(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 862 531 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.08.2021 Bulletin 2021/32

(51) Int Cl.:
F01C 1/22 *(2006.01)* ***F01C 21/06*** *(2006.01)*
F01C 21/10 *(2006.01)*

(21) Application number: **20206548.8**

(22) Date of filing: **09.11.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **05.02.2020 KR 20200013868**
29.04.2020 KR 20200051903

(71) Applicant: **Tenergy Co. Ltd**
Gyeonggi-do 16229 (KR)

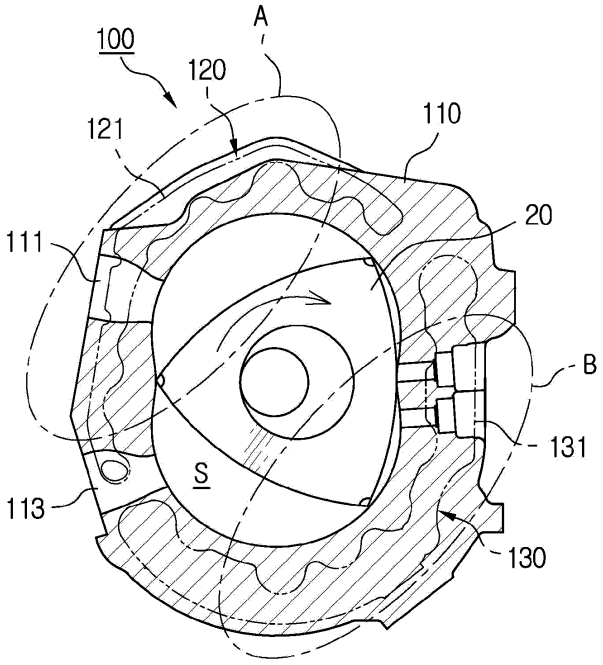
(72) Inventors:
- **AHN, Eun Soo**
Gyeonggi-do, 16359 (KR)
- **KIM, Myung Kyu**
Gyeonggi-do, 18487 (KR)

(74) Representative: **Müller Schupfner & Partner**
Patent- und Rechtsanwaltspartnerschaft mbB
Schellerdamm 19
21079 Hamburg (DE)

(54) ROTARY ENGINE WITH IMPROVED IN-HOUSING THERMAL LOAD IMBALANCE

(57) Rotary engine comprising:
- a housing (110) provided therein with a receiving space (S) to which a rotor (20) is rotatably coupled, the housing having an intake port (111) and an exhaust port (113);
- a heating unit (120) formed in a first section (A) of the housing (110), the intake port (111) being provided in the first section, the heating unit (120) being configured to heat the housing (110) cooled during intake and compression strokes; and
- a cooling unit (130) formed in a second section (B) of the housing, the exhaust port (113) being provided in the second section, the cooling unit (130) being configured to cool the housing (110) heated during combustion and exhaust strokes.

FIG. 3



EP 3 862 531 A1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Applications No. 10-2020-0013868, filed on February 05, 2020 and No. 10-2020-0051903, filed on April 29, 2020 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety

BACKGROUND

Technical Field

[0002] The present disclosure relates to a rotary engine capable of improving a thermal load imbalance in a housing, in which a four-stroke cycle is performed, by applying a heating unit and a cooling unit to the housing.

Description of the Related Art

[0003] In general, a rotary engine is operated to rotate a rotor located in a section where fuel and air are mixed for combustion. Such a rotary engine was developed in 1951 by Felix Wankel of Germany.

[0004] Referring to FIG. 1, in principle, a rotary engine 1 is operated while a rotor 20 rotates along a curved surface called an epitrochoid within an engine housing 10.

[0005] The rotary engine 1 has a simple structure and high efficiency, so it can be made smaller in size than a piston engine. Thus, the rotary engine enables a vehicle equipped therewith to be reduced in weight, and is advantageous for the weight of the vehicle because it has a high degree of freedom for its installation position.

[0006] The piston engine generates a lot of vibration as its piston reciprocates, whereas the rotary engine has less vibration as it rotates in a certain direction.

[0007] On the other hand, the rotary engine 1 may be irregularly worn on the inner wall of its combustion chamber due to lack of durability, resulting in a poor rate of fuel consumption by incomplete combustion of fuel.

