

PATENT PORTFOLIO

PHILIP J. G. DINGLE

VALVE TRAIN FOR AN INTERNAL COMBUSTION ENGINE

(12) UK Patent Application (19) GB (11) 2536799 (13) A		(43) Date of A Publication	28.09.2016
(21) Application No:	1603362.3	(51) INT CL:	F01L 9/02 (2006.01) F01L 13/00 (2006.01) F01L 1/344 (2006.01)
(22) Date of Filing:	26.02.2016	(56) Documents Cited:	US 5233951 A US 4153016 A
(71) Applicant(s): Daimler AG Mercedesstrasse 137, Stuttgart 70327, Germany		(58) Field of Search:	INT CL F01L, F16K Other: WPI, EPODOC
(72) Inventor(s): Phillip Dingle			
(74) Agent and/or Address for Service: Hofstetter Schurack & Partner Balanstr. 57, D-81541 München, Germany			
(54) Title of the Invention: Valve train for an internal combustion engine Abstract Title: Variable actuation valve train for an internal combustion engine			
(57) A valve train 10 for an internal combustion engine, comprising at least one charge cycle valve 12 for a cylinder engine, comprising a valve stem 14, a cap 22 slidably coupled thereto, wherein the charge cycle valve 12 is actuatable via the valve stem 14 and the cap 22 by at least one actuating element (24, Fig. 1) at least one hydraulic chamber 38 bounded at least partially by the valve stem 14 and the cap 22 which has at least one through opening 40 for discharging hydraulic medium from the hydraulic chamber 38; at least one sleeve 42 slidably arranged on the cap 22, and being slidable in relation to the cap 22 between at least one covering position in which the through opening 40 is covered by the sleeve 42, and at least one release position in which the sleeve 42 uncovers the through opening 40; and an actuator 44 configured to slide the sleeve 42 in relation to the cap 22 thereby varying the actuation of the charge cycle valve 12. The invention is intended at providing a variable actuation valve with a relatively low complexity and installation space.			
		<p>Fig.6</p>	
		GB 2536799 A	

- **Filing Date: 24 February 2016**
- **Novelty:** A lost-motion valve train specifically intended for the Daimler OM470/1/2/3 family of engines is disclosed. A hydraulic link is formed by a cap over the top of the valve stem having cross-holes through which the oil may escape if not occluded by a moveable control sleeve. Many VVA strategies are thereby enabled, including Miller cycle.
- **Comments:** This is a particularly simple and elegant solution for VVA

INJECTOR

(12) UK Patent Application (19) GB (11) 2540532 (13) A		(43) Date of A Publication 25.01.2017
(21) Application No: 1509754.6	(51) INT CL: F02M 43/04 (2006.01)	
(22) Date of Filing: 05.06.2015	(56) Documents Cited: EP 2604847 A2 WO 2001/079685 A2 US 5458292 A US 20060202052 A1 JP H1026058 JP H09317593	
(71) Applicant(s): Delphi International Operations Luxembourg S.à.r.l. Avenue de Luxembourg, Bascharage L-4940, Luxembourg	(58) Field of Search: INT CL F02M Other: WPI, EPODOC	
(72) Inventor(s): Philip John Gregory Dingle		
(74) Agent and/or Address for Service: DELPHI FRANCE SAS PO Box CS 65059, Bât. Le Raspail, ZAC Paris Nord II 22, avenue des Nations, Roissy CDG Cedex 95972, France (including Overseas Departments and Territories)		
(54) Title of the Invention: Injector Abstract Title: Dual Fuel Injector with Concentric Needles		
(57) Dual fuel injector 2 for an internal combustion engine, comprising concentrically arranged needles 6, 8, an inner needle 8 for controlling a flow of a high reactivity fuel such as diesel / DME received via a pilot piston shuttle, and an outer needle 6, in which the inner needle 8 is arranged and guided, for controlling a flow of a lower reactivity gaseous fuel; the inner and outer needles both being controlled by a single actuator 102 and control valve 82, wherein the injector can operate in a dual fuel operational mode, or in a high reactivity fuel only mode, as required for example on depletion of gaseous fuel. The injector may be used in a fuel injection apparatus 100 or a fuel system with two distinct fuel sources, and may be applied in the heavy duty trucking sector.		

GB 2540532 A

- **Filing Date:** 05 June 2016
- **Novelty:** This describes a dual-fuel injector concept having concentric needles which can be applied to a slightly modified common rail injector. The main fuel may be gaseous while the pilot fuel may be diesel or DME, the novelty being that only one control actuator is required, not two, and a full power limp-home capability is possible.
- **Comment:** Having left Delphi by this point, its production intent status is unknown.

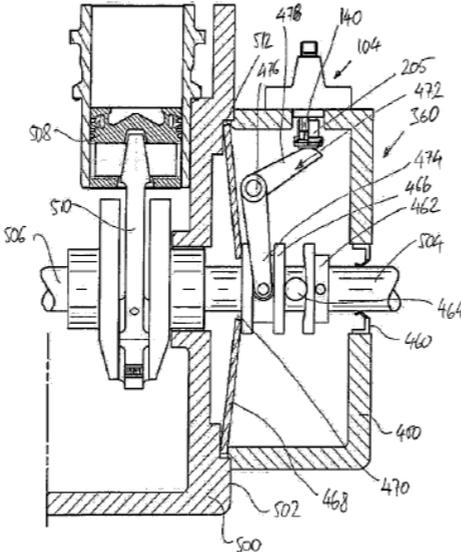
FUEL INJECTION EQUIPMENT

(12) UK Patent Application (19) GB (11) 2530761 (13) A		(43) Date of A Publication	06.04.2016
(21) Application No:	1417308.2	(51) INT CL:	F02D 41/30 (2006.01)
(22) Date of Filing:	01.10.2014	(56) Documents Cited:	WO 2007/066565 A1 CA 002848849 A1 DE 010141888 A1 JP 2014173493 A JP 2010196506 A JP 2007231908 A US 20140032081 A1 US 20050011485 A
(71) Applicant(s):	Delphi International Operations Luxembourg S.à.r.l. Avenue de Luxembourg, L-4940 Bascharage, Luxembourg	(58) Field of Search:	INT CL F02D Other: EPODOC, WPI
(72) Inventor(s):	Philip Dingle	(74) Agent and/or Address for Service:	Delphi Diesel Systems Limited Courteney Road, GILLINGHAM, Kent, ME8 0RU, United Kingdom
(54) Title of the Invention: Fuel injection equipment Abstract Title: Control strategy for multi-point fuel injection equipment			
(57) A fuel injection method adapted to control the fuel injection equipment 12 of an internal combustion engine 10, the equipment being provided with direct in-cylinder fuel injectors 46, 64. Each cylinder 14 of the engine is fuelled by a first fuel injector 46 and also by a second fuel injector 64. The method comprises a first strategy (102, figs 2-6) for controlling the first injectors 46 and a second strategy (104, figs 2-6) for controlling the second injectors 64. Each strategy comprises the steps of commanding pressure, opening time and duration, the first strategy being different from the second strategy. Some of these differences may be: different pressures within the first and second injectors; they can open at different times deepening upon the angular position of the crankshaft; the duration of opening may be different. There may be a control module for controlling the fuel injection equipment, there can be a first and second control module controlling the first and second control strategy respectively. When fuelling a plurality of cylinders the first injectors may belong to a first set of injectors and the second injectors may belong to a second set of injectors.			
Fig. 1			

GB 2530761 A

- **Filing Date:** 01 October 2014
- **Novelty:** Intended for “side injection” engines, i.e. not with a single central on-axis injector, so that two or more fuel injectors can be accommodated. This allows much greater flexibility in injection strategy, and several beneficial strategies are disclosed for such engines, which can include opposed piston 2-strokes.
- **Comment:** Some of these strategies are likely to appear in future engines.

FUEL INJECTION SYSTEM AND FUEL PUMP

(19)	 Europäisches Patentamt European Patent Office Office européen des brevets	
		(11) EP 2 796 705 A
(12)	EUROPEAN PATENT APPLICATION	
(43)	Date of publication: 29.10.2014 Bulletin 2014/44	(51) Int Cl: F02M 59/18 (2006.01)
(21)	Application number: 13164627.5	
(22)	Date of filing: 22.04.2013	
(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	(72) Inventor: Dingle, Philip Rochester, MI Michigan 48306 (US) (74) Representative: Neill, Andrew Peter Delphi Diesel Systems Patent Department Courteney Road Gillingham, Kent ME8 0RU (GB)
(71)	Applicant: Delphi International Operations Luxembourg S.à r.l. 4940 Bascharage (LU)	
(54)	Fuel injection system and fuel pump	
(57)	<p>A fuel injection system (100) for an internal combustion engine is disclosed. The fuel injection system comprises at least one electronically-controlled fuel injector (102), a fuel pump (104) for supplying pressurised fuel to the or each injector (102), and a controller (130) arranged to control the injection of fuel from the or each injector (102). The fuel pump (104) comprises a pump chamber (146), a pumping element (140), and a drive mechanism (360) for driving the pumping element (140) in a pumping stroke in which the volume of the pump chamber (146) is reduced, and a filling stroke in which the volume of the pump chamber (146) is increased and in which fuel is admitted to the pump chamber (146) from a fuel source (116). The drive mechanism (360) comprises a biasing arrangement (468) arranged to apply a resilient biasing force, such as a spring force, to the pumping element (140) to drive the pumping stroke. In this way, the resilient biasing force acts to pressurise the fuel for injection, providing a simplified fuel injection system with electronic control of the injection timing and duration. Fuel pumps suitable for use in such a system are also disclosed.</p>	
		
	FIGURE 7	

- **Filing Date:** 22 April 2013
- **Novelty:** Intended to be a low cost common rail fuel injection system for small engines, it utilized the constant force part of the displacement curve of a diaphragm spring to give a constant rail pressure. Pumping was done by the spring and retraction by the engine cam. No pressure control was needed.
- **Comments:** A good idea that was ultimately not pursued.

FUEL INJECTOR

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 May 2011 (12.05.2011)

PCT

(10) International Publication Number
WO 2011/054613 A1

(51) International Patent Classification:
F02M 45/12 (2006.01) F02M 63/00 (2006.01)
F02M 47/02 (2006.01)

(74) Agent: GREGORY, John; Courteney Road, Gillingham
Kent ME8 0RU (GB).

