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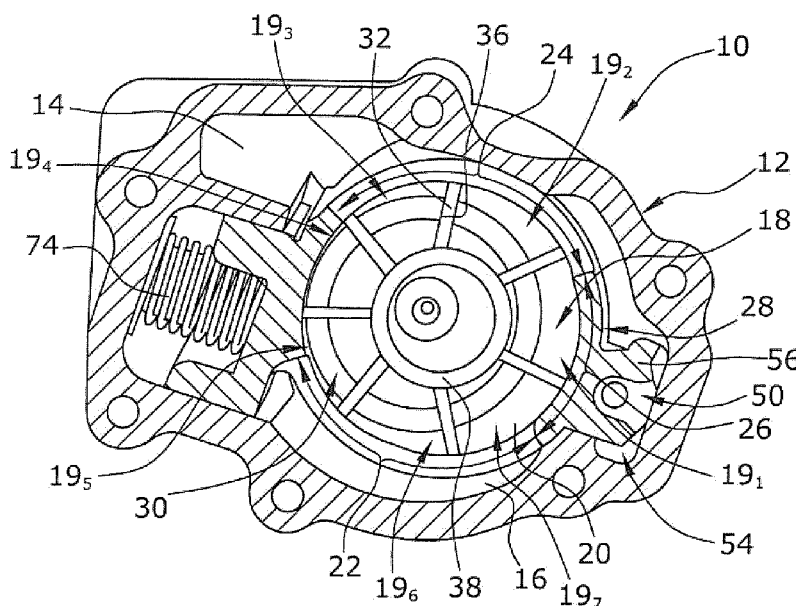


Fig. 1

(57) Abstract: The present invention refers to a lubricant vane pump (10) for providing pressurized lubricant for an internal combustion engine. The lubricant vane pump (10) is provided with a pump housing (12) with a pump rotor (30), whereby the pump rotor (30) is provided with radially slidable vanes (32) rotating in a shiftable control ring (28) which envelopes a pump chamber (18) with numerous rotating pump compartments (19₁-19₇) rotating from a charge zone (22) to a discharge zone (24). A pretensioning element (74) is pushing the control ring (28) to a high pumping volume direction. High lubricant pressure in a control chamber (54) causes the control ring (28) to be moved to a low pumping volume direction against the pretensioning element (74). A pump outlet cavity (14) is connected fluidically to the control chamber (54). The control ring (28) is provided with a pressure-relief-valve (52, 52') integrated into the control ring (28) and connecting or disconnecting the control chamber (54) with the pump compartment (19₁) between the charge zone (22) and the discharge zone (24) under defined connection

conditions.



WO 2014/146675 A1

Lubricant vane pump

DESCRIPTION

The present invention refers to a mechanical variable lubricant vane pump for providing pressurized lubricant for an internal combustion engine.

A mechanical lubricant vane pump is generally a volumetric pump which is driven by the engine. The lubricant vane pump is provided with a pump rotor body holding radially slidable vanes rotating inside a shiftable control ring. The slidable vanes, the rotor body and the control ring wall define a plurality of rotating pump compartments, rotating in a pump chamber. The pump chamber is separated into a charge zone with an inlet opening, a discharge zone with an outlet opening and an intermediate zone between the charge zone and the discharge zone. The intermediate zone is, seen in rotating direction, arranged between the charge zone and the discharge zone. The pump compartments rotate from the charge zone, through the intermediate zone to the discharge zone inside the control ring. The pump comprises a pretensioning element which pushes the control ring to a high pumping volume direction.

The control chamber acts against the pretensioning element when the pressure in the control chamber rises, so that, if the rotational speed increases, the control ring is pushed into a low pumping volume direction to keep the outlet pressure constant; if the rotational speed decreases, the control ring is pushed into a high

pumping volume direction, so that the lubricant is still pressurized with a more or less constant outlet pressure level, more or less independent of the rotational speed of the pump rotor or of the engine.

- 5 The lubricant pumped by the lubricant vane pump is incompressible oil with an unavoidable fraction of compressible air. When the rotating pump compartments arrive at the discharge zone, the pressurized lubricant of the pump outlet cavity can flow backwards into the pump cavity so that oscillations of the lubricant volume
10 can occur until the pressure outside and inside this pump compartment is equalized. The lubricant oscillation can lead to high pressure peaks and to hydraulic noise which causes acoustic noise, increased wear and micro-vibrations of the lubricant vane pump.

