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(54) ONLINE VIBRATION DETECTOR FOR CONTINUOUS CASTER CRYSTALLIZER

(57) An online detecting apparatus for oscillation of a mold of a continuous casting machine includes a sensor (101, 201, 301, 401, 501) for detecting oscillation, a transmitter (103, 203, 303, 403, 502) and a signal processor (104, 204, 304, 404, 503). The sensor is placed in a dry, clean and temperature appropriate environment (109, 209, 309, 409, 505), which can ensure the online detecting apparatus work stably and reliably for a long time.

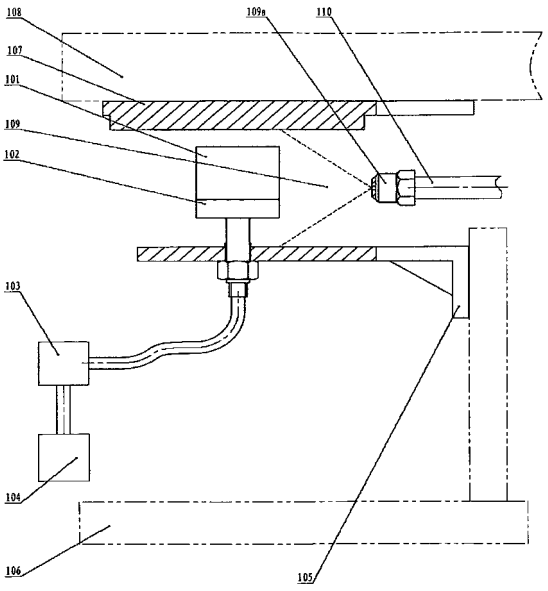

FIG. 1

EP 2 324 942 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of mold oscillation detection, and more particularly, to an online detecting apparatus for mold oscillation of a continuous casting machine.

BACKGROUND OF THE INVENTION

[0002] Setting proper oscillation amplitude, frequency and waveform based on the steel grade, cross section and casting speed of billet on a mold of a continuous casting machine, is important to ensure quality and quantity of the billet produced by the continuous casting machine. In order to detect reliability of a mold oscillation apparatus, it is required to detect an oscillation condition of the mold online, such as amplitude, frequency, waveform, oscillation synchronism of different parts of the mold, and whether there is deviation.

[0003] Current mold oscillation detection technology (such as Chinese patent No. CN1951604A; "The Study on Ultra-low Frequency of Continuous Casting Mould Oscillation Testing System Based on LabVIEW", Chapter 4 "Hardwire Plan and Design for Oscillation Analysis System", China Master Dissertations Full-text Database; "Analysis of Continuous Casting Machine Mold Oscillation-Monitoring", Chapter 2 "Testing for Mold oscillation apparatus", China Master Dissertations Full-text Database; "The Research and Design on Online Detecting System for Mold oscillation apparatus of a Continuous Casting Machine", Chapter 4 "Hardwire Design", China Master Dissertations Full-text Database) only focuses on selecting an oscillation sensor and an installation position for the oscillation sensor and usually selecting the oscillation sensor with higher technology performance, but ignoring protection of the oscillation sensor. However, when the oscillation sensor works in a hot, steam and oil mist filled environment, the original technology performance can not be guaranteed for a long time. The current mold oscillation detection technology can not satisfy requirements that the online detecting system for mold oscillation must work stably and reliably for a long time.

[0004] Under the current mold oscillation detection technology, the oscillation sensor is isolated through sealing and can work for a long time with the original technology performance in the laboratory condition. But once the oscillation sensor works in a hot, steam and oil mist filled environment where the mold of the continuous casting machine works, the original technology performance can be kept only for the first few days and will drop down quickly in one month. For example, the stainless end cover of an eddy current type oscillation sensor's cable connector will become rusty and loose, measurement range will get narrower, linearity will get worse, and sensitivity will get decreased. And at high temperature, the plug of a piezoelectric acceleration transducer may drop and stop working.

SUMMARY OF THE INVENTION

[0005] In view of the above, embodiments of the present invention provide online detecting apparatus for mold oscillation of a continuous casting machine, which can work stably and reliably for a long time.

[0006] In the present invention, a sensor for detecting oscillation is placed in a dry, clean and temperature appropriate environment.

[0007] According to an embodiment of the present invention, an online detecting apparatus for oscillation of a mold of a continuous casting machine is provided. The online detecting apparatus includes a sensor for detecting oscillation, a transmitter and a signal processor, where the sensor is isolated from atmosphere and placed in a dry, clean and temperature appropriate environment. Preferably, the sensor is in an isolated room. Preferably, the isolated room is filled with circulating gas, and the gas is dry, clean and temperature appropriate.

[0008] Herein, the mold of the continuous casting machine may be fixed on mold oscillation apparatus, and the mold oscillation apparatus includes an oscillation part and a non-oscillation part.

[0009] Preferably, the isolated room may include an inner sleeve and an outer sleeve, the inner sleeve and the sensor are installed on the non-oscillation part, the outer sleeve is installed on the oscillation part, and the gas flows into the inner sleeve from the gas inlet pipe and vents through a gap between the inner sleeve and the outer sleeve.

