July 6, 1937. S. W. RUSHMORE 2,086,441

COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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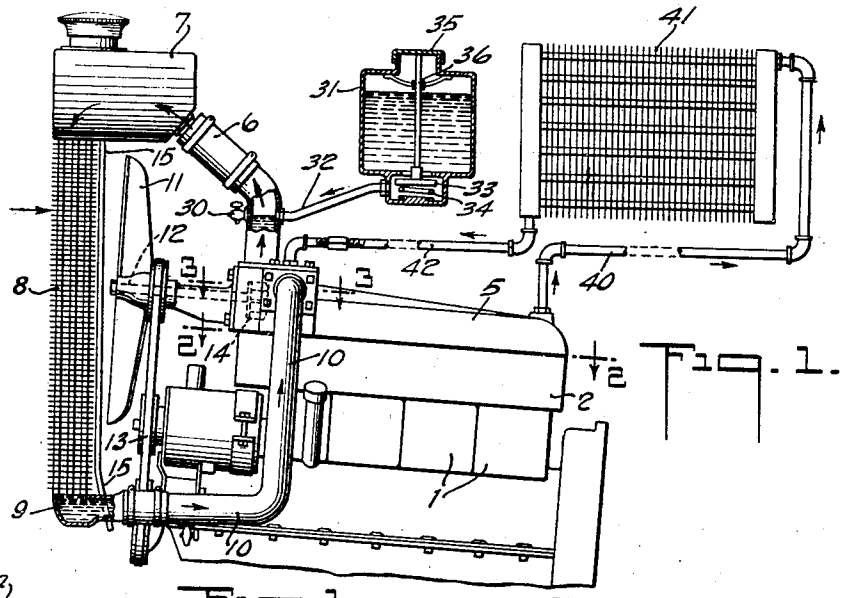

Fig. 1.

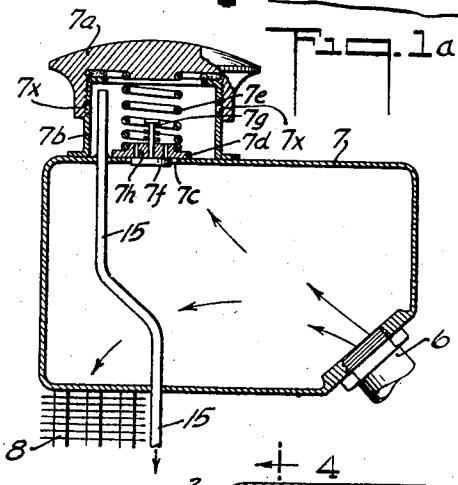

Fig. 1a.

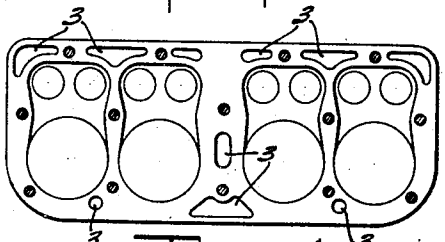

Fig. 2.

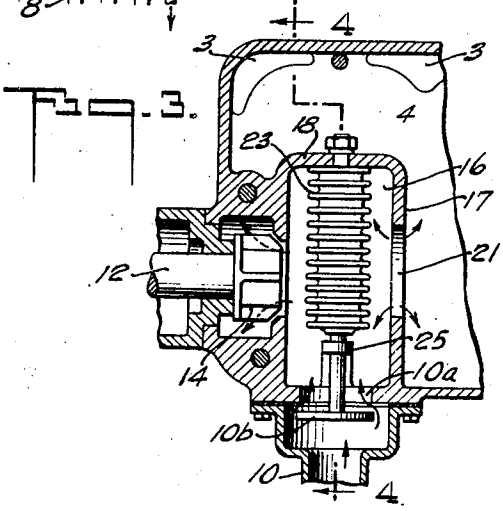

Fig. 3.

