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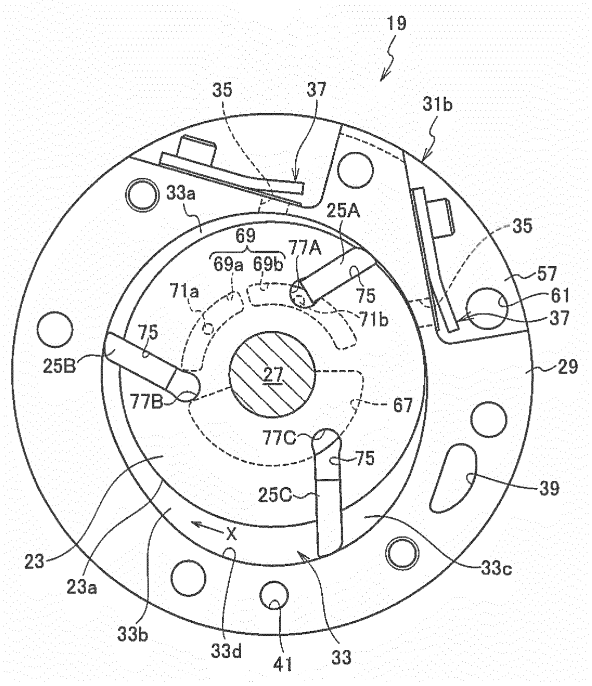
(54) **GAS COMPRESSOR**

(57) A back pressure space (77) of a vane groove (75) having completed communication with an intermediate-pressure supply groove (67) communicates with a first supply section (69a) until refrigerant pressure in each of compression chambers (33a, 33b, 33c) having been partitioned by vanes (25) of the vane grooves (75) reach the highest pressure, and then high pressure is supplied from the first supply section (69a). At a time point when the back pressure space (77) having completed communication with an intermediate-pressure supply groove (67) communicates with the first supply section (69a) of a high-pressure supply groove (69), the preceding back pressure space (77) adjacent to that back pressure space (77) on the downstream side of the rotation direction X completes communication with the first supply section (69a).

FIG. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a so-called vane rotary-type gas compressor.

BACKGROUND ART

[0002] Conventionally, various gas compressors have been proposed as indicated in Patent Literature 1.

[0003] Fig. 16 shows a compression block disposed in a gas compressor pertaining to Patent Literature 1.

[0004] This compression block has a cylinder block 100 and a pair of side blocks 101 disposed on the left and right of the cylinder block 100. A cylinder chamber 105 is formed in the cylinder block 100 and the pair of the side blocks 101. The cylinder block 100 is provided with a suction port 110 and two discharge ports 108.

[0005] A rotor 102 is rotatably disposed in the cylinder chamber 105. The rotor 102 is formed with a plurality of vane grooves 106 at intervals. A vane 103 is disposed in each vane groove 106 so as to freely retractable from an outer peripheral surface of the rotor 102. A back pressure space 107 (107A, 107B and 107C) is formed in the vane groove 106 on the back surface side of the vane 103. The back pressure space 107 opens to both side surfaces of the rotor 102.

[0006] An intermediate-pressure supply groove 113 and a high-pressure supply groove 114 are formed in a wall surface on the cylinder chamber 105 side of each side block 101, on a rotation locus of the back pressure space 107. An intermediate pressure that is a pressure higher than that of a sucked refrigerant and is lower than that of the discharged refrigerant is supplied to the intermediate-pressure supply groove 113. High pressure that is a pressure equivalent to that of the discharged refrigerant is supplied to the high-pressure supply groove 114.

[0007] Compression chambers 105a, 105b and 105c are formed in the cylinder chamber 105 by being surrounded by the two vanes 103. The compression chambers 105a, 105b and 105c perform a suction process, a compression process and a discharged process and repeat this series of the processes, at the time of rotation of the rotor 102.

[0008] In the suction process, the refrigerant is sucked from the suction port 110 by gradual increase in volumes of the compression chambers 105a, 105b and 105c. In the compression process, the refrigerant is compressed by gradual decrease in volumes of the compression chambers 105a, 105b and 105c. In the discharged process, when the volumes of the compression chambers 105a, 105b and 105c are gradually decreased and a refrigerant pressure becomes at least a predetermined pressure, an open/close valve 109 opens and the refrigerant is discharged from the discharge port 108.

[0009] In such a series of processes, as to each of the vane 103, although the refrigerant pressures in the compression chambers 105a, 105b and 105c press each of the vanes 103 in a direction (hereinafter, a "storage direction") in which each of the vane 103 is stored in the vane groove 106, a tip of each of the vane 103 slides along an inner wall of the cylinder chamber 105 by a back pressure acting on the back pressure space 107 and thereby the compression chambers 105a, 105b and 105c are able to reliably compress the refrigerant.

[0010] Here, in the suction process and in an early stage of the compression process in which pressure in the storage direction is small, an intermediate pressure from the intermediate-pressure supply groove 113 is made to act as the back pressure. In addition, in a later stage of the compression process and in the discharged process in which the pressure in the storage direction of the vane 103 is large, high pressure from the high-pressure supply groove 114 is made to act as the back pressure. In this way, a sliding resistance of the vane 103 is made as small as possible so as to achieve low fuel consumption by changing the back pressure made to act on the vane 103, in accordance with the pressure in the storage direction of the vane 103.

CITATION LIST

PATENT LITERATURE

[0011] Patent Literature I: Japanese Patent Laid-Open Publication No. 2013-194549

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0012] Fig. 17 is a graph showing changes in a pressure P105a in the compression chamber 105a, a pressure P105b in the compression chamber 105b and a pressure P107A in the back pressure space 107A in accordance with a rotation angle of the rotor. As shown in Fig. 17, at an angle of 180 degrees, the back pressure space 107A having completed communication with the intermediate-pressure supply groove 113 communicates with the high-pressure supply groove 114.

[0013] In the example shown in Fig. 16, when the back pressure space 107B shifts a communication state from the intermediate-pressure supply groove 113 to the high-pressure supply groove 114, the preceding rotation downstream back pressure space 107A is already in communication with the high-pressure supply groove 114. Accordingly, when the following rotation upstream back pressure space 107B completes shifting of the communication state to the high-pressure supply groove 114, the two back pressure spaces 107A and 107B are simultaneously brought into a state of communicating with the high-pressure supply groove 114.

[0014] Since the pressure P107B in the rotation upstream back pressure space 107B is intermediate pressure, the pressure P107A in the rotation downstream back pressure space 107A that communicates with the rotation upstream back pressure space 107B via the high-pressure supply groove 114 becomes temporarily lower than a pressure to be supplied to the high-pressure supply groove 114 as shown by P in Fig. 17. Since, in the vane 103 on the rotation downstream side, the pressures of the refrigerant in the compression chambers 105a, 105b and 105c which are in the later stage of the compression process and in the discharged process act in the storage direction of the vane 103, there is a possibility that the vane 103 may be temporarily stored in the vane groove 106 and chattering may occur.