[0008] That is, the rotary engine 1 must be configured such that the contact surfaces between the rotor 20 and the housing 10 are in close contact with each other with a small gap therebetween so as to prevent leakage of fuel or oil while the rotor 20 continues to rotate in the housing 10.

[0009] In other words, if metals continue to rotate at high speed in a state in which they in close contact with each other, they may be worn due to friction therebetween. Accordingly, a sealing pad 21 called an apex seal is attached to each corner of the rotor 20 to protect the housing 10 and the rotor 20. However, this sealing pad 21 may be easily worn due to the characteristics of high-speed rotation as well.

[0010] Referring to FIG. 2, the rotary engine 1 operates in a four-stroke cycle (i.e., in the order of (a) intake → (b) compression → (c) combustion → (d) exhaust) while the rotor 20 rotates in one direction within the housing 10.

[0011] In this case, the intake section 11 and exhaust section 13 in the housing 10 have different temperatures while the four-stroke cycle is performed in the housing 10. That is, since the housing 10 has a structure in which the intake section 11 is continuously cooled and the exhaust section 13 is continuously exposed to high temperature and high pressure, the temperature variation in each region of the housing is large.

[0012] The durability of the housing 10 having the above structure is weakened due to thermal expansion and contraction, which may lead to problems such as abrasion of the inner peripheral surface of the housing 10 or gas leakage and engine damage.

[Patent Document]

[0013] Korean Patent Application Publication No. 10-2002-0061929 (published on July 25, 2002)

SUMMARY

[0014] The present disclosure has been made keeping in mind the above problems occurring in the related art, and the present disclosure is intended to propose a rotary engine capable of attaining a uniform temperature distribution in a housing, in which a four-stroke cycle is performed, by applying a heating unit and a cooling unit to the housing, thereby improving a thermal load imbalance in the housing.

[0015] Additional advantages, objects, and features of the disclosure will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the disclosure.

[0016] In accordance with an aspect of the present disclosure, there is provided a rotary engine that includes a housing provided therein with a receiving space to which a rotor is rotatably coupled, the housing having an intake port and an exhaust port, a heating unit formed in a first section of the housing, the intake port being provided in the first section, the heating unit being configured to heat the housing cooled during intake and compression strokes, and a cooling unit formed in a second section of the housing, the exhaust port being provided in the second section, the cooling unit being configured to cool the housing heated during combustion and exhaust strokes.

[0017] The heating unit may heat the first section by circulating some of exhaust gas, discharged through the exhaust port, along a heating line installed in the first section.

[0018] The cooling unit may cool the second section by circulating coolant along a cooling line installed in the second section.

[0019] The cooling line may include a main passage provided on one side thereof with an inlet, and a plurality

of branch passages branched from the other side of the main passage.

[0020] The branch passages may include a first circulation part disposed in a high-temperature region of the second section, and a second circulation part disposed in a middle-low temperature region of the second section.

[0021] The branch passages may each further include a temperature sensor and a flow control valve, to allow the flow rates of the coolants supplied to the respective branch passages to be adjusted differently according to the temperature of the second section.

[0022] When the first circulation part has a higher coolant temperature than the second circulation part, some of the coolant passing through the second circulation part may be supplied to the first circulation unit.

[0023] The temperature sensor may be installed at each outlet of the branch passages, and the flow control valve may be installed at each before-branch inlet of the branch passages.

[0024] It is to be understood that both the foregoing general description and the following detailed description of the present disclosure are exemplary and explanatory and are intended to provide further explanation of the disclosure as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The above and other objects, features and other advantages of the present disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view illustrating an internal structure of a typical rotary engine;

FIG. 2 is a view illustrating a sequence of operation of the rotary engine of FIG. 1;

FIG. 3 is a view illustrating an internal configuration of a rotary engine, whose housing is provided with a heating unit and a cooling unit, according to the present disclosure;

FIG. 4 is a perspective view illustrating the heating unit according to the present disclosure;

FIG. 5 is a perspective view illustrating the cooling unit according to the present disclosure; and

FIG. 6 is a view illustrating circulation of coolant through the cooling unit according to the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0026] Exemplary embodiments of the present disclosure will be described below in more detail with reference to the accompanying drawings.

