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(54) **ENGINE SYSTEM WITH THERMOSTAT ARRANGEMENT FOR CONTROLLING COOLANT FLOW THROUGH A BYPASS CIRCUIT**

(57) The present disclosure provides an engine system (10) comprising an engine (11), a primary coolant circuit (9) and a thermostat arrangement (20). A main coolant circuit (12) extends between the engine and a heat exchanger (14) for circulating coolant therebetween. A main bypass circuit (13) directs coolant through the engine whilst bypassing the heat exchanger. The thermostat arrangement is mounted in the primary coolant circuit for controlling coolant flow through the main bypass circuit. The thermostat arrangement is configurable between a first state for enabling coolant flow through the main coolant circuit and through the main bypass circuit and a second state for enabling coolant flow through the main coolant circuit and blocking coolant flow through the main bypass circuit.

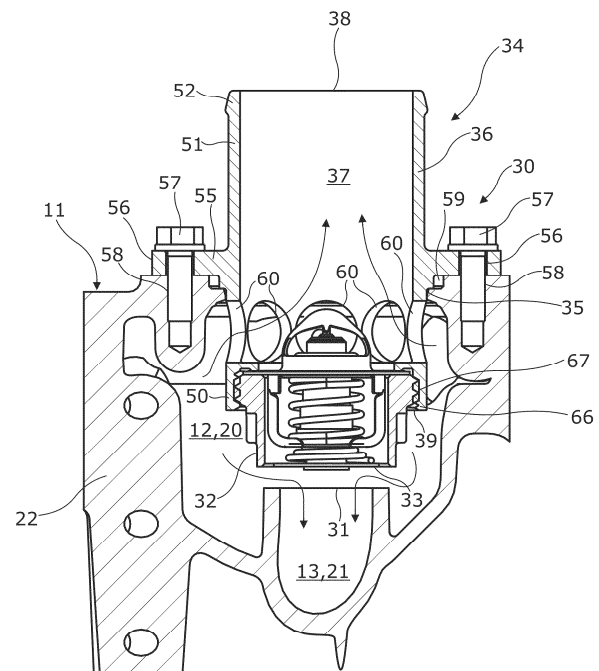


Fig. 2

## Description

### Technical Field

[0001] This disclosure is directed towards an engine system with a thermostat arrangement for controlling coolant flow through a main bypass circuit and a main coolant circuit, a thermostat arrangement for such an engine system, a diversion adapter for such a thermostat arrangement and a method of operating an engine system with the thermostat arrangement.

### Background

[0002] Vehicles and machines, including backhoe loaders, excavators, loaders and the like, commonly comprise an engine assembly including an engine, particularly an internal combustion engine, for providing power for driving the machine and operating its components. Engines are typically designed to operate effectively within a range of temperatures and thus a coolant system is typically provided to maintain the engine temperature within such an operational range. During warm up, the coolant system may recirculate coolant through the engine to retain heat therein. Once the engine has reached a sufficient temperature, the coolant system redirects the coolant to a radiator, where the coolant is cooled and returned to the engine for providing cooling to the engine.

[0003] Thermostat valves are commonly incorporated into the coolant system and switch the coolant flow between recirculation through the engine and circulation to the radiator, based on the coolant temperature. For example, US2023251675A1 discloses a thermostatic device, US11002176B2 discloses a temperature regulator and US11493941 B2 discloses a thermostatic valve.

[0004] It has been found that the thermostatic valve arrangement is not suitable for all applications. In particular, the coolant system may need to be reconfigured to supply coolant to components requiring it when the engine is at low temperatures, such as by implementing secondary coolant systems with coolant flows controlled separate to the thermostat valves and directed only to those components, without ever passing through the engine.

### Summary

[0005] An object of the present disclosure is therefore to provide an engine system with an improved cooling system. A further object of the present disclosure is to provide an engine system with more flexibility when supplying coolant to components other than the engine.

[0006] The present disclosure therefore provides an engine system, diversion adapter, thermostat arrangement and method in accordance with the claims.

[0007] In the present disclosure, the engine system comprises an engine, a primary coolant circuit and a thermostat arrangement mounted in the primary coolant

circuit. The primary coolant circuit comprises a main coolant circuit and a main bypass circuit and the thermostat arrangement is for controlling coolant flow through the main bypass circuit. The main coolant circuit extends between the engine and a heat exchanger for circulating coolant therebetween. The main bypass circuit may extend at least partially through the engine and is for directing coolant through the engine whilst bypassing the heat exchanger. The thermostat arrangement is configurable between first and second states. In the first state the thermostat arrangement is for enabling coolant flow through the main coolant circuit and through the main bypass circuit. In the second state the thermostat arrangement is for enabling coolant flow through the main coolant circuit and for blocking coolant flow through the main bypass circuit.

[0008] As a result, the coolant flow is always supplied through the main coolant circuit, such as to at least one cooler therein. This enables components of the engine system to be directly mounted in the main coolant circuit, simplifying the design thereof and reducing the need for complex secondary coolant systems. Yet furthermore, the main coolant circuit can have components located therein that warm up quickly and thus can supply heat to the engine itself whilst the engine is warming up, thereby accelerating overall system warm up.

[0009] The present disclosure also provides a diversion adapter comprising a hollow adapter body and at least one diversion aperture extending through the adapter body. The adapter body comprises an adapter channel extending therethrough. The hollow adapter body and adapter channel extend between internal and external openings. The internal opening is for receiving a valve of the thermostat arrangement. The at least one diversion aperture is configured to enable coolant to flow from external to the diversion adapter, through the at least one diversion aperture and into the adapter channel, bypassing the valve.

[0010] The present disclosure further provides a thermostat arrangement comprising the diversion adapter disclosed herein and a valve mounted in the internal opening. The valve is configurable between first and second states. The valve may be configured to selectively allow the flow of coolant through the valve such that in the first state the valve is configured to block coolant flow through the valve and in the second state the valve is configured to allow coolant flow through the valve. The valve may be configured to, when the thermostat arrangement is mounted in an engine, block coolant flow into the main bypass circuit in the second state and not block coolant flow into the main bypass circuit in the first state.

[0011] The present disclosure further provides a method of operating the engine system. The method comprises operating the thermostat arrangement between first and second states. In the first state coolant flows through the main coolant circuit and through the main bypass circuit. In the second state coolant flows through

the main coolant circuit and coolant flow through the main bypass circuit is blocked. In addition, the method may comprise operating a valve between the first and second states. In the first state the valve may block flow through itself, whilst in the second state the valve may allow flow through itself.

