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ENGINE COOLING SYSTEM

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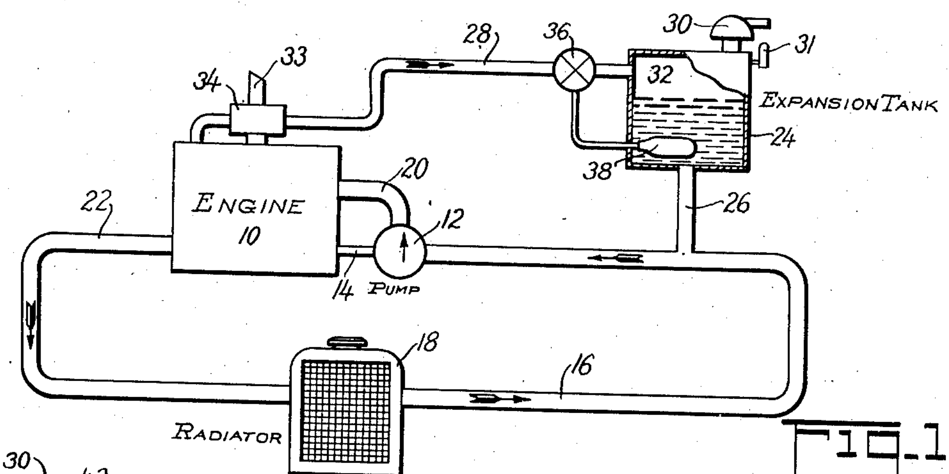

FIG. 1

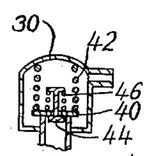

FIG. 4

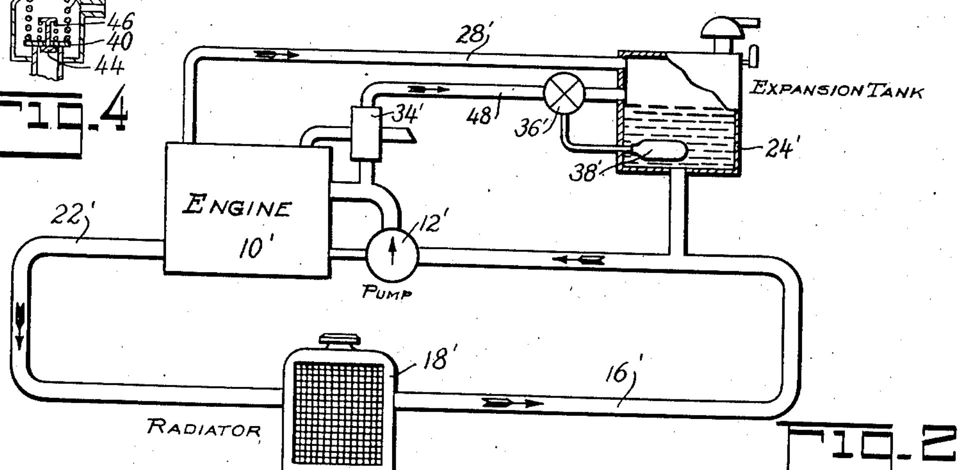

FIG. 2

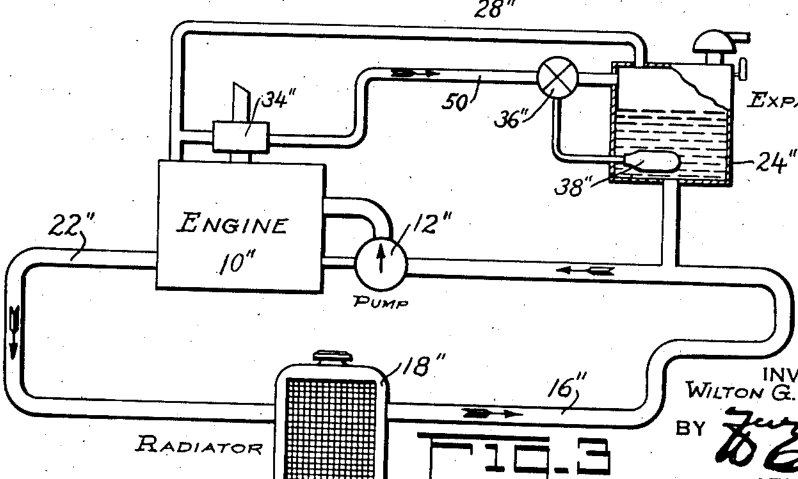

FIG. 3

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ENGINE COOLING SYSTEM

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13 Claims. (Cl. 123—174)

This invention relates to a liquid cooling system and is particularly directed to a sealed liquid cooling system employing forced circulation.

