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(54) Title: VARIABLE-AREA FUEL INJECTOR WITH IMPROVED CIRCUMFERENTIAL SPRAY UNIFORMITY

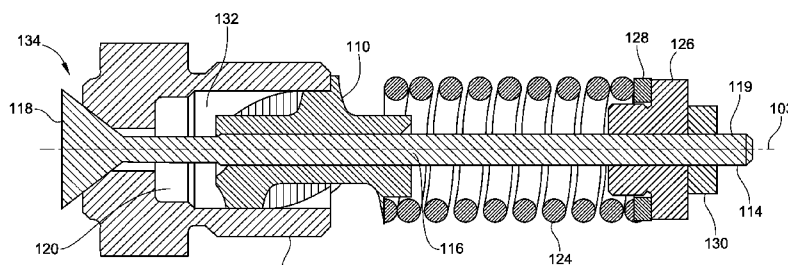


FIG. 2

(57) Abstract: A fuel injector having a body with a bore, which defines a fuel manifold. The injector also has a variable-area injector arrangement having a pintle with a conical head and a pintle spring connected to the body. The pintle spring urges a tip of the pintle to seal against an exit orifice of the body, such that application of pressurized fuel within the body causes the pintle to move. Above some threshold pressure, the pressurized fuel causes the conical head to move out of contact with the exit orifice of the body. This, in turn, provides a corresponding variable area for passage of the pressurized fuel through the exit orifice about the conical head of the pintle. The injector further includes a swirler configured to create a swirling action in the flow of pressurized fuel through the fuel manifold, wherein the manifold is upstream of the exit orifice.



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## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2010/055352****A. CLASSIFICATION OF SUBJECT MATTER*****F02M 61/18(2006.01)i, F02M 51/06(2006.01)i, F02M 61/16(2006.01)i, F02M 63/00(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 61/18; F02M 67/04; F02M 47/02; F02M 61/16; F02M 51/00

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 models

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

eKOMPASS(KIPO internal) &amp; Keywords: fuel,injector, swirler, pintle, spring

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003-0201344 A1 (CHRISTOPHER WARK) 30 October 2003 See abstract, paragraphs 0015-0018; figures 1-3	1, 6, 9-11, 14, 17, 18 , 20, 22
A	See abstract, paragraphs 0015-0018; figures 1-3	2-5, 7, 8, 12, 13, 15 , 16, 19, 21, 23-25
A	EP 1375904 A1 (DELPHI TECHNOLOGIES, INC.) 02 January 2004 See abstract, paragraphs 0014-0017; figures 1, 3	1-25
A	US 2007-0001033 A1 (PASQUALI et al.) 04 January 2007 See abstract, paragraphs 0021-0025; figures 2, 4	1-25
A	US 4,865,002 A (BORST et al.) 12 September 1989 See abstract, column 3 line 56 - column 5 line 25; figure 1	1-25

 Further documents are listed in the continuation of Box C. See patent family annex.

\* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search

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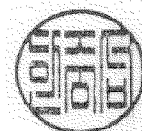
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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003-0201344 A1	30.10.2003	None	
EP 1375904 A1	02.01.2004	None	
US 2007-0001033 A1	04.01.2007	AT 352714 T BR P10602704A CN 1880753 A DE 602005000514 D1 DE 602005000514 T2 EP 1734251 A1 EP 1734251 B1 ES 2279500 T3 PT1734251E US 7204434 B2	15.02.2007 21.02.2007 20.12.2006 15.03.2007 25.10.2007 20.12.2006 24.01.2007 16.08.2007 30.03.2007 17.04.2007
US 4,865,002 A	12.09.1989	JP 01-253564 A US 04865002A A	09.10.1989 12.09.1989