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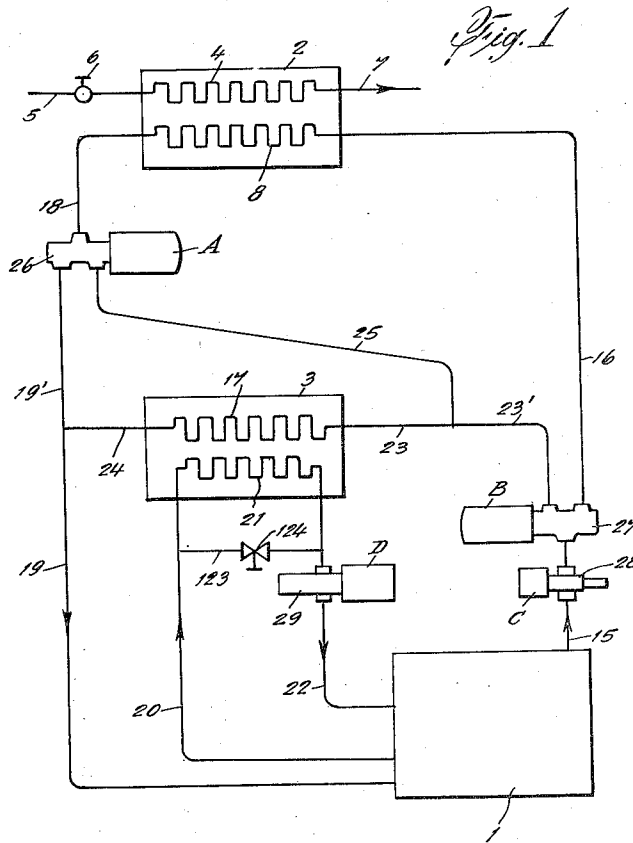
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COOLING SYSTEM FOR DIESEL ENGINES

Filed March 15, 1945

2 Sheets-Sheet 1



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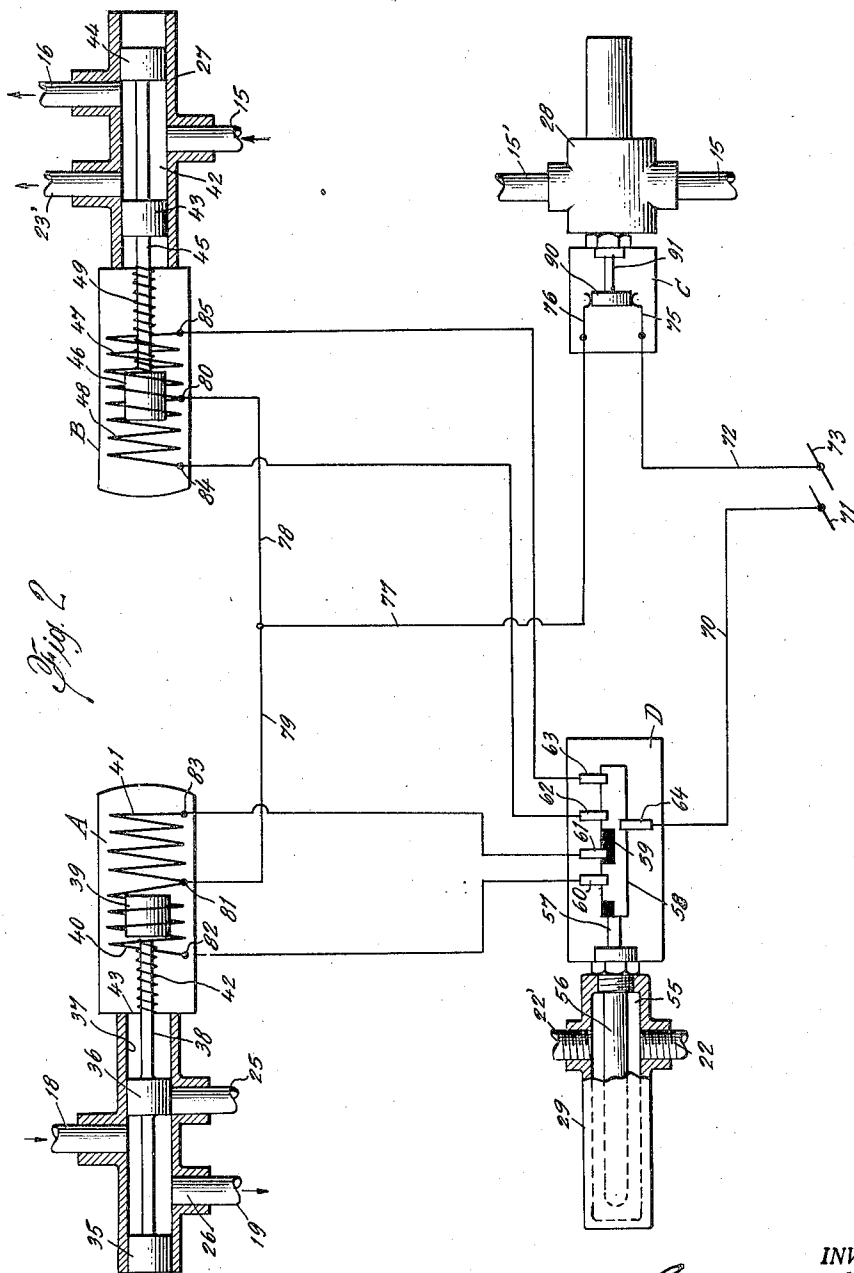
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COOLING SYSTEM FOR DIESEL ENGINES