15 In the state of the art pumps, the hydraulic noise of the lubricant vane pumps is reduced by pre-compressing the lubricant-air-mixture in the pump compartment passing an intermediate zone between the charge zone and the discharge zone before the pump compartment is connected to the discharge zone. This measure reduces the efficiency of the lubricant vane pump.

- 20 It is an object of the present invention to provide an efficient lubricant vane pump with reduced hydraulic noise.

This object is solved with the lubricant vane pump with the features of claim 1.

25 The lubricant vane pump for providing a pressurized lubricant for an internal combustion engine comprises a pump housing with a pump rotor. The pump rotor is provided with numerous radially

slidable vanes rotating in a shiftable control ring. The vanes are preferably arranged not exactly radially but stabbing, so that they are more or less inclined with respect to a radial plane. The control ring is provided shiftable. The term "shiftable" here is not restricted
5 to a linear movement of the control ring.

The pump rotor is provided with numerous radially slidable vanes rotating in a shiftable control ring enveloping a pump chamber wherein numerous rotating pump compartments are rotating from a charge zone to a discharge zone. A pretensioning element pushes
10 the control ring to a high pumping position. A pressure control chamber is pushing the control ring to a low pumping volume direction against the force of the flexible pretensioning element and dependent on the liquid pressure in the control chamber.

The lubricant leaving the pump compartment in the discharge zone
15 flows directly into the pump outlet cavity which is directly connected to the control chamber. The direct fluidic connection between the control chamber and the pump outlet cavity can be realized by a conduit which causes no relevant pressure drop even at high lubricant flow rates through the conduit.

20 The control ring is shiftable between a high pumping volume position and a low pumping volume position. The pumping performance and the delivery pressure of the vane pump can be adapted to the lubricant pressure demand. By changing the compartment displacement the pumping volume of the vane pump
25 can be varied by radially shifting the control ring so that the pump compartment displacement per rotation is changed.

The control ring is provided with a pressure-relief-valve integrated

into the control ring and selectively connecting or disconnecting the control chamber with a pump compartment between the charge zone and the discharge zone under defined connection conditions. The pressure-relief-valve avoids effectively high local differential
5 pressure peaks in the outlet cavity and in the discharge zone in general. The pressure-relief-valve ensures a pressure equalization between the pump outlet cavity and the pump compartment in the intermediate zone even before the rotating pump compartment arrives at the discharge zone.

10 When the rotating pump compartment arrives at the discharge zone, the pressure differences are reduced so that the pressure peaks, the technical noise and the wear are reduced as well accordingly.

The pressure-relief-valve can be provided as a pressure-controlled-
15 valve or as a position-controlled-valve. A position-controlled-valve is closed only when the control ring is in an extreme position.

Preferably, the pressure relief valve is provided as a pressure-
controlled-valve. This pressure-controlled-valve is activated, when
a defined over-pressure is present in the pump outlet cavity with
20 respect to the pump compartment in the discharge zone.

Preferably, the pressure-relief-valve is a one-way-valve, which opens when a defined over-pressure in the control chamber with respect to the corresponding pump compartment is exceeded.

According to another alternative or additional preferred
25 embodiment, the pressure-relief-valve is provided with a valve inlet opening, whereby the valve inlet opening is covered by a

control chamber wall portion when the control ring is in the extreme high pumping volume position. This means that the lubricant vane pump includes a position-controlled-valve. This valve is purely dependent on and controlled by the position of the control ring. If the maximum pumping capacity is required, the pressure-relief-valve is closed, so that the pump performance is not reduced.

Preferably, the pressure-relief-valve is provided as a mechanical-check-valve. This mechanical check-valve provides a simple and reliable form of the pressure-controlled-valve. In contrast to an electrically activated valve, this type of valve is simply controlled by pressure difference.

