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Luther et al.

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[54] **LIQUID COOLING SYSTEM FOR EXHAUST VALVES OF INTERNAL COMBUSTION ENGINES**

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[52] **U.S. Cl.** **123/41.14,** 123/41.77, 123/41.85

[51] **Int. Cl.**.....**F01p 11/02,** F01p 3/14

[58] **Field of Search**..123/41.14, 41.77, 41.85, 41.41, 123/189

[56] **References Cited**

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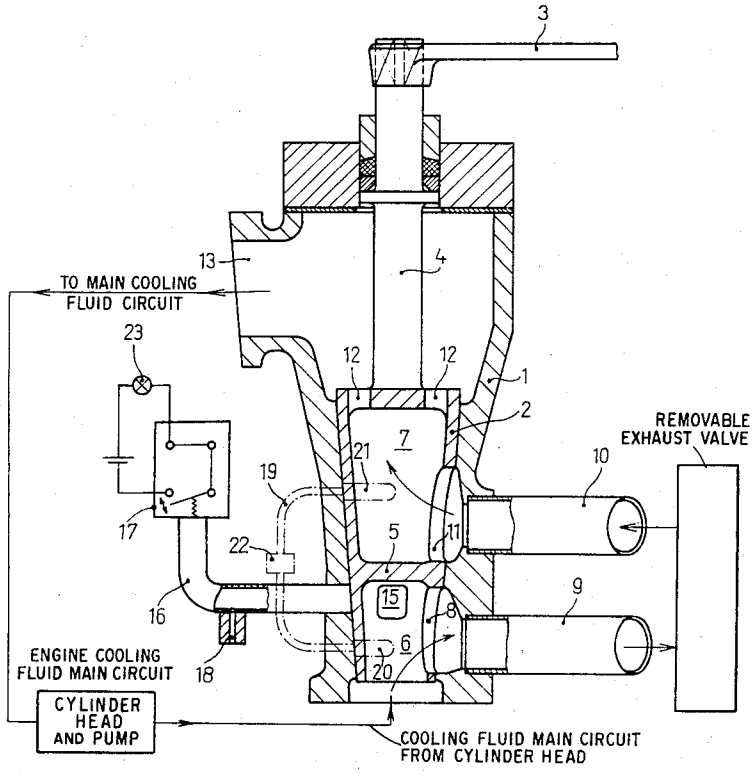
Assistant Examiner—Dennis D. Toth
Attorney—Robert D. Flynn et al.

[57] **ABSTRACT**

The cooling liquid supply and removal ducts in the cylinder block include within the fluid circuit a separate valve shutting off communication of cooling fluid to the exhaust valve unit from the cooling fluid circuit of the engine, so that the exhaust valve seats and units can be replaced without draining cooling fluid from the engine; preferably, the high pressure and low pressure sides of the engine cooling fluid circuits are interconnected by a short circuit or bypass line which has a constriction formed therein, to which a pressure sensor can be connected, giving an alarm if there is pressure build-up, indicative of operation of the cooling fluid circuit with the valve connecting the exhaust valve cooling system of the engine being closed. The control valve itself is preferably a single unit having separated cones with flow openings therethrough.