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Application March 15, 1945, Serial No. 582,848

9 Claims. (Cl. 123—178)

This invention relates to cooling systems for Diesel and other internal combustion engines, and has for its principal object the provision of an improved system for controlling the temperature of the lubricating oil thereof, and also for controlling the temperature of the engine cooling water. The present application constitutes a continuation-in-part of my co-pending application Serial No. 575,498, filed January 31, 1945.

The use of heat exchangers in connection with marine installations of internal combustion engines has become practically universal. A common arrangement for Diesel engine cooling systems provides two heat exchangers; one for cooling the engine jacket water, and the other for cooling the engine lubricating oil. Sea water is circulated through these heat exchangers as the coolant, the usual arrangement providing for series flow of the sea water, first through the lubricating oil heat exchanger and thence through the jacket water cooler.

A somewhat less common engine cooling system provides for cooling the engine jacket water, as described above, but instead of circulating sea water through the lubricating oil cooler, the cooled jacket water is employed as the cooling medium. This type of cooling system has the advantage of exposing only one of the two heat exchangers or coolers to the corrosive action of sea water, and the further advantage that, upon starting a cold engine, the engine and the lubricating oil and the jacket water temperatures are elevated to the proper operating temperature range much more rapidly than when the colder sea water is circulated through the lubricating oil cooler. This type of cooling system has the disadvantage of requiring the use of somewhat larger heat exchangers for a given installation, which, to some extent, offsets the advantages derived therefrom.

However, the advantage obtained by circulating jacket water through the lubricating oil cooler, that is to say, the initial rapid heating of the engine lubricating oil and maintenance of optimum lubricating oil temperature during operation, has become extremely important in view of current operations of Diesel engine propelled naval vessels in the northern and southern cold sea areas. Reports show that, in many cases, the chilled engine lubricating oil in vessels operating in these areas, and not equipped for jacket water circulation through the lubricating oil coolers, never reaches the proper operating temperature even after hours of engine operation, resulting in accelerated wear of all bearing surfaces, early en-

gine failure, decreased reliability, and excessive maintenance and repair requirements. This is particularly true in the case of high-speed Diesel engines, and it has been definitely established that engine deterioration is very rapid whenever operation proceeds with either lubricating oil or jacket water circulating at a temperature below 130° F.

The principal object of the present invention is to avoid the difficulties encountered by the use of sea water circulating through the lubricating oil cooler, and to take maximum advantage of circulating jacket water through such cooler for rapid heating of the chilled lubricating oil upon starting cold engines, and, in addition, to provide for automatic control of the temperatures of the lubricating oil and jacket water within the optimum operating range, as specified by the engine designer, regardless of variations in the power at which the engine is operated, or variations in the temperature of the sea water.