Preferably, the pressure-relief-valve is arranged in a section of the control ring in an intermediate zone between the charge zone and the discharge zone. The pressure-relief-valve, which can be realized as a radial groove conduit or bore in the control ring, allows a calibrated leakage so that high differential pressure peaks can effectively be avoided. According to a preferred embodiment, this section of the control ring defines a plunger body in the control chamber.

According to another preferred embodiment, the pressure-relief-valve is directly connected to the pump chamber via a pressure-relief-conduit which can be provided as a bore.

According to a preferred embodiment, the pump outlet cavity is fluidically directly connected to the control chamber. The direct connection between the pump outlet cavity and the control chamber can be realized by an opening which causes no relevant

pressure drop even at high flow rates through the opening.

Preferably, the pretensioning element is a spring. In a special embodiment, the spring is provided as a mechanical metal spring. The spring is provided with a spring tension, so that a defined
5 pretensioning of the spring is present. The spring force determines the level of the discharge pressure of the lubricant.

The following is a detailed description of embodiments of the invention with reference to the drawings, in which:

10 Fig.1: shows a transversal cross section of a first embodiment of a lubricant vane pump 10 in maximal eccentric position,

Fig.2: shows a longitudinal cross section of the lubricant vane pump 10 of figure 1 in a controlled position, and

15 Fig.3: shows a second embodiment of a lubricant vane pump with the pressure-relief-valve in the opened position.

The figures show a lubricant vane pump 10 being a part of a pumping system for supplying an internal combustion engine with pressurized lubricant. The lubricant vane pump 10 pumps the lubricant to the combustion engine with a pump outlet pressure
20 and is driven by the engine.

The lubricant vane pump 10 comprises a pump housing 12 with a pump inlet cavity 16 and a pump outlet cavity 14, whereby the housing 12 also comprises two chamber side walls 20 covering the

pump chamber 18. The pump housing 12 also defines the pump inlet cavity 16 for sucking the lubricant from a lubricant tank and the pump outlet cavity 14 for feeding the lubricant with the pump outlet pressure to the engine. The pump chamber 18 is separated, in circumferential direction, into a charge zone 22 which is connected to the pump inlet cavity 16, a discharge zone 24 which is connected to the pump outlet cavity 14 and an intermediate zone 26 between the charge zone 22 and the discharge zone 24.

In the pump chamber 18 a shiftable control ring 28 and a pump rotor 30 with seven slidable vanes 32 are arranged. The pump rotor 30 is provided with a driven rotor hub 34 which is provided with vane slits 36 wherein the slidable vanes 32 are arranged radially shiftable. The vanes 32 separate the pump chamber 18 into pump compartments ($19_1 - 19_7$) so that the pump chamber 18 comprises seven rotating pump compartments ($19_1 - 19_7$). In the center of the rotor hub 34 a support ring 38 is provided which supports the radially inward ends of the slidable vanes 32. The pump rotor 30 rotates around a static rotor axis in anti-clockwise direction.

The seven rotating pump compartments ($19_1 - 19_7$) have a pump chamber sector angle of about 51° . Each rotating pump compartment ($19_1 - 19_7$) continuously rotates from the charge zone 22 via the intermediate zone 26 to the discharge zone 24 and back to the charge zone 22.

Figure 2 shows a perspective sectional view of the lubricant vane pump 10, wherein details of a valve arrangement 50 including a pressure-relief-valve 52, are shown. The lubricant, which is supplied to the engine through the pump outlet cavity 14, is also

conducted via the control chamber 54 and via the pressure-relief-valve 52 to the rotating pump compartment 19₁ in the intermediate zone.

The pressure-relief-valve 52 is provided in a plunger body 56 of the control ring 28. This plunger body 56 is provided in the control chamber 54 and is pushed radially by the outlet pressure against the spring force of the counteracting pretensioning element 74. The pressure-relief-valve 52 of the first embodiment is provided as a mechanical check-valve with a valve spring 62. The pressure-relief-valve 52 has an axial flow direction and is connected to the intermediate zone 26 via a axial inlet opening 60 and outlet opening 62. The inlet opening 60 is always accessible, independent of the radial position of the control ring 28.

The pressure-relief-valve 52 opens if a certain differential pressure between the pressure at the outlet opening 62 and the pressure inside the rotating pump compartment 19₁ in the intermediate zone 26 exceeds a certain constant value defined by the valve spring 62. Above the defined differential pressure, the pressure-relief-valve 52 is open, so that the differential pressure is reduced, and the liquid oscillation, the pump vibration and the fluidic noise are reduced.