[0027] Regarding the reference numerals assigned to the elements in the drawings, it should be noted that the same elements will be specified by the same reference numerals, wherever possible, even though they are illustrated in different drawings.

[0028] FIG. 3 is a view illustrating an internal configuration of a rotary engine, whose housing is provided with a heating unit and a cooling unit, according to the present disclosure. FIG. 4 is a perspective view illustrating the heating unit according to the present disclosure. FIG. 5 is a perspective view illustrating the cooling unit according to the present disclosure.

[0029] Referring to FIG. 3, a rotary engine 100 with improved in-housing thermal load imbalance according to an exemplary embodiment of the present disclosure may include a housing 110, a heating unit 120, and a cooling unit 130.

[0030] The configuration of the present disclosure will be described in detail as follows.

[0031] First, the housing 110 may form a main body of the rotary engine 100. The housing 110 may be provided therein with a receiving space S, and a rotor 20 may be eccentrically coupled to the receiving space S.

[0032] The housing 110 may have an intake port 111 provided on one side thereof. A predetermined ratio of fuel and air required to operate the rotary engine 100 may be injected through the intake port 111.

[0033] An exhaust port 113 may be provided beneath the intake port 111 so as to allow exhaust gas after having been subjected to a four-stroke cycle (intake → compression → combustion → exhaust) (see FIG. 2) to be discharged to the outside.

[0034] In this case, the receiving space S of the housing 110 may have an inner peripheral surface formed with a predetermined curvature so as to correspond to the rotation trajectory of the rotor 20. Since the process in which the four-stroke cycle is performed in the housing 110 by eccentric rotation of the rotor 20 is a known technique, a detailed description thereof will be omitted.

[0035] The heating unit 120 may be formed in a first section A of the housing 110, wherein the intake port 111 is provided in the first section A. The heating unit 120 may heat the housing 110 cooled during the intake and compression strokes of the four-stroke cycle.

[0036] Specifically, the heating unit 120 may circulate the exhaust gas, which is discharged through the exhaust port 113, along a heating line 121 formed in the first section A. Thus, the heating unit 120 may heat the first section A of the housing 110.

[0037] Referring to FIG. 4, the heating line 121 may be provided in a form in which a hollow pipe is bent to correspond to the area of the first section A (see FIG. 3). Both sides of the heating line 121 may be provided with an exhaust inlet 123 and an exhaust outlet 125 which communicate with the exhaust port 113. Accordingly, some of the exhaust gas discharged through the exhaust port 113 may be circulated along the heating line 121 through the exhaust inlet 123 and then discharged back

to the exhaust port 113 through the exhaust outlet 125.

[0038] Referring to FIG. 3 again, the cooling unit 130 may be formed in a second section B of the housing 110, wherein the exhaust port 113 is provided in the second section B. The cooling unit 130 may cool the housing 110 heated during the combustion and exhaust strokes of the four-stroke cycle.

[0039] Specifically, the cooling unit 130 may cool the second section B by circulating coolant along a cooling line 131 formed in the second section B. The cooling line 131 may be branched into a plurality of lines in order to improve cooling efficiency. Referring to FIG. 5, the cooling line 131 may include a main passage 133, which is provided on one side thereof with a coolant inlet 131a, and a plurality of branch passages 135 branched from the other side of the main passage 133. The branch passages 135 are merged back into one coolant outlet 131b. Accordingly, the coolant, which is supplied through the coolant inlet 131a and then circulated along the branch passages 135, may be discharged through the coolant outlet 131b to the outside of the housing 110.

[0040] Referring to FIG. 6, the branch passages 135 may include a first circulation part 135a disposed in a high-temperature region (where a ignition plug is installed) of the second section B in which the combustion stroke is mainly performed, and a second circulation part 135b disposed in a middle-low temperature region of the second section B, namely, around the high-temperature region.

