

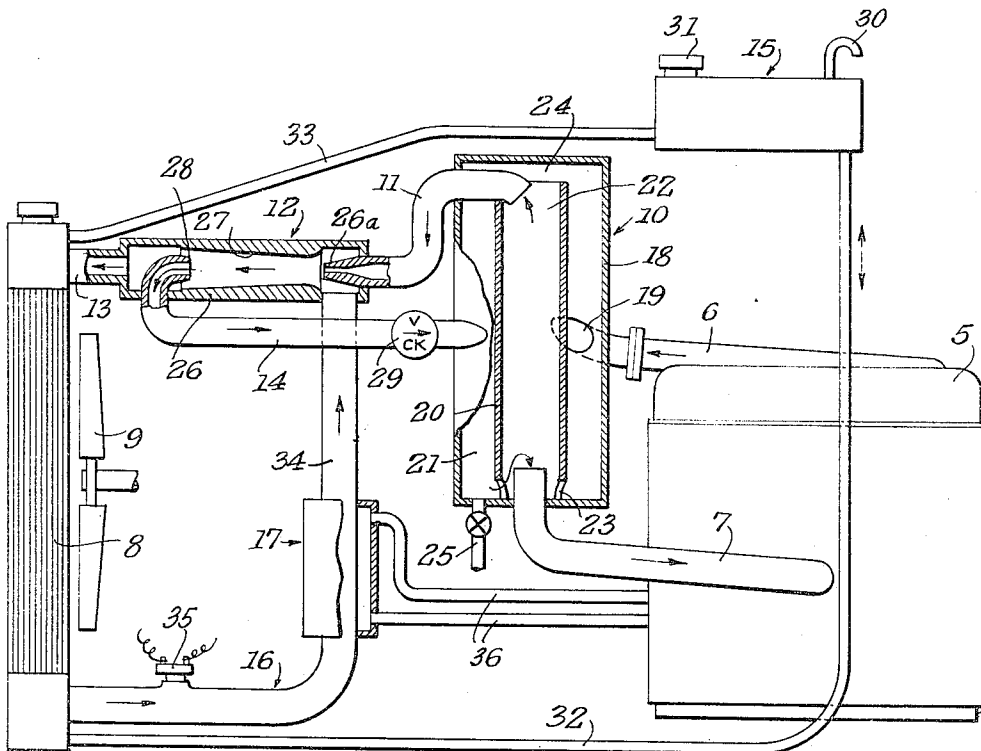
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COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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1

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COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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This invention relates to a cooling system for internal combustion engines and the like and deals more particularly with a system using liquid cooling. Since water is the usual liquid used in such cooling systems, this disclosure will consider water only, although other liquids, such as kerosene, alcohol, etc., alone, or mixed with water may be used. The vapor phase of the water in this system will be referred to as steam.

The invention contemplates a cooling arrangement in which water circulates through an engine at or near its boiling point and the principal area of heat transfer is in a state of ebullition, the cooling of the heated surfaces of the engine taking place by ebullition. In the cooling systems of engines with high specific output, for instance, such an arrangement has many important advantages, among which is that the heat transfer rate of boiling water is much greater than the conventional heat transfer by convection only.

If boiling is not a factor, the temperature of any given portion of the cylinder head walls of an engine depends, largely, on the coolant velocity over and past such walls. It is a practical impossibility to obtain uniform water velocities through the complex maze of cored passages of a cylinder head. Hence, some areas of the head necessarily run hotter than others. On the other hand, metal temperatures in a cylinder head, cooled by ebullition or boiling, are substantially more uniform throughout than if cooling is by convection only.

Another important feature of the present invention is that the same deals with an arrangement in which the circulation of the coolant is not effected by a pump or comparable mechanical means but rather by the action of the steam generated on the hot surfaces in the water passages of an engine and which, while rising through the passages, carries a surplus of coolant to adequately wet said surfaces.

Accordingly, an object of the present invention is to provide an efficient liquid cooling system, for the purposes indicated, that operates with a coolant maintained at a temperature sufficiently high so as to effect the principal transfer of heat by ebullition or boiling.

