



EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.02.2019 Bulletin 2019/06

(51) Int Cl.:
F02M 59/36 ^(2006.01) **F02M 59/46** ^(2006.01)
F02M 41/14 ^(2006.01)

(21) Application number: **18183555.4**

(22) Date of filing: **13.07.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Delphi Technologies IP Limited**
Saint Michael (BB)

(72) Inventor: **MACLANE, Stephen, Joseph**
Gillingham, Kent ME8 0RU (GB)

(74) Representative: **Delphi France SAS**
c/o Delphi Technologies
Campus Saint Christophe
Bâtiment Galilée 2
10, avenue de l'Entreprise
95863 Cergy Pontoise Cedex (FR)

(30) Priority: **01.08.2017 GB 201712342**

(54) **FUEL PRESSURISING DEVICE**

(57) A pressurising device of a direct fuel injection equipment comprising a digital inlet metering valve controlling an inlet fluid communication to a pump and wherein, the DIMV switches to an open state after said the

pump initiates a filling phase (PF) and, switches to a closed state when approaching the end of said filling phase (PF).

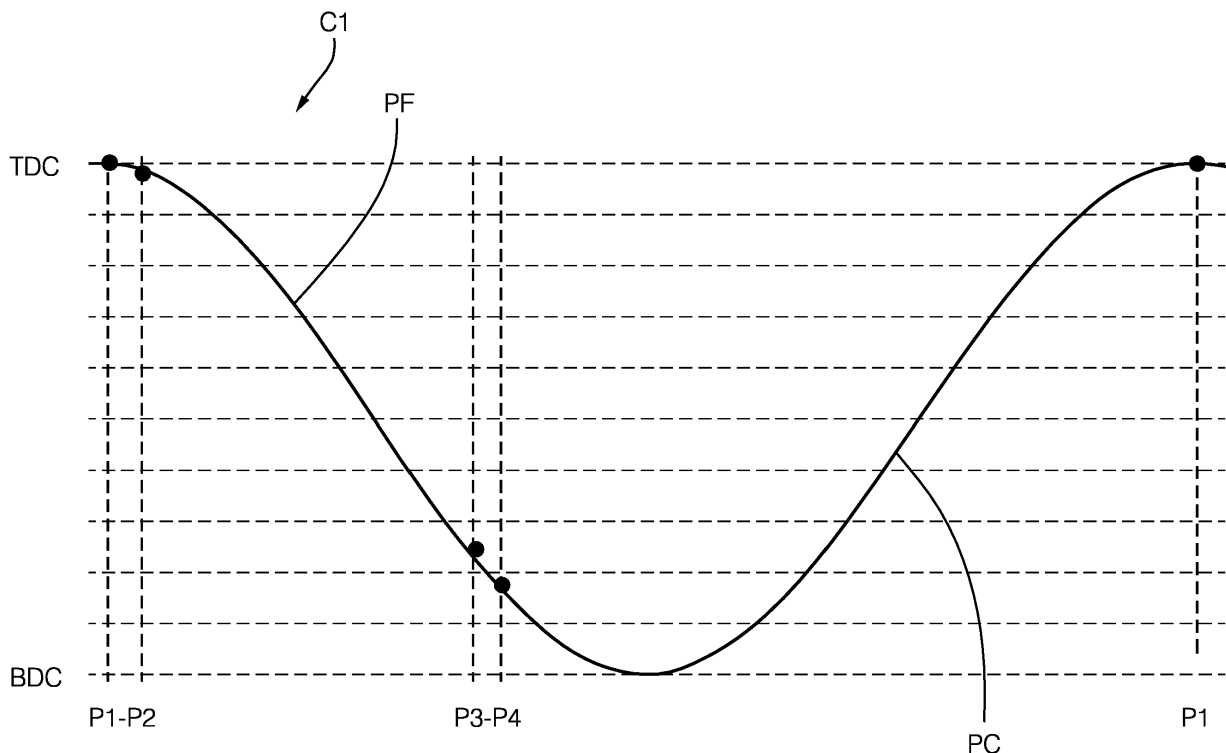


FIG. 2

Description

TECHNICAL FIELD

[0001] The present invention relates to a pressurising device of a fuel injection equipment wherein a single metering valve controls the inlet flow into a high pressure pump performing one or two pumping cycles.

BACKGROUND OF THE INVENTION

[0002] A diesel fuel injection equipment arranged on an internal combustion engine comprises a high pressure pump receiving a low pressure upstream fuel flow and delivering to a common rail and to injectors a high pressure downstream flow. An inlet metering valve connected to a command unit limits said upstream flow to the quantity required to match the engine torque and power demand.

[0003] Unfortunately, said high pressure diesel pumps often suffer a drop in volumetric efficiency due to an inability to fill the pumping chamber at high speeds. This is becoming notably more of a problem with the pumps needing to run at engine speeds of up to 6000RPM. This problem is made worse with twin headed pumps, the biggest known restriction being said inlet metering valve.

SUMMARY OF THE INVENTION

[0004] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a pressurising device of a direct fuel injection equipment (FIE) of a diesel internal combustion engine, said pressurising device comprising a digital inlet metering valve (DIMV), controlling an inlet fluid communication to a pump performing, in use, a pumping cycle in a pumping head, said cycle being the alternation of a filling phase and a compression phase. The DIMV switches to an open state after said cycle initiates a filling phase and, switches to a closed state when approaching the end of said filling phase.

[0005] Also, the DIMV and the pump are integrated in a single housing forming in compact assembly of the FIE. also, the pump comprises:

- the pumping head defining a compression chamber having an inlet controlled by an inlet valve and an outlet controlled by an outlet valve and, a piston reciprocally moving, in use, between BDC and TDC along a pumping axis to perform said pumping cycle.

[0006] The DIMV comprises an electro 2-way valve controlling the inlet into a buffer chamber connected to the inlet.

[0007] Also, in use, in open state of the DIMV the fuel fills said buffer chamber and from there fills the compression chamber of the pumping head that is in filling phase PF and which volume increases.

[0008] Also, the pump is a twin-head-pump performing, in use, said first pumping cycle in said first pumping head and, a second pumping cycle in a second pumping head, said cycles being the alternation of a filling phase and a compression phase, said first and second cycles being in opposition of phase of one another so that, the compression phase of a cycle is simultaneous to the filling phase of the other cycle. The DIMV controls the inlet fluid communication to said twin-head-pump and it switches to an open state after either cycle initiates a filling phase and, switches to a closed state when approaching the end of said filling phase.

