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(54) **A HYDRAULIC CAMSHAFT AND A HYDRAULIC CONTROLLING SYSTEM THEREOF**

(57) The present invention relates to a hydraulic camshaft and its control system; when the engine runs in high and intermediate load, ECU respectively issues four groups of shift signals to the solenoid valve corresponding to the signals of the cam phase sensor. The solenoid valve then changes the oil pressure of the oil channels in the four hydraulic units on the camshaft. The status of the hydraulic units of every two neighboring cylinders is opposite to each other; on-off shift occurs when the cam of each cylinder rotates to the base circle position in orders. The present invention is simple in structure and is practical. The gas intake valve provided in this invention is characteristic of two-stage lift. The engine performance and economical efficiency are improved, and the emission is reduced.

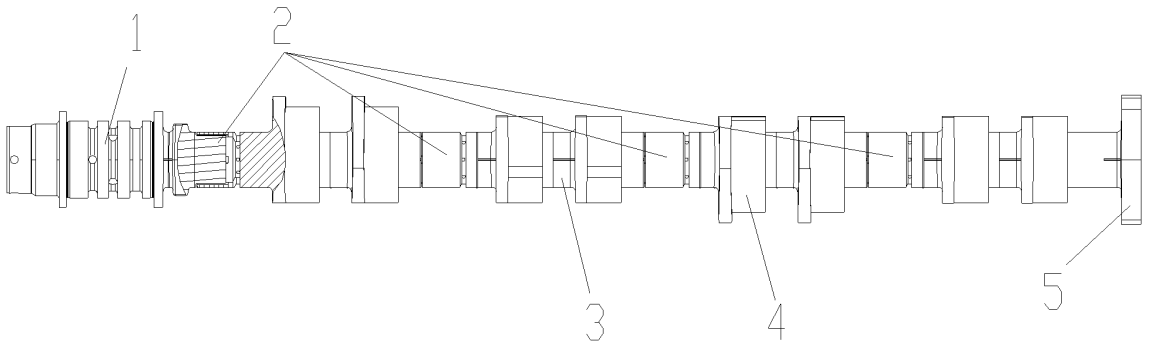

FIG 1

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Description

Field of the Invention

[0001] The present invention relates to a hydraulic camshaft and its control system, in particular, it relates to a hydraulic electromagnetic camshaft for automobile engines.

Description of the Prior art

[0002] Currently, technical solutions providing two-stage valve lift of engines have become considerably mature in international market. Generally speaking, many technical solutions are available to achieve this object. For example, using a two-stage hydraulic tappet or a rocker arm is one of the choices; engines provided by Schaeffler, Eton and Delphi are typical examples of such solution. Another example is employing two types of driving cams; Honda i-vtec is one of such examples.

[0003] Besides solely relying on an independent ECU (electric control unit) for control of the components, hydraulic systems are widely employed in these solutions. Although compared with electromagnetic control, hydraulic system involves less design complexity, it requires longer execution time. Therefore, the conventional hydraulic system only remains preferable choice for engines where no very quick instantaneous response is required.

Summary of the Invention

[0004] In view of the deficiencies of prior art, one technical object of the present invention is to provide a hydraulic camshaft and its control system, which feature simple structure and quick response.

[0005] In view of the deficiencies of prior art, another technical object of the present invention is to provide a hydraulic camshaft and its control system, which enables the variation of the gas valve lift so as to improve engine performance accordingly

[0006] The technical objects of the present invention are achieved by adopting the following technical solutions:

[0007] This invention provides a hydraulic camshaft comprising a front-end of camshaft and a camshaft body, wherein an integrated hydraulic assembly is provided between the front end of the camshaft and the camshaft body; said hydraulic assembly enables the hydraulic camshaft move along its axial direction.

[0008] Said integrated hydraulic assembly is capable of causing the hydraulic camshaft move 10mm along the axial direction.

[0009] Said hydraulic camshaft also comprises driving cams and a signal cam, and the driving cams are composed of two different kinds of cams, and they are selected corresponding to the axial position of the camshaft.

[0010] Said integrated hydraulic assembly comprises an oil hole, a guide groove and an oil chamber, the oil hole communicating with the external oil channel and leading through to the oil chamber. The oil pressure in the oil chamber determines the axial position of the camshaft; the guide groove is connected with the camshaft, and it limits the axial movement of the camshaft.

