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(71) Applicant(s):  
Delphi Technologies IP Limited  
Erin Court, Bishop's Court Hill, St Michael, Barbados

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(72) Inventor(s):  
David J Lane

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(74) Agent and/or Address for Service:  
Delphi France SAS  
c/o Delphi Technologies, Campus Saint Christophe,  
Batiment Galilee 2, 10 avenue de l'Entreprise,  
95863 Cergy Pontoise CEDEX,  
France (including Overseas Departments and Territories)

(54) Title of the Invention: **High pressure fuel pump**  
Abstract Title: **Pressure balancing of a high pressure fuel pump**

(57) An arrangement 10 of a fuel pump 12 on the crankcase 14 of an internal combustion engine is disclosed. The pump has a housing 22 which encloses a camshaft bore 26, in which a camshaft 30 is arranged, and a compression bore 28 which guides a piston 44. The crank housing 22 encloses an inner space S14 and is provided with an opening 18 in which part of the pump 20 is engaged. An end of the camshaft 30F extends through the opening for connection to a driving means. The arrangement defines a flow path F which allows fluid communication joining the piston bore 28 to camshaft bore via the internal space of the crankcase S14. The arrangement allows pressure to balance either side of the cam follower and minimises the number of manufacturing steps. The invention extends to a fuel pump adapted to be part of the arrangement, which may be a diesel pump.

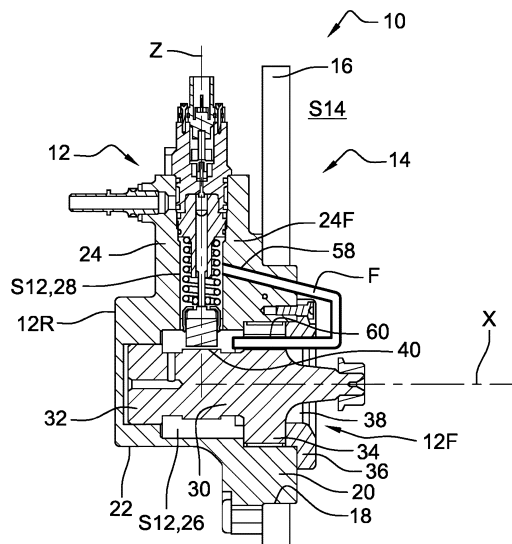
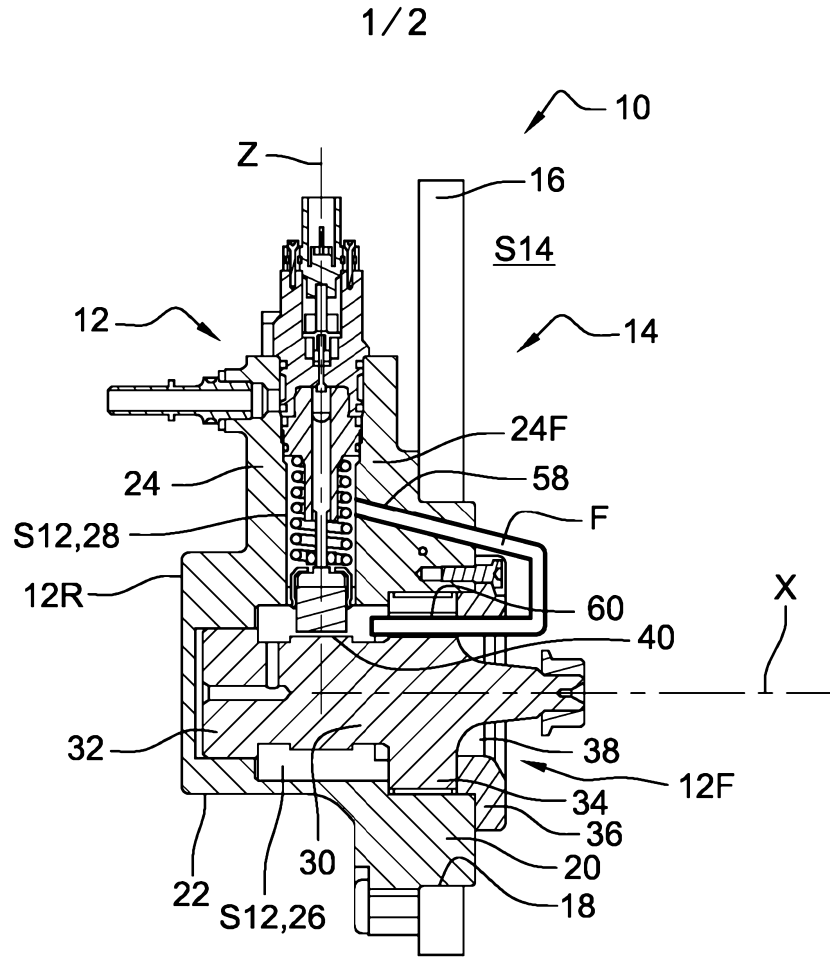
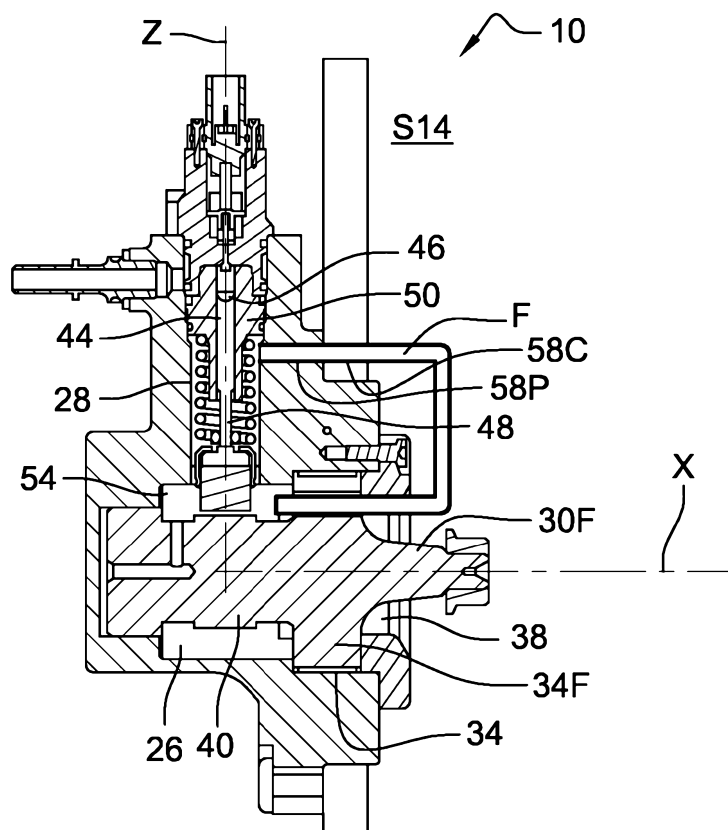