[0009] Also, the DIMV and the twin-head-pump are integrated in a single housing forming in compact assembly of the FIE.

[0010] Also, in use, low pressure fuel exiting the DIMV is delivered to the twin-head-pump wherein it is compressed in the first pumping cycle or in the second pumping cycle.

[0011] Also, the twin-head-pump comprises:

- the first pumping head defining a first compression chamber having a first inlet controlled by a first inlet valve and a first outlet controlled by a first outlet valve and, a first piston reciprocally moving, in use, between BDC and TDC along a first axis to perform said first pumping cycle;
- the second pumping head defining a second compression chamber having a second inlet controlled by a second inlet valve and a second outlet controlled by a second outlet valve and, a second piston reciprocally moving, in use, between BDC and TDC along a second axis to perform said second pumping cycle and wherein,

the digital inlet metering valve DIMV comprises an electro 2-way valve controlling the inlet into a buffer chamber connected to the first inlet and to the second inlet.

[0012] Also, in use, in open state of the DIMV the fuel fills said buffer chamber and from there fills the compression chamber, of the pumping head, that is in filling phase PF and which volume increases.

[0013] The invention further extends to a fuel injection equipment for a diesel internal combustion engine, said FIE comprising a pressurising unit as previously described.

[0014] The invention further extends to a control method of a fuel injection equipment as claimed in claim, the method comprising the following steps:

- receiving signals enabling to determine the quantity of fuel required to be injected in the engine;
- computing the duration that the DIMV needs to be in open state to enable said required quantity of fuel to enter the pump ;
- switching the DIMV to said open state when the pumping cycle initiates a filling phase;
- switching the DIMV to the closed state when the du-

ration time has lapsed.

[0015] The step switching the DIMV to an open state enables fuel to fill the buffer chamber when the pumping cycle initiates a filling phase, the inlet valves being closed preventing fuel entry into the compression chamber then, subsequent to said switching step, the method comprises the step

- keeping the DIMV in said open state when the inlet valve opens.

[0016] The method may comprise the following steps:

- computing the duration that the DIMV needs to be in open state to enable said required quantity of fuel to enter the twin-head-pump ;
- switching the DIMV to said open state when either one of the pumping cycles initiates a filling phase;
- switching the DIMV to the closed state when the duration time has lapsed.

[0017] The step switching the DIMV to an open state enables fuel to fill the buffer chamber when either of the pumping cycles initiates a filling phase, both first and second inlet valves, being closed preventing fuel entry into the compression chambers then, subsequent to said switching step, the method comprises the step

- keeping the DIMV in said open state when either one of the first or second inlet valve opens.

[0018] The invention further extends to an electronic command unit adapted execute a method as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is a partial sketch of a fuel injection equipment comprising a pressurising device as per the invention.

Figure 2 is a pumping cycle of a pressurising device of figure 1.

Figure 3 is a second embodiment of a pressurising device as per the invention.

Figure 4 is a plot of two pumping cycles in opposition of phase as performed by said second embodiment of figure 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] In reference to the figures 1 and 2, a diesel internal combustion engine provided with a direct fuel injection equipment 6 is controlled by a command unit

(ECU) 8. In use, diesel fuel stored in a tank at low pressure, or atmospheric pressure, is sent to a pressurising device 10 comprising a digital inlet metering valve 12, hereafter DIMV 12, and a high pressure pump 14. After being pressurised in said pump 14, the fuel is delivered to a common rail then to fuel injectors, which along with the tank are drawn in dotted lines in the figures.

[0021] The pump 14 comprises a pumping head 16 and, upon command signals received from the ECU 8 the DIMV 12 controls the upstream flow entering said pumping head 16. The DIMV 12 is an electro actuated 2-way valve comprising an actuator such as a solenoid, controlling a valve member opening, or closing, the fuel entry into a buffer chamber 20 wherefrom said fuel is oriented toward the pumping head 16; said pumping head 16 performing a pumping cycle C1, shown in figure 2, that is the alternation of a filling phase PF and of a compression phase PC.

[0022] In an alternative not shown, the pump 14 comprises two or more pumping heads, all performing a pumping cycle in phase with each other. The buffer chamber 20 is, in this alternative, in fluid communication with all the pumping heads of the pump 14.

[0023] In the pumping head 16, fuel is pressurised in a compression chamber 22 defined at the end of a bore 24 in which a piston 26 urged by a rotating cam 28 is reciprocally guided along a pumping axis X1. During the filling phase PF, when the piston moves from TDC (top dead center) to BDC (bottom dead center), pressure drops in said compression chamber 22 opening an inlet 32 by moving an inlet valve member 30. Fuel at low pressure is sucked through said inlet 32 in said compression chamber 22. During the following compression phase PC when the piston moves from BDC to TDC, the pressure in said compression chamber 22 rises moving the inlet valve member 30 into a closed position of the inlet 32. The fuel is then pressurised in said compression chamber 22 prior to being expelled when said pressure overcomes a threshold forcing an outlet valve member 34 to open an outlet 36.

[0024] The figures show a single rotating cam urging the pistons but, in alternative embodiments, the pump 14 may comprise several cams.

[0025] In a multi-head pump 14, all heads being in phase and performing the same pumping cycle C1, the cam 28 is can be a multi-lobe cam and, the pumping axes are arranged to create the simultaneity of the pumping cycles. For instance, in a two head pump an elliptical cam having two lobes, may urge simultaneously two pistons opposed at 180° and, in a four head pump, a square came (with rounded corners) simultaneously urges four piston arranged at 90° from each other.

[0026] Typically, the inlet valve members 30 is a passive valve moving under the influence of pressure difference between the compression chamber and the other side of the valve member, the inlet channel. In other alternatives, the valve 30 can cooperate with an actuator, such as a solenoid, which advances the opening or re-

tards the closing of the valve member.

[0027] Thanks to this arrangement, a DIMV 12 controls the inlet to the pumping head. The following sequence, illustrated by figure 2 where the cycle C1 starts with a filling phase PF describes steps of a method 100 executed by the ECU 8 in order to control the fuel quantity compressed in the compression chamber.