[0015] The present invention has been made in view of the above-mentioned circumstances and an object of the present invention is to prevent occurrence of chattering of the vane by a temporary reduction in pressure in the back pressure space of the vane, for example, in the later stage of the compression process and in the discharged process, and to maintain operating performance as a gas compressor.

SOLUTION TO PROBLEM

[0016] In order to achieve the above-mentioned object, a gas compressor of the present invention includes:

a tubular cylinder block having therein a cylinder chamber in which a refrigerant is compressed;
side blocks that are attached to side parts of the cylinder block and seal an opening of the cylinder chamber on the side parts ;
a rotor that rotates in the cylinder chamber and has a plurality of vane grooves opening to an outer peripheral surface facing an inner peripheral surface of the cylinder chamber at intervals in a rotation direction;
a plurality of vanes that is respectively stored in the respective vane grooves, protrudes and retracts from the outer peripheral surface, comes into sliding contact with the inner peripheral surface of the cylinder chamber, and partitions a space between the inner peripheral surface and the outer peripheral surface of the rotor into a plurality of compression chambers;
an intermediate-pressure supply section that is formed in at least one of the side blocks, communicates with a back pressure space at a groove bottom of each of the vane grooves storing the vanes for partitioning the compression chambers from a suction process to a compression process, and supplies, to the back pressure space, an intermediate pressure larger than a refrigerant pressure in each of the compression chambers from the suction process to the compression process; and
a high-pressure supply section that is formed in at least one of the side blocks, communicates with the back pressure space in each of the vane grooves storing the vanes for partitioning the compression chambers from the compression process to a discharged process after communication with the intermediate-pressure supply section has been completed, and supplies, to the back pressure space, high pressure larger than the refrigerant pressure in each of the compression chambers from the compression process to the discharged process and larger than the intermediate pressure, wherein
the high-pressure supply section is divided into a plurality of mutually independent supply sections in the rotation direction,
the second supply section that is positioned at least secondarily from the most upstream side in the rotation direction is formed into a shape in which the second supply section, while communicating with the back pressure space of one vane groove, does not simultaneously communicate with the back pressure space of the other vane groove adjacent to the vane groove on the upstream side in the rotation direction, and the high-pressure supply section is formed in a range in which it simultaneously communicates with the back pressure space of the one vane groove and the back pressure space of the other vane groove adjacent to the vane groove on the upstream side in the rotation direction.

BRIEF DESCRIPTION OF DRAWINGS

[0017]

[Fig. 1] Fig. 1 is a cross-sectional diagram showing an overall configuration of a vane rotary-type gas compressor according to a first embodiment of the present invention.
[Fig. 2] Fig. 2 is a cross-sectional diagram along the I-I line of the gas compressor in Fig. 1.
[Fig. 3] Fig. 3 is a cross-sectional diagram along the II-II line of the gas compressor in Fig. 1.
[Fig. 4] Fig. 4 is an explanatory diagram showing essential parts of a compression block shown in Fig. 3, in an enlarged manner.
[Fig. 5] Fig. 5 is an explanatory diagram showing a virtual example of a case where a first supply section and a second supply section of a high-pressure supply groove in Fig. 3 are disposed apart from each other at an interval at which a back pressure space of a vane groove does not communicate with any of them.
[Fig. 6] Fig. 6 is a graph showing changes in pressure in the compression chamber and pressure in the back pressure space of the vane in the vane groove in Fig. 5, in accordance with a rotation angle of a rotor.
[Fig. 7] Fig. 7 is an explanatory diagram showing a communication cross-sectional area between the first supply section of the high-pressure supply groove and the back pressure space in the vane groove, and a communication cross-sectional area

between the second supply section of the high-pressure supply groove and the back pressure space in the vane groove, in Fig. 3.

[Fig. 8] Fig. 8 is a graph showing changes in the pressure in the compression chamber and the pressure in the back pressure space of the vane in the vane groove in Fig. 3 in accordance with the rotation angle of the rotor.

[Fig. 9] Fig. 9 is a cross-sectional diagram of a vane rotary-type gas compressor according to a second embodiment of the present invention, at a position corresponding to the cross-sectional diagram in Fig. 2.

[Fig. 10] Fig. 10 is a cross-sectional diagram of the vane rotary-type gas compressor according to the second embodiment of the present invention, at a position corresponding to the cross-sectional diagram in Fig. 3.

[Fig. 11] Fig. 11 is an explanatory diagram showing essential parts of a compression block shown in Fig. 10 in an enlarged manner.

[Fig. 12] Fig. 12 is an explanatory diagram showing a positional relation between a region in which a projection stroke of the vane relative to the vane groove is reduced at a rate equal to or more than a constant level and an interval between the first supply section and the second supply section in the compression block shown in Fig. 10.

[Fig. 13] Fig. 13 is a graph showing changes in the pressure in the compression chamber and the pressure in the back pressure space in the vane groove in Fig. 12 in accordance with the rotation angle of the rotor.

[Fig. 14] Fig. 14 is an explanatory diagram showing a positional relation, during a period when the vane is in sliding contact with a region in which the projection stroke of the vane relative to the vane groove is reduced at a rate equal to or more than a constant level, between the region concerned and an interval between the first supply section and the second supply section, in the compression block shown in Fig. 10.

[Fig. 15] Fig. 15 is a graph showing changes in the pressure in compression chamber and the pressure in the back pressure space of the vane in the vane groove in Fig. 10 in accordance with the rotation angle of the rotor.

[Fig. 16] Fig. 16 is an explanatory diagram showing an inside of a compression block of a conventional gas compressor.

[Fig. 17] Fig. 17 is a graph showing changes in pressure in a compression chamber and pressure in a back pressure space of a vane in a vane groove in Fig. 16 in accordance with the rotation angle of the rotor.

DESCRIPTION OF EMBODIMENTS

[First Embodiment]

[0018] The first embodiment of the present invention will be described with reference to Fig. 1 to Fig. 8.

[0019] As shown in Fig. 1, a gas compressor 1 according to the present embodiment includes a substantially cylindrical housing 2, a compression section 3 stored in the housing 2, a motor section 4 that transmits driving force to the compression section 3 and an inverter section 5 which is fixed to the housing 2 and which controls driving of the motor section 4.

[0020] The housing 2 is configured by a front head 7 in which a not shown suction port is formed and a bottomed cylindrical rear case 9 whose opening is closed by the front head 7.

[0021] The compression section 3 is fixed to an inner wall 13 of the rear case 9. The compression section 3 is formed with a suction chamber 11 on one side and is formed with a discharge chamber 15 on the other side so as to partition the inside of the housing 2. In addition, a not shown discharge port which communicates the discharge chamber 15 with a refrigerating cycle is formed in an outer periphery of the rear case 9. Additionally, an oil sump 17 which stores an oil O for maintaining lubricity of the compression section 3 is formed under the discharge chamber 15.

[0022] The compression section 3 includes a compression block 19 that forms a cylinder chamber 33, an oil separator 21 fixed to the compression block 19, a rotor 23 that is rotatably stored in the cylinder chamber 33, a vane 25 (refer to Fig. 3) that protrudes and retracts from the rotor 23 to partition the cylinder chamber 33, and a drive shaft 27 that is fixed integrally with the rotor 23 to transmit the driving force thereto.