12 Claims, 2 Drawing Figures



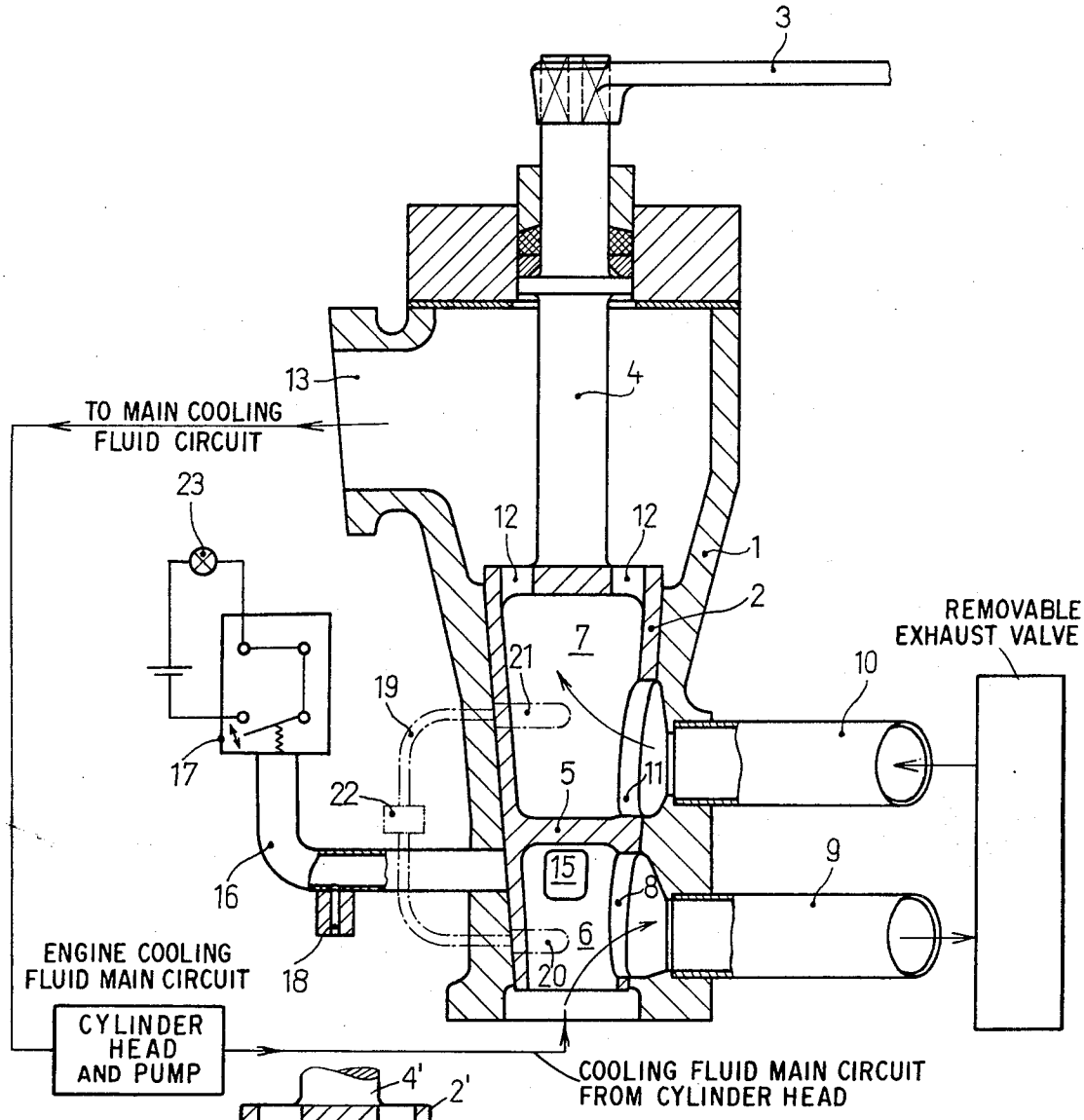

3
13
4
TO MAIN COOLING FLUID CIRCUIT
23
12
12
1
2
REMOVABLE EXHAUST VALVE
7
21
19
10
17
5
11
22
15
9
16
8
6
20
18
ENGINE COOLING FLUID MAIN CIRCUIT
CYLINDER HEAD AND PUMP
COOLING FLUID MAIN CIRCUIT FROM CYLINDER HEAD

FIG. 1

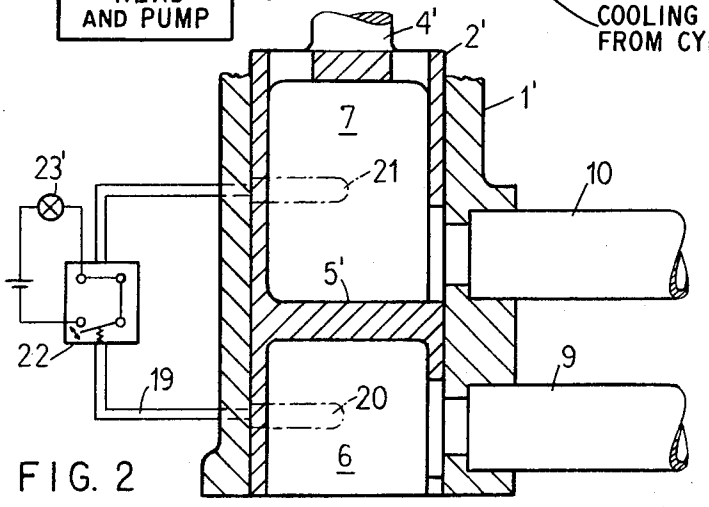

4'
2'
1'
7
23'
21
10
5'
22
19
20
9
6

FIG. 2

LIQUID COOLING SYSTEM FOR EXHAUST VALVES OF INTERNAL COMBUSTION ENGINES

The present invention relates to internal combustion engines, and more particularly to a liquid cooling system of exhaust valves and exhaust valve seats which can be separately removed or replaced from the cylinder block of the internal combustion engine.