[0041] In addition, each of the branch passages 135 may be provided with a temperature sensor 137 and a flow control valve 139. The temperature sensor 137 may be installed at each outlet of the branch passages 135, and the flow control valve 139 may be installed at each before-branch inlet of the branch passages 135. Thus, the flow rates of the coolants supplied to the respective branch passages 135 may be adjusted differently according to the temperature of the second section B. For example, when the coolant temperature in the first circulation part 135a is higher than that in the second circulation part 135b, a controller (not shown) may control some of the coolant passing through the second circulation part 135b to be supplied to the first circulation unit 135a.

[0042] As described above, the rotary engine 100 with improved in-housing thermal load imbalance according to the present disclosure can attain a uniform temperature distribution in the housing 110, in which the four-stroke cycle is performed, by applying the heating and cooling units 120 and 130 to the housing 110, thereby improving a thermal load imbalance in the housing 110.

[0043] As is apparent from the above description, the rotary engine having the above-mentioned configuration according to the present disclosure can attain a uniform temperature distribution in the housing, in which the four-stroke cycle is performed, by applying the heating and cooling units to the housing. Therefore, it is possible to improve a thermal load imbalance in the housing.

[0044] Although the present disclosure has been described with respect to the illustrative embodiments, it will be apparent to those skilled in the art that various variations and modifications may be made without departing from the spirit and scope of the disclosure as defined in the following claims.

Claims

1. A rotary engine comprising:

   a housing provided therein with a receiving space to which a rotor is rotatably coupled, the housing having an intake port and an exhaust port;
   a heating unit formed in a first section of the housing, the intake port being provided in the first section, the heating unit being configured to heat the housing cooled during intake and compression strokes; and
   a cooling unit formed in a second section of the housing, the exhaust port being provided in the second section, the cooling unit being configured to cool the housing heated during combustion and exhaust strokes.

2. The rotary engine according to claim 1, wherein the heating unit heats the first section by circulating some of exhaust gas, discharged through the exhaust port, along a heating line installed in the first section.

3. The rotary engine according to claim 1 or 2, wherein the cooling unit cools the second section by circulating coolant along a cooling line installed in the second section.

4. The rotary engine according to claim 3, wherein the cooling line comprises:

   a main passage provided on one side thereof with an inlet; and
   a plurality of branch passages branched from the other side of the main passage.

5. The rotary engine according to claim 4, wherein the branch passages comprise:

   a first circulation part disposed in a high-temperature region of the second section; and
   a second circulation part disposed in a middle-low temperature region of the second section.

6. The rotary engine according to claim 4 or 5, wherein the branch passages each comprise a temperature sensor and a flow control valve, to allow the flow rates of the coolants supplied to the respective branch passages to be adjusted differently accord-

ing to the temperature of the second section.

7. The rotary engine according to claim 5 or 6, wherein when the first circulation part has a higher coolant temperature than the second circulation part, some of the coolant passing through the second circulation part is supplied to the first circulation unit.

8. The rotary engine according to claim 6, wherein:

the temperature sensor is installed at each outlet of the branch passages; and
the flow control valve is installed at each before-branch inlet of the branch passages.

