W. H. FARR.

COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES.

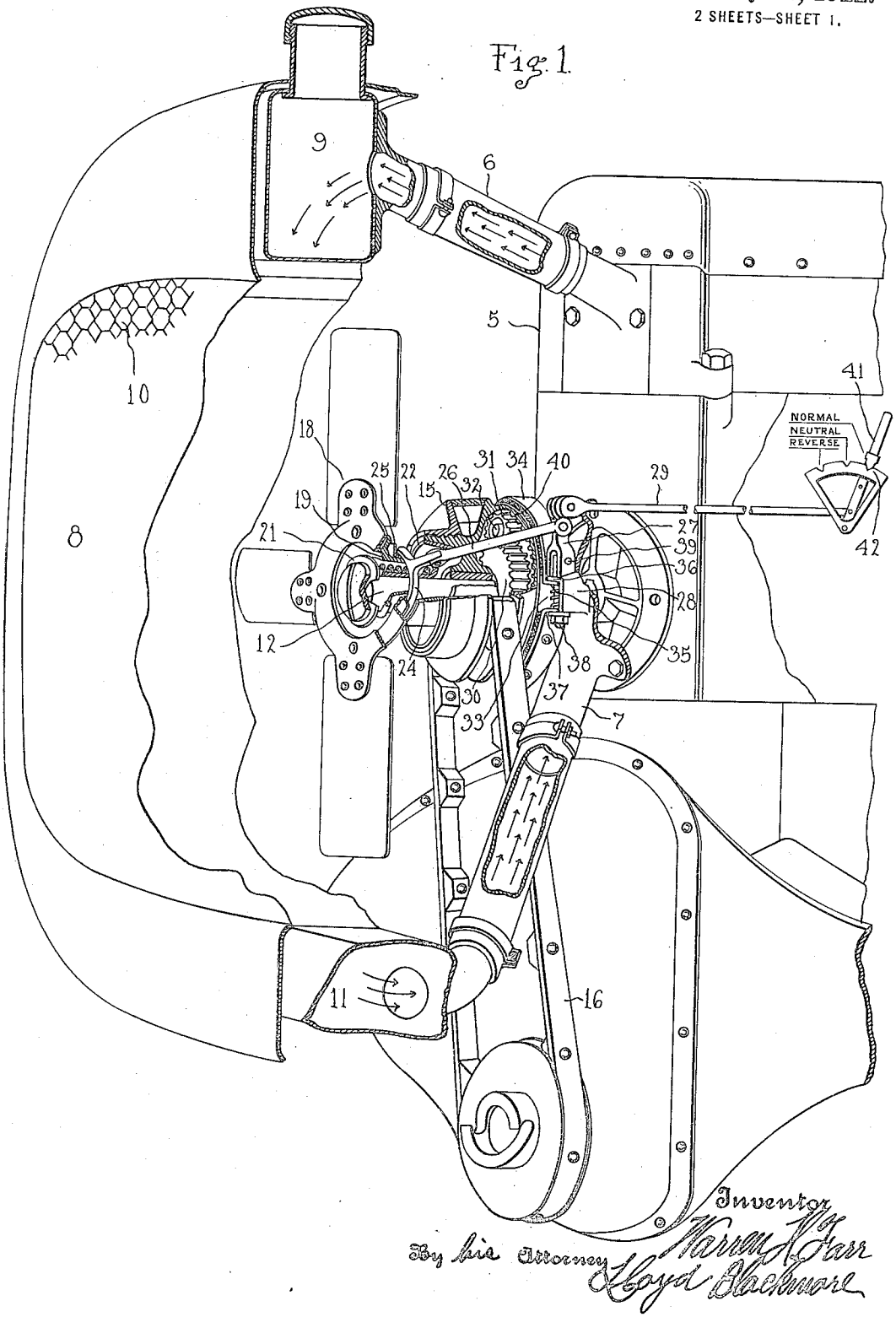
APPLICATION FILED JUNE 10, 1919.

1,422,426.

Patented July 11, 1922.

2 SHEETS—SHEET 1.

Fig. 1.