[0028] The control method 100 comprises the following steps:

- receiving 110 signals enabling to determine the quantity of fuel required to be injected in the engine;
- computing 120 the duration that the DIMV 12 needs to be in open state to enable said required quantity of fuel to enter the pump 14;
- keeping 134 the DIMV 12 in said open state when the inlet valve 30 opens;
- switching 130 the DIMV 12 to said open state when pumping cycle C1 initiates a filling phase PF;
- switching 140 the DIMV 12 to the closed state when the duration time has lapsed.

[0029] The steps of this method 100 are detailed in reference to figure 2 where points are identified and commented:

Point P1

- the pumping cycle C1 is at TDC and, pressurised fuel is expelled out of the compression chamber 22,
- the inlet 32 is closed, the outlet 36 is open,
- the ECU 8 commands to open the DIMV 12 for the fuel to enter and fill the buffer chamber 20.

Point P2 just after point P1

- the cycle C1 starts a filling phase PF, the pressure in the compression chamber 22 starts to drop,
- the inlet 32 opens enabling fuel in the buffer chamber 20 to enter the compression chamber 22,
- the outlet 36 closes.
- the ECU 8 keeps the open command sent to the DIMV 12 for allowing fuel to flow through the buffer chamber 20 and directly in the compression chamber 22.

Point P3

- the pumping cycle C1 approaches the end of the filling phase PF,
- the inlet 32 remains open,
- the outlet 36 remains closed,
- as the duration computed at the method step 120 is reached, the ECU 8 commands to close the DIMV 12 and, depending on pressure differ-

ence between the buffer chamber 20 and the compression chamber 22, fuel in the buffer chamber 20 continues, for a very short while, to enter the compression chamber 22.

Point P4 just after point P3

- the pumping cycle C1 further approaches the end of the filling phase PF, the pressure in the compression chamber 22 is now superior to the pressure in the buffer chamber 20,
- the inlet 32 closes and, the outlet 36 remains closed,
- the DIMV 12 remains closed until the next filling phase starting with a new point P1.

[0030] As can be followed through the pumping cycle and the sequence of points, the fuel enters the compression chamber as soon as the inlet valve opens at beginning of the filling phase PF and, when the DIMV 12 closes the pressure difference between the buffer chamber 20 and the compression chamber cancels very rapidly, this closing the inlet valve and ending said fuel entry right after closing the DIMV 12. The fuel quantity in the compression chamber is then controlled by closing the DIMV 12.

[0031] During a filling phase PF, the pressure drops in the compression chamber and:

in a first step, at very beginning of said filling phase PF, the DIMV 12 opens while the inlet is still closed. Fuel only enters and fills the buffer chamber 20 wherein pressure rises;

in a subsequent second step said rising pressure in the buffer chamber overcomes said dropping pressure in the compression chamber and consequently the inlet opens. The DIMV 12 remaining open, fuel in the buffer chamber enters the compression chamber and, a fuel flow can directly go through the chamber 20 in the compression chamber and,

in a final third step at completion of the computed opening duration of the DIMV 12, the fuel quantity needed to match the engine demand has entered the compression chamber, the DIMV 12 closes, the pressure in the buffer chamber 20 drops quickly and, this is immediately followed by closing of the inlet.

[0032] In reference to the figures 3 and 4 is presented a second embodiment of the invention wherein the pressurising device 10 of the fuel injection equipment 6 comprises the DIMV 12, and a twin-head-pump 14.

[0033] To ease and simplify the description, numeral references previously used are kept for designating features having the same function, said features keeping their numeral references and may be now identified as "first".

[0034] The twin-head-pump 14 comprises the first pumping head 16, previously identified as the pumping

head 16, and a second pumping head 18. Upon command signals received from the ECU 8, the DIMV 12 controls the upstream flow entering said two pumping heads 16, 18. The DIMV 12 is an electro actuated 2-way valve comprising an actuator such as a solenoid controlling a valve member opening, or closing, the fuel entry into the buffer chamber 20 wherefrom said fuel is oriented toward the first pumping head 16 performing the first pumping cycle C1 or, toward the second pumping head 18 performing a second pumping cycle C2. Each pumping cycle C1, C2 is the alternation of a filling phase PF and a compression phase PC and, in said twin-head-pump 14 the two cycles C1, C2 are in opposition of phase, the filling phase PF of a pumping head being simultaneous to the compression phase PC of the other pumping head.

[0035] In an alternative not shown, the pump 14 is a multi-head pump comprising three, four or more pumping heads, some performing said first pumping cycle C1, the other performing the second pumping cycle C2 in opposition of phase with C1. In this alternative, the buffer chamber 20 is in fluid communication with all the pumping heads of the multi-head pump 14.

[0036] The first pumping head 16 is, as previously described, with the first compression chamber 22, the first bore 24, the first piston 26, the first pumping axis X1, the first inlet valve member 30, the first inlet 32, the first outlet valve member 34 and the first outlet 36.

[0037] Similarly to the first pumping head 16, in the second pumping head 18 fuel is pressurised in a second compression chamber 38 defined at the end of a second bore 40 in which a second piston 42 urged by said rotating cam 28 is reciprocally guided along a second pumping axis X2. During the second filling phase PF2, when said second piston 42 moves from TDC to BDC, pressure drops in said second compression chamber 38 moving a second inlet valve member 44 and opening a second inlet 46 through which fuel at low pressure is sucked in the second compression chamber 38. During the following second compression phase PC2 when the piston moves from BDC to TDC, the pressure in said second compression chamber 38 rises moving the second inlet valve member 46 into a closed position of the second inlet 46. The fuel is then pressurised in said second compression chamber 38 prior to being expelled when said pressure overcomes a threshold forcing a second outlet valve member 48 to open a second outlet 50.

[0038] As shown in figure 3, in a twin-head-pump 14 the cam 28 is typically a two-lobe cam opposed at 180°, as in an oval or elliptical shape and, the pumping axis X1, X2 are at 90° from each other. Said arrangement of cam profile and angled axis creates the opposition of phases although other arrangements, such as a one lobe cam and two pistons opposed at 180° or, pistons urged by different cams may achieve a similar result.

[0039] In a four-head pump 14 not shown, a third head is opposed at 180° of the first head 16 and, a fourth head is opposed at 180° of the second head 18, thus the first

and third heads performing the first cycle C1 and, the second and fourth heads performing the second cycle C2.