With these and other objects in view, as well as other advantages that may be incident to the use of the improvements, the invention consists in the parts and combination thereof hereinafter set forth and claimed, with the understanding that the several necessary elements constituting the same may be varied in proportion and arrangement without departing from the nature and scope of the invention, as defined in the appended claims.

In order to make the invention more clearly understood, there are shown in the accompanying drawings means for carrying the invention into practical use, without limiting the improvements in their useful application to the particular construction, which, for the purpose of explanation, has been made the subject of the illustrations.

Fig. 1 of the accompanying drawings is a diagrammatic view of a system of automatically controlling the temperature of the lubricating oil and jacket water of an internal combustion engine wherein the jacket water, by a simple and improved method, is employed to control the temperature of the lubricating oil; and

Fig. 2 is a diagrammatic view of the valves, thermal-responsive elements and electrical circuits, and means for the automatic operation of the system, all of the same being schematically presented for the purpose of illustrating the inventive idea.

Like numerals in both figures of the drawings refer to similar parts.

Referring to the drawings, a system for con-

trolling the temperature of the lubricating oil and jacket water of an internal combustion engine is shown as comprising, generally, an engine 1, a jacket water cooler 2, and a lubricating oil cooler 3. The jacket water cooler 2 is provided with a heat-transfer element 4 through which sea water, or other fluid coolant, is circulated from pipe 5 and valve 6, and from which the coolant escapes through pipe 7. This cooler is also provided with a heat-transfer element 8, through which jacket water to be cooled is supplied from the engine. The cooled jacket water escapes from the heat-transfer element 8 through pipe 18, in which is positioned a suitable valve 26 by means of which the jacket water escaping through pipe 18 may be automatically caused to flow through pipe 19 or pipe 25, on its return to the engine 1, as more fully described hereinafter.

In the pipe 15, through which the jacket water leaves the engine, is positioned a thermally-responsive switch element 28 and a suitable valve 27, by means of which water flowing from the engine, through pipe 15, may be directed through pipe 16 or through pipe 23, as hereinafter described. The pipe 23 is adapted to deliver jacket water from the engine to the heat-transfer element 17 of the lubricating oil cooler 3, the opposite end of which is connected by pipe 24 with the jacket water return pipe 19. Cooler 3 is also provided with a heat-transfer element 21 through which lubricating oil is circulated, from the engine through pipe 20, and back to the engine by pipe 22, in which may be positioned a thermally-responsive element 29.

Heated jacket water from the engine 1 is delivered by pipe 15 through the two-way, automatically-controlled valve 27 to either pipe 16 or to pipe 23, or to both. Accordingly, all or a portion of the heated jacket water may be delivered to the cooler 2, or all or a portion thereof may be passed through the cooler 3, as may be required. The water leaving the cooler 2, by pipe 18, delivered to the two-way, automatically-controlled valve 26, may be directed back to the engine through pipe 19, or all or a portion thereof may be shunted through pipe 25 into pipe 23, so as to pass the same through element 17 of the cooler 3 before it is delivered by pipe 24 to the return pipe 19, in which case valve 27 would be positioned to close the valve-port governing fluid flow in the limb 23' of pipe 23.

For simplicity and clearness, temperature and pressure-indicating means, and other auxiliary equipment common to systems of this order, have not been shown in the drawings. Also, reference should be made to my co-pending application previously referred to, as features and means disclosed in both applications may be combined and coordinated to produce a desired end result.

Valve 6, which may be manually or automatically controlled, serves to govern the quantity of sea water or other coolant passing through the element 4 in the cooler 2. If desired, the same purpose may be served by the provision of a circulating water by-pass around this cooler. Lubricating oil from the engine may also be bypassed around the lubricating oil heat exchanger and directly back to the engine through the by-pass pipe 123, and an automatic, spring-loaded, pressure-relief valve 124, when the engine is initially started. The by-pass pipe 23 can be arranged to by-pass other parts of the engine lubrication system as well as the heat exchanger 3, such as lubricating oil filters, strainers, etc.