[0011] Said integrated hydraulic assembly of the present invention is also provided with an ECU and a solenoid valve, which control the oil pressure in the oil chamber jointly.

[0012] According to another aspect of the present invention, a hydraulic electromagnetic camshaft is provided comprising a front-end of camshaft, a camshaft body, a solenoid valve and an ECU, wherein an integrated hydraulic assembly is set between the front-end of camshaft and the camshaft body and enables the hydraulic camshaft move along its axial direction. Said integrated hydraulic assembly includes an oil hole, a guide groove and an oil chamber, wherein the oil hole communicates with an external oil channel and leads through to the oil chamber, the oil pressure in the oil chamber determines the axial position of the camshaft; the guide groove is connected with the camshaft and limits the axial movement of the camshaft, and the ECU and the solenoid valve jointly control the oil pressure in the oil chamber.

[0013] According to the present invention, the hydraulic control system of the above recited hydraulic camshaft comprises a solenoid valve and an ECU, which operates jointly to control the hydraulic pressure in the integrated hydraulic assembly.

[0014] According to the present invention, each cylinder of the engine is provided with a cylinder hydraulic unit.

[0015] More specifically, the first cylinder, the second cylinder, the third cylinder and the fourth cylinder are respectively provided with a first cylinder hydraulic unit, a second cylinder hydraulic unit, a third cylinder hydraulic unit and a fourth cylinder hydraulic unit.

[0016] The hydraulic control system also comprises a sensor, which detects and transfers the detected signal to the ECU. The ECU issues signals to the solenoid valve, based on which the solenoid valve control the oil pressures of the oil channels in the four hydraulic units corresponding to the four cylinders respectively.

[0017] Said sensor is a cam phase sensor, which detects the phases of the signal cam.

[0018] The operation status of the hydraulic units of each two neighboring cylinders is opposite to each other, that is, when the first cylinder hydraulic unit and the third cylinder hydraulic unit are switched on; the second cylinder hydraulic unit and the fourth cylinder hydraulic unit are switched off. Such status shift occurs when the cam of each cylinder rotates to the base circle position in orders.

[0019] To summarize, the present invention primarily has the following characteristics:

(1) An integrated hydraulic assembly is provided between the front-end of camshaft and the camshaft

body, and it enables the camshaft move 10mm along the axial direction;
(2) The driving cams of this camshaft are composed of two kinds of cams, and they are selected according to the axial position of camshaft ;
(3) The axial position of the camshaft is determined by the oil pressure in the oil chamber, and the oil pressure is regulated by an independent ECU and a solenoid valve ;
(4) Said hydraulic camshaft features quick response; the longest response time is 300 crankshaft degrees, so that abnormal combustion such as misfire and backfire can be avoided;
(5) Each cylinder is provided with an independent hydraulic unit so that the cam shift of the engine may occur at the most appropriate time and thus improve stability of the engine upon shift.

[0020] According to the present invention, the cam shift in each cylinder is implemented sequentially based on the hydraulic system recited above so that the cam shift control is optimized and a quick engine response is thus realized. Meanwhile, the present invention enables that the cam shift may only occur in some selective cylinders according to specific operation requirements for the engine. That is, the technical solution provided in the present invention applies for engines that involve selective cylinder deactivation.

[0021] Compared with prior art, the present invention has the following advantages: The present invention features simple and practical structure; the gas intake valve lift may be alternated between two levels so that engine performance, fuel efficiency and emission reduction are improved. More specifically: due to the variable gas intake valve lift, the engine performance is remarkably improved, and exhaust emission and fuel consumption of the engine according to present invention is obviously lower than other engines having the same displacement; The present invention features simple and compact structure, which is desirable, for it involves very slight volume change of the whole engine; On the basis that each cylinder is independently controlled, control modes are flexible and diversified. The torque output of the engine running at low speed is improved.

Brief Description of the Drawings

[0022]

FIG 1 is a sectional view of the hydraulic camshaft of the present invention;
FIG 2 is a sectional view of the hydraulic assembly of the present invention in switched-off status;
FIG 3 is a sectional view of the hydraulic assembly of the present invention in switched-on status;
FIG 4 is the schematic diagram of the overall hydraulic system of present invention.