[0040] Typically, the first and second inlet valve members 30, 44 are passive valves moving under the influence of difference between the pressure in the compression chamber and the pressure on the other side of the valve member. In other alternatives, the valves 30, 44 can cooperate with an actuator, such as a solenoid, which advances the opening or retards the closing of the valve member.

[0041] Thanks to this arrangement, a single DIMV 12 controls the inlet to the two pumping heads. The following sequence, illustrated in figure 4 where the first cycle C1 starts with a filling phase PF and the second cycle C2 starts with a compression phase PC, describes steps of the method 100 executed by the ECU 8 in order to control the fuel quantity compressed in the two compression chambers.

[0042] The control method 100 comprises the following steps:

- receiving 110 signals enabling to determine the quantity of fuel required to be injected in the engine;
- computing 120 the duration that the DIMV 12 needs to be in open state to enable said required quantity of fuel to enter the twin-head-pump 14;
- keeping 134 the DIMV 12 in said open state when either one of the first or second inlet valve opens 30, 44;
- switching 130 the DIMV 12 to said open state when either one of the pumping cycles C1, C2 initiates a filling phase PF;
- switching 140 the DIMV 12 to the closed state when the duration time has lapsed.

[0043] The steps of this method 100 are detailed in reference to figure 4 where points are identified and commented:

Point P1

- the first cycle C1 is at TDC and, pressurised fuel is expelled out of the first compression chamber 22,
- the first inlet 32 is closed, the first outlet 36 is open,
- the second cycle C2 is at BDC and, the second compression chamber 38 is filled with fuel at low pressure,
- the second inlet 46 is closed and, the second outlet 50 is closed,
- the ECU 8 commands to open the DIMV 12 for the fuel to enter and to fill the buffer chamber 20.

Point P2 just after point P1

- the first cycle starts a filling phase PF, the pressure in the first compression chamber 22 drops,
- the first inlet 32 opens enabling fuel in the buffer chamber 20 to enter the first compression chamber 22, 5
- the first outlet 36 closes.
- the second cycle starts a compression phase PC, the pressure in the second compression chamber 38 starts to rise, 10
- the second inlet 46 remains closed, the second outlet 50 remains closed,
- the ECU 8 maintains the open command sent to the DIMV 12 for allowing fuel to flow through the buffer chamber 20 and directly in the first compression chamber 22. 15

Point P3

- the first cycle approaches the end of the filling phase PF, 20
- the first inlet 32 remains open and, the first outlet 36 remains closed,
- the second cycle C2 approaches the end of the compression phase PC, the pressure in the second compression chamber 38 continues to rise, 25
- the second inlet 46 remains closed, the second outlet 50 remains closed,
- the ECU 8 commands to close the DIMV 12 and, depending on pressure difference between the buffer chamber 20 and the first compression chamber 22, fuel in the buffer chamber 20 continues, for a short while, to enter the first compression chamber 22. 30

Point P4 just after point P3

- the first cycle C1 further approaches the end of the filling phase PF, the pressure in the first compression chamber 22 is now superior to the pressure in the buffer chamber 20, 40
- the first inlet 32 closes and, the first outlet 36 remains closed,
- the second cycle C2 further approaches the end of the compression phase PC, the pressure in the second compression chamber 38 continues to rise, 45
- the second inlet 46 remains closed, the second outlet 50 remains closed, 50
- the DIMV 12 remains closed.

Point P5

- the first cycle is at BDC, the first compression chamber 22 is now filled with low pressure fuel, 55
- the first inlet 32 remains closed, the first outlet 36 remains closed,

- the second cycle is at TDC, the pressure in the second compression chamber 38 is maximum,
- the second inlet 46 is closed and, the second outlet 50 opens to expel pressurised fuel out of the second compression chamber 38,
- the ECU 8 commands to open the DIMV 12 for the fuel to enter the buffer chamber 20.

Point P6 soon after point P5

- the first cycle C1 starts a compression phase PC, the pressure in the first compression chamber 22 starts to rise,
- the first inlet 32 remains closed, the first outlet 36 remains closed.
- the second cycle C2 starts a filling phase PF, the pressure in the second compression chamber 38 starts to drop,
- the second inlet 46 opens to enable fuel in the buffer chamber 20 to enter the second compression chamber 38 and, the second outlet 50 closes,
- the ECU 8 keeps the open command sent to the DIMV 12 for allowing fuel to flow through the buffer chamber 20 and directly in the second compression chamber 38.

Point P7

- the first cycle approaches the end of the compression phase PC, the pressure in the first compression chamber 22 continues to rise,
- the first inlet 32 remains closed, the first outlet 36 remains closed,
- the second cycle approaches the end of the filling phase PF,
- the second inlet 46 remains open and, the second outlet 50 remains closed,
- the ECU 8 commands to close the DIMV 12 and, depending on pressure difference between the buffer chamber 20 and the second compression chamber 38, fuel in the buffer chamber 20 continues, for a short while, to enter the second compression chamber 38.

Point P8 just after point P7

- the first cycle further approaches the end of the compression phase PC,
- the first inlet 32 remains closed, the first outlet 36 remains closed,
- the second cycle further approaches the end of the filling phase PF, the pressure in the second compression chamber 38 is now superior to the pressure in the buffer chamber 20,
- the second inlet 46 closes and, the second outlet 50 remains closed,

- the DIMV 12 remains closed.

[0044] As can be followed through the pumping cycles and the sequence of points, the fuel enters the compression chamber as soon as the inlet valve member opens at beginning of the filling phase PF and, later in said phase when the DIMV 12 closes the pressure difference between the buffer chamber 20 and the compression chamber cancels which closes the inlet valve member right after the DIMV 12 closes, ending said fuel entry. The fuel quantity in the compression chamber is then controlled by closing the DIMV 12.

[0045] Thanks to this arrangement a single DIMV 12 and buffer chamber 20 serve two pumping head.

[0046] Similarly to the first embodiment, during a filling phase, pressure drops in the compression chamber and:

in a first step, at very beginning of said filling phase PF, the DIMV 12 opens while all inlets are closed. Fuel can only enter and fill the buffer chamber 20 wherein pressure rises;

in a subsequent second step said rising pressure in the buffer chamber overcomes said dropping pressure in the compression chamber consequently opening the inlet and, the DIMV 12 remaining open, fuel in the buffer chamber enters the compression chamber and, a fuel flow can directly go through the buffer chamber 20 in the compression chamber and, in a final third step at completion of the computed opening duration of the DIMV 12, the fuel quantity needed to match the engine demand has entered the compression chamber, the DIMV 12 closes, the pressure in the buffer chamber 20 drops quickly and, this is immediately followed by closing of the inlet.

