(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 857 672 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.04.2015 Bulletin 2015/15

(51) Int Cl.:
F02M 63/02 *(2006.01)* ***F02M 55/02*** *(2006.01)*
F02M 55/04 *(2006.01)*

(21) Application number: **14186943.8**

(22) Date of filing: **30.09.2014**

(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

(30) Priority: **02.10.2013 GB 201317451**

(71) Applicant: **Delphi International Operations Luxembourg S.à r.l.**
4940 Bascharage (LU)

(72) Inventors:
- **Dratch, Rodolphe**
  41260 La Chasussee Saint Victor (FR)
- **Doradoux, Laurent**
  41190 Herbault (FR)
- **Beduneau, Jean Luc**
  41000 Blois (FR)
- **Legrand, Philippe**
  41350 St. Gervais La Foret (FR)

(74) Representative: **Neill, Andrew Peter et al**
Delphi Diesel Systems
Patent Department
Courteney Road
Gillingham, Kent ME8 0RU (GB)

(54) Fuel injection equipment

(57) A fuel injector equipment (10) has at least 35% of the high pressure fuel contained inside the injectors (12).

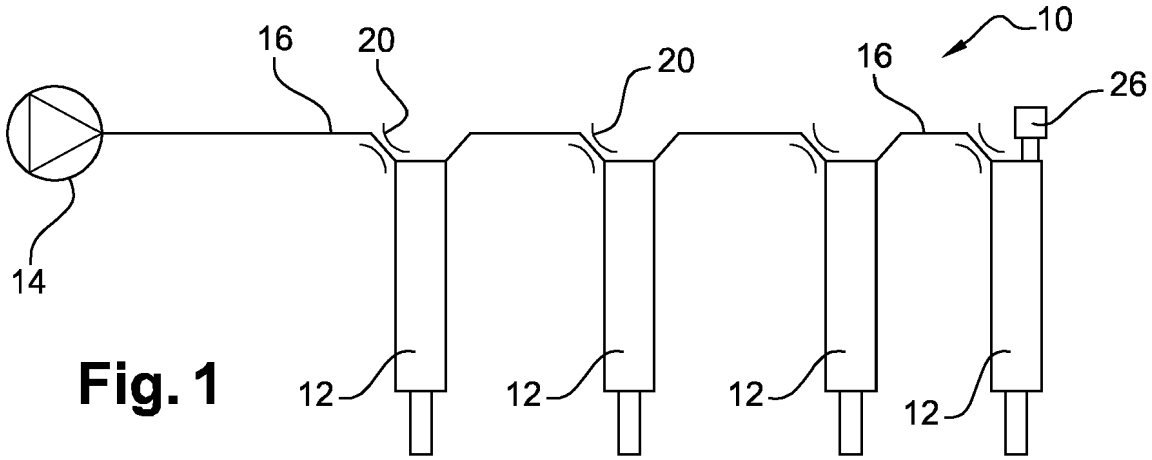

Fig. 1

EP 2 857 672 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to high pressure fuel injection equipment for internal combustion engine.

BACKGROUND OF THE INVENTION

[0002] In a fuel injection equipment (FIE), also known as a common rail system, after the occurrence of an injection event the fuel sprayed in the combustion chamber of an internal combustion engine is replaced by high pressure fuel contained in the FIE, per se, in the common rail, in the pipes connecting the common rail to each injector and in the injector itself.

[0003] Each injection event generates hydraulic waves that propagate inside the high pressure fuel contained in the FIE. It may happen that engines having closely spaced injection events, such as engines having multiple injection within each cycle, that the fuel injected during an event is not entirely replaced inside the injector when occurs the subsequent event. The fuel, even at high pressure does not have the time to flow to the tip of the nozzle. To overcome this issue, the Applicant has disclosed, in todays filed application GB1317441.2, fuel injectors having a largely increased internal volume occupied by the high pressure fuel. Furthermore said volume is concentrated in the vicinity of the spray holes so, after an injection event, the fuel sprayed is immediately replaced.

[0004] A further question relates to the FIE as a all. The current developments, As operating pressures increase, as the available space in the engine compartment decreases and as engine cold start needs to be immediate, recent FIE development attempt to minimize the quantity and volume of high pressure fuel contained within the FIE. When increasing the injectors internal volume to optimize the injection events, new FIE architecture are now required.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to provide fuel injector equipment (FIE) wherein at least 35%, and preferably 45%, of the high pressure fuel is contained inside the injectors, the FIE comprising a high pressure fuel pump, a plurality of interconnecting pipes, a plurality of injectors and a pressure sensor; all being in fluid connection in series so that they form an open chain.