Another object of the invention is to provide an improved separating means for the water and steam mixture circulating from the cooling passages of an engine, the same being especially efficient to induce free circulation of the coolant circuit and rendered so efficient by the absence of restrictions to the circulation.

A further object of the invention is to provide an engine cooling system that operates in a manner to effect a low temperature differential between the temperature of coolant circulating to the engine, on the one hand, and the temperature of coolant circulating from the engine, on the other. This important feature not only results in reduced taper between the top and bottom of a cylinder usually caused by temperature differential, but the higher temperature in any part of the cylinder actively prevents or inhibits condensation of products of combustion on

2

cylinder walls under load conditions, such condensation usually causing corrosion, sludging and excessive wear.

A still further object of the invention is to provide a cooling system of the character referred to having adequate venting at all times. This feature is important because raising water to its boiling point causes elimination therefrom of air and other non-condensable entrained gases, and adequate venting provides for free escape of such air and gases and further affords ready egress from the system of any leakage from the combustion chamber of an engine into the cooling spaces therearound.

Other objects of the invention are to provide a cooling system in which aeration of the coolant is prevented; to which coolant may be added while the system is in operation and under all load conditions; and which may be used to effect heat exchange as with a cooler for the lubricating oil of an engine.

A yet further object of the invention is to provide a cooling system that operates to provide a constant operating temperature of an engine regardless of fluctuations of load, speed or ambient temperature.

The invention also has for its objects to provide such means that are positive in operation, convenient in use, easily installed in a working position and easily disconnected therefrom, economical of manufacture, relatively simple, and of general superiority and serviceability.

The invention also comprises novel details of construction and novel combinations and arrangements of parts, which will more fully appear in the course of the following description. However, the drawing merely shows and the following description merely describes one embodiment of the present invention, which is given by way of illustration or example only.

In the drawing, like reference characters designate similar parts in the several views.

The figure is a semi-diagrammatic view showing the application of a preferred form of the present liquid cooling system to a conventional automotive installation comprising a motor, radiator and fan.

The engine 5 that is illustrated is generally conventional of water-cooled internal combustion engines that operate on a variety of different fuels. In the usual manner, said engine is provided with a line or conduit 6 from which coolant, a mixture of water and steam, is discharged and a line or conduit 7 to conduct return water to the engine. The radiator 8 is also generally conventional as is the fan 9. It will be understood, of course, that said fan is driven by engine 5 although not so shown.

According to the present invention, the liquid cooling system for said engine 5, that is illustrated, comprises, generally, a steam separator 10 that receives the discharge from conduit 6, returns the water of said discharge to the engine by way of conduit 7, and directs the steam thereof into a conduit 11, a steam jet circulator 12 that receives the flow from conduit 11 and induces an accelerated flow through a conduit 13 into the top of radiator 8, and a similar flow, by way of conduit 14, back to the separator 10, a displacement and vent tank 15 connected in circuit with the radiator and preferably located at an elevation above the top of said radiator, and a flow circuit 16 between said steam jet circulator 12 and the bottom of the radiator and including heat exchange means 17, the same establishing a radiator flow circuit independent of the flow circuit through the engine and the steam separator.

The steam separator 10 is shown as comprising a preferably vertically disposed housing 18 to which the conduit 6 has a tangential connection 19, said connection being preferably made to the housing about midway between its closed top and bottom. A tubular insert 20, vertically disposed within housing 18, divides the interior of the separator into an outer chamber 21 that is recep-

tive of the discharge from conduit 6, and an inner chamber 22. Openings 23 in insert 20 communicate the chambers at the bottom of the separator and a space 24 communicates said chambers at the top.

Conduit 7 extends through the bottom of housing 18 and partly upwardly into the bottom of insert 20. Thus liquid in the bottom of chamber 22 discharges into conduit 7 for conduction back to the engine 5. The conduit 11 is directed into the top of chamber 22 and receives steam therefrom. The separator may be drained as through a valve-provided line 25.

