

March 2, 1954

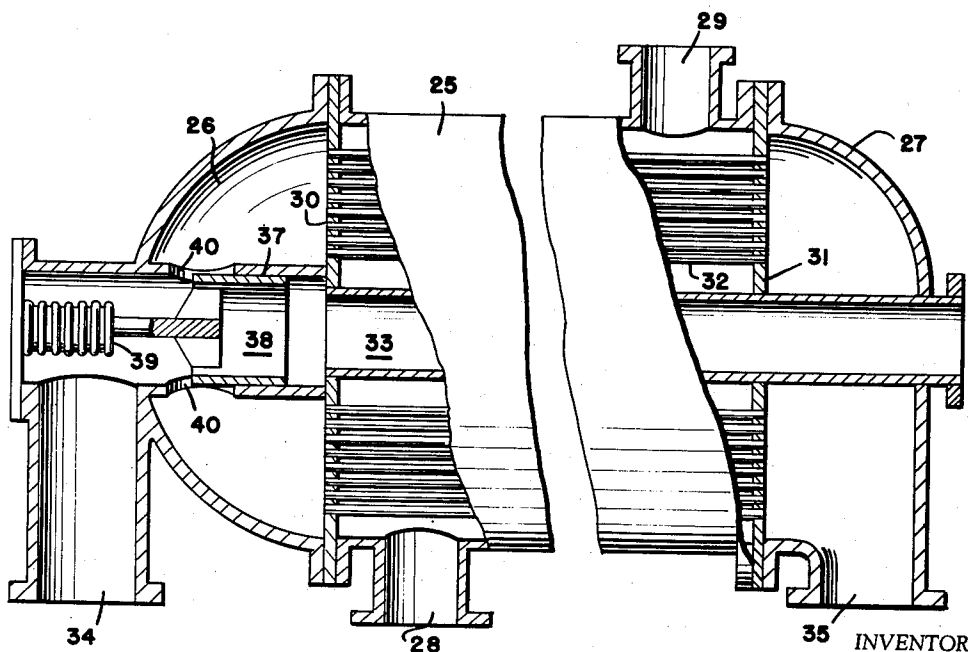
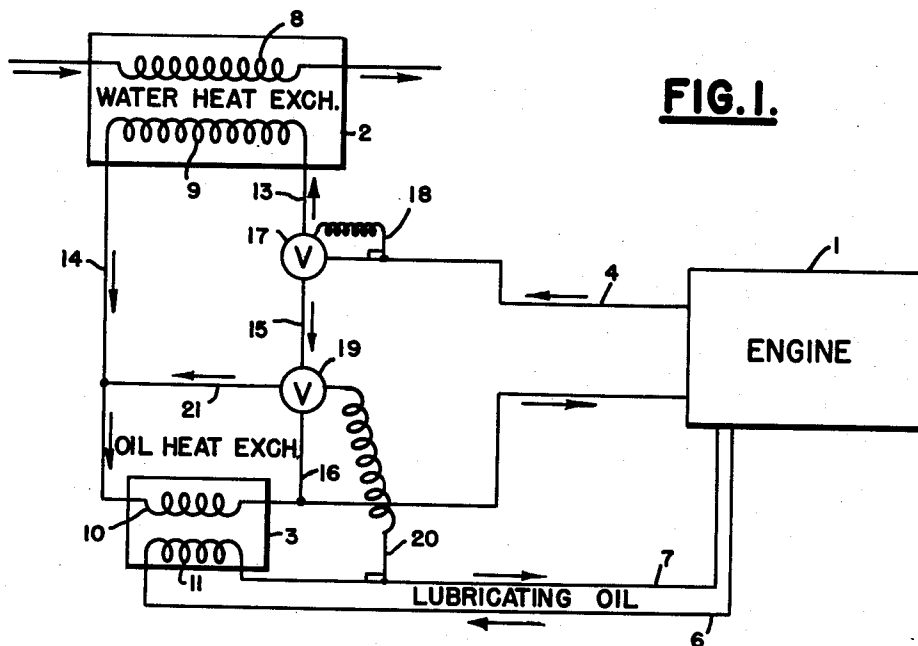
T. J. BAY