Figure 3 shows a second embodiment of the valve arrangement 50'. The valve arrangement 50' is provided with a simple radial pressure relief conduit 70 comprising a distal valve inlet opening 78 and a proximal outlet opening 80. The pressure relief conduit 70 is provided in the plunger body 56, whereby the radial movement of the plunger body 56 including the control ring 28 is stopped by the circumferential pump chamber wall 20 in the maximum pumping

volume position. In this position, the pressure-relief-valve inlet opening 78 is covered and closed by the circumferential pump chamber wall 20, so that no pressure relief is possible in the maximum pumping volume position on the control ring 28.

- 5 As soon as the control ring 28 is not in its maximum volume pumping position, the pressure-relief-valve 52' is continuously open.

Reference-List

	10	lubricant vane pump
	12	pump housing
	14	pump outlet cavity
5	16	pump inlet cavity
	18	pump chamber
	19	rotating pump compartments
	20	pump chamber side wall
	22	charge zone
10	24	discharge zone
	26	intermediate zone
	28	control ring
	30	pump rotor
	32	slidable vanes
15	34	rotor hub
	36	vane slits
	38	support ring
	50, 50'	valve arrangement
	52, 52'	pressure-relief-valve
20	54	control chamber
	56	plunger body
	60	inlet opening
	62	outlet opening
	70	pressure relief conduit
25	71	pressure relief conduit
	74	pretensioning element
	76	groove
	78	valve inlet opening

CLAIMS

1. A lubricant vane pump (10) for providing pressurized lubricant for an internal combustion engine, with
a pump housing (12) with a pump rotor (30), whereby the
5 pump rotor (30) is provided with radially slidable vanes (32)
rotating in a shiftable control ring (28) which envelopes a
pump chamber (18) with numerous rotating pump
compartments (19₁ - 19₇) rotating from a charge zone (22)
to a discharge zone (24),
10 a pretensioning element (74) pushing the control ring (28) to
a high pumping volume direction,
a control chamber (54), whereby high lubricant pressure in
the control chamber (54) causes the control ring (28) to be
moved to a low pumping volume direction against the
15 pretensioning element (74), and
a pump outlet cavity (14), whereby the pump outlet cavity
(14) is fluidically connected to the control chamber (54),
characterized in that
the control ring (28) is provided with a pressure-relief-valve
20 (52, 52') integrated into the control ring (28) and connecting
or disconnecting the control chamber (54) with the pump
compartment (19₁) between the charge zone (22) and the
discharge zone (24) under defined connection conditions.
- 25 2. Lubricant vane pump (10) of claim 1, whereby the pressure-
relief-valve (52) opens when a defined over-pressure in the
control chamber (54) with respect to the pump compartment
(19₁) is exceeded.

3. Lubricant vane pump (10) of claim 1, whereby the pressure-relief-valve (52') is provided with a valve inlet opening (78), whereby the valve inlet opening (78) is covered by a control chamber wall portion (80) when the control ring (28) is in the high pumping volume position.
- 5
4. Lubricant vane pump (10) of one of the preceding claims 1 or 2, whereby the pressure-relief-valve (52) is provided as a mechanical check-valve.
- 10
5. Lubricant vane pump (10) of one of the preceding claims, whereby the pressure-relief-valve (52, 52') is arranged in a section of the control ring (28) in an intermediate zone (26) between the charge zone (22) and the discharge zone (24).
- 15
6. Lubricant vane pump (10) of claim 5, whereby the section of the control ring (28) defines a plunger body (56) in the control chamber (54).
- 20
7. Lubricant vane pump (10) of one of the preceding claims, whereby the pressure-relief-valve (52') is directly connected to the pump chamber (18) via a pressure-relief-conduit (70).
8. Lubricant vane pump (10) of one of the preceding claims, whereby the pump outlet cavity (14) is fluidically directly connected to the control chamber (54).
- 25
9. Lubricant vane pump (10) of one of the preceding claims,

wherein the pretensioning element (74) is a spring.