[0023] The compression block 19 is configured by a cylinder block 29, a pair of side blocks 31, and the cylinder chamber 33 formed on an inner periphery of the cylinder block 29.

[0024] As shown in Fig. 3, the cylinder block 29 has the distorted elliptical cylinder chamber 33 therein. An opening of this cylinder chamber 33 is closed by holding both ends of the cylinder block 29 by the pair of the side blocks 31.

[0025] As shown in Fig. 3 and Fig. 4, the rotor 23 is disposed such that one place is in contact with an inner wall of the cylinder chamber 33, is disposed with a position displaced from the center (the center of gravity) of the cylinder chamber 33 being set as the center of rotation, and is provided with a vane groove 75 that opens to an outer peripheral surface of the rotor 23, and a back pressure space 77 on the back surface side of the vane 25.

[0026] The cylinder chamber 33 is partitioned into a plurality of pieces in a rotation direction X of the rotor 23 by the plurality of vanes 25 that protrudes and retracts from the plurality of vane grooves 75 in the rotor 23.

Thereby, a plurality of compression chambers 33a, 33b and 33c is formed between an inner peripheral surface 33d of the cylinder chamber 33 and an outer peripheral surface 23a of the rotor 23.

[0027] In addition, the cylinder block 29 is provided with a suction slot 39 through which the refrigerant is sucked into the cylinder chamber 33, a discharge slot 35 through which the refrigerant having been compressed in the cylinder chamber 33 is discharged, an open/close valve 37 which opens/closes the discharge slot 35 and a cylinder-side oil supply path 41 which communicates with an oil supply path of the side block 31.

[0028] As shown in Fig. 1, the pair of the side blocks 31 are configured by a front-side block 31a and a rear-side block 31b and the oil separator 21 is fixed to the rear-side block 31b.

[0029] The front-side block 31a is provided with a front-side end surface 43 that abuts on the cylinder block 29, a not shown suction slot that communicates with the suction slot 39 and sucks the refrigerant from the suction chamber 11, a front-side bearing 47 that rotatably supports the drive shaft 27 and a front-side oil supply path 49 that communicates with the cylinder-side oil supply path 41.

[0030] The front-side end surface 43 is provided with a pressure supply groove, and the pressure supply groove includes an intermediate-pressure supply groove 51 that supplies, to the back pressure space 77, an intermediate pressure (a middle pressure) higher than that of the sucked refrigerant and lower than that of the discharged refrigerant and a high-pressure supply groove 53 that is provided at a position facing a high-pressure supply groove 69 on the rear-side block 31b side.

[0031] In addition, the front-side bearing 47 is formed with an annular front-side annular groove 55, which is provided in communication with the one-end side of the front-side oil supply path 49. Note that the other-end side of the front-side oil supply path 49 is in communication with the cylinder-side oil supply path 41.

[0032] As shown in Fig. 2, the rear-side block 31b includes a rear-side end surface 57 that abuts on the cylinder block 29, an oil supply hole 59 through which the oil O stored under the discharge chamber 15 is sucked, a rear-side bearing 63 that rotatably supports the drive shaft 27, and a rear-side oil supply path 59b that communicates with the cylinder-side oil supply path 41.

[0033] The rear-side end surface 57 includes a discharge hole 61 through which the refrigerant having been compressed in the cylinder chamber 33 is discharged, an intermediate-pressure supply groove 67 (corresponding to an intermediate-pressure supply section in the claims) which supplies, to the back pressure space 77, the oil of intermediate pressure higher than pressure (suction pressure) of the sucked refrigerant and lower than pressure (discharged pressure) of the discharged refrigerant, and the high-pressure supply groove 69 (corresponding to a high-pressure supply section in the claims) which supplies, to the back pressure space 77, the oil of high pressure that is the pressure (the discharge pressure) of the discharged refrigerant.

[0034] The high-pressure supply groove 69 is divided into mutually independent first supply section 69a (corresponding to an upstream-side supply section) and second supply section 69b (corresponding to a downstream-side supply section) in the rotation direction X of the rotor 23.

[0035] In addition, high-pressure supply paths 71a and 71b respectively open to the first supply section 69a and the second supply section 69b, and the respective high-pressure supply paths 71a and 71b are in communication with a rear-side annular groove 73 on their one-end sides and are in communication with the first supply section 69a and the second supply section 69b, respectively, on their other-end sides.

[0036] Note that the high-pressure supply groove 53 of the front-side block 31a facing the high-pressure supply groove 69 is also divided into two supply sections (not shown) which are similar to the first supply section 69a and the second supply section 69b.

[0037] The back pressure space 77 (refer to Fig. 3 and Fig. 4) formed in the rotor 23 communicates with the intermediate-pressure supply grooves 51 and 67 at a compression first-half position and communicates with the high-pressure supply grooves 53 and 69 at a compression later-half position, by rotation of the rotor 23.

[0038] In a state shown in Fig. 4, a back pressure space 77B of the vane groove 75 in a vane 25B which partitions the compression chamber 33b having moved from a suction process to a compression process and the compression chamber 33a that is positioned on the downstream side of the compression chamber 33b in the rotation direction X of the rotor 23 and has moved from the compression process to a discharged process by rotation of the rotor 23 terminates communication with the intermediate-pressure supply groove 67. Then, the back pressure space 77B is about to communicate with the first supply section 69a that is positioned on the upstream side of the rotation direction X of the rotor 23, from now on.

[0039] In this state, a back pressure space 77A of the vane groove 75 in a vane 25A that precedes the vane 25B in the downstream side of the vane 25B in the rotation direction X of the rotor 23 has already completed communication with the first supply section 69a and is in communication with the second supply section 69b positioned on the downstream side in the rotation direction X.

[0040] In addition, in the rotation direction X of the rotor 23, the first supply section 69a is formed into a shape in which the back pressure space 77A of the preceding vane 25A and the back pressure space 77B of the next vane 25B that follows the vane 25A do not communicate with the first supply section 69a simultaneously. Namely, in the rotation direction X of the rotor 23, the first supply section is formed such that an angle range in which the first supply section 69a extends becomes smaller than a difference between the angle at which the back pressure space 77A is positioned and the angle at which the back pressure space 77B is positioned. In short, a distance between the back pressure space 77A and the back pressure space 77B in the rotation direction X of the rotor 23 is set larger than a width of the first supply section 69a.

[0041] In a similar way, in the rotation direction X of the rotor 23, the second supply section 69b is formed into a shape in which the back pressure space 77A of the preceding vane 25A and the back pressure space 77B of the next vane 25B that follows the vane 25A do not communicate with the second supply section 69b simultaneously. Namely, in the rotation direction X of the rotor 23, the second supply section is formed such that an angle range in which the second supply section 69b extends becomes smaller than the difference between the angle at which the back pressure space 77A is positioned and the angle at which the back pressure space 77B is positioned. In short, the distance between the back pressure space 77A and the back pressure space 77B in the rotation direction X of the rotor 23 is set larger than a width of the second supply section 69b.

