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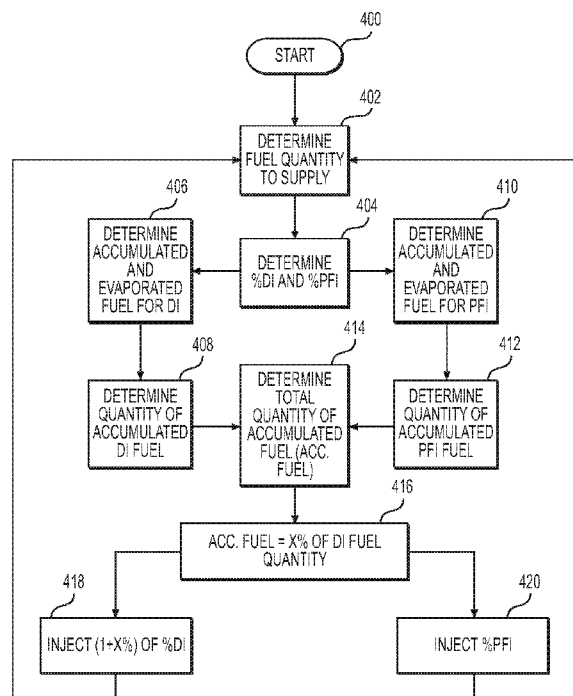
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[Continued on next page]

(54) Title: INTERNAL COMBUSTION ENGINE HAVING TWO FUEL INJECTORS PER CYLINDER AND CONTROL METHOD THEREFOR

**FIG. 11**

(57) Abstract: A two-stroke internal combustion engine has a crankcase, a cylinder block defining at least one cylinder, a cylinder, a crankshaft, at least one piston, at least one scavenge port, at least one throttle body for supplying air to an interior of the crankcase, at least one direct fuel injector fluidly communicating with at least one combustion chamber for injecting fuel directly in the at least one combustion chamber; and at least one port fuel injector fluidly communicating with the interior of the crankcase for injecting fuel upstream of the at least one combustion chamber. Methods for controlling an engine having at least one direct fuel injector and at least one port fuel injector are also described.



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- of inventorship (*Rule 4.17(iv)*)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2016/053184

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F02M 69/10; F02D 3/00; F02D 41/30; F02D 41/32; F02D 41/34; F02M 21/02 (2016.01)

CPC - F02D 41/3094; F02D 3/00; F02D 41/30; F02D 41/32; F02D 41/34; F02D 2400/04 (2016.11)

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)

IPC - F02D 3/00; F02D 41/30; F02D 41/32; F02D 41/34; F02M 21/02; F02M 51/00; F02M 69/10

CPC - F02D 3/00; F02D 41/30; F02D 41/3094; F02D 41/32; F02D 41/34; F02D 2400/04; F02M 21/02; F02M 21/0248; F02M 51/00; F02M 69/10

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

USPC - 123/73A; 123/73C; 123/294; 123/299; 123/300; 123/431; 123/492 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google, YouTube

Search terms used: two-stroke, two-cycle, internal combustion engine, ICE, chamber, direct, fuel injector, fuel injection, port, upstream, chamber, fuel quantity, ratio, percent, per cent, transition, electronic, ECU, phase-in, phase-out

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,092,287 A (MOTOYAMA et al) 03 March 1992 (03.03.1992) entire document	1-26
A	US 4,779,581 A (MAIER) 25 October 1988 (25.10.1988) entire document	1-26
A	WO 2006/079172 A1 (ORBITAL ENGINE COMPANY (AUSTRALIA) PTY LIMITED) 03 August 2006 (03.08.2006) entire document	1-26
A	US 2006/0272599 A1 (JOHNSON) 07 December 2006 (07.12.2006) entire document	1-26
A	US 5,241,939 A (NONAKA) 07 September 1993 (07.09.1993) entire document	1-26

☐ 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

16 November 2016

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2016/053184

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 supplemental page

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 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.:
1-26

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

International application No.

PCT/IB2016/053184

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I, claims 1-26 are drawn to a method for controlling a two-stroke internal combustion engine comprising determining a first fuel quantity.

Group II, claim 27-33 are drawn to a two-stroke internal combustion engine comprising a crankcase.

The inventions listed in Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, a method for controlling a two-stroke internal combustion engine comprising determining a first fuel quantity to be supplied to the at least one combustion chamber, determining a ratio of the first fuel quantity to be injected by the at least one direct fuel injector, and determining a ratio of the first fuel quantity to be injected by the at least one port fuel injector, are not present in Group II; and, the special technical features of Group II, a two-stroke internal combustion engine comprising a crankcase, a cylinder block, the cylinder block defining at least one cylinder, each of the at least one cylinder defining at least one exhaust port, a cylinder head, a crankshaft disposed at least in part in the crankcase, at least one piston disposed in the at least one cylinder, a least one connecting rod, at least one scavenge port, and at least one throttle body, are not present in Group I.

Groups I and II share the technical features of a two-stroke internal combustion engine comprising having at least one combustion chamber, at least one direct fuel injector for injecting fuel directly in the at least one combustion chamber, and at least one port fuel injector for injecting fuel upstream of the at least one combustion chamber.

However, these shared technical features do not represent a contribution over the prior art. Specifically, WO 2006/079172 A1 to Orbital Engine Company (Australia) Pty Limited teaches of a two-stroke internal combustion engine (internal combustion engine 20, Fig. 1; Pg. 5, Lns. 26-28 regarding an engine incorporating the fuel injection system of the present invention may be spark-ignited and operate on a two or four stroke cycle) comprising having at least one combustion chamber (combustion chamber 60, Fig. 1; Abstract), at least one direct fuel injector (direct injector 12, Fig. 1) for injecting fuel directly in the at least one combustion chamber (Abstract), and at least one port fuel injector (port or manifold injector 26, Fig. 1) for injecting fuel upstream of the at least one combustion chamber (Fig. 1; Abstract).

Since none of the special technical features of the Groups I-II inventions are found in more than one of the inventions, unity is lacking.