(21) International Application Number:
PCT/EP2010/064853

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD,
SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date:
5 October 2010 (05.10.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09175036.4 4 November 2009 (04.11.2009) EP

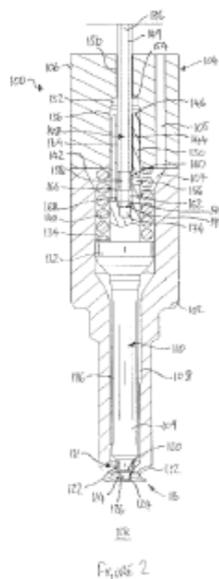
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(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG,
ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

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[Continued on next page]

(54) Title: FUEL INJECTOR



(57) Abstract: A fuel injector (100; 200; 300) for an internal combustion engine is disclosed. The injector includes a slave piston (130; 230; 330) provided with a control bore (144; 244; 344) and associated with a valve needle (110; 210; 310), such that movement of the slave piston causes movement of the valve needle. An end of the slave piston remote from the valve needle is exposed to fuel pressure in a control chamber (152; 252; 352) of the injector, in use. A control piston (148; 348) is operable to move relative to the slave piston so as to control fuel flow through first and second control ports that connect the control bore to a high-pressure fuel supply and a low-pressure drain respectively. By suitable positioning of the control piston, the valve needle can be biased in an opening direction and in a closing direction and, optionally, the valve needle can be held in one or more intermediate positions between its fully-lifted and fully-seated positions. Proportional control of the position and velocity of the valve needle is possible, and a low-force actuator can be used to control the valve needle.

WO 2011/054613 A1

- **Filing Date:** 04 Nov 2009
- **Novelty:** Proportional needle valve lift (as opposed to the conventional bi-polar motion), using a follow-up servo with a low leakage feature
- **Comments:** Three different embodiments disclosed for different types of common rail injector

SYSTEM FOR DOSING REAGENT



(11) EP 2 295 748 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
19.12.2012 Bulletin 2012/51

(51) Int. Cl.:
F01N 3/10 (2006.01) F01N 13/04 (2010.01)
F01N 3/035 (2006.01) F01N 11/00 (2006.01)
F01N 3/20 (2006.01) F01N 3/021 (2006.01)
F01N 3/08 (2006.01)

(21) Application number: 10187323.0

(22) Date of filing: 22.05.2009

(54) System for dosing reagent

System zur Dosierung der Reagenz
Système de dosage de réactif

(84) Designated Contracting States:
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 SE SI SK TR
Designated Extension States:
AL BA RS

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(30) Priority: 06.06.2008 GB 0810382

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(43) Date of publication of application:
16.03.2011 Bulletin 2011/11

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
09160908.1 / 2 131 020

(56) References cited:
GB-A- 2 304 821 US-A- 5 189 876
US-A- 5 600 774 US-A- 2002 247 040

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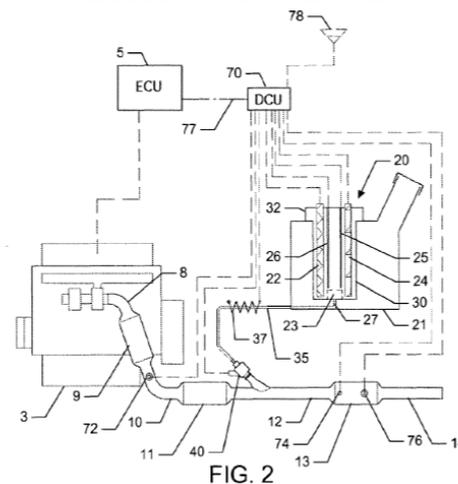


FIG. 2

Note: Within nine months of the publication of the present Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 2 295 748 B1

- **Filing Date:** 06 June 2008
- **Novelty:** An omnibus patent that brings together several prior art features to describe a complete reductant dosing system, typically intended for aqueous urea
- **Comments:** A system with most of the described features is being developed for production

DUAL-MODE COMBUSTION APPARATUS AND METHOD



(12) **United States Patent**
Dingle (10) **Patent No.:** **US 7,685,990 B2**
(45) **Date of Patent:** **Mar. 30, 2010**

(54) **DUAL MODE COMBUSTION APPARATUS AND METHOD**
(75) **Inventor:** Philip J. G. Dingle, Rochester, MI (US)
(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 108 days.

(21) **Appl. No.:** 11/998,465

(22) **Filed:** Nov. 29, 2007

(65) **Prior Publication Data**

US 2009/0139487 A1 Jun. 4, 2009

(51) **Int. Cl.**
F02B 5/00 (2006.01)
F02B 3/00 (2006.01)

(52) **U.S. Cl.** 123/299; 123/305; 123/276; 239/533.3

(58) **Field of Classification Search** 123/276, 123/299, 305, 300
See application file for complete search history.

(56) **References Cited**

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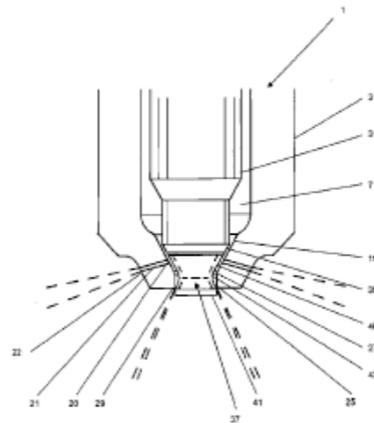
Primary Examiner—Thomas N Moulis

(74) *Attorney, Agent, or Firm*—Thomas N. Twomey

(57) **ABSTRACT**

A fuel injection apparatus for a fuel injector nozzle includes a moveable valve needle slidably located within a nozzle body, the nozzle body having an internal surface defining a valve seat between a fuel supply path and fuel outlets. The valve needle includes an obturator piston that is engagable with an axial fuel outlet and a two-stage lift mechanism for enabling lift of the valve needle. In a first stage lifted position of the valve needle, the valve face is spaced apart from the valve seat, and the obturator piston is positioned such that a fuel flow passage is opened between the obturator piston and the axial fuel outlet. In a second stage lifted position, the valve face is spaced further apart from the valve seat and the obturator piston is positioned such that the fuel flow passage between the obturator piston and the axial fuel outlet is substantially closed.

23 Claims, 11 Drawing Sheets



- **Filing Date:** 29 Nov 2007
- **Novelty:** This disclosure combined various prior art concepts from both pintle and hole-type nozzles in a manner to offer the prospect of discrete premixed and diffusion sprays for PPCI combustion
- **Comment:** Concept not considered to be production feasible at that time, but hardware built for subsequent evaluation by Detroit Diesel Corp.

FUEL INJECTOR & METHOD FOR CONTROLLING FUEL INJECTORS



US007552717B2

(12) **United States Patent**
Dingle

(10) **Patent No.:** US 7,552,717 B2
(45) **Date of Patent:** Jun. 30, 2009

(54) **FUEL INJECTOR AND METHOD FOR CONTROLLING FUEL INJECTORS**

(75) **Inventor:** Philip J. G. Dingle, Rochester, MI (US)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** 11/890,737
(22) **Filed:** Aug. 7, 2007

(65) **Prior Publication Data**
US 2009/0038589 A1 Feb. 12, 2009

(51) **Int. Cl.**
F02D 41/30 (2006.01)
F02D 28/00 (2006.01)

(52) **U.S. Cl.** 123/480; 701/103

(58) **Field of Classification Search** 123/480, 123/456, 435, 467, 494, 468; 701/103, 104
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
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6,425,879 B1* 7/2002 Egger et al. 604/68

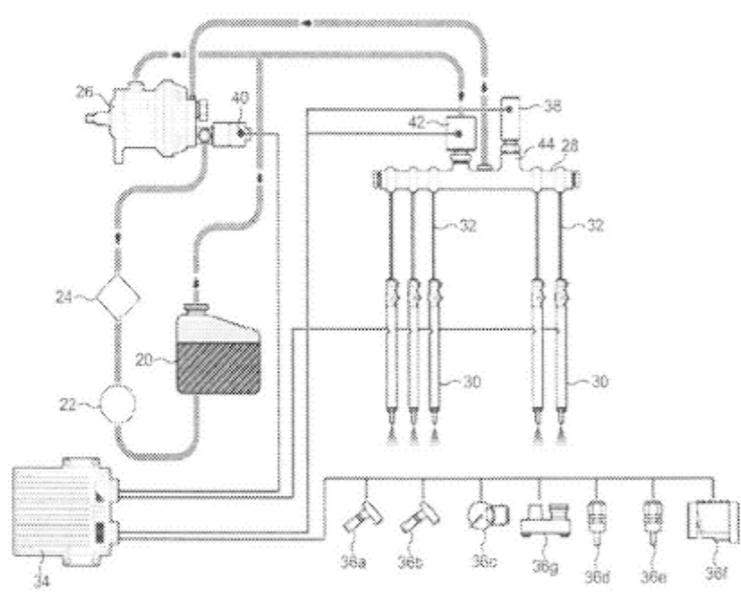
(10) **Patent No.:** US 7,552,717 B2
(45) **Date of Patent:** Jun. 30, 2009

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7,343,809 B2* 3/2008 Baumann et al. 73/728

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Primary Examiner—Stephen K. Cronin
Assistant Examiner—Johnny H. Hoang
(74) *Attorney, Agent, or Firm*—Thomas W. Twomey

(57) **ABSTRACT**
A fuel injector for an internal combustion engine, the fuel injector comprising an injector body, a fuel supply passage defined in the injector body, the fuel supply passage containing fuel under high pressure in use of the injector, a pressure sensor for measuring the pressure of fuel in the passage in use, wherein the pressure sensor is situated within the injector body and is separated from fuel in the passage in use, and a method of fuel injection, comprising constructing a hydraulic behavior profile by fuel pressure measurement, using the hydraulic behavior profile to predict fuel pressure that will prevail in a fuel injector during an injection event, and supplying a control signal to the fuel injector to control the amount of fuel injected during the injection event in accordance with the predicted fuel pressure. By predicting the fuel pressure that will prevail during an injection event, the fuel delivered during the injection event can be accurately controlled.