The steam jet circulator 12 is shown as comprising a preferably horizontal housing 26 into one end of which a steam jet nozzle 26a is introduced, the latter being provided on the end of conduit 11. The housing 26 is provided with a venturi tube 27 into which nozzle 26a discharges, the accelerated flow from said tube discharging, through conduit 13, into the top of radiator 8.

The flow conduit 14 has its inlet end 28 disposed in the path of discharge flow from venturi tube 27, the outlet of said conduit tangentially entering chamber 21. A check valve 29 is in conduit 14, to obviate back flow therein. It will be noted that the conduits 6 and 14, both tangentially entering chamber 21, produce flow in the same circumferential direction.

The vent tank 15 is shown as provided with a vent to atmosphere 30 and with a filler cap 31 through which water may be introduced to replenish any losses there may be in the radiator circulation system. A flow line 32 connects the bottom of the radiator and tank 15, and a vent line 33 connects the top of said radiator and said tank 15.

The flow circuit 16 is shown as a water circulating line 34 from the bottom of radiator 8 to housing 26 of the steam jet circulator, said line 34 entering said housing rearward of the discharge from nozzle 26a. A temperature-actuated switch 35 may be provided in line 34 for reasons later explained.

The heat exchanger 17 may conventionally be used to utilize the temperature of water in line 34 to cool any flow in lines 36. The latter lines may circulate lubricant being used by the engine 5 or for other analogous purposes.

The steam and water mixture from the engine 5 enters outer chamber 21 of the steam separator 10 at high velocity and by reason of the swirling motion directed thereto, causes considerable turbulence in said outer chamber as the steam in said mixture rises and the water therein settles. Thus, the turbulent water in the outer chamber finds entry through openings 23 into the quiet of inner chamber 22. Similarly, the turbulent steam in the outer chamber finds entry through space 24 into the quiet of said inner chamber 22. Since there is little or no turbulence in inner chamber 22, the water entering the bottom thereof is substantially free of steam and gas bubbles. It is this steam and bubble-free flow of water that returns to the engine by way of conduit 7.

The circulation to the steam separator 10 is similar to the circulation in a water tube steam boiler. The steam bubbles forming in the engine jacket and cylinder head rise and carry the water along. The column of water in the inner chamber 22 is, of course, much heavier than the column of steam and water in the engine, in conduit 6, and in outer chamber 21 of the separator. This difference in weight of the two columns together with the action of the expanding steam bubbles in the latter column, as said bubbles rise, causes efficient and rapid circulation in the circuit that comprises the engine, the steam separator and the two conduits 6 and 7.

The steam jet circulator 12 serves a three-fold purpose: as means for circulating coolant in the radiator circuit, as a condenser for the steam from the steam separator 10, and as a condensate return means to the separator. The mentioned radiator circuit comprises circulator 12,

conduit 13, radiator 8, and conduit 34 of the flow circuit 16.

The displacement and vent tank 15 serves to vent the system by way of line 33. Air liberated by the boiling of coolant water and other non-condensable gases, which enter the steam separator, are carried along with the steam into the top of radiator 8 and thence through line 33 into tank 15. The same is vented through vent 30. Since tank 15 is at atmospheric pressure, the filler cap 31 may be used for adding coolant to the system during operation of the apparatus. Said tank 15 also accommodates increase in the volume of the water in the radiator circuit at elevated temperatures, and also of the water carried over into the circuit with the steam from the engine-circulating circuit. At high loads, the steam generated in the engine-circulating circuit displaces a considerable amount of water which is carried over into the steam separator and causes a rise in the water level therein. Much of this water is, in turn, carried over with the steam into the radiator circuit from whence it is discharged into tank 15 by way of vent line 33. This water transfer from the separator 10 to the tank 15 continues until the water level in the separator is low enough to establish a balanced condition between the water carried over with the steam and the amount of water returned through conduit 14 to the separator.

Should the engine load drop, less steam will be generated and the pressure in the separator 10 will drop, accordingly. This drop will cause a return of water from tank 15 to the radiator circuit through line 33. At the same time, water from the top of the radiator will overflow through conduit 13 into conduit 14 and, past check valve 29, into separator chamber 21. The change in water level in separator 10 and tank 15, therefore, follows changes in load conditions on engine 5.