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By his Attorney
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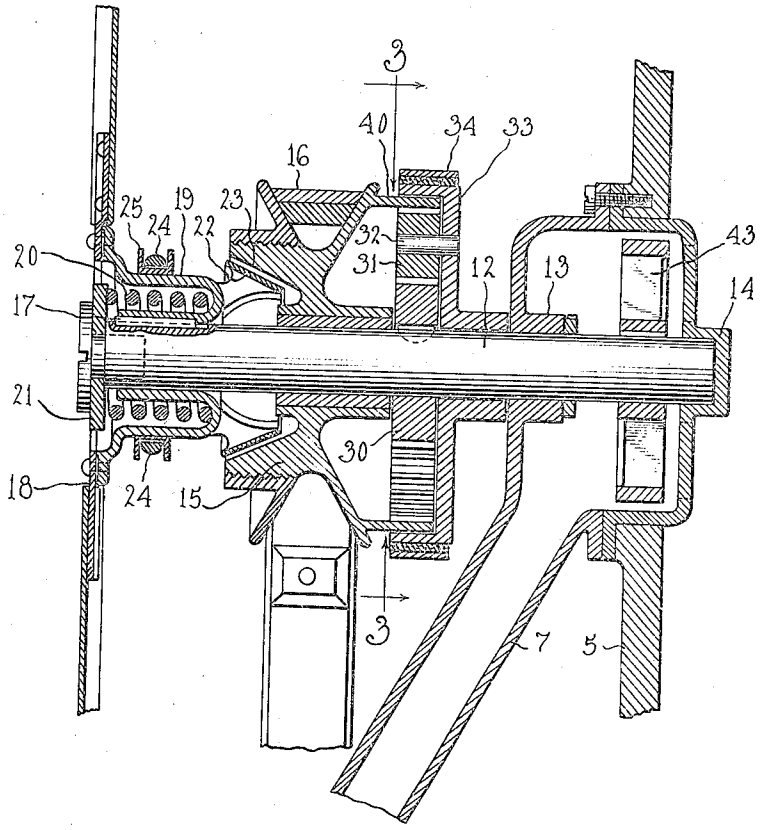
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2 SHEETS—SHEET 2.

Fig. 2.



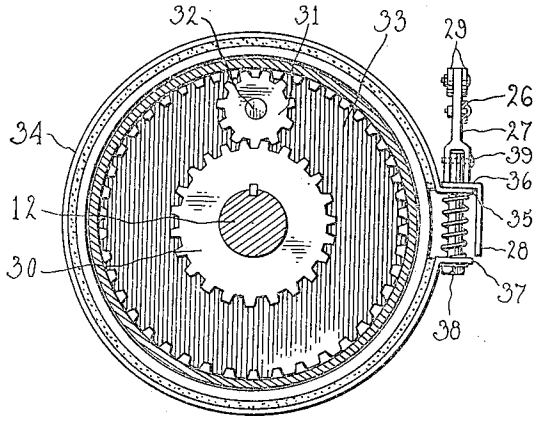


Fig. 3.

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UNITED STATES PATENT OFFICE.

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COOLING SYSTEM FOR INTERNAL-COMBUSTION ENGINES.

1,422,426. Specification of Letters Patent. Patented July 11, 1922.

Application filed June 10, 1919. Serial No. 303,036.

To all whom it may concern:

Be it known that I, WARREN H. FARR, a citizen of the United States, and resident of New York city, New York County, State of New York, have invented certain new and useful Improvements in Cooling Systems for Internal-Combustion Engines, of which the following is a specification.

My invention relates to cooling systems designed for use with motor vehicles to cool the same, and particularly to cooling systems wherein a cooling liquid is caused to circulate through the cooling jacket of the engine and through a radiator exposed to the cooling action of a stream of air, to thereby effect an interchange of heat between the heated cooling liquid and the air; the radiator and the cooling jacket of the engine being connected with one another through suitable conduits so that the cooling liquid may flow through the radiator and cooling jacket in succession.

In cooling systems of the general type above referred to the flow of cooling liquid through the radiator is likely to be interrupted by the freezing or incipient freezing of the said liquid under conditions of low atmospheric temperature, the tendency to freezing or the formation of slush being the greatest at the lower end of the radiator where the cooling liquid is at its lowest temperature. This freezing of the lower end of the radiator or the incipient freezing thereof characterized by the formation of slush, obviously interferes with the flow of cooling liquid through the radiator, and may arrest the flow entirely; and it often happens that although the temperature of the cooling liquid within the cooling jacket of the engine may be well above the boiling point, there may nevertheless be no flow whatever through the radiator, because of the obstruction due to freezing at the lower end thereof.