[0010] Alternatively, the isolated room may include a flexible sealing connecting piece, the flexible sealing connecting piece is used to connect the oscillation part and the sensor's fixed mount, and the gas flows into the isolated room through the gas inlet pipe and vents through a vent pipe. The vent pipe is equipped with a non-return valve.

[0011] Preferably, the flexible sealing connecting piece may be a twistable rubber connecting piece.

[0012] Preferably, the isolated room and the sensor may be installed on the non-oscillation part, and the gas flows into the isolated room from the gas inlet pipe and vents through a gap between the isolated room and the oscillation part.

[0013] Alternatively, the isolated room and the sensor may be installed on the oscillation part, and the gas flows into the isolated room through the gas inlet pipe and vents through the vent hole on the side wall of the isolated room.

[0014] Preferably, the gas may be nitrogen. And the gas also could be other kinds of gas which has been purified, dried and temperature adjusted.

[0015] Embodiments of the present invention place the oscillation sensor (including connectors) in a dry, clean and temperature appropriate environment, which can keep the oscillation sensor in a good technology performance for a long time and satisfy the requirement of de-

tecting the mold oscillation of the continuous casting machine online.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Drawings herein are used for facilitating further understanding of the present invention and form a part of the present invention. The exemplary embodiments and descriptions of the present invention are used for understanding the present invention and are not for use in limiting the protection scope of the present invention. In the drawings,

FIG.1 is a schematic diagram illustrating an online detecting apparatus in which an oscillation sensor is in a dry, clean and temperature appropriate environment;

FIG.2 is a schematic diagram illustrating a mold oscillation online detecting apparatus in which an isolated room includes an inner sleeve and an outer sleeve;

FIG.3 is a schematic diagram illustrating a mold oscillation online detecting apparatus in which an isolated room includes a twistable rubber connecting piece;

FIG.4 is a schematic diagram illustrating a mold oscillation online detecting apparatus, which has a space between the isolated room and a mold vibratile part; and

FIG.5 is a schematic diagram illustrating a mold oscillation online detecting apparatus in which an isolated room has a vent hole on its side wall.

DETAILED DESCRIPTION OF THE INVENTION

[0017] The present invention will be described in further detail hereinafter with reference to accompanying drawings and embodiments to make the technical solution and merits therein clearer.

[0018] In embodiments of the present invention, an online detecting apparatus for mold oscillation of a continuous casting machine is provided. The apparatus includes a sensor for detecting oscillation, a transmitter and a signal processor, where the sensor is isolated from the atmosphere and placed in a dry, clean and temperature appropriate environment. Preferably, the sensor is in an isolated room. Preferably, the isolated room is filled with circulating gas, and the gas is dry, clean and temperature appropriate.

[0019] Generally, a dry, clean and temperature appropriate environment means that: for the gas around the sensor, humidity is less than 60%, no solider with a diameter bigger than 150 μm exists, and temperature is within a working range of the sensor.

[0020] Herein, the mold of the continuous casting machine is fixed on a mold oscillation apparatus, and the mold oscillation apparatus includes an oscillation part and non-oscillation part.

[0021] Preferably, the isolated room may include an inner sleeve and an outer sleeve, the inner sleeve and the sensor therein are installed on the non-oscillation part, and the outer sleeve is installed on the oscillation part. The gas flows into the inner sleeve through a gas inlet pipe and then vents through a gap between the inner sleeve and the outer sleeve.

[0022] Alternatively, the isolated room may include a flexible sealing connecting piece. The flexible sealing connecting piece is used to connect the oscillation part and a fixed mount for supporting the sensor. The gas flows into the isolated room through the gas inlet pipe, and then vents through a vent pipe. The vent pipe is equipped with a non-return valve.

[0023] Preferably, the flexible sealing connecting piece may be a twistable rubber connecting piece.

[0024] The isolated room and the sensor therein may be installed on the non-oscillation part, and the gas flows into the isolated room through the gas inlet pipe, then vents through a gap between the isolated room and the oscillation part.

[0025] Or, the isolated room and the sensor therein may be installed on the oscillation part, and the gas flows into the isolated room through the gas inlet pipe, and then vents through a vent hole on a side wall of the isolated room.

[0026] Preferably, the gas may be nitrogen. And the gas also could be other kinds of gas which has been purified, dried and temperature adjusted.

FIG.1 is a schematic diagram illustrating an online detecting apparatus in which an oscillation sensor is in a dry, clean and temperature appropriate environment. As shown in **FIG.1**, an eddy current type sensor **101** and its stainless end cover **102** are fixed on a non-oscillation part **106** of a mold oscillation apparatus by a fixed mount **105**. An oscillation induction plate (designed based on an installation requirement of a selected sensor) **107** facing the eddy current type sensor **101** is fixed to an oscillation part **108** of the mold oscillation apparatus so as to detect oscillation amplitude of the oscillation part **108** on a vertical direction. Changes of the relative position of the oscillation induction plate **107** to the eddy current type sensor **101** are converted to an electrical signal in the eddy current type sensor **101**, and the electrical signal is transmitted to a signal processor **104** via a transmitter **103**. According to the received signal, the signal processor **104** gives out the mold's oscillation amplitude and also the mold's oscillation speed, accelerated speed, oscillation frequency, waveform, deflection rate and other parameters for evaluating performance of the mold oscillation apparatus by using, for example, differential opera-

tions. In addition, there is a gas inlet pipe **110** and a nozzle **109a** near the eddy current type sensor **101**. The dry, clean and temperature appropriate gas flows in through the gas inlet pipe **110** and then jets out of the nozzle 109a so as to form a space **109** filled with the dry, clean and temperature appropriate gas around the sensor **101**, and thus ensure that the eddy current type sensor **101** and the stainless end cover **102** work in a dry, clean and temperature appropriate environment. Therefore, the online detecting apparatus can work stably and reliably for a long time.

