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(54) **Title**: CONTROL SYSTEM FOR CONTROLLING A POSITIVE DISPLACEMENT PUMP

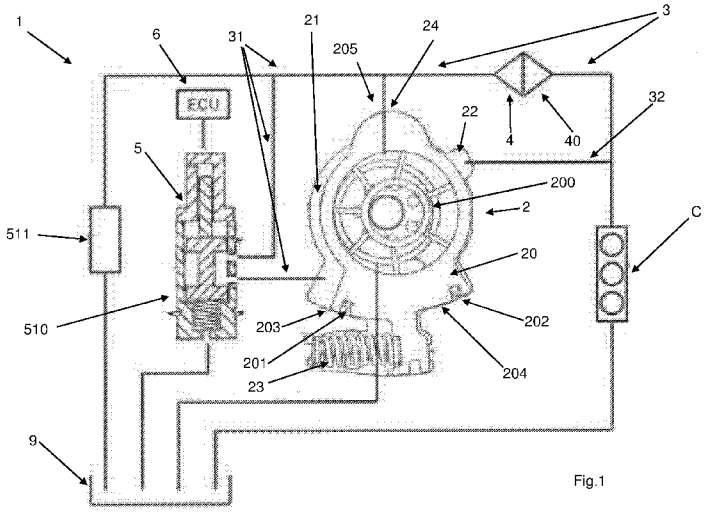

Fig.1

(57) **Abstract**: A control system comprising: - a variable volume positive displacement rotary pump (2), in turn comprising: i) a stator (20) that is movable so as to determine a variation in the volume of the pump (2); ii) a first and a second thrust chamber (21, 22) for thrusting the stator (20) and designed to be filled with a fluid processed by the pump so as to regulate the movement of the stator (20); -a supply line (3) for supplying the fluid processed by the pump (2) to a load. -an element (4) that defines a localized loss in load, said element (4) being located along said supply line (3); The first and second thrust chambers (21, 22) are supplied up-stream and downstream of said element (4) that defines a localized loss in load, respectively.

DESCRIPTION

Control system for controlling a positive displacement pump

Technical field

The object of the present invention is a control system and method for controlling a variable volume positive displacement rotary pump.

Background art

There are known variable displacement pumps for circulation of the lubrication oil in an internal combustion engine and any possible auxiliaries.

Variable displacement makes it possible to regulate the flow rate of the lubrication oil, optimizing it based on the operating mode of the engine. In fact, in the case of a fixed displacement pump, the flow rate should be such as to ensure adequate lubrication even at low speeds, but this would determine an excessive flow rate at higher speeds (therefore requiring greater consumption by the engine to ensure circulation of the lubricant and imposing higher pressures and thus greater stress on the circuit).

A variable displacement pump for circulation of lubrication oil is known in the prior art, for example as disclosed in patent US 2013263815.

In this case, two thrust chambers are shown that act in opposition to each other and move a stator, inside of which a vane rotor rotates. The movement of the stator determines a variation in the displacement of the pump. Access to at least one of the two thrust chambers is regulated by a throttle valve. One of the two thrust chambers acts jointly with the force exerted by a spring. The spring exerts a force that pushes the stator to a position of maximum displacement. By balancing the oil pressure in the two thrust chambers, the displacement of the pump can thus be regulated.

The Applicant has verified that when the variable displacement pump is utilized on mid-range/high-powered engines for heavy vehicles in which demanding use of the engine and the engine brake is frequent, there is a problem consisting of a marked delay in the increase in flow rate/pressure needed for quickly activating the actuator of the engine brake and for

protecting the internal members of the engine from stress.

Object of the invention

In this context, the technical task underlying the present invention is to offer a control system and method for controlling a pump that make it possible to overcome the drawbacks described hereinabove. In particular, an aim of the present invention is to offer a control system and method for controlling a pump that make better lubrication of a load possible, regardless of the operating conditions.