2,670,933

ENGINE COOLING APPARATUS

Filed Feb. 24, 1950

3 Sheets-Sheet 1



THOMAS J. BAY

BY

A. H. Helveston

ATTORNEY

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THOMAS J. BAY

A.H. Heurston

ATTORNEY

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3 Sheets-Sheet 3

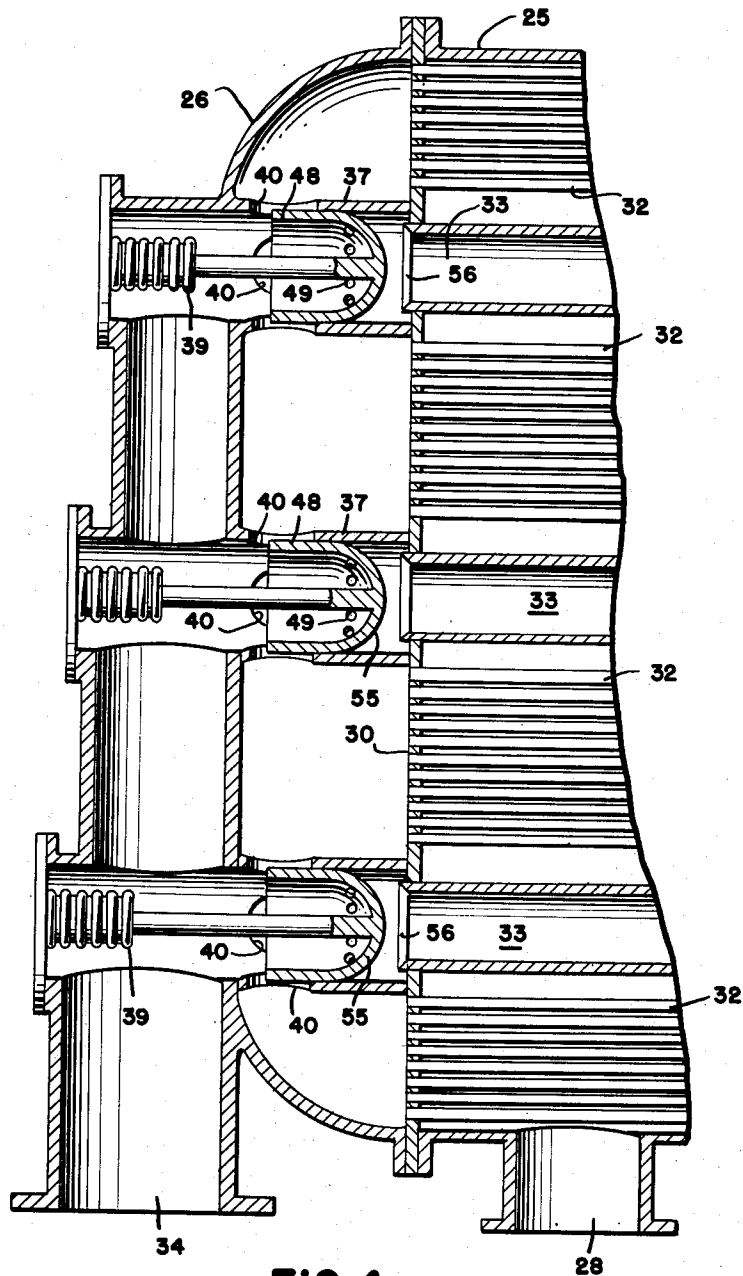


FIG. 4.

INVENTOR

THOMAS J. BAY

BY

A. H. Helveston

ATTORNEY

UNITED STATES PATENT OFFICE

2,670,933

ENGINE COOLING APPARATUS

Thomas J. Bay, Lyden, Wash.