FIG. 1

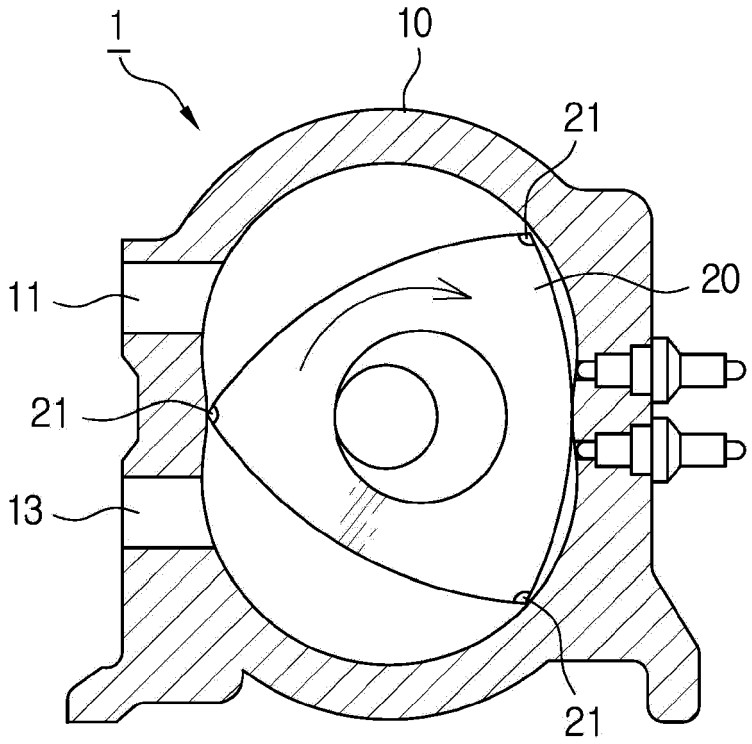

1
10
21
11
20
21
13
21

FIG. 2

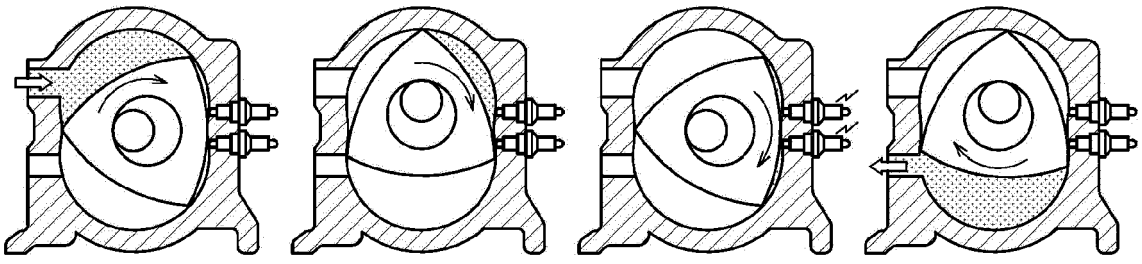