### **Brief Description of the Drawings**

**[0012]** By way of example only, embodiments of apparatuses and methods of the present disclosure are now described with reference to, and as shown in, the accompanying drawings, in which:

FIGURE 1 is a schematic of an engine system of the present disclosure;

FIGURE 2 is a cross-sectional view through a portion of an engine and thermostat arrangement of the engine system of Figure 1 when the thermostat arrangement is in a first state, in which coolant can flow through a main coolant circuit and main bypass circuit of the engine system;

FIGURE 3 is the same as Figure 2, except the thermostat arrangement is illustrated in a second state, in which coolant can flow through the main coolant circuit and is blocked from entering the main bypass circuit; and

FIGURES 4 and 5 are top and bottom perspective views respectively of the thermostat arrangement illustrated in Figures 2 and 3.

### **Detailed Description**

**[0013]** The ensuing description provides preferred exemplary embodiment(s) only, and is not intended to limit the scope, applicability, or configuration of the invention. Rather, the ensuing description of the preferred exemplary embodiment(s) will provide those skilled in the art with an enabling description for implementing a preferred exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements, including combinations of features from different embodiments, without departing from the scope of the invention. Specific details are given in the following description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that embodiments may be practised without these specific details. For example, well-known processes, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

**[0014]** It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present dis-

closure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact. This flexibility is required in practise to allow the implementation of the technique in different iterations to allow the technology to be targeted at the intended use, varying for engine architectures, application usage patterns, or alternative fuels.

**[0015]** The present disclosure is generally directed towards a thermostat arrangement for an engine system that always enables coolant flow through a main coolant circuit, whilst selectively directing coolant to a main bypass circuit. The thermostat arrangement may comprise a diversion adapter to which a valve can be mounted. The valve is configured to control flow into the main bypass circuit, whilst the diversion adapter includes pathways therethrough to ensure that coolant can always flow around the main coolant circuit, regardless of the state of the valve.

**[0016]** Figures 1 illustrates an engine system 10 in accordance with the present disclosure. The engine system 10 comprises an engine 11 and a primary coolant circuit 9 for supplying coolant to the engine 11.

**[0017]** The engine system 10 may provide power to various types of vehicles, applications and/or machines and the present disclosure is thus also directed to a vehicle or machine comprising the engine system 10. For example, the engine system 10 may power a generator or a vehicle such as a vehicle capable of on-highway and off-highway use, an off-highway vehicle or machine, a railway locomotive, an earth-moving machine, such as a wheel loader, excavator, dump truck, backhoe, motor grade, material handler and the like.

**[0018]** The engine 11 may be of any suitable type requiring a coolant flow therethrough. In particular, the engine 11 may be an internal combustion engine, such as a compression-ignition or spark-ignition engine.

**[0019]** Whilst the present disclosure is predominantly directed towards the components of the engine system 10 providing cooling to the engine 11, it will be appreciated that the engine system 10 may comprises a plurality of additional features such that it can provide power as required. For example, although not illustrated, the engine system 10 may comprise an air intake system, an exhaust system, at least one turbocharger, at least one supercharger and/or the like.

**[0020]** The primary coolant circuit 9 is configured such that fluid or liquid coolant, such as comprising water, can flow therethrough and extends at least partially through the engine 11. The primary coolant circuit 9 comprises a

main coolant circuit 12 and a main bypass circuit 13.

**[0021]** When the engine 11 is at a relatively high temperature, the coolant receives heat from the engine 11 and the primary coolant circuit 9 carries the heated fluid away from the engine 11 via the main coolant circuit 12. Alternatively, whilst the engine 11 is warming up, the coolant may be circulated through the main bypass circuit 13 so as to return heated coolant to the engine 11 to retain the heat therein, thereby accelerating warm-up. However, during warm up, in accordance with the present disclosure coolant can still flow around the main coolant circuit 12 without passing through the main bypass circuit 13.

**[0022]** The primary coolant circuit 9 is generally configured for coolant to flow in one direction therearound. References herein to 'downstream' and 'upstream' are made with reference to the standard coolant flow direction. The primary coolant circuit 9, main coolant circuit 12 and/or main bypass circuit 13 may be substantially closed loop circuits.

**[0023]** The engine system 10 further comprises a thermostat arrangement 30 mounted in the primary coolant circuit 9 for controlling the coolant flow through the main coolant circuit 12 and main bypass circuit 13. The thermostat arrangement 30 may control the proportion of coolant flowing into each of the main coolant circuit 12 and main bypass circuit 13 and may do so based upon the temperature of the coolant. The main bypass circuit 13 may comprise a bypass inlet 31 located in the main coolant circuit 12 and the thermostat arrangement 30 may be mounted adjacent to the bypass inlet 31 for controlling coolant flow therethrough.

**[0024]** The thermostat arrangement 30 is configurable between first and second states. In the first state (shown in Figure 2) the thermostat arrangement 30 enables coolant flow through the main coolant circuit 12 and through the main bypass circuit 13. In the second state (shown in Figure 3) the thermostat arrangement 30 enables coolant flow through the main coolant circuit 12 whilst blocking coolant flow through the main bypass circuit 13.

**[0025]** In particular, in the first state, the thermostat arrangement 30 may keep the bypass inlet 31 open during engine 11 warm-up so that heated coolant can return the heat to the engine 11 via the main bypass circuit 13. In the second state, the thermostat arrangement 30 may close the bypass inlet 31 once the engine 11 is at a relatively high temperature so that heat can be extracted from the coolant outside of the engine 11 in the main coolant circuit 12.

**[0026]** The main coolant circuit 12 extends between the engine 11 and a heat exchanger 14 such that coolant can be circulated therebetween. The heat exchanger 14 may be a radiator, as is typical in a vehicle, and may be configured to receive heat transferred from the coolant flowing therethrough and expel such heat to the external environment, thereby lowering the coolant temperature for return to the engine 11.

**[0027]** The main coolant circuit 12 may further comprise a main pump 15 for selectively controlling flow therearound. The main pump 15 may be located between the heat exchanger 14 and the engine 11 upstream of the engine 11 as illustrated, although in other embodiments may be located between the heat exchanger 14 and the engine 11 downstream of the engine 11. The main bypass circuit 13 may lead back into the main coolant circuit 12 upstream of the main pump 15 as illustrated.

**[0028]** The primary coolant circuit 9 may comprise a heat exchanger bypass circuit 18 for directing coolant from the main coolant circuit 12 around the heat exchanger 14 without passing therethrough. The heat exchanger bypass circuit 18 may feed coolant back into the main coolant circuit 12 upstream of the main pump 15 as illustrated. The main coolant circuit 12 may comprise a heat exchanger thermostat 17 for controlling whether coolant flows through the heat exchanger 14 and/or through the heat exchanger bypass circuit 18, such that heat is only extracted from the coolant by the heat exchanger 14 when it is above a preset temperature.