FIG.2 is a schematic diagram illustrating a mold oscillation online detecting apparatus in which an isolated room includes an inner sleeve and an outer sleeve. As shown in **FIG.2**, an eddy current type sensor **201** and a stainless end cover **202** are fixed on a non-oscillation part **206** of a mold oscillation apparatus by a fixed mount **205**. An oscillation induction plate **207**, designed based on an installation requirement of the selected sensor and facing the eddy current type sensor **201**, is fixed to an oscillation part **208** of the mold oscillation apparatus to detect oscillation amplitude of the oscillation part **208** on a vertical direction. Changes of the relative position of the oscillation induction plate **207** to the eddy current type sensor **201** are converted to an electrical signal in the eddy current type sensor **201**, and the electrical signal is transmitted to a signal processor **204** via a transmitter **203**. According to the received signal, the signal processor **204** gives out the mold's oscillation amplitude and also the mold's oscillation speed, accelerated speed, oscillation frequency, waveform, deflection rate and other parameters for evaluating performance of the mold oscillation apparatus by using, for example, differential operations. The eddy current type sensor **201** is in an isolated room **209** which is formed by an inner sleeve **209a** and relevant parts. The dry, clean and temperature appropriate gas flows into the isolated room **209** through a gas inlet pipe **210**, and vents through a gap **211** between the inner sleeve **209a** and the oscillation induction plate **207** designed in an outer sleeve mode. Thereby, the eddy current type sensor **201** and the stainless end cover **202** can work in a dry, clean and temperature appropriate environment, and the online detecting apparatus can work stably and reliably for a long time.

FIG.3 is a schematic diagram illustrating a mold oscillation online detecting apparatus in which an isolated room includes a twistable rubber connecting piece **309a**. As shown in **FIG.3**, an eddy current type sensor **301** and a stainless end cover **302** are fixed on a non-oscillation part **306** of mold oscillation apparatus by a fixed mount **305**. An oscillation induction plate **307** facing the eddy current type sensor **301** is fixed to an oscillation part **308** of the mold oscillation apparatus to detect oscillation amplitude of the oscillation part **308** on a vertical direction. Changes of the relative position of the oscillation induction plate **307** to the eddy current type sensor **301** are converted to an electrical signal in the eddy current type sensor **301**, and the electrical signal is transmitted to a signal processor **304** via a transmitter **303**. According to the received signal, the signal processor **304** gives out the mold's oscillation amplitude and also the mold's oscillation speed, accelerated speed, oscillation frequency, waveform, deflection rate and other parameters for evaluating performance of the mold oscillation apparatus by using, for example, differential operations. The eddy current type sensor **301** is in an isolated room **309** which is formed by the twistable rubber connecting piece **309a** and relevant parts. The dry, clean and temperature appropriate gas flows into the isolated room **309** through a gas inlet pipe **310**, and vents through a vent pipe **311**. Thereby, the eddy current type sensor **301** and the stainless end cover **302** can work in a dry, clean and temperature appropriate environment and the online detecting apparatus can work stably and reliably for a long time. Preferably, a non-return **312** is equipped on the vent pipe **311**, and the non-return **312** closes itself when air pressure in the isolated room **309** is low or gas supply is shut off so as to keep the isolated room dry and clean all the time.

FIG.4 is a schematic diagram illustrating a mold oscillation online detecting apparatus, which has a gap between an isolated room and an oscillation part of the mold. As shown in **FIG.4**, an eddy current type sensor **401** and a stainless end cover **402** are fixed on a non-oscillation part **406** of a mold oscillation apparatus by a fixed mount **405**. An oscillation induction plate **407** facing the eddy current type sensor **401** is fixed to an oscillation part **408** of the mold oscillation apparatus. A detecting surface of the oscillation induction plate **407** is parallel to an oscillation direction set by the mold to detect deviation of the mold (not shown in the figure). Changes of the relative position of the oscillation induction plate **407** to the eddy current type sensor **401** are converted to an electrical signal in the eddy current type sensor **401**, and the electrical signal is transmitted to a signal processor **404** via a transmitter **403**. According to the received signal, the signal processor **404** gives out the mold's deviation information. The eddy current type sensor **401** and the stainless end cover **402** are in an isolated room **409** which is formed by a wall **409a** of the isolated room and relevant parts. The dry, clean and temperature appropriate gas flows into the isolated room **409** through a gas inlet pipe **410**, and vents through a gap **411** between the isolated room **409** and the oscillation induction plate **407**. Thereby, the eddy current type sensor **401** and

the stainless end cover **402** can work in a dry, clean and temperature appropriate environment, and the online detecting apparatus can work stably and reliably for a long time.