(a) INTAKE
(b) COMPRESSION
(c) COMBUSTION
(d) EXHAUST

FIG. 3

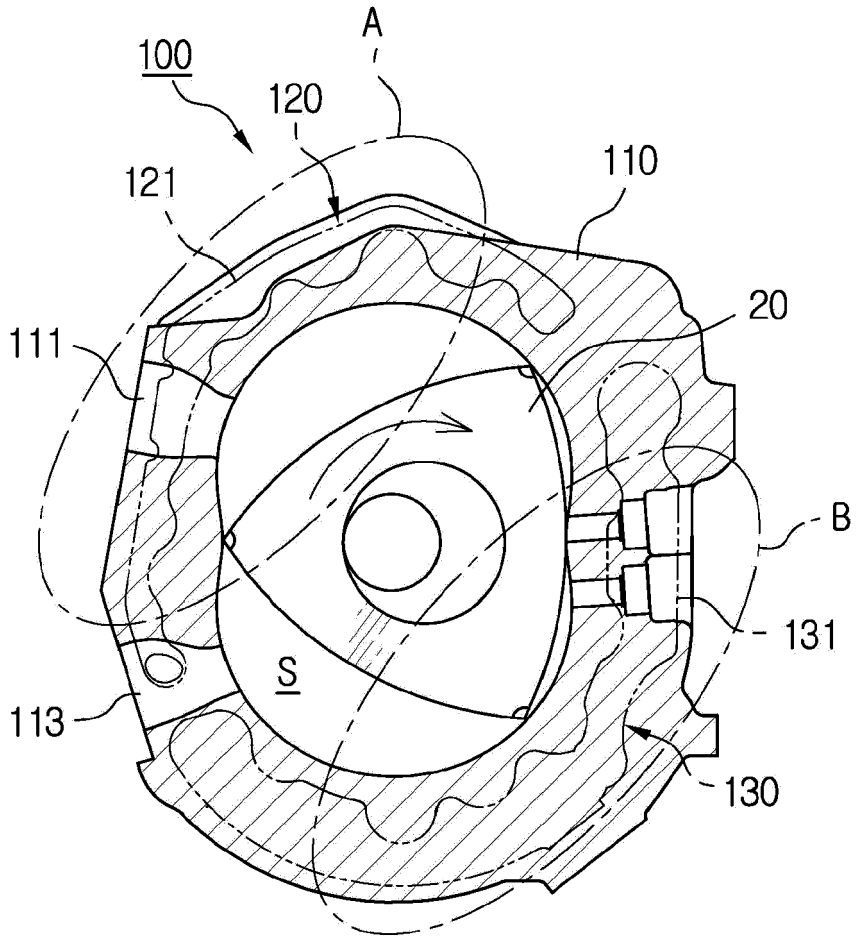


FIG. 4