4 Claims, 14 Drawing Sheets



- **Filing Date:** 07 August 2007
- **Novelty:** Incorporation of a non-wetted magnetostrictive pressure sensing device integrated into each injector (replacing the rail pressure sensor), and methods of using the resulting signals to give superior injection control
- **Comments:** Similar in principle to the current production Denso iArt system, but conveniently filed 3 weeks prior to the comparable Denso patent

FLUID DELIVERY SYSTEM



US008027751B2

(12) **United States Patent**
Dingle

(10) **Patent No.:** US 8,027,751 B2
(45) **Date of Patent:** Sep. 27, 2011

(54) **FLUID DELIVERY SYSTEM**

(75) **Inventor:** Phillip J. G. Dingle, Rochester, MI (US)

(73) **Assignee:** Delphi Technologies Holding S.arl,
Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(h) by 1106 days.

(21) **Appl. No.:** 11/879,210

(22) **Filed:** Jul. 16, 2007

(65) **Prior Publication Data**
US 2009/0019835 A1 Jan. 22, 2009

(51) **Int. Cl.**
G06F 19/00 (2011.01)

(52) **U.S. Cl.** 700/282; 417/521

(58) **Field of Classification Search** 700/286,
700/291, 282, 281; 60/282; 417/44.1, 12;
604/891.1
See application file for complete search history.

(56) **References Cited**

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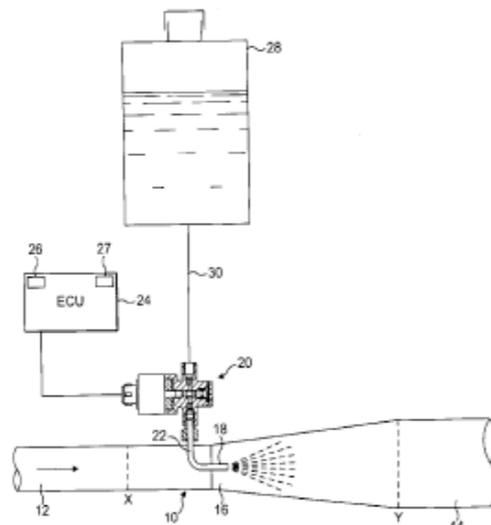
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2004/0093856 A1 * 5/2004 Dingle et al. 60/286
2010/0023170 A1 * 1/2010 Sherwood 700/282
* cited by examiner

Primary Examiner — Kideest Bahta
(74) *Attorney, Agent, or Firm* — Thomas N. Twomey

(57) **ABSTRACT**

A fluid delivery system for delivering a metered dose of fluid from a supply tank (28) to a downstream chamber or vessel (10), comprises a pump apparatus (20) comprising a pump plunger (32) which is operable to perform a pumping stroke under the control of an electromagnetic actuator (36), including a solenoid (36a), to effect delivery of the fluid and a control unit (24) for supplying an input signal (58) to the solenoid (36a) to initiate a current flow to the solenoid (36a) and thereby initiate movement of the pump plunger (32). An electronic device (54) provides an output signal to indicate that movement of the pump plunger has stopped at the end of the pumping stroke, and a timer determines a time difference between the input signal (58) being supplied to the solenoid (36a) and the output signal being output by the electronic device (54). A processor (26) compares the time difference with a predetermined time difference and determines, as a result of the comparison, whether or not the pump plunger (32) has performed a valid pumping stroke in which an intended volume of fluid is displaced.

21 Claims, 4 Drawing Sheets



- **Filing Date:** 16 July 2007
- **Novelty:** Provides failure diagnostic information for OBD reporting in connection with SCR dosing systems by monitoring plunger stroke travel, timing and speed
- **Comments:** Intended for use with positive displacement dosing pumps. Concept being developed further for production

COMBUSTION ENGINE TECHNOLOGY



(19) **United States**
 (12) **Patent Application Publication** (10) **Pub. No.: US 2008/0271709 A1**
Dingle (43) **Pub. Date: Nov. 6, 2008**

(54) **COMBUSTION ENGINE TECHNOLOGY**

(57) **ABSTRACT**

(76) **Inventor:** **Phillip J. G. Dingle**, Rochester, MI (US)

A fuel system for use in a combustion chamber of a compression ignition internal combustion engine comprises a pump arrangement having a pump chamber for fluid and a piston which is movable outwardly from the combustion chamber in response to pressure generated within the combustion chamber as a result of combustion so as to pressurise fluid within the pump chamber. The system also includes a control valve assembly for controlling the supply of fluid that is pressurised within the pump chamber to an accumulator volume. In one particular aspect, the invention provides a fuel system for use in an engine having at least two engine cylinders, comprising a first pump arrangement associated with one of the engine cylinders and a second pump arrangement associated with the other of the engine cylinders, each of the first and second pump arrangements having a pump chamber for fluid and a piston which is movable outwardly from the combustion chamber in response to pressure generated within the combustion chamber as a result of combustion so as to pressurise fuel within the pump chamber. At least one control valve assembly controls the supply of fluid that is pressurised within the pump chamber of at least one of the pump arrangements to an accumulator volume.

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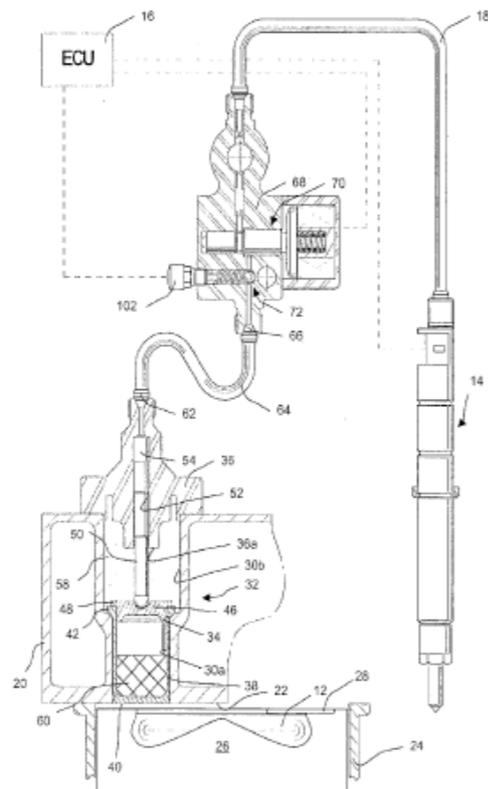
(21) **Appl. No.:** **11/799,670**

(22) **Filed:** **May 2, 2007**

Publication Classification

(51) **Int. Cl.**
F02M 61/04 (2006.01)

(52) **U.S. Cl.** **123/447**



- **Filing Date:** 02 May 2007
- **Novelty:** An attempt at a lower cost de-contented version of the earlier concept [slide 13], but still employing cylinder pressure to generate rail pressure.
- **Comments:** Not pursued

OUTWARD-OPENING GAS-EXCHANGE VALVE SYSTEM FOR AN INTERNAL COMBUSTION ENGINE



US007377249B1

(12) **United States Patent**
Dingle

(10) **Patent No.:** US 7,377,249 B1
(45) **Date of Patent:** May 27, 2008

(54) **OUTWARD-OPENING GAS-EXCHANGE VALVE SYSTEM FOR AN INTERNAL COMBUSTION ENGINE**

(75) **Inventor:** Philip J. G. Dingle, Rochester, MI (US)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** 11/725,345

(22) **Filed:** Mar. 19, 2007

(51) **Int. Cl.**
F02N 3/00 (2006.01)
F01L 1/28 (2006.01)

(52) **U.S. Cl.** 123/188.8; 123/79 R

(58) **Field of Classification Search** 123/79 R, 123/188.8, 188.17, 90.12, 90.14
See application file for complete search history.

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Mello, J. P. and Linna, J.R.; "Homogeneous Charge Compression Ignition (HCCI)—The Pathway to Clean Diesel Engines?"; ITAX, LLC; Cambridge, Mass; Jan. 30, 2003.

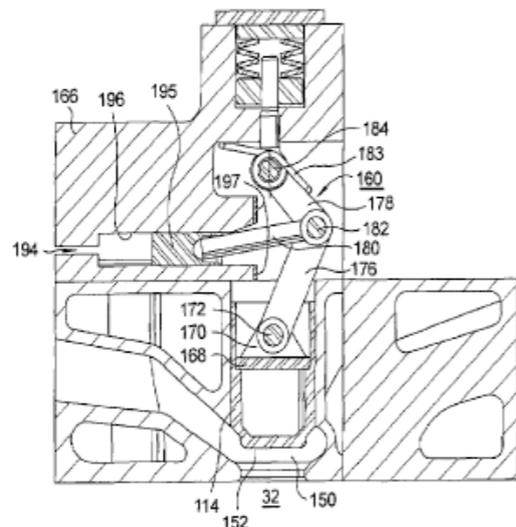
* cited by examiner

Primary Examiner—John T. Kwon
(74) *Attorney, Agent, or Firm*—Paul L. Marshall

(57) **ABSTRACT**

An outwardly-opening gas-exchange valve assembly for an internal combustion engine. The valve assembly includes a port in a firing chamber in an engine head, the port having a valve seat on a side opposite from the firing chamber. A piston-shaped poppet valve head slides in a bore in the engine head for mating with the valve seat to occlude passage of gas across the valve seat. Withdrawal of the poppet valve head from the seat opens the firing chamber to communication with an intake or exhaust manifold runner in the engine head. The poppet valve head may be actuated by an overcenter lever arrangement actuated selectively by hydraulic pressure or mechanical actuation. In a preferred embodiment, OO intake and exhaust valves are radially arranged in a hemispherical fire deck and may include an adjustable pitch helical channel to induce swirl to the incoming gas.

