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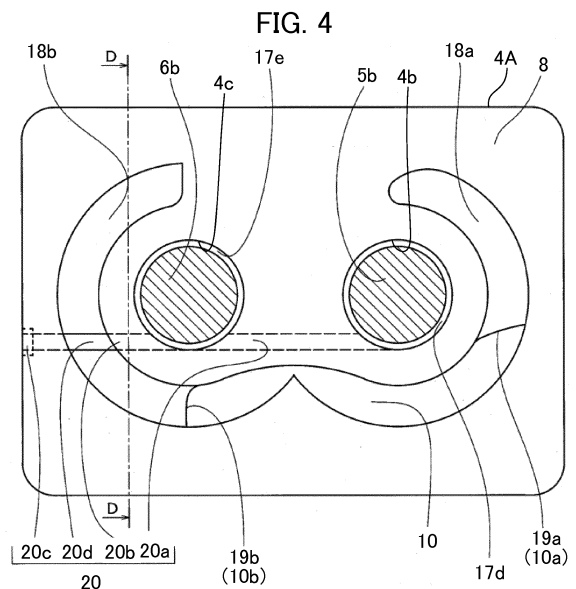
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(54) **SCREW TYPE FLUID MACHINE**

(57) There is provided a screw fluid machine having high energy efficiency and high performance, this screw fluid machine being capable of suppressing oil from being mixed with the main stream of gas sucked from an inlet to lower intake gas heating.

An intermediate portion 4A of a casing 4 includes, formed therein, a male penetration hole 4b through which a male rotor shaft 5b of a male rotor 5 passes, a female penetration hole 4c through which a female rotor shaft 6b of a female rotor 6 passes, an inlet opening 10 positioned below the male penetration hole 4b and the female penetration hole 4c so as to suck gas from a motor 14 toward the male rotor 5 and the female rotor 6, and an oil exhaust passage portion 20 that communicates with the male penetration hole 4b and the female penetration hole 4c so as to return the oil that has lubricated the shaft support means 12a and 13a toward the motor 14 are. The oil that has lubricated the shaft support means 12a and 13a is caused to flow into the oil exhaust passage portion 20 through a male oil passage 17d and a female oil passage 17e and is caused to flow from an edge 10b in a horizontal direction of the inlet opening 10 toward the motor 14.



Description

[Technical Field]

[0001] The present invention relates to a screw fluid machine that handles HFC-based and HFO-based coolants, natural coolants such as air or carbon dioxides, and other compressible gases.

[Background Art]

[0002] A screw fluid machine has been broadly used as a refrigeration and air-conditioning compressor and an air compressor. The screw fluid machine is a main component of a heat pump apparatus such as an air-conditioner, a chiller, and a refrigerator. There is a strong demand for energy-saving apparatuses, and it has become more important to achieve high energy efficiency and high performance.

[0003] A conventional screw fluid machine is configured such that oil that has lubricated shaft support means that rotatably supports the rotor shafts of a male rotor and a female rotor flows into an inlet along the wall surfaces close to the male rotor and the female rotor, and the oil is mixed with the main stream of gas sucked from the inlet and is returned to an oil reservoir.

[Summary of Invention]

[Technical Problem]

[0004] However, in the oil returning configuration of the conventional screw fluid machine, since the oil is mixed with the main stream of gas sucked from the inlet, heat exchange occurs between gas and oil to increase intake gas heating, and compression efficiency decreases.

[0005] Therefore, an object of the present invention is to provide a screw fluid machine having high energy efficiency and high performance, capable of suppressing oil from being mixed with the main stream of gas sucked from an inlet to suppress intake gas heating.

[Solution to Problem]

[0006] In order to solve the problem, a screw fluid machine according to an aspect of the present invention includes: a male rotor and a female rotor configured to rotate while engaging with each other; shaft support means for rotatably supporting driving shafts of the male rotor and the female rotor; driving means for driving the male rotor and the female rotor; a casing configured to accommodate the male rotor, the female rotor, the shaft support means, and the driving means; and oil supply means for supplying oil to the shaft support means, wherein the casing has an intermediate portion positioned between the driving means, and the male rotor and the female rotor, the intermediate portion includes, formed therein, a male penetration hole through which

the driving shaft of the male rotor passes, a female penetration hole through which the driving shaft of the female rotor passes, an inlet opening for sucking gas from the driving means toward the male rotor and the female rotor, and an oil exhaust passage portion communicating with the male penetration hole and the female penetration hole so as to return the oil that has lubricated the shaft support means toward the driving means, and the oil that has lubricated the shaft support means is returned from the inlet opening toward the driving means through the oil exhaust passage portion so as to avoid the gas that passes through the inlet opening.

[Advantageous Effects of Invention]

[0007] According to the present invention, it is possible to provide a screw fluid machine having high energy efficiency and high performance, this screw fluid machine being capable of suppressing oil from being mixed with the main stream of gas sucked from an inlet to suppress intake gas heating.

[Brief Description of Drawings]

[0008]

[Fig. 1]

Fig. 1 illustrates a horizontal cross-sectional view of a screw fluid machine according to a first embodiment.

[Fig. 2]

Fig. 2 illustrates a cross-sectional view along line A-A in Fig. 1, of the screw fluid machine according to the first embodiment.

[Fig. 3]

Fig. 3 illustrates a cross-sectional view along line B-B in Fig. 1, of the screw fluid machine according to the first embodiment.

[Fig. 4]

Fig. 4 illustrates a cross-sectional view along line C-C in Fig. 1, of the screw fluid machine according to the first embodiment.

[Fig. 5]

Fig. 5 illustrates a cross-sectional view along line D-D in Fig. 4, of the screw fluid machine according to the first embodiment.

[Fig. 6]

Fig. 6 illustrates a cross-sectional view along line C-C in Fig. 1, of a screw fluid machine according to a second embodiment.

[Fig. 7]

Fig. 7 illustrates a cross-sectional view along line C-C in Fig. 1, of a screw fluid machine according to a third embodiment.

[Description of Embodiments]

[0009] Hereinafter, a screw fluid machine 1 according

to a first embodiment of the present invention will be described with reference to Fig. 1.

[0010] An overall configuration of the screw fluid machine 1 will be described with reference to Figs. 1 to 4.

[0011] Fig. 1 illustrates a horizontal cross-sectional view of the screw fluid machine 1 according to the present embodiment and Fig. 2 illustrates a cross-sectional view along line A-A in Fig. 1, of the screw fluid machine 1 of the first embodiment. Fig. 3 illustrates a cross-sectional view along line B-B in Fig. 1, of the screw fluid machine 1 according to the first embodiment. Fig. 4 illustrates a cross-sectional view along line C-C in Fig. 1, of the screw fluid machine 1 according to the first embodiment.