Operation

Before starting, the system is filled with coolant water through the conventional cap on radiator 8, after which said cap is tightly closed. The usual overflow pipe, if present, is also tightly closed. The engine 5 and separator 10 receive this water by way of conduits 14, 6 and 7.

The water in the engine heats rapidly after starting, setting up circulation between said engine and the steam separator 10. Since the lubricating oil in the engine will also heat up, the increase in the temperature thereof will heat conduit 34 passing through exchanger 17 and will cause the water in said conduit to rise, setting up circulation in the radiator circuit.

As the temperature of the coolant in the engine circuit reaches the boiling point, steam will be generated in an amount commensurate to the load conditions on the engine. The pressure of this steam rises in the separator 10 and forces water in conduit 11 outwardly through nozzle 26a. The steam follows this water and the same carries coolant water into the venturi tube which imparts high velocity to the coolant. At the same time, the steam in the coolant water will be condensed due to the restriction imposed thereon by said nozzle and the entry portion of the venturi tube.

That amount of the coolant that was initially steam is returned to the outer chamber 21 of the separator. The conduit 14 receives this water at high velocity at inlet 28 and conducts the same past check valve 29. In practice, conduit 14 is proportioned to return water somewhat in excess of the amount initially represented by the steam passing through conduit 11. Also, this action has proven to be entirely automatic because the excess water returned to chamber 21, raises the level of water in the separator 10 and this, in turn, causes more water to be carried through conduit 11 with the steam. This maintains until a balance is established in which the return water equals the water entering the injector through conduit 11.

5

Further, this water level in the steam separator varies with load conditions, since, at high loads, the turbulence in the outer chamber 21 is quite great with the result that more water than normal will be carried out by the steam until the lowering of the water level gradually reduces the amount of water being carried out until a state of balance has been reached.

The circulation in the radiator circuit is established by the force induced by injector 12, the rate of flow varying somewhat with the amount of steam generated, as load conditions change. After the latter circuit has been established, the relatively cooler water circulating in conduit 34 serves to cool the oil in lines 36.

The limit switch 35 will close if the temperature in conduit 34 becomes higher than a pre-determined maximum. The same may control the ignition system, for instance, to stop the engine under abnormal conditions, as when the fan belt breaks, the radiator becomes excessively clogged or air flow for cooling said radiator is impaired.

Two or more steam jets may be used, if desired, instead of the single one shown.

While the foregoing has illustrated and described what is now contemplated to be the best mode of carrying out the invention, the construction is, of course, subject to modification without departing from the spirit and scope of the invention. It is, therefore, not desired to restrict the invention to the particular form of construction illustrated and described, but to cover all modifications that may fall within the scope of the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. Apparatus for circulating the coolant water of an internal combustion engine that is provided with a radiator comprising a steam separator having a vertical wall dividing said separator into two vertical chambers, there being openings provided in the top and bottom portions of said wall whereby the two chambers are in top and bottom communication, a first flow conduit for conducting a mixture of water and steam from said engine to one of said chambers, a second flow conduit for conducting coolant water from the other of said chambers back to the engine after separation of steam from said mixture, a jet device having a conduit connecting the same to the separator, said device being receptive of steam and such water that is carried thereby that exits from the separator for condensing the same, circulating means for circulating and cooling the condensate flowing from the jet device, said means comprising said radiator and conduits connecting the same in series with the jet device, and a displacement tank for accommodating coolant water displaced from said means by steam generated in the engine, said tank being located above said circulating means and having a conduit connecting the same thereto.

2. Apparatus according to claim 1: a conduit receiving part of the condensate in the jet device, said conduit being connected to the first-mentioned chamber for conducting said condensate to the said chamber.

3. Apparatus according to claim 1: a conduit receiving part of the condensate in the jet device, said conduit being connected to the first-mentioned chamber for conducting said condensate to the said chamber, and means provided in said latter conduit for checking back flow from said chamber to the jet device.