Separately changeable exhaust valves and exhaust valve seats have been described (see, for example, Belgian Pat. No. 739,859). Such separately cooled valves are set into an enclosing valve seat or valve housing, the valve housing being removed for refinishing or repair of the valve seats as a unit, so that the entire cylinder block need not be disturbed.

The exhaust valves in internal combustion engines are highly thermally loaded. It has therefore been proposed to provide separate liquid cooling for the valve seats, or the surrounding region thereof, which is readily obtained by conducting cooling fluid, such as cooling water from the cooling ducts of the cylinder head, or cover, or from the cylinder block. Replaceable exhaust valve housings can be constructed to be liquid cooled. When such an exhaust valve housing is to be removed, then the cooling fluid must be drained, at least to the extent that the level of the cooling fluid within the engine is lower than the level of the connection to the exhaust valve housing. This is a time consuming procedure, and introduces additional costs since losses in cooling fluid are unavoidable which may become serious if the cooling fluid has expensive additives mixed therein. Additionally, if re-filling of the cooling fluid should be neglected, danger of damage to essential parts of the engine may result due to insufficient cooling capacity in the engine.

It is an object of the present invention to provide an arrangement which permits ready removal of replaceable or removable exhaust valve housings without time consuming handling of cooling fluid, and in which the danger of damage to the engine due to errors in operation of the cooling fluid circuit are avoided.

SUBJECT MATTER OF THE PRESENT INVENTION

Briefly, the cooling fluid circuit is provided in both its pressure as well as on its drain side with shut-off valves interrupting the circuit in the connection to the exhaust valve housings. Thus, when an exhaust valve housing is to be removed from a cylinder head, or from the cylinder block of an internal combustion engine, it is only necessary to block the cooling fluid circuit and, if any cooling fluid is lost, it is only a small quantity present within the exhaust valve housing itself. The arrangement thus enables rapid maintenance, without substantial loss of expensive cooling fluids and entirely avoids the possibility of damage due to neglect of refilling of the engine cooling system after removal of a valve housing. The relatively small amount which might be lost by removal of a filled cooling fluid housing is not sufficient to interfere with proper cooling operation of the entire engine.

In accordance with a preferred embodiment of the invention, the shut-off valve for the pressure as well as the drain lines is formed as a single combined switch-over valve unit, formed, for example, on a rotatable shaft. Thus, interruption of the connection of the exhaust valve of any cylinder to the main cooling fluid circuit requires only a single rotation, that is a single manual operation to bring the shut-off valve into closing position. Preferably, the shut-off valve is a rotatable cone simultaneously interrupting pressure and drain lines for any one exhaust valve which is placed in a conical chamber formed with openings, the valve unit itself being a matching, hollow cone having openings formed therein which match the connection lines when in one rotary position, and which shut off from the lines when in another, for example 90° offset rotary position. A single conical element, in which the cone is sub-divided in the middle provides a compact simple and reliable unit.

The invention will be described by way of example with reference to the accompanying drawing, wherein

FIG. 1 is a schematic longitudinal cross-sectional view of a shut-off valve in an internal combustion engine and

FIG. 2 is a fragmentary, schematic view illustrating features of another embodiment.

The internal combustion engine itself can be of any type and is not shown or illustrated. The inlet of the cooling fluid from the pressure side of the internal combustion engine is formed by a chamber **6**; the outlet, that is return flow to the main cooling circuit of the engine is formed by a chamber **7** and outlet stub **13**. The shut-off valve itself, essentially, includes a housing **1** (FIG. 1) or **1'** (FIG. 2) in which a conical valve element **2** (FIG. 1) or a cylindrical element **2'** (FIG. 2) is rotatably placed. A handle **3** is connected to the valve unit, and transfers rotary motion over a shaft **4**, **4'**, respectively. The valve element itself is formed as a hollow cone **2** (FIG. 1) or cylinder **2** (FIG. 2), sub-divided by a cross member **5**, **5'** into two chambers, one forming chamber **6**, **6'** for the inlet and the other a chamber **7**, **7'** for the return or low pressure side.

Chambers **6** and **7** (**6'**, **7'**) are aligned; preferably superposed, if the valve is vertically located. Element **2** is conical; element **2'** is cylindrical, fitting into a matching chamber in the housing **1'**.