[0042] As described above, restrictions are caused on the angle range in which the first supply section 69a extends and the angle range in which the second supply section 69b extends, on the basis of the difference between the angle at which the back pressure space 77A is positioned and the angle at which the back pressure space 77B is positioned.

[0043] Similarly, restrictions are caused on the angle range in which the first supply section 69a extends and the angle range in which the second supply section 69b extends, on the basis of a difference between the angle at which the back pressure space 77B is positioned and an angle at which a back pressure space 77C is positioned.

[0044] Likewise, restrictions are caused on the angle range in which the first supply section 69a extends and the angle range in which the second supply section 69b extends, on the basis of a difference between the angle at which the back pressure space 77C is positioned and the angle at which the back pressure space 77A is positioned.

[0045] In this way, the shapes of the first supply section 69a and the second supply section 69b are determined on the basis of the angle at which the back pressure space 77 is positioned in the rotation direction X of the rotor 23.

[0046] Note that a distance between the intermediate-pressure supply groove 67 and the first supply section 69a and a distance between the second supply section 69b and the intermediate-pressure supply groove 67 in the rotation direction X of the rotor 23 are set larger than a width of the back pressure space 77 in the rotation direction X of the rotor 23.

[0047] As shown in Fig. 1, the oil supply hole 59 is formed in communication with a rear-side oil supply path 59a, and the rear-side oil supply path 59b is formed by branching from the rear-side oil supply path 59a. The rear-side oil supply path 59b is in communication with the cylinder-side oil supply path 41.

[0048] The rear-side bearing 63 is formed with the annular rear-side annular groove 73, which is in communication with a rear-side communication path 65. The rear-side communication path 65 is in communication with the rear-side annular groove 73 on its one-end side and opens to the high-pressure supply groove 69 on its other-end side.

[0049] The oil separator 21 is fixed to the rear-side block 31b, the refrigerant having been compressed in the cylinder chamber 33 flows into the oil separator 21, and the refrigerant and the oil O are separated from each other therein.

[0050] The drive shaft 27 is fixed to the rotor 23 on its one side and is rotatably supported by the bearings 47 and 63 of the respective side blocks 31a and 31b. In addition, the motor section 4 is fixed to the other side of the drive shaft 27.

[0051] The motor section 4 includes a stator 79 fixed to the inner wall 13 of the rear case 9 and a motor rotor 81 that is rotatably disposed on the inner periphery side of the stator 79 and rotates by a magnetic force. The motor rotor 81 transmits a rotational drive force to the compression section 3, due to the rotation by the magnetic force.

[0052] Here, there will be described an interval between the first supply section 69a and the second supply section 69b of the high-pressure supply groove 69 in the rotation direction X of the rotor 23.

[0053] In the present embodiment, as shown in Fig. 3 and Fig. 4, the distance between the first supply section 69a and the second supply section 69b in the rotation direction X of the rotor 23 is set narrower than the width of the back pressure space 77 in the rotation direction X of the rotor 23.

[0054] Here, as shown in Fig. 5, it is assumed that the interval between the first supply section 69a and the second supply section 69b of the high-pressure supply groove 69 in the rotation direction X of the rotor 23 is wider than the width of the back pressure space 77. Fig. 5 is an explanatory diagram showing a virtual example of a case where the first supply section and the second supply section of the high-pressure supply groove in Fig. 3 are separately disposed at an interval at which the back pressure space of the vane groove does not communicate with any of them.

[0055] Fig. 6 is a graph showing changes in a pressure P33a in the compression chamber 33a, a pressure P33b in the compression chamber 33b and a pressure P77B of the back pressure space 77B, in accordance with a rotation angle of the rotor. As shown in Fig. 6, at an angle of 180 degrees, the back pressure space 77B having completed communication with the intermediate-pressure supply groove 67 communicates with the high-pressure supply groove 69. In the present embodiment, the high-pressure supply groove 69 is constituted by the first supply section 69a and the second supply section 69b, and the back pressure space 77B communicates with the first supply section 69a and thereafter communicates with the second supply section 69b, along with rotation of the rotor 23 that rotates in the rotation direction X.

[0056] Since the interval between the first supply section 69a and the second supply section 69b of the high-pressure supply groove 69 in the rotation direction X of the rotor 23 is larger than the width of the back pressure space 77B, there is generated a state where the back pressure space 77B does not communicate with any of the first supply section 69a and the second supply section 69b when a communication destination of the back pressure space 77B shifts from the first supply section 69a to the second supply section 69b.

[0057] At this time, the vane 25B stored in the vane groove 75, the back pressure space 77B of which is positioned between the first supply section 69a and the second supply section 69b, receives force acting in a direction of intruding into the vane groove 75 from the inner peripheral surface 33d of the cylinder chamber 33 since the compression chambers 33a and 33b partitioned by the vane 25B stay from the later stage of the compression process to the discharged process. Namely, when the back pressure space 77B is positioned between the first supply section 69a and the second supply section 69b, the volume of the back pressure space 77B is in a state of being reduced.

[0058] However, since the back pressure space 77B does not communicate with any of the first supply section 69a and the second supply section 69b at this position, it is not possible to release the high pressure of the amount corresponding to the reduced volume of the back pressure space 77B to any place other than the back pressure space 77B. Accordingly, in the middle stage of shifting the communication destination of the back pressure space 77B from the first supply section 69a to the second supply section 69b, the pressure in the back pressure space 77 temporarily rises as shown by P1 in Fig. 6. Namely, since there is generated a state where the back pressure space 77B is not in a communication state with any of the first supply section 69a and the second supply section 69b, the pressure in the back pressure space 77 temporarily rises as shown by P1 in Fig. 6.

[0059] When such a pressure rise in the back pressure space 77B is generated, the vane 25B which is receiving force of the direction of intruding into the vane groove 75 from the inner peripheral surface 33d of the cylinder chamber 33 attempts to project from the vane groove 75 by the risen pressure in the back pressure space 77B. Then, there is a possibility that pressing force of the vane 25B against the inner peripheral surface 33d of the cylinder chamber 33 may be increased more than necessary and the sliding resistance between the vane 25B and the inner peripheral surface 33d of the cylinder chamber 33 may be increased.

[0060] The similar phenomenon to the above can be generated in a state where the vane 25A and a vane 25C are not in communication with any of the first supply section 69a and the second supply section 69b.

[0061] Accordingly, in the gas compressor 1 of the present embodiment, as shown in Fig. 7, when the communication destination of the back pressure space 77 is shifted from the first supply section 69a to the second supply section 69b, there is ensured, by a fixed amount or more, a cross-sectional area obtained by summing up a communication cross-sectional area S1 between the back pressure space 77 and the first supply section 69a and a communication cross-sectional area S3 between the back pressure space 77 and the second supply section 69b.

[0062] Specifically, when the back pressure space 77 is in communication with the first supply section 69a and the second supply section 69b, it is possible to release the high pressure in the back pressure space 77 to the high-pressure supply paths 71a and 71b through which the high pressure oil O is supplied to the first supply section 69a and the second supply section 69b, and the rear-side communication path 65 continued to the high-pressure supply paths 71a and 71b, the rear-side annular groove 73, the rear-side oil supply path 59a, and the oil supply hole 59.