In operation of this improved system, upon

initially starting the engine, and with the engine in operation, the jacket water is rapidly heated, and this heated water directly enters the heat exchanger 3, providing for rapid heating of the cold lubricating oil circulating through the oil heat exchanger element 21. In this connection, it will be understood that in most types of internal combustion engines, the amount of heat dissipated into the jacket water by the operation of the engine is about ten times the amount of heat dissipated into the lubricating oil. Therefore, the jacket water is heating very much more rapidly than the lubricating oil upon starting a cold engine, because, in this present system, the principal jacket water cooling is governed by heat exchanger 2. In the preferred method of operating this system, as the jacket water temperature becomes elevated to the operating range, the temperature of the heated water being returned to the engine through the pipe 19 is gradually reduced by blending therewith some jacket water which has been cooled by having been passed through cooler 2. From cooler 2 said cooled water carried by pipe 18 is directed by valve 26 into pipe 19, wherein it is mixed with water leaving the heat exchanger 3, through pipe 24, the cooler admixture then being returned to the engine.

The positioning of the valves 26 and 27 to selectively direct the flowing streams of jacket water to bring about a desired modification of the temperature of the water being returned to the engine, and/or the temperature of the lubricating oil also being delivered to the engine, may be automatically governed, for example, by the lubricating oil temperature, a suitable temperature-responsive means 29 being positioned in the oil circulating pipe line in pipe 20 or in pipe 22 (as indicated), and adapted, when thermally influenced by the oil flowing therethrough, to operate said valves. By these means, as will be more fully brought out herein, it will be understood that upon starting a cold engine, the temperature of the lubricating oil can be rapidly raised to the desired optimum operating temperature and maintained substantially at the optimum temperature during the continued operation of the engine. Also, by these means, when the lubricating oil is at the optimum temperature, sufficient jacket water is forced through the cooler 2 to maintain a constant predetermined temperature of the jacket water regardless of the temperature of the sea water circulating through the jacket water cooler, and regardless of variations in the power being generated by the engine.

With a substantially constant temperature maintained in the jacket water leaving the engine through the operation of the automatically-governed valves 26 and 27, causing more or less heat to be released by the heated jacket water, it will be noted that at any given engine power, the temperature of the jacket water and lubricating oil circulated to and from the engine remains substantially constant, regardless of all changes in the temperature or quantity of the sea water circulated through jacket water cooler 2. This is apparent by reference to the drawings. At constant engine power, heat dissipated to and from the oil and jacket water in the engine and the heat exchangers or coolers is substantially constant. Therefore, with a constant engine jacket water discharge temperature, the temperature of the jacket water entering the engine is substantially constant, because the rise in tempera-

ture of the water flowing through the engine is constant. Thus, the temperature of the jacket water leaving the lubricating oil heat exchanger 3 is constant, and as the amount of heat dissipated to the jacket water from the lubricating oil in the lubricating oil heat exchanger is constant, the temperature rise of the jacket water and lubricating oil to and from the lubricating oil heat exchanger remains constant.

Thus, regardless of changes in the temperature and quantity of the sea water, the oil and the jacket water temperatures to and from the engine are maintained substantially constant at any given engine power, which is a very desirable engine operating condition from the standpoint of engine service life and reliability. By properly proportioning the size of the heat exchangers, and by suitably adjusting the automatic control means, it is possible to provide for cooling the lubricating oil flowing to the engine to a temperature as low, or even lower, than the temperature of the jacket water flowing to the engine. Also, the system renders possible a minimum temperature rise of the jacket water flowing through the engine, which is very desirable for certain types of engine installations.

Referring to Fig. 2, 26 and 27 represent, schematically, valves of any type suitable for the purpose described. Valve 26 is provided with a piston comprising members 35 and 36 which are fitted to, and adapted to slide within, the valve bore 37, said two members being carried by the operating rod 38. Fluid enters the valve bore through pipe 18, and when the piston is in the position shown, is free to issue from the valve through pipe 19, the outlet port to pipe 25 being closed by the piston member 36. The valve operating rod 38 is provided with an armature 39 positioned axially within the two solenoid coils 40 and 41, by means of which the valve is selectively operated electrically. With the valve in the position shown, the coil 40 would be energized. When both coils are equally energized, the armature would assume a mid-position, and when only coil 41 is energized, the armature would be moved to the extreme right, causing the member 35 to close the outlet port to pipe 19 and thus permitting fluid to flow through pipe 18, into the valve bore, and out through pipe 25. When the coils 40 and 41 are de-energized, the armature is caused to assume this extreme position to the right by the spring 42, which, as shown, may be positioned upon rod 38 between the wall 43 and the inner face of the armature 39. Valve 27 is similar to valve 26 in all essential details.