The defined technical task and the specified aims are substantially achieved by a control system and method for controlling a pump, comprising the technical characteristics set forth in one or more of the appended claims.

Brief decription of drawings

Further characteristics and advantages of the present invention will become more apparent from the approximate and thus non-limiting description of a preferred, but not exclusive, embodiment of a control system and method for controlling a pump, as illustrated in Figure 1.

In fact, Figure 1 is a schematic view of a specific application of a control system for controlling a pump according to the present invention.

Detailed description of preferred embodiments of the invention

In the accompanying figure, a control system for controlling a positive displacement pump is indicated by the reference number 1.

This system 1 comprises the positive displacement pump 2, which is of the variable volume rotary type.

As explained above, variable displacement makes it possible to optimize operation under different conditions.

The pump 2 comprises a stator 20 that is movable so as to determine a variation in the volume of the pump 2.The stator 20 is conveniently hollow and a rotor 200, typically a vane rotor, is present inside the stator. Movement of the position of the stator 20 with respect to the axis of rotation of the rotor 200 allows for variation in the volume of the pump

2.Movement of the stator 20 can be of various types, for example it could be a tilting, rotational, or translational type of movement. In the solution illustrated in the figure, the movement of the stator 20 is of the rotational type where the first, the second and the third arc are indicated by reference numbers 203, 204, 205, with common centres, on which the stator 20 rotates.

The pump 2 further comprises a first thrust chamber 21 for thrusting the stator 20.This first thrust chamber 21 is designed to be filled with a fluid processed by the pump 2.In this manner, it is possible to bring about movement of the stator 20. As indicated above, a variation in the volume of the pump 2 is associated with a movement of the stator 20.The fluid processed by the pump 2 is a liquid, typically oil. Therefore, this fluid is not compressible.

In the solution illustrated in the accompanying figure, the first chamber 21 is defined by the fluid dynamic seal realized by the first arc 203 and the gasket 201.

The system 1 comprises a supply line 3 for supplying the fluid processed by the pump 2 to a load.In Figure 1, this load comprises/consists in a lubrication system for an internal combustion engine. It is indicated by the reference letter “C”.

The supply line 3 extends downstream of a delivery side 24 of the pump 2.The supply line 3 starts precisely from the delivery side of the pump 2.

The system 1 conveniently comprises an element 4 that defines a localized loss in load. This element 4 is located along the supply line 3. It is located before the load C.

The element 4 that defines a localized loss in load preferably consists in/comprises a filter 40 for the fluid in transit in said supply line 3. The filter 40 determines a loss in load that can amount to as much as 2-3 bars, based on temperature, flow rate and blockage.

As an alternative, the element 4 could also consist in another component that determines an abrupt localized type of pressure loss.

The first thrust chamber 21 is supplied upstream of said element 4 that defines a localized loss in load.

The second thrust chamber 22 is supplied downstream of said element 4 that defines a localized loss in load.

Upstream and downstream refer to the direction of the fluid along the supply line 3.

The first and the second chamber 21, 22 are connected to the load supply line 3 at two points, one upstream and one downstream of the element 4 (of the filter 40).

The system 1 conveniently comprises a first branch 31 that supplies said first thrust chamber 21. The first branch 31 extends starting from said supply line 3 upstream of said element 4 that determines a localized loss in load.

The system 1 also comprises a second branch 32, which, downstream of said element 4, connects the load supply line 3 with the second thrust chamber 22.

In the solution illustrated in the figure, the thrusting action of the fluid present in the first chamber 21 is opposite the thrusting action of the fluid present in the second chamber 22.

In the solution illustrated in the figure, the fluid in the first thrust chamber 21 exerts a pressure that thrusts the stator 20 towards a maximum volume configuration.

