therein at points spaced apart transversely of said radiator, which openings are of uniform size and face in the same direction;

(g) a reservoir surmounting said upper header;

(h) port means interconnecting said reservoir and said upper header in coolant communication; and

(i) means for connecting said reservoir to said engine cooling means on the inlet side of said pump.

13. In combination:

(a) a heat exchanger having a transversely extending header;

(b) a uniformly stepped duct disposed in said header and extending transversely of said heat exchanger; and decreasing uniformly in area step by step from one side of said heat exchanger to the other; and

(c) said duct having openings of uniform size at the ends of the respective steps thereof and facing in the same direction.

14. In combination:

(a) a heat exchanger having a transversely extending, generally horizontal header;

(b) a generally horizontal, uniformly stepped duct disposed in said header and extending transversely of said heat exchanger and decreasing uniformly in area step by step from one side of said heat exchanger to the other;

(c) said duct having openings of uniform size at the ends of the respective steps thereof and facing in the same direction;

(d) said duct having upturned baffles at certain of said steps, respectively; and

(e) said baffles being located opposite and in the paths of flow from certain of said openings, respectively.

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