LIST OF REFERENCES

[0047]

TDC	top dead center	
BDC	bottom dead center	
X1	first pumping axis	
X2	second pumping axis	
C1	first pumping cycle	
PF1	filling phase of the first pumping cycle	
PC1	compression phase of the first pumping cycle	
C2	second pumping cycle	
PF2	filling phase of the second pumping cycle	
PC2	compression phase of the second pumping cycle	
P1 - P8	points	
6	fuel injection equipment	
8	command unit - ECU	
10	pressurising device	
12	digital inlet metering valve - DIMV	
14	pump - twin-head-pump	
16	first pumping head	

18	second pumping head	
20	buffer chamber	
22	first compression chamber	
24	first bore	
5 26	first piston	
28	cam	
30	first inlet valve member	
32	first inlet	
34	first outlet valve member	
10 36	first outlet	
38	second compression chamber	
40	second bore	
42	second piston	
44	second inlet valve member	
15 46	second inlet	
48	second outlet valve member	
	50 second outlet	
	100 method	
	110 receiving signals	
20 120	computing	
	130 switching to open	
	134 keeping open	
140	switching to close	

Claims

- Pressurising device (10) of a direct fuel injection equipment (FIE) of a diesel internal combustion engine, said pressurising device (10) comprising a digital inlet metering valve (DIMV, 12) controlling an inlet fluid communication to a pump (14) performing, in use, a pumping cycle (C1) in a pumping head (16), said cycle (C1) being the alternation of a filling phase (PF) and a compression phase (PC) and wherein, the DIMV (12) switches to an open state after said cycle (C1) initiates a filling phase (PF) and, switches to a closed state when approaching the end of said filling phase;
and wherein,
the pump (14) comprises:

- the pumping head (16) defining a compression chamber (22) having an inlet (32) controlled by an inlet valve (30) and an outlet (36) controlled by an outlet valve (34) and, a piston (26) reciprocally moving, in use, between BDC and TDC along a pumping axis (X1) to perform said pumping cycle (C1);

and wherein,
the digital inlet metering valve (DIMV) (12) comprises an electro 2-way valve controlling the inlet into a buffer chamber (20) connected to the inlet (32).
- Pressurising unit (10) as claimed in the preceding claim wherein the DIMV (12) and the pump (14) are integrated in a single housing forming in compact

assembly of the FIE.

3. Pressurising unit (10) as claimed in any one of the preceding claims wherein, in use, in open state of the DIMV (12) the fuel fills said buffer chamber (20) and from there fills the compression chamber (22) of the pumping head (16) that is in filling phase (PF) and which volume increases. 5
4. Pressurising unit (10) as claimed in claim 1, wherein the pump (14) is a twin-head-pump (14) performing, in use, said first pumping cycle (C1) in said first pumping head (16) and, a second pumping cycle (C2) in a second pumping head (18), said cycles (C1, C2) being the alternation of a filling phase (PF) and a compression phase (PC), said first (C1) and second (C2) cycles being in opposition of phase of one another so that, the compression phase (PC) of a cycle is simultaneous to the filling phase (PF) of the other cycle, and wherein, the DIMV (12) controls the inlet fluid communication to said twin-head-pump (14) and it switches to an open state after either cycle (C1, C2) initiates a filling phase (PF) and, switches to a closed state when approaching the end of said filling phase. 10 15 20 25
5. Pressurising unit (10) as claimed in claim 4 wherein the DIMV (12) and the twin-head-pump (14) are integrated in a single housing forming in compact assembly of the FIE. 30
6. Pressurising unit (10) as claimed in any claims 4 or 5 wherein, in use, low pressure fuel exiting the DIMV (12) is delivered to the twin-head-pump (14) wherein it is compressed in the first pumping cycle (C1) or in the second pumping cycle (C2). 35
7. Pressurising unit (10) as claimed in any of the claims 4 to 6 wherein the twin-head-pump (14) comprises: 40
 - the first pumping head (16) defining a first compression chamber (22) having a first inlet (32) controlled by a first inlet valve (30) and a first outlet (36) controlled by a first outlet valve (34) and, a first piston (26) reciprocally moving, in use, between BDC and TDC along a first axis (X1) to perform said first pumping cycle (C1);
 - the second pumping head (18) defining a second compression chamber (38) having a second inlet (46) controlled by a second inlet valve (44) and a second outlet (50) controlled by a second outlet valve (48) and, a second piston (42) reciprocally moving, in use, between BDC and TDC along a second axis (X2) to perform said second pumping cycle (C2) and wherein, 45 50 55

the digital inlet metering valve (DIMV) (12) comprises an electro 2-way valve controlling the inlet into a buff-

er chamber (20) connected to the first inlet (32) and to the second inlet (46).

8. Pressurising unit (10) as claimed in claim 7 wherein, in use, in open state of the DIMV (12) the fuel fills said buffer chamber (20) and from there fills the compression chamber (22, 38) of the pumping head (16, 18) that is in filling phase (PF) and which volume increases.
9. Fuel injection equipment (6) for a diesel internal combustion engine, said FIE comprising a pressurising unit (10) as claimed in any one of the preceding claims.
10. Control method (100) of a fuel injection equipment (6) as claimed in claim 9, the method comprising the following steps:
 - receiving (110) signals enabling to determine the quantity of fuel required to be injected in the engine;
 - computing (120) the duration that the DIMV (12) needs to be in open state to enable said required quantity of fuel to enter the pump (14);
 - switching (130) the DIMV (12) to said open state after the pumping cycle (C1) initiates a filling phase (PF);
 - switching (140) the DIMV (12) to the closed state when the duration time has lapsed and, wherein the step switching (130) the DIMV (12) to an open state enables fuel to fill the buffer chamber (20) when the pumping cycle (C1) initiates a filling phase (PF), the inlet valves (30) being closed preventing fuel entry into the compression chamber then, subsequent to said switching step (130), the method (100) comprises the step
 - keeping (134) the DIMV (12) in said open state when the inlet valve opens (30).
11. Control method (100) as claimed in claim 10, the fuel injection equipment being as claimed in claim 4, the method comprising the following steps:
 - computing (120) the duration that the DIMV (12) needs to be in open state to enable said required quantity of fuel to enter the twin-head-pump (14);
 - switching (130) the DIMV (12) to said open state when either one of the pumping cycles (C1, C2) initiates a filling phase (PF);
 - switching (140) the DIMV (12) to the closed state when the duration time has lapsed.
12. Control method (100) as claimed in claim 11, the pressurising device (10) being as claimed in either

of the claims 7 or 8, wherein the step switching (130) the DIMV (12) to an open state enables fuel to fill the buffer chamber (20) when either of the pumping cycles (C1, C2) initiates a filling phase (PF), both first and second inlet valves (30, 44) being closed preventing fuel entry into the compression chambers then, subsequent to said switching step (130), the method (100) comprises the step

- keeping (134) the DIMV (12) in said open state when either one of the first or second inlet valve opens (30, 44).