[0063] In order to ensure a high-pressure release route which is equal to or better than the above, in the gas compressor 1 of the present embodiment, an interval at which the total of the above-mentioned communication cross-sectional areas S1 and S3 becomes at least a minimum path cross-sectional area in a high-pressure oil O supply route for the first supply section 69a and the second supply section 69b, from the high-pressure supply paths 71a and 71b down to the oil supply hole 59, is provided between the first supply section 69a and the second supply section 69b in the rotation direction X of the rotor 23.

[0064] Next, an operation of the gas compressor 1 according to the present embodiment will be described.

[0065] First, an electric current flows through a coil having been wound on the stator 79 of the motor section 4 by control of the inverter section 5 shown in Fig. 1. Magnetic force is generated by electric current flowing through the coil, and the motor rotor 81 disposed on the inner periphery of the stator 79 rotates.

[0066] The drive shaft 27 on the one-end side of which the motor rotor 81 is fixed rotates by rotation of the motor rotor 81, and also the rotor 23 which is fixed on the other-end side of the drive shaft 27 rotates.

[0067] The refrigerant flows into the suction chamber 11 together with rotation of the rotor 23, and the refrigerant is sucked into the cylinder chamber 33 from the suction chamber 11 via a suction slot (not shown) of the front-side block 31a (the suction process). The refrigerant having been sucked into the cylinder chamber 33 enters the compression chambers 33a, 33b and 33c formed in the cylinder chamber 33 by the plurality of vanes 25, and thereby the refrigerant in the compression chambers 33a, 33b and 33c is compressed by rotation of the rotor 23 (the compression process).

[0068] The refrigerant having been compressed in the cylinder chamber 33 pushes the open/close valve 37 open, and is discharged from the discharge slot 35 (the discharged process) and is discharged from the discharge hole 61 into the discharge chamber 15 via the oil separator 21. In addition, the refrigerant having been discharged from the discharge hole 61 is separated into the refrigerant and the oil O by the oil separator 21, the refrigerant is discharged from a not shown discharge port to the not shown refrigerating cycle, and the oil O is stored under the discharge chamber 15.

[0069] The oil having been stored under the discharge chamber 15 is supplied from the oil supply hole 59 in the rear-side block 31b to the rear-side bearing 63 through the rear-side oil supply path 59a.

[0070] The high-pressure oil having been supplied to the rear-side bearing 63 is reduced to intermediate pressure higher than the pressure (the suction pressure) of the sucked refrigerant and lower than the pressure (the discharged pressure) of the discharged refrigerant, by being squeezed between the rear-side bearing 63 and the drive shaft 27, and the oil O having been reduced to the intermediate pressure is supplied to the intermediate-pressure supply groove 67 through a gap between the drive shaft 27 and the rear-side block 31b.

[0071] The intermediate pressure oil O having been supplied to the intermediate-pressure supply groove 67 supplies the intermediate pressure to the back pressure space 77 and supplies the intermediate pressure to the back surface of the vane 25 such that the vane 25 projects from the vane groove 75, over a range from the refrigerant suction process to the compression process as shown in Fig. 3.

[0072] In addition, the high-pressure oil O having been supplied to the rear-side bearing 63 is supplied from the high-pressure supply paths 71a and 71b opening to the rear-side end surface 57 to the first supply section 69a and the second supply section 69b of the high-pressure supply groove 69, via the rear-side communication path 65.

[0073] The high-pressure oil O having been supplied to the first supply section 69a and the second supply section 69b supplies the high pressure to the back pressure space 77 and supplies the high pressure to the back surface of the vane 25 such that the vane 25 projects from the vane groove 75, over a range from the refrigerant compression process to the discharged process as shown in Fig. 3. In addition, the first supply section 69a and the second supply section 69b communicate with the not shown respective corresponding supply sections of the high-pressure supply groove 53 on the front-side block 31a side via the back pressure space 77, and the high pressure is also supplied from each of the supply sections of the high-pressure supply groove 53 to the back pressure space 77.

[0074] Furthermore, the high-pressure oil O flows into the rear-side oil supply path 59a from the oil supply hole 59, passes through the rear-side oil supply path 59b by being branched from the rear-side oil supply path 59a, and is supplied from the front-side oil supply path 49 to the front-side bearing 47 via the cylinder-side oil supply path 41.

[0075] The high-pressure oil O having been supplied to the front-side bearing 47 has intermediate pressure by being squeezed between the front-side bearing 47 and the drive shaft 27, and the oil O having been reduced to the intermediate pressure is supplied to the intermediate-pressure supply groove 51 through the gap between the drive shaft 27 and the front-side block 31 a.

[0076] The high-pressure oil O having been supplied from the high-pressure supply grooves 53 and 69 of the front-side block 31a and the rear-side block 31b is supplied to the back pressure space 77 of the rotor 23 at a rotation latter-half position of the rotor 23 to impart the back pressure for making the vane 25 project from the vane groove 75.

[0077] According to the gas compressor 1 of the present embodiment, the back pressure space 77 of the vane groove 75 having completed communication with the intermediate-pressure supply groove 67 communicates with the first supply section 69a of the high-pressure supply groove 69, and the high pressure is supplied from the first supply section 69a thereto.

[0078] Thereafter, this back pressure space 77 completes communication with the first supply section 69a before the back pressure space 77 of the next vane groove 75 that is positioned on the upstream side of the rotation direction X communicates with the first supply section 69a and communicates with the second supply section 69b that is independent of the first supply section 69a and is positioned on the downstream side of the rotation direction X, and thus the high pressure is again supplied to the back pressure space.

[0079] Accordingly, at a time point when the back pressure space 77 having completed communication with the intermediate-pressure supply groove 67 communicates with the first supply section 69a of the high-pressure supply groove 69, the preceding back pressure space 77 adjacent to the back pressure space 77 on the downstream side in the rotation direction X does not communicate with the first supply section 69a simultaneously.

[0080] In Fig. 4, there is shown a situation in which the back pressure space 77A completes communication with the first supply section 69a before the back pressure space 77B of the next vane groove 75 that is positioned on the upstream side in the rotation direction X communicates with the first supply section 69a and communicates with the second supply section 69b that is independent of the first supply section 69a and is positioned on the downstream side in the rotation direction X, and thus the high pressure is again supplied to the back pressure space 77A.

[0081] Accordingly, the preceding back pressure space 77A adjacent to the back pressure space 77B on the downstream side in the rotation direction X does not communicate with the first supply section 69a simultaneously at a time point when the back pressure space

77B communicates with the first supply section 69a of the high-pressure supply groove 69. The similar relation is established not only between the back pressure space 77A and the back pressure space 77B, but also between the back pressure space 77B and the back pressure space 77C, and between the back pressure space 77C and the backpressure space 77A.

[0082] It is possible to prevent the pressure in the preceding back pressure space 77 from being temporarily lowered from the high pressure by the intermediate pressure before the following next back pressure space 77 rises to the high pressure, by allowing the two back pressure spaces 77 not to communicate with the first supply section 69a simultaneously. Accordingly, it is possible to prevent the occurrence of chattering in which the vane 25 repeats contact with and separation from the inner peripheral surface 33d of the cylinder chamber 33, by a temporary reduction of pressure in the back pressure space 77 of the vane 25 in the early stage of the compression process.