[0023] The description of the reference numerals of the major components in the attached drawings:

1-Front-end of camshaft , 2-integrated hydraulic assembly, 3-driving cam, 4-camshaft body, 5-signal cam, 6-oil hole ,7-guide groove ,8-oil chamber, 9-the first cylinder hydraulic unit , 10-the second cylinder hydraulic unit, 11-the third cylinder hydraulic unit, 12-the fourth cylinder hydraulic unit, 13-solenoid valve , 14-ECU(electronic control unit), 15-cam phase sensor.

Detailed Description of the Preferred Embodiments

[0024] The technical solution of the present invention is described in details below with reference to the attached drawings and the specific embodiments. The embodiments described as follows are preferred embodiments among diversified embodiments of the present invention.

[0025] FIG 1 is the sectional view of the hydraulic camshaft of the present invention; FIG 2 is the sectional view of the hydraulic assembly unit in switched-off status; FIG 3 is the sectional view of the hydraulic unit in switched-on status; FIG 4 is the schematic diagram of the overall hydraulic system of present invention. As shown in FIG 4 in combination with FIG 1- FIG 3, the hydraulic camshaft and its control system provided by the present invention mainly includes a hydraulic electromagnetic camshaft, a solenoid valve 13, a cam phase sensor 15 and an ECU 14.

[0026] When the engine runs in high and intermediate load, ECU 14 respectively issues four groups of shift signals to the solenoid valve 13 corresponding to the signals of the cam phase sensor 15. The solenoid valve 13 then changes the oil pressure of the oil channels in the four hydraulic units on the camshaft. The status of the hydraulic units of every two neighboring cylinders is opposite to each other, that is to say, when the first cylinder hydraulic unit 9 and the third cylinder hydraulic unit 11 are switched on, the second cylinder hydraulic unit 10 and the fourth cylinder hydraulic unit 12 are switched off; such on-off shift occurs when the cam of each cylinder rotates to the base circle position in orders. The whole cycle of such a shift is described as follows:

[0027] The oil pressure in the first cylinder hydraulic unit 9 reduces; simultaneously the oil pressure in the second cylinder hydraulic unit 10 increases, so that the cam shift of the first cylinder is completed;

[0028] In the same way, the oil pressure in the second cylinder hydraulic unit 10 reduces, so that the cam shift of the second cylinder is completed;

[0029] The oil pressure in the third cylinder hydraulic unit 11 reduces; simultaneously the oil pressure in the fourth cylinder hydraulic unit 12 increases, so that the cam shift of the third cylinder is completed;

[0030] In the same way, the oil pressure in the fourth cylinder hydraulic unit 12 reduces, so that cam shift of

the fourth cylinder is completed;

[0031] When the engine is shifted to the lower valve lift, the whole processes are reversed with respect to the above recited processes.

[0032] In the process of shifting the driving cam, oil in the external channel enters the oil chamber 8 via oil hole 6, and the axial movement of the camshaft is guided and limited by the guide groove 7.

[0033] Below is a further description of the technical solution of the present invention with reference to the above mentioned FIGs :

[0034] As shown in FIG 1-FIG 3, the present invention also provides a hydraulic electromagnetic camshaft, including a front-end of camshaft 1, a camshaft body 4, a solenoid valve 13 and an ECU 14, wherein an integrated hydraulic assembly 2 is set between the front-end of camshaft 1 and the camshaft body 4, and such integrated hydraulic assembly enables the hydraulic camshaft move along its axial direction. The integrated hydraulic assembly 2 comprises an oil hole 6, a guide groove 7 and an oil chamber 8, the oil hole 6 communicates with the external oil channel and leads through to the oil chamber 8, the oil pressure in the oil chamber 8 determines the axial position of the camshaft, and the guide groove 7 is connected with the camshaft and limits the axial movement of the camshaft. The ECU 14 and the solenoid valve 13 jointly control the oil pressure in the oil chamber 8.