13. Electronic command unit (8) adapted execute a method (100) as claimed in any one of the claims 10 to 12.

20

25

30

35

40

45

50

55

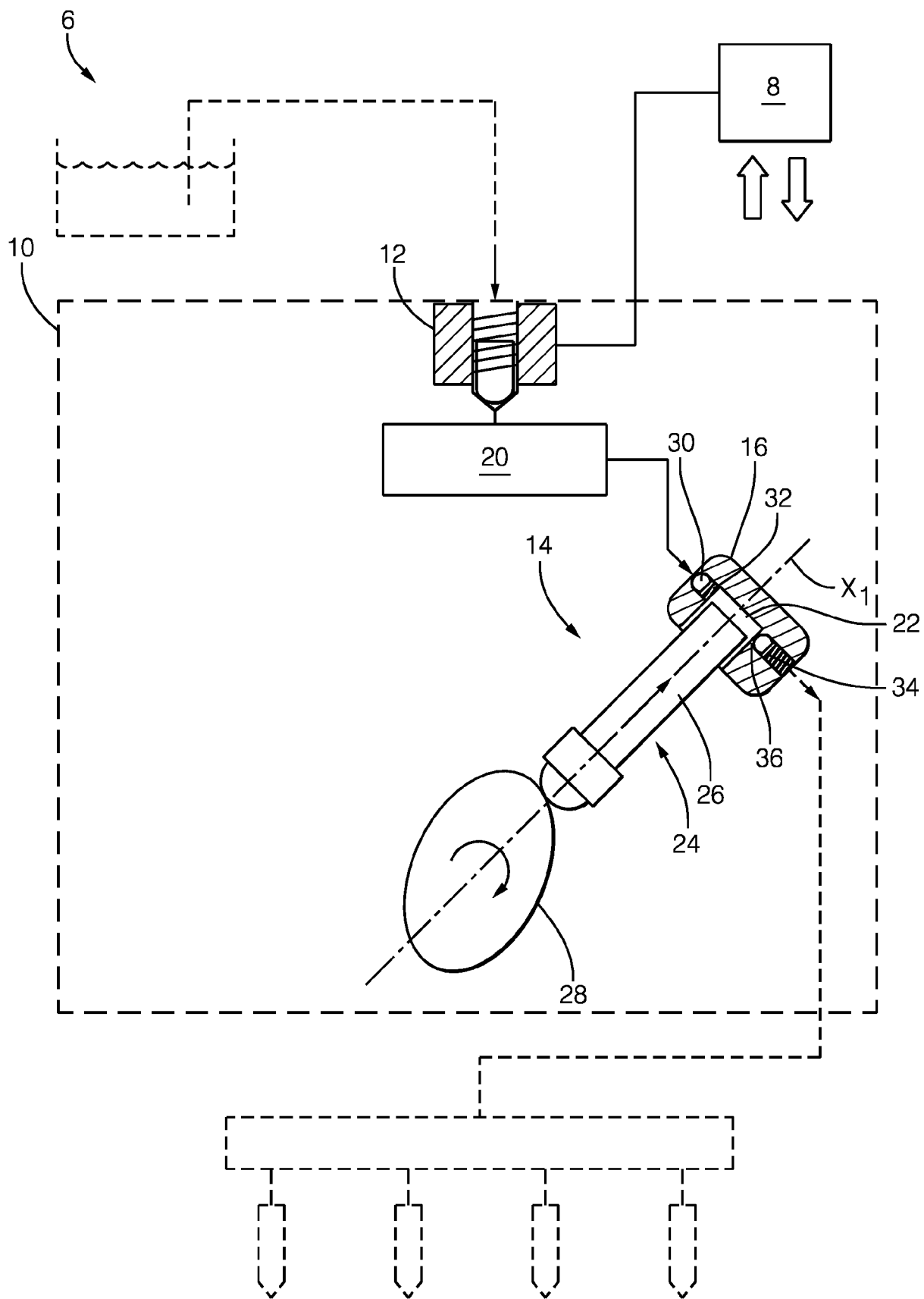


FIG. 1

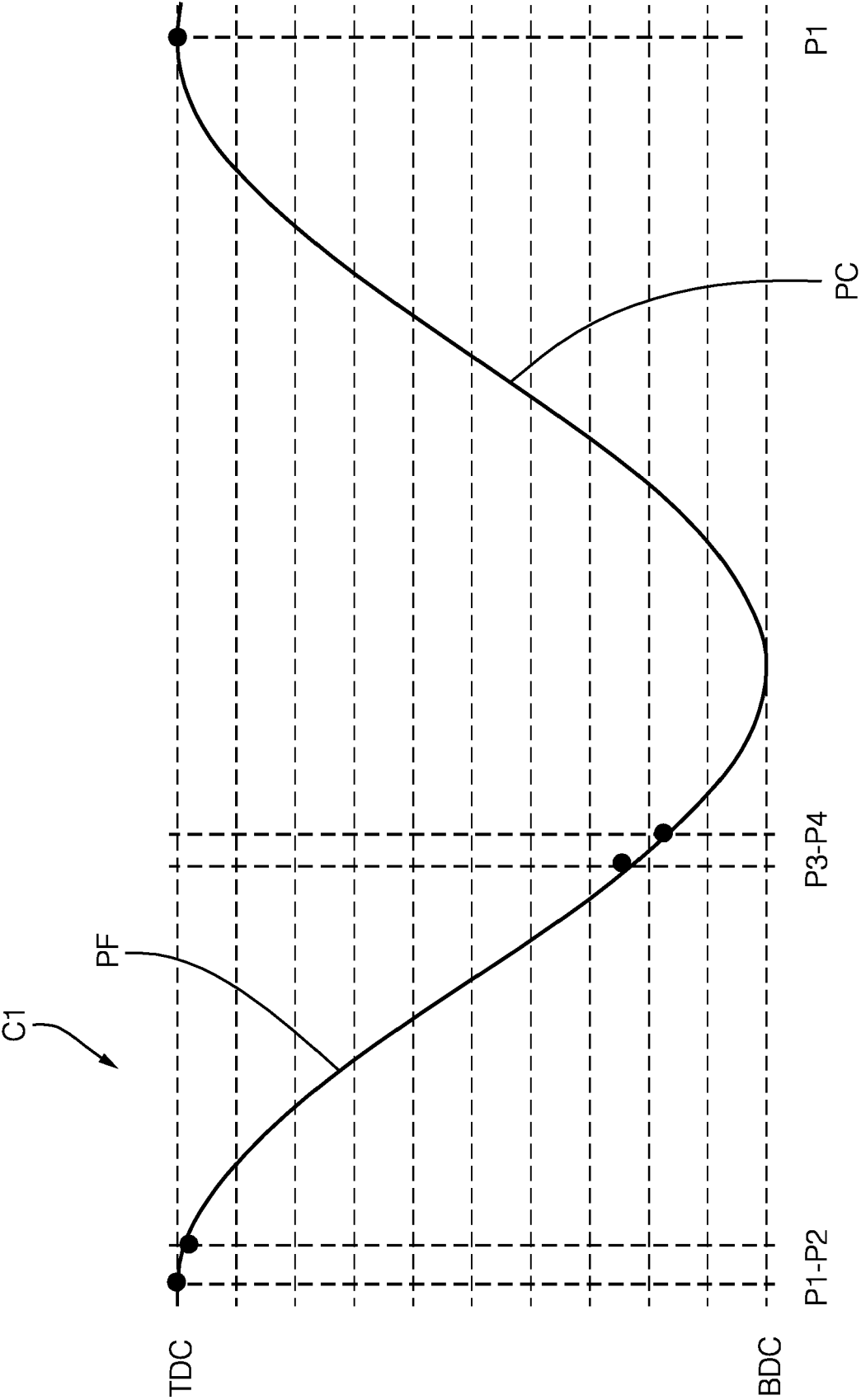


FIG. 2

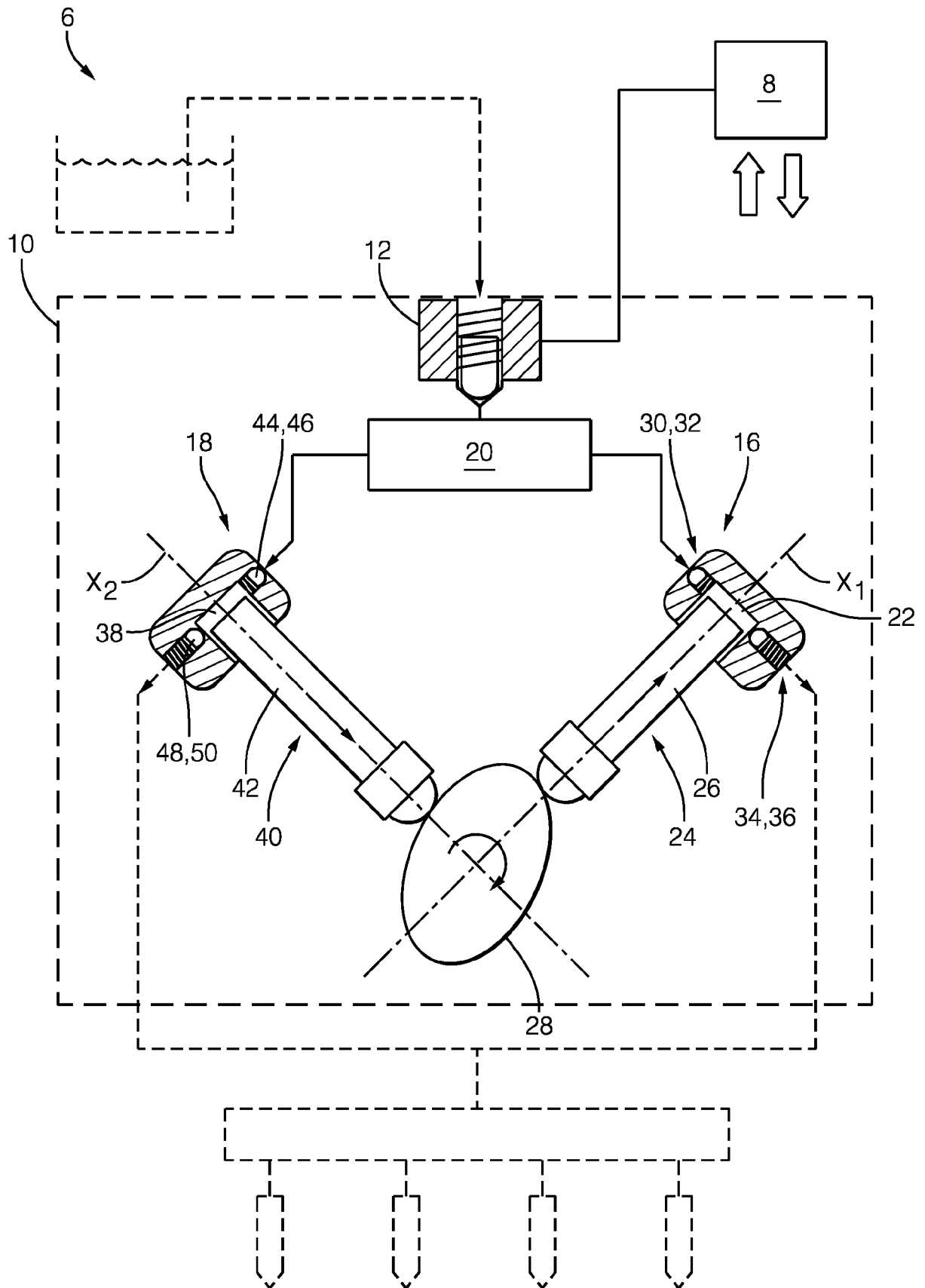


FIG. 3

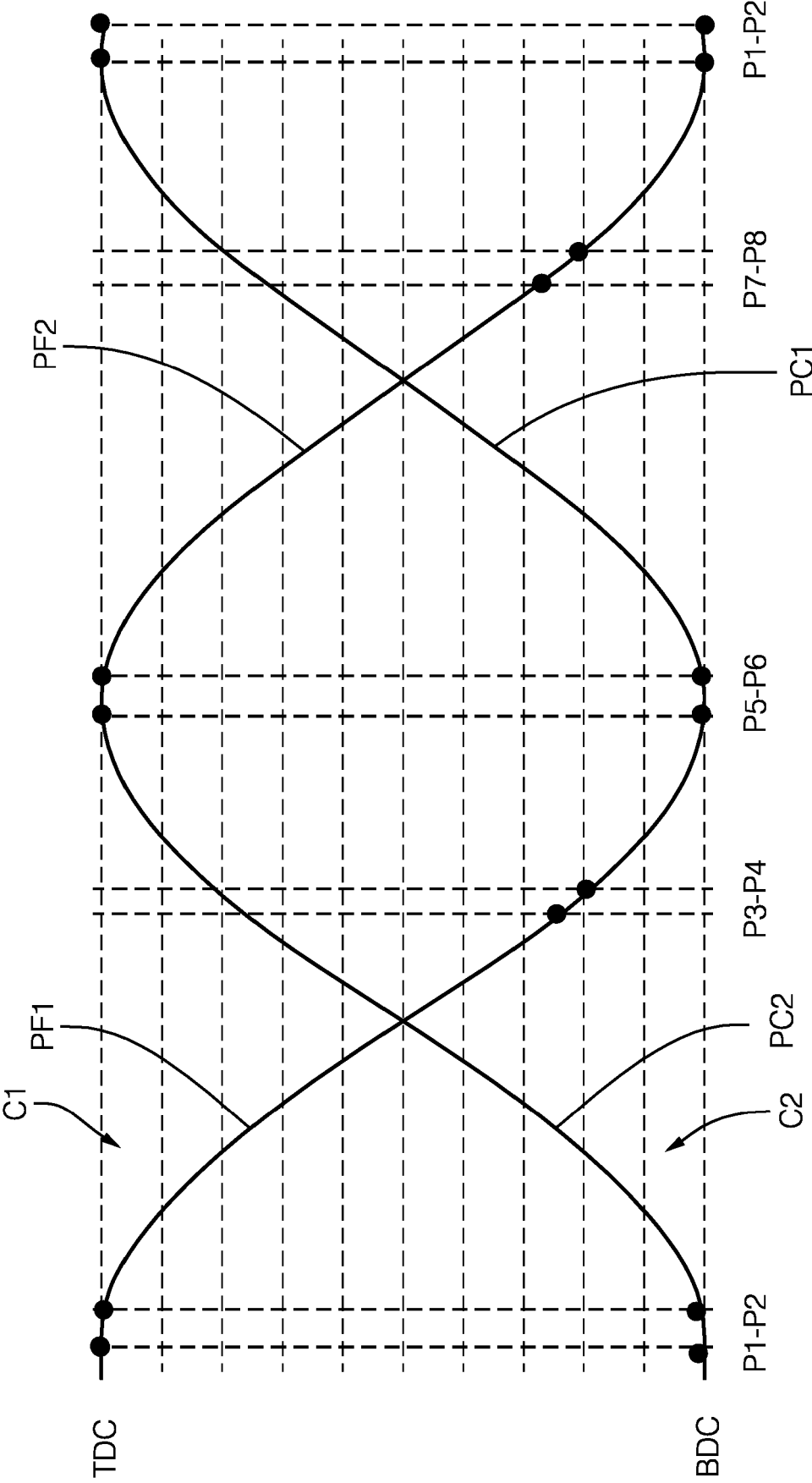


FIG. 4



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 18 3555

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 647 824 A1 (DELPHI TECH HOLDING SARL [LU]) 9 October 2013 (2013-10-09) * paragraphs [0043], [0046], [0051]; figure 1 *	1,3,9, 10,13	INV. F02M59/36 F02M59/46 F02M41/14
X	US 2006/000447 A1 (RICCO MARIO [IT] ET AL) 5 January 2006 (2006-01-05) * paragraph [0015] - paragraph [0024]; figure 1 *	1,3,9, 10,13	