[0012] As illustrated in Fig. 1, the screw fluid machine 1 includes a compressing portion 2, a driving portion 3, and a casing 4 that accommodates the compressing portion 2 and the driving portion 3. As illustrated in Figs. 1 and 2, the screw fluid machine 1 causes gas sucked from an inlet port 15 formed in the casing 4 into the screw fluid machine 1 to pass through a motor 14 and then causes the gas to be sucked into an operating chamber from an inlet opening 10 of the operating chamber formed in an intermediate portion 4A. The screw fluid machine 1 compresses the sucked gas and exhausts the gas outside the screw fluid machine 1 from an exhaust port 16 through an exhaust opening 11 of the operating chamber.

[0013] The compressing portion 2 includes a male rotor 5 that is rotated by the motor 14 which is driving means arranged in the driving portion 3, a female rotor 6 that rotates while engaging with the male rotor 5, the casing 4 that accommodates the male rotor 5 and the female rotor 6, shaft support means 12a, 12b, 13a, and 13b, oil supply means 17 of inlet-side shaft support means, and oil supply means (not illustrated) of exhaust-side shaft support means.

[0014] The male rotor 5 and the female rotor 6 include a male rotor shaft 5b and a female rotor shaft 6b, respectively, as rotating shafts. The inlet-side shaft support means 12a is made up of two roller bearings that support an inlet side of the male rotor shaft 5b of the male rotor 5, and the exhaust-side shaft support means 12b is made up of a roller bearing and a ball bearing that support an exhaust side of the male rotor shaft 5b of the male rotor 5. The inlet-side shaft support means 13a is made up of a roller bearing that supports an inlet side of the female rotor shaft 6b of the female rotor 6, and the exhaust-side shaft support means 13b is made up of a roller bearing and a ball bearing that support an exhaust side of the female rotor shaft 6b of the female rotor 6.

[0015] The casing 4 includes the intermediate portion 4A positioned between the compressing portion 2 and the driving portion 3. A male penetration hole 4b, a female penetration hole 4c, an inlet opening 10, and an oil exhaust passage portion 20 are formed in the intermediate portion 4A. The male rotor shaft 5b of the male rotor 5 also passes through the male penetration hole 4b to form a male oil passage 17d. The female rotor shaft 6b of the female rotor 6 passes through the female penetration

hole 4c to form a female oil passage 17e. The inlet opening 10 has horizontal edges 10a and 10b positioned on the lower sides of the male penetration hole 4b and the female penetration hole 4c. Moreover, the inlet opening 10 is widely open to the male rotor 5 and narrowly open to the female rotor 6.

[0016] A plurality of operating chambers are formed by tooth spaces 5a and 6a of the male rotor 5 and the female rotor 6, a bore 7 (a wall surface facing each rotor in a radial direction) of the casing 4, an inlet end surface 8 of the casing 4, and an exhaust end surface 9 of the casing 4. Here, although the casing 4 illustrated in Fig. 1 is illustrated as an integral structure as an example, the casing 4 may have a divided structure in which the casing 4 is divided into the compressing portion 2 and the driving portion 3 or the compressing portion 2 is divided by a casing portion in which the exhaust-side shaft support means of the male and female rotors is arranged.

[0017] Next, a configuration of the oil supply means 17 will be described in detail.

[0018] An oil supply main path 17a and an oil supply branch path 17b are formed in the casing 4 as oil supply paths to the inlet-side shaft support means 12a of the male rotor 5 and the inlet-side shaft support means 13a of the female rotor 6. Although oil is supplied using a method of supplying oil separated by an oil separator (not illustrated) by pressure difference, oil may be supplied using other methods. In the male rotor 5, oil supplied from the oil supply main path 17a to the inlet-side shaft support means 12a does not flow toward the motor 14 with the aid of a seal member 17c that prevents oil from leaking toward the motor 14 but flows up to the male oil passage 17d formed when the male rotor shaft 5b of the male rotor 5 passes through the male penetration hole 4b of the intermediate portion 4A after the oil lubricates the inlet-side shaft support means 12a. In the female rotor 6, oil supplied from the oil supply branch path 17b to the inlet-side shaft support means 13a flows up to a female oil passage 17e formed when the female rotor shaft 6b of the female rotor 6 passes through the female penetration hole 4c of the intermediate portion 4A after the oil lubricates the inlet-side shaft support means 13a.

[0019] The oil exhaust passage portion 20 for guiding oil from the male oil passage 17d and the female oil passage 17e toward an oil reservoir 21 will be described with reference to Figs. 4 and 5.

[0020] Fig. 5 illustrates a cross-sectional view along line D-D in Fig. 4, of the screw fluid machine 1 according to the first embodiment.

[0021] As illustrated in Figs. 4 and 5, the inlet opening 10 of the operating chamber and a male rotor-side inlet groove 18a and a female rotor-side inlet groove 18b formed on an anti-rotor side of the inlet end surface 8 are formed in the inlet end surface 8 of the intermediate portion 4A. Moreover, the oil exhaust passage portion 20 is also formed in the intermediate portion 4A.

[0022] The inlet opening 10 are formed below the male rotor shaft 5a and the female rotor shaft 6b. The male

inlet groove 18a and the female inlet groove 18b are formed so as to extend along portions of the outer circumferences of the male rotor shaft 5a and the female rotor shaft 6b, respectively. A boundary 19a between the inlet opening 10 and the male inlet groove 18a is positioned on a right side of a lower portion of the female rotor shaft 6b in Fig. 4, and a boundary 19b between the inlet opening 10 and the female inlet groove 18b is positioned immediately below the female rotor shaft 6b. The boundaries 19a and 19b correspond to the edges 10a and 10b in the horizontal direction of the inlet opening 10, respectively.

[0023] The oil exhaust passage portion 20 includes a communication passage 20a, an exhaust passage 20b, a plug 20c, and an exhaust groove 20d. The communication passage 20a, the exhaust passage 20b, and the exhaust groove 20d are formed by performing a single instance of drilling on the casing 4 so as to extend in a horizontal direction, and the plug 20c closes the hole in the outer surface of the casing 4. The communication passage 20a connects the lower portion of the male oil passage 17d and the lower portion of the female oil passage 17e. The exhaust passage 20b connects the female inlet groove 18b and the lower portion of the female oil passage 17e. That is, the exhaust passage 20b communicates with the female penetration hole 4c and extends toward a side away from the male penetration hole 4b and is open to the female inlet groove 18b. Since the oil exhaust passage portion 20 is processed as a large-diameter hole, the exhaust groove 20d is formed by cutting the bottom surface of the female inlet groove 18b. Due to this, when the oil exhaust passage portion 20 is processed as a small-diameter hole, the exhaust groove 20d is not formed.