The system 1 conveniently comprises regulating means 5 for regulating the pressure of the fluid in the first thrust chamber 21. This means 5 regulates the filling and emptying of the first chamber 21 with the fluid processed by the pump. In the solution illustrated, the regulating means 5 comprises a modulating spool valve 510. The regulating means 5 (particularly the modulating spool valve 510) is located along the first branch 31.

In a first operating mode of the pump 2, the regulating means 5 brings about a pressure in the first chamber 21 that is capable of balancing the

remaining forces acting upon the stator 20, keeping it in dynamic equilibrium.

In a second operating mode of the pump 2, the regulating means 5 brings about an increase in pressure in the first thrust chamber 21, with respect to the first operating mode, so as to bring about movement of the stator 2 into the maximum volume configuration of the pump 2.

In a predetermined configuration of the regulating means 5, the modulating spool valve 510 determines the emptying of the first thrust chamber 21. In this case, the fluid present in the first thrust chamber 21 is re-directed into a tank 9 upstream of the suction of the pump 2.

The modulating spool valve 510 comprises a piston that variously sets into communication three openings afforded on a cylinder along which the piston moves. As the piston is moved along the cylinder, it is possible, for example, to pass from the first to the second operating mode.

The pump 2 comprises elastic means 23 that act upon the stator 20.In the solution illustrated by way of example in the figure, the elastic means 23 exerts an action jointly with the fluid present in the first thrust chamber 21 so as to position the stator 20 in the maximum volume configuration.

The elastic means 23 comprises for example a compression spring. Leaving the condition of maximum volume, the spring is compressed. In this manner, even in the case where there is a breakdown in the electronics management of the control system, the pump 2 progresses towards a situation of maximum volume, minimizing the risk of “seizing”.

With respect to the first operating mode, the second operating mode of the pump 2 enables a more demanding functioning of the load (for example such functioning can involve operating conditions in which the engine brake is activated or mid-range/high-powered engines are operating on heavy vehicles).

The fact that the first chamber 21 is supplied from a point where there is higher pressure, with respect to a point supplying the second chamber 22, makes the response of the system and passage of the stator into the

maximum volume configuration faster, preventing, among other things, vibrations or undesired reactions.

The system 1 conveniently comprises an electronic control unit 6 for commanding the regulating means 5. This electronic control unit 6 determines the switching between the first and second operating mode of the pump 2.

The first branch 31 is conveniently connected to a maximum pressure safety valve 511. In the case of excess pressure along the supply line 3, this valve 511 enables the fluid to be discharged into a collection system (which is, in turn, operatively connected to the suction of the pump 2 and advantageously it coincides with the tank 9 mentioned hereinabove).

In the solution illustrated in the accompanying figure, the second chamber 22 is defined by the fluid dynamic sealing realized with the contribution of the third arc 205, the second arc 204 and the gasket 202.

The object of the present invention is also a method for controlling the operation of a positive displacement rotary pump 2 comprising a rotor 200 and a stator 20.The pump 2 is a variable displacement pump. A variation in the volume of the pump is associated with a movement of the stator. The control method is conveniently implemented by a control system 1 that has one or more of the characteristics described hereinabove.

The method comprises the stage of conveying a fluid exiting from the delivery side 24 of the pump 2 along a supply line 3 for supplying a load C.This comprises having the fluid pass through at least one filter 40.

The method further comprises the stage of positioning the stator 20 of the pump 2 in a position corresponding to an intermediate volume of the pump between the maximum and the minimum. This stage further comprises the following sub-stages:

-collecting part of the fluid in transit along the supply line 3 and conveying it into a first thrust chamber 21 for thrusting the stator 20;

-collecting part of the fluid in transit along said supply line 3, downstream of the filter 40 and conveying it into a second thrust chamber 22 for

thrusting a stator 20 of the pump 2.

The stage of conveying the fluid into the second thrust chamber 22 (this typically takes place through the second branch 32) brings about an increase in the pressure in this chamber 22. When an opposite force exerted by the elastic means 23 is surpassed, the stator 20 begins to move, leaving a position associated with the maximum volume of the pump 2.