Liquid cooling systems for aircraft engines consist essentially of a liquid-cooled jacket for the engine, a pump for circulating liquid therethrough, a radiator, an expansion tank, a liquid connection from the jacket to the expansion tank, and a pressure relief valve for the expansion tank. It is an object of this invention to provide a novel and simple means for increasing the pressure on the liquid in the expansion tank to a sufficient extent to prevent boiling of the liquid in the pump or at any other point in the system. Specifically, the invention consists in the provision of means for raising the temperature of the liquid in the expansion tank thereby increasing the vapor pressure in this tank.

Other objects of the invention will become apparent from reading the annexed detailed description in connection with the drawing, in which:

Figs. 1, 2 and 3 schematically illustrate three different embodiments of the invention; and

Fig. 4 is a detail view of a safety valve.

Referring to the preferred embodiment illustrated in Fig. 1, a liquid-cooled internal combustion engine is indicated at 10 and a liquid circulating pump 12 is driven from this engine by a shaft 14. A conduit 16 connects a cooling radiator 18 with the inlet of the pump 12, and a conduit 20 connects the delivery side of the pump to the engine coolant jacket. A conduit 22 provides a return from the engine jacket to the radiator thereby completing the main liquid circulating circuit including the engine jacket radiator and pump.

An expansion tank 24 is connected to the main circulating circuit at the inlet side of the pump by a conduit 26. A line 28 connects an upper portion of the jacket at its discharge end with the expansion tank 24 thereby providing a vent for the jacket. In actual practice the cross-sectional area of line 28 is quite small so that only a limited quantity of liquid flows therethrough into the expansion tank. A conventional safety pressure relief valve 30 opens to relieve excessive pressure within the tank 24 and also opens when the pressure therein drops below atmospheric pressure. As schematically illustrated in Fig. 4, the valve 30 comprises a main valve element 40 biased to a closed position by a spring 42 which is designed to allow valve element 40 to open when the pressure inside the expansion tank becomes excessive. In addition a valve element 44 cooperates with a central opening in the valve element 40. The valve element 44 is biased closed by a spring 46 of such strength that this valve opens when the pressure inside the expansion tank drops below atmospheric pressure. The liquid cooling system so far described is conventional.

During the operation of the system it is desirable that all air be eliminated from the system. Accordingly, a conventional thermostatic radiator-type air-vent valve 31 is connected to the space 32 above the liquid in the expansion tank 24. Instead of the air-vent valve 31 a small opening may be provided at an upper portion of the expansion tank to permit the escape of air as the pressure in the space 32 rises. In normal operation, the temperature of the liquid in the expansion tank rises above 212° F. so that with water in the expansion tank, the vapor pressure in space 32 will exceed atmospheric pressure and force the air out of this space. Accordingly, the pressure in the space 32 above the liquid in the expansion tank is the vapor pressure of the liquid corresponding to the particular temperature of the liquid in the tank, i. e., during normal operation the liquid in the expansion tank is right at the boiling point for the temperature and pressure conditions existing in the tank. For example, if some of the vapor in the space 32 were suddenly condensed, the resulting reduction in pressure in this space would cause boiling of the liquid since for this new pressure the temperature of the liquid in the tank would be above its boiling point.

The pressure at the inlet of pump 12 is equal to the vapor pressure in the space 32 plus the pressure head due to the elevation of the tank 24 relative to the pump. In a liquid cooling system for an aircraft engine, the elevation of the tank 24 relative to the pump is necessarily quite small so that the pressure at the inlet of the pump 12 can only be slightly greater than the vapor pressure in the space 32. Also, because of the cooling effect produced by the radiator 18, the inlet pump temperature is less than the temperature in the tank 24. Thus, the temperature and pressure conditions of the liquid at the pump inlet are such that at this point in the system the liquid is somewhat below its boiling point. However, as the liquid is picked up by the pump it is momentarily accelerated whereupon there is a substantial conversion of liquid pressure head to velocity head. As a result, the temperature of the liquid in the pump may be above the boiling point of the liquid for this reduced pressure whereupon the boiling of the liquid occurs in the pump.