[0035] The hydraulic control system of the hydraulic camshaft comprises a cam phase sensor 15, a solenoid valve 13 and an ECU 14, wherein the solenoid valve 13 and the ECU 14 jointly control the hydraulic pressure in the integrated hydraulic assembly 2. Each cylinder of the engine, is provided with an independent hydraulic unit, that is to say, the first cylinder, the second cylinder, the third cylinder and the fourth cylinder are respectively provided with a first cylinder hydraulic unit 9, a second cylinder hydraulic unit 10, a third cylinder hydraulic unit 11 and fourth cylinder hydraulic unit 12. A cam phase sensor 15 detects the phase signal and transfers the detected signals to the ECU 14, and the ECU 14 issues four groups of cam shift signals to the solenoid valve 13, and the solenoid valve 13 controls the oil pressure of the oil channels in the four hydraulic units corresponding to the four cylinders respectively. The operation status of the hydraulic units in each two neighboring cylinders is opposite to each other, that is to say, when the first cylinder hydraulic unit 9 and the third cylinder hydraulic unit 11 are switched on, the second cylinder hydraulic unit 10 and the fourth cylinder hydraulic unit 12 are switched off. Such status shift occurs when the cam of each cylinder rotates to the base circle position in orders.

[0036] Finally, it must be mentioned that: The above description and embodiments are merely used to describe rather than limit the present invention. Although the detailed description of the present invention is provided with reference to preferred embodiments, those skilled in the art should understand that all the modifications or equitable substitutions to the present invention without deviation from the spirit and conception of present invention shall be covered by the claims of present invention.

Claims

1. A hydraulic camshaft, **characterized in that**: including a front-end of camshaft(1) and a camshaft body (4), an integrated hydraulic assembly (2) is set between the front-end of camshaft (1) and the camshaft body (4); said integrated hydraulic assembly enables the hydraulic camshaft move along the axial direction of the camshaft.

2. The hydraulic camshaft of claim 1, **characterized in that**: said integrated hydraulic assembly (2) is capable of causing the hydraulic camshaft move 10mm along axial direction.

3. The hydraulic camshaft of claim 1, **characterized in that**: said hydraulic camshaft also comprises driving cams (3) and a signal cam (5); the driving cams (3) are composed of two kinds of cams, and are selected according to the axial position of the camshaft.

4. The hydraulic camshaft of claim 1 or 3, **characterized in that**: said integrated hydraulic assembly (2) comprises an oil hole (6), a guide groove (7) and an oil chamber (8), wherein, the oil hole (6) communicates with the external oil channel and leads through to the oil chamber (8); the oil pressure in the oil chamber (8) determines the axial position of the camshaft; the guide groove (7) is connected with the camshaft and limits the axial movement of the camshaft.

5. The hydraulic camshaft of claim 4, **characterized in that**: said integrated hydraulic assembly also includes an ECU (14) and a solenoid valve (13), which are used to jointly control the oil pressure in the oil chamber (8).

6. A hydraulic electromagnetic camshaft **characterized in that**: it includes a front-end of camshaft (1), a camshaft body (4), a solenoid valve (13) and an ECU (14), wherein an integrated hydraulic assembly (2) is provided between the front-end of camshaft (1) and the camshaft body (4), and said integrated hydraulic assembly(2) enables the hydraulic camshaft move along the axial direction; said integrated hydraulic assembly (2) includes an oil hole (6), a guide groove (7) and an oil chamber (8), the oil hole (6) communicates with an external oil channel and leads through to the oil chamber (8); the oil pressure in the oil chamber (8) determines the axial position of the camshaft, the guide groove (7) is connected with the camshaft and limits the axial movement of the cam-

shaft, and the ECU (14) and the solenoid valve (13) jointly control the oil pressure in the oil chamber (8).

7. A hydraulic control system of the hydraulic camshaft of any of claims 1-4, **characterized in that**: said hydraulic control system includes a solenoid valve (13) and an ECU (14), wherein the solenoid valve (13) and the ECU (14) jointly control the hydraulic pressure in the integrated hydraulic assembly (2).

8. The hydraulic control system of claim 7, **characterized in that**: each cylinder of the engine, above which the hydraulic camshaft is located, is provided with an independent cylinder hydraulic unit.

9. The hydraulic control system of claim 8, **characterized in that**: the first cylinder, the second cylinder, the third cylinder and the fourth cylinder are respectively provided with a first cylinder hydraulic unit (9), a second cylinder hydraulic unit (10), a third cylinder hydraulic unit (11) and a fourth cylinder hydraulic unit (12).