The object of my invention is to provide a cooling system wherein the temperature of the radiator, as well also as the temperature of the engine, are under the control of the operator; to the end that the radiator may be maintained at a proper temperature and prevented from freezing, while at the same time the temperature of the cooling liquid circulating through the radiator and the water jacket of the engine may be kept at a point sufficiently low to prevent overheating of the engine. That is, the temperature of the cooling liquid within the cylinder jacket and the upper part of the radiator is, by the use of my invention, kept from attaining too high a temperature soon after the engine is started with a frozen or partially frozen radiator, because of the interruption of the circulation of cooling water due to the condition of the radiator, and is kept at a temperature sufficiently low to prevent over-heating of the engine after a proper circulation of cooling liquid shall have been established through the cooling system.

A further object of my invention is to provide a cooling system wherein a proper circulation of the cooling liquid through the system may be readily and quickly established when the engine started, even though the radiator may be frozen or partially frozen; such a condition of the radiator being likely to be encountered after the engine has been permitted to remain at rest for a considerable period exposed to a low temperature, as will be appreciated.

A further object of my invention is to provide a cooling system of the class described wherein the temperature of the cooling liquid circulating through the system is to a considerable extent under the control of the operator; and may be regulated at will in such a way as to secure a temperature of cooling liquid sufficiently high to insure an efficient operation of the engine on the one hand, and at a temperature sufficiently low to prevent a too great cooling action of the radiator on the other.

With the above and other objects of invention in view my invention consists in the improved cooling system for internal combustion engines and auxiliary features thereof illustrated in the drawings accompanying and forming a part of this specification, and in such variations and modifications thereof as will be obvious to those skilled in the art to which my invention relates, as long as such variations and modifications come within the scope of the concluding claims wherein the distinguishing features wherein my invention consists are particularly pointed out.

Referring to the drawings wherein the preferred embodiment of my invention is illustrated:

Figure 1 is a fragmentary perspective

view illustrating my invention as applied to an internal combustion engine equipped with an ordinary type of radiator and conduits connecting the upper and lower ends thereof with the cooling jacket of the engine;

Figure 2 is a detail sectional view taken upon a vertical plane extending longitudinally of the fan and pump operating shaft; and,

Figure 3 is a view showing a section upon a transverse plane indicated by the line 3—3, Figure 2.

Referring to the drawings, the reference numeral 5 designates an internal combustion engine, and 6, 7 designate conduits through which a cooling liquid may flow from the jacket of the engine through a radiator indicated in its entirety by the reference numeral 8; the conduit 6 leading from the upper end of the water jacket of the engine and discharging into the upper end of the radiator, while the conduit 7 leads from the lower end of the radiator and discharges into the lower end of the water jacket of the engine. The radiator 8 may be of any of the types, kinds, or constructions of radiator in common use in cooling systems for internal combustion engines.

The cooling liquid flows normally from the top of the radiator through the same and out at the lower portion thereof, and suitable air passages are provided through which air may flow through the radiator to thereby effect an interchange of heat between the air and the cooling liquid flowing through the radiator, as is usual in radiators of the class used in connection with cooling systems for internal combustion engines. The radiator illustrated is provided with an upper chamber or reservoir 9 into which the conduit 6 discharges, and by the use of which the cooling liquid is uniformly distributed throughout the entire upper end of the cellular intermediate portion 10 of the radiator; and with a lower cooling liquid collecting reservoir 11 within which the cooling liquid collects after it has passed downward and through the cellular structure of the radiator, and from which lower reservoir or chamber the cooled liquid is returned to the engine jacket through the return conduit 7.

The reference numeral 12 designates a shaft supported in suitable bearings 13—14, and 15 designates a driving pulley loose and rotatable upon the shaft 12, and which pulley is driven from a rotating shaft of the engine through a suitable belt 16.

Supported at the free outer end of the shaft 12 and secured thereto so as to rotate therewith by means of a key 17 is a fan 18, the blades of which are carried by a hub 19 slidable upon the shaft 12, but in constant driving engagement with the said shaft through the key 17 above referred to. This hub is cup-shaped in form, and a spring 20 is located within the same; said spring acting between the bottom wall of the hub and a washer 21 secured to the free end of the shaft, and which washer obviously forms a stop for the outer end of the spring. This spring therefore acts to force the hub and fan toward the right, Figure 2, thereby forcing a conical clutch member 22 carried by the said hub into engagement with a conical clutch recess 23 formed in the driving pulley 15; the normal position of the parts being such that the clutch member 22 is in contact with the inner surface of the recess 23, so that the fan will be driven from the pulley 15 through the clutch members above referred to because of the frictional engagement between the clutch member and the recess.

