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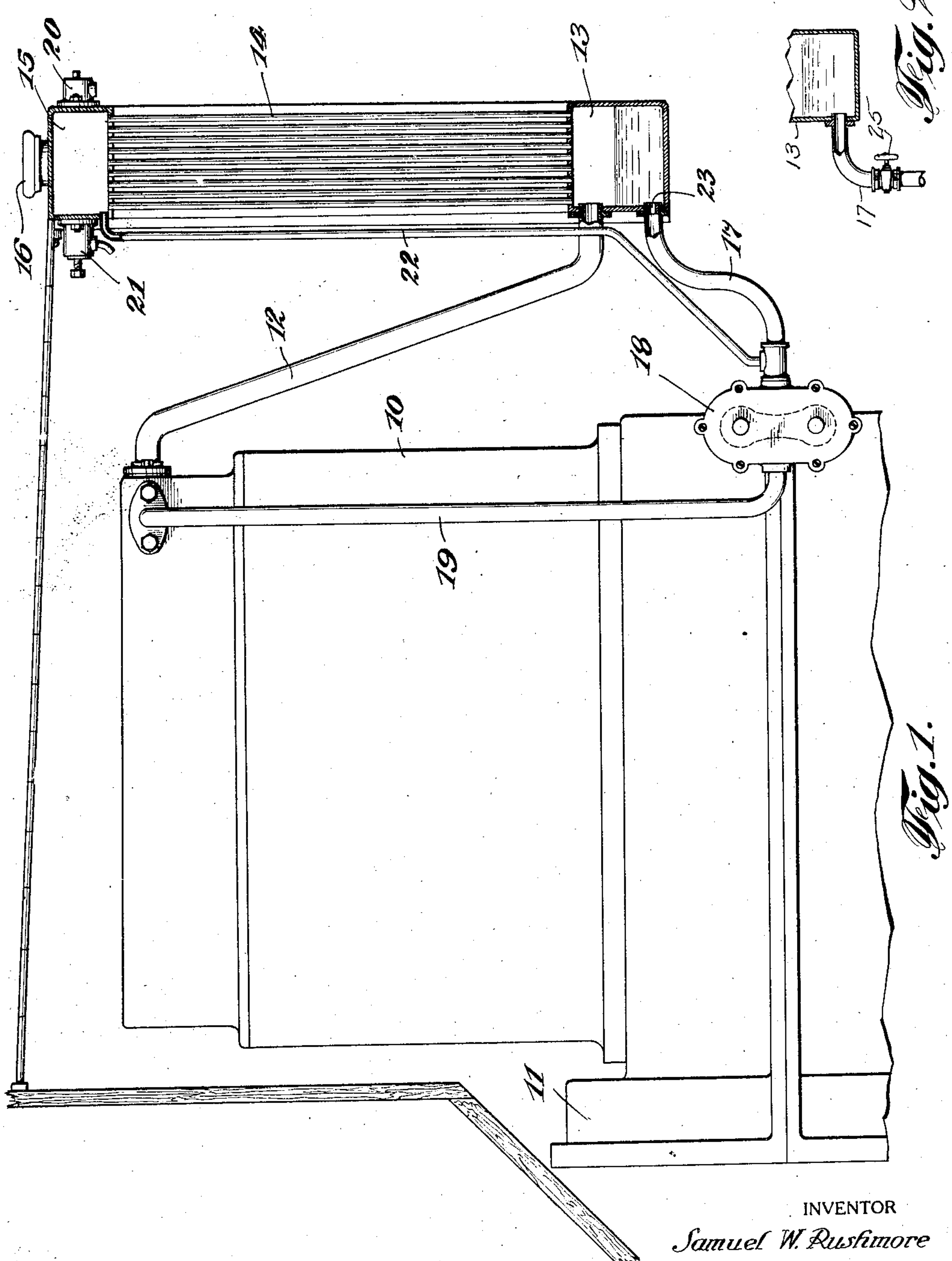

Fig. 2.

Fig. 1.