10. The hydraulic control system of claim 9, **characterized in that**: the hydraulic control system also includes a sensor, the sensor detects and transfers signals to an ECU(14), and the ECU (14) issues four sets of cam shift signals to the solenoid valve (13), and the solenoid valve (13) controls the oil pressure of the oil channels in the four cylinder hydraulic units corresponding to the four cylinders respectively.

11. The hydraulic control system of claim 10, **characterized in that**: said sensor is a cam phase sensor (15), and it detects and transfer the detected signals from a signal cam (5).

12. The hydraulic control system of claim 10 or 11, **characterized in that**: the operation status of the cylinder hydraulic units of each two neighboring cylinders is opposite to each other, that is to say, when the first cylinder hydraulic unit (9) and the third cylinder hydraulic unit (11) are switched on, the second cylinder hydraulic unit (10) and the fourth cylinder hydraulic unit (12) are switched off; such status shift occurs when the cam of each cylinder rotates to the base circle position in orders.

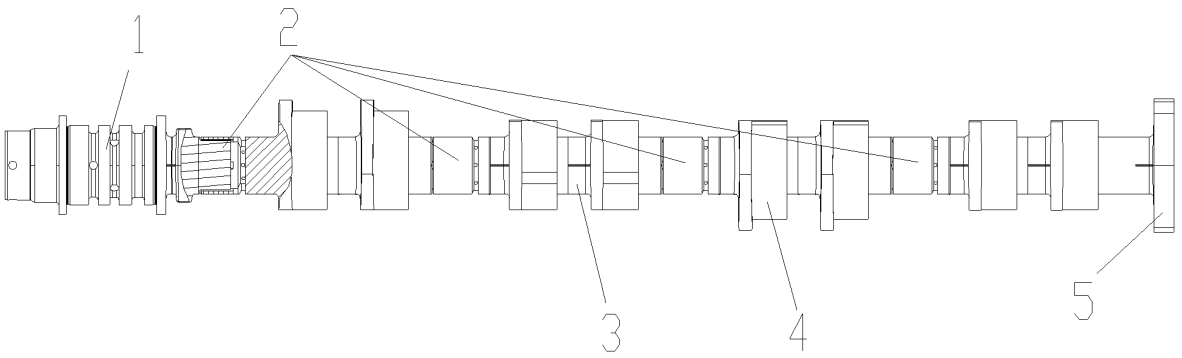

FIG 1

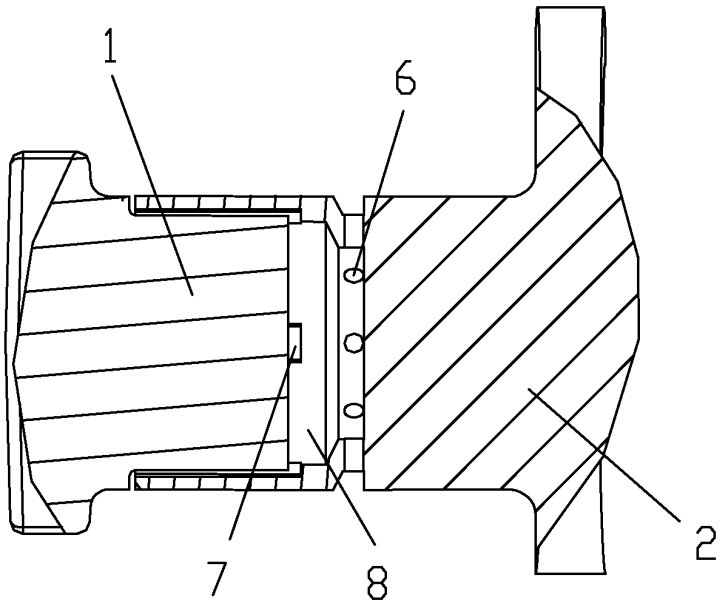

FIG 2

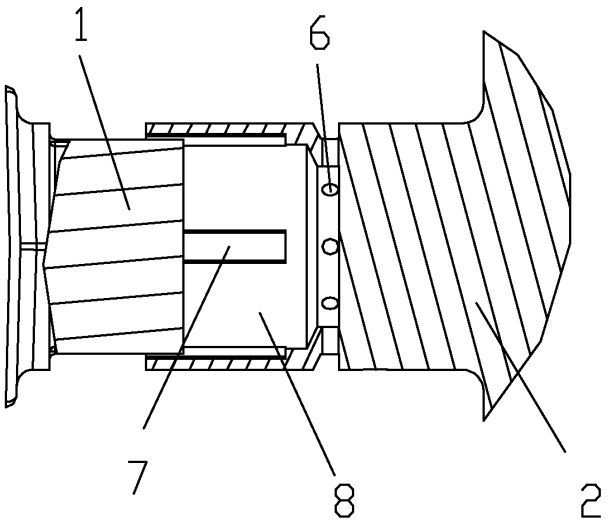

FIG 3

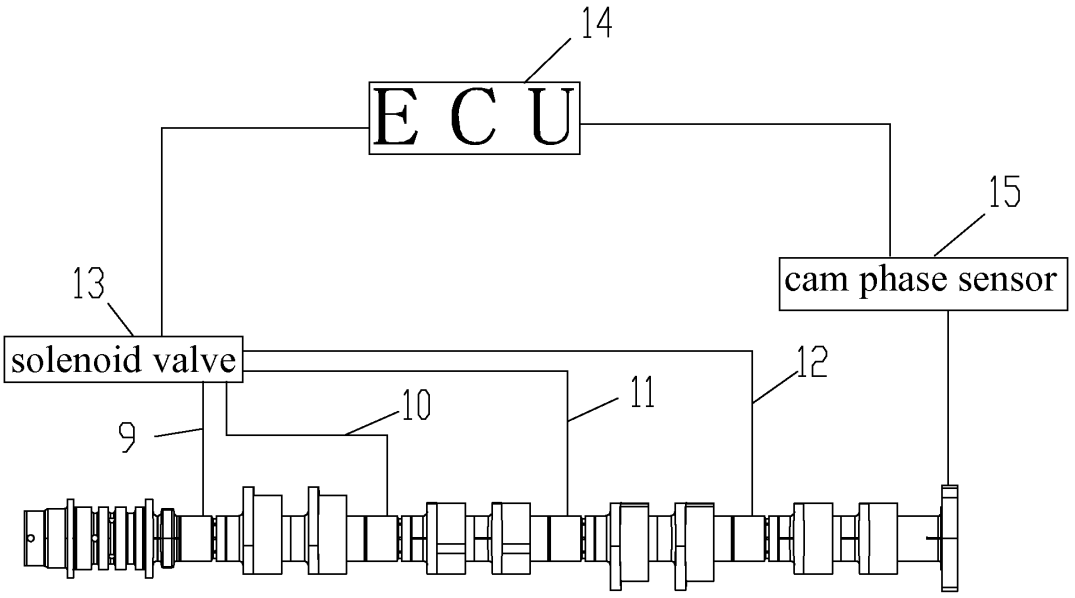

FIG 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/073182

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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 F01L 1

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