X	EP 0 902 181 A2 (DENSO CORP [JP]; NIPPON SOKEN [JP]) 17 March 1999 (1999-03-17) * paragraph [0039] - paragraph [0049]; figures 2, 4, 6 * * paragraph [0069] - paragraph [0087] *	1-3,9, 10,13	
X	EP 0 816 672 A2 (NIPPON SOKEN [JP]) 7 January 1998 (1998-01-07) * column 27, line 51 - column 28, line 6 *	1-3,9, 10,13	
X	EP 2 050 952 A1 (DELPHI TECH INC [US]) 22 April 2009 (2009-04-22) * the whole document *	1-13	TECHNICAL FIELDS SEARCHED (IPC) F02M
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 November 2018	Examiner Tortosa Masiá, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

 1
 EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 18 3555

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-11-2018

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2647824 A1	09-10-2013	NONE	
US 2006000447 A1	05-01-2006	AT 337482 T DE 602004002105 T2 EP 1612402 A1 ES 2268614 T3 JP 3170381 U JP 2006017109 A JP 2010043647 A US 2006000447 A1	15-09-2006 08-02-2007 04-01-2006 16-03-2007 15-09-2011 19-01-2006 25-02-2010 05-01-2006
EP 0902181 A2	17-03-1999	DE 69820550 D1 DE 69820550 T2 EP 0902181 A2	29-01-2004 04-11-2004 17-03-1999
EP 0816672 A2	07-01-1998	DE 69720603 D1 DE 69720603 T2 DE 69731241 D1 DE 69731241 T2 EP 0816672 A2 EP 1221552 A2 US 6016790 A	15-05-2003 04-03-2004 18-11-2004 02-03-2006 07-01-1998 10-07-2002 25-01-2000
EP 2050952 A1	22-04-2009	EP 2050952 A1 JP 2009097505 A US 2009126690 A1	22-04-2009 07-05-2009 21-05-2009