**[0029]** The main coolant circuit 12 may also extend through at least one other component of the engine system 10 for supplying coolant thereto such that the coolant receives heat therefrom. As in the illustrated embodiment, the main coolant circuit 12 may extend through at least one cooler 16 of the engine system 10, which may be a transmission oil cooler 16. The at least one cooler 16 may be located between the heat exchanger 14 and engine 11 downstream of the engine 11 as illustrated, although in other embodiments it or other cooled components of the engine system 10 may be located upstream of the engine 11 and downstream of the heat exchanger 14.

**[0030]** The engine system 10 may further comprise a secondary coolant circuit 40 around which coolant can also circulate for cooling components of the engine system 10 separately to those in the primary coolant circuit 9. The coolant in the secondary coolant circuit 40 may generally be at a lower temperature than the coolant in the primary coolant circuit 9.

**[0031]** The secondary coolant circuit 40 may extend through a secondary heat exchanger 41, a secondary pump 42, at least one cooler 43, 44 (such as hydraulic oil cooler 43 and charge air cooler 44 as illustrated) and back to the secondary heat exchanger 41. The secondary coolant circuit 40 may also comprise a secondary thermostat 45 for controlling flow between the secondary heat exchanger 41 and a secondary bypass circuit 46 for bypassing the secondary heat exchanger 41.

**[0032]** The engine 11 and thermostat arrangement 30 are illustrated in further detail in Figures 2 and 3. In particular, the engine 11 may comprise a main coolant channel 20, which may form part of the main coolant circuit 12, extending therethrough and may comprise a bypass channel 21, which may form part of the main bypass circuit 13, extending therethrough.

**[0033]** The bypass inlet 31 is formed at the entrance of

the bypass channel 21 from the main coolant circuit 12. In Figures 2 and 3 the main coolant and bypass channels 20, 21 extend into and out of the page. For example, the bypass channel 21 extends from the bypass inlet 31 and then onwards out of the page towards the reader such that the continuation of the bypass channel 21 is not shown in Figures 2 and 3. In other words, the inlet to the main coolant channel 20 and outlet from the bypass channel 21 are formed in the section that has been removed in order to form the cross-section shown in Figures 2 and 3.

**[0034]** The main coolant and/or bypass channels 20, 21 may be located and/or extend at least partially in and/or through a cylinder head 22 of the engine 11 as illustrated. However, the main coolant and/or bypass channels 20, 21 may additionally or alternatively extend at least partially through an engine block and/or crankcase (not illustrated), or any other suitable part, of the engine 11. Thus, the point of connection (i.e. the bypass inlet 31) between the main coolant channel 20 and bypass channel 21 may be in the cylinder head 22 as illustrated or, in alternative embodiments, in the engine block, crankcase or other part of the engine 11.

**[0035]** The engine 11 may include additional components not illustrated in the Figures, such as cylinders, pistons, valves, connecting rods, crankshafts and the like. The primary coolant circuit 9 is configured to supply coolant to such components for either warming or cooling the components depending upon the engine 11 state.

**[0036]** The thermostat arrangement 30 may be mounted adjacent to the bypass inlet 31 such that it can selectively block the bypass inlet 31, depending upon whether it is in the first or second states. When in the first state, the bypass inlet 31 is uncovered or opened by the thermostat arrangement 30 as in Figure 2, such that coolant can flow from the main coolant channel 20 into the bypass channel 21. When in the second state, the bypass inlet 31 is substantially entirely covered or closed by the thermostat arrangement 30 as in Figure 3, such that coolant is blocked from flowing from the main coolant channel 20 into the bypass channel 21.

**[0037]** The thermostat arrangement 30 may be arranged such that, in both the first and second states, coolant can flow out of the engine 11 through the main coolant channel 20. However, the flowrate out of the engine 11 through the main coolant circuit 12 may be lower in the first state than in the second state. The main coolant circuit 12 may extend through the thermostat arrangement 30 and the flowrate along the main coolant circuit 12 in the thermostat arrangement 30 may be less in the first state than in the second state.

**[0038]** The thermostat arrangement 30, which is illustrated in further detail in Figures 4 and 5, may comprise a valve 32 configurable between the first and second states. The valve 32 may be mounted adjacent to the bypass inlet 31 such that it can selectively block the bypass inlet. The valve 32 may be located in the main coolant circuit 12 and/or main coolant channel 20 as

illustrated, but in alternative embodiments the valve 32 is located at least partially inside the main bypass circuit 13 and/or bypass channel 21.

**[0039]** In the first state the valve 32 may be separated from the bypass inlet 31 for allowing coolant flow through the main bypass circuit 13 via the bypass inlet 31. In the second state, the valve 32 may block the bypass inlet 31 for blocking coolant flow through the main bypass circuit 13. In particular, a valve head 33 of the valve 32 may be configured to entirely cover the bypass inlet 31 in the second state, as shown in Figure 3.

**[0040]** In addition, the valve 32 may selectively allow the flow of coolant therethrough. Thus, in the first state, the valve 32 blocks coolant flow therethrough, whilst in the second state the valve 32 allows coolant flow therethrough, as illustrated by the arrows in Figures 2 and 3.

**[0041]** The valve 32 may be a thermostat valve and may be of any suitable type for controlling the flow based upon the temperature of the coolant. The valve 32 may be a mechanical valve with a passive temperature sensing device, such as a thermal actuator (e.g. utilising wax) and/or an active solenoid valve triggered by a temperature sensor, which could be located at the valve 32 or at another part of the main coolant or bypass circuits 12, 13.

**[0042]** The valve 32 may be configured to switch between the first and second states based upon the temperature of the coolant. The valve 32, and thus the thermostat arrangement, may be configured to be in the first state when coolant is below a predetermined temperature (such as during warm up) and in the second state when the coolant is above the predetermined temperature (such as after the engine 11 has warmed up). In the first state the valve 32 may be considered closed, because it does not allow flow through itself, although in such a state it has opened the bypass inlet 31. In the second state the valve 32 may be considered open, because it allows flow through itself, although in such a state it has closed the bypass inlet 31.

**[0043]** The thermostat arrangement 30 may further comprise a diversion adapter 34 mounted to the engine 11, such as to the cylinder head 22 as illustrated. The thermostat arrangement 30 may be at least partially externally mounted to the engine 11. In particular, the diversion adapter 34 may be mounted such that it extends partially inside and partially outside of the engine 11, such as the main coolant channel 20 thereof.