[0083] Furthermore, the back pressure space 77 completes communication with the second supply section 69b before the back pressure space 77 of the next vane groove 75 which is positioned on the upstream side in the rotation direction X communicates with the second supply section 69b. Accordingly, at a time point when the back pressure space 77 having completed communication with the first supply section 69a of the high-pressure supply groove 69 communicates with the second supply section 69b of the high-pressure supply groove 69, the preceding back pressure space 77 adjacent to the downstream side of the back pressure space 77 in the rotation direction X does not communicate with the second supply section 69b simultaneously.

[0084] Fig. 8 is a graph showing changes in the pressure P33a of the compression chamber 33a, the pressure P33b of the compression chamber 33b and the pressure P77B of the back pressure space 77B in accordance with the rotation angle of the rotor. As shown in Fig. 8, at the angle of 180 degrees, the back pressure space 77B having completed communication with the intermediate-pressure supply groove 67 communicates with the high-pressure supply groove 69. In the present embodiment, the high-pressure supply groove 69 is constituted by the first supply section 69a and the second supply section 69b and the back pressure space 77B communicates with the first supply section 69a and thereafter communicates with the second supply section 69b, along with rotation of the rotor 23 that rotates in the rotation direction X.

[0085] As shown by P in the graph in Fig. 17, there occurred a phenomenon in which the pressure in the preceding back pressure space 107 is temporarily lowered from the high pressure, by a pressure which is in the middle of rising from the intermediate pressure of the following next back pressure space 107 to the high pressure. However, it is possible to prevent occurrence of the phenomenon as shown in the graph in Fig. 8 by making the two back pressure spaces 77 not simultaneously communicate with the second supply section 69b. Accordingly, it is possible to prevent the occurrence of chattering in which the vane 25 repeats contact with and separation from the inner peripheral surface 33d of the cylinder chamber 33 by a temporary reduction of pressure in the back pressure space 77 of the vane 25 in the later stage of the compression process and in the discharged process.

[0086] Furthermore, according to the gas compressor 1 of the present embodiment, the total of the communication cross-sectional areas S1 and S3 of the back pressure space 77 with the first supply section 69a and the second supply section 69b when the communication destination of the back pressure space 77 shifts from the first supply section 69a to the second supply section 69b is set to be a minimum path cross-sectional area or more of the supply route of the high-pressure oil O to the first supply section 69a and the second supply section 69b.

[0087] In the middle stage of shifting the communication destination of the back pressure space 77 from the first supply section 69a to the second supply section 69b, the back pressure space 77 communicates, in the minimum path cross-sectional area or more, with at least one of the first supply section 69a or the second supply section 69b, and thus there can be ensured a destination to which the high pressure in the back pressure space 77 is released.

[0088] Accordingly, it is possible to prevent, as shown in the graph in Fig. 8 by the above-mentioned configuration, such a phenomenon as indicated by P1 in the graph in Fig. 6, namely, the phenomenon in which, in shifting the communication destination of the back pressure space 77 from the first supply section 69a to the second supply section 69b, the pressure in the back pressure space 77 temporarily rises by a shortage of the cross-sectional area of a route along which the high pressure in the back pressure space 77 is released.

[0089] Thereby, there is prevented a phenomenon in which the pressing force of the vane 25 against the inner peripheral surface 33d of the cylinder chamber 33 is increased more than necessary by a temporary pressure increase in the back pressure space 77 and thus the sliding resistance between the both is incresed. Therefore, it is possible to prevent increase in the sliding resistance of the vane 25 to the inner peripheral surface 33d of the cylinder chamber 33 due to increase in the power required for rotation of the rotor 23 by the temporary pressure increase in the back pressure space 77 in the later stage of the compression process and in the discharged process, thereby being able to maintain the operating performance as the gas compressor 1.

[0090] Note that it is desirable that the second supply section 69b of the high-pressure supply groove 69 be formed into a shape of the largest possible size in the rotation direction X within a range in which the two back pressure spaces 77 mutually adjacent in the rotation direction X of the rotor 23 do not simultaneously communicate with each other. Consequently, it is possible to allow the back pressure space 77 in which pressure has been increased from the intermediate pressure toward the high pressure due to communication with the first supply section 69a to communicate with the second supply section 69b from an earlier stage of the compression process of the compression chambers 33a, 33b and 33c, and thereafter to stabilize the pressure in the back pressure space 77 to the high pressure.

[0091] Accordingly, it is possible to start the discharged process of the compression chambers 33a, 33b and 33c at an earlier stage, the open/close valve 37 of the discharge slot 35 is opened at an earlier stage and the high-pressure refrigerant in the compression chambers 33a, 33b and 33c is efficiently and sufficiently discharged, and thereby it is possible to achieve enhancement of refrigerant compression efficiency.

[0092] In the present embodiment, it was assumed that the high-pressure supply groove 69 is divided into the two mutually independent first supply section 69a and second supply section 69b in the rotation direction X. However, the present invention is applicable also in a case where the high-pressure supply groove 69 is divided into three or more supply sections in the rotation direction X. In that case, the relation of the present invention is applied to the communication cross-sectional area of an upstream-side supply section or a downstream-side supply section with the back pressure space 77 when the back pressure space 77 moves striding over the two adjacent supply sections in the rotation direction X.

[Second Embodiment]

[0093] Next, the second embodiment of the present invention will be described with reference to Fig. 9 to Fig. 15.

[0094] Fig. 9 and Fig. 10 show a structure of a vane rotary-type gas compressor according to the second embodiment. The gas compressor of the second embodiment has a rear-side block 31b2 different from the rear-side block 31b of the first embodiment. Configurations other than the rear-side block 31b2 are the configurations that are similar to those of the first embodiment. The same symbols are attached to the same constituent points as those in the first embodiment, a description thereof is omitted and only different configurations will be described.

[0095] In the present embodiment, an interval 69c having a size that is not less than that of the back pressure space 77 of the vane groove 75 is provided between the first supply section 69a and the second supply section 69b in the rotation direction X of the rotor 23. Namely, the interval 69c provided between the first supply section 69a and the second supply section 69b is set larger than the width of the back pressure space 77 of the vane groove 75.

[0096] In a state shown in Fig. 11, the back pressure space 77B of the vane groove 75 in the vane 25B which partitions the compression chamber 33b having moved from the suction process to the compression process by rotation of the rotor 23 and the compression chamber 33a which is positioned on the downstream side of the compression chamber 33b in the rotation direction X of the rotor 23 and which has moved from the compression process to the discharged process communicates with the first supply section 69a of the high-pressure supply groove 69.

[0097] In this state, the back pressure space 77A of the vane groove 75 in the vane 25A that precedes the vane 25B in the downstream side of the vane 25B in the rotation direction X of the rotor 23 has already completed communication with the second supply section 69b and starts to communicate with the intermediate-pressure supply section 67 that is positioned on the downstream side of the rotation direction X.