4. Apparatus according to claim 1: in which said separator has a circular cross-section, and the two chambers thereof are arranged concentrically, and in which the first and second flow conduits are connected to said separator tangentially to induce turbulences therein, and, thereby, effect a more ready separation of the steam from the mentioned mixture.

6

5. Apparatus for circulating the coolant water of an internal combustion engine that is provided with a radiator, said apparatus comprising a steam separator having two chambers in communication, said engine having a flow conduit to one of said chambers to conduct a mixture of coolant water and steam to said latter chamber and a flow line from the other chamber to conduct coolant water back to the engine after separation of said water from said steam, a jet device receptive of the steam and such water carried thereby that exits from the separator, and circulating means comprising said radiator and conduits connecting the same in series with the jet device to circulate and cool the condensate of the steam and water in the jet device, a vented tank, and conduits connecting said tank and the radiator in series and receptive of coolant water displaced by steam in the steam separator and in excess of the amount of water that can be accommodated in the radiator.

6. Apparatus for circulating the coolant water of an internal combustion engine that is provided with a radiator, said apparatus comprising a steam separator having two chambers in communication, said engine having a flow conduit to one of said chambers to conduct a mixture of coolant water and steam to said latter chamber and a flow line from the other chamber to conduct coolant water back to the engine after separation of said water from said steam, a jet device receptive of the steam and such water carried thereby that exits from the separator, and circulating means comprising said radiator and conduits connecting the same in series with the jet device to circulate and cool the condensate of the steam and water in the jet device, a vented tank, and conduits connecting said tank and the radiator in series and receptive of coolant water displaced by steam in the steam separator and in excess of the amount of water that can be accommodated in the radiator, said tank being disposed at an elevation above that of the top of the radiator.

7. In apparatus for circulating the coolant water of an internal combustion engine, a steam separator connected in series with said engine and provided with an outer chamber receptive of a water-steam mixture rising from the engine when heated, an inner chamber in top and bottom communication with the outer chamber and provided with a lower draining connection to the engine of water precipitated out of the water-steam mixture, and a steam-conducting conduit from the upper end of the inner chamber.

8. In apparatus according to claim 7: a conduit from the engine conducting the water-steam mixture to the outer chamber of the steam separator, and said conduit being tangentially connected to said chamber to induce a turbulent flow of said mixture into the chamber.

9. In apparatus for circulating the coolant water of an internal combustion engine provided with a water-cooling radiator and with a device for separating the steam from the coolant water that is discharged by the engine, water circulating means comprising said radiator, a jet circulator receptive of steam from the separator and, while condensing the same, directing a flow thereof into the upper part of the radiator, and a return conduit from the lower part of the radiator to the jet circulator, said jet circulator being provided with a flow accelerating nozzle through which the steam is passed, and said return conduit being connected to the jet circulator rearward of said nozzle.

10. In apparatus for circulating the coolant water of an internal combustion engine provided with a water-cooling radiator and with a device for separating the steam from the coolant water that is discharged by the engine, water circulating means comprising said radiator, a jet circulator receptive of steam from the separator and, while condensing the same, directing a flow thereof into the upper part of the radiator, and a return conduit from the lower

7

part of the radiator to the jet circulator, said jet circulator being provided with a flow accelerating nozzle through which the steam is passed, and with a venturi tube that further accelerates the flow from the nozzle.

11. In apparatus for circulating the coolant water of an internal combustion engine provided with a water-cooling radiator and with a device for separating the steam from the coolant water that is discharged by the engine, water circulating means comprising said radiator, a jet circulator receptive of steam from the separator and, while condensing the same, directing a flow thereof into the upper part of the radiator, and a return conduit from the lower part of the radiator to the jet circulator, a heat exchanger having flow connections to the engine and operatively

8

associated with the return conduit from the lower part of the radiator, said heat exchanger, when the flow in the connections thereof is at a higher temperature than the water in the return connection, inducing circulation of said water and said water, when circulating, cooling the flow in the connections.

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