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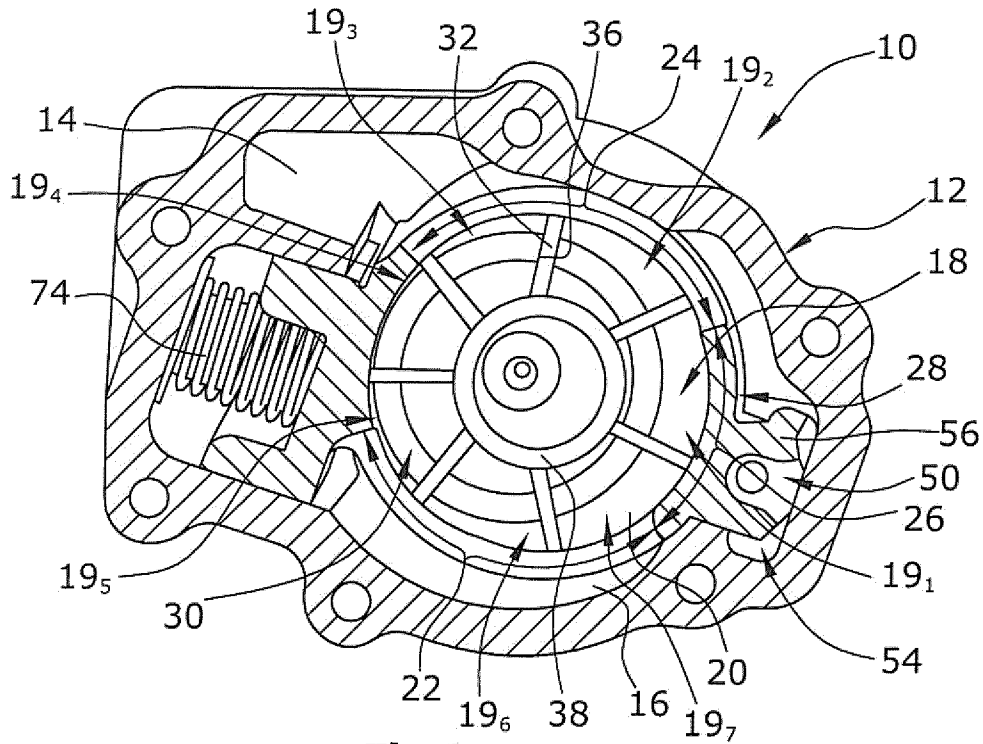