[0006] In a first embodiment of the FIE, all the injectors are fluidly connected in series, a high pressure pump delivering fuel to the first injector of the series and a high pressure sensor monitoring the fuel pressure in the vicinity of the last injector of the series.

[0007] In a second embodiment of the FIE, all the injectors are fluidly connected in parallel to a high pressure fuel distributor receiving fuel from a high pressure pump.

[0008] The FIE can further comprise a pressure sensor monitoring the pressure inside the distributor and, eventually a valve controlling the pressure in the distributor. The valve enables some fuel to exit the distributor when the pressure exceeds a threshold.

[0009] In a third embodiment, the FIE comprises at least another distributor each injector being directly connected to one of the distributors.

[0010] The high pressure pump of the FIE delivers fuel to a first distributor, said another distributor being fluidly connected to the first distributor. Therefore, the pump and the distributors are arranged in series on an inlet line. The FIE further comprises a pressure sensor monitoring the pressure inside said another distributor, so the pressure sensor is arrange by the end of the inlet line.

[0011] Furthermore, the FIE may comprise a damping mean for damping hydraulic waves propagating in the high pressure fuel.

[0012] In the first embodiment of the FIE the damping mean is arranged in preferably the vicinity of the injector. Should the FIE comprises a plurality of injectors a damping mean is being arranged in the vicinity of each injector.

[0013] In the second or third embodiments, the damping mean is arranged upstream the injector, preferably in the vicinity of the distributor. Should the FIE comprises a plurality of injectors a damping mean is being arranged upstream each injector, preferably in the vicinity of the distributor.

[0014] The damping mean is arranged in the vicinity of an injector or of a distributor, for instance on the connecting pipes upstream the injector.

[0015] For instance, the damping mean can be a restriction.

BRIEF DESCRIPTION OF THE DRAWING

[0016] The present invention is now described by way of example with reference to the accompanying figures wherein:

Figure 1 is a sketch of a first architecture of fuel injection equipment as per the invention.

Figure 2 is a sketch of a second architecture of fuel injection equipment as per the invention.

Figure 3 is a sketch of a third architecture of fuel injection equipment as per the invention, this architecture being an alternative to the second architecture.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] In all embodiments described the FIE has four injectors 12 even though the teachings of the invention are directly applicable to any FIE having another number of injectors 12.

[0018] Figure 1 represents a first embodiment the FIE 10 which constituents are in fluid connection in series forming an open chain comprising a high pressure fuel

pump 14 supplying fuel via interconnecting pipes 16 to the first injector, then from said first to the second injector, then from the second to the third injector, then from the third to the fourth injector. A pressure sensor 26 is arranged at the end of the chain.

[0019] The high pressure fuel contained in the injectors 12 is at least 35%, and preferably over 45% of the total quantity of high pressure fuel contained in the FIE 10. To achieve such ratio the injectors are of the type having an internal buffer volume holding high pressure fuel.

[0020] In operation, when an injector 12 proceeds to an injection and sprays fuel in a combustion chamber, said injector 12 fills up again by receiving fuel contained in the pipes to which it is connected. The sensor 26 then observes a pressure decrease that is compensated by new fuel pressurized by the pump 14.

[0021] Also, in alternative embodiments, as hydraulic waves generated by the high pressure pump 14 or by an injection event propagate within the high pressure fuel in both directions, the FIE 10 is provided with restrictions 20 that act as fluid dampers. In a preferred FIE as shown on figure 1 the restrictions 20 are arranged just upstream each injector 12.

[0022] In a non-represented structure, the pump flows the fuel in a continuous line wherein are arranged T-type connections, each T connecting to an injector. In such structure the preferred location for the damper 20 is between the injector and the T.

[0023] The restriction can also be arranged inside the injector as this is detailed in the application GB1317441.2.

[0024] Figure 2 represents a second embodiment of the FIE 10 which further comprises a high pressure fuel distributor 28 that is directly connected, on one side, downstream the high pressure pump 14 for receiving the fuel and, on the other side, upstream the injectors 12, for distributing said fuel in parallel. The pressure inside the distributor 28 is monitored by the pressure sensor 26 and, a pressure relief valve 18 is arranged so to enable fuel to exit the FIE 10 in case of a fuel pressure rising over a predetermined threshold.

[0025] The ratio here above presented (35% preferred to 45%) also applies to the second embodiment.

[0026] In a FIE as shown on figure 2, restrictions 20 can be arranged between the restrictions 20 ant the injectors. In a preferred arrangement, the restrictions 20 are arranged in the vicinity of the distributor 28. Furthermore, another restriction, not represented can be added on the line from the pump to the distributor.

