



(88) Date of publication of the international search report:

25 June 2015

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F02B 47/08; F02M 25/07 (2013.01)

USPC - 123/568.21, 568.22

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(8) - F02B 47/08; F02M 25/07 (2013.01)

USPC - 123/568.21, 568.22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 123/568.11, 568.31; 701/103, 108, 113 (text search - see terms below)

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

PatBase; Google Scholar; Google Patents

Search Terms: dedicated, committed, permanent, constant, cylinder, piston, chamber, EGR, recirculate, warm-up, cold, start, catalyst, temperature, engine, coolant, oil, direct, inject, port, isolate, individual, separate, donor, valves, volume, size, displace, large,... etc.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011/0253113 A1 (Roth et al.) 20 October 2011 (20.10.2011), para [0003], [0034], [0051], [0086]-[0088] and [0094]	1-11
Y	US 2010/0217503 A1 (Leone et al.) 26 August 2010 (26.08.2010), para [0051] and [0067]	1-11
Y	US 2009/0308070 A1 (Alger II et al.) 17 December 2009 (17.12.2009), fig 1, para [0013], [0021], [0023]-[0025] and [0035]	12-15
Y	US 5,398,653 A (Merritt) 21 March 1995 (21.03.1995), fig 9, col 3, ln 22-25, col 10, ln 58-64, col 11, ln 59-63	12-15
Y	WO 2010/116064 A1 (Quiney) 14 October 2010 (14.10.2010), fig 2, Description	8
Y	US 2006/0037578 A1 (Nakamura) 23 February 2006 (23.02.2006), para [0026] and [0056]	15
A, P	US 2012/0260894 A1 (Hayman) 18 October 2012 (18.10.2012), para [0015], [0021]	12-15

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

* 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

13 December 2013 (13.12.2013)

Date of mailing of the international search report

16 JAN 2014

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

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 extra sheet below--

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.:
Group I: Claims 1-11
Group II: Claims 12-15
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.

Box No. III Observations where unity of invention is lacking

*Note: There are two claims numbered 28. For purposes of this opinion, the initial claim 28 is numbered 28A and the second claim 28 is numbered 28B.

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 must be paid.

Group I: Claims 1-11, directed to an internal combustion engine and system for controlling a warmup operation.

Group II: Claims 12-15, directed to an internal combustion engine and system having a specific relationship between an exhaust gas recirculation cylinder volume and exhaust cylinder displacement volume.

Group III: Claims 16-25, directed to an internal combustion engine and system having an exhaust gas recirculation stroke cycle that may be distinct from an exhaust stroke cycle.

Group IV: Claim 26, directed to an internal combustion engine and system for controlling an exhaust gas recirculation fraction.

Group V: Claims 27-28A, directed to a method of fueling an exhaust gas recirculation cylinder in response to hydrogen produced by the cylinder.

Group VI: Claims 28B-35, directed to an internal combustion engine and system to control combustion in an exhaust gas recirculation cylinder in response to low fluid mass conditions in the cylinder.

Group VII: Claims 36-54, directed to an internal combustion engine and system to modulate a fueling amount in an exhaust gas recirculation cylinder in response to a target value.

The inventions listed as Groups I, II, III, IV, V, VI and VII 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 inventions of Groups I-VI do not include the special technical feature of a controller structured to interpret a target EGR fraction, and to modulate a fueling amount in the dedicated EGR cylinder in response to the target EGR fraction as required by Group VII.

The inventions of Groups I-V and VII do not include the special technical feature of a system to operate the cylinders or modulate a fueling amount in response to a low fluid mass condition in the dedicated EGR cylinder as required by Group VI.

The inventions of Groups I-IV and VI-VII do not include the special technical feature of interpreting a hydrogen amount produced by a dedicated EGR cylinder; determining a fuel amount for the dedicated EGR cylinder in response to the hydrogen amount; and fueling the dedicated EGR cylinder in response to the determined fuel amount as required by Group V.

The inventions of Groups I-III and V-VII do not include the special technical feature of a means for providing an EGR fraction that differs from the fraction defined by the ratio of the dedicated EGR cylinders to the total number of cylinders as required by Group IV.

The inventions of Groups I-II and IV-VII do not include the special technical feature wherein the cylinders from the plurality of cylinders that are not dedicated EGR cylinders each comprise an exhaust stroke cycle, and wherein the EGR stroke cycle may be distinct from the exhaust stroke cycle as required by Group III.

The inventions of Groups I and III-VII do not include the special technical feature wherein the EGR displacement volume is distinct from the exhaust cylinder displacement volume as required by Group II.

The inventions of Groups II-VII do not include the special technical feature of the dedicated EGR cylinder comprising a direct injector; a controller structured to interpret a warmup condition, and in response to the warmup condition to provide a warmup operation command; and the direct injector being responsive to the warmup operation command as required by Group I.

Groups I-VII share the technical feature of a dedicated EGR cylinder. However, this shared technical feature does not represent a contribution over prior art as being anticipated by US 2009/0308070 A1 to Alger II et al. (hereinafter 'Alger') which discloses a dedicated EGR cylinder (para [0012]).

Groups I-IV and VI-VII share the technical feature of an internal combustion engine having a plurality of cylinders; at least one of the plurality of cylinders comprising a dedicated EGR cylinder. However, this shared technical feature does not represent a contribution over prior art as being anticipated by Alger which discloses an internal combustion engine having a plurality of cylinders (para [0013]); at least one of the plurality of cylinders comprising a dedicated EGR cylinder (para [0012]).

Therefore, Groups I-VII lack unity under PCT Rule 13 because they do not share a same or corresponding technical feature.