Application February 24, 1950, Serial No. 146,122

2 Claims. (Cl. 257—2)

(Granted under Title 35, U. S. Code (1952),
sec. 266)

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The invention described herein may be made and used by or for the Government of the United States for governmental purposes without the payment to me of any royalties thereon or therefor.

This application is a continuation in part of my copending application, Serial No. 775,512, filed September 22, 1947, now Patent 2,498,637, issued February 28, 1950.

This invention relates to cooling systems for internal combustion engines and to apparatus for use in such systems, and particularly to systems of the type disclosed in my Patent No. 2,365,166, granted December 19, 1944. The principal objects of the present invention are to provide apparatus for use in systems like those disclosed in that patent and in this specification, and also to provide a system improved in certain respects over the earlier one.

The system disclosed in Patent No. 2,365,166 constituted improvements in internal combustion engine cooling wherein the engine cooling water after having passed in heat exchange relation with a prime cooling medium is then passed in heat exchange relation with the lubricating oil or a portion of the same. Among the objects of that invention were provision of means for controlling the cooling water temperature and for controlling the temperature of the lubricating oil. One desirable possibility in such a system is to provide for the rapid elevation of temperature of both the water and the lubricating oil on starting the cold engine. This serves to minimize engine wear, render the installation more reliable in service and reduce expense of maintenance.

While the system provided in the above mentioned prior patent has given good service and in many applications is very satisfactory, I have in the present instance devised an improvement on that system particularly valuable to provide for bringing the lubricating oil to proper operating temperature as rapidly as possible after starting a cold engine to provide for close control of lubricating oil temperature in cases where the engine design provides for relatively large rise in lubricating oil temperature during its circulation through the engine and to provide automatic maintenance of the cooling system in case of valve breakdown. I have further devised improved apparatus for use in the new system as well as in the system previously disclosed.

With the object of clearly disclosing the invention, the accompanying drawings will be discussed in connection with the description as presenting preferred embodiments from which numerous de-

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partures may be made within the scope of the invention.

Figure 1 is a representation of a complete system for controlling the temperatures of water and of lubricating oil for an internal combustion engine.

Figure 2 shows a heat exchanger with a preferred form of thermostatic valve incorporated in its structure.

Figure 3 shows a heat exchanger with a modified form of valve.

Figure 4 shows a further form of heat exchanger involving sectional structure and a plurality of valves.

In Figure 1 the major elements of the engine cooling system comprise the internal combustion engine 1, water heat exchanger 2 and oil heat exchanger 3. The engine heat exchange medium leaves the water jacket by pipe 4 and returns through pipe 5. The entire flow or any portion of the circulating lubricating oil is taken from any suitable point in the lubricating system at 6 and returned at 7.

Both heat exchangers are represented as being of the type in which two fluids are passed in heat exchange relation with each other but without mixture of the two fluids. In order to convey this idea the two fluids are shown as passing through separate coils within the exchangers. Thus in exchanger 2 the primary cooling medium passes through coil 8, and the engine jacket water through coil 9, and in the oil heat exchanger 3 water passes through coil 10 while the lubricating oil flows in coil 11.

The various elements of the piping represented for conveying the several fluids involve a section 13 to the water heat exchanger, a section 14 between the two heat exchangers, a portion 15 from valve 17 to valve 19, and a section 16 constituting a by-pass around the oil heat exchanger to pipe 5. Valves 17 and 19 are thermostatically controlled valves hereinafter fully described. In the case of valve 17 the control element 18 is in thermal relationship with the water leaving the engine, while the thermostatic element 20 of valve 19, though the valve controls water circulation, is in thermal relation with, and controlled by the temperature of the oil leaving heat exchanger 3.

Figure 1 is diagrammatic in nature and does not, save in a general manner, indicate the construction of the various elements.