[0024] A large part of the oil that has lubricated the inlet-side shaft support means 12a and has flowed into the male oil passage 17d flows into the communication passage 20a, flowing in a horizontal direction to flow into the female oil passage 17e, and merges with the oil that has lubricated the inlet-side shaft support means 13a in the female oil passage 17e, and a large part of the merging oil flows in a horizontal direction while passing through the exhaust passage 20b and is exhausted toward the female inlet groove 18b. The oil exhausted to the female inlet groove 18b falls along the female inlet groove 18b and flows into the oil reservoir 21 positioned close to the motor 14 from the edge 10b of the inlet opening 10. In this manner, the oil that has lubricated the inlet-side shaft support means 12a and 13a flows in a direction (a horizontal direction in the present embodiment) crossing a vertical direction due to the oil exhaust passage portion 20 and then flows toward the motor 14 from the edge 10b of the inlet opening 10.

[0025] Therefore, since the oil that has lubricated the inlet-side shaft support means 12a and 13a is returned to the motor 14 while creeping along the wall that forms the edge 10b of the inlet opening 10, it is possible to suppress the oil from being mixed with the main stream

of gas sucked from the inlet opening 10 and to suppress intake gas heating. In this way, it is possible to realize the screw fluid machine 1 having high energy efficiency and high performance.

[0026] Since the oil that has lubricated the inlet-side shaft support means 12a and 13a flows in a direction (a horizontal direction in the present embodiment) crossing the vertical direction due to the oil exhaust passage portion 20 and falls along the female inlet groove 18b so that the amount of oil present as an oil film on the female inlet groove 18b, it is possible to decrease the temperature of the oil by exchanging heat with the casing 4. As a result, it is possible to reduce heating of the gas sucked from the inlet opening 10.

[0027] The communication passage 20a of the oil exhaust passage portion 20 communicates with the male penetration hole 4b and the female penetration hole 4c, and the exhaust passage 20b of the oil exhaust passage portion 20 communicates with the female penetration hole 4c and extends toward a side away from the male penetration hole 4b. Due to this, since the communication passage 20a and the exhaust passage 20b can be formed by performing a single instance of drilling on the casing 4, it is possible to form the communication passage 20a and the exhaust passage 20b easily.

[0028] The motor 14 rotates the male rotor 5, and the exhaust passage 20b communicates with the female penetration hole 4c and extends toward a side away from the male penetration hole 4b. Since an opening of the casing 4 narrows with a decrease in the size of the casing 4 on the side of the inlet opening 10 where the motor 14 is not provided, when the exhaust passage 20b is configured to extend from the female penetration hole 4c toward a side away from the male penetration hole 4b, it is possible to increase the distance from an exit of the exhaust passage 20b to the inlet opening 10 and to decrease the temperature of the oil. Therefore, it is possible to suppress heating of the gas sucked from the inlet opening 10.

[0029] Next, a screw fluid machine 1 according to a second embodiment of the present invention will be described with reference to Fig. 6. The same members as those of the screw fluid machine 1 according to the first embodiment will be denoted by the same reference numerals, and the description thereof will be omitted and different portions only will be described.

[0030] Fig. 6 illustrates a cross-sectional view along line C-C in Fig. 1, of the screw fluid machine 1 according to the second embodiment.

[0031] As illustrated in Fig. 6, the inlet opening 10 is positioned at the center of the male rotor shaft 5b and the female rotor shaft 6b and has a shape symmetrical to a surface parallel to the drawing sheet. A male oil exhaust passage portion 50 and a female oil exhaust passage portion 51 are formed in the intermediate portion 4A instead of the oil exhaust passage portion 20, and the communication passage 20a that connects the lower portion of the male oil passage 17d and the lower portion of

the female oil passage 17e is not formed.

[0032] The male oil exhaust passage portion 50 includes a male exhaust passage 50a, a plug 50b, and an exhaust groove 50c. The male exhaust passage 50a and the exhaust groove 50c are formed by performing drilling on the casing 4 so as to extend in a horizontal direction, and the plug 50b closes a hole in the outer surface of the casing 4. The male exhaust passage 50a connects the male inlet groove 18a and the lower portion of the male oil passage 17d. That is, the male exhaust passage 50a communicates with the male penetration hole 4b and extends toward a side away from the female penetration hole 4c and is open to the male inlet groove 18a. Since the male oil exhaust passage portion 50 is processed as a large-diameter hole, the exhaust groove 50c is formed by cutting the bottom surface of the male inlet groove 18a.

[0033] The female oil exhaust passage portion 51 includes a female exhaust passage 51a, a plug 51b, and an exhaust groove 51c. The female exhaust passage 51a and the exhaust groove 51c are formed by performing drilling on the casing 4 so as to extend in a horizontal direction, and the plug 51b closes a hole in the outer surface of the casing 4. The female exhaust passage 51a connects the female inlet groove 18b and a lower portion of the female oil passage 17e. That is, the female exhaust passage 51a communicates with the female penetration hole 4c and extends toward a side away from the male penetration hole 4b and is open to the female inlet groove 18b. Since the female oil exhaust passage portion 51 is processed as a large-diameter hole, the exhaust groove 51c is formed by cutting the bottom surface of the female inlet groove 18b.

[0034] A large part of the oil that has lubricated the inlet-side shaft support means 12a and has flowed into the male oil passage 17d flows in a horizontal direction while passing through the male exhaust passage 50a and flows into the male inlet groove 18a. The oil exhausted to the male inlet groove 18a falls along the male inlet groove 18a and flows from the edge 10a of the inlet opening 10 into the oil reservoir 21 positioned close to the motor 14. In this manner, the oil that has lubricated the inlet-side shaft support means 12a flows from the edge 10a of the inlet opening 10 toward the motor 14 after flowing in a direction (a horizontal direction in the present embodiment) crossing a vertical direction due to the male oil exhaust passage portion 50.

[0035] A large part of the oil that has lubricated the inlet-side shaft support means 13a and has flowed into the female oil passage 17e flows in a horizontal direction while passing through the female exhaust passage 51a and is exhausted to the female inlet groove 18b. The oil exhausted to the female inlet groove 18b falls along the female inlet groove 18b and flows from the edge 10b of the inlet opening 10 into the oil reservoir 21 positioned close to the motor 14. In this manner, the oil that has lubricated the inlet-side shaft support means 13a flows from the edge 10b of the inlet opening 10 toward the motor 14 after flowing in a direction (a horizontal direction

in the present embodiment) crossing in a vertical direction due to the female oil exhaust passage portion 51.