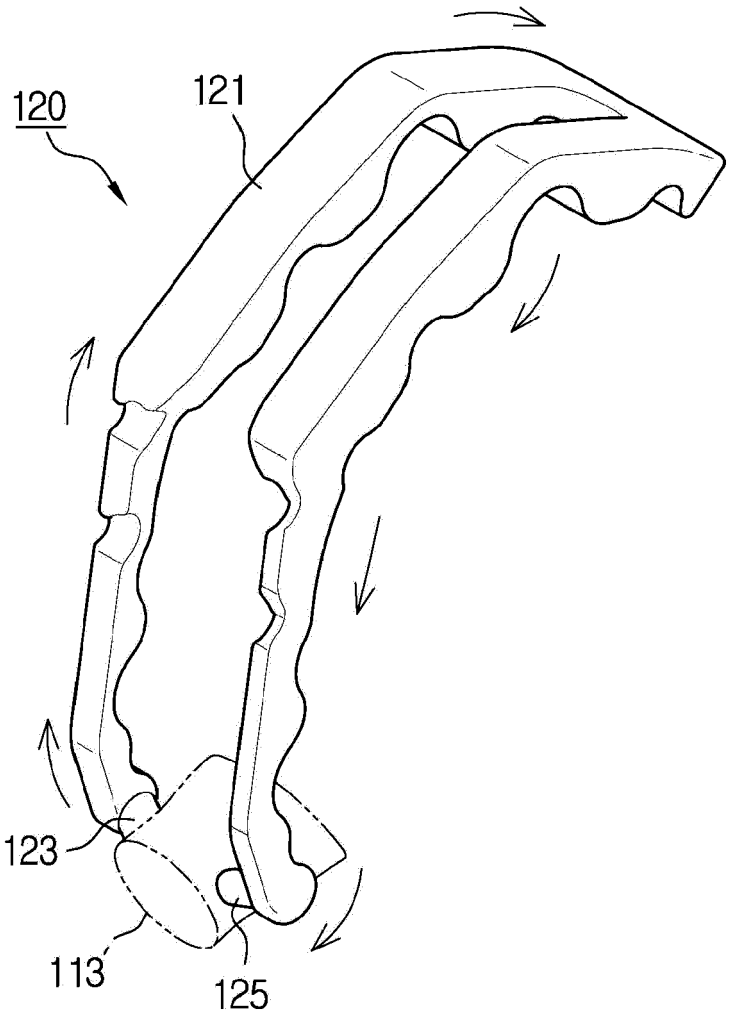


FIG. 5

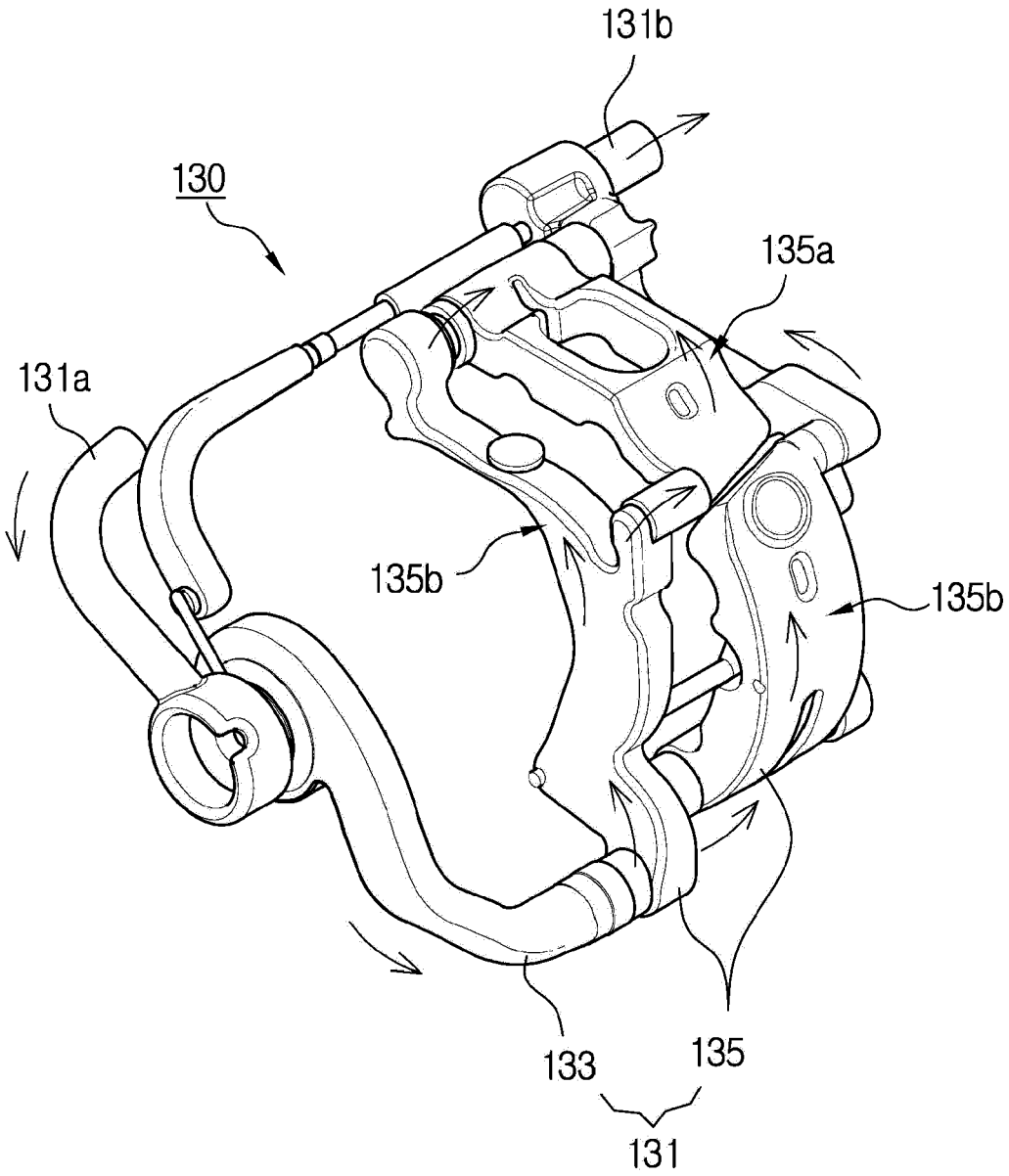
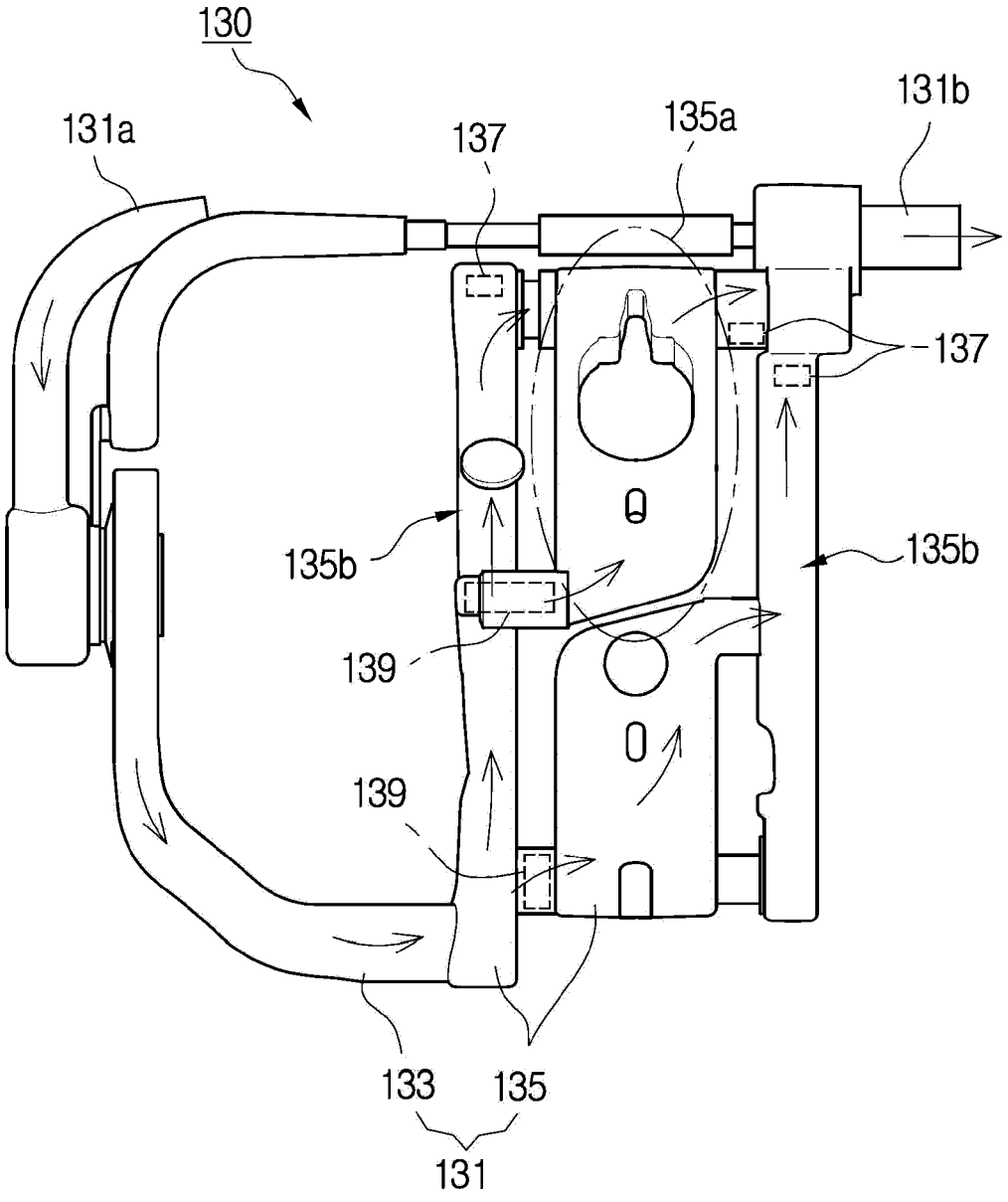