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COOLING SYSTEM FOR INTERNAL-COMBUSTION ENGINES.

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My present invention relates to cooling systems of the general character disclosed in my prior Patent No. 1,378,724, of May 17, 1921. This patent disclosed a type of cooling system which utilized a more or less conventional air cooled radiator so that it operates as an up-flow steam condenser. The honeycomb of the condenser is disposed between the upper and lower water chambers of the radiator, the boiling water and steam from the engine jacket being short circuited through the lower tank and pumped back to the jacket. The steam and excess water from the jacket usually enter the lower tank in a somewhat turbulent condition and the steam escapes and rises in the honeycomb or the tubes to such height as may be necessary for condensation thereof. The condensate flows back by gravity in intimate heat exchange relation with the upflowing current of steam.

This system, while entirely satisfactory under normal conditions of engine operation, develops certain disadvantageous features of operation, under certain conditions, as when used on high power motor trucks and rail cars where the space available for the condenser is relatively small. This is because the cross sectional area of each condensing tube or passage must be correspondingly small in order to get the required area of cooling surface in such small space. In such small passages, the down-flowing condensate interferes with the upflowing steam so that under certain conditions it is forced upwardly by the steam into the upper chamber of the radiator and, under accumulating steam pressure, it may be then forced out through the blow-off or safety valve and in this way the supply of water in the system may be rapidly depleted.

I find, also, that where the condensers are of relatively small condensing capacity so that they have to work almost constantly at full or nearly full capacity, and where the excess of water discharged with the steam from the jacket into the lower chamber of the radiator is considerable, as where the supply to the jackets is greatly in excess of that required for properly cooling the engine, by boiling alone, without any substantial overflow of water in liquid form, the turbulence in the lower chamber becomes great enough to force large amounts of water into the condensing tubes, further aggravating the difficulty above mentioned, causing excessive back pressures and raising the temperature in the engine jackets above the uniform point desired.

Both of the difficulties above mentioned may be overcome according to my present invention, which includes means for preventing the accumulation of any considerable amount of water in the upper tank and for insuring that the entire condensing surface will operate at maximum efficiency before internal pressures can cause waste at the safety valve.

I employ a circulating pump for returning water from the lower tank to cooling jacket and in accordance with my present invention the header above the condensing tubes is connected to the intake of this pump by a pipe which may be of relatively small cross section. The pipe from the lower tank to the pump is provided at the tank with an outlet orifice of relatively small cross section to limit the rate of flow from the lower tank to the pump. Inasmuch as the pump is purposely made of a capacity considerably greater than that required to handle the small amount of water which can pass to it through this orifice, there will be a certain amount of suction in the drain pipe from the upper tank and any condensate forced into the upper chamber will readily flow or be sucked back to the pump and by it returned to the engine jacket. Hence broadly stated, my invention includes a pump drawing water from both the upper and lower chambers. This is conducive to uniform condenser pressures and the conventional blow-off valve cannot become operative until the condenser is operating at full capacity.

While my pump thus connected is adapted to take care of a great excess of water in the circulating system and in the tubes and upper chamber of the radiator, I prefer to have an intake orifice and to have it so proportioned that the water delivered therethrough will be just sufficient to supply the engine jacket with a quantity of water slightly greater than that needed to satisfy the maximum evaporative requirements of the engine. By thus regulating the size of the orifice, the supply of water to the jacket becomes a simple boiler feeding problem, the jacket itself being nothing but a miniature steam boiler and water being fed thereto as fast as it can be boiled off.

The supply of water to the jacket through the restricted orifice should be constant and it will be evident that if the pump is permitted to develop any substantial vacuum in the pipe from the lower water tank, the flow of water through the orifice will be accelerated and the jacket will be over-supplied. The drain pipe from the upper header prevents the formation of any substantial vacuum in the outlet pipe from the lower water chamber and thus causes the supply to the pump from the lower header to be always determined by a gravitational flow, as limited by the size of the orifice.