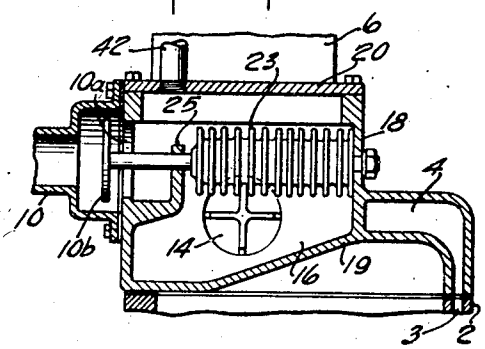

Fig. 4.

INVENTOR
SAMUEL W. RUSHMORE
BY
ATTORNEY

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Fig. 5.

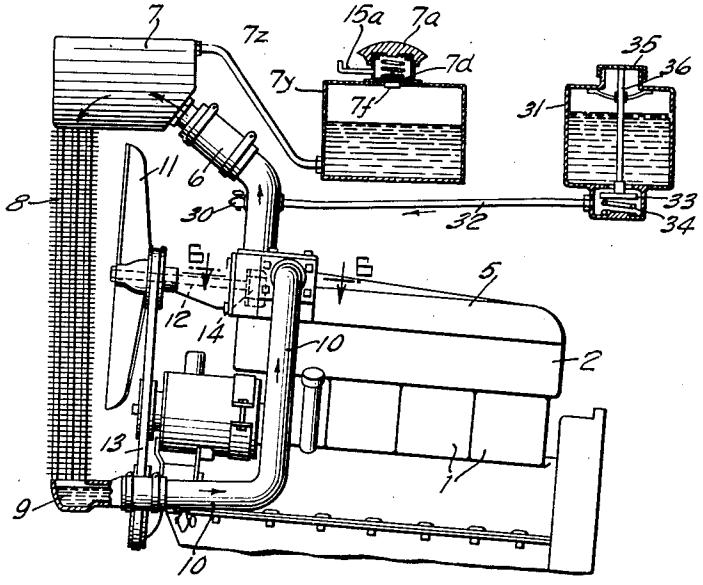


Fig. 6.

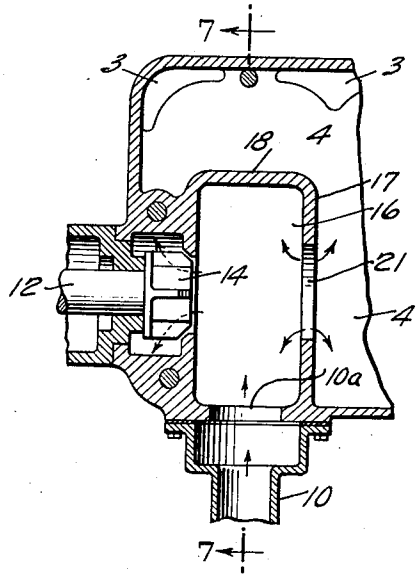
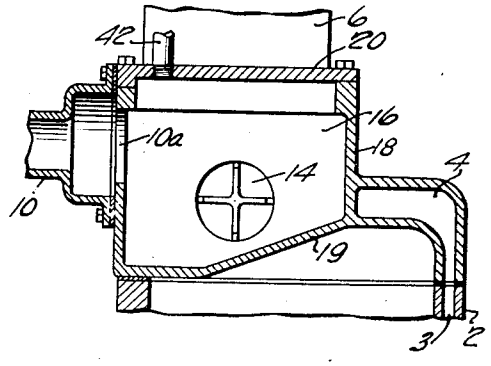


Fig. 7.



INVENTOR
SAMUEL W. RUSHMORE.
BY
George C. Rand
ATTORNEY

Patented July 6, 1937 2,086,441

UNITED STATES PATENT OFFICE

2,086,441

COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Samuel W. Rushmore, Plainfield, N. J.

Application August 25, 1934, Serial No. 741,396

2 Claims. (Cl. 123—178)

This invention relates to engine cooling systems of the class described in my Patent No. 1,651,157, of November 27, 1927, and in my pending application, Ser. No. 735,619, filed July 17, 1934, and has as its main purpose to permit or enable the employment of the system, as described in the said pending application in cases where, owing to limitations of space or weight, it is impractical to employ a surge or reserve water tank large enough to take care of the amount of water ejected by boiling in the water jacket, in operation of that system.