[0027] The operation of the FIE of the second embodiment is now described. The pump 14 flows high pressure fuel to the distributor 28. When an injector 12 proceeds to an injection and sprays fuel in a combustion chamber, said injector 12 fills up again by receiving fuel flowing from the distributor 28. The sensor 26 then observes a pressure decrease in the distributor 28 that is compensated by new fuel pressurized by the pump 14.

[0028] Figure 3 is a third embodiment which indeed is an alternative to the second embodiment. As an illustrative example, while the second FIE fits an engine having in-line cylinders, the third FIE would fit a V-type engine.

[0029] The third FIE comprises an inlet line 30 fluidly connecting in series the pump 14 and two distributors 28, 32, arranged one downstream the other on the inlet line 30. The injectors 12 are divided in two groups, the injectors 12 of one group being all directly connected to one distributor 28, 32. The pressure sensor 26 is arranged at the end of the inlet line that is distant from the pump 14.

[0030] In a FIE as shown on figure 3, restrictions 20 can also be arranged between the restrictions 20 ant the injectors. In a preferred arrangement and similarly to the second embodiment, the restrictions 20 are arranged in the vicinity of the distributor 28. Another restriction can be added on the line from the pump to the first distributor 28.

[0031] The operation of the third FIE is similar to the operation of the second FIE, the fuel injecting during an injection event and missing in an injector 12 being replaced by fuel contained in the distributor to which said injector is connected.

[0032] Further alternative FIE architecture, not represented, can easily be organized. For instance the pump 14 can deliver fuel to two distributors connected in parallel, rather than in series as in the third FIE.

[0033] As previously mentioned the number of injector is not limited to four as well as the number of distributor is not limited to two. Alternatives with more than two distributors can be arranged in following the teachings, for instance, of the third embodiment.

[0034] In all embodiments, the ratio previously presented (35% preferred to 45%) is respected with injectors each holding from 1 cm^3 to 2 cm^3 consequently, the volume contained by the single or two distributors is reduced relative to a well-known common rail.

Claims

1. Fuel injector equipment (FIE) (10) wherein at least 35% of the high pressure fuel is contained inside the injectors (12), the FIE comprising a high pressure fuel pump (14), a plurality of interconnecting pipes (16), a plurality of injectors (12) and a pressure sensor (26); all being in fluid connection in series so that they form an open chain.

2. FIE (10) as set in the preceding claim comprising at least 45% of the high pressure fuel inside the injectors (12).

3. FIE (10) as set in any of the preceding claim wherein all the injectors (12) are fluidly connected in series, a high pressure pump (14) delivering fuel to the first injector (12) of the series and a high pressure sensor (26) monitoring the fuel pressure in the vicinity of the

last injector (12) of the series.

4. FIE (10) as set in any of the claims 1 or 2 wherein all the injectors (12) are fluidly connected in parallel to a high pressure fuel distributor (28) receiving fuel from a high pressure pump (14).

5. FIE (10) as set in claim 4 further comprising a pressure sensor (26) monitoring the pressure inside the distributor (28).

6. FIE (10) as set in any of the claim 4 or 5 further comprising a valve (18) controlling the pressure in the distributor (28), the valve (18) enabling some fuel to exit the distributor (28) when the pressure exceeds a threshold.

7. FIE (10) as set in any of the claims 4 to 6 further comprising at least another distributor (32) each injector (12) being directly connected to one of the distributors (28, 32).

8. FIE (10) as set in claim 7 wherein the high pressure pump (14) delivers fuel to a first distributor (28), said another distributor (32) being fluidly connected to the first distributor (28), the FIE (10) further comprising a pressure sensor (26) monitoring the pressure inside said another distributor (32).

9. FIE (10) as set in any of the preceding claims comprising a damping mean (20) for damping hydraulic waves propagating in the high pressure fuel.

10. FIE (10) as set in claim 3 taken in combination with claim 9 wherein the damping mean (20) is arranged in the vicinity of the injector (12).

11. FIE (10) as set in claim 10 comprising a plurality of injectors (12) and damping means (20), each damping mean (20) being arranged in the vicinity of an injector (12).

12. FIE (10) as set in any of the claims 4 or 7 taken in combination with claim 9 wherein the damping mean (20) is arranged in the vicinity of the distributor (28).

13. FIE (10) as set in claim 12 comprising a plurality of injectors (12) and damping means (20), each damping mean (20) being arranged between a distributor and an injector in the vicinity of the distributor (28).