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

CNKI,CNPAT,WPI,EPODOC,PAJ: camshaft, engine, hydraulic, ECU, axial

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US6481401B1(Schafer),19 Nov.2002 (19.11.2002),the abstract and the abstract drawing	1
A		2-12
A	US20050066924A1(Lehmann et al.),31 Mar.2005(31.03.2005),the whole document	1-12
A	DE102004002290A1 (AUDI AG),04 Aug.2005(04.08.2005), the whole document	1-12
A	CN2581698Y(WMAG Xiaodong),22 Oct.2003(22.10.2003), the whole document	1-12
A	CN1529041A(FANG Ji),15 Sep.2004(15.09.2004), the whole document	1-12

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

* Special categories of cited documents:

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"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	Date of mailing of the international search report
15 Oct.2009(15.10.2009)	**05 Nov. 2009 (05.11.2009)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer ZHANG, Yubing Telephone No. (86-10)62085432

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2009/073182

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US6481401B1	2002-11-19	DE10020119A	2001-10-25
US20050066924A1	2005-03-31	DE10346443 A	2005-05-04
DE102004002290A1	2005-08-04	NONE	
CN2581698Y	2003-10-22	NONE	
CN1529041A	2004-09-15	WO2005038201A	2005-04-28

Form PCT/ISA /210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

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PCT/CN2009/073182

CLASSIFICATION OF SUBJECT MATTER

F01L 1/047(2006.01)i
F01L 1/34(2006.01)i
F01L 1/245(2006.01)i

Form PCT/ISA /210 (extra sheet) (July 2009)