In the normal condition of the parts the fan is therefore driven directly from the shaft 12 through the hub 19 and key 17, as will be appreciated.

The hub 19 may be moved to the left to thereby move the conical clutch 22 out of engagement with the recess 23 by means of a yoke the side or arms 24 of which lie within a groove provided in a collar 25 which is secured to and rotates with the hub 19. The yoke 24 is connected with and operated through a link 26, the right hand end of which is pivotally connected with an oscillating cam member 27 the lower end of which rests upon a fixed stop 28, and which cam member is itself operated through a manually operable rod 29 pivotally connected with the upper end thereof.

The reference numeral 30 designates a gear fixed upon and rotating with the shaft 12, and which gear is in mesh with a pinion 31 rotatable upon a pin 32 carried by a rotating brake drum 33 which is loose upon the shaft 12; and which brake drum may be grasped and held against rotation by a brake band 34 which engages its periphery. One end 35 of this brake band is held in a fixed position as by an overlaying portion 36 of the abutment 28, while the other end 37 of said brake band is provided with an opening through which a bolt or equivalent tension member 38 extends, and to the upper end of which the oscillating cam 27 is pivotally secured, as at 39; from which it follows that when the cam 27 is rocked upon its pivotal support 39 by force communicated to it through the rod 29 the bolt 38 will be pulled upward, because of the engagement between the lower end of the cam member and the fixed abutment 28, thus drawing the two ends 35—37 of the brake band toward one another and grasping the periphery of the brake drum 33 and preventing the rotation of the said drum.

The driving pulley 15 is provided with a laterally extending annular drum 40 provided with internal teeth which mesh with

the teeth of the pinion 31; the gear 30, pinion 31 and internal teeth of the annular drum 40 forming a train of planetary gearing through which the shaft 12 will be driven if and when the brake drum 33 is held against rotation by the brake band 34 as hereinbefore explained.

It will be appreciated from the above that when the conical clutch 22 is in engagement with the interior of the clutch recess 23 of the driving pulley 15 the fan 18 will be driven directly, and at the same speed as the pulley; the brake drum 33 at such times being carried around with the pulley at one half the speed of rotation thereof, as is usual in planetary gearing. When, however, the clutch member 22 is moved to the left through the rod 26 and yoke 24 into the position shown in Figure 2 of the drawing direct driving connection between the pulley 15 and the hub 19 will be interrupted; and motion will then be communicated to the shaft 12 through the drum 40, the pinion 31 carried by the brake drum 33 which will then be held against rotation by the brake band 34, and the gear 30; the shaft being obviously rotated at a higher speed than when driven directly from the pulley 15, and the direction of rotation of the shaft being reversed from that in which it was driven directly from the said pulley through the clutch 23, 22.

When the clutch member 22 is disconnected from the driving pulley the brake drum 33 will obviously be held against rotation by the brake band 24, as hereinbefore explained, thus permitting the drum 40 to drive the shaft through the pinion 31, as will be appreciated.

It will be further appreciated that if the operating rod 29 is placed in an intermediate position by properly positioning the lever 41 and locking mechanism 42 whereby it is operated and locked in its extreme position, and which members are so located as to be conveniently accessible to the operator of the vehicle, the clutch member 22 will then be out of driving engagement with the conical recess 23, but the brake band 34 will not be contracted to such an extent as to grasp the periphery of the brake drum 33 and hold it against rotation. When the parts are in such a position the shaft 12 will obviously remain at rest, and the fan 18 will not be rotated.

It will be appreciated that my invention is not limited to the use of any particular type, class or construction of radiator, and that the same may be used with any of the kinds of radiator used in cooling systems of the general circulating type to which my invention relates. Furthermore, although the features of my invention thus far referred to are capable of use in cooling systems of the type commonly designated as thermo-siphon systems, and in which no means acting positively upon the cooling liquid are provided for inducing a flow of such cooling liquid through the system, I have herein illustrated my invention as embodied in a cooling system having a pump for producing a flow of cooling liquid through the system; and my invention, considered in its more specific aspect, is considered as including a pump for more positively inducing a flow of cooling liquid through a cooling system wherein my invention consists. Such a pump is designated by the reference numeral 43, the same being secured to and driven by the shaft 12 and the action thereof being obviously to produce a more positive and vigorous flow of cooling liquid through the system as a whole.