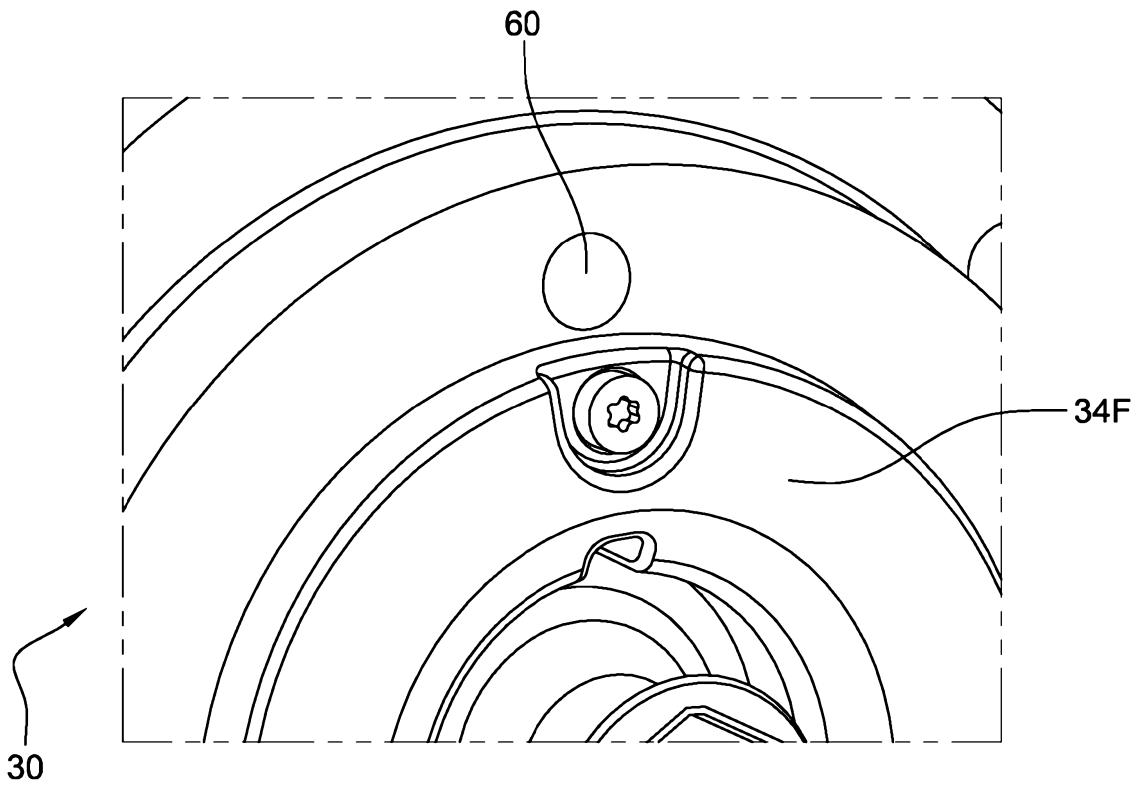
Fig. 1



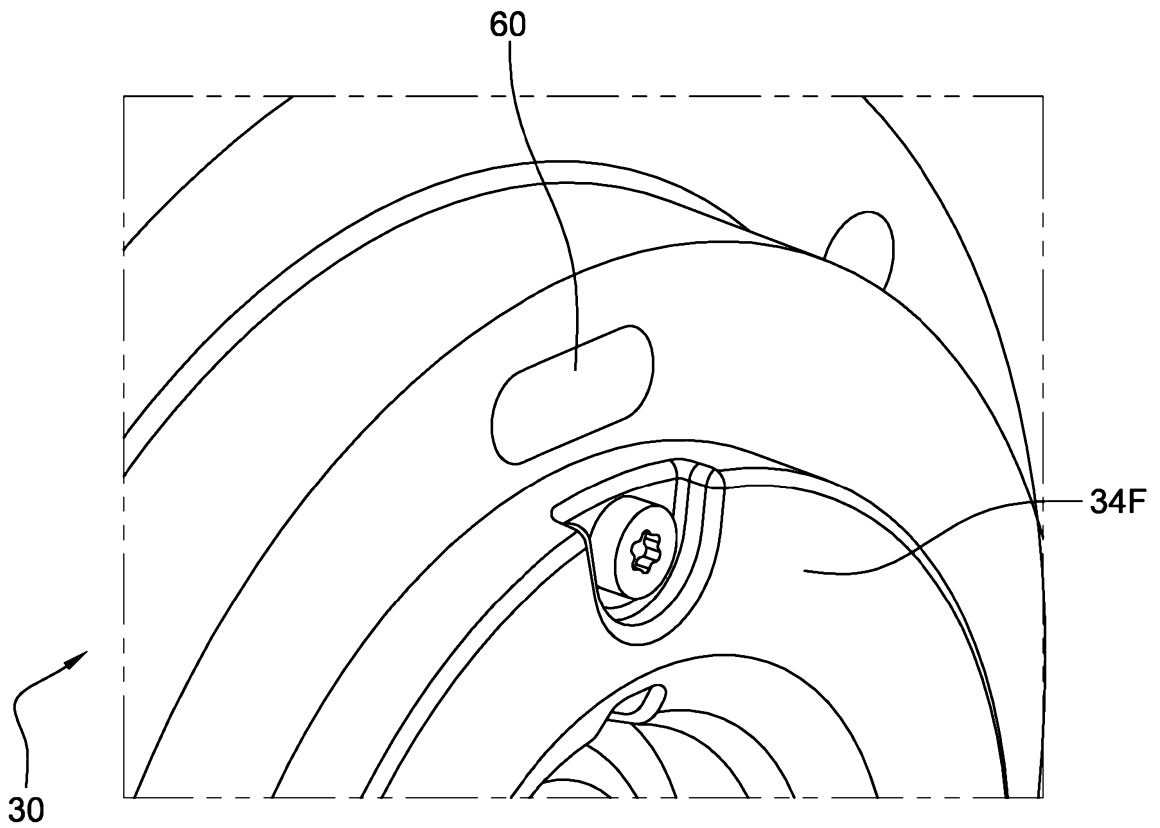
**Fig. 1**



**Fig. 2**



**Fig. 3**



**Fig. 4**

## **HIGH PRESSURE FUEL PUMP**

### 5 TECHNICAL FIELD

The present invention relates to a high pressure fuel pump wherein a camshaft cooperates with a piston to pressurise fuel in a compression chamber, the invention being about balancing the pressures on both side of a cam follower.