The stage of conveying the fluid into the first chamber 21 makes it possible to balance the imbalance between the forces and to re-balance the stator 20 in a different position, with respect to the maximum volume position.

The position of the stator 20 is conveniently defined by the equilibrium at least of the following stresses:

-the pressure exerted on the stator 20 by the fluid present in the first chamber 21;

-the pressure exerted on the stator 20 by the fluid present in the second chamber 22;

-the force exerted on the stator by the elastic means 23.

There is thus obtained new equilibrium, with which a first operating mode of the pump 2 is associated.

Conveying the fluid into the first chamber 21 takes place through the first branch 31.The second thrust chamber 22 exerts an opposite thrust, with respect to the first chamber 21.

The method further comprises the stage of increasing the pressure of the fluid in the first thrust chamber 21, this determining a movement of the stator 20 into a maximum volume configuration. The stage of increasing the pressure of the fluid in the first chamber 21 comprises the introduction of additional fluid in the first chamber 21, taking it from the supply line 3 upstream of the filter 40 (through the first branch 31).

This takes place using the regulating means 5, which increases the pressure in the first thrust chamber 21, thereby moving the stator 20

towards a maximum volume configuration. Passage from the first to the second operating mode of the pump 2 is associated with a situation involving more demanding functioning (for example, but not necessarily, frequent recourse to the engine brake). Conveniently, passage from the first to the second operating mode of the pump 2 is determined by a command coming from an electronic control unit 6 based on the detection of a predetermined input (for example through sensors or an explicit user command).

The passage from the first to the second operating mode of the pump 2 determines a movement of the stator 20 accompanied by an increase in the volume of the pump 2.In said second operating mode of the pump 2, the pressure in said first chamber 21 is higher than it is in the first operating mode of the pump 2.

The invention thus conceived makes it possible to achieve multiple advantages.

First of all, it allows for rapid adaptation of the operation of the pump 2 in the case in which particularly demanding functioning is required (as one example, in the case in which the engine brake is activated). In this manner, the stator 20 can progress towards a position with which the maximum volume of the pump 2 is associated, thus ensuring a greater fluid flow rate so as to meet more demanding functioning needs.

Moreover, in this situation in which the second thrust chamber 22 is acting in opposition to the first thrust chamber 21, the latter can exert greater pressure with respect to the second thrust chamber. This is a result of the fact that the first chamber 21 is supplied from a point on the line 3 upstream of the filter, whereas the second chamber 22 is supplied from a point on the line 3 downstream of the filter. The first chamber 21 is thus supplied from a point where there is higher pressure, with respect to a point supplying the second chamber 22.This makes the response of the system and passage of the stator into the maximum volume configuration faster, preventing, among other things, vibrations or undesired reactions.

The invention thus conceived is susceptible to numerous modifications and variants, all of which falling within the scope of the inventive concept characterizing the invention. Moreover, all details may be replaced with other technically equivalent elements. All the materials used, as well as the dimensions, may in practice be of any type, according to needs.

CLAIMS

1. A control system comprising:

- a variable volume positive displacement rotary pump (2), in turn comprising:

i) a stator (20) that is movable so as to determine a variation in the volume of the pump (2);

ii) a first and a second thrust chamber (21, 22) for thrusting the stator (20) and designed to be filled with a fluid processed by the pump so as to regulate the movement of the stator (20);

-a supply line (3) for supplying the fluid processed by the pump (2) to a load;

-an element (4) that defines a localized loss in load, said element (4) being located along said supply line (3);

characterized in that said first and second thrust chambers (21, 22) are supplied upstream and downstream of said element (4) that defines a localized loss in load, respectively.

2.The system according to claim 1, characterized in that said element (4) that defines a localized loss in load comprises/consists in a filter (40) for the fluid, said filter being located along said supply line (3).