This boiling in the pump considerably reduces the efficiency of the pump and it is an object of this invention to eliminate this boiling so that the pump handles only liquid. To accomplish this result, means are provided to raise the temperature of the liquid in the expansion tank 24 thereby increasing the vapor pressure in the space 32. For example, if water is used as the liquid coolant and if the temperature in the expansion tank is normally about 250° F., then a 5° increase in temperature of the water in this tank will increase the vapor pressure in space 32 approximately three pounds per square inch. With a pump inlet temperature of approximately 235° F., this increase in vapor pressure in space 32 would normally be sufficient to prevent boiling in the pump.

In order to raise the temperature of the liquid in the expansion tank, the engine exhaust discharging through the manifold 33 is passed through an engine-exhaust heater 34 in heat exchange relation with the liquid returning to the expansion tank through the line 28. The pressure rise produced by the pump 12 provides for circulation of liquid through the vent line 28 to the expansion tank so that the heater 34 serves to heat up the liquid in the expansion tank 24. A thermostatic valve 36 is located in the line 28 to control the flow therethrough into the expansion tank 24 and a thermally responsive bulb 38, located in the expansion tank 24, is connected to and regulates this valve 36 so as to maintain a desired temperature in the expansion tank 24. In this way the vapor pressure in space 32 is increased sufficiently to prevent boiling in the pump 12. A conventional by-pass or other means may be provided to prevent valve 36 from completely closing the line 28.

At this point it may be noted that if a sufficient temperature rise is maintained through the engine jacket, the temperature in the expansion tank 24 and the depending vapor pressure in the space 32 may be high enough to prevent boiling in the pump 12 without the addition of the heater 34.

In the modification illustrated in Fig. 2, a separate flow path 40 is provided for returning liquid to the expansion tank direct from the outlet of the pump 12'. The exhaust heater 34' is placed in heat exchange relation with the line 40 and a thermostatic valve 36' in this line is controlled by a thermally responsive bulb 38' located in the expansion tank. The heater 34' is thereby operative to raise the temperature in the expansion tank to the desired extent. The balance of the cooling system illustrated in Fig. 2 is similar to Fig. 1. The construction of Fig. 1 has the advantage in that since the liquid being returned through line 28 has been in heat exchange relation with the engine, it is not necessary for the heater 34 to impart as much heat to the liquid returning to this line as compared to the amount of heat required to be absorbed by the liquid returning through line 40 in Fig. 2.

The modification illustrated in Fig. 3 is similar to Fig. 1 except that instead of placing the engine exhaust heater in the conventional vent line 28, a separate line 50 is provided in parallel with the line 28'' and an engine exhaust heater 34'' is placed in heat exchange relation with the line 50. The thermostatic flow control valve 36'' is placed in this line under the control of a thermally responsive bulb 38'' located in the expansion tank. Fig. 3 is otherwise similar to Fig. 1.

In all three modifications, an engine exhaust heater is used to heat liquid returning to the expansion tank. However, the invention is not so limited since obviously other means may be employed for heating the liquid in the expansion tank. The amount of heat it is necessary to introduce into the cooling system by the heating of the liquid in the expansion tank is quite small due to the small magnitude to the flow in the expansion tank circuit and probably does not amount to more than 2% of the heat rejection of the engine.

In each of the above described pressurized cooling systems, the system is operated at a pressure sufficiently high to prevent boiling at any point in the system. Other means have been suggested for obtaining this result, for example, it has been proposed to supercharge the space 32 with an air pressure sufficient to raise the liquid pressure in the pump to prevent boiling therein. It has also been proposed to trap air in the expansion tank to obtain the required additional pressure. However, applicant's system has the advantage of completely eliminating air since the entire system is filled with coolant liquid and coolant vapor. This improves the performance of the pump since it is only required to handle liquid and also reduces the corrosion characteristics of the liquid coolant since it is not combined with any entrained air. An additional advantage of the system illustrated in Fig. 1 is that the heater 34 would tend to prevent freezing of the liquid in the vent line 28.

While I have described my invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding my invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. I aim in the appended claims to cover all such modifications and changes.

I claim as my invention:

1. In a sealed liquid cooling system for an internal combustion engine, a pump for circulating liquid through a jacket for said engine, an expansion tank for said liquid connected to the inlet side of said pump, and a heater utilizing the engine exhaust gases for heating the liquid in said expansion tank.