### 10 BACKGROUND OF THE INVENTION

In a high pressure fuel pump of a fuelling equipment of an internal combustion engine, a camshaft rotates in a camshaft bore and urges via a cam follower a piston to reciprocal displacements in a compression bore. Said cam follower is slidably guided at an end of said compression bore preventing fluid  
15 transfer between the compression bore and the camshaft bore thus generating pressure variations and pressure spikes within the pump and the equipment. Pressure balancing means have been developed such as external piping joining said two bores or, holes running within the pump housing and made during the foundry process. Said solutions are complex and expensive since requiring long  
20 and difficult additional manufacturing steps.

### SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing an arrangement of a fuel pump on the crankcase  
25 of an internal combustion engine.

The pump has a housing enclosing a camshaft bore wherein a camshaft arranged between bearings is rotatable about a camshaft axis and, a compression bore wherein a piston is guided along a compression axis.

The crankcase has a housing enclosing an crankcase inner space, said  
30 crankcase housing being provided with an opening in which part of the pump housing is engaged, a front end of the camshaft extending through said opening for enabling connection of driving means.

The arrangement defines a fluid communication joining the compression bore to the camshaft bore via the crankcase inner space.

More precisely, said fluid communication comprises a first portion extending between the compression bore and the crankcase inner space and, a second portion extending between the crankcase inner space and the camshaft bore.

5 In an embodiment, the first portion comprises a first hole entirely extending in a front wall of the pump housing, said first hole opening at an inner end in the compression bore and at an outer end in said part of the pump engaged in the crankcase opening.

In another embodiment, the first portion comprises a first hole  
10 comprising a pump portion extending in the pump housing and a crankcase portion extending in a wall of the crankcase.

Whichever embodiment is, said first portion may comprise a plurality of first holes.

The second portion of the fluid communication comprises second hole  
15 extending through the camshaft and, more precisely, through a portion of the camshaft forming a front wheel defining a front bearing.

Said second portion of the fluid communication may comprise a plurality of second holes extending through the camshaft.

In another alternative, the second portion of the fluid communication  
20 may be provided through the front bearing, said front bearing being, for instance, a roller bearing and said second portion of the fluid communication being provided between rollers.

The application extends to a high pressure fuel pump adapted to be part of an arrangement as described above, the pump having a housing adapted to be  
25 fixed against a wall of crankcase of an internal combustion engine.

Said high pressure pump may be a diesel pump.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now described by way of example with  
30 reference to the accompanying drawings in which:

Figures 1 and 2 are axial sections of a pump arrangement as per a first and a second embodiment of the invention.

Figures 3 and 4 detail two construction alternatives on the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figures 1 and 2 show an arrangement 10 of a fuel pump 12 fixed on a crankcase 14, said arrangement being part of a fuel injection equipment of an internal combustion engine wherein fuel is pressurised in the pump 12 to several thousands of bars prior to be flown toward fuel injectors.

The example chosen to illustrate the invention is a diesel pump pressure, said pump 12 having a rear side 12R (left of the figures) opposed to a front side 12F (right of the figure) fixed to a front wall 16 of the crankcase 14. For positioning and fixing said pump 12 on said crankcase 14, said crankcase front wall 16 is provided with an opening 18 in which is complementary engaged a cylindrical protrusion 20 of the front side 12F of the pump 12 and, as sketched on the figures, said opening 18 opens into a crankcase inner space S14 normally filled with lubrication oil and wherein, in use, are arranged pump driving means such as gears.

More precisely, the pump 12 has a housing 22 with peripheral walls 24 surrounding a T-shaped inner space S12 defining a camshaft bore 26, extending along a camshaft axis X, in which perpendicularly opens a compression bore 28, extending along a compression axis Z. In the camshaft bore 26 is arranged a camshaft 30 rotatable between a rear bearing 32 defined by a camshaft rear wheel which peripheral rear journal is complementary engaged in a rear bushing placed in a recess of a pump rear wall and, a front rear bearing 34 defined by a camshaft front wheel 34F which peripheral front journal rotates in a front bushing arranged in a cylindrical opening of a pump front wall 24F. As shown, the camshaft bore 26 extends through the pump front wall 24F and, a front plate 36 is screwed to said front wall 24F before said bore opening, said plate 36 having a thick washer-like shape provided with a central opening 38 smaller than the camshaft bore opening.