After having passed through the cylinder head of the engine, not shown in the drawing, and entirely conventional, cooling fluid reaches the entrance chamber **6** of the conical valve element **2** and, when the valve is open, passes through an opening **8** formed in the side wall of the conical valve element **2**, to enter an entrance line **9**, to be applied to a valve housing, not specifically illustrated and which may be of a conventional type, for example as illustrated in the aforementioned Belgian Patent. After cooling the exhaust valve, that is, after passing through the exhaust valve housing, cooling liquid is conducted over line **10** back to the valve unit. Line **10** leads to an opening **11** in the side wall of valve element **2**, then into chamber **7** in valve element **2** from where it can leave through openings **12** formed in the end portion of valve element **2** to be conducted through an outlet stub **13**, and returned to the drain line of the main cooling fluid system.

If handle **3** is moved, for example over 90° or more, the valve element **2** is rotated such that openings **8** and **11** formed in the side wall of element **2** no longer match the connection points of lines **9**, **10** to the valve housing **1**, thus interrupting communication between chambers **6** and line **9**, and line **10** and chamber **7** respectively.

Upon rotation of handle 3, therefore, that is, upon changing of the position of the valve element 2 to a not shown shut-off position, the exhaust valves can be removed, that is, the housing can be taken out and any loss of cooling fluid will be restricted to that within the housing and within the short connections of lines 9 and 10. No other cooling fluid can be drained from chamber 6, or the cylinder head, or the main cooling fluid circuit of the engine, and no cooling fluid can accidentally be removed from the drain line of the main cooling fluid circuit connected to stub 13.

When the valve unit is closed, a further opening 15 formed in the wall of the valve unit 2 matches with a connection to a pressure line 16 formed in the housing 1 of the valve. Pressure line 16 connects to a schematically shown pressure switch 17, of commercial type which, when a certain overpressure is sensed in line 16, closes an electrical contact to provide an electrical alarm signal. Thus, if the engine should be started while the valve 3 is closed, then the cooling fluid pumps will build up pressure in chamber 6, which is transmitted over opening 15 into pressure line 16, causing pressure switch 17 to respond and indicate an alarm condition. Simultaneously, a small amount of cooling water can be bled from a bleed opening 18 formed in the pressure line 16. If then the handle 3 of the valve unit is brought to the position shown in the Figure, that is, if the fluid circuit is re-established, then pressure line 16 and with it the pressure switch 17 is slowly relieved of pressure through the bleed opening 18, thus re-setting the pressure switch, and removing the alarm signal. As indicated schematically in the Figure, the alarm in pressure switch 17 is caused by build-up of static pressure in the duct 16, closing an electrical circuit which indicates by a lamp 23 that an alarm condition exists. Instead of lamp 23, any other alarm system, such as an acoustic signal may be used.

Incorporated in the housing, or as a separate interconnection, a short circuit or bypass line 19 is provided, interconnecting the inlet chamber 6 with the outlet chamber 7. For ease of distinction from the other lines, line 19 is shown in chain-dotted form. Line 19 is not strictly necessary, but can be omitted. Line 19 is connectable between chambers 6 and 7 by connecting with matching openings 20, 21, formed in the walls of the valve unit 2. By suitable placement of the openings 20, 21, line 19 can be connected to be in fluid communication with chambers 6 and 7 when the valve element 2 is in the opened, as well as in the closed position; alternatively, and if an exactly defined shut-off position of valve unit 2 is possible, interconnection can be arranged to occur only when the valve unit 2 is in closed, that is, shut-off condition. In this latter case, bypass or shunt line 19 can be constructed to have a comparatively low fluid resistance, since loss of cooling fluid for cooling of the exhaust valves, when the valve 2 is in open condition, is not a serious matter if the line 19 is comparatively small with respect to the ducts 9, 10. The bypass line does, however, provide for intercommunication and complete closing of the main fluid circuit so that, if the valve element 2 should accidentally be closed while the machine is being started, at least some cooling fluid can circulate in the main cooling fluid circuit, that is, between chambers 6 and 7.

The shunt line 19 may be used to replace line 16 or, if desired, be additional thereto. A switch can be included in line 19, as schematically shown at 22, which responds to a predetermined fluid flow, and principally to flow speed, and which gives an alarm at device 23' when cooling fluid is circulated in substantial amounts, or at substantial speed over shunt line 19. Instead of a flow sensitive switch 22, a pressure sensitive switch can likewise be provided, responding to a build-up of pressure, for example adjacent a constriction formed in line 19. Thus, the switch in line 19 may be similar to switch 17, reacting to an increase in static pressure in a stub line, branches off line 19.