Fitted within the bore 42 of valve 27 is a piston comprising members 43 and 44 carried by the operating rod 45. In the valve setting shown, fluid enters the bore 42 through pipe 15 and issues through pipes 16 and 23'. The armature 46 carried by the rod 45 is shown as midway between the two solenoid coils 47 and 48, indicating that both are similarly electrically energized. When both coils are de-energized, spring 49 acts to move the armature to its normal extreme left or outward position, in which case the outlet port to pipe 16 is closed by the member 44, and fluid entering the valve through pipe 15 will issue through pipe 23'. Preferably, both of the valves 26 and 27 are controlled by a single, thermally-actuated means 29 having a suitable chamber 55 through which fluid delivered by the pipe con-

nection 22' passes before issuing from the pipe connection 22.

Positioned within the chamber 25, and in contact with said fluid, is a heat-responsive element 56 having a rod 57 which carries the contact plate 58, having an insulated portion 59. The element 56, by means of the rod 57, is adapted to move the plate 58 axially, forward and back, depending upon the temperature of the fluid being circulated through the chamber 55. Contact fingers 60, 61, 62, 63 and 64 are adapted to complete circuits through plate 58 to operate valves 26 and 27 in a predetermined manner, in response to the temperature of said fluid circulating through chamber 55.

Conductor 70 connects contact finger 64 with conductor 71 of the power source. Conductor 72 connects conductor 73 of the power source with contact finger 75 of the thermally-actuated switch 28. Contact finger 76 of said switch is connected by conductor 77 with conductor 78, which is connected at 80 with the coils 47 and 48, and by conductor 79 which is connected at 81 with the coils 40 and 41. Electrical contact between the fingers 75 and 76 of the switch 28 is completed by the conducting member 90 carried by the rod 91, by means of which the member is moved axially into and out of contact with the fingers 75 and 76 in response to temperature changes of the fluid circulated through pipes 15 and 15' in contact with the heat-sensitive actuating means. The thermal switch member 28 is indicated as positioned in pipe 15 through which jacket water from the engine issues. In this instance, the switch would be so adjusted that the electric circuit between the fingers 75 and 76 would be open, and would remain open by the retraction of the contact member 90 from between said fingers, until the jacket water leaving the engine has been heated to a predetermined temperature. When said predetermined temperature has been attained, due to the thermal response of the device, rod 91 is moved outwardly, bringing the member 90 in contact with said fingers 75 and 76 to complete the circuit between conductors 72 and 77. Accordingly, while the engine is idle and cold, the circuit is open between the fingers 75 and 76, de-energizing the entire electric control system.

Under the influence of the springs 42 and 49, both of the valves 26 and 27, when the solenoid coils 40, 41, 47 and 48 are deenergized, assume their extreme outward positions. Accordingly, it will be noted that upon starting a cold engine, and until the jacket water has become heated sufficiently to cause thermally-actuated switch device 28 to close the circuit between the fingers 75 and 76, all of the jacket water will be circulated from the engine by pipe 15, through valve 27 to pipe 23, through the heater-transfer element 17 of the cooler 3, and then by pipe 24 to the return pipe 19 leading back to the engine. At the same time, the lubricating oil is being circulated from the engine by pipe 20, through the heat-transfer element 21 of the cooler 3, and back to the engine through pipe 22, in which latter pipe is positioned the thermally-actuated valve control device 29. The rapidly-heating jacket water quickly raises the temperature of the lubricating oil. The jacket water relatively soon will reach the predetermined temperature for which switch unit 28 has been set to close the contact between the fingers 75 and 76, thereby placing the valve control system in readiness to function. Likewise, the

temperature of the lubricating oil will be increasing.