It will be appreciated that the fan 18 will induce a flow of air through the cellular structure of the radiator 8 and toward the engine when the clutch members 22, 23 are in engagement and the parts are operating normally, the same as in cooling systems heretofore in common use.

In view of the premises it will be appreciated that if the radiator has become frozen while the vehicle has been at rest and the engine out of operation, or incipiently or partially frozen by the formation of ice crystals within the cooling liquid to an extent sufficient to hinder the free flow of cooling liquid downward through the radiator in its normal direction of flow, then when the engine is to be started the clutch 22 will be moved to the left, Figure 2, thereby interrupting the driving connection through which the fan 18 is driven in its normal direction of rotation and causing the brake band 34 to grasp the periphery of the brake drum 33 and hold it against rotary motion. When now the engine is started the fan will be driven in a reverse direction and at increased speed through the driving pulley 15, the internally toothed drum 40, the pinion 31 which will be held against revolution about the gear 30, the shaft 12, and the key 17 which maintains a driving engagement between the shaft and the hub 19 of the fan; which reversed direction of rotation will induce a flow of warm air from the engine toward and through the radiator, thus quickly raising the temperature of the cooling liquid to a degree such that circulation thereof through the radiator may be established.

The freezing or incipient freezing of the radiator of a cooling system occurs first at the lower portion thereof, where the temperature of the cooling liquid is the lowest, and in cooling systems unequipped with my invention a radiator which is frozen to such an extent as to prevent a downward flow of cooling liquid therethrough may not become thawed out until the cooling liquid has been

heated to the boiling temperature in the cooling jacket of the engine and in the upper end of the radiator, because of the slow rate of conduction of heat downward through the radiator structure, the thawing action being of course further retarded by the flow of cold air through the cellular portion of the radiator. In a cooling system equipped with my invention, however, a large volume of hot air heated by the engine is forced through the air passages of the radiator at starting, thus quickly thawing it and warming the cooling liquid to a temperature such that it may circulate properly through the cooling system. It will of course be appreciated that the reversing of the direction of the fan here explained may be resorted to in order to limit the cooling effect of the radiator and secure a temperature of cooling liquid sufficiently high to prevent overcooling of the engine and the operation thereof at a temperature high enough for securing maximum efficiency; although the stopping of the fan below referred to will ordinarily be sufficiently effective to limit the cooling action of the radiator and the fall of temperature in the cooling liquid.

The above explanation it will be appreciated does not contemplate more than a reversal of the direction of the flow of air through the air passages of the radiator, and the flow of heated air warmed by the engine, as distinguished from cold air from the external atmosphere, through the cellular structure of the radiator at starting, and until the cooling liquid is heated to such a degree that it will circulate properly. I prefer, however, in addition to provide for reversing the direction of flow of the cooling liquid itself through the cooling system, which end is obviously attained by providing a pump which acts upon the cooling liquid to accelerate its flow and by connecting said pump into and with the cooling system in such a way that it acts to reverse the direction of flow of the cooling liquid when the direction of the flow of air through the radiator is reversed. Thus the impeller 43 of the rotary cooling liquid pump will obviously rotate reversely when the direction of rotation of the fan 18 is reversed and force heated cooling liquid from the cooling jacket of the engine directly into the lower end of the radiator at or adjacent which the extent or degree of freezing or slush formation will be greater, thereby the more quickly thawing out the radiator and heating the cooling liquid to a temperature such that it will resume its normal downward direction of flow when the direction of rotation of the fan and of the pump are restored to their normal directions.

A further feature of advantage inherent in my improved cooling system is the facility with which, especially in cold weather, a too great cooling of the cooling liquid may be avoided, and a temperature of the same sufficiently high to secure an efficient operation of the engine secured. This regulation of engine temperature to avoid excessive cooling may be accomplished by placing the operating lever 41 whereby the clutch 22 and brake band 34 are actuated in an intermediate position, so that while the direct driving connection whereby the fan is rotated in its normal direction is interrupted the planetary gear or equivalent driving connection through which it is operated reversely is not made operative, because the brake band 34 has not been made to grasp the brake drum 33 and hold it stationary as is necessary for reverse driving through the planetary gearing. In this condition of the parts the flow of air through the air passages of the radiator will not be augmented by the fan, neither will the rate of flow of the cooling liquid be accelerated by the cooling liquid pump; from which it follows that the cooling liquid will be subjected to reduced cooling action as it flows through the radiator, both because of the reduced volume of air flowing through the radiator and the slower rate of flow through the cooling system which flow, under the conditions above assumed and in the embodiment of my invention illustrated, will be in accordance with the thermo-siphon principle of operation.