14. FIE (10) as set in any of the claims 9 to 13 wherein the damping mean (20) is a restriction (20).

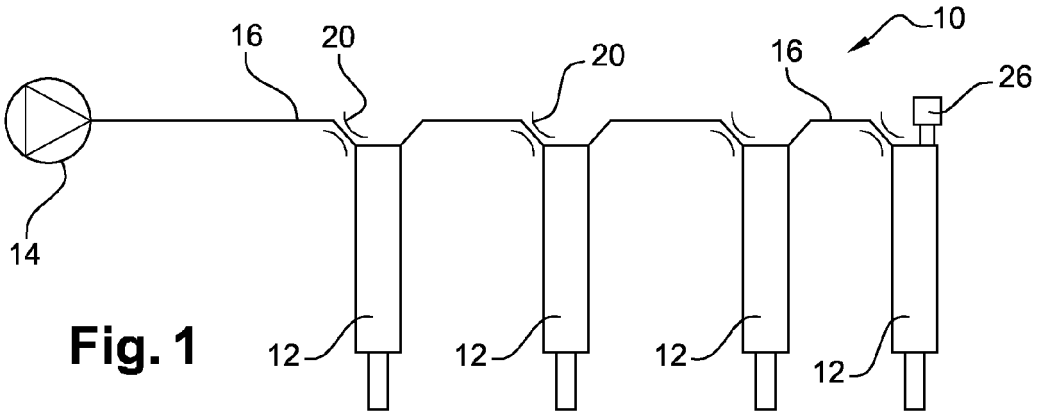

Fig. 1

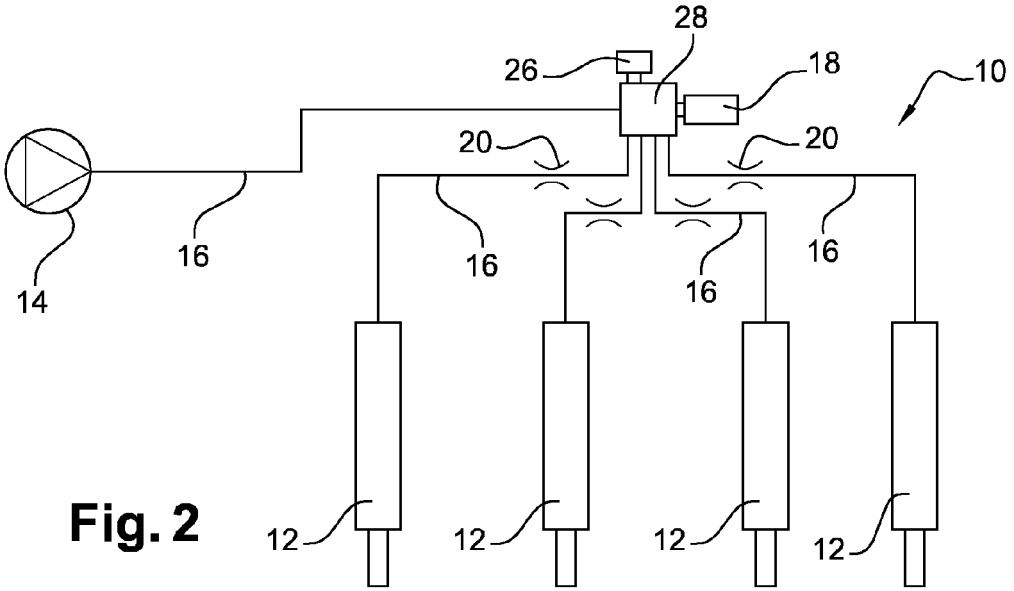

Fig. 2

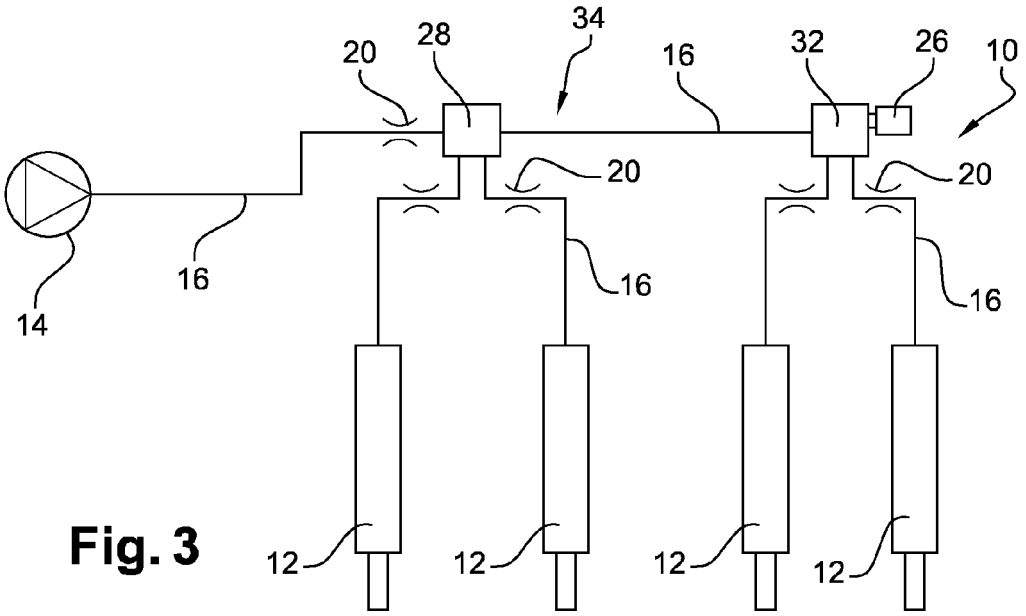

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 14 18 6943

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 1 612 405 A1 (FIAT RICERCHE [IT]) 4 January 2006 (2006-01-04) * paragraphs [0009], [0014], [0017], [0047], [0050], [0059], [0060], [0070], [0071]; figures 2,3,4,8 *	1-13	INV. F02M63/02 F02M55/02 F02M55/04
X	DE 10 2009 055129 A1 (BOSCH GMBH ROBERT [DE]) 30 June 2011 (2011-06-30) * paragraphs [0020], [0023], [0042], [0050]; figures *	1-3, 9-11,14	
X	WO 2007/009279 A1 (GANSER HYDROMAG [CH]; GANSER MARCO) 25 January 2007 (2007-01-25) * page 14, paragraph 2; figures 1-9 * * page 28, paragraph 2 *	1,2,4,5, 9,12,14	
X	WO 2012/107634 A2 (WAERTSILAE FINLAND OY [FI]; VOUTILAINEN VESA [FI]) 16 August 2012 (2012-08-16) * page 7, paragraph 2; figures *	1,2,9,14	
X	DE 10 2006 040248 A1 (BOSCH GMBH ROBERT [DE]) 6 March 2008 (2008-03-06) * paragraphs [0008], [0009]; figures *	1-3	TECHNICAL FIELDS SEARCHED (IPC) F02M
X	WO 2006/100142 A1 (BOSCH GMBH ROBERT [DE]; PAUER THOMAS [DE]) 28 September 2006 (2006-09-28) * page 4, paragraph 2; figures *	1-3	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 February 2015	Godrie, Pierre