**[0044]** The engine 11 may comprise an engine opening 35, for example through the cylinder head 22, into the main coolant channel 20 and located in proximity to, adjacent and/or over the bypass inlet 31. The thermostat arrangement 30, for example the diversion adapter 34 as illustrated, may be mounted into the engine opening 35 so as to be partially mounted in the main coolant channel 20. The bypass inlet 31 and engine opening 35 may be aligned with one another such that the bypass inlet 31 is entirely accessible from directly through the engine opening 35 and/or such that, when the thermostat arrangement 30 is mounted into the engine opening 35, the valve

32 (preferably the valve head 33 thereof) is mounted over, for selectively blocking, the bypass inlet 31.

**[0045]** The diversion adapter 34 comprises a hollow adapter body 36, which may be a substantially cylindrical tube as illustrated, comprising an adapter channel 37 therethrough. The adapter body 36 and adapter channel 37 may extend along an adapter length between an external opening 38 and an internal opening 39. The adapter body 36 may comprise a substantially straight hollow tube, with the external and internal openings 38, 39 being aligned with each other along the tube. The diversion adapter 34 may be substantially rigid such that it cannot substantially flex along the adapter length.

**[0046]** The adapter body 36 may comprise an external portion 50 extending from the external opening 38 and an internal portion 50 extending from the internal opening 39. The internal and external portions 50, 51 may meet each other as illustrated, such that the adapter body 36 is split along the adapter length by the internal and external portions 50, 51, and may each be substantially (optionally cylindrical) hollow tubes. The adapter body 36 may be configured to be located partially in the main coolant channel 20, such as with the internal opening 39 and internal portion 50 therein, and partially outside of the engine 11, such as with the external opening 38 and external portion 50 mounted outside of the engine 11.

**[0047]** The external portion 51 may be configured such that at least one conduit 65 can be sealingly mounted thereto. For example, the at least one conduit 65 may comprise flexible tubing and may extend from the external opening 38 to the at least one cooler 16. Thus the at least one conduit 65 may partially form the main coolant circuit 12, extending from the external opening 38 through to the at least one cooler 16 such that coolant can pass there along. The external portion 51 may comprise at least one lip 52 to which the at least one conduit can be securely mounted, such as via a hose clamp.

**[0048]** The diversion adapter 34 may comprise at least one flange 55 mounted to and extending outwardly away from the adapter body 36. The at least one flange 55 enables the diversion adapter 34 to be secured to the engine 11. The at least one flange 55 may comprise at least one flange aperture 56 therethrough for receiving at least one fastener 57, which may be at least one bolt as illustrated. When the diversion adapter 34 is mounted to the engine 11, the at least one fastener 57 may extend through the at least one flange aperture 56 into a corresponding fastener hole 58 in the engine 11.

**[0049]** The internal and external portions 50, 51 may meet each other at the at least one flange 55. The at least one flange 55 may be located substantially midway along the adapter length and may be located in the region of between 30% and 70% along the adapter length.

**[0050]** The diversion adapter 34 may comprise a seal ring 59, such as an O-ring, between (a) the adapter body 36 and/or at least one flange 55 and (b) the engine 11. The seal ring 59 may ensure that the diversion adapter 34 fully seals the engine opening 35 when mounted to the engine

11.

**[0051]** The valve 32 is mounted at or in the internal opening 39 such that, when the thermostat arrangement 30 is mounted to the engine 11, the valve 32 (preferably the valve head 33 thereof) is mounted over, for selectively blocking, the bypass inlet 31. The valve 32 may be mounted to the diversion adapter 34 at the internal opening 39 via any suitable fastening type. For example, as illustrated, the internal portion 50 and/or adapter channel 37 may comprise an internal screw thread 66 adjacent to the internal opening 39 to which the valve 32 is mountable, such as by having a corresponding external screw thread 67 thereon. If the external and internal openings 38, 39 are aligned with one another along the adapter channel 37, the valve 32 may be visible through the external opening 39.

**[0052]** The diversion adapter 34 may further comprise at least one diversion aperture 60 extending through the adapter body 36. The at least one diversion aperture 60 may be located between the external and internal openings 38, 39 and may extend from outside of the adapter body 36 into the adapter channel 37. The at least one diversion aperture 60 may extend through the internal portion 50 and may be located between the internal opening 39 and the at least one flange 55.

**[0053]** The diversion adapter 34 may comprise a plurality of diversion apertures 60 extending in an array and/or aligned with each around the adapter body 36. The diversion adapter 34 may comprise at least three or at least six diversion apertures 60. Each diversion aperture 60 may comprise a hole, which may be substantially circular as illustrated, extending through the wall of the adapter body 36.

**[0054]** When the diversion adapter 34 is mounted to the engine 11, the at least one diversion aperture 60 is mounted inside the engine 11 and in the main coolant channel 20. Thus, in use, the at least one diversion aperture 60 is located between the valve 32 and the external opening 38, inside the engine 11 and the main coolant channel 20.

**[0055]** The diversion adapter 34 may comprise any suitable material and may be formed of metal. The diversion adapter 34 may be cast from metal.

**[0056]** The main coolant circuit 12 extends through the diversion adapter 34 and in particular through the at least one diversion aperture 60, as illustrated by the arrows through the at least one diversion aperture 60 in Figures 2 and 3. Hence the main coolant circuit 12 extends through the at least one diversion aperture 60, through the adapter channel 37 and through the external opening 38.

**[0057]** Since the at least one diversion aperture 60 is always open (i.e. the valve 32 or any other valve does not selectively block the at least one diversion aperture 60), the main coolant circuit 12 always extends therethrough, including in both the first and second states. As a result, coolant can always flow through the at least one diversion aperture 60 and the thermostat arrangement 30 always allows coolant flow through it as part of the main coolant

circuit 12.

**[0058]** When the valve 32 is in the first state, coolant flow through the valve 32 may be blocked and thus the main coolant circuit 12 is only through the thermostat arrangement 30 via the at least one diversion aperture 60. However, when the valve 32 is in the second state, coolant can flow through the valve 32 (as shown by the arrows in Figure 3) and into the adapter channel 37. Hence coolant is supplied into the adapter channel 37 upstream of the at least one diversion aperture 60 by the valve 32. In the second state, therefore, the main coolant circuit 12 extends from the main coolant channel 20 through the valve 32, into the adapter channel 37 and through the external opening 38, in addition to extending through the at least one diversion aperture 60.

**[0059]** As a result, the flowrate of coolant along the main coolant circuit 12 through the thermostat arrangement 30 may be less, but non-zero, in the first state than in the second state. The thermostat arrangement 30 may be configured to, in the first state, direct at least 75% of the coolant flowrate from the main coolant channel 20 therethrough in the main coolant circuit 20 and direct less than 25% of the coolant flowrate from the main coolant circuit 20 through the main bypass circuit 13. The thermostat arrangement 30 may also be configured to, in the second state, direct 100% of coolant flow therethrough in the main coolant circuit 20.