Some engines can be damaged even if they are operated only for a very brief period of time without an open cooling fluid circuit. Thus, it is desirable that possible damage to such engines should be avoided if the valve unit 2 is in closed condition, and to immediately give an alarm when an attempt is made to operate the engine without effective cooling. Any electrical control circuit can be connected to the switches 17, or 22, respectively, to interrupt or govern the engine so that it cannot come up to speed. Such automatic control systems are known and are not described in detail. Such a control system may, for example, be effective to act directly on a controller for fuel pumps, to reduce the fuel supply to zero, thus stopping the engine. If a short operating period with closed exhaust valve connections can be tolerated, then a time circuit can be included in the fuel pump control which delays action of the alarm control circuit on the fuel pump for a certain period of time, for example sufficient to enable operating personnel to open the valve 2 by manipulating lever 3. This avoids unnecessary start-stop operations.

The illustrative example shows interconnection of the control valve to a single exhaust valve of an engine. A number of similar ducts 9, 10 can be connected circumferentially around the valve element 2 within the housing 1, thus enabling control by a single valve of a number of fluid circuits for a number of exhaust valves.

The shunt line 19 can be arranged to have a flow resistance in accordance with various design requirements. If the flow resistance is high, the normal operation of the engine ensures adequate supply of cooling fluid to ducts 9, 10, and thus to the exhaust valves; yet, some interconnection and some fluid flow is maintained even if the valve should accidentally have been left closed, thus substantially reducing the danger to starting of the engine after inadvertent failure to reopen the valve. Under such operating conditions, the pressure built up in line 19 can readily be indicated by a pressure switch, for example similar to switch 17. A warning and alarm arrangement, and particularly one in which the engine itself is stopped is known, for example as described in German Pat. No. 742,697, to which reference is made.

We claim:

1. Liquid cooling system adapted for fluid connection to removable exhaust valves of liquid cooled internal combustion engines having a main cooling fluid circuit in which cooling fluid circulates when the engine is operating, said system comprising

a valve cooling fluid circuit (9, 10), connectable to cool the valves;

and a shut-off element 1(1, 2; 6, 7) interconnecting the main cooling fluid circuit and the valve cooling fluid circuit to permit selective isolation of the valve cooling fluid circuit and removal of the exhaust valve without interference with the main fluid circuit.

2. System according to claim 1, wherein the fluid circuits comprise

pressure lines and drain lines;

and a single movable valve element is interposed in the pressure lines of the main fluid circuit and the valve fluid circuit for at least one exhaust valve, and the drain lines of the main fluid circuit and the valve fluid circuit for at least one exhaust valve, and operable to simultaneously interrupt communication between the main fluid circuit and the valve fluid circuit and thus isolate the valve fluid circuit.

3. System according to claim 1, wherein the shut-off element comprises

a common housing (1) having a chamber of circular cross-section formed therein, a pressure inlet formed at one end of the chamber and a drain outlet formed at the other end of the chamber;

a pressure outlet opening (8, 9) and a drain inlet opening (10, 11) formed intermediate said inlets and outlets;

a rotatable elongated valve element (2) of circular cross section located in said chamber, said valve element (2) being hollow and having separating means (5) located intermediate its length to separate the valve element into two portions;

and openings (8, 11) formed in said rotatable valve element simultaneously alignable with the inlet and outlets, and the outlet and inlet openings, respectively.

4. System according to claim 3, wherein the valve element is cylindrical.

5. System according to claim 3, wherein the valve element is conical.

6. System according to claim 1, wherein the main fluid circuit has a main pressure line and a main drain line;

and said system further comprises a shunt line (19) interconnecting said main pressure and main drain lines.

7. System according to claim 6, wherein the shunt line (19) has a flow resistance which is high in comparison to the flow resistance of the main fluid circuit.

8. System according to claim 7, including a sensing element (17, 22) responsive to closed position of the shut-off element (1, 2) and giving a warning signal when the internal combustion engine is started.

9. System according to claim 8, wherein the sensing element comprises a fluid condition sensing element (17, 22) responsive to cooling fluid pressure, or flow, arising upon starting of the internal combustion engine.

10. System according to claim 9, wherein the sensing element is a pressure switch, hydraulically connected to the pressure line adjacent the shut-off element and responsive to a predetermined pressure build-up;

and a hydraulic connection is provided to the main pressure line connected adjacent the shut-off element and to the pressure switch.

11. System according to claim 10, including a bleed nozzle (18) in said hydraulic connection.

12. System according to claim 7, including a fluid condition sensing element (17, 22) responsive to fluid pressure or flow and hydraulically connected to the shunt line.

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