16 Claims, 9 Drawing Sheets



- **Filing Date:** 19 March 2007
- **Novelty:** Uses an over-center linkage for desmodromic control of outward-opening gas-exchange valves. A preload mechanism controls valve seating load and acts as a cylinder pressure over-pressure relief valve
- **Comments:** Outward-opening valves are a key enabler for camless operation in diesel engines. Also an enabler for radial valves which in turn enable high BMEP

EXHAUST VALVE ARRANGEMENT AND A FUEL SYSTEM INCORPORATING AN EXHAUST VALVE ARRANGEMENT



US007533656B2

(12) **United States Patent**
Dingle

(10) **Patent No.:** US 7,533,656 B2
(45) **Date of Patent:** May 19, 2009

(54) **EXHAUST VALVE ARRANGEMENT AND A FUEL SYSTEM INCORPORATING AN EXHAUST VALVE ARRANGEMENT**

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(75) **Inventor:** Philip J. G. Dingle, Rochester, MI (US)

* cited by examiner

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

Primary Examiner—Erick Solis

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

(74) *Attorney, Agent, or Firm*—Thomas N. Twomey

(21) **Appl. No.:** 11/634,666

(22) **Filed:** Dec. 6, 2006

(65) **Prior Publication Data**

US 2008/0135001 A1 Jun. 12, 2008

(51) **Int. Cl.**
F02M 37/12 (2006.01)
F02M 37/14 (2006.01)

(52) **U.S. Cl.** 123/507; 123/58.9; 123/78 AA;
123/81 C; 123/188.5; 123/90.11

(58) **Field of Classification Search** 123/507,
123/58.9, 188.5, 78 AA, 81 C, 90.11
See application file for complete search history.

(56) **References Cited**

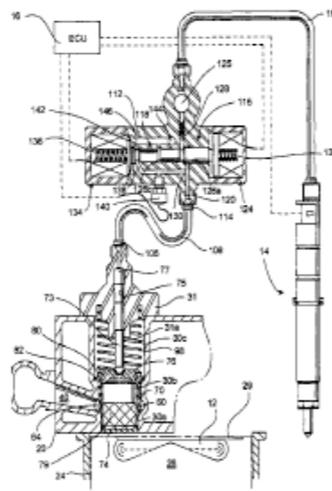
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4,625,684 A * 12/1986 Van Averboste 123/48 A
5,113,805 A * 5/1992 Kawamura 123/21

(57) **ABSTRACT**

An exhaust valve arrangement for use in a combustion chamber of a compression ignition internal combustion engine, includes a piston which is movable outwardly from the combustion chamber in response to pressure generated within the combustion chamber as a result of combustion, and an outer sleeve within which the piston is movable. The outer sleeve is an exhaust valve which is actuatable between open and closed positions to open and close, respectively, an exhaust passage from the combustion chamber. The exhaust valve arrangement further includes a pump chamber for receiving fluid, and a pumping plunger coupled to the piston and movable with the piston so as to pressurise fluid (e.g. fuel) within the pump chamber as the piston is urged outwardly from the combustion chamber. The pressure within the pump chamber is proportional to cylinder pressure and is sensed by a sensor which provides an output signal to an Engine Control Unit (ECU 16). An accumulator volume receives fluid that is pressurised within the pump chamber. Where the fluid is fuel, the accumulator volume is arranged to deliver fuel to one or more injectors of a common rail fuel injection system. Alternatively the accumulator volume may be arranged to deliver pressurised fluid to one or more engine systems e.g. for actuation purposes.

32 Claims, 13 Drawing Sheets



- **Filing Date:** 06 December 2006
- **Novelty:** An attempt at a cylinder pressure operated high pressure fuel pump and common rail injection system
- **Comments:** Incorporated an outward-opening exhaust valve actuating the fuel pump plunger, and features use of the locked-off fuel pressure as a surrogate for cylinder pressure sensing. Considered too radical and expensive for production

VALVE LASH ADJUSTER HAVING ELECTRO-HYDRAULIC LOST-MOTION CAPABILITY



(12) **United States Patent**
Dingle

(10) **Patent No.:** US 7,509,933 B2
(45) **Date of Patent:** Mar. 31, 2009

(54) **VALVE LASH ADJUSTER HAVING ELECTRO-HYDRAULIC LOST-MOTION CAPABILITY**

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6,920,868 B2* 7/2005 Ruggiero et al. 123/568.14

(75) **Inventor:** Philip J. G. Dingle, Rochester, MI (US)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

* cited by examiner

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 326 days.

Primary Examiner—Ching Chang
(74) *Attorney, Agent, or Firm*—Thomas W. Two

(21) **Appl. No.:** 11/368,739

(22) **Filed:** Mar. 6, 2006

(65) **Prior Publication Data**

US 2007/0204818 A1 Sep. 6, 2007

(51) **Int. Cl.**
F01L 1/14 (2006.01)

(52) **U.S. Cl.** 123/90.52; 123/90.39; 123/90.43; 74/569

(58) **Field of Classification Search** 123/90.39, 123/90.44, 90.45, 90.46, 90.48, 90.52, 90.55, 123/90.43; 74/559, 567, 569
See application file for complete search history.

(56) **References Cited**

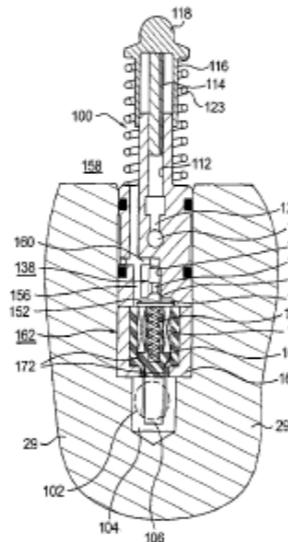
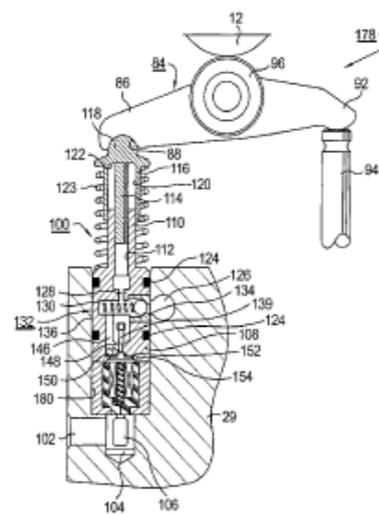
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5,680,841 A * 10/1997 Hu 123/322

(57) **ABSTRACT**

In a Type 2 engine, a valve deactivation hydraulic lash adjuster (DHLA) in accordance with the invention replaces a conventional hydraulic lash adjuster in the train of a gas-exchange valve in a compression-ignited engine. In a Type 3 engine, a similar DHLA is disposed within an articulated rocker arm which is made selectively competent (valve activating) or incompetent (valve deactivating) thereby. A solenoid valve within the assembly diverts hydraulic fluid between support and non-support of a piston slidably disposed in a housing and terminating in a ball head. The valve is force-balanced. The preferred hydraulic fluid is diesel fuel, allowing for smaller diameter passages and cleaner operation than in prior art systems, eliminating the need for an accumulator chamber and accumulator piston as in the prior art. An alternate version of a type 3 engine having a DHLA, in accordance with the invention, is also shown.

11 Claims, 10 Drawing Sheets



- **Filing Date:** 06 March 2006
- **Novelty:** A deactivation hydraulic lash adjuster (DHLA) incorporates a fast response balanced control valve and solenoid actuator which enables lost motion capability when using a low viscosity oil
- **Comments:** This concept was based on the packaging dimensions of the Delphi Diesel common rail injector control valve and actuator. A version integrated into a collapsible rocker was also disclosed

METHODS FOR OPERATING A COMPRESSION IGNITION ENGINE



(12) **United States Patent**
Quader et al. (10) **Patent No.:** US 7,188,587 B1
 (45) **Date of Patent:** Mar. 13, 2007

(54) **METHODS FOR OPERATING A COMPRESSION IGNITION ENGINE**

(75) **Inventors:** **Ather A. Quader**, Rochester Hills, MI (US); **John E. Kirwan**, Troy, MI (US); **Phillip J. Dingle**, Rochester, MI (US); **Malcolm James Grieve**, Fairport, NY (US)

(73) **Assignee:** **Delphi Technologies, Inc.**, Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** 11/290,909

(22) **Filed:** Nov. 30, 2005

(51) **Int. Cl.**
F02B 41/00 (2006.01)

(52) **U.S. Cl.** 123/26; 123/432

(58) **Field of Classification Search** 123/26, 123/27 GE, 432
 See application file for complete search history.

(56) **References Cited**

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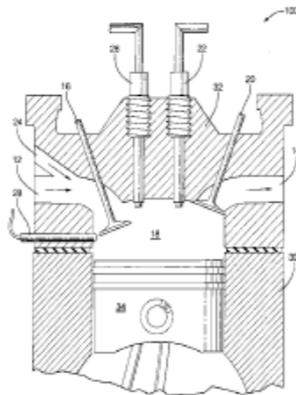
(Continued)

Primary Examiner—Noah P. Kamen
(74) Attorney, Agent, or Firm—Paul L. Marshall

(57) **ABSTRACT**

A method of operating a compression ignition engine is disclosed. The method comprises, introducing an enriching component into a combustion chamber during an intake stroke, igniting the enriching component during the compression stroke, introducing a main injection of fuel to the combustion chamber after the ignition of the enriching component, igniting the main injection of fuel, and introducing a supplemental gas to the combustion chamber after igniting the main injection of fuel.

18 Claims, 1 Drawing Sheet



- **Filing Date:** 30 November 2005
- **Novelty:** A concept in which reformer gas is introduced during the intake stroke followed by ignition of that fuel, then a main injection is introduced which combusts in the presence of that diluent, followed by late-cycle injection of oxygen-rich air or similar
- **Comments:** Seen at the time as a possible application for the Delphi fuel reformer

METHOD AND APPARATUS FOR OPTIMIZED COMBUSTION IN AN INTERNAL COMBUSTION ENGINE UTILIZING HOMOGENEOUS CHARGE COMPRESSION IGNITION AND VARIABLE VALVE ACTUATION



US007308872B2

(12) **United States Patent**
Sellnau et al.

(10) **Patent No.:** US 7,308,872 B2
(45) **Date of Patent:** Dec. 18, 2007

(54) **METHOD AND APPARATUS FOR OPTIMIZED COMBUSTION IN AN INTERNAL COMBUSTION ENGINE UTILIZING HOMOGENEOUS CHARGE COMPRESSION IGNITION AND VARIABLE VALVE ACTUATION**

(75) **Inventors:** Mark C. Sellnau, Bloomfield Hills, MI (US); Philip J. G. Dingle, Rochester, MI (US)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 265 days.