### Industrial Applicability

**[0060]** In the method of operating the engine system, the thermostat arrangement is operated between the first and second states. In particular, the valve 32 may be operated between the first and second states based upon whether the coolant temperature has reached the predetermined temperature. The valve 32 may switch automatically between the first and second states. The valve 32 may not be configurable in anything other than the first and second states, other than when switching between the first and second states.

**[0061]** For example, in the case of the valve 32 comprising a passive temperature sensing device, once the coolant reaches the predetermined temperature the valve 32 may automatically switch from the first state to the second state. Alternatively, if the valve 32 is an actively controlled valve, for example by a controller connected to valve 32 and the temperature sensor, once the data from the temperature sensor indicates that the coolant has reached the predetermined temperature the controller may operate the valve 32 to swap from the first state to the second state.

**[0062]** The first state may thus be implemented when the coolant is below the predetermined temperature and the predetermined temperature may be selected such that the first state is applied whilst the engine 11 is warming up. In the first state, the thermostat arrangement 30 and valve 32 are configured as shown in Figure 2 such that they do not block the bypass inlet 31. In particular, the

valve head 33 may be separated from the bypass inlet 31 and the valve 32 may not allow coolant to flow through the valve 32 itself.

**[0063]** In the first state, coolant can therefore flow out of the main coolant channel 20 in two paths. The first path is through the at least one diversion aperture 60, through the adapter channel 37 and out of the external opening 38 into the at least one conduit 65. Hence the main coolant circuit 12 is maintained, with the coolant from the at least one conduit 65 flowing to the at least one cooler 16, heat exchanger 14 (and/or heat exchanger bypass circuit 18), main pump 15 and back into the engine 11 where it re-enters the main coolant channel 20.

**[0064]** In the second path, the coolant can flow from the main coolant channel 20 into the bypass channel 21 through the bypass inlet 31. Therefore, coolant is supplied to the main bypass circuit 13. The main bypass circuit 13 extends through the engine 11 and then back to the main coolant channel 20, such as through the main pump 15 as illustrated. The main bypass circuit 13 may be configured so as to return heated coolant back into the engine 11 without losing too much heat. Therefore, the heated coolant can be used to accelerate engine 11 warm-up by retaining heat in the engine 11.

**[0065]** The second state may be implemented when the coolant has reached or is above the predetermined temperature and the predetermined temperature may be selected such that the second state is applied once the engine 11 has warmed up to operationally efficient temperatures. In the second state, the thermostat arrangement 30 and valve 32 are configured as shown in Figure 3 such that they block the bypass inlet 31. In particular, the valve head 33 may be in contact with and cover or entirely block the bypass inlet 31, preventing any flow therethrough, and the valve 32 may allow coolant to flow through the valve 32 itself.

**[0066]** In the second state, coolant can therefore flow out of the main coolant channel 20 in two paths. The first path is the same as that of the first state. However, the second path is directly through the valve 32, and thus through the internal opening 39. The result is that a higher flowrate of coolant is supplied through the adapter channel 37 and onwards to the rest of the main coolant circuit 12, such that, for example, the efficiency of cooling the at least one cooler 16 and of the extraction of heat by the heat exchanger 14 is increased.

**[0067]** The engine system 10 as shown in Figure 1 may also be operated further based upon whether the engine 11 is warming up and/or whether the thermostat arrangement 30 is in the first or second states. In particular, during warm up the coolant in the main coolant circuit 12 may pass through the at least one cooler 16, such as a transmission oil cooler, and receive heat therefrom. The heat exchanger thermostat 17 may be configured to direct the coolant through the heat exchanger bypass circuit 18 when the coolant is below a preset temperature such that no heat is extracted therefrom by the heat exchanger 14.

**[0068]** The heat in the coolant from the at least one cooler 16 (or other component of the engine system 10 in the main coolant circuit 12) can thus be returned to the engine 11 for supply thereto, accelerating warm up of the engine 11. The preset temperature may be substantially the same as the predetermined temperature, such that the heat exchanger thermostat 17 and thermostat arrangement 30 switch at substantially the same time and/or coolant temperature.

**[0069]** In addition, coolant can be supplied at the same time to any component requiring coolant even whilst the engine 11 is warming up and heated coolant is being circulated therearound via the bypass circuit 13.

**[0070]** A further benefit of the engine system 10 can be considered with reference to the secondary coolant circuit 40. In other systems, the transmission oil cooler 16 may need to be located in the secondary coolant circuit 40, in a separate branch to the hydraulic oil cooler 43 and/or charge air cooler 44.

**[0071]** It will be appreciated that various alternatives to the embodiments described above still fall within the scope of the present disclosure. For example, valve 32 and diversion adapter 34 may be integrated with one another, such as by the diversion adapter 34 forming the valve 32 housing, such that the thermostat arrangement 30 is a single item. All of the disclosure above, other than that related to the threads 66, 67, would still apply to such an integrated thermostat arrangement 30.

## Claims

### 1. An engine system comprising:

an engine;

a primary coolant circuit comprising:

a main coolant circuit extending between the engine and a heat exchanger for circulating coolant therebetween; and  
a main bypass circuit for directing coolant through the engine whilst bypassing the heat exchanger; and

a thermostat arrangement mounted in the primary coolant circuit for controlling coolant flow through the main bypass circuit and configurable between:

a first state for enabling coolant flow through the main coolant circuit and through the main bypass circuit; and  
a second state for enabling coolant flow through the main coolant circuit and blocking coolant flow through the main bypass circuit.

### 2. The engine system of claim 1 wherein the thermostat

arrangement is configured to be in the first state when coolant is below a predetermined temperature and in the second state when the coolant is above the predetermined temperature.

3. The engine system of claim 1 or claim 2 wherein the main coolant circuit extends from the engine, through the thermostat arrangement and to the heat exchanger.

4. The engine system of any preceding claim wherein the first state is for directing at least 75% of the coolant flow through the main coolant circuit and less than 25% of the coolant flow through the main bypass circuit.

5. The engine system of any preceding claim wherein the main bypass circuit comprises a bypass inlet located in the main coolant circuit and the thermostat arrangement is mounted adjacent to the bypass inlet.

6. The engine system of claim 5 wherein the main coolant circuit is at least partially formed by a main coolant channel extending through the engine, wherein the bypass inlet is located in the main coolant channel.

7. The engine system of claim 5 or claim 6 wherein the thermostat arrangement comprises a valve configurable between the first state, in which the valve is separated from the bypass inlet for allowing coolant flow through the main bypass circuit via the bypass inlet, and the second state, in which the valve blocks the bypass inlet for blocking coolant flow through the main bypass circuit.