Other expedients might be resorted to for preventing a vacuum in the pipe from the pump and as a matter of fact, a gravity feed is not essential to successful operation since if the pressure differential at opposite sides of the orifice is maintained always uniform, the rate of flow through the orifice will remain uniform and the same result accomplished.

It is not a difficult matter to determine the flow necessary for supplying the jacket with slightly more than the maximum amount of water necessary and the difference between the amount required when the engine is running at high speed and the amount required when the engine is idling is not very great. Hence in the preferred operation the surplus water flowing with the steam from the jacket to the radiator is never very great and is often practically negligible.

The invention may be more fully understood from the following description in connection with the accompanying drawing, wherein—

Fig. 1 is a view in side elevation of an engine equipped with a cooling system embodying my present invention, the radiator being shown in section;

Fig. 2 is a fragmentary detail illustrating an alternative method of controlling the flow of water to the pump.

The cylinder jacket 10 of the engine 11 communicates at its upper forward end with an outlet pipe 12 down which water from the jacket is adapted to flow to the lower tank or header 13 of an upflow steam condenser. The condenser includes above the tank 13 a "honeycomb" in the nature of a plurality of vertically disposed air cooled steam condensing tubes 14 of relatively restricted cross section. These tubes communicate at their upper ends with an upper tank or header 15 provided with the usual filler cap 16. Water drains from the lower tank 13 through a pipe 17 to circulating pump 18 which returns the water to the engine jacket through a return pipe 19 delivering at the forward upper end of the jacket close to the outlet pipe 12. Pump 18 is preferably a gear pump.

As more fully set forth in my copending application Ser. No. 746,024, filed on even date herewith, the relatively close juxtaposition of the inlet and outlet from the jacket 10 provides a low resistance short circuited circulating path for water through the upper forward end of the jacket. By virtue of this construction, the main body of water in the jacket remains quiescent until boiling begins and the jacket water is quickly raised to the desired temperature.

Two outlet valves are associated with the upper tank or header 15 of the radiator. One of these valves 20 is in the nature of a breather permitting escape of air from header 15, when pressures in the lower end of the condenser become excessive. Valve 20, however, is designed to automatically close when steam or water rising upwardly from the tubes 14 materially increases the temperature in header 15. The other valve 21 is the conventional blow-off or safety valve adapted to permit the escape of steam or water when excessive pressure obtains in the header 15.

This latter valve proves a source of considerable annoyance when the engine is working under a heavy load, since the generation of an unusual amount of heat in the engine results in violent ebullition and steam evolution in the tank 13. The water in tank 13 is at this time in an extremely turbulent condition and consequently a considerable quantity of it is forced or blown up the tubes 14 into the header 15. The presence of this water even though it is in a frothy or bubbling state, causes considerable back pressure in the condenser which is quickly relieved by a discharge of steam and water through the safety valve 21. A great deal of the cooling fluid escapes in this manner and it is partially to prevent such loss and the consequent inconvenience of frequently replenishing the water in the system that I make use of the drain pipe 22.

Pipe 22 prevents any water from being trapped in the header 15 and rapidly drains it back to the pipe 17 adjacent the intake of the pump 18. A restricted orifice 23 in the pipe 17 at the outlet from tank 13 predetermines and limits the amount of water which can gravitationally flow to the pump from tank 13. The pump 18 is purposely so designed that it is capable of taking care of a considerably larger flow than the flow which can occur through pipe 23. Consequently, there is an actual suction or subnormal pressure developed in pipe 17 and transmitted through pipe 22 to header 15. In consequence of this construction, pipe 22 not only serves to drain water from header 15 but to suck water therefrom and from the tops of the tubes 14, whereby condenser back pressure is quickly relieved without any loss of water from the system and pressure is maintained substantially constant throughout the entire body of the condenser.

It will be evident that while the safety valve 21 may still become operative under very extreme conditions of overload, it cannot possibly operate before the condenser is working to full capacity and then only steam can escape so that the loss of water through this valve becomes negligible.