[0036] According to the screw fluid machine 1 of the present embodiment, since the screw fluid machine 1 has the male oil exhaust passage portion 50 close to the male rotor 5 and the female oil exhaust passage portion 51 close to the female rotor 6, it is possible to cause the oil to pass from both edges 10a and 10b of the inlet opening 10 and to suppress heat exchange between the oil and the inlet gas. Therefore, it is possible to realize the screw fluid machine 1 having high energy efficiency and high performance, capable of suppressing intake gas heating.

[0037] Next, the screw fluid machine 1 according to a third embodiment of the present invention will be described with reference to Fig. 7. The same members as those of the screw fluid machine 1 according to the first embodiment will be denoted by the same reference numerals, and the description thereof will be omitted and different portions only will be described.

[0038] Fig. 7 illustrates a cross-sectional view along line C-C in Fig. 1, of the screw fluid machine 1 according to the third embodiment.

[0039] As illustrated in Fig. 7, an exhaust relief groove 40 that exhausts oil to a side lower than the inlet opening 10 is formed in a portion of a surface in which the female inlet groove 18b is formed and which is positioned below the female rotor shaft 6b of the female rotor 6.

[0040] In this way, since oil is returned from a side lower than the inlet opening 10, it is possible to further suppress the oil from being mixed with the main stream of the gas sucked from the inlet opening 10 and to further suppress intake gas heating. In this way, it is possible to realize the screw fluid machine 1 having higher energy efficiency and higher performance.

[0041] The present invention is not limited to the above-described embodiments. Various additions and modifications can be conceived by those skilled in the art without departing from the spirit of the present invention.

[0042] For example, although the motor 14 drives the male rotor 5, the motor 14 may drive the female rotor 6. In this case, the oil exhaust passage portion 20 may be formed in the male oil passage 17d rather than the female oil passage 17e. Moreover, the exhaust relief groove 40 may be formed in both the male inlet groove 18a and the female inlet groove 18b of the second embodiment.

[Reference Signs List]

[0043]

1	Screw fluid machine
4	Casing
4A	Intermediate portion
4b	Male penetration hole
4c	Female penetration hole
5	Male rotor

5b	Male rotor shaft
6	Female rotor
6b	Female rotor shaft
8	End surface
10	Inlet opening
10a, 10b	Edge
12a, 13a	Inlet-side shaft support means
14	Motor
17	Oil supply means
17d	Male oil passage
17e	Female oil passage
18a	Male inlet groove
18b	Female inlet groove
20	Oil exhaust passage portion
20a	Communication passage
20b	Exhaust passage
50	Male oil exhaust passage portion
50a	Male exhaust passage
51	Female oil exhaust passage portion
51a	Female exhaust passage

Claims

1. A screw fluid machine comprising:

a male rotor and a female rotor configured to rotate while engaging with each other;
shaft support means for rotatably supporting driving shafts of the male rotor and the female rotor;
driving means for driving the male rotor and the female rotor;
a casing configured to accommodate the male rotor, the female rotor, the shaft support means, and the driving means; and
oil supply means for supplying oil to the shaft support means, wherein
the casing has an intermediate portion positioned between the driving means, and the male rotor and the female rotor,
the intermediate portion includes, formed therein, a male penetration hole through which the driving shaft of the male rotor passes, a female penetration hole through which the driving shaft of the female rotor passes, an inlet opening for sucking gas from the driving means toward the male rotor and the female rotor, and an oil exhaust passage portion communicating with the male penetration hole and the female penetration hole so as to return the oil that has lubricated the shaft support means toward the driving means, and
the oil that has lubricated the shaft support means is returned from the inlet opening toward the driving means through the oil exhaust passage portion so as to avoid the gas that passes through the inlet opening.

2. The screw fluid machine according to claim 1, wherein
the inlet opening is positioned below the male penetration hole and the female penetration hole, and
the oil that has lubricated the shaft support means is caused to flow into the oil exhaust passage portion through a male oil passage formed by passing the driving shaft of the male rotor through the male penetration hole and a female oil passage formed by passing the driving shaft of the female rotor through the female penetration hole so that the oil flows from an edge in a horizontal direction of the inlet opening toward the driving means.

3. The screw fluid machine according to claim 2, wherein
the oil exhaust passage portion is configured to cause the oil to flow in a direction crossing a vertical direction.

4. The screw fluid machine according to claim 2 or 3, wherein
the oil exhaust passage portion has a communication passage that communicates with the male penetration hole and the female penetration hole, and
an exhaust passage that communicates with the male penetration hole and extends toward a side away from the female penetration hole, or communicates with the female penetration hole and extends toward a side away from the male penetration hole.

5. The screw fluid machine according to claim 4, wherein
the exhaust passage communicates with the female penetration hole and extends toward the side away from the male penetration hole when the driving means rotates the male rotor, and
the exhaust passage communicates with the male penetration hole and extends toward the side away from the female penetration hole when the driving means rotates the female rotor.

6. The screw fluid machine according to claim 4, wherein
a male inlet groove that communicates with an end on one side, in a horizontal direction, of the inlet opening along a portion of an outer circumference of the driving shaft of the male rotor and a female inlet groove that communicates with an end on the other side, in the horizontal direction, of the inlet opening along a portion of an outer circumference of the driving shaft of the female rotor are formed in an end surface of the intermediate portion close to the male rotor and the female rotor, and
the exhaust passage of the oil exhaust passage portion is open to the male inlet groove or the female inlet groove.

7. The screw fluid machine according to claim 2 or 3, wherein
the oil exhaust passage portion has a male exhaust passage that communicates with the male penetration hole and extends toward a side away from the female penetration hole and a female exhaust passage that communicates with the female penetration hole and extends toward a side away from the female penetration hole.
8. The screw fluid machine according to claim 7, wherein
a male inlet groove that communicates with an end on one side, in a horizontal direction, of the inlet opening along a portion of an outer circumference of the driving shaft of the male rotor and a female inlet groove that communicates with an end on the other side, in the horizontal direction, of the inlet opening along a portion of an outer circumference of the driving shaft of the female rotor are formed in end surfaces of the intermediate portion close to the male rotor and the female rotor, and
the male exhaust passage is open to the male inlet groove and the female exhaust passage is open to the female inlet groove.
9. The screw fluid machine according to claim 6 or 8, wherein
an exhaust relief groove that exhausts oil to a side lower than the inlet opening is formed in a portion of a surface, in which the male inlet groove and/or the female inlet groove are/is formed, and which is positioned below the rotor shaft of the male rotor and/or the female rotor.