Between said rear and front 34F wheels, the camshaft is thinner and it comprises a cam 40 facing the compression bore 28 opening. The camshaft 30 further comprises a front end 30F frontwardly extending beyond the front bearing 34 through said front plate opening 38 outside the pump housing 22, said front end 30F protruding in said the crankcase inner space S14 for complementary receiving said driving means.

In the pump is further arranged a piston 44 slidably guided in the compression bore 28, said piston 44 extending between a head 46 and a foot 48, the piston head 46 being engaged in a compression head member 50 inserted in the compression bore. Said compression head member 50 is provided with a  
5 piston guiding bore adjusted to the piston diameter, an upper end of said guiding bore defining a compression chamber, the piston head 46 also partially defining said compression chamber wherein the fuel is pressurised. At the opposite end of the piston, the piston foot 48 cooperates with a cam follower 54 slidably adjusted and guided in an inner end portion of the compression bore, said inner end being  
10 proximal to the opening in the camshaft bore. The follower 54 is adjusted in the compression bore 28 with a thin functional clearance enabling guiding and sliding. The follower 54 is downwardly urged in permanent contact against the cam 40 by a spring arranged in the compression bore and compressed between said follower 54 and said compression head member 50.

15 Opposite to its opening in the camshaft bore, an inlet valve assembly coaxially arranged with the compression bore plugs the outer opening of the compression bore, said inlet valve assembly comprising a valve member, a control actuator and an electric connector.

In use, the pressures in the two bores vary because of the reciprocal  
20 displacements of the cam follower 54, the functional clearance not being large enough to enable important fluid transfer between the bores. To balance the pressures between the compression bore 28 and the camshaft bore 26, a large fluid communication F is provided between said bores and the crankcase inner space S14. Said fluid communication F comprises a first portion F1 defined by a first  
25 hole 58 joining the compression bore 28 to the crankcase inner space S14 and, a second portion F2 defined by a second hole 60 joining the crankcase inner space S14 to the camshaft bore 26.

In a first embodiment of the arrangement 10 shown on figure 1, the first  
30 hole 58 entirely extends through the pump housing front wall 24F, opening at an inner end in the compression bore and, at the opposite outer end in the cylindrical protrusion 20 of the front side 12F of the pump 12 inside said crankcase front wall opening 18. Said first hole 58 may be drilled angled relative to the camshaft axis

X, as it is sketched on figure 1 or alternatively, it can be drilled parallel to said camshaft axis X.

In a second embodiment of the arrangement 10, shown on figure 2, the first hole 58 extends through the wall of the pump and through the wall of the crankcase thus comprising a pump portion 58P and a complementary crankcase portion 58C.

Moreover, said first portion F1 of the fluid communication can comprise one hole 58 or a plurality of holes 58 drilled through the pump front wall 24F or through the pump wall and the crankcase wall, only one being sketched on the figures.

The second hole 60 parallel to the camshaft axis X is drilled through the camshaft front wheel 34F. Said second hole 60 can be circular or oblong as shown in the examples of figures 3 and 4 or having any other shape. Also, said second portion F2 of the fluid communication can comprise one hole 60 or a plurality of holes 60 drilled through the front wheel 34F, only one being sketched on the figures.

In an alternative not shown, the second portion F2 of the fluid communication may be provided through the front bearing itself. For instance if said front bearing is a roller bearing, said fluid communication F2 is provided without any additional drilling as the fluid may pass between the rollers.

#### LIST OF REFERENCES

	X	axis
	Z	axis
25	S12	inner space of the pump
	S14	inner space of the crankcase
	F	fluid communication
	F1	first portion of the fluid communication
	F2	second portion of the fluid communication
30	10	arrangement
	12	pump
	12R	rear side of the pump



	12F	front side of the pump
	14	crankcase
	16	front wall of the crankcase
	18	opening in the wall of the crankcase
5	20	cylindrical protrusion of the pump front
	22	housing of the pump
	24	wall of the housing of the pump
	24F	front wall of the pump housing
	26	camshaft bore
10	28	compression bore
	30	camshaft
	30F	front end protrusion of the camshaft
	32	rear bearing
	34	front bearing
15	34F	front journal
	36	front plate
	38	opening in the front plate
	40	cam
	44	piston
20	46	head of the piston
	48	foot of the piston
	50	compression head member
	54	cam follower
	58	first hole
25	58P	pump portion of the first hole
	58C	crankcase portion of the first hole
	60	second hole