It will be appreciated, finally, that the thawing out of a frozen or partially frozen radiator being due, in the embodiment of my invention illustrated, both to a reversed flow of heated air through the radiator and to a reversed flow of heated cooling liquid into the lower end thereof, the said thawing may be accomplished, somewhat more slowly to be sure, by either one of the above operations, and is not dependent upon the presence of both in a single device. Therefore the radiator thawing function or end may be attained either by causing a flow of warm air to take place from the engine through the air passages of the radiator, or by causing a flow of heated cooling liquid to take place from the cooling jacket of the engine into the lower end of the radiator, or in both said ways. Again the limitation of the cooling action to avoid too great cooling of the engine may be accomplished by stopping the fan and thus reducing the flow of air through the radiator without stopping the action of the cooling liquid pump when such a pump is present in the system, by stopping the cooling liquid pump without stopping the fan when a fan is present in the system, or by arresting the normal operation of both the fan and of the cooling liquid pump if and when both are used as in the embodiment of my invention illustrated and described herein.

Having thus described and explained my invention, I claim and desire to secure by Letters Patent:

1. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; and means for causing the cooling liquid to flow through the cooling system provided by the elements aforesaid in a direction the reverse of the direction in which the said cooling liquid normally flows.

2. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; and manually operable means for reversing the normal direction of flow of cooling liquid through the cooling system provided by the elements aforesaid.

3. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; and means for causing the cooling liquid to flow from said cooling jacket and into the lower end of the radiator through the cooling system provided by the elements aforesaid in a direction the reverse of the direction in which the said cooling liquid normally flows.

4. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of said radiator with the cooling jacket of the engine; a pump for producing a flow of cooling liquid through the cooling system provided by the elements aforesaid in a direction from the lower end of said radiator toward the cooling jacket of the engine; and means whereby said pump may be caused to produce a flow of cooling liquid in a reverse direction to thereby supply heated cooling liquid to the lower end of the radiator.

5. In a cooling system for internal combustion engines, a radiator located adjacent the engine and having passages through which air may flow to thereby effect an interchange of heat between the air and the cooling liquid flowing through the radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating fan located between the radiator and the engine and adapted to induce a flow of air through the air passage aforesaid of the radiator and toward the engine; a shaft whereby said fan is operated; and operating means for said shaft whereby the same may be rotated either in a forward or in a reverse direction.

6. In a cooling system for internal combustion engines, a radiator located adjacent the engine and having passages through which air may flow to thereby effect an interchange of heat between the air and the cooling liquid flowing through the radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a shaft; a fan carried by said shaft; a pump with which said shaft is operatively connected and which pump is adapted to cause a flow of cooling liquid through the radiator, the cooling jacket of the engine, and the conduits aforesaid; means for driving said shaft in one direction; and means for reversing the direction of rotation of said shaft and for driving it in a reverse direction.

7. In a cooling system for internal combustion engines, a radiator located adjacent the engine and having passages through which air may flow to thereby effect an interchange of heat between the air and the cooling liquid flowing through the radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating fan; and operating means whereby said fan may be driven in either a forward or in a reverse direction to thereby cause air to flow through the passage aforesaid and toward the engine, or from the engine through said passages to heat the radiator.

8. In a cooling system for internal combustion engines, a radiator located adjacent the engine and having passages through which air may flow to thereby effect an interchange of heat between the air and a cooling liquid flowing through the radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating shaft located between the radiator and the engine; a fan carried by said shaft; a clutch whereby said fan may be operatively connected with and disconnected from said shaft; a driving pulley carried by said shaft and rotatable thereupon; means whereby said shaft may be driven in one direction by said driving pulley; and gearing intermediate said driving pulley and said shaft and whereby it may be driven in a reverse direction.