FIG.5 is a schematic diagram illustrating a mold oscillation online detecting apparatus in which an isolated room has a vent hole on its side wall. As shown in **FIG.5**, an accelerated speed sensor **501** is fixed on an oscillation part **504** of a mold oscillation apparatus. The accelerated speed sensor **501** includes sensors adapted to measure accelerated speeds in three directions, up-down, left-right and front-back. The accelerated speed signals detected by the sensors are converted to electrical signals, and the electrical signals are transmitted to a signal processor **503** via a transmitter **502**. According to the received signal, the signal processor gives out the oscillation part **504's** oscillation accelerated speed and also the oscillation part **504's** oscillation speed, amplitude, oscillation frequency, waveform, deflection rate, deviation and other parameters for evaluating performance of the mold oscillation apparatus by using, for example, integral operations. The accelerated speed sensor **501** and connectors are installed in an isolated room **505**. The dry, clean and temperature appropriate gas flows into the isolated room **505** which is formed by a wall **505a** of the isolated room and relevant parts through a gas inlet pipe **506**, and vents through a vent hole **507** on the side wall of the isolated room **505**. Thereby, the accelerated speed sensor **501** and its connectors can work in a dry, clean and temperature appropriate environment, and the online detecting apparatus can work stably and reliably for a long time.

[0027] The foregoing descriptions are only preferred embodiments of this invention and are not for use in limiting the protection scope thereof. Any changes and modifications can be made by those skilled in the art without departing from the spirit of this invention and therefore should be covered within the protection scope as set by the appended claims.

Claims

1. An online detecting apparatus for oscillation of a mold of a continuous casting machine, comprising: a sensor(101, 201, 301, 401, 501) for detecting oscillation, a transmitter(103, 203, 303, 403, 502) and a signal processor(104, 204, 304, 404, 503); wherein the sensor(101, 201, 301, 401, 501) is placed in a dry, clean and temperature appropriate environment (109, 209, 309, 409, 505).

2. The online detecting apparatus of claim 1, wherein the sensor(101, 201, 301, 401, 501) is in an isolated room.

3. The online detecting apparatus of claim 2, wherein the isolated room(209, 309, 409, 505) is filled with circulating gas, and the gas is dry, clean and temperature appropriate.

4. The online detecting apparatus of claim 3, wherein the mold of the continuous casting machine is fixed on a mold oscillation apparatus and the mold oscillation apparatus includes an oscillation part (208,308, 408, 504) and a non-oscillation part(206, 306, 406).

5. The online detecting apparatus of claim 4, wherein the isolated room comprises an inner sleeve(209a) and an outer sleeve(207); wherein the inner sleeve (209a) and the sensor(201) in the inner sleeve(209a) are installed on the non-oscillation part(206), and the outer sleeve(207) is installed on the oscillation part (208); wherein the gas flows into the inner sleeve through a gas inlet pipe(210), and vents through a gap(211) between the inner sleeve(209a) and the outer sleeve(207).

6. The online detecting apparatus of claim 4, wherein the isolated room comprises a flexible sealing connecting piece adapted to connect the oscillation part and a fixed mount(305) for supporting the sensor; the gas flows into the isolated room through a gas inlet pipe(310), then vents through a vent pipe(311).

7. The online detecting apparatus of claim 6, wherein the vent pipe is equipped with a non-return valve (312).

8. The online detecting apparatus of claim 6, wherein the flexible sealing connecting piece is a twistable rubber connecting piece(309a).

9. The online detecting apparatus of claim 4, wherein the isolated room(409) and the sensor in the isolated room(409) are installed on the non-oscillation part (406), and the gas flows into the isolated room(409) through a gas inlet pipe(410) and vents through a gap(411) between the isolated room(409) and an oscillation induction plate(407) on the oscillation part (408).

10. The online detecting apparatus of claim 4, wherein the isolated room(501) and the sensor in the isolated room(501) are installed on the oscillation part(504), and the gas flows into the isolated room(505) through a gas inlet pipe(506) and vents through a vent hole (507) on a side wall of the isolated room(505).

11. The online detecting apparatus of any of claims 1 to 10, wherein the gas is nitrogen.

12. The online detecting apparatus of any of claims 1 to 10, wherein the gas is purified, dried and temperature adjusted gas.

13. An online detecting method for oscillation of a mold of a continuous casting machine by using the online detecting apparatus of any of claims 1-10, comprising:

detecting, by a sensor placed in a dry, clean and temperature appropriate environment, the oscillation of the mold of the continuous casting machine, generating an electrical signal indicating the oscillation detected, and transmitting the electrical signal to a signal processor via a transmitter connected to the sensor; and
generating, by the signal processor, oscillation information according to the electrical signal received.