3. The system according to claim 1 or 2, characterized in that the fluid in the first thrust chamber (21) exerts a pressure that thrusts the stator (20) towards a maximum volume configuration.

4. The system according to any one of the preceding claims, characterized in that it comprises regulating means (5) for regulating the pressure of the fluid in the first thrust chamber (21).

5. The system according to claim 4, characterized in that in a first operating mode of the pump (2) the regulating means (5) brings about a pressure in the first chamber (21) that is capable of balancing the remaining forces acting upon the stator (20), keeping it in dynamic equilibrium;

in a second operating mode of the pump (2), the regulating means (5)

brings about an increase in pressure in the first thrust chamber (21), with respect to the first operating mode, so as to thrust the stator (20) towards a maximum volume configuration.

6. The system according to claim 4 or 5, characterized in that the regulating means (5) comprises a modulating spool valve (510), which is controlled by an electronic control unit (6); in a predetermined configuration of the regulating means (5), the modulating spool valve (510) determines the discharge of the fluid from the first thrust chamber (21).

7. The system according to any one of the preceding claims, characterized in that it comprises:

- a first branch (31), which supplies said first thrust chamber (21); said first branch (31) extending starting from said supply line (3) upstream of said element (4) that determines a localized loss in load;

- a second branch (32), which, downstream of said element (4), connects the load supply line (3) with the second thrust chamber (22).

8. The system according to any one of the preceding claims, characterized in that said pump (2) comprises elastic means (23) that exerts an action jointly with the fluid present in the first thrust chamber (21) so as to position the stator (20) in the maximum volume configuration.

9. The system according to any one of the preceding claims, characterized in that the pump (2) comprises a vane rotor (200) rotating within the stator (20).

10. A method for controlling the operation of a positive displacement rotary pump comprising a rotor and a stator, there being associated a variation in the volume of the pump with a movement of the stator, and said method comprising the stages of:

- conveying a fluid processed by the pump (2) along a supply line (3) for supplying a load (C) and having said fluid pass at least through one filter (40);

- positioning the stator (20) of the pump in a position corresponding to an intermediate volume of the pump between the maximum and the

minimum, said stage comprising the sub-stages of:

i) collecting part of the fluid in transit along said supply line (3) upstream of the filter (40) and conveying it into a first thrust chamber (21) for thrusting the stator (20) of the pump (2);

ii) collecting part of the fluid in transit along said supply line (3) downstream of the filter (40) and conveying it into a second thrust chamber (22) for thrusting a stator (20) of the pump (2);

- increasing the pressure of the fluid in the first thrust chamber (21), this determining a movement of the stator (20) into a maximum volume configuration; the stage of increasing the pressure of the fluid in the first chamber (21) comprising the introduction of additional fluid in the first chamber (21), taking it from the supply line (3) upstream of the filter (40).