2. In a liquid cooling system for a mechanism, a pump for circuating a cooling liquid in heat exchange relation with said mechanism, an expansion tank for said liquid connected to the inlet side of the pump, and means operative to maintain the vapor pressure of the liquid in said tank above a predetermined value.

3. In a liquid cooling system for an internal combustion engine, a pump for circulating liquid through a cooling jacket for said engine, a vented expansion tank for said liquid connected to the inlet side of the pump, and an engine-exhaust heater for heating the liquid in said expansion tank.

4. In a liquid cooling system for an internal combustion engine, a pump for circulating liquid through a cooling jacket for said engine, an expansion tank for said liquid connected to the inlet side of said pump, a conduit extending from an upper portion and adjacent the discharge end of said jacket to said expansion tank, and a heater utilizing the engine exhaust gases for heating the liquid returning to the expansion tank through said conduit.

5. In a liquid cooling system for an internal combustion engine, a pump for circulating liquid through a cooling jacket for said engine, an expansion tank for said liquid connected to the

inlet side of said pump, a conduit extending from an upper portion and adjacent the discharge end of said jacket to said expansion tank, a heater utilizing the engine exhaust gases for heating the liquid returning to the expansion tank through said conduit, and a thermostatic valve in said conduit responsive to the temperature of the liquid in the expansion tank.

6. In a liquid cooling system for an internal combustion engine, a pump for circulating liquid through a cooling jacket for said engine, an expansion tank for said liquid connected to the inlet side of said pump, conduit means through which said pump is operative to return a part of said circulating liquid to said expansion tank, and means operative to maintain the vapor pressure of the liquid in said tank above a predetermined value.

7. In a liquid cooling system for an internal combustion engine, a pump for circulating liquid through a cooling jacket for said engine, an expansion tank for said liquid connected to the inlet side of said pump, conduit means through which said pump is operative to return a part of said circulating liquid to said expansion tank, an engine-exhaust heater for heating the liquid returning through said conduit means, and a thermostatic valve controlling the flow through said conduit means in response to the temperature in said expansion tank.

8. In a liquid cooling system for an internal combustion engine, a pump for circulating liquid through a cooling jacket for said engine, a radiator disposed between the discharge end of said jacket and the pump inlet for cooling said liquid, an expansion tank for said liquid connected to the inlet side of said pump, and means operative to maintain the vapor pressure of the liquid in said tank above a predetermined valve.

9. In a liquid cooling system for a mechanism, a pump for circulating a cooling liquid in heat exchange relation with said mechanism, an expansion chamber for said liquid connected to the inlet side of said pump, and means including a flow passageway through which said liquid flows into said chamber from a point downstream of said pump for maintaining a desired liquid vapor pressure in said chamber.

10. In a liquid cooling system for a mechanism, a pump for circulating a cooling liquid in heat exchange relation with said mechanism, a radiator disposed between the discharge end of said jacket and the pump inlet for cooling said liquid, an expansion chamber for said liquid connected to the inlet side of said pump, a passageway through which said pump is operative to return liquid to said chamber, and means controlling the flow through said passageway and operative to maintain a desired liquid vapor pressure in said chamber.

11. In a liquid cooling system for a mechanism, a pump for circulating a cooling liquid in heat exchange relation with said mechanism, an expansion tank for said liquid connected to the inlet side of said pump, and means for maintaining the vapor pressure of the liquid in said tank above a predetermined value, said means including a liquid passage through which warm liquid enters said expansion tank.

12. In a liquid cooling system for a mechanism, a pump for circulating a cooling liquid in heat exchange relation with said mechanism, an expansion tank for said liquid connected to the inlet side of said pump, and means for maintaining the vapor pressure of the liquid in said tank above a predetermined value, said means including a liquid passage through which liquid heated by said heat exchange circulation relative to said mechanism is returned to said expansion tank.

13. In a liquid cooling system for a mechanism, a pump for circulating a cooling liquid in heat exchange relation with said mechanism and through a cooling radiator for said liquid, an expansion tank for said liquid connected to the inlet side of said pump, and means for maintaining the vapor pressure of the liquid in said tank above a predetermined value, said means including a liquid passage through which warm liquid is returned by said pump to said expansion tank.

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