According to my present invention, the circulating system is sealed from the atmosphere. I thereby avoid or reduce the loss of water through the constant breathing through the overflow pipe, and of antifreeze mixtures employed in winter. Also, where high output is desired, with minimum size and weight of radiator, the pressure and consequent temperature range of boiling may be increased, and the upper part of the radiator core at times utilized as a downflow condenser, thereby increasing the rate of heat flow per unit area of radiator core and also of the engine surfaces exposed to the air flow.

I close the system to the atmosphere and employ a pressure relief or safety valve to limit the pressure to a desired value and also a vacuum-relieving valve to permit in-breathing of air to avoid an undesirable reduction in the boiling point under certain conditions such as reduced load. These relief and vacuum valves are preferably incorporated in the water filling cap.

I also provide an improved arrangement for employing the steam for heating the passenger space of a motor vehicle.

I may prevent all circulation in the cooling circuit until the water jacket boils, by arranging an auxiliary tank supplying water to the system at a level only slightly above the outlet from the water jacket, so that the upper parts of the uptake pipe and of the radiator core, as well as the upper tank of the radiator, are normally empty. When the water jacket boils, the pump plus the steam, start circulation and the empty upper part of the core for a time operates as a downflow condenser.

The above and other features of my invention may be more fully understood from the following description in connection with the accompanying drawings, in which

Fig. 1 is a side elevation conventionally indicating a common type of four-cylinder automobile engine, to which my invention may be applied;

Fig. 1a is a transverse section through the upper chamber of the radiator and filler cap;

Fig. 2 is a plan view of the cylinder block showing the conventional water circulating passages connecting the cylinder jackets with the head jacket;

Fig. 3 is a section on the line 3—3, Fig. 1;

Fig. 4 is a section on the line 4—4, Fig. 3;

Fig. 5 is a side elevation of an engine like that shown in Fig. 1, but showing certain modifications of the water supply means;

Fig. 6 is a section on the line 6—6, like Fig. 3 except with the thermostat and valve omitted; and

Fig. 7 is a section on the line 7—7, but without the thermostat and valve.

In these drawings like parts are indicated by like numerals; and the parts similar to those in my prior application Ser. No. 735,619, are as follows:

The upper ends of engine cylinders 1 are surrounded by the conventional water jacket 2 communicating through openings 3, 3, with the water jacket space 4 of the head block 5. The cooling circuit includes the uptake pipe 6, discharging into the upper header or tank 7, through which the water and/or steam cooling medium flows downward through the honeycomb or tubular air-cooled conduits 8 to the bottom tank 9 and through return conduit 10, to the water jacket of the head. The air draft is drawn through the radiator cooling elements 8 by fan 11 on shaft 12 and is driven from the engine by belt 13. Circulation of water through the above circuit is assisted by a suitable pump, in this case a rotor 14 such as commonly employed on the Ford motor to assist thermo-circulation of water from the head jacket and into the uptake conduit 6. The pump could be located in the low level part of return conduit 10, as is more common, but there are advantages in employing the high level suction pump in connection with my present invention, which will be explained in due course.

Means for utilizing the cooling capacity of this circuit so as to ensure boiling in the water jacket under average conditions, without danger of escape of steam under special conditions of maximum heat evolution in the cylinder, includes a chamber 16 into which the pool water return pipe 10 discharges, and from which the uptake pump 14 assists flow of water into the uptake conduit 6. As shown in Figs. 3 and 4, this chamber may be formed by a side wall 17, and end wall 18, the roof of the combustion chamber 19 constituting the bottom of the chamber and the top being closed in

