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F02M 31/02 (2006.01) **F02D 41/30** (2006.01)

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(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, BN, 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, IR, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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.

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[Continued on next page]

- (54) Title:** REDUCING FUEL CONSUMPTION OF SPARK IGNITION ENGINES

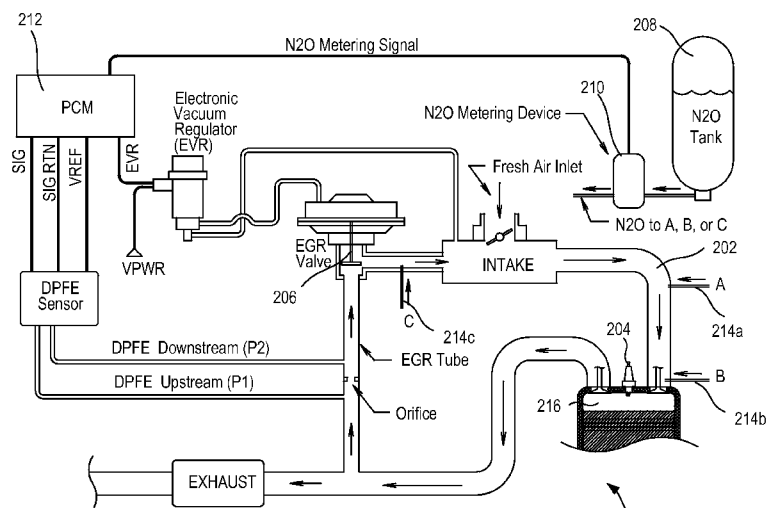


FIG. 2

- (57) Abstract:** Atomic oxygen is provided for the purpose of promoting reliable ignition and smooth combustion in a spark ignition internal combustion engine is to disperse a low concentration of an atomic oxygen precursor, such as nitrous oxide (N₂O), into the flammable mixture of air and gasoline vapor prior to the time of ignition. The introduction of N₂O may take place in the intake manifold, in the stream of exhaust gas being returned as part of the EGR process, or directly into the combustion chamber (for example through a small orifice in the base of the spark plug or through a small nozzle located elsewhere in the cylinder head). Introduction of N₂O directly into the combustion chamber may be continuous, or it may be pulsed so as to occur at the time of, or shortly before, spark ignition.



- *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:

13 November 2014

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/027279**A. CLASSIFICATION OF SUBJECT MATTER****F02M 25/07(2006.01)i, F02M 31/02(2006.01)i, F02M 33/00(2006.01)i, F02D 41/30(2006.01)i**

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)

F02M 25/07; B01J 8/02; F02P 23/04; F02B 3/00; F02M 19/03; F02M 31/02; F02M 33/00; F02D 41/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywordsrigrtition, engine, recirculated, oxygen, UV and precursor**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2001-0054416 A1 (YOSHIZAKI, KOUJI et al.) 27 December 2001 See paragraphs [0045]-[0088] and claim 1.	1-3 , 13
Y		8-12
A		4-7 , 14-33, 98
Y	US 5237969 A (SAKIN, LEV) 24 August 1993 See abstract and claims 1-7 .	8-12
A	US 2006-0175719 A1 (DELISLE, GILLES) 10 August 2006 See abstract and paragraphs [0027] , [0038] , [0042] .	1-33 , 98
A	US 2010-0012080 A1 (HOKKANEN, VESA et al.) 21 January 2010 See abstract and paragraphs [0005]- [0012] .	1-33 , 98
A	US 5643543 A (GUIBARD, ISABELLE et al.) 01 July 1997 See abstract and claims 1-2 .	1-33 , 98

 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

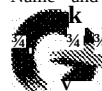
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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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:

Group 1, claims 1-33,98 are directed to a system and method of spark ignition internal combustion engine for providing atomic oxygen with an exhaust gas recirculation.

Group 2, claims 34-36 are directed to a spark ignition internal combustion engine comprising a light source for producing UV radiation.

Group 3, claims 37-39 are directed to a spark ignition internal combustion engine comprising an electric discharge device.

Group 4, claims 40-97 are directed to a system and method of spark ignition internal combustion engine for providing charge dilution and introducing atomic oxygen.

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 any 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.: 1-33,98

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.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US20 14/027279

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2001-0054416 AI	27/12/2001	DE 60108298 D1 DE 60108298 T2 EP 1156201 A2 EP 1156201 A3 EP 1156201 B1 JP 03552645 B2 JP 2001-329902 A US 6634345 B2	17/02/2005 22/12/2005 21/11/2001 16/04/2003 12/01/2005 11/08/2004 30/11/2001 21/10/2003
US 5237969 A	24/08/1993	None	
US 2006-0175719 AI	10/08/2006	AU 2003-225904 AI AU 2003-225904 B2 AU 2004-233193 AI CA 2479374 AI CA 2479374 C CN 100363610 CO CN 1643245 A CN 1643245 CO CN 1777748 A CN 1777748 CO EP 1495225 AI EP 1611337 AI US 2004-0211389 AI US 2005-0230854 AI US 6736376 B1 US 7093826 B2 US 7111829 B2 US 7513489 B2 WO 03-081015 AI WO 2004-094810 AI	08/10/2003 22/03/2007 04/11/2004 02/10/2003 18/03/2008 23/01/2008 20/07/2005 23/01/2008 24/05/2006 19/11/2008 12/01/2005 04/01/2006 28/10/2004 20/10/2005 18/05/2004 22/08/2006 26/09/2006 07/04/2009 02/10/2003 04/11/2004
US 2010-0012080 AI	21/01/2010	DE 112008000329 T5 SE 0700380 A SE 530875 C2 US 8701627 B2 WO 2008-100212 AI	24/12/2009 16/08/2008 30/09/2008 22/04/2014 21/08/2008
US 5643543 A	01/07/1997	EP 0665048 AI EP 0665048 B1	02/08/1995 04/08/1999