Fig.1

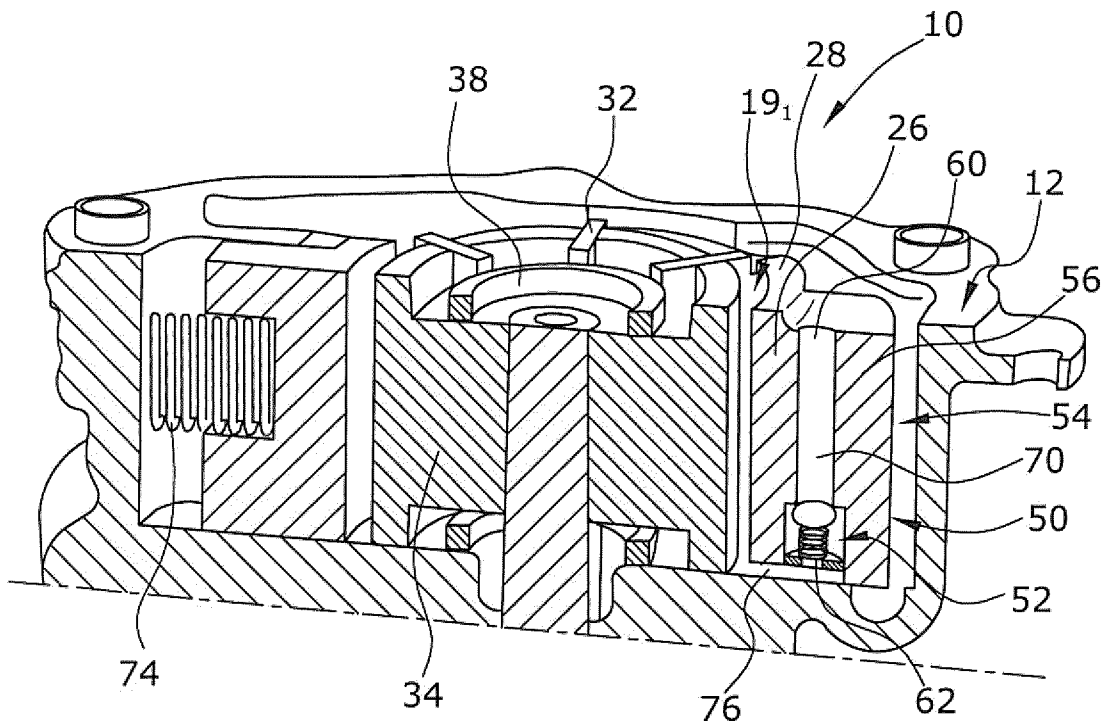


Fig.2

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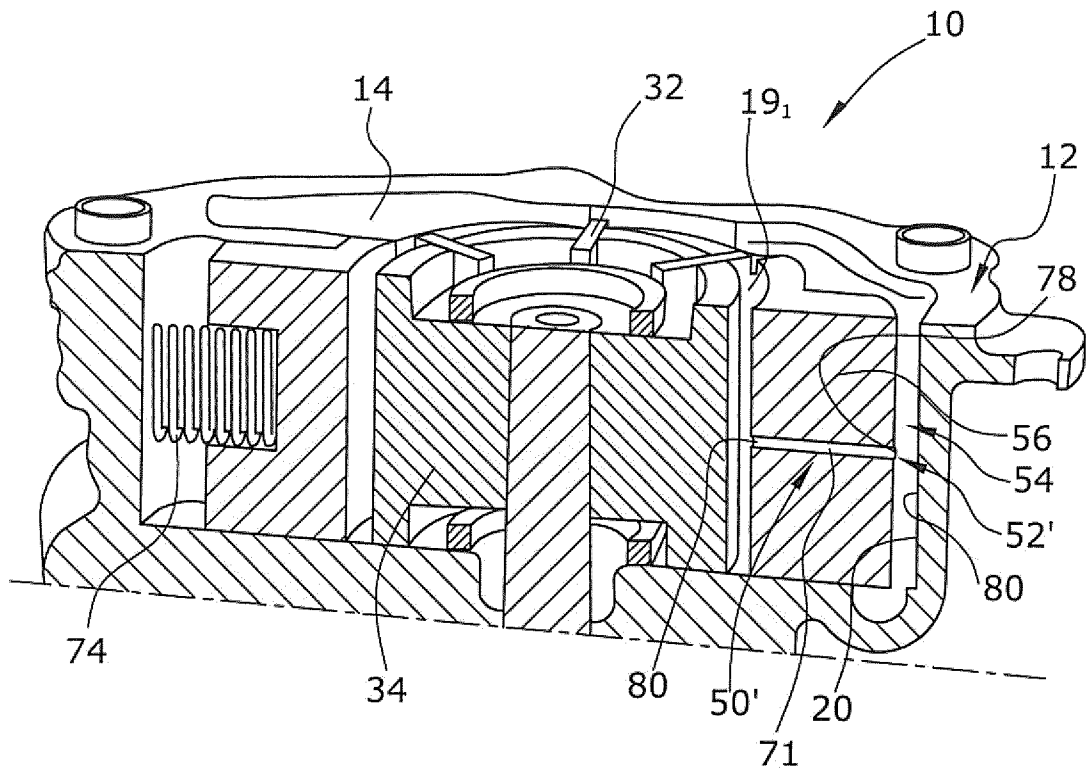


Fig.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/055527

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F04C14/22 F04C14/10 F04C2/344
 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

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A	EP 1 790 855 A2 (BORGWARNER INC [US] SLW AUTOMOTIVE INC [US]) 30 May 2007 (2007-05-30) figure 2 paragraph [0033] - paragraph [0038] paragraph [0041] - paragraph [0042] -----	1
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Further documents are listed in the continuation of Box C.

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	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search 30 September 2013	Date of mailing of the international search report 11/10/2013
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Papastefanou, M
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/EP2013/055527

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