(21) **Appl. No.:** 11/027,109
(22) **Filed:** Dec. 30, 2004

(65) **Prior Publication Data**
US 2006/0144356 A1 Jul. 6, 2006

(51) **Int. Cl.**
FOIL 1/34 (2006.01)

(52) **U.S. Cl.** 123/90.16; 123/90.39; 123/90.44

(58) **Field of Classification Search** 123/90.15, 123/90.16, 90.17, 90.18, 90.27, 90.31; 464/1, 464/2, 160

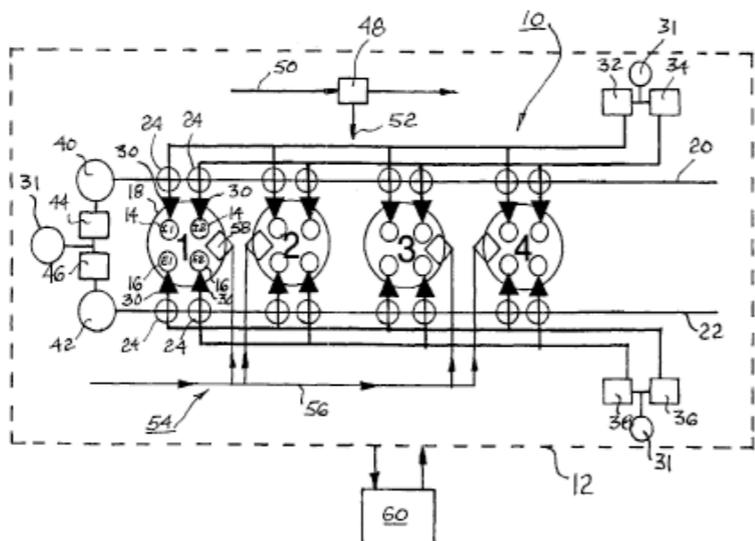
See application file for complete search history.

(56) **References Cited**
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6,830,020 B1 12/2004 El Tahay et al.
2005/0183693 A1 * 8/2005 Yang et al.

* cited by examiner
Primary Examiner—Ching Chang
(74) *Attorney, Agent, or Firm*—Paul L. Marshall

(57) **ABSTRACT**
A valvetrain system mechanization for an internal combustion engine using compression ignition, including homogeneous charge compression ignition, having two intake and one or more exhaust valves per cylinder. The valves are operated by dual overhead camshafts having two-step cams. The intake and exhaust camshafts are provided with phasers for varying the opening and closing of the intake and exhaust valves. A two-step roller finger follower is disposed for each valve between the cam lobes and the valve stem. The two sets of intake and exhaust valves are controlled by separate oil control valves. Swirl of gases may be introduced by mismatching the lifts of the valves. The valve opening times, closing times, lifts, fuel injection, compression ratio, and exhaust gas recirculation may be varied to optimize combustion conditions for a range of engine operating modes.

4 Claims, 19 Drawing Sheets



- **Filing Date:** 30 December 2004
- **Novelty:** A DOHC valve train mechanization employing two-step cam lobes and followers and cam phasers wherein each of the intake and exhaust valves may be controlled independently to influence end-of-compression temperatures as a means to enable HCCI combustion
- **Comments:** Elements of this strategy have been adopted for the Delphi GDCl combustion system currently in development

APPARATUS AND METHOD FOR MODE-SWITCHING FUEL INJECTOR NOZZLE



US007243862B2

(12) **United States Patent**
Dingle

(10) **Patent No.:** US 7,243,862 B2
(45) **Date of Patent:** Jul. 17, 2007

(54) **APPARATUS AND METHOD FOR MODE-SWITCHING FUEL INJECTOR NOZZLE**

(75) **Inventor:** Philip J. G. Dingle, Rochester, MI (US)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 188 days.

(21) **Appl. No.:** 11/027,796

(22) **Filed:** Dec. 30, 2004

(65) **Prior Publication Data**
US 2005/0224606 A1 Oct. 13, 2005

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/819,586, filed on Apr. 7, 2004.

(51) **Int. Cl.**
F02M 39/00 (2006.01)
F02M 41/00 (2006.01)
F02M 59/00 (2006.01)
F02M 61/00 (2006.01)
F02M 67/02 (2006.01)
B05B 7/10 (2006.01)

(52) **U.S. Cl.** 239/533.2; 239/533.12; 239/533.3; 239/88; 239/406; 239/408

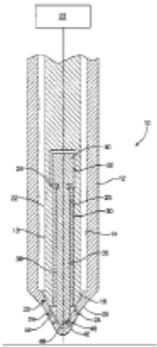
(58) **Field of Classification Search** 239/533.2, 239/533.12, 533.14, 533.3, 585.1-585.5, 239/88-93, 398, 406, 418, 5.8
See application file for complete search history.

(56) **References Cited**
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(Continued)
Primary Examiner—Davis D. Hwu
(74) *Attorney, Agent, or Firm*—David P. Wood

(57) **ABSTRACT**
A fuel injector nozzle and method for dispersing fuel during a normal combustion operation and a supplemental combustion operation, the fuel injector nozzle comprising: a plurality of first outlet openings configured to disperse fuel in a first arrangement; and a plurality of second outlet openings configured to collide with the fuel passing through the plurality of first openings to disperse fuel in a second arrangement, wherein either the first or second arrangement is selected by the position of the piston.

29 Claims, 8 Drawing Sheets



- **Filing Date:** 30 December 2004
- **Novelty:** A variable spray angle nozzle may be created by combining a two-row variable orifice nozzle design with a colliding sprays geometry in which the first row sprays are then subsumed into the larger second row sprays
- **Comments:** If reduced to practice, this arrangement could be used in a partially premixed combustion system in which the small hole first-row spray is directed down the bore and the wide angle late injection spray is directed into the bowl

APPARATUS AND METHOD FOR REDUCTANT DOSING OF AN EXHAUST



(12) **United States Patent**
Dingle et al. (10) **Patent No.:** **US 7,707,825 B2**
 (45) **Date of Patent:** **May 4, 2010**

(54) **APPARATUS AND METHOD FOR REDUCTANT DOSING OF AN EXHAUST** (58) **Field of Classification Search** 60/274, 60/277, 286, 295, 301, 303, 324
 See application file for complete search history.

(75) **Inventors:** **Phillip J. G. Dingle**, Rochester, MI (US);
Joachim Kupe, Davisburg, MI (US)

(73) **Assignee:** **Delphi Technologies, Inc.**, Troy, MI (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 603 days.

(21) **Appl. No.:** **11/897,746**

(22) **Filed:** **Jun. 6, 2006**

(65) **Prior Publication Data**
 US 2007/0295003 A1 Dec. 27, 2007

Related U.S. Application Data
 (62) Division of application No. 10/637,365, filed on Aug. 8, 2003, now abandoned.
 (60) Provisional application No. 60/427,205, filed on Nov. 18, 2002.

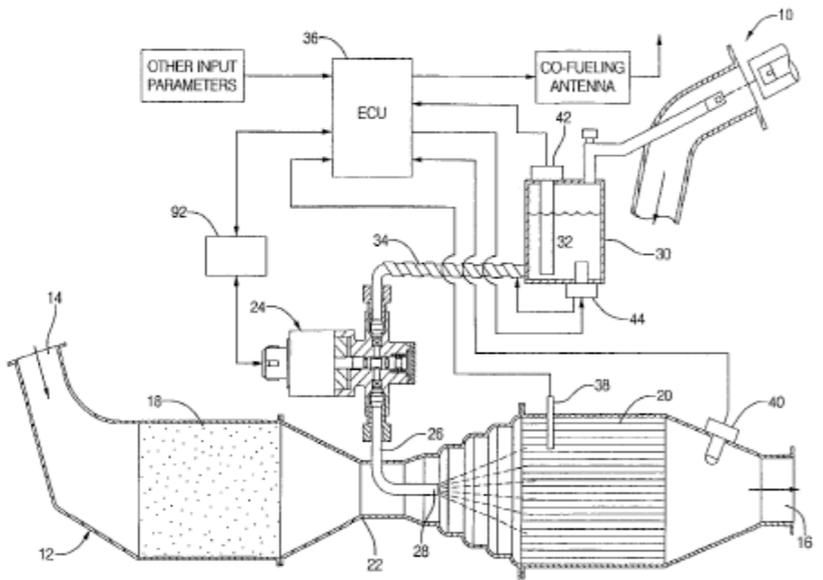
(51) **Int. Cl.**
F01N 3/00 (2006.01)
 (52) **U.S. Cl.** 60/286; 60/274; 60/277; 60/295; 60/303; 60/324

(56) **References Cited**
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 2007/0163232 A1 * 7/2007 Ueno 60/274

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 Primary Examiner—Tu M Nguyen
 (74) *Attorney, Agent, or Firm*—Thomas N. Twomey

(57) **ABSTRACT**
 A high-pressure metering pump for providing reductant in a single fluid engine exhaust dosing system having a solenoid for actuating a piston slidably received within an inner bore of a valve housing of the pump, the inner bore having a pressure chamber with an inlet check valve and an outlet check valve; and wherein movement of the piston causes high pressure reductant to be received at an atomizer of the system, the atomizer being disposed in a location to cause a maximum reduction of undesirable pollutant in the combustion gases of an engine.