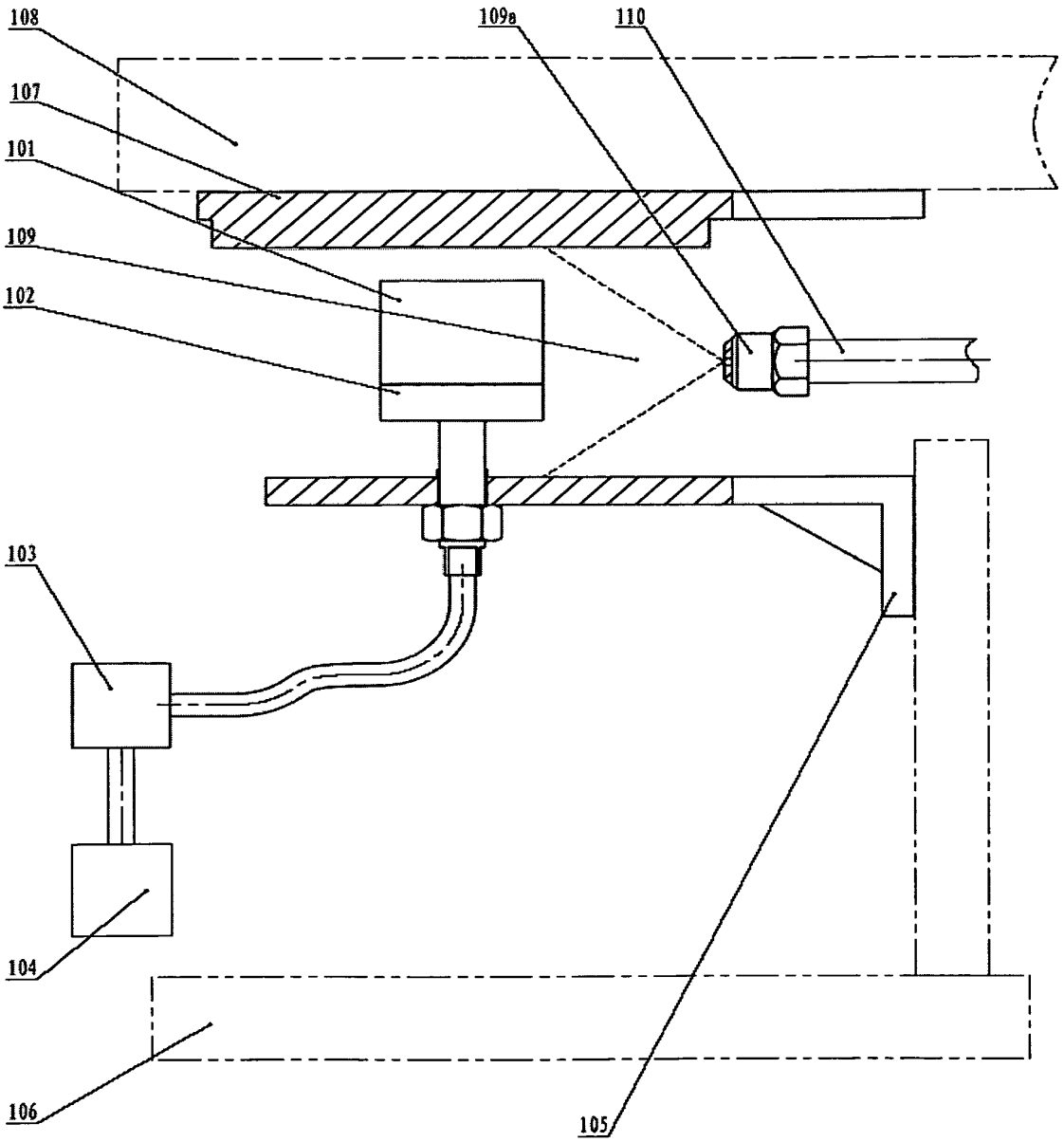

FIG. 1

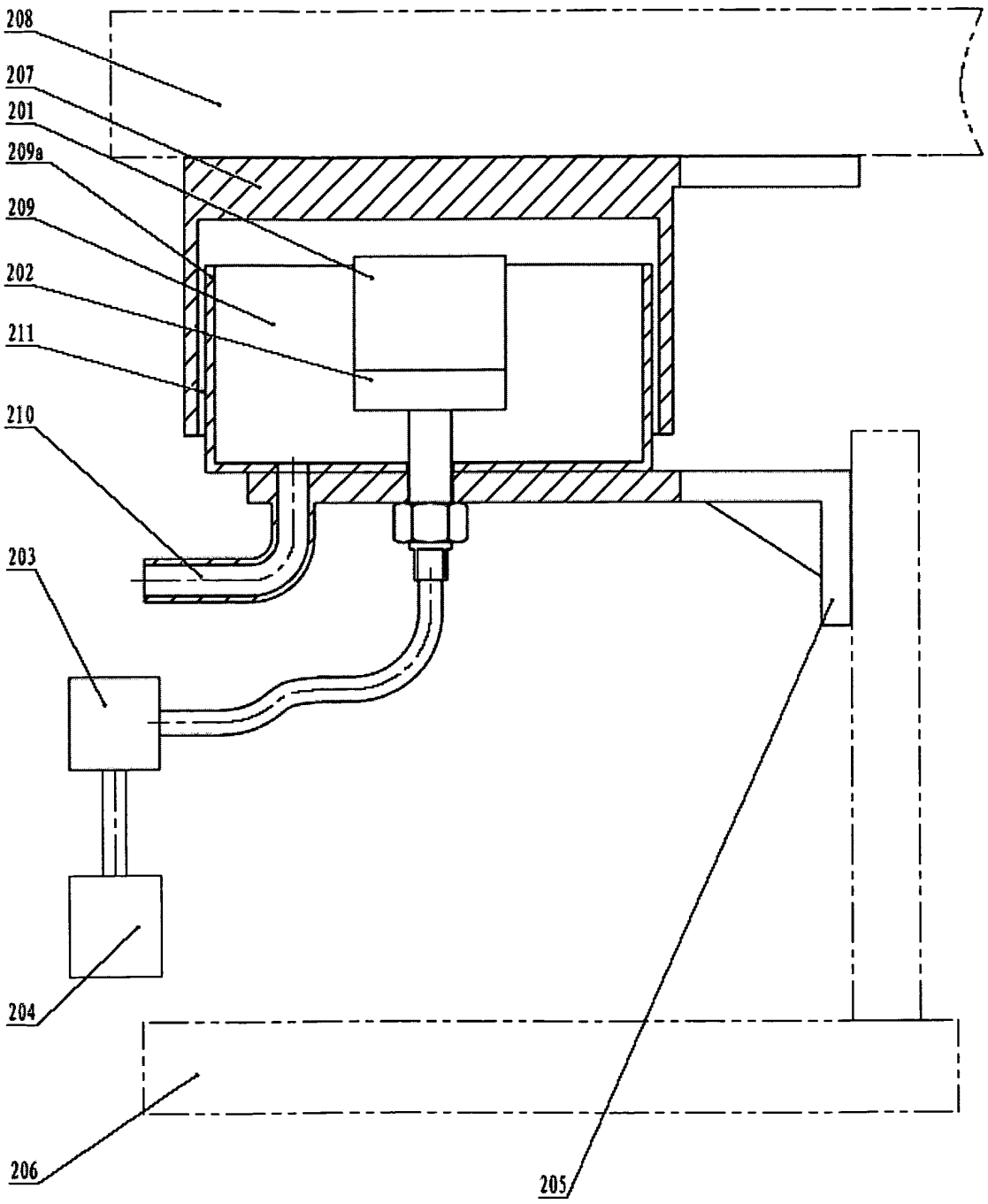

FIG. 2

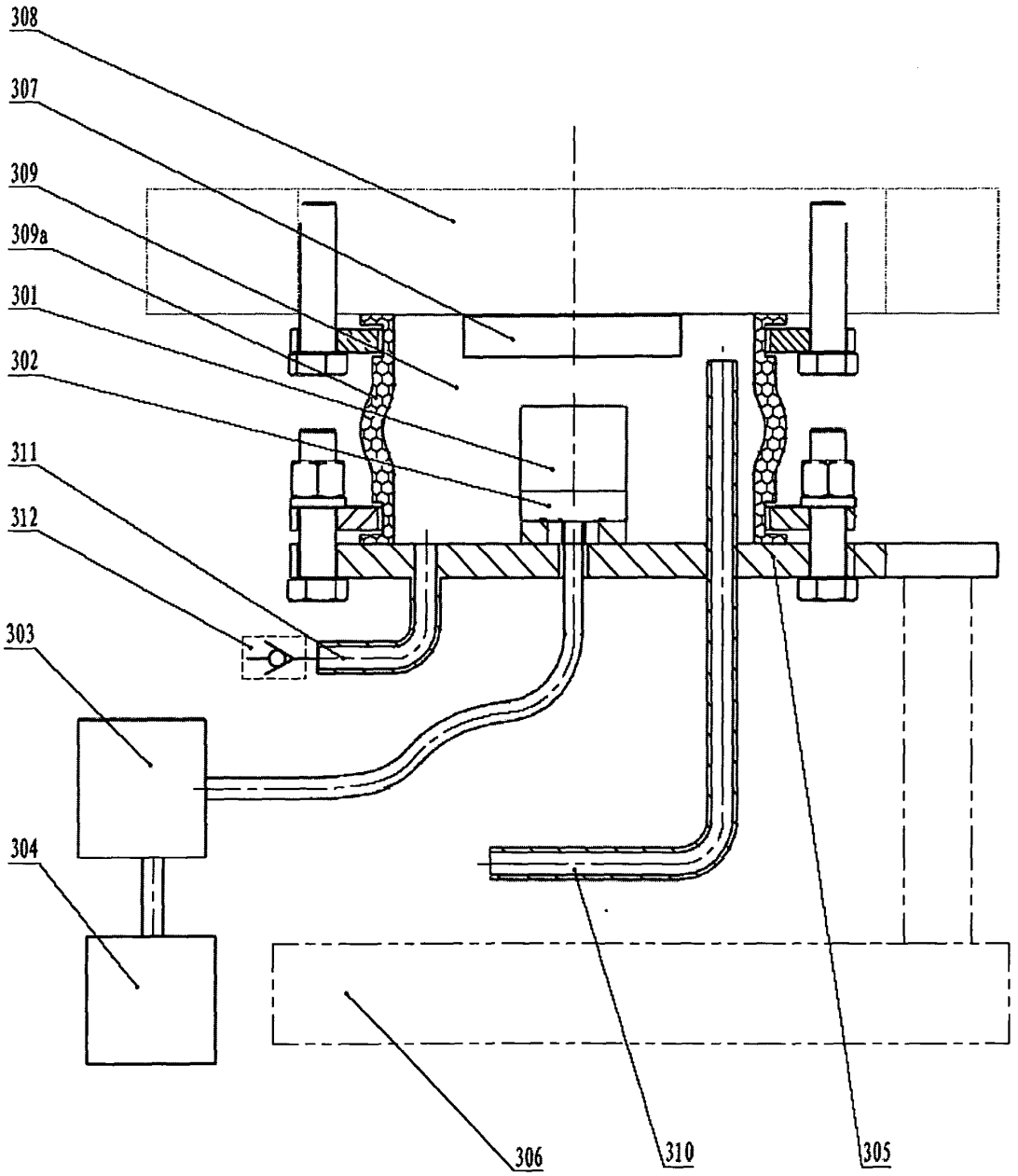

FIG. 3

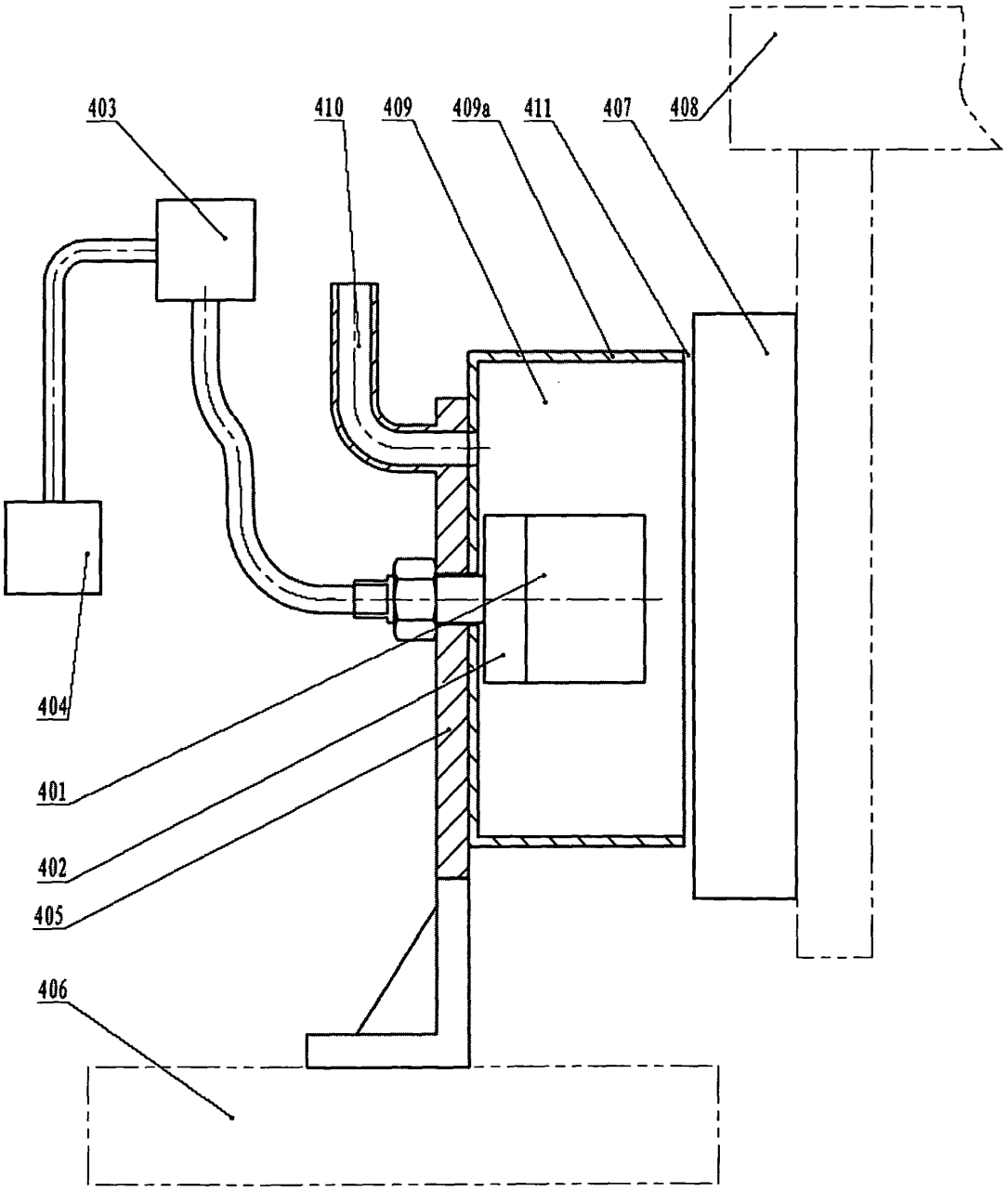

FIG. 4

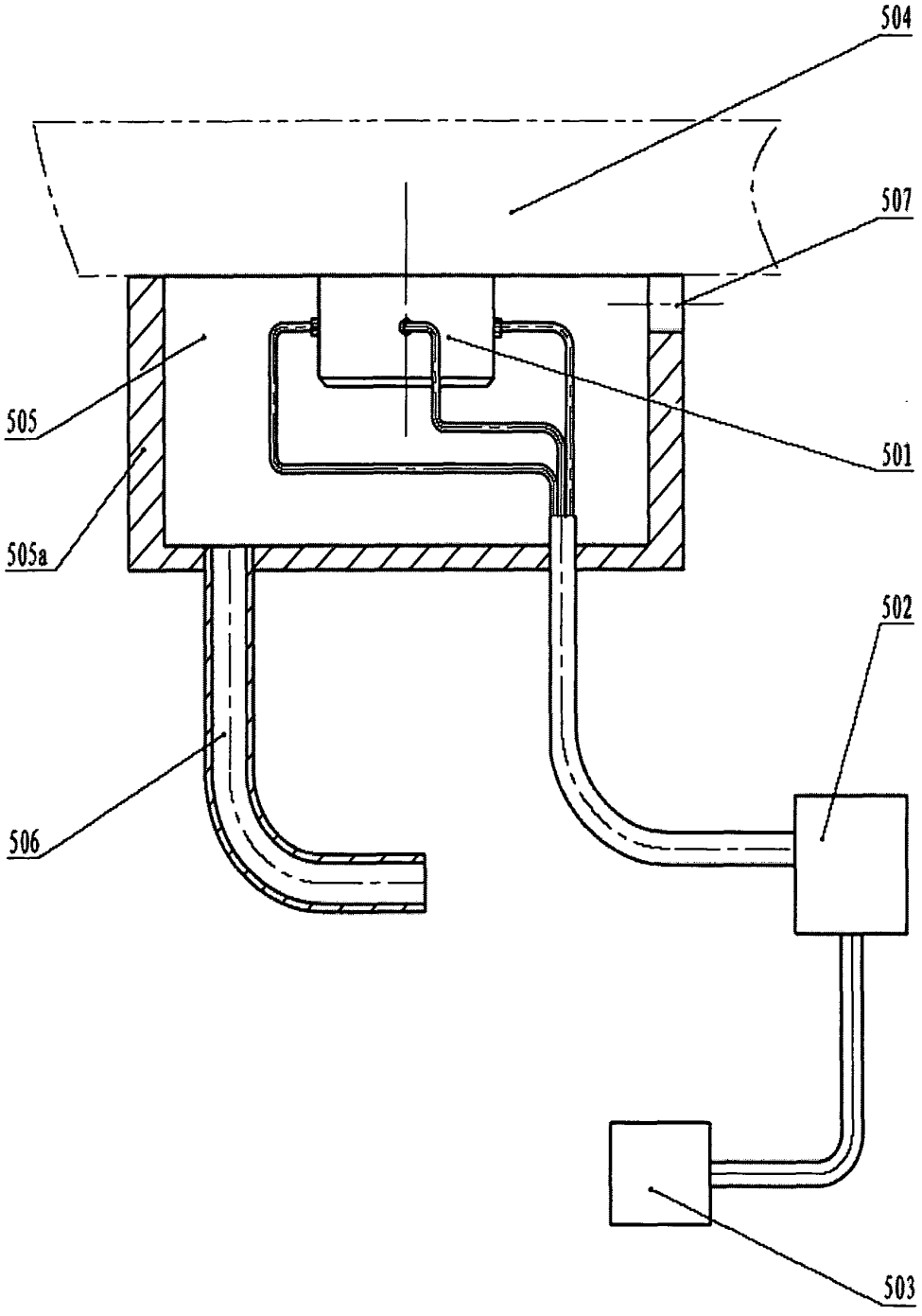

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/073230

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: B22D 11/-, 2/00

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)

WPI;EPODOC;PAJ;CNPAT;CNKI: continuous, cast, crystallizer, mould, mold, vibrate, oscillate, librate, sensor, detect, examine, measure, circumstance, ambient, environment, atmosphere, dry, clean, clear, temperature, nitrogen, N, protect, gas

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	CN 101337264 A (TIAN, Zhiheng et al.) 07 Jan. 2009 (07.01.2009) See claims 1-12	1-12
X	ZHU, Qikun The Study on Ultra-low Frequency of Continuous Casting Mould Vibration Testing System Based on LabVIEW. Chinese Master's Theses Full-text Database. Engineering Science and Technology I. 15 Dec.2007, No.6, page 19, line 3- page 26, the last line, ISSN 12671-6779	1, 2 ,12
Y		3-12
Y	CN 1182210 A (TAIHE ELECTRICAL XIANGFAN CO LTD) 20 May 1998 (20.05.1998) See claim 1	3-12
Y	CN 1197512 A (BOSCH GMBH ROBERT) 28 Oct. 1998 (28.10.1998) See claims 1-7, figures 1-4	5, 11, 12

☐ 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	Date of mailing of the international search report
30 Oct. 2009 (30.10.2009)	**19 Nov. 2009 (19.11.2009)**
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 HOU, Yanpin Telephone No. (86-10)62084500

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2009/073230

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101337264 A	07.01.2009	None	
CN 1182210 A	20.05.1998	CN 1105907 C	16.04.2003
CN 1197512 A	28.10.1998	DE 19705402 A1	22.01.1998
		WO 9803861 A1	29.01.1998
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		JP 3983295 B2	26.09.2007

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/073230

Continuation of : second sheet A. CLASSIFICATION OF SUBJECT MATTER

B22D 11/16（2006.01）i

B22D 2/00（2006.01）i

B22D 11/114（2006.01）i

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REFERENCES CITED IN THE DESCRIPTION

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