## CLAIMS:

1. Arrangement (10) of a fuel pump (12) on the crankcase (14) of an internal combustion engine,  
5 the pump (12) having a housing (22) enclosing a camshaft bore (26) wherein a camshaft (30) arranged between bearings (32, 34) is rotatable about a camshaft axis (X) and, a compression bore (28) wherein a piston (44) is guided along a compression axis (Z) and,  
the crankcase (14) having a housing enclosing an crankcase inner space  
10 (S14), said crankcase housing being provided with an opening (18) in which part (20) of the pump housing is engaged, a front end of the camshaft (30F) extending through said opening (18) for enabling connection of driving means and wherein,  
the arrangement (10) defines a fluid communication (F) joining the compression bore (28) to the camshaft bore (26) via the crankcase inner space  
15 (S14).
2. Arrangement (10) as claimed in the preceding claim wherein said fluid communication (F) comprises a first portion (F1) extending between the compression bore (28) and the crankcase inner space (S14) and, a second portion  
20 (F2) extending between the crankcase inner space (S14) and the camshaft bore (26).
3. Arrangement (10) as claimed in claim 2 wherein said first portion (F1) comprises a first hole (58) entirely extending in a front wall (24F) of the pump  
25 housing, said first hole (58) opening at an inner end in the compression bore (28) and, at an outer end in said part (20) of the pump engaged in the crankcase opening (18).
4. Arrangement (10) as claimed in claim 2 wherein said first portion (F1)  
30 comprises a first hole (58) comprising a pump portion (58P) extending in the pump housing and a crankcase portion (58C) extending in a wall (16) of the crankcase.

5. Arrangement (10) as claimed in any one of the claims 3 or 4 wherein said first portion (F1) comprises a plurality of first holes (58).
6. Arrangement (10) as claimed in any one of the claims 2 to 5 wherein said  
5 second portion (F2) of the fluid communication comprises second hole (60) extending through the camshaft.
7. Arrangement (10) as claimed in claim 6 wherein said second portion (F2) of the fluid communication comprises a plurality of second holes (60) extending  
10 through the camshaft.
8. Arrangement (10) as claimed as in any one of the claims 2 to 5 wherein said second portion (F2) of the fluid communication is provided through the front bearing (34).  
15
9. Arrangement (10) as claimed in claim 8 wherein said front bearing (34) is a roller bearing, said second portion (F2) of the fluid communication being provided between rollers.
- 20 10. High pressure fuel pump (12) adapted to be part of an arrangement (10) as claimed as in any one of the preceding claims, the pump (12) having a housing adapted to be fixed against a wall of crankcase of an internal combustion engine.
11. High pressure diesel pump (12) as claimed as in claim 10.  
25



**Application No:** GB1719215.4

**Examiner:** Dr Nicholas Wigley

**Claims searched:** 1-11

**Date of search:** 19 April 2018

**Patents Act 1977: Search Report under Section 17**

**Documents considered to be relevant:**

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	EP2657505 A1 (DELPHI TECH HOLDING SARL) See whole document, especially Figure 1 noting conduit 51
A	-	US2004/105761 A1 (FELMANN & FRASCH) See whole document, especially Figure 1b noting conduit 53
A	-	US2016/108875 A1 (LAMM & BOECKING) See whole document, especially Figure 1 noting bore 11
A	-	DE102009003094 A1 (BOSCH GMBH ROBERT) See whole document, especially Figure 1 noting balancing bore 11
A	-	DE102012216594 A1 (BOSCH GMBH ROBERT) See whole document, especially Figure 1 noting channel 17a
A	-	US2016/215663 A1 (KURODA) See whole document, especially Figure 3 noting communication hole 53

**Categories:**

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>X</sup> :

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Worldwide search of patent documents classified in the following areas of the IPC

B60K; F02B; F02M; F04B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI & Patents Fulltext



**International Classification:**

<b>Subclass</b>	<b>Subgroup</b>	<b>Valid From</b>
F02M	0059/02	01/01/2006
B60K	0025/02	01/01/2006
F02B	0067/04	01/01/2006
F02M	0037/04	01/01/2006
F02M	0039/02	01/01/2006
F04B	0009/04	01/01/2006