by a plate 20. As in my said patent and pending application, this chamber not only provides a short circuit-completing path from the return pipe to the uptake conduit 6, but has fluid-interchange communication with the head jacket space through one or more suitably restricted openings as at 21, said opening or openings being preferably in the wall of the chamber which is opposite the intake of the pump. As indicated by the arrows, the water supply to the jacket flows out through 21 and steam or hot water can flow in the reverse direction, from the head jacket 4 into the chamber 16. Such interchange of cooling fluid between the chamber and the head jacket will be simultaneously in both directions, under certain conditions, as when there is little or no boiling; and under other conditions, as when the cylinder jackets are actively boiling, the flow will be pulsating, steam or steam-foamed hot water flowing from the head jacket into chamber 16 and then water from chamber 16 flowing into the head jacket. The latter is like the ordinary geyser effect which results from boiling at the bottom of the cylinder jacket where the water is subjected to substantial depth pressure.

The flow of the cool water from pipe 10 through inlet opening 10*a*, may be controlled, if desired, by an inlet valve 10*b* carried by a thermostat 23, as in said application Ser. No. 735,619. This thermostat is preferably of the metallic bellows type, containing a liquid boiling at a temperature corresponding to that which it is desired to maintain in the chamber 16. As is well known in the art, the boiling point of a given liquid contained in the thermostat, may be varied somewhat by changing the pressure within the bellows, either when charging it or by applying adjusting external spring pressure after the bellows is sealed. Preferably a stop, 25, is provided to limit expansion of the bellows beyond wide open position of valve 10*b*.

Special features of the design and operation of my above described apparatus, are as follows:

The pump 14 operates continuously at speed proportional to the speed of the engine. Upon starting the engine cold, the cool water inlet 10 is closed, so that there is no circulation through the cooling circuit, and, at first there is practically no interchange of water between the chamber 16 and the water jackets. At this stage only the water in the water jacket is being heated. As the jacket water heats up, there begins to be increasing thermocirculation through restricted communication 21; and, by the time jacket water is near boiling, the water in the chamber 16 will be heated to its normal minimum, for which the thermostat is set. Thereafter, variable condensing and boiling in the bellows, will tend to cause closing or opening movements of valve 10*b*, according as the temperature of the fluid mixture in chamber 16, rises or falls. Alternately, with increasing load, the bellows will open the valve wide and thereafter, with further increase in load and steam evolution, the valve will remain wide open but the temperature of the cooling medium in the compartment 16, will be controlled by boiling in the jacket and condensing in the boiling circuit.

The new features characteristic of my present system are as follows:

Fig. 1*a* is an enlarged detail of the top tank 7 having a filler cap 7*a*, on tube 7*b* in which is the upper end of the usual overflow pipe 15. The pipe is sealed in and communicates with the radiator tank only through the opening 7*c*, which opening is normally closed by the valve disc 7*d* under pressure of the helical spring 7*e*. The relief valve disc 7*d* in turn carries a vacuum-breaking valve 7*f* which is held by a light coiled spring 7*g* normally to close the vents 7*h* in the main valve disc.

If the circuit is normally full of water, under light or medium load, the water will boil in the engine jacket at about atmospheric pressure while the pressure in the top tank will generally be somewhat higher, depending upon the speed of the pump and also the amount of openings of the thermostat-controlled valve.

In the arrangement described in my pending application there being no pressure in the top tank, the water flow and, to some degree, the pressure or vacuum in the engine jacket will vary with the pump speed. With the present arrangement, however, discharge of water displaced by the steam bubbles in the engine jacket will be opposed by the pressure relief valve and a pressure will pile up in the top tank and in the radiator depending upon the amount of thermostat valve opening and upon the characteristics of the centrifugal pump.

In the case of the Ford-8, for example, using the standard Ford radiator and an efficient pump, under maximum load and speed, the water discharged through each engine jacket will not much exceed one half gallon, and therefore I have not found it necessary to employ other than the standard Ford radiator and top tank.

Of course, the top tank should be normally empty so that it will serve as a surge tank to hold water which may be forced out under such conditions of maximum load and speed. To facilitate maintaining a water level that will leave the top tank empty, I provide a test or filling cock 30 in the outlet 6 from the pump 14. This cock may be left open while water is poured in to fill the system and water flows out of said cock; then allowing it to drain off to the level of cock 30. This may leave some excess water in the radiator part of the system, but the thermostat is designed to keep valve 10*b* closed until the water boils in the jacket, and such excess may be either blown out through the filler cap by the above described intermittent geyser-like discharge of steam and water; or preferably cock 30 will be left open and the engine stopped and re-started to open and close the valve 10*b*, water being drained off or added, as shown to be necessary by the test cock. As a practical matter, excess water will always take care of itself by blow-off, as above described, and the necessary thing is to provide means for refilling to the level of the cock.

To maintain this normal water level I provide an auxiliary tank 31, which discharges through pipe 32 into uptake pipe 6, at the level of cock 30. It operates on the bubble principle. That is to say, it is hermetically sealed at the top and water can flow out at the bottom only as air or gas bubbles back through said pipe, which can occur only when the outlet of said pipe is uncovered by loss of water. For convenience in filling this auxiliary tank, I provide an outlet valve 33, in the bottom of the tank, normally closed by spring 34, whenever the cap 35 is removed. The tank is filled while the valve is closed and when the cap 35 is replaced it operates through stem 36 to depress the valve and hold it normally open for operation on the above described bubble-back principle.

It will be evident that with this arrangement of tank 7 and parts of uptake pipe 6 and core 8

above the normal water level, there will be a gap in the water circuit, the pump 4 being primarily designed merely for assisting thermo-circulation through the circuit when the upper tank is full of water. Consequently, with the present empty gap in the upper part of the circuit, such pump will not be powerful enough to suck down the water level in the radiator core 8 and push it up in pipe 6 to the extent which would be necessary to force water circulation through the top tank 7. Consequently, in operation, water in the engine jacket soon reaches the boiling point; and it is only when it boils hard enough, that the steam in combination with the pump, is able to lift the water in uptake pipe 6 to the level of tank 7, whence it can flow down into radiator core 8.

It results that at low load, the flow of cooling fluid from the water jacket to the top tank of the radiator may be mostly steam, which will be condensed partly in said top tank and partly by downflow into the empty upper part of the radiator core 8. However, a steady state seems to be unusual, and I have observed that in practice, instead of a steady outflow of steam from the engine jacket through opening 21 to the short circuit compartment 16 and a correspondingly steady return flow of water, there is a more or less violent breathing or pulsating action through the opening 21. Consequently, there is a similar tendency to pulsation in uptake pipe 6 so that the proportions of steam or steam bubbles and foam and/or water mingled therewith, may vary widely.

I have taken advantage of the pulsating action between the engine jacket and compartment 16, through constricted opening 21, to cause a flow of steam through a heater for the passenger space of the car. This is accomplished by connecting a pipe 40 from the top of the water jacket, preferably at the rear thereof, to the top of the radiator 41 located in the car, a return pipe 42 being connected to the top of the compartment 16. This takes advantage of a pressure differential due to the constriction and also of the above described pulsating effect. A sudden instantaneous rise in pressure in the jacket, seems to force a quantity of practically weightless steam from the rear cylinder head into the car heater; but, owing to its inertia, the water in the return pipe to compartment 16 remains relatively stationary during such pressure pulsation. However, the broad claims for the car heater and circuit therefor, through which steam is caused to flow around a constriction between the water jacket and the uptake pipe, have been transferred to my copending application Ser. No. 13,186, filed March 27, 1935, which, among other things, shows and describes a similar constriction and a similar heater circuit similarly arranged.

Referring more in detail to the pressures employed in the cooling system, I may say that the pressure relief valve 7d may be designed or adjusted for opening at a pressure of, say, four or five pounds, while the vacuum relief valve should open at very slight vacuum, preferably an inch of mercury, or less. I find that even under a full sustained load, with a maximum jacket pressure of 5 pounds, not more than two quarts of water will be expelled from the engine jacket even when initially filled full of water; and by filling it only about half the height of the radiator, there will be no loss of water, under the hardest running.