10 Claims, 7 Drawing Sheets



- **Filing Date:** 06 June 2004
- **Novelty:** Disclosed a positive displacement variable frequency high injection pressure dosing pump and supporting system for aqueous urea in SCR exhaust aftertreatment
- **Comments:** Formed the basis for a dosing system that is subsequently being developed for production

ELECTRO-HYDRAULIC LOST-MOTION VALVE TRAIN

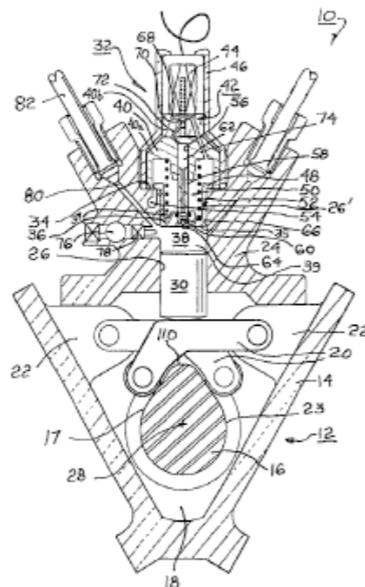


(12) **United States Patent**
Dingle et al. (10) **Patent No.:** US 7,077,083 B2
 (45) **Date of Patent:** Jul. 18, 2006

(54) **ELECTRO-HYDRAULIC LOST-MOTION VALVE TRAIN**
 (75) **Inventors:** Philip J. Dingle, Rochester, MI (US); Mark C. Sellman, Bloomfield Hills, MI (US)
 (73) **Assignee:** Delphi Technologies, Inc., Troy, MI (US)
 (*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
 (57) **ABSTRACT**

(21) **Appl. No.:** 10997,464
 (22) **Filed:** Nov. 24, 2004
 (65) **Prior Publication Data**
 US 2006/0107914 A1 May 25, 2006
 (51) **Int. Cl.**
FOIL 9/02 (2006.01)
 (52) **U.S. CL.** 123/90.12; 123/90.15; 123/90.13; 123/198 F; 251/129.19
 (58) **Field of Classification Search** 123/90.15, 123/90.16, 90.12, 90.13, 198 F
 See application file for complete search history.
 (56) **References Cited**
 U.S. PATENT DOCUMENTS
 4,716,863 A * 1/1988 Pruzan 123/90.15
 22 Claims, 8 Drawing Sheets

An electro-hydraulic lost motion system for variable valve activation including a master piston and an accumulation piston in a first bore, defining a hydraulic pressure chamber therebetween, in response to rotation of an engine cam. A slave piston in the engine head and hydraulically connected to the pressure chamber opens and closes an engine valve. A servo-valve behind the accumulation piston controls the mobility of the accumulation piston via a fluid control chamber. When the control chamber is made hydraulically rigid, the system actuates the engine valve. When the control chamber is vented through the servo-valve, the accumulation piston is movable in lost motion, preventing the engine valve from opening. All intermediate degrees of valve opening are possible. Preferably, the servo-valve, control chamber, accumulation piston, and a control piston are comprehended in a modular subassembly which may be positioned adjacent the master piston or the slave piston.



- **Filing Date:** 24 November 2004
- **Novelty:** A proposal for using common rail servo components to create a cost-effective lost-motion flexible valve train system
- **Comments:** No target application, so not pursued

DIRECT IN-CYLINDER REDUCTANT INJECTION SYSTEM AND A METHOD OF IMPLEMENTING SAME



US006679200B2

(12) **United States Patent**
Dingle

(10) **Patent No.:** US 6,679,200 B2
(45) **Date of Patent:** Jan. 20, 2004

(54) **DIRECT IN-CYLINDER REDUCTANT INJECTION SYSTEM AND A METHOD OF IMPLEMENTING SAME**

(75) Inventor: **Philip J. G. Dingle**, Rochester, MI (US)

(73) Assignee: **Delphi Technologies, Inc.**, Troy, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 33 days.

(21) Appl. No.: **10/183,737**
(22) Filed: **Jun. 27, 2002**
(65) **Prior Publication Data**
US 2003/0226545 A1 Dec. 11, 2003

Related U.S. Application Data
(60) Provisional application No. 60/387,680, filed on Jun. 11, 2002.

(51) **Int. Cl.**⁷ **F02M 25/00; F02M 27/02**
(52) **U.S. Cl.** **123/1 A**
(58) **Field of Search** 123/1 A

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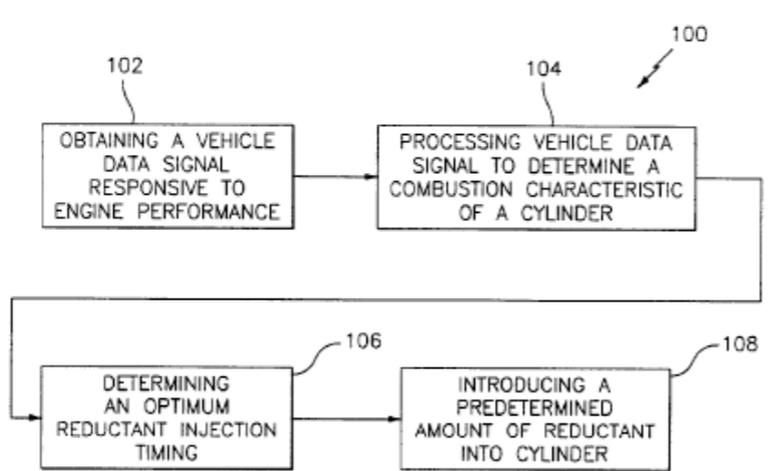
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6,266,955 B1 * 7/2001 Liang et al. 123/1 A

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Primary Examiner—Erick Solis
(74) *Attorney, Agent, or Firm*—Jimmy L. Funke

(57) **ABSTRACT**
The above discussed and other drawbacks and deficiencies are overcome or alleviated by a reductant injection system for an internal combustion engine including a selective reduction system communicated with the internal combustion engine, a vehicle sensor communicated with the internal combustion engine, a controller, wherein the controller is communicated with the selective reduction system and the vehicle sensor and a reductant storage device communicated with the selective reduction system. In addition, a method for increasing NOx conversion efficiency in an internal combustion engine having a reductant injection system is provided, wherein the method includes obtaining a vehicle data signal responsive to the engine performance of the internal combustion engine, processing the vehicle data signal so as to determine a combustion characteristic of a combustion cylinder, determining an optimum reductant injection timing and introducing a predetermined amount of reductant into the combustion cylinder responsive to the optimum reductant injection timing. Furthermore, a medium encoded with a machine-readable computer program code for increasing NOx conversion efficiency in an internal combustion engine having a reductant injection system is provided, wherein the medium includes instructions for causing controller to implement the aforementioned method.

42 Claims, 4 Drawing Sheets



- **Filing Date:** 27 June 2002
- **Novelty:** Proposes use of a micro-dosing pump to inject reductant into the engine cylinder following combustion and immediately prior to exhaust valve opening, to achieve selective non-catalytic reduction (SNCR) under all running conditions
- **Comments:** SNCR occurs at ~900°C, so works even before SCR catalyst is functional. May work in exhaust port too. Potential as a supplement to SCR

FUEL PUMP



US006406269B1

(12) **United States Patent**
Dingle et al.

(10) **Patent No.:** US 6,406,269 B1
(45) **Date of Patent:** Jun. 18, 2002

(54) **FUEL PUMP**

(75) **Inventors:** Philip John Gregory Dingle,
Rochester, MI (US); George Nicholas
Felton, Gillingham (GB)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI
(US)

(*) **Notice:** Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** 09/634,517

(22) **Filed:** Aug. 8, 2000

(30) **Foreign Application Priority Data**

Aug. 10, 1999 (GB) 9918871

(51) **Int. Cl.⁷** F04B 49/00; F15B 15/24;
F02M 37/04

(52) **U.S. Cl.** 417/218; 417/274; 417/470;
92/13; 92/60.5; 123/502; 123/504

(58) **Field of Search** 417/218, 470,
417/274, 499; 123/500-504; 92/13, 60.5,
129

(56) **References Cited**

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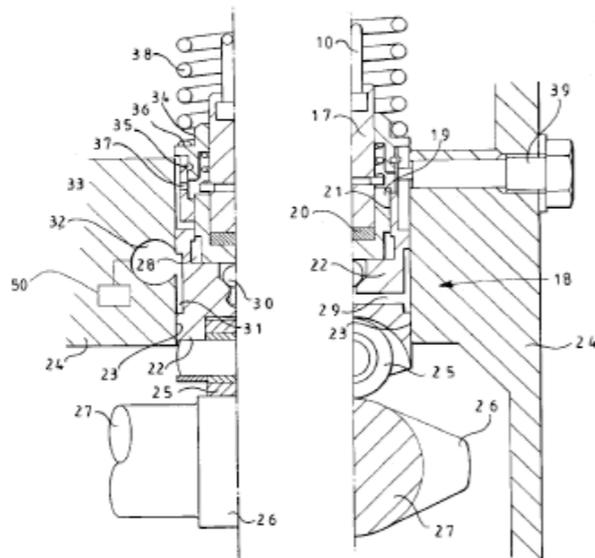
* cited by examiner

Primary Examiner—Charles G. Freay
(74) *Attorney, Agent, or Firm*—Thomas N. Twomey

(57) **ABSTRACT**

A fuel pump comprises a pumping plunger reciprocable within a plunger bore under the action of a cam drive arrangement. The cam drive arrangement comprises first and second surfaces defining therebetween a chamber, the volume of which can be controlled to control the spacing of the first and second surfaces so as to permit control of the axial length of the cam drive arrangement. The first surface may be defined by a tappet member which acts to transmit a force from the cam drive arrangement to the pumping plunger, the second surface being defined by a piston member which is slidable within a tappet bore formed in the tappet member. The invention also relates to an arrangement for use in a fuel pump comprising a pumping plunger which is reciprocable within a plunger bore under the action of a drive arrangement and a tappet member which is slidable within a further bore provided in a housing for transmitting a force from the drive arrangement to the pumping plunger. The arrangement comprises a yoke secured to the housing, the yoke having at least one projection extending into the bore provided in the housing, the or each projection cooperating with the tappet member so as to substantially prevent angular movement of the tappet member within the further bore.

22 Claims, 10 Drawing Sheets



- **Filing Date:** 08 August 2000

- **Novelty:** Discloses the use of a hydraulic tappet within a roller follower intended to advance the injection timing for pump-line-nozzle injection systems under cold running [long ignition delay] conditions

- **Comments:** A similar arrangement but using production Delphi hydraulic lifter components went forward into production

FUEL SYSTEM



US006267086B1

(12) **United States Patent**
Dingle et al.