FIG. 6



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 20 6548

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2013/061031 A2 (COMPOUND ROTARY ENGINES LTD [GB]) 2 May 2013 (2013-05-02) * page 4, line 9 - line 23 * * page 10, line 11 - line 27; figure 2 *	1-8	INV. F01C1/22 F01C21/06 F01C21/10
X	US 8 839 623 B2 (NAKASUKA SHINICHI [JP]; SAHARA HIRONORI [JP] ET AL.) 23 September 2014 (2014-09-23) * column 4, line 8 - line 31; figure 1 *	1-3	
A	US 3 302 623 A (HANS-GEORG ZIMMERMANN) 7 February 1967 (1967-02-07) * claim 1; figure 2 *	1-8	
A	US 6 776 136 B1 (KAZEMPOUR SHAHROUKH M [US]) 17 August 2004 (2004-08-17) * abstract; figures 2-4 *	1-8	
			TECHNICAL FIELDS SEARCHED (IPC) F01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 April 2021	Descoubes, Pierre

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 20 6548

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15-04-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013061031 A2	02-05-2013	CN 104011332 A	27-08-2014
		DE 112012004417 T5	04-09-2014
		GB 2509017 A	18-06-2014
		US 2014261291 A1	18-09-2014
		WO 2013061031 A2	02-05-2013
US 8839623 B2	23-09-2014	CN 101300417 A	05-11-2008
		DK 1942265 T3	05-12-2011
		EP 1942265 A1	09-07-2008
		ES 2369567 T3	02-12-2011
		JP 4614290 B2	19-01-2011
		JP WO2007029662 A1	19-03-2009
		US 2009139227 A1	04-06-2009
		WO 2007029662 A1	15-03-2007
US 3302623 A	07-02-1967	DE 1272621 B	11-07-1968
		US 3302623 A	07-02-1967
US 6776136 B1	17-08-2004	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- KR 1020200013868 **[0001]**
- KR 1020200051903 **[0001]**
- KR 1020020061929 **[0013]**