8. The engine system of any preceding claim wherein the thermostat arrangement comprises a diversion adapter mounted to the engine, the diversion adapter comprising:

an external opening for directing coolant to the heat exchanger;  
at least one diversion aperture for receiving coolant flow in the first and second states; and  
an adapter channel for directing fluid from the at least one diversion aperture to the external opening.

9. The engine system of claims 7 and 8 wherein diversion adapter comprises an internal opening and the valve is mounted to the diversion adapter at the internal opening.

10. The engine system of any one of claims 7 to 9 wherein the valve is configured to selectively allow the flow of coolant through the valve such that in the

first state the valve blocks coolant flow through the valve, whilst in the second state the valve allows coolant flow through the valve.

11. A diversion adapter for the thermostat arrangement of the engine system of any one of the preceding claims, the diversion adapter comprising:

a hollow adapter body comprising an adapter channel extending therethrough, the hollow adapter body and adapter channel extending between internal and external openings, the internal opening being for receiving a valve of the thermostat arrangement; and  
at least one diversion aperture extending through the adapter body configured to enable coolant to flow from external to the diversion adapter, through the at least one diversion aperture and into the adapter channel, bypassing the valve.

12. A diversion adapter as claimed in claim 11 wherein the adapter channel comprises an internal screw thread adjacent to the internal opening configured to receive the valve.

13. A diversion adapter as claimed in claim 11 or claim 12 wherein the adapter body comprises:

an internal portion comprising the internal opening and configured to be mounted inside an engine of the engine system, wherein the at least one diversion aperture extends through the inner portion; and/or  
an external portion comprising the external opening and configured to be mounted outside of the engine, wherein the external portion is configured such that at least one conduit of the main coolant circuit can be sealingly mounted to the external portion.

14. A thermostat arrangement comprising the diversion adapter as claimed in any one of claims 11 to 13 and a valve mounted in the internal opening, wherein the valve is configurable between first and second states, wherein the valve is configured to selectively allow the flow of coolant through the valve such that in the first state the valve is configured to block coolant flow through the valve and in the second state the valve is configured to allow coolant flow through the valve.

15. A method of operating an engine system, the engine system comprising:

an engine;  
a primary coolant circuit comprising:

a main coolant circuit extending between the engine and a heat exchanger for circulating coolant therebetween; and  
a main bypass circuit extending through the engine for directing coolant through the engine whilst bypassing the heat exchanger; and

a thermostat arrangement mounted in the primary coolant circuit for controlling coolant flow through the main bypass circuit,

wherein the method comprises operating the thermostat arrangement between:

a first state in which coolant flows through the main coolant circuit and through the main bypass circuit; and  
a second state in which coolant flows through the main coolant circuit and coolant flow through the main bypass circuit is blocked.