(10) **Patent No.:** US 6,267,086 B1
(45) **Date of Patent:** Jul. 31, 2001

(54) **FUEL SYSTEM**

(75) **Inventors:** Philip John Gregory Dingle,
Rochester, MI (US); Godfrey Greeves,
Middlesex (GB)

(73) **Assignee:** Delphi Technologies, Inc., Troy, MI
(US)

(*) **Notice:** Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** 09/478,030

(22) **Filed:** Jan. 5, 2000

(30) **Foreign Application Priority Data**

Jan. 12, 1999 (GB) 9900479

(51) **Int. Cl.⁷** F02B 47/00

(52) **U.S. Cl.** 123/25 R; 123/25 C; 123/575

(58) **Field of Search** 123/25 R, 25 C,
123/25 J, 25 A, 575, 525, 526; 239/96,
575, 525, 526

(56) **References Cited**

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5,762,033 * 6/1998 Rembold et al. 123/25 C

FOREIGN PATENT DOCUMENTS

JP-8246979 * 9/1996 (JP) .

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Primary Examiner—Henry C. Yuen

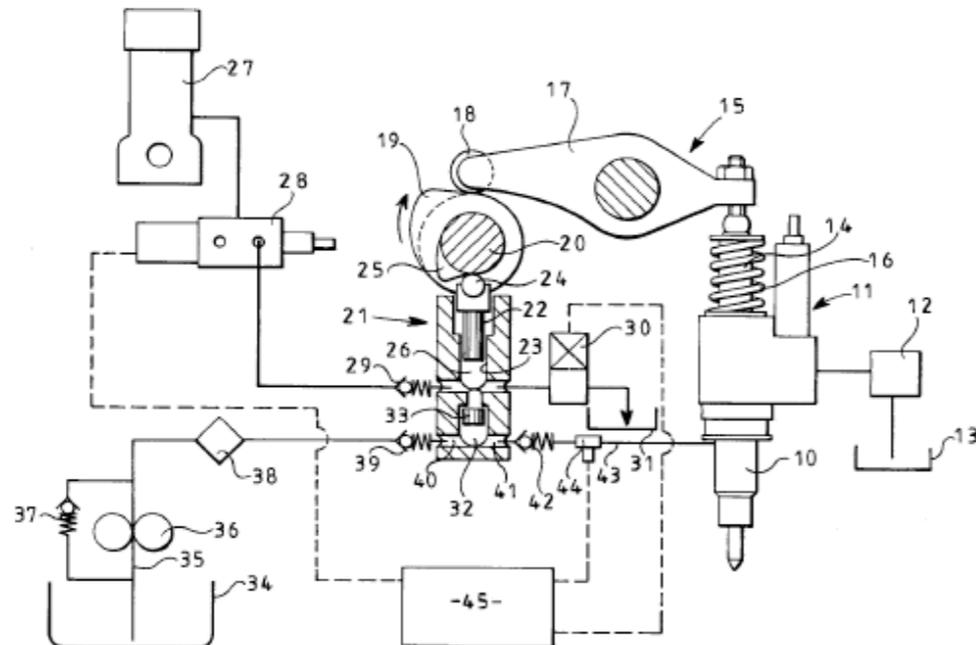
Assistant Examiner—Mahmoud Gimie

(74) *Attorney, Agent, or Firm*—Ohlandt, Greeley, Ruggiero
& Perle, L.L.P.

(57) **ABSTRACT**

A fuel system comprising a unit pump/injector and a cam
actuated plunger pump arranged to supply an auxiliary fluid
to the injector, wherein the plunger pump is located adjacent
the unit pump/injector.

12 Claims, 1 Drawing Sheet



- **Filing Date:** 05 January 2000

- **Novelty:** Concept provides shot-to-shot control over secondary fuel blending with a main fuel in an electronic unit injector injection system

- **Comments:** Concept was developed and applied for Real-Time Water Emulsion research in the SwRI Clean Diesel Consortium where it received extensive use

COMPACT PIN-WITHIN-A-SLEEVE THREE-WAY VALVE

US005497806A

United States Patent [19] **Patent Number:** 5,497,806
Swank et al. [45] **Date of Patent:** Mar. 12, 1996

[54] **COMPACT PIN-WITHIN-A-SLEEVE THREE-WAY VALVE** 4,561,468 12/1985 Kreitchman et al. .
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[75] **Inventors:** Bryan W. Swank; Arpad M. Pataki, both of Columbus, Ind.; Bela Doszpoly, Budapest, Hungary; Mark S. Cavanagh, Columbus, Ind.; John D. Lane, Columbus, Ind.; Kent V. Shields, Columbus, Ind.; Philip J. G. Dingle, Rochester, Mich.

[73] **Assignees:** Cummins Engine Company, Inc., Columbus, Ohio; Lucas Industries PLC, West Midlands, England

[21] **Appl. No.:** 293,935
 [22] **Filed:** Aug. 22, 1994

Related U.S. Application Data

[63] Continuation of Ser. No. 41,424, Mar. 31, 1993, abandoned.
 [51] **Int. Cl.⁹** F15B 13/044; F16K 11/00
 [52] **U.S. Cl.** 137/625.65; 137/625.25; 251/129.07
 [58] **Field of Search** 137/625.25, 625.65; 251/129.07

[56] **References Cited**
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 3,016,917 1/1962 Hunt
 3,151,624 10/1964 Koutnik
 3,680,782 8/1972 Monpetit et al.
 3,800,832 4/1974 Urspenour et al. 137/625.65
 4,176,822 12/1979 Chadwick

FOREIGN PATENT DOCUMENTS
 64-69876 3/1989 Japan
Primary Examiner—Gerald A. Michalsky
Attorney, Agent, or Firm—Sixby, Friedman, Leedom & Ferguson

[57] **ABSTRACT**
 A three-way valve including a valve housing having a valve chamber and a high pressure fluid supply inlet, high pressure fluid outlet and drain communicating with the valve chamber is disclosed. A movable member is reciprocally received in the valve chamber so as to be reciprocated between first and second positions for selectively fluidically communicating the outlet with either the inlet or drain. A first valve seat is formed in the valve housing and concentrically disposed in the valve chamber for sealing communication between the outlet and drain and a second valve seat is concentrically disposed in a cavity formed in the movable member for sealing communication between the inlet and outlet. A floating pin is received in the movable valve member cavity at a one end of the movable valve member and cooperates with the second valve seat for selectively sealing fluidic communication between the inlet and the outlet. An actuating device is mounted on the valve housing adjacent an end of the movable valve member opposite the floating pin for advancing the movable valve member toward the first position when energized and for allowing the movable valve member to retract to the second position when de-energized.

5 Claims, 2 Drawing Sheets

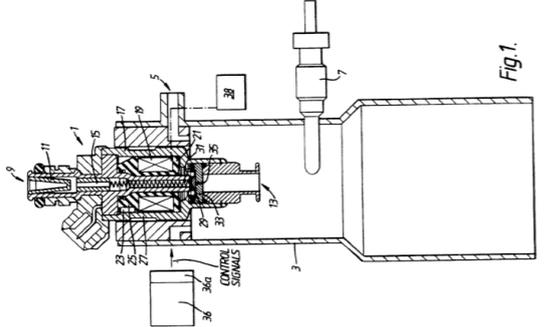
- **Filing Date:** 03 March 1993
- **Novelty:** The Cummins-proposed architecture of the valve was modified such that it enabled actuation of the 3-way valve by a direct-pull solenoid actuator, thus improving upon the prior art which required a high-mass push-rod
- **Comments:** Original version designed by Cummins Fuel Systems Group; they were seeking a lower cost and more responsive valve. Subsequently used in production in the Cummins CAPS fuel system ~1996 - 2006. Also appears as EP0622573 B1

FUEL INJECTION NOZZLE FOR BURNER

<p>PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau</p> <p>INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)</p>	
<p>(51) International Patent Classification 5 : F23D 11/38, F01N 3/20</p>	<p>(11) International Publication Number: WO 94/09317</p> <p>(43) International Publication Date: 28 April 1994 (28.04.94)</p>
<p style="font-size: small;">A1</p>	
<p>(21) International Application Number: PCT/GB93/02142</p> <p>(22) International Filing Date: 18 October 1993 (18.10.93)</p> <p>(30) Priority data: 9221892.4 19 October 1992 (19.10.92) GB</p> <p>(71) Applicant (for all designated States except US): LUCAS INDUSTRIES PUBLIC LIMITED COMPANY [GB/GB]; Brueton House, New Road, Solihull, West Midlands B91 3TX (GB).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only) : DINGLE, Philip, John, Gregory [GB/US]; 1195 Bear Creek Court, Rochester, MI 48306-4603 (US).</p> <p>(74) Agent: MATHISEN, MACARA & CO.; The Coach House, 6-8, Swakeleys Road, Ickenham, Uxbridge, Middlesex UB10 8BZ (GB).</p>	<p>(81) Designated States: DE, GB, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p>Published With international search report.</p>
<p>(54) Title: FUEL INJECTION NOZZLE FOR BURNER</p>	
<p>(57) Abstract</p> <p>A fuel injection nozzle (1) comprises a housing (10) formed with a passage (11) for the flow of fuel from an inlet (12) to an outlet orifice (13). A flexibly mounted rod (21) is displaceable with respect to the sides of the outlet orifice (13) to dislodge accumulated deposits of carbonaceous or like material. A burner device incorporating the fuel injection nozzle (1) is also described.</p>	

- **Filing Date:** 19 Oct 1992
- **Novelty:** Nozzle incorporates a flail for keeping the orifice clear of carbon deposits
- **Comments:** Intended for use with DPF regeneration burner. Not pursued

BURNER DEVICES

 Europäisches Patentamt European Patent Office Office européen des brevets		 Publication number: 0 454 351 A3
EUROPEAN PATENT APPLICATION		
Application number: 91303425.2	Int. Cl. ⁵ : F23D 11/24, F01N 3/02	
Date of filing: 17.04.91		
Priority: 27.04.90 GB 9009519	Inventor: Dingle, Philip John Gregory 1195 Bear Creek Rochester, Michigan 48064 (US)	
Date of publication of application: 30.10.91 Bulletin 91/44	Representative: Bibby, William Mark et al Mathisen, Macara & co. The Coach House 6-8 Swakeleys Road Ickenham Uxbridge UB10 8BZ (GB)	
Designated Contracting States: DE ES FR GB IT		
Date of deferred publication of search report: 18.12.91 Bulletin 91/51		
Applicant: LUCAS INDUSTRIES PUBLIC LIMITED COMPANY Brueton House, New Road Solihull, West Midlands B91 3TX (GB)		
54 Burner devices.		
57 A burner device suitable for use in a vehicle includes a fuel injector (1) for connection to the pressurised fuel supply contained in the fuel tank of the vehicle. An electromagnetically controlled valve (19 to 35) is arranged to regulate the flow of fuel through the injector (1) into a combustion can (3). The operation of the electromagnetically controlled valve is controlled in dependence on the required heating effect of the device. The device is suitable for use as a cab heater for the vehicle, or for burning off carbon de		
		

