



(51) International Patent Classification:

F02M 61/18 (2006.01) F02M 61/04 (2006.01)
F02M 61/16 (2006.01)

(21) International Application Number:

PCT/US2024/019360

(22) International Filing Date:

11 March 2024 (11.03.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/496,531 17 April 2023 (17.04.2023) US

(71) Applicant: CUMMINS INC. [US/US]; 500 Jackson Street, Columbus, Indiana 47201 (US).

(72) Inventors: PRIMUS, Raymond; 4151 North CR 400 W, Bargersville, Indiana 46106 (US). LASKA, Andrew Jacob; 7980 North CR 400 W, Columbus, Indiana 47201 (US). SHAULL, Anthony Allan; 3480 Elizabeth Street, Columbus, Indiana 47203 (US). PHILLIPS, Ross A.; 3753 W Suburban Ct, Columbus, Indiana 47201 (US).

(74) Agent: COLLIER, Douglas A.; Taft Stettinius & Hollister LLP, One Indiana Square, Suite 3500, Indianapolis, Indiana 46204 (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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, 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, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: FUEL INJECTOR FOR GASEOUS FUEL AND VALVE SEAT FOR THE SAME

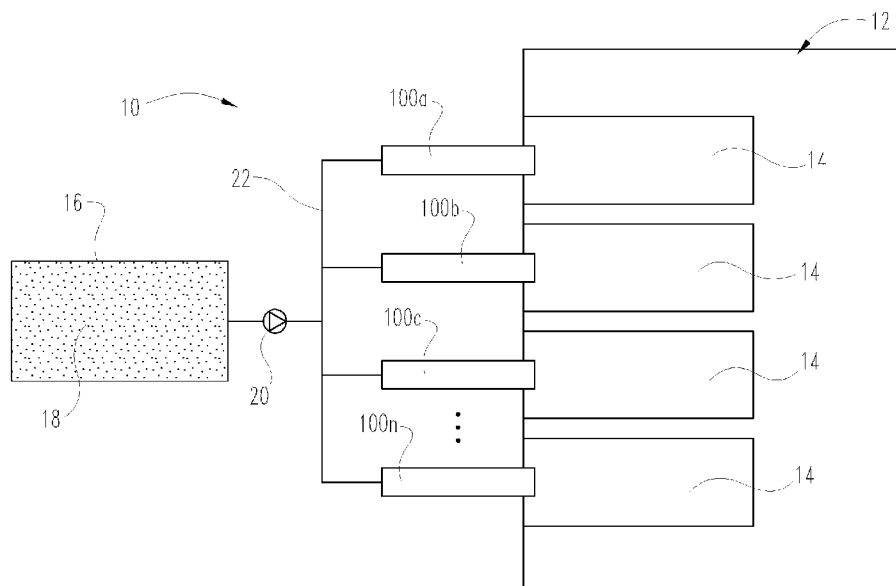


Fig. 1

(57) Abstract: A fuel injector for gaseous fuel is provided. The fuel injector includes at least one valve having a valve seat and a plunger. The valve seat includes an outer seat member and an inner seat member that is spaced radially inwardly from the outer seat member to define a gaseous fuel flow passage therebetween.



SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

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

30 January 2025 (30.01.2025)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/19360

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. F02M 61/18 (2024.01)

ADD. F02M 61/16, F02M 61/04 (2024.01)

CPC - INV. F02M 61/18, F02M 61/1886

ADD. F02M 61/1893, F02M 2200/46

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)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 106089500 A (Dongfeng Commercial Vehicle Co Ltd) 9 November 2016 (09.11.2016), entire document, especially Fig. 1-3, page 3 paragraph 13, page 4 paragraph 1; page 5 paragraph 6	1-7, 9-20 ----- 8
A		8
A	US 2006/0060675 A1 (Cooke et al.) 23 March 2006 (23.03.2006), entire document	1-20
A	US 2020/0116113 A1 (Liebherr-Components Deggenndorf GmbH) 16 April 2020 (16.04.2020), entire document	1-20
A	US 6,065,692 A (Brinn Jr.) 23 May 2000 (23.05.2000), entire document	1-20
A	US 2009/0008480 A1 (Cooke) 8 January 2009 (08.01.2009), entire document	1-20

☐ 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

"D" document cited by the applicant in the international application

"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

21 May 2024

Date of mailing of the international search report

AUG 23 2024

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. 571-273-8300

Authorized officer

Kari Rodriguez

Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/19360

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:

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 searched, the appropriate additional search fees must be paid.

Group I: Claims 1-20 directed to an elongated injector body, an outer seat member including an outer first end; an inner seat member including an inner first end (Fig. 2-8).

Group II: Claims 21-22 directed to a guide post, and the plunger movable along the guide post (Fig. 9-11).

The inventions listed as 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:

-*- See Extra 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 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.:
1-20

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 -

SPECIAL TECHNICAL FEATURES

The invention of Group I includes the special technical feature of an elongated injector body, an outer seat member including an outer first end; an inner seat member including an inner first end, not required by the claims of Group II.

The invention of Group II includes the special technical feature of a guide post, and the plunger movable along the guide post, not required by the claims of Group I.

COMMON TECHNICAL FEATURES

Groups I and II share the common technical features of a fuel injector, the fuel injector comprising:

a valve assembly, the valve assembly including at least one valve, wherein the at least one valve includes: a valve seat, wherein the valve seat includes: an outer seat member; and an inner seat member located at least partially within the outer seat member, wherein the inner seat member is spaced inwardly from the outer seat member to admit gaseous fuel flow between the outer seat member and the inner seat member; and a plunger that closes and opens the at least one valve.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by CN 106089500 A to Dongfeng Commercial Vehicle Co Ltd (hereinafter "DCV"), which discloses a fuel injector ("The invention relates to a fuel injection electromagnetic valve, in particular to a straight-through two-channel gas injection valve", page 1 paragraph 1), the fuel injector comprising: a valve assembly (Fig. 1-2, moving iron core 3, valve seat 4, sub valve seat 6, page 3 paragraph 13 - page 4 paragraph 1), the valve assembly including at least one valve, wherein the at least one valve includes: a valve seat (Fig. 1-2, valve seat 4, sub valve seat 6, page 3 paragraph 13 - page 4 paragraph 1), wherein the valve seat includes: an outer seat member (Fig. 1-2, valve seat 4, page 3 paragraph 13); and an inner seat member (Fig. 1-2, sub valve seat 6, page 4 paragraph 1) located at least partially within the outer seat member (See Fig. 1-2, the inner seat member 6 is shown to be disposed within the outer seat member 4.), wherein the inner seat member is spaced inwardly from the outer seat member to admit gaseous fuel flow between the outer seat member and the inner seat member (See Fig. 1, there is shown to be a space between the inner valve seat and the outer valve seat to allow fuel to flow between when the valve is open.); and a plunger (Fig. 1-2, moving iron core 3, page 3 paragraph 13) that closes and opens the at least one valve (See Fig. 1-2, figure 1 depicts the valve in open position while figure 2 depicts the valve in closed position.).

As the common technical features were known in the art at the time of the invention, these cannot be considered special technical feature that would otherwise unify the groups.

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