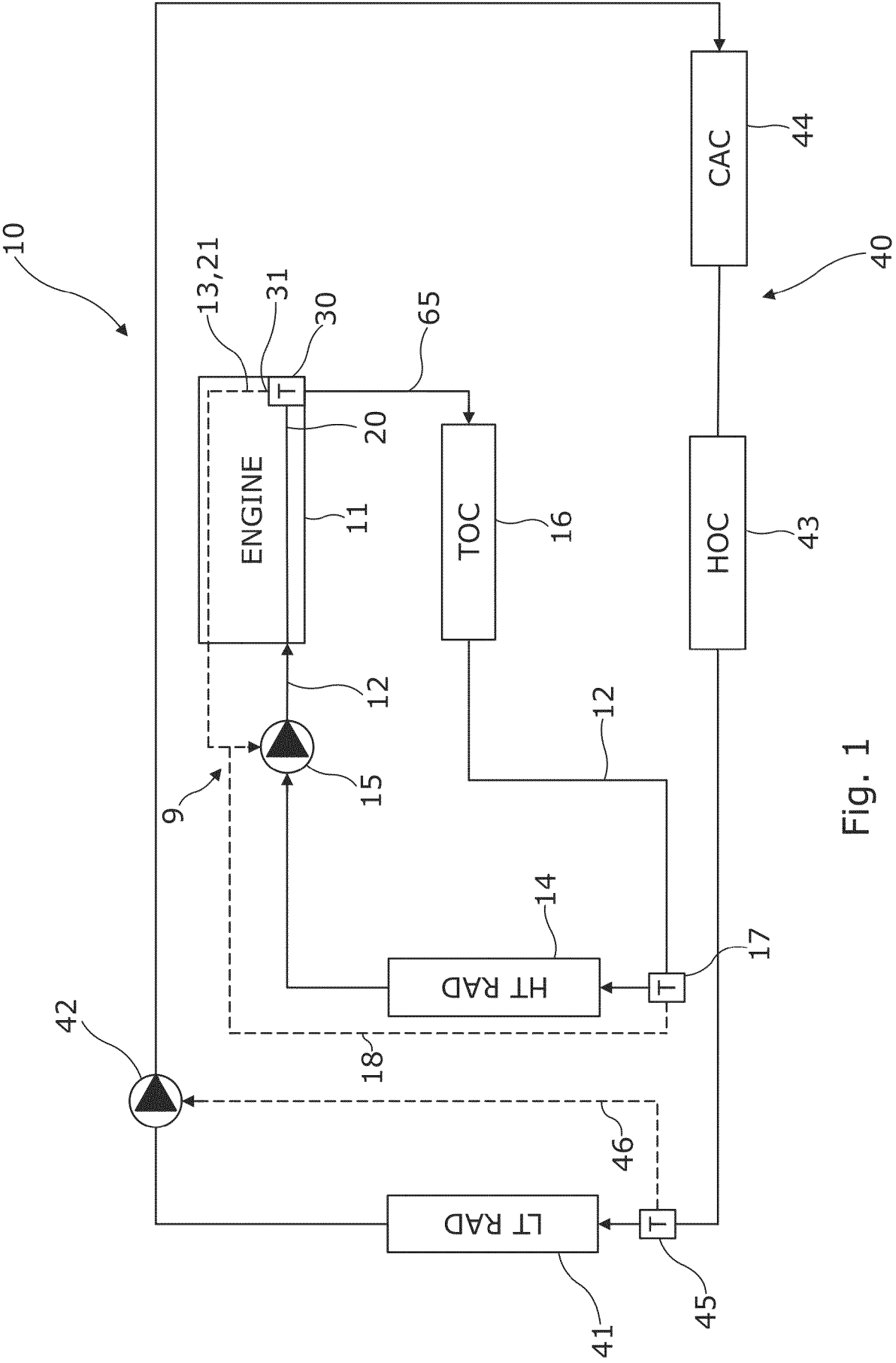


Fig. 1

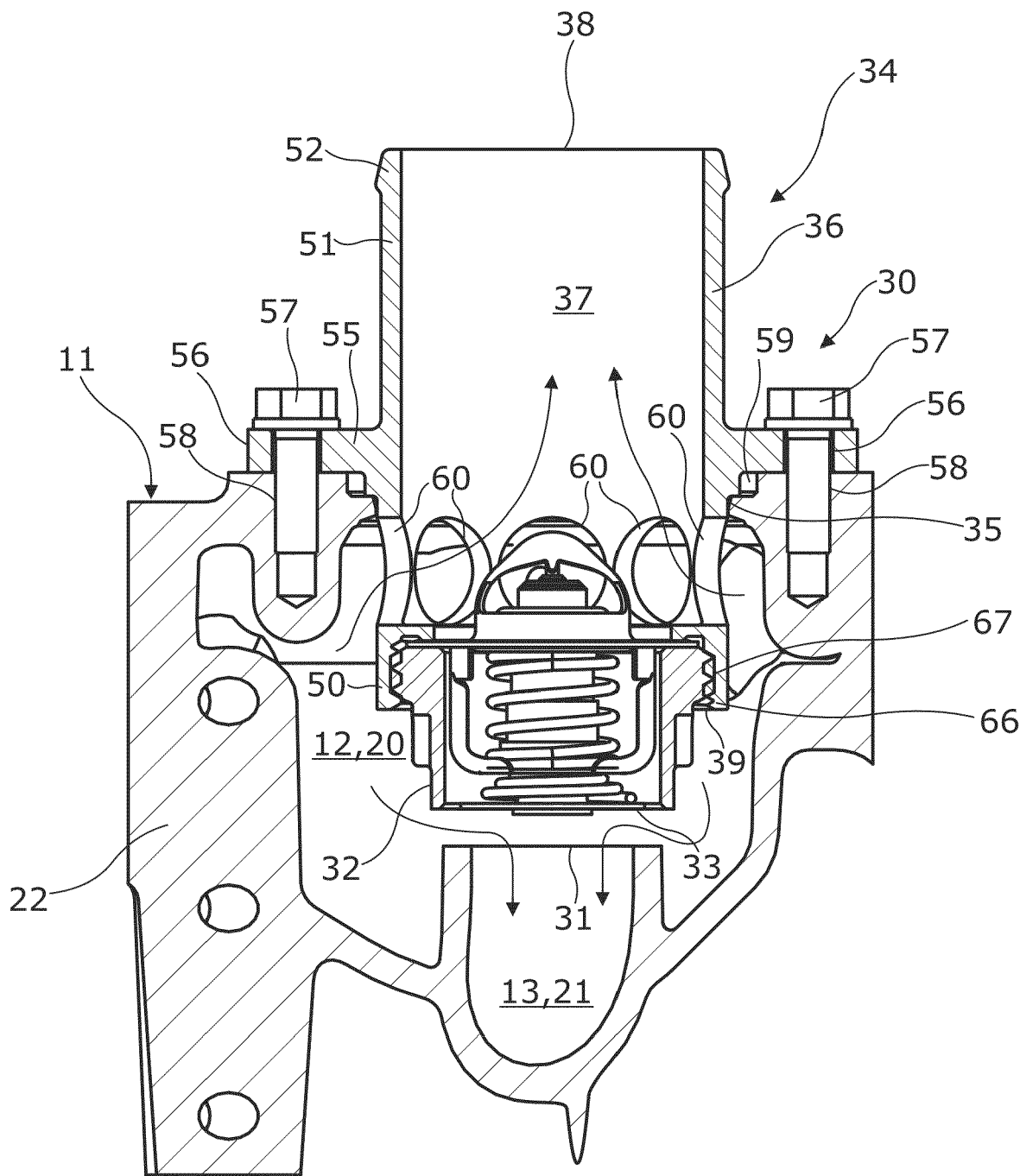


Fig. 2

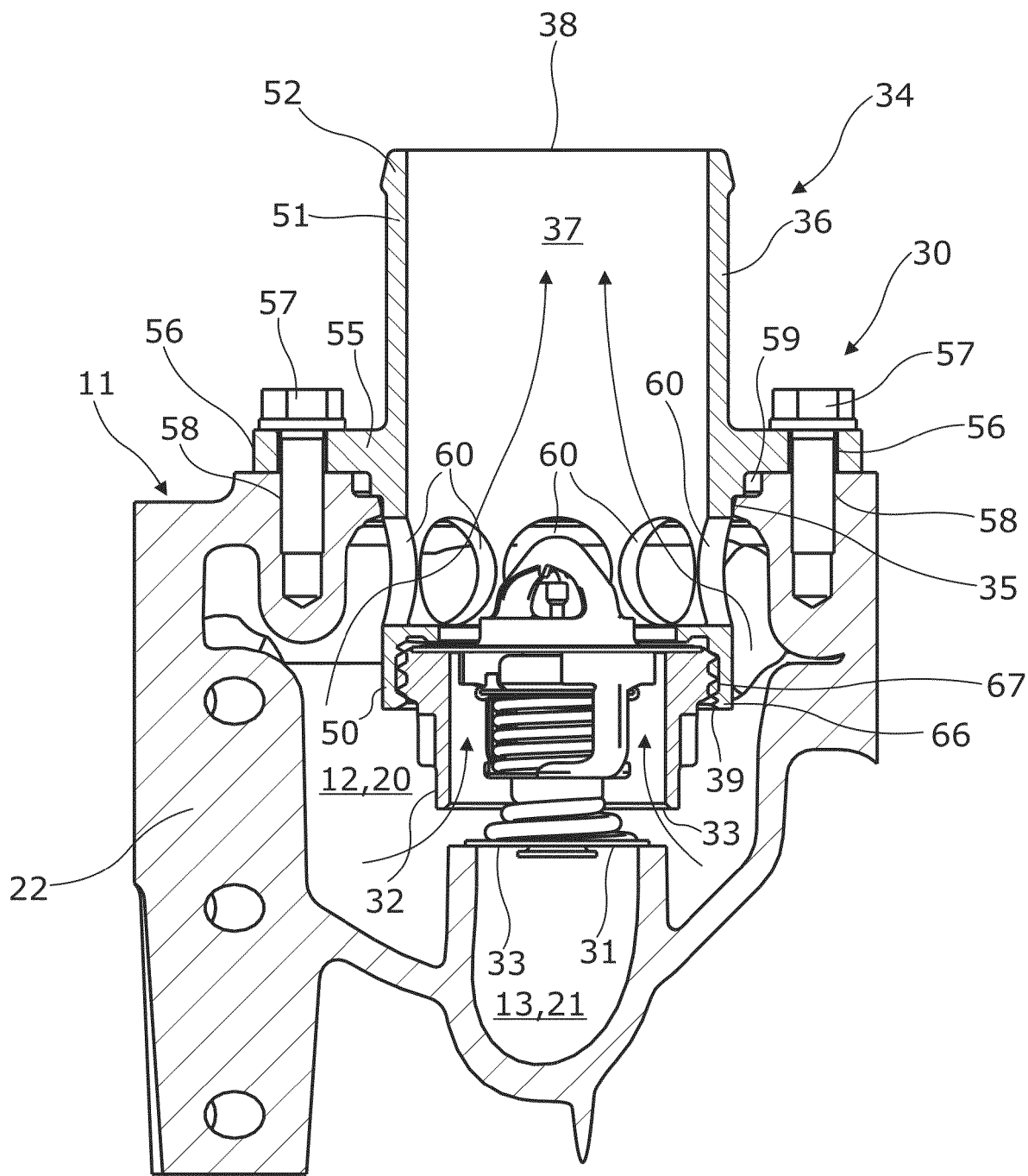


Fig. 3

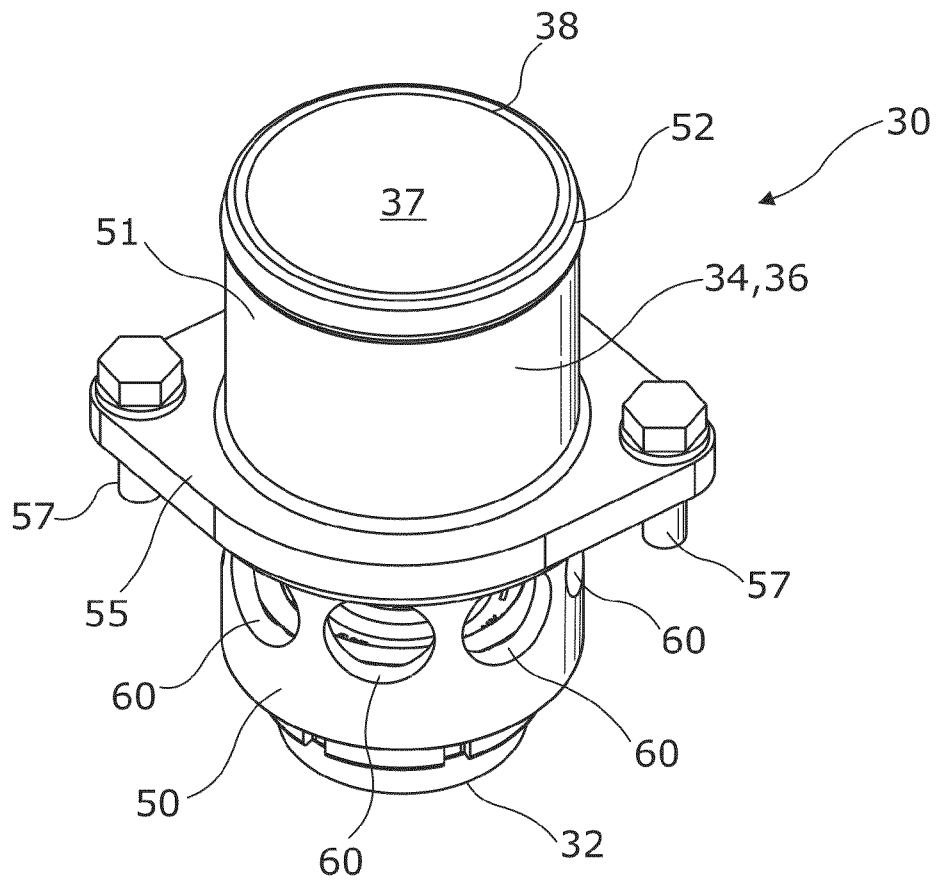


Fig. 4

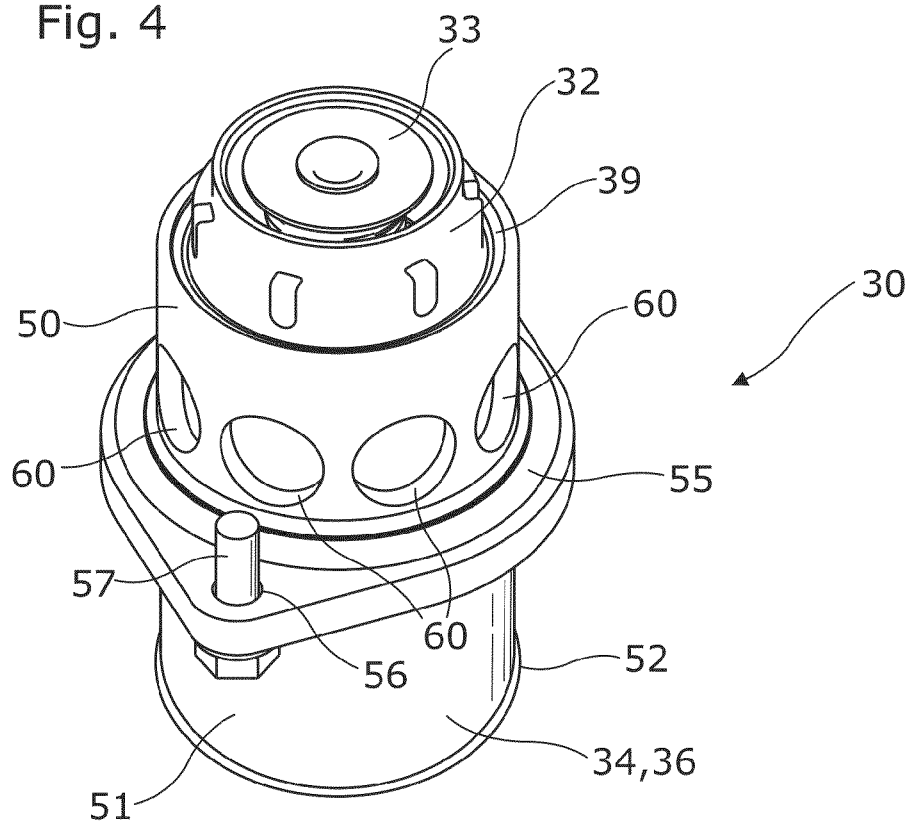


Fig. 5



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Application Number

EP 25 20 8031

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| The present search report has been drawn up for all claims                                                                                                                                                                                                                            |                                                                                                                          |                                  |                                         |
| Place of search                                                                                                                                                                                                                                                                       |                                                                                                                          | Date of completion of the search | Examiner                                |
| Munich                                                                                                                                                                                                                                                                                |                                                                                                                          | 3 January 2026                   | Seifert, Marco                          |
| CATEGORY OF CITED DOCUMENTS                                                                                                                                                                                                                                                           |                                                                                                                          |                                  |                                         |
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| T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                                                                                          |                                  |                                         |

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