EP 0 454 351 A3

- **Filing Date:** 17 April 1991
- **Novelty:** Use of a gasoline port fuel injector in a combustion chamber in which the combustion air is used to cool the injector and provide air swirl for improved combustion
- **Comments:** Functional feasibility demonstrated; not pursued

LOAD COMPENSATING FUEL SYSTEM

US005419294A

United States Patent [19] **Dingle**

[11] **Patent Number:** 5,419,294
 [45] **Date of Patent:** May 30, 1995

[54] **LOAD COMPENSATING FUEL SYSTEM**
 [75] **Inventor:** Philip J. G. Dingle, Rochester, Mich.
 [73] **Assignee:** Lucas Industries public limited company, England

[21] **Appl. No.:** 78,182
 [22] **PCT Filed:** Sep. 16, 1991
 [86] **PCT No.:** PCT/GB91/01581
 § 371 **Date:** Oct. 15, 1993
 § 102(e) **Date:** Oct. 15, 1993
 [87] **PCT Pub. No.:** WO92/06288
 PCT Pub. Date: Apr. 16, 1992

[30] **Foreign Application Priority Data**
 Sep. 28, 1990 [GB] United Kingdom 9021224

[51] **Int. Cl.⁶** F02D 41/04
 [52] **U.S. Cl.** 123/399; 123/357
 [58] **Field of Search** 123/357, 399, 494, 488, 123/396

[56] **References Cited**
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 3905824 11/1989 Germany .
 11643 6/1985 Japan .
 306250 4/1989 Japan .

Primary Examiner—Henry C. Yuen
Assistant Examiner—Thomas N. Moulis
Attorney, Agent, or Firm—Andrus, Scales, Starke & Sawall

[57] **ABSTRACT**
 A fuel system for an engine (10) has a transducer (16) which supplies an input signal to an electronic fuel control system (15) representing driven demand. A variable gain amplifier (19) modifies the signal applied to the control system and is controlled by a load sensor (20) which detects when a suddenly applied load is placed on the engine such as when an air conditioning compressor (18) is brought into operation or when the power output of the alternator (17) is suddenly increased.

4 Claims, 1 Drawing Sheet

- **Filing Date:** 28 September 1990
- **Novelty:** Throttle pedal gain is modified as parasitic load (e.g. A/C) is applied so that vehicle acceleration response as perceived by the operator remains uniform
- **Comments:** Not used for intended project. Also appears as EP0550488 B1

VALVE ARRANGEMENTS

PCT		WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau	
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)			
(51) International Patent Classification ⁵ : F02M 21/02, 47/02		A1	(11) International Publication Number: WO 92/05357
			(43) International Publication Date: 2 April 1992 (02.04.92)
(21) International Application Number: PCT/GB91/01596		(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE, DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB, GB (European patent), GR (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent), SU*, US.	
(22) International Filing Date: 18 September 1991 (18.09.91)		Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
(30) Priority data: 9020740.8 24 September 1990 (24.09.90) GB			
(71) Applicant (for all designated States except US): LUCAS INDUSTRIES PUBLIC LIMITED COMPANY [GB/GB]; Brueton House, New Road, Solihull, West Midlands B91 3TX (GB).			
(72) Inventor; and (75) Inventor/Applicant (for US only) : DINGLE, Philip, John, Gregory [GB/US]; 1195 Bear Creek, Rochester, MI 48064 (US).			
(74) Agent: MATHISEN, MACARA & CO.; The Coach House, 6-8 Swakeleys Road, Ickenham, Uxbridge, Middlesex UB10 8BZ (GB).			
(54) Title: VALVE ARRANGEMENTS			
(57) Abstract			
<p>A valve arrangement forming the fuel injector of a combustion engine fuelled by gas has a servo valve (10) and a pilot valve (20). The servo valve regulates a flow of fuel from the inlet (13) to the outlet (14) of a main conduit (12). The pilot valve (20) comprises an electromagnetically-controlled plate valve located in a subsidiary conduit S which connects the main conduit (12) to a further outlet (23). The pilot valve controls the differential pressure of fuel across the servo valve causing the latter to regulate the flow in the main conduit (12).</p>			

- **Filing Date:** 24 Sept 1990
- **Novelty:** Uses an available low cost precision injector as a pilot valve to control a high flow valve in a servo relationship
- **Comments:** Intended for gaseous fuels on MD and HD engines. Not pursued

ENGINE STARTING AID

United States Patent [19]
Dingle

[11] Patent Number: 5,040,497
[45] Date of Patent: Aug. 20, 1991

[54] ENGINE STARTING AID
[75] Inventor: Philip J. G. Dingle, Rochester, Mich.
[73] Assignee: Lucas Industries PLC, Birmingham, England
[21] Appl. No.: 474,530
[22] Filed: Feb. 2, 1990

[30] Foreign Application Priority Data
Feb. 1, 1989 [GB] United Kingdom 8902129
[51] Int. Cl.⁵ F02N 17/00; F02M 31/00
[52] U.S. Cl. 123/179 H; 123/298;
123/549
[58] Field of Search 123/179 H, 297, 298,
123/549, 557

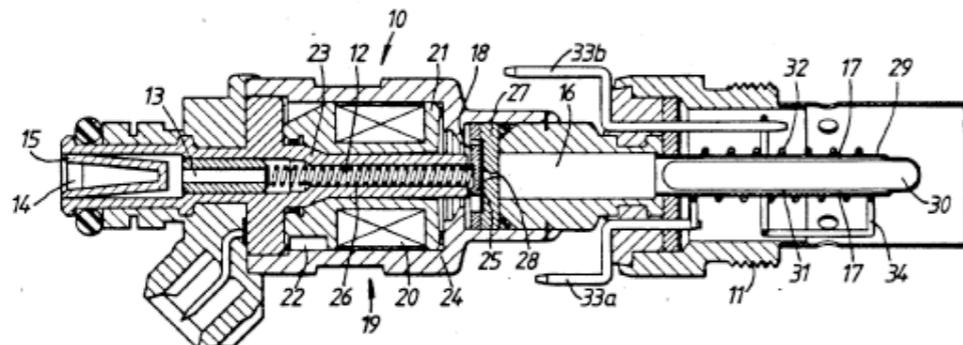
[56] References Cited
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4,849,604 7/1989 Woolcott 123/179 H
4,934,907 6/1990 Kroner 123/557

Primary Examiner—Andrew M. Dolinar
Assistant Examiner—Marguerite Macy
Attorney, Agent, or Firm—Leydig, Voit & Mayer

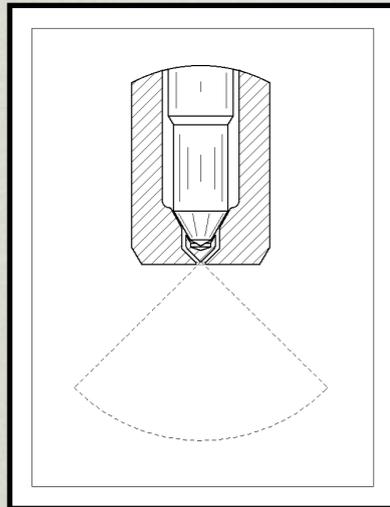
[57] ABSTRACT
A starting aid for a diesel engine comprises a housing (10) having a longitudinal passageway (12). Fuel is admitted to an upstream section (13) of the passageway via an inlet opening (14) and the fuel exits a downstream section (16) of the passageway via outlet openings (17). An electromagnetically-controlled plate valve (18) regulates a flow of fuel from the upstream, to the downstream section of the passageway, and a helical heater coil (32) heats the fuel as it passes along an annular part (31) of the downstream section (16) of the passageway (12).

6 Claims, 2 Drawing Sheets

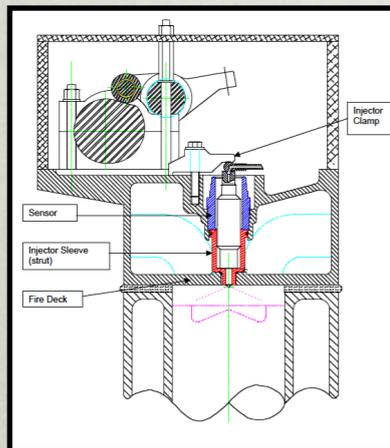


- **Filing Date:** 02 February 1990
- **Novelty:** A combination of a pulse-width modulated gasoline port injector with a flame type cold start aid for improved cold start behavior
- **Comments:** Prior art inlet manifold flame cold start aids had imprecise control over fuel flow and thus heat input to the intake air. Feasibility was demonstrated; not pursued

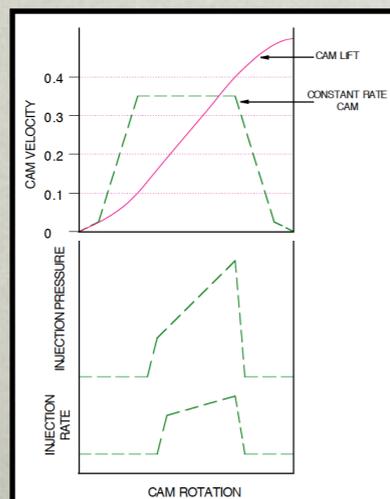
OTHER INTELLECTUAL PROPERTY AWARDS



- Meritorious Award for “Fan Spray Nozzle”



- Defensive Publication: “Method for Sensing Cylinder and Other Pressures in an I.C. Engine”



- Defensive Publication: “Use of Model-Based Control System with Non-Constant Velocity Cam Forms”

PATENT APPLICATIONS UNDER CONSIDERATION

- Rotary Tip Nozzle - Patent pending currently
- Differential Drive Generator
- Camless Gas Exchange Valve Actuator
- Air Hybrid System for Compression Ignition Engines
- A DME-specific fuel injection system