Although most of the time there will be little or no pressure in the top tank, so that the radiator cap may be removed without danger, there may be times, as when stopping suddenly at top of a long hill, or where there is an accumulation of air in the tank, with the engine only idling, when removal of the cap might permit a small outrush of hot water or steam. I therefore provide one or more holes, 7x, in the filler tube which will be uncovered and permit a slight outflow of air, steam or water to relieve the pressure and also to give ample warning not to fully remove the cap until the pressure has ceased.

From the above it will be evident that the pressure relief and vacuum breaking valves may be used either where the system is full of water or where it is maintained at a low level, as for instance that of cock 30 in Fig. 1. In this connection, it is to be noted that the thermostatic valve is mainly of importance where the system is nearly filled with water. When the cooling circuit is broken by a gap at the top, due to low level of water in the system, the thermostat 23 and valve 10b are relatively useless and may be omitted, as in the modification illustrated in Figs. 5, 6, and 7. In Fig. 5, the engine is shown the same as in Fig. 1, and the water cooling circuit is the same as concerns uptake pipe 6, top tank 7, radiator core 8, bottom tank 9, return pipe 10, fan 11, shaft 12 and pump 14. Also the auxiliary water supply tank 31, pipe 32, valve 33, spring 34, cap 35, rod 36 and bubble pipe 32 are the same and the connection of the latter is at the same level with the cock 30.

The internal arrangements shown in Figs. 6 and 7 are also the same as concerns shaft 12, pump 14, compartment 16, closed in by walls 17, 18, with the top of the combustion chamber forming the bottom 19 and the plate 20 closing in the top thereof. The only difference is that the thermostat and valve are omitted from Figs. 6 and 7. In Fig. 5, the radiator connection is omitted for convenience in illustration. It will be noted, however, that the filler cap 7a with its pressure relief valve 7d and vacuum breaking valve 7f, is located on top of an auxiliary surge tank 7y which communicates with the main top tank 7 through pipe 7z. The vent pipe 15a corresponds in function to the overflow pipe 15 of Fig. 1 and Fig. 1a. As before explained, the gap in the cooling circuit above the level of cock 30, in combination with the pump 14, compartment 16, and construction 21, render the thermostatic valve unnecessary.

I claim:

1. A cooling system for internal combustion engines, including a water jacket for the engine, a cooling circuit including a downflow, air-cooled radiator having a core extending above the top and below the bottom of the jacket, an upflow pipe to the upper part of the radiator, a return pipe and a pump to assist water circulation in said circuit; means associating said cooling circuit with the water jacket, including a chamber providing a short circuit-completing path between the lower end of the upflow pipe, and the upper end of the return pipe, and which communicates with the upper part of the engine jacket only through restricted flow paths; and means for predetermining an initial water level in said circuit that is substantially below the level of the top of the radiator core so that the water surfaces in upflow and downflow paths of the circuit are normally separated by a gap of height too great to permit circulation by

the pump until assisted by boiling in the water jacket.

2. A cooling system for internal combustion engines, including a water jacket for the engine, a cooling circuit including a downflow, air-cooled radiator having a core extending above the top and below the bottom of the jacket, an upflow pipe to the upper part of the radiator, a return pipe and a pump to assist water circulation in said circuit; means associating said cooling circuit with the water jacket, including a chamber providing a short circuit-completing path between the lower end of the upflow pipe, and the upper end of the return pipe, and which communicates with the upper part of the engine jacket only through restricted flow paths; means for predetermining an initial water level in said circuit that is substantially below the level of the top of the radiator core so that the water surfaces in upflow and downflow paths of the circuit are normally separated by a gap of height too great to permit circulation by the pump until assisted by boiling in the water jacket; in combination with means for minimizing loss of cooling fluid including automatic relief valves communicating with a high point in said circuit, one valve opening outward and set to automatically vent internal pressures a predetermined amount above atmospheric, and another opening inward and set to automatically relieve subnormal pressures a predetermined amount below atmospheric.

SAMUEL W. RUSHMORE.