The orifice 23 in the pipe 17 is designed to permit the passage of a quantity of water slightly in excess of the maximum evaporative requirements of the engine, the flow through the orifice being gravitational. In order that this flow be substantially constant, and entirely independent of the speed of the pump, it is obviously necessary to provide some means for preventing a vacuum on the pipe 17. In the present instance, it is accomplished by the relatively restricted pipe 22 which in addition to its above noted draining functioning, serves to prevent any substantial vacuum from being created in pipe 17 or, in other words, serves as a pressure equalizer to maintain a substantially constant pressure differential. An additional feature of importance is the fact that the rate of flow to the boiler is not only independent of the speed of the pump, but is independent of the cooling effect on the radiator and will continue constant regardless of whether the car is running and drawing a strong draught of air through the radiator or whether the engine is idling with a consequent slight cooling effect.

It is to be borne in mind that the supply of water through orifice 23 to the pump is ample at all times to satisfy the requirements of the jacket. The slight excess which is sometimes drawn through pipe 22 will be introduced into the jacket at a time when ebullition is very violent and consequently when such excess can do no harm.

In the particular embodiment of the invention which I have illustrated, the pipe 22 serves the double function of a drain pipe and a pressure equalizer, but both of these functions might be separately served by other means. The regulation of the flow of water to the jacket 10 may be and preferably is reduced to a simple boiler feeding problem, it being necessary merely to supply slightly more water than can be boiled off when the heat evolution in the engine is at a maximum. Broadly considered, however, the usefulness of the apparatus is not limited to this preferred method of operation. The apparatus will continue to operate by the boiling and condensing cycle and the intake from the upper chamber will be useful even where there is a great excess of water in the entire circulating system including radiator tubes and upper chamber.

In Fig. 2, I have illustrated a slightly modified form of the device in which the flow of water from tank 13 through pipe 17 to the pump is controlled by a manually adjustable valve 25 instead of by the orifice 23. The valve possesses advantages over the orifice in that it may be adjusted to compensate for wear on the pump, or for extreme weather conditions.

I claim:

1. In a cooling system for internal combustion engines, a force feed water circulating system of small heat radiating capacity serially including a water jacket, a water outlet from said jacket, a water container to which said outlet is connected and a return conduit including a pump between said container and jacket in combination with an air cooled element of large radiating capacity above said water container, a chamber above the air cooled element into which hot water is adapted to escape and means for draining the water from said chamber back to the cooling water circuit.

2. In a cooling system for internal combustion engines, a force feed water circulating system of small heat radiating capacity serially including a water jacket, a water outlet from said jacket, a water container to which said outlet is connected and a return conduit including a pump between said container and jacket in combination with an air cooled element of large radiating capacity above said water container, a chamber above the air cooled element into which hot water is adapted to escape and means for draining the water from said chamber back to the cooling water circuit, said means including a drain pipe opening into the bottom of the chamber and connected to the return conduit from the container.

3. In a cooling system for internal combustion engines, a force feed water circulating system of small heat radiating capacity serially including a water jacket, a water outlet from said jacket, a water container to which said outlet is connected and a return conduit including a pump between said container and jacket in combination with an air cooled element of large radiating capacity above said water container, a chamber above the air cooled element into which hot water is adapted to escape and means for draining the water from said chamber back to the cooling water circuit, said means including a drain pipe opening into the bottom of the chamber and connected to the return conduit from the container, said return conduit be-

ing of restricted cross-section at the container whereby the pump will create a low pressure in the drain pipe.

4. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open in combination with means for preventing the collection of water in the upper chamber and for draining the water from the upper chamber back to the system.

5. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open in combination with an outlet pipe from the upper chamber and means whereby the pump produces a suction in the outlet pipe.

6. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open in combination with a drain pipe from the upper chamber to the return conduit, said return conduit having a restricted flow portion therein between the tank and the pump, said drain pipe delivering into the return conduit between the restricted portion and the pump.

7. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open in combination with a restricted flow portion in the return pipe to limit the amount of water draining from the tank to the pump to a quantity considerably less than the capacity of the pump and means whereby suction in the return conduit caused by such failure of water supply from the tank operates to relieve pressures in the upper chamber.

8. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open, said return pipe including a restricted orifice to limit the amount of water draining from the tank to the pump to a quantity considerably less than the capacity of the pump and means whereby suction in the return conduit caused by such failure of water supply from the tank operates to prevent the accumulation of water in the upper chamber.

9. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open, said return pipe including a restricted orifice to limit the amount of water draining from the tank to the pump to a quantity considerably less than the capacity of the pump and means whereby suction in the return conduit caused by such failure of water supply from the tank operates to equalize pressures throughout the condenser.

10. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said condenser including a plurality of restricted air cooled passages above the tank and a chamber into which the upper ends of the passages open, said return pipe including a restricted orifice to limit the amount of water draining from the tank to the pump to a quantity considerably less than the capacity of the pump and means whereby suction in the return conduit caused by such failure of water supply from the tank operates to prevent back pressure in the condenser.

11. In a cooling system for internal combustion engines, a force feed water circulating system of small heat dissipating capacity serially including a water jacket, a water outlet from said jacket, a radiator including a water container to which said outlet is connected and in which variable

amounts of excess water may be circulated, a return conduit including a pump between the container and jacket, a restriction in the conduit between the container and the pump and a vacuum preventing connection to said conduit between the restriction and the pump whereby the amount of water flowing through the restriction will be substantially constant regardless of the supply as determined by the boiling and condensing rates and regardless of the speed or capacity of the pump.

12. In a cooling system for internal combustion engines, a force feed water circulating system of small heat radiating capacity serially including a water jacket, a water outlet from the jacket, a radiator including a water container to which the outlet is connected and in which variable amounts of excess water may be circulated, and a return conduit including a pump between said container and jacket, in combination with an air cooled element of large radiating capacity above said water container and means for rendering the rate of flow of water through the return conduit independent of the supply as determined by the boiling and condensing rates and independent of the speed of the pump.

13. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit and means for gravitationally feeding water from the tank to the pump at a predetermined rate and independently of the speed of the pump.

14. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said conduit including a restricted orifice limiting the flow of water from the tank to the pump to an amount slightly in excess of the evaporative requirements of the engine.

15. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said conduit including a restricted orifice limiting the flow of water from the tank to the pump to an amount slightly in excess of the evaporative requirements of the engine, and means for preventing a vacuum in the conduit between the pump and the orifice.

16. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said conduit including a restricted orifice limiting the flow of water from the tank to the pump to an amount slightly in excess of the evaporative requirements of the engine, and means for maintaining a constant pressure differential on opposite sides of the orifice.

17. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, said conduit including a restricted orifice limiting the flow of water from the tank to the pump to an amount slightly in excess of the evaporative requirements of the engine, and means for adjusting the size of the orifice.

18. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, and means for maintaining a predetermined constant rate of water flow from the tank to the pump slightly in excess of the maximum evaporative requirements of the jacketed element to be cooled.

19. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, and means for maintaining a predetermined constant rate of water flow from the tank to the pump slightly in excess of the maximum evaporative requirements of the jacketed element to be cooled, said means being independent of the pressure in the tank.

20. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, and means for maintaining a predetermined constant rate of water flow from the tank to the pump slightly in excess of the maximum evaporative requirements of the jacketed element to be cooled, said means being independent of the speed of the pump.

21. In a cooling system for internal combustion engines, a jacketed element to be cooled, an upflow air cooled steam condenser including a bottom tank through which

water from the jacket is adapted to be short circuited, a return conduit from the tank to the jacket, a pump in said conduit, and means for maintaining a predetermined constant rate of water flow from the tank to the pump slightly in excess of the maximum evaporative requirements of the jacketed element to be cooled, said means being independent of the cooling effect on the condenser.

Signed at Plainfield, in the county of Union, and State of New Jersey, this 25th day of October, A. D. 1924.

SAMUEL W. RUSHMORE.