FIG. 1

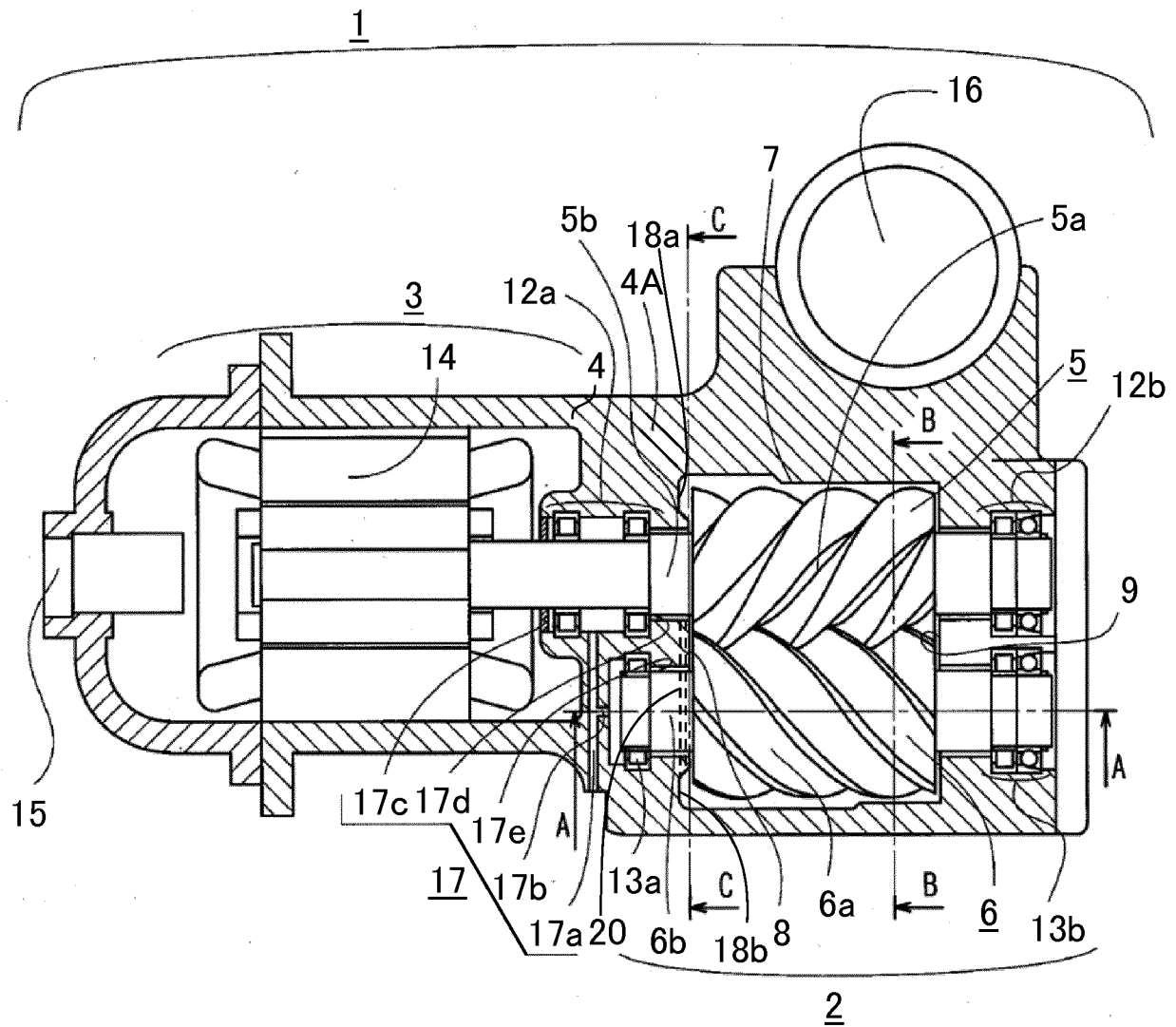


FIG. 2

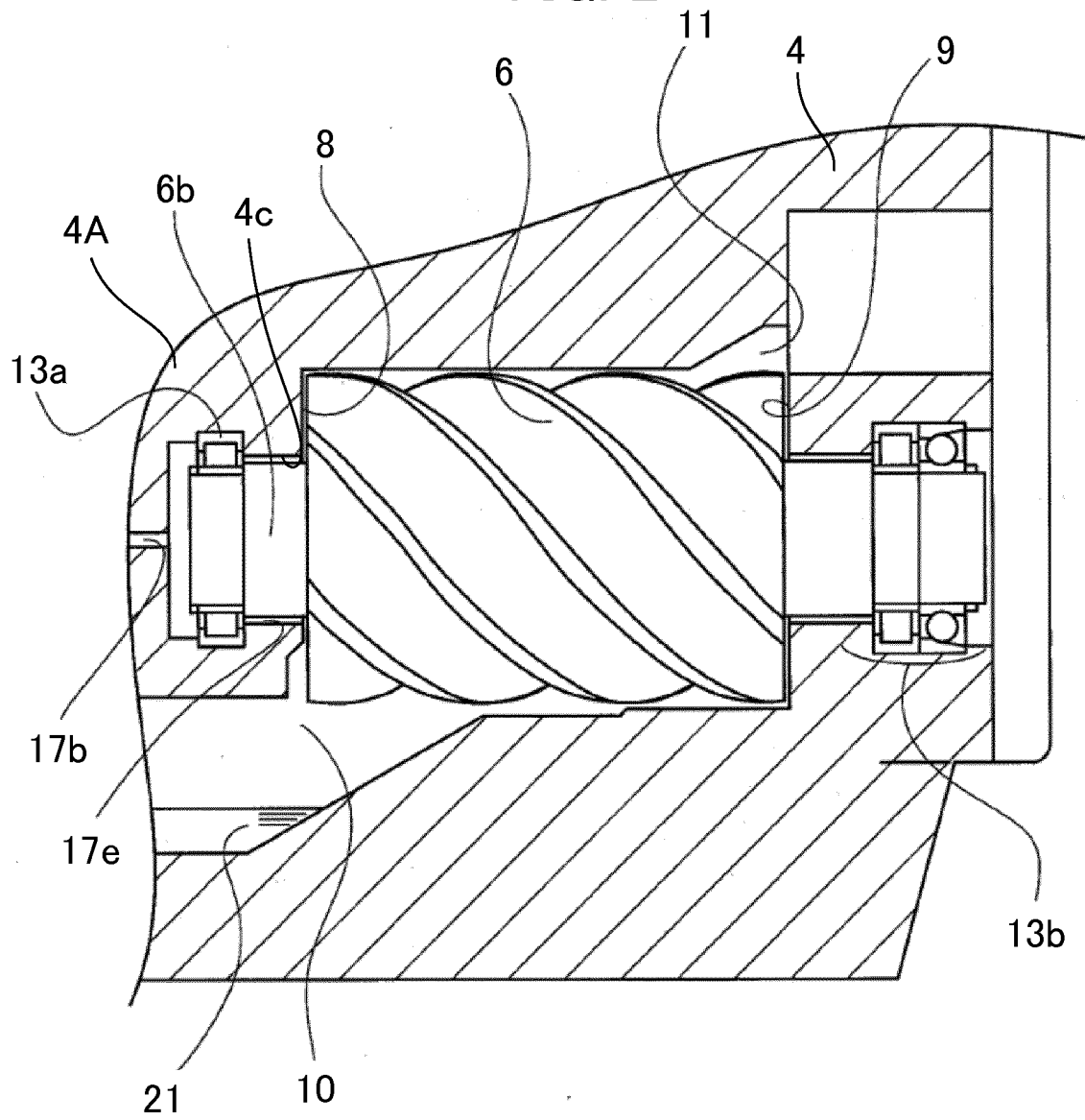


FIG. 3

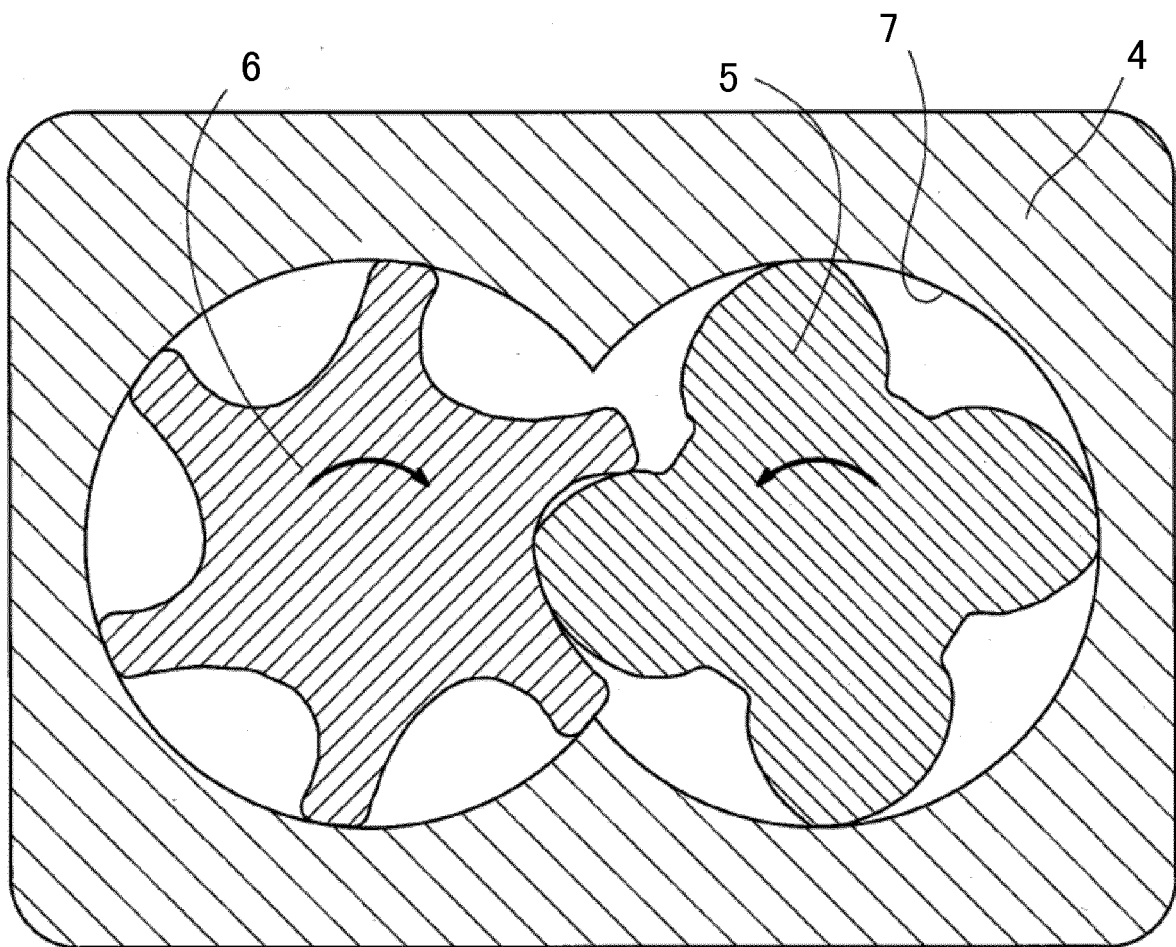


FIG. 4

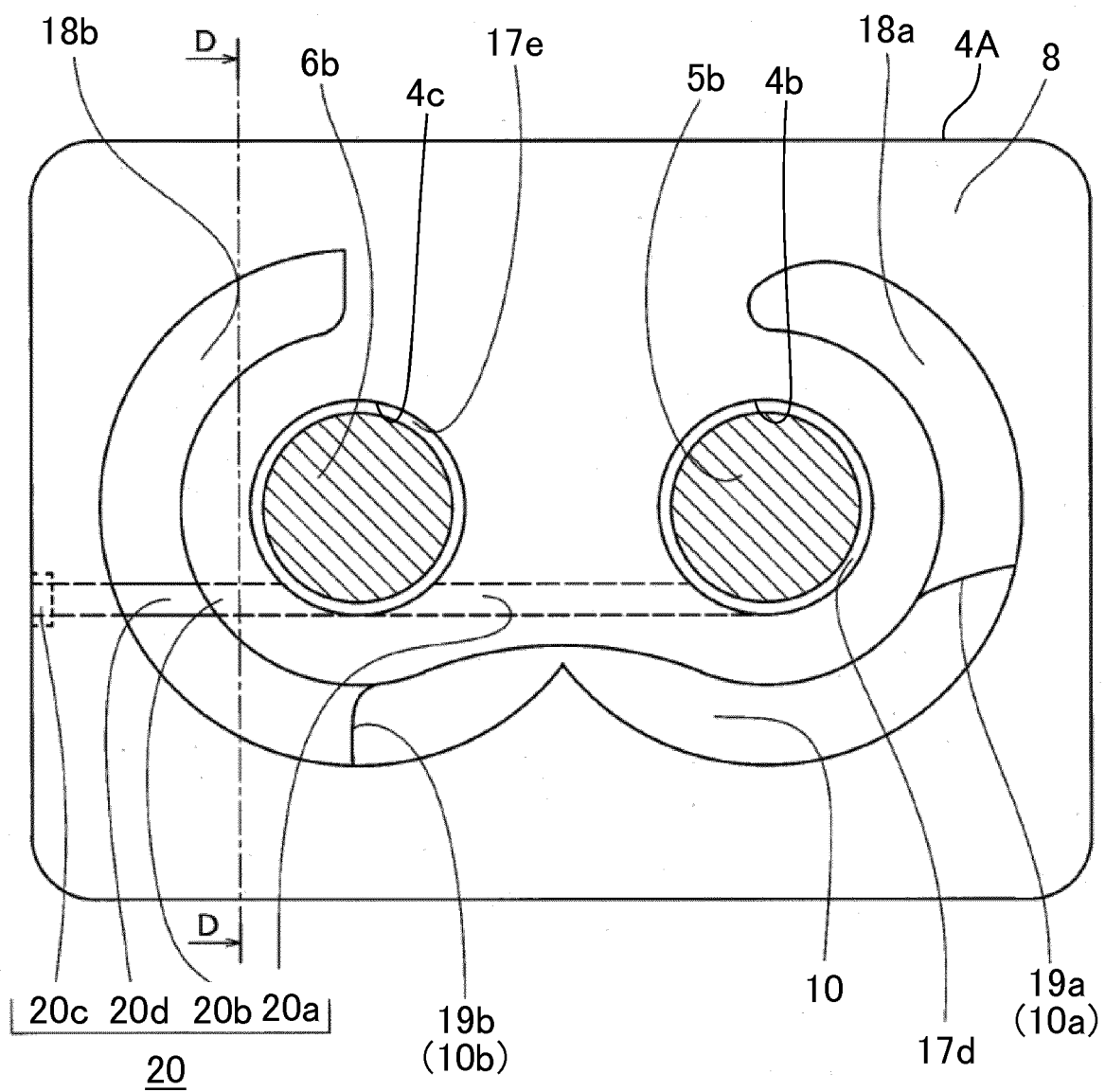


FIG. 5

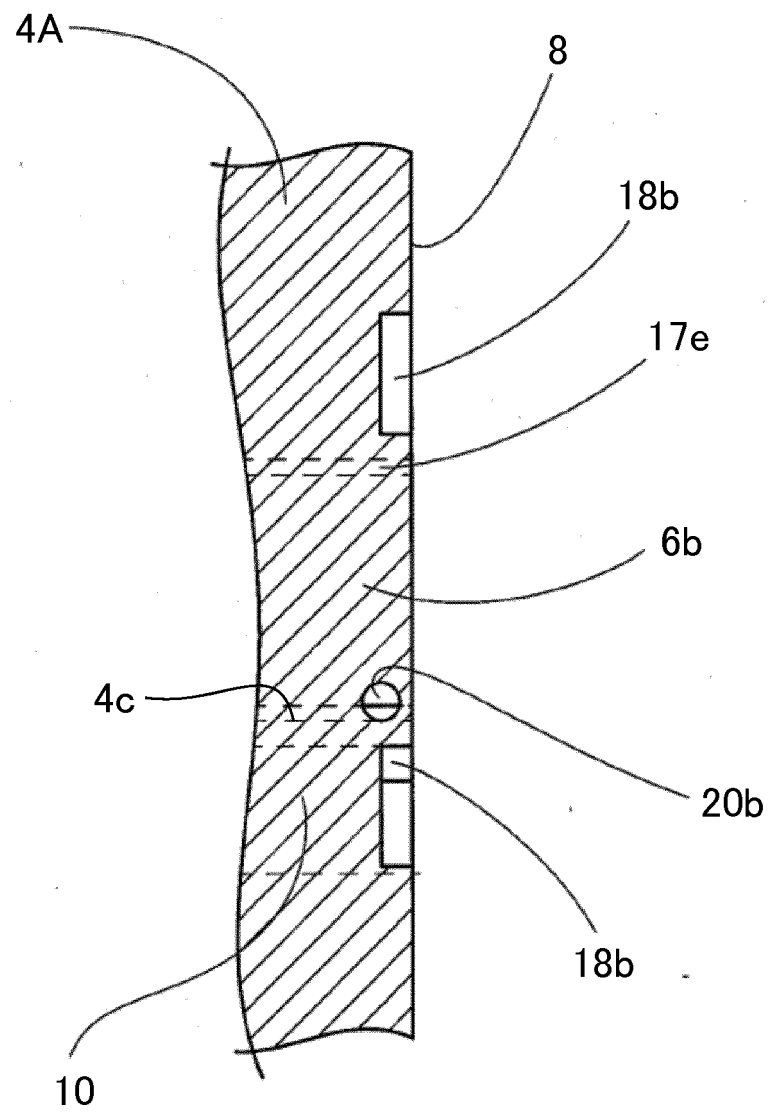


FIG. 6