Therefore, when the automatic valve control system takes over, the position of the thermally-actuated contact member 58 of the device 29 is preferably such that solenoid coil 40 of the valve 26, and both solenoid coils 47 and 48 of the valve 27, are energized. In this manner, valve 27 may be selectively positioned to cause some of the heated jacket water to by-pass the cooler 3, and by means of pipe 16 to be delivered to the heat-transfer element 8 of the jacket water cooler 2, and then by pipe 18 to pass through valve 26 to pipe 19, therein to blend with the jacket water leaving the cooler 3, through pipe 24, and then back to the engine. In this manner, the quantity of water passing through either or both of the heat exchangers 2 and 3 may be controlled for the purpose of modifying the temperature of either or both the jacket water and the lubricating oil.

Should the temperature of the lubricating oil tend to increase above the desired optimum operating temperature, the increased heat of the oil being circulated through the engine will further actuate the thermally-responsive valve control means 29 to so position the contact member 58 as to cause the energization of the solenoid coils 40 of valve 26 and 47 of valve 27. This will cause a selective positioning of the valves whereby all of the jacket water leaving the engine through pipe 15 will pass through valve 27 to pipe 16 for delivery through the heat-transfer element 8 of the cooler 2, then through valve 26 to pipe 25 for delivery by pipe 23 (the valve port to 23' being closed by valve 27) to the heat-transfer element 17 of the cooler 3, and then by pipes 24 and 19 (the valve port to pipe section 19' being closed by valve 26) back to the engine.

It is to be understood that valves of any suitable design may be employed, and that the control or selective positioning of the valves employed may be by any suitable thermally-actuated means adapted for the purpose of carrying out the inventive idea herein set forth. Also, as previously pointed out, the system shown in Fig. 2 of the drawings is purely schematic to diagrammatically illustrate a working embodiment of certain features of the invention.

Broadly, the invention provides an improved system of the kind described (1) in which a jacket water cooler and an oil cooler are employed, and in which, when initially starting a cold engine and in order to rapidly bring the lubricating oil up to the desired temperature, all of the jacket water from the engine may be passed through the lubricating oil cooler to transfer its heat thereto; (2) in which either the jacket water temperature or the oil temperature, or both, may be modified by controlling the flow of jacket water circulated simultaneously through both the jacket water cooler and the lubricating oil cooler, whereby the temperature of the jacket water may be reduced and/or less heat be transferred to the oil; (3) in which, when required, the jacket water may be passed first through the jacket water cooler and then through the lubricating oil cooler before being returned to the engine, as, for example, to increase the degree of lubricating oil cooling; and (4) in which, when jacket water leaving the engine is passed first through the jacket water cooler and then through the lubricating oil cooler, some of the cooled water from the jacket water cooler may be by-passed around the oil cooler and directly mixed with the water being returned to

the engine, for the purpose of reducing the amount of oil cooling effect and/or for decreasing the temperature of the engine jacket water.

From the foregoing, it will be apparent that a very efficient system is provided for controlling the temperature of both the cooling water and the lubricating oil of the engine, by means of which the service life of internal combustion engines is improved, and the necessity for maintenance and repair decreased. Also, the improved system insures the rapid heating of chilled lubricating oil upon starting a cold engine, and the rapid warming up of a cold engine upon starting. The temperature of the jacket water and lubricating oil is controlled entirely automatically. The lubricating oil heat exchanger is not subjected to the corrosive action of sea water. The improved system permits of simplified piping arrangement and the control of the temperatures of both the jacket water and lubricating oil by simple, automatic governing means. The system has the additional advantage of providing for relatively small temperature rise of jacket water circulated through the engine with minimum size of lubricating oil heat exchangers.

It will be understood that, whereas the above description of the present engine cooling system is particularly adaptable to marine engine installations, it is equally applicable to all other internal engine installations. For land installations, the term "sea water," as employed herein, may be more properly termed "cooling water" or a cooling fluid obtained from an external source, and for aircraft installations the primary cooling medium may be air.

It will be understood, as previously stated, that the above description and accompanying drawings, comprehend only the general and preferred embodiment of the invention, and that various changes in construction, proportion and arrangement of the parts may be made within the scope of the appended claims without sacrificing any of the advantages of the invention.