While it appears that external pipes and valves are employed, this is not necessarily true, as will appear later from description of my newly devised heat exchanger. The description will proceed

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by setting forth the system as applied to a marine engine installation wherein sea water constitutes the prime heat exchanger medium flowing in coil 3, but it is to be noted that the heat exchanger 2 might be of any type capable of cooling the fluid passing in coil 9. Since the present system is modified particularly for improved performance in connection with rapidly bringing the engine to an efficient operating temperature, this operation will be first described and is as follows:

On starting of the engine, cold water under the influence of the engine water pump flows in the direction of the arrows at pipes 4 and 5. The water is forced to flow through pipe 15 since the valve 17 is closed to flow there through by operation of its thermostatic element 18. For purposes of this diagrammatic presentation, valve 17 is indicated as of a type allowing flow in one or both of two directions, flow being allowed through 13 and 15 when the water at 13 has reached a predetermined elevated temperature and through 15 only at lower temperatures. Valve 19 is of the type which I have in my previous patent specification described as a three-way valve. Its operation is to direct fluid flow in one or the other of two directions in this case to pipes 21 or 16 depending upon the temperature of the oil affecting the element 20. When the thermostat 20 is at a low temperature, action of valve 19 is to send all the water through pipe 21 and thus through coil 10 of heat exchanger 3. Therefore, under starting conditions the course of the engine jacket water will be in sequence through pipes 4, 15, valve 19, pipe 21, coil 10 and pipe 5 back to the engine jacket. The water heat exchanger 2 is completely by-passed, as is evident, and thus the engine water, subject only to a minimum amount of heat radiation, will have its temperature raised rapidly by the heat supplied by the engine. Further all the engine water flows through heat exchanger 3. Since in practically all internal combustion engines a great deal more heat passes into the cooling water than passes into the lubricating oil, it will be seen that the heat exchange relationship between the rapidly heating water and the oil in exchanger 3 will serve to increase the temperature of the cold oil rapidly, which is one of the main objects of the system. When the oil is at proper operating temperature, valve 19 will act to control the amount of water passing through 10 from the engine. When full operating conditions have been reached all the cooled water from heat exchanger 2 will pass through heat exchanger 3, while part of the water will by-pass both heat exchangers and return to the engine. In case the oil is cooled to too low a temperature, valve 19 will open partially, allowing some of the hot water from valve 17 to pass through pipe 21 to the oil heat exchanger 3. In this manner a very close control of the lubricating oil temperature is possible. This is of especial benefit in connection with engines using a small quantity of oil which may have to absorb a great deal of heat at high power operation of the engine.

Figure 2 indicates a heat exchanger containing the essential elements for constituting the water heat exchanger 2 shown in the diagram of Figure 1. This heat exchanger comprises a cylindrical shell 25, water chests 26 and 27 at either end of the shell and a tube assembly comprising headers or tube sheets 30 and 31 and tubes 32. Inlet 28 and outlet 29 are provided for the fluid, which will flow exteriorly of the tubes 32, in the case here described, said fluid being sea water. In addition to the heat exchanger tubes, there is pro-

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vided a by-pass tube 33 also secured in the tube sheets 30 and 31. Water inlet 34 is provided in the water chest 26 and an outlet 35 in water chest 27. As in integral portion of the inlet 34, there is an extension constituting a valve body 37 having openings 40 in its sides. A valve closure 38, operated by a thermostatic element 39, serves to control flow through the openings 40 and, indirectly, through the by-pass tube 33. As will be apparent from the drawing, valve closure 38, when in its extended position, will uncover openings 40. When in its retracted position the closure 38 will cut off communication from the inlet 34 to the water chest 26. At intermediate positions the water flow will be divided. Communication from inlet 34 through tube 33 is allowed at all times. Thermostat element 39 is assumed to expand when the incoming water is hot and contract when it is cold, it being contemplated that suitable adjustments may be provided in known manner. The element may be of any of the bellows, bimetallic or other type.

As applied in the system according to Figure 1, the space within the shell 25 corresponds to coil 8. The assembly of tubes 32 corresponds to coil 9, the thermostat valve to valve 17, tube 33 to by-pass pipe 15, and element 39 to element 18.