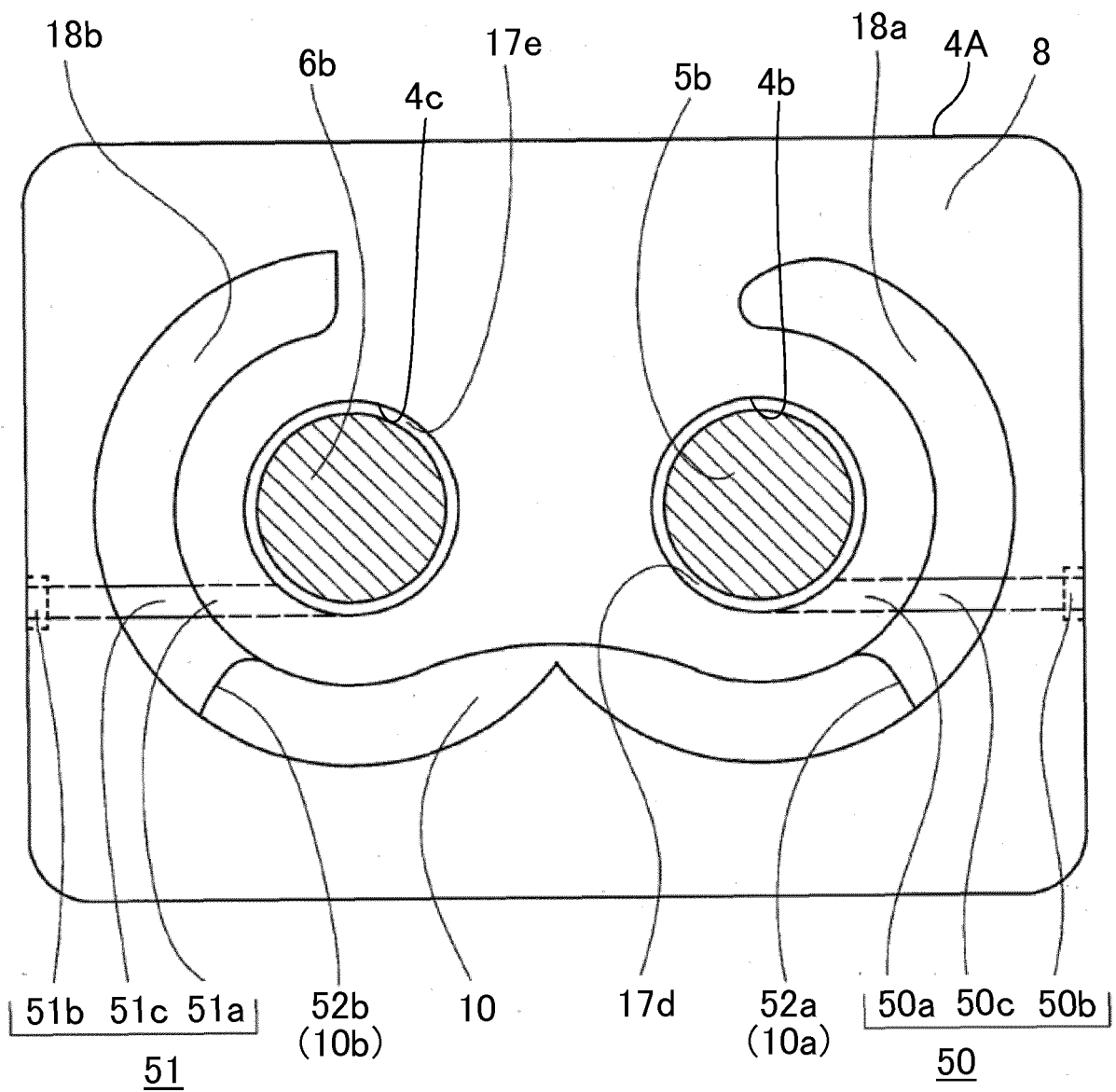
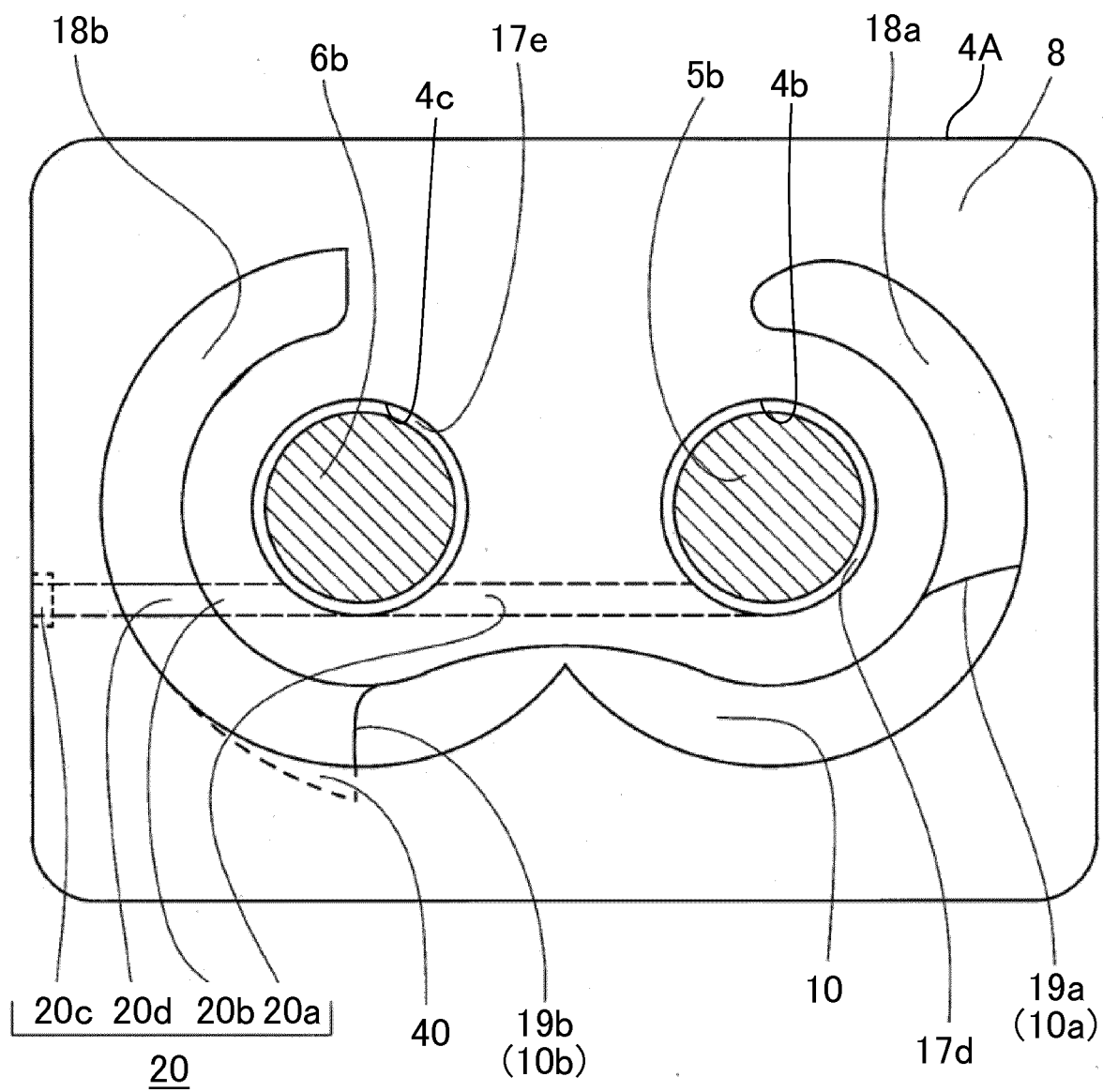


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/041299

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F04C18/16(2006.01) i, F04C29/02(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)

Int. Cl. F04C18/16, F04C29/02

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2015-42847 A (HITACHI APPLIANCES, INC.) 05	1
A	March 2015, paragraphs [0012]-[0022], fig. 2, 5 (Family: none)	2-9
Y	JP 2001-323887 A (HITACHI, LTD.) 22 November 2001,	1
A	paragraphs [0005]-[0012], fig. 1, 2 (Family: none)	2-9
A	US 3178104 A (WILLIAMS, Raymond F.) 13 April 1965, entire text, all drawings & GB 994325 A	1-9

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

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