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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 November 2012 (15.11.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/155030 A3

(51) International Patent Classification:
F02D 19/06 (2006.01) *F02M 63/02* (2006.01)
F02M 43/04 (2006.01) *F02M 45/08* (2006.01)
F02M 47/02 (2006.01)

(21) International Application Number:
PCT/US2012/037483

(22) International Filing Date:
11 May 2012 (11.05.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/105,138 11 May 2011 (11.05.2011) US

(71) Applicant *(for all designated States except US)*: **CATERPILLAR INC.** [US/US]; 100 N.E. Adams Street, Peoria, IL 61629-9510 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **KIM, Hoisan** [KR/US]; 2617 W. Carlisle Lane, Dunlap, IL 61525 (US). **DING, Xiangdong** [CA/US]; 3936 W. Creighton Terrace, Peoria, IL 61615 (US). **SOMMARS, Mark, F.** [US/US]; 114 Running Elk Court, Hopewell, IL 61565-9414 (US).

(74) Agents: **MONTEITH, J., Derel** et al.; 100 N.E. Adams Street, Peoria, IL 61629-9510 (US).

(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, QA, RO, RS, RU, RW, 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.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: DUAL FUEL INJECTOR, ENGINE USING THE SAME AND METHOD OF OPERATING THE ENGINE

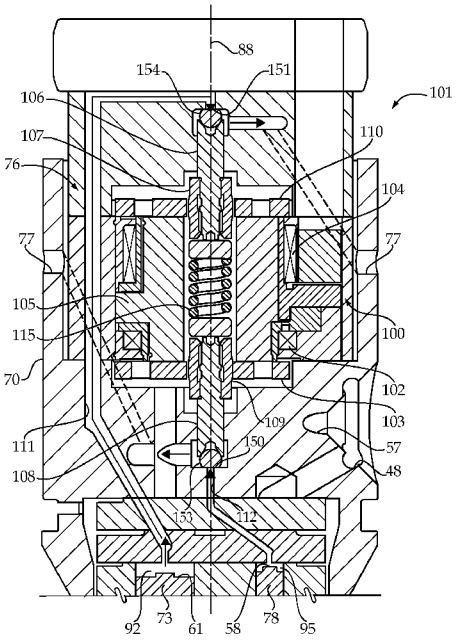


Figure 3

(57) Abstract: A dual fuel injector (100) may be used to inject both gas and liquid fuel into a cylinder (7) of a compression ignition engine (5). An injector body (12) defines a first set of nozzle outlets (90), a second set of nozzle outlets (90), a first fuel inlet (33) and a second fuel inlet (36). A dual solenoid actuator (100) includes a first armature (110), a first coil (102), a second armature (103) and a second coil (104) that share a common centerline (54). The dual solenoid actuator (100) has a non-injection configuration at which the first armature (110) is at an un-energized position and the second armature (103) is at an un-energized position. The dual solenoid actuator (100) has a first fuel injection configuration at which the first fuel inlet (48) is fluidly connected to the first set of nozzle outlets (90), the first armature (110) is at an energized position and the second armature (103) is at the un-energized position. The dual solenoid actuator (100) has a second fuel injection configuration at which the second fuel inlet (57) is fluidly connected to the second set of nozzle outlets (96), the first armature (110) is at the un-energized position and the second armature (103) is at an energized position. The dual solenoid actuator (100) may also include a combined fuel injection configuration.

WO 2012/155030 A3

WO 2012/155030 A3

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
3 January 2013

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/037483

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02D19/06 F02M43/04 F02M47/02 F02M63/02 F02M45/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02D F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002/070295 A1 (BAKER S MICHAEL [CA] ET AL) 13 June 2002 (2002-06-13) paragraphs [0005], [0108], [0109], [0140] - [0142]; figures 1,4,9	1,4-10
Y	WO 02/46599 A1 (FEV MOTORENTECH GMBH [DE]; LAUMEN HERMANN JOSEF [DE]) 13 June 2002 (2002-06-13) abstract; figures	1,4-10
A	US 2009/020631 A1 (MASHIDA MAKOTO [JP] ET AL) 22 January 2009 (2009-01-22) abstract; figures 1-6	1
A,P	WO 2011/162681 A1 (SCANIA CV AB [SE]; KYLSTROEM KIM [SE]) 29 December 2011 (2011-12-29) the whole document	2,5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 September 2012	26/10/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Landriscina, V

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/037483

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-4

   Fuel injector according to claim 1 with a dual solenoid actuator

   ---

2. claims: 5-8

   Engine according to claim 5 with a dual fuel system

   ---

3. claims: 9, 10

   Method of operating an engine according to claim 9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/037483

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002070295 A1	13-06-2002	AU 2002342473 A1	10-06-2003
		BR 0214298 A	21-09-2004
		CA 2465182 A1	30-05-2003
		CN 1589369 A	02-03-2005
		EP 1448884 A1	25-08-2004
		US 2002070295 A1	13-06-2002
		US 2004256495 A1	23-12-2004
		WO 03044358 A1	30-05-2003
WO 0246599 A1	13-06-2002	AT 293751 T	15-05-2005
		DE 10061035 A1	13-06-2002
		EP 1339965 A1	03-09-2003
		JP 2004515440 A	27-05-2004
		US 2003010848 A1	16-01-2003
		WO 0246599 A1	13-06-2002
US 2009020631 A1	22-01-2009	JP 4297181 B2	15-07-2009
		JP 2009024512 A	05-02-2009
		US 2009020631 A1	22-01-2009
WO 2011162681 A1	29-12-2011	SE 1050662 A1	23-12-2011
		WO 2011162681 A1	29-12-2011