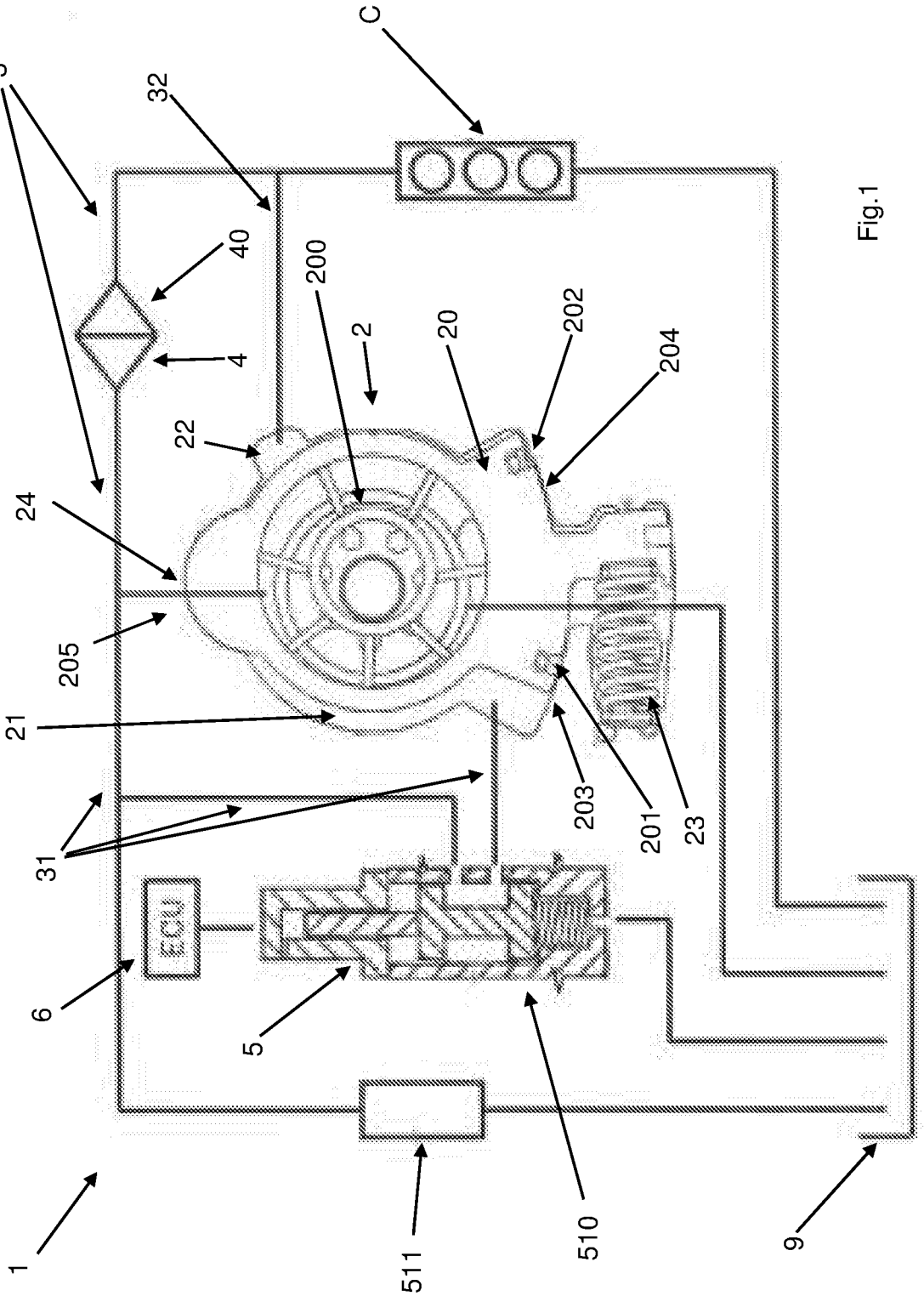
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Fig.1

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/057150

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04C2/344 F04C14/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2011 086681 A1 (BOSCH GMBH ROBERT [DE]) 23 May 2013 (2013-05-23) paragraph [0027] - paragraph [0039] figures 1,2	1-3,7-10
A	DE 20 2006 015508 U1 (JOMA HYDROMECHANIC GMBH [DE]) 7 December 2006 (2006-12-07) paragraph [0028] - paragraph [0029] figures 1,2	1-10
A	WO 2008/137037 A1 (BORGWARNER INC [US]; HUNTER DOUGLAS G [US]) 13 November 2008 (2008-11-13) page 3, line 11 - page 7, line 8 figures 1,2	1-10

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/057150

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/142611 A1 (MAHLE INT GMBH [DE]; WAGNER RENE [DE]) 16 December 2010 (2010-12-16) page 7, paragraph 4 - page 8, paragraph 2 page 10, paragraph 1 - paragraph 2 figures 1,2 -----	1-10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2015/057150

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