[0098] Here, there will be described the position of the interval 69c between the first supply section 69a and the second supply section 69b of the high-pressure supply groove 69 in the rotation direction X of the rotor 23. When the rotor 23 rotates in the rotation direction X after the state shown in Fig. 11, the back pressure space 77B completes communication with the first supply section 69a and the back pressure space 77B communicates with the interval 69c provided between the first supply section 69a and the second supply section 69b. At this time, there is generated a state where the back pressure space 77B is not in communication with any of the first supply section 69a and the second supply section 69b.

[0099] In this state, when the projection stroke of the vane 25B relative to the vane groove 75 is reduced along with rotation of the rotor 23 in the rotation direction X, the volume of the back pressure space 77B is reduced. At this time, since the back pressure space 77B is not in communication with any of the first supply section 69a and the second supply section 69b, it is not possible to release the high pressure of the amount corresponding to the reduced volume to them.

[0100] Accordingly, there is assumed a case where, when the vane 25B is in sliding contact with a region indicated by a range (A) in Fig. 12 on the inner peripheral surface 33d of the cylinder chamber 33, namely, the region in which the projection stroke of the vane 25B relative to the vane groove 75 is reduced at a rate equal to or more than a constant level along with rotation of the rotor 23 in the rotation direction X, the interval 69c is disposed at a position whit which the back pressure space 77B communicates.

[0101] Fig. 12 is an explanatory diagram showing a positional relation between the region in which the projection stroke of the vane 25B relative to the vane groove 75 is reduced at a rate equal to or more than a constant level and the interval 69c.

[0102] In this case, the volume of the back pressure space 77B is reduced at a rate in accordance with a reduction rate of the projection stroke of the vane 25B in a state where the back pressure space 77B is isolated from the first supply section 69a and the second supply section 69b, and the pressure in the back pressure space 77B temporarily rises as indicated by P1 in Fig. 13.

[0103] In a case where such a pressure rise of the back pressure space 77B is generated, the vane 25B which receives force acting in a direction of intruding into the vane groove 75 from the inner peripheral surface 33d of the cylinder chamber 33 attempts to project from the vane groove 75 by the risen pressure in the back pressure space 77B. Then, there is a possibility that the pressing force of the vane 25B against the inner peripheral surface 33d of the cylinder chamber 33 may be increased more than necessary and the sliding resistance between the vane 25B and the inner peripheral surface 33d of the cylinder chamber 33 may be increased.

[0104] Accordingly, it is configured such that a region in which the reduction rate of the projection stroke of the vane 25 relative to the vane groove 75 along with rotation of the rotor 23 in the rotation direction X on the inner peripheral surface 33d of the cylinder chamber 33 becomes a reduction rate not more than a predetermined threshold value which is lower than the above-mentioned constant rate is set as a region in which the reduction rate of the projection stroke is small, and the interval 69c is disposed so that the back pressure space 77 communicates with the interval 69c when the vane 25 comes into sliding contact with the region in which the reduction rate of the projection stroke concerned is small in the gas compressor 1 of the present embodiment.

[0105] Specifically, in the present embodiment, the inner peripheral surface 33d of the cylinder chamber 33 is, as shown in Fig. 14, formed so that four regions of:

(a) a region in which the projection stroke of the vane 25 that is in sliding contact with the inner peripheral surface 33d of the cylinder chamber 33 from the vane groove 75 is increased along with rotation of the rotor 23 in the rotation direction X;
(b) a region in which the projection stroke of the vane 25 that is in sliding contact with the inner peripheral surface 33d of the cylinder chamber 33 from the vane groove 75 is decreased along with rotation of the rotor 23 in the rotation direction X;
(c) a region in which the projection stroke of the vane 25 that is in sliding contact with the inner peripheral surface 33d of the cylinder chamber 33 from the vane groove 75 is decreased along with rotation of the rotor 23 in the rotation direction X and in which a reduction rate thereof is smaller than that in the region in (b); and
(d) a region in which the projection stroke of the vane 25 that is in sliding contact with the inner peripheral surface 33d of the cylinder chamber 33 from the vane groove 75 is decreased along with rotation of the rotor 23 in the rotation direction X and in which a reduction rate thereof is larger than that in the region in (c) and is smaller than that in the region in (b)

are sequentially successive in the rotation direction X of the rotor 23.

[0106] Accordingly, the interval 69c is disposed at a position where the back pressure space 77 communicates with the interval when the vane 25 is in sliding contact with the region (c) in which the reduction rate of the projection stroke of the vane 25 along with rotation of the rotor 23 in the rotation direction X is the smallest.

[0107] Next, an operation of the gas compressor 1 according to the present embodiment will be described.

[0108] Also in the present embodiment, at a time point when the back pressure space 77 having completed communication with the intermediate-pressure supply groove 67 communicates with the first supply section 69a of the high-pressure supply groove 69, the preceding back pressure space 77 adjacent to the back pressure space 77 on the downstream side in the rotation direction X does not communicate with the first supply section 69a simultaneously.

[0109] Accordingly, at a time point when the back pressure space 77 having completed communication with the intermediate-pressure supply groove 67 communicates with the first supply section 69a of the high-pressure supply groove 69, the preceding back pressure space 77 adjacent to the back pressure space 77 on the downstream side in the rotation direction X does not communicate with the first supply section 69a simultaneously.

[0110] It is possible to prevent the pressure in the preceding back pressure space 77 from being temporarily lowered from the high pressure by the intermediate pressure before the following next back pressure space 77 rises to the high pressure, by allowing the two back pressure spaces 77 not to communicate with the first supply section 69a simultaneously. Accordingly, it is possible to prevent the occurrence of chattering in which the vane 25 repeats contact with and separation from the inner peripheral surface 33d of the cylinder chamber 33, by a temporary reduction of pressure in the back pressure space 77 of the vane 25 in the early stage of the compression process.

[0111] Furthermore, the back pressure space 77 completes communication with the second supply section 69b before the back pressure space 77 of the next vane groove 75 which is positioned on the upstream side in the rotation direction X communicates with the second supply section 69b. Accordingly, at a time point when the back pressure space 77 having completed communication with the first supply section 69a of the high-pressure supply groove 69 communicates with the second supply section 69b of the high-pressure supply groove 69, the preceding back pressure space 77 adjacent to the downstream side of the back pressure space 77 in the rotation direction X does not communicate with the second supply section 69b simultaneously.

[0112] Accordingly, as shown in the graph in Fig. 15, it is possible to prevent the occurrence of chattering in which the vane 25 repeats contact with and separation from the inner peripheral surface 33d of the cylinder chamber 33 by a temporary reduction of pressure in the back pressure space 77 of the vane 25 in the later stage of the compression process and in the discharged process.

[0113] Furthermore, according to the gas compressor 1 of the present embodiment, the interval 69c between the first supply section 69a and the second supply section 69b is positioned such that, when the back pressure space 77 communicates with the interval 69c between the first supply section 69a and the second supply section 69b, the vane 25 stored in the vane groove 75 of the back pressure space 77 comes into sliding contact with the region (c) in which the reduction rate of the projection stroke of the vane 25 along with rotation of the rotor 23 in the rotation direction X is the smallest.