What I claim is:

1. A system for controlling the temperature of the cooling water and of the lubricating oil of an internal combustion engine, including a first heat exchanger for governing the temperature of the engine lubricating oil, a second heat exchanger for cooling the engine jacket water, means for circulating lubricating oil from the engine through the first said heat exchanger, means for circulating jacket water from the engine through both of said heat exchangers simultaneously, and means for controlling the quantity of water circulated through the first said heat exchanger for controlling the temperature of the lubricating oil being delivered to the engine.

2. A system for controlling the temperature of the cooling water and of the lubricating oil of an internal combustion engine, including a first heat exchanger for governing the temperature of the engine lubricating oil, a second heat exchanger for cooling the engine jacket water, means for circulating lubricating oil from the engine through the first said heat exchanger, means for circulating jacket water from the engine through both of said heat exchangers simultaneously, and means governed by the temperature of the circulating lubricating oil controlling the quantity of water circulated through each of said heat exchangers.

3. A system for controlling the temperature of the cooling water and of the lubricating oil of an internal combustion engine, including a first heat

exchanger for governing the temperature of the engine lubricating oil, a second heat exchanger for cooling the engine jacket water, means for circulating lubricating oil from the engine through the first said heat exchanger, means for circulating jacket water from the engine through both of said heat exchangers simultaneously, and means whereby water circulated through the second said heat exchanger may subsequently be passed through the first said heat exchanger for governing the temperature of the lubricating oil.

4. A system for controlling the temperature of the cooling water and of the lubricating oil of an internal combustion engine, including a first heat exchanger for governing the temperature of the engine lubricating oil, a second heat exchanger for cooling the engine jacket water, means for circulating lubricating oil from the engine through the first said heat exchanger, means for circulating jacket water from the engine through both of said heat exchangers simultaneously, and means governed by the temperature of the circulating jacket water for passing all of the engine jacket water through the first said heat exchanger.

5. A system for controlling the temperature of the cooling water and of the lubricating oil of an internal combustion engine, including a first heat exchanger for governing the temperature of the engine lubricating oil, a second heat exchanger for cooling the engine jacket water, means for circulating lubricating oil from the engine through the first said heat exchanger, means for circulating jacket water from the engine through both of said heat exchangers simultaneously, and means whereby water circulated through the second said heat exchanger may be circulated through the first said heat exchanger for governing the temperature of said jacket water.

6. The method of controlling the temperature of the jacket water and that of the lubricating oil of an internal combustion engine, which comprises subjecting a circulating stream of jacket water simultaneously to lesser cooling and to greater cooling in two separate heat exchanger

zones, subjecting a circulating stream of lubricating oil in indirect heat exchange relationship to the water circulating through the zone of lesser cooling, and returning to the engine, jacket water from either or both of said zones, depending upon whether the heat of the jacket water entering the engine is above or below a predetermined operating temperature.

7. A system for controlling the temperature of the jacket water and of the lubricating oil of an internal combustion engine, which comprises a heat exchanger through which lubricating oil from the engine is circulated, a jacket water cooler, means for circulating water from the engine through the heat exchanger and cooler, and temperature-controlled means governed by the heat of the jacket water for by-passing jacket water around said cooler.

8. A system for controlling the temperature of the jacket water and that of the lubricating oil of an internal combustion engine, which includes a lubricating oil heater and a jacket water cooler, means for simultaneously circulating jacket water from the engine through said heater and said cooler and for returning the same to the engine, means for circulating lubricating oil from the engine through said heater and back to the engine, and means governed by the heat of the lubricating oil being circulated controlling the temperature of the jacket water leaving the engine.

9. A system for controlling the temperature of the jacket water and that of the lubricating oil of an internal combustion engine, which comprises an oil heater, a jacket water cooler, means for circulating jacket water from the engine through the heater and the cooler to the engine, means for circulating jacket water from the cooler back to and through the heater, means for circulating lubricating oil from the engine through the heater, and means governed by the temperature of the circulating oil for circulating jacket water simultaneously through both the cooler and the heater.

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