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 18 6943

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.

13-02-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1612405 A1	04-01-2006	AT 413528 T	15-11-2008
		EP 1612405 A1	04-01-2006
		JP 4403098 B2	20-01-2010
		JP 2006017105 A	19-01-2006
		US 2006000451 A1	05-01-2006
DE 102009055129 A1	30-06-2011	CN 102667134 A	12-09-2012
		DE 102009055129 A1	30-06-2011
		EP 2516839 A1	31-10-2012
		WO 2011085858 A1	21-07-2011
WO 2007009279 A1	25-01-2007	AT 488690 T	15-12-2010
		BR PI0613413 A2	11-01-2011
		CN 101223352 A	16-07-2008
		EP 1904741 A1	02-04-2008
		JP 5120655 B2	16-01-2013
		JP 2009501863 A	22-01-2009
		US 2008296413 A1	04-12-2008
		WO 2007009279 A1	25-01-2007
WO 2012107634 A2	16-08-2012	CN 103380288 A	30-10-2013
		EP 2673493 A2	18-12-2013
		FI 20115124 A	10-08-2012
		JP 2014508245 A	03-04-2014
		KR 20140009335 A	22-01-2014
		US 2014007844 A1	09-01-2014
		WO 2012107634 A2	16-08-2012
DE 102006040248 A1	06-03-2008	DE 102006040248 A1	06-03-2008
		WO 2008025597 A1	06-03-2008
WO 2006100142 A1	28-09-2006	AT 448402 T	15-11-2009
		CN 101163879 A	16-04-2008
		DE 102005012928 A1	28-09-2006
		EP 1864014 A1	12-12-2007
		JP 4651057 B2	16-03-2011
		JP 2008533387 A	21-08-2008
		KR 20070110377 A	16-11-2007
		US 2008184962 A1	07-08-2008
		WO 2006100142 A1	28-09-2006

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- GB 1317441 A **[0003] [0023]**