[0114] Accordingly, when the back pressure space 77 communicates with the interval 69c between the first supply section 69a and the second supply section 69b, the projection stroke of the vane 25 is hardly reduced as shown by a part surrounded by a round frame in Fig. 15 and also the volume of the back pressure space 77 is hardly reduced. Therefore, as shown in Fig. 15, a temporary pressure increase in the back pressure space 77 is not generated when the back pressure space 77 communicates with the interval 69c.

[0115] Consequently, as indicated by P1 in the graph in Fig. 13, when the communication destination of the back pressure space 77 becomes the interval 69c between the first supply section 69a and the second supply section 69b, it is possible to prevent, as shown in the graph in Fig. 15, a phenomenon in which the releasing route for the high pressure in the back pressure space 77 is eliminated and the pressure in the back pressure space 77 temporarily rises.

[0116] Thereby, there is prevented a phenomenon in which the pressing force of the vane 25 against the inner peripheral surface 33d of the cylinder chamber 33 is increased more than necessary by a temporary pressure increase in the back pressure space 77 and thus the sliding resistance between the both is incresed. Therefore, it is possible to prevent increase in the sliding resistance of the vane 25 to the inner peripheral surface 33d of the cylinder chamber 33 due to increase in the power required for rotation of the rotor 23 by the temporary pressure increase in the back pressure space 77 in the later stage of the compression process and in the discharged process, thereby being able to maintain the operating performance as the gas compressor 1.

[0117] Note that it is desirable that the second supply section 69b of the high-pressure supply groove 69 be formed into a shape of the largest possible size in the rotation direction X within a range in which the two back pressure spaces 77 mutually adjacent in the rotation direction X of the rotor 23 do not simultaneously communicate with each other. Consequently, it is possible to allow the back pressure space 77 in which pressure has been increased from the intermediate pressure toward the high pressure due to communication with the first supply section 69a to communicate with the second supply section 69b from an earlier stage of the compression process of the compression chambers 33a, 33b and 33c, and thereafter to stabilize the pressure in the back pressure space 77 to the high pressure.

[0118] Accordingly, it is possible to start the discharged process of the compression chambers 33a, 33b and 33c at an earlier stage, the open/close valve 37 of the discharge slot 35 is opened at an earlier stage and the high-pressure refrigerant in the compression chambers 33a, 33b and 33c is efficiently and sufficiently discharged, and thereby it is possible to achieve enhancement of refrigerant compression efficiency.

[0119] Note that, although, in the present embodiment, the interval 69c provided between the first supply section 69a and the second supply section 69b is set larger than the width of the back pressure space 77 of the vane groove 75, the interval 69c may have a size smaller than that of the back pressure space 77 in the rotation direction X of the rotor 23. In this case, when the back pressure space 77 strides over the interval 69c in shifting the communication destination of the back pressure space 77 from the first supply section 69a to the second supply section 69b of the high-pressure supply section 69, the communication cross-sectional area of the back pressure space 77 for each of the supply sections 69a and 69b is reduced by an amount of overlapping the interval 69c.

[0120] Since the communication cross-sectional area is reduced, when the vane 25 intrudes into the back pressure space 77 side of the vane groove 75 along with rotation of the rotor 23 and the volume of the back pressure space 77 is reduced, efficiency of releasing the high pressure in the back pressure space 77 to the first supply section 69a and the second supply section 69b is reduced by the amount of the reduced volume. Then, there is a possibility that the pressure in the back pressure space 77 may temporarily rise in the later stage of the compression process and in the discharged process, the pressing force of the vane 25 against the inner peripheral surface 33d of the cylinder chamber 33 may be increased more than necessary and the sliding resistance between the vane 25 and the inner peripheral surface 33d of the cylinder chamber 33 may be increased.

[0121] However, the interval 69c is disposed at a position where the back pressure space 77 communicates with the interval 69c when the vane 25 is in sliding contact with the region (c) in which the reduction rate of the projection stroke of the vane 25 along with rotation of the rotor 23 in the rotation direction X is the smallest. Therefore, there can be prevented a temporary rise in the pressure in the back pressure space 77 by reduction in the releasing efficiency of the high pressure in the back pressure space 77. Accordingly, it is possible to prevent a phenomenon in which the sliding resistance of the vane 25 to the inner peripheral surface 33d of the cylinder chamber 33 is increased by the temporary pressure increase in the back pressure space 77 in the later stage of the compression process and in the discharged process and thus the power required for rotation of the rotor 23 is incresed, thereby being able to maintain the operating performance as the gas compressor 1.

[0122] Note that, in the present embodiment, a region of the inner peripheral surface 33d of the cylinder chamber 33 with which the vane 25 comes into sliding contact when the back pressure space 77 communicates with the interval 69c was determined by the use of the reduction rate of the projection stroke of the vane 25 to the vane groove 75 as a standard. In the determination, an upper limit value of an allowable range of the reduction rate of the projection stroke of the vane 25 to the vane groove 75 is determined in accordance with an allowable range for a temporary increase in pressure in the back pressure space 77.

[0123] Then, the determined upper limit value is set as a predetermined threshold value, and there is determined a region in which the reduction rate of the projection stroke of the vane 25 on the inner peripheral surface 33d of the cylinder chamber 33 becomes not more than this threshold value. The interval 69c may be disposed such that, when the vane 25 comes into sliding contact with the thus determined region on the inner peripheral surface 33d of the cylinder chamber 33, the back pressure space 77 communicates with the interval 69c.

[0124] By making the determination in this way, it is possible to maintain the temporary pressure increase of the back pressure space 77 by a reduction in projection stroke of the vane 25 within the allowable range during a period when the back pressure space 77 is in communication with the interval 69c between the first supply section 69a and the second supply section 69b. Accordingly, it is possible to prevent increase in the sliding resistance of the vane 25 to the inner peripheral surface 33d of the cylinder chamber 33 due to increase in the power required for rotation of the rotor 23 by the temporary pressure increase in the back pressure space 77 in the later stage of the compression process and in the discharged process, thereby being able to maintain the operating performance as the gas compressor 1.

[0125] In the present embodiment, it has been made such that the high-pressure supply groove 69 is divided into the two mutually independent first supply section 69a and second supply section 69b in the rotation direction X. However, the present invention is applicable also in a case where the high-pressure supply groove 69 is divided into three or more supply sections in the rotation direction X. In that case, the relation of the present invention is applied to a relative position of the interval between the two supply sections adjacent to each other in the rotation direction X and the inner peripheral surface of the cylinder chamber.

[Other Embodiments]

[0126] In the above-mentioned plurality of embodiments, the second supply section 69b of the high-pressure supply groove 69 was set to have a size at which the two back pressure spaces 77 adjacent to each other in the rotation direction X of the rotor 23 do not communicate with each other simultaneously. For example, the second supply section 69b may have a space of a size larger than the size of the first supply section 69a in the rotation direction X. Consequently, it is possible to allow the back pressure space 77 in which pressure has been increased from the intermediate pressure toward the high pressure due to communication with the first supply section 69