9. In a cooling system for internal combustion engines, a radiator located adjacent the engine and having passages through which air may flow to thereby effect an interchange of heat between the air and a cooling liquid flowing through the radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating shaft located between the radiator and the engine; a fan carried by said shaft; a clutch whereby said fan may be operatively connected with and disconnected from said shaft; a driving pulley carried by said shaft and rotatable thereupon;

means whereby said shaft may be driven in one direction by said driving pulley; gearing interemdiate said driving pulley and said shaft and whereby it may be rotated in a reverse direction; a pump carried by said shaft and adapted to cause a flow of cooling liquid through the radiator, the cooling jacket of the engine, and the conduits aforesaid; and manually operable means for controlling the direction of the rotation of the shaft aforesaid, and for disconnecting the same from said driving pulley so that said shaft may remain at rest.

10. In a cooling system for internal combustion engines, a radiator located adjacent the engine and having passages through which air may flow to thereby effect an interchange of heat between the air and a cooling liquid flowing through the radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating fan located between the radiator and the engine and adapted to induce a flow of air through the passages aforesaid of the radiator and toward the engine; means for operating said fan; means for reversing the direction of rotation of said fan to thereby cause a flow of air heated by the engine to flow through the air passages aforesaid of the radiator; and manually operable means for controlling the operating means for said fan to thereby cause it to rotate in either one of the two directions aforesaid, or to remain at rest at the will of the operator.

11. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of said radiator with the cooling jacket of the engine; means for causing a cooling liquid to flow through the cooling system provided by the elements aforesaid; and manually operable means whereby the said liquid may be made to flow through said cooling system in either its normal or in a reverse direction at the will of the operator.

12. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of said radiator with the cooling jacket of the engine; a pump for producing a flow of cooling liquid through the cooling system provided by the elements aforesaid in a direction from the lower end of said radiator toward the cooling jacket of the engine; means whereby said pump may be caused to produce a flow of cooling liquid in a reverse direction to thereby supply heated cooling liquid to the lower end of the radiator; and manually operable means for controlling the action of said pump to thereby produce a flow of cooling liquid in either of the two directions aforesaid.

13. In a cooling system for internal combustion engines, a radiator through which a cooling liquid may flow; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; and means for causing the cooling liquid to flow from said cooling jacket through the conduit which connects the lower end of said radiator with said jacket, and into the lower end of the radiator to thereby heat said radiator.

14. In a cooling system for internal combustion engines, a radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating fan located adjacent said radiator and adapted to induce a flow of air therethrough; a shaft whereby said fan is operated; and means for driving said shaft in either a forward or in a reverse direction, and at different speeds.

15. In a cooling system for internal combustion engines; a radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a shaft; a fan carried by said shaft; a pump carried by said shaft and adapted to produce a flow of cooling liquid through said radiator, the cooling jacket of the engine, and the conduits aforesaid; and means for driving said shaft in either a forward or in a reverse direction, and at different speeds.

16. In a cooling system for internal combustion engines, a radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating shaft; a fan carried by said shaft; and operating means through which said shaft may be driven in either a forward or in a reverse direction, or permitted to remain at rest.

17. In a cooling system for internal combustion engines, a radiator; conduits connecting the upper and lower ends of the radiator with the cooling jacket of the engine; a rotating shaft; a fan carried by said shaft; a driving pulley supported by and rotatable upon said shaft; a clutch whereby said fan may be operatively connected with said driving pulley; gearing intermediate said driving pulley and said shaft and adapted to drive the same at increased speed relative to the speed of said driving pulley, and in a reverse direction from the direction in which said shaft is driven by said driving pulley; a pump operatively connected with said shaft and adapted to cause a flow of cooling liquid through said conduits, said radiator, and the cooling jacket of the engine; and manually operable means for securing the driving of said shaft through either said clutch or through said gearing.

18. In a cooling system for internal combustion engines, a radiator; conduits con-

necting the upper and lower ends of said radiator with the cooling jacket of the engine; a rotating shaft; a fan carried by said shaft; a pulley supported by and rotatable upon said shaft; a clutch whereby said pulley may be connected with and disconnected from said fan; a drum carried by said shaft and rotatable thereupon; a pinion carried by said drum; a sleeve carried by said pulley and extending into said drum, and having a series of internal teeth in engagement with the pinion carried by said drum; a pinion carried by said shaft and operatively connected therewith to drive the same, and with which the pinion carried by said drum is in mesh; a brake band extending about said drum and adapted to grasp the same; and manually operable means for operating said clutch and said brake band.

In testimony whereof I affix my signature.

WARREN H. FARR.