In operation sea water will circulate through the shell around the tubes. Upon starting the engine, cold water from the engine will enter inlet 34, from pipe 4 of Figure 1, and pass directly through valve housing 37; valve 38, and by-pass tube 33, the downstream end of which is connected to tube 15 of Figure 1. Since the water is cold, thermostat 39 is contracted and ports 40 in valve housing 37 are closed by valve 38 so all the water coming from the engine must pass into tube 15 of Figure 1 which conveys it to three-way thermostatic valve 19 of Figure 1. Since the lubricating oil circulating through tube 7 from the oil heat exchanger 3 is also cold when the engine is started, the thermostat bulb 20 in thermal contact with the cold oil in pipe 7 causes three-way valve 19 to divert the entire quantity of water entering it from tube 15 to tube 21, allowing none of it to pass into tube 16. Thus the flow of jacket water when the cold engine is first started is as follows: through pipe 4 to valve 38; to by-pass tube 33; to tube 15; through valve 19 to pipe 21, through the jacket water circuit of the oil heat exchanger 3, and back to the engine through tube 5.

Since the cooling tubes of the water heat exchanger are being by-passed, the heat absorbed by the jacket water in the engine is not being dissipated and the jacket water rapidly increases toward the desired operating range. When it reaches the desired temperature the thermostat 39 expands, gradually opening ports 40 in valve housing 37 and permitting sufficient jacket water flow through the cooling tubes 32 for cooling, as necessary to maintain a constant temperature of the jacket water passing from the engine through tube 4. This cooled water is discharged from tubes 32 into water chest 27, and thence out of the water heat exchanger through outlet 35 and into tube 14 of Figure 1.

It will be noted that jacket water is not admitted to cooling tubes 32 until its temperature leaving the engine has been elevated to operating range. Prior to this time, all the heat absorbed by the jacket water flowing through the engine is available for heating the lubricating oil in oil heat exchanger 3. In this way the lubricating oil is rapidly heated to the desired operating

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range. When the lubricating oil approaches the desired temperature, thermostat bulb 20 actuates three-way valve 19 and causes a division of flow of jacket water at this point, i. e., part of the hot jacket water is permitted to circulate directly back to the engine through pipe 5 and the remainder continues to flow through pipes 21 and 14 to the oil heat exchanger. Since the lubricating oil is heated more slowly than the jacket water when the engine is started, by the time hot jacket water is permitted by valve 19 to flow through pipe 21, cooled jacket water from the jacket water heat exchanger is flowing through pipe 14 into which tube 21 discharges, and under this intermediate condition a mixture of hot and cooled jacket water flows into the oil heat exchanger.

We may now consider the conditions obtaining when the engine has been operating for some time and temperature conditions have stabilized. Valve 17 is now dividing the flow of jacket water so as to maintain a constant temperature of the jacket water leaving the engine. Valve 19 is dividing the flow of hot jacket water, entering it from tube 15, between tubes 21 and 16. Just sufficient flow of hot water is permitted through tube 21 to dilute the cooled water coming from the water heat exchanger as necessary to keep the lubricating oil, flowing to the engine from the oil heat exchanger through pipe 7, at the desired operating temperature. The balance of the hot jacket water flowing into valve 19 from tube 15 passes through tube 16 and combines with the jacket water issuing from the oil heat exchanger in pipe 5. Thus, by proper initial adjustment of thermostatic valves 17 and 19, the temperature of the jacket water leaving the engine and the temperature of the lubricating oil entering the engine are both automatically maintained within the desired operating range, and at the same time the temperature of the jacket water entering the engine can be reheated to a temperature approaching or even higher than the temperature of the lubricating oil entering the engine.

Figure 3 illustrates a heat exchanger and valve of a modified design. All parts are similar to those in Figure 2 and identical reference characters are used, except for the valve closure which is referred to as 48 since it is different from the valve closure 38. The action of this valve is somewhat different from that of Figure 2 in that positive cut-off occurs in both positions. This form of valve is capable of closing communication with by-pass tube 33. In operation of this device, cold water entering inlet 34 will pass through openings 49 and by-pass 33. When the water has warmed sufficiently action of the element 39 will uncover openings 49 allowing an increasing portion of the water to pass through tubes 32, water chest 27, and outlet 35. When the valve is entirely extended, no water is by-passed by reason of the seating of the spherical face 55 on seat 56. A further difference is that by-pass 33 discharges into water chest 27, rather than having a separate outlet.

Figure 4 represents a modified type of heat exchanger for use either with an oil or water system, and comprising a plurality of thermostat controlled valves. Reference characters are applied to the same elements involved in the construction of Figure 3. Major differences involved comprise dividing the tube assemblies by providing a plurality of by-pass tubes 33 with their associated thermostat valves. Action of the

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valves will be identical with that heretofore described. Provision of the plurality of valves entails a number of advantages, prominent among which are use of standard sizes of valves for various sizes of heat exchanger, and possibility of satisfactory operation, even though one or more of the valves should fail. It is contemplated that the valves will be so constructed that upon failure they will act to open communication with the tubes 32 in order to utilize the full heat exchange capacity of the system. This may be accomplished by constructing thermostat valves 39 so as to contain fluid at sub-atmospheric pressure. In case of a leak in the bellows wall of the thermostat air enters and expands the chamber thereby closing the short circuiting by-pass 33 and insuring maintenance of the full cooling action of tubes 32.

The valves may be of the type shown in Figure 2.

In the heat exchangers described above, the by-pass is as shown in order to secure the advantages of integral construction of the valve. Negligible heat exchange will occur due to the relatively small surfaces exposed.

It is believed that advantages not specifically referred to will be obvious, as will modifications not departing from the scope of the appended claims.

I claim:

1. Heat-exchange apparatus comprising a casing having inlet and outlet openings, header plates disposed in said casing for forming inlet and outlet chambers, heat-exchange tubes carried by said headers in communication with both chambers, a by-pass tube having one end in communication with said inlet chamber and the other end projecting outwardly through said casing, and valve mechanism for distributing influent between said exchanger and said by-pass tubes, said mechanism including a tubular valve housing projecting from said inlet opening to said by-pass tube, an open-ended sleeve valve slidably mounted in said housing, and heat-responsive means actuated by the temperature of said influent for slidably moving said sleeve valve, said valve housing being provided with a port permitting flow outwardly from the housing into said inlet chamber, and said heat-responsive means operating to move said sleeve valve to close said port upon low temperature influent conditions and to gradually open the port in response to increasing temperature gradients, whereby distribution of said influent between said by-pass and said heat-exchange tubes is automatically and infinitely variable, the open-ended sleeve valve at all times permitting a portion of said influent to by-pass said heat-exchange tubes for delivery in a relatively unmodified temperature condition at a desired location.

2. Heat-exchange apparatus comprising a casing, header plates disposed in said casing for forming inlet and outlet chambers with the casing end walls, heat-exchange tubes carried between said headers in communication with both chambers, a by-pass tube having one end in communication with said inlet chamber and the other end projecting outwardly through said casing, and valve mechanism for distributing influent between said exchanger and said by-pass tubes, said mechanism including a tubular valve housing disposed about the inlet chamber opening of said by-pass tube and projecting from said disposition outwardly through said inlet chamber casing walls, an influent conduit com-

municating with said tubular housing outside of said casing wall, an open-end sleeve valve slidably mounted in said housing within said inlet chamber, said housing being formed with a port permitting flow outwardly from it into said inlet chamber, and heat-responsive means disposed in said housing between said influent conduit and said port for actuating said valve, said heat-responsive means being adapted to move said valve to close said port upon low temperature influent conditions and to gradually open said port in response to increasing temperature gradients, whereby the distribution of said influent between said by-pass and heat-exchange tubes is automatically and infinitely variable; the open-end sleeve valve at all times permitting a portion of said influent to by-pass said heat-exchange tubes for delivery in a relatively unmodified temperature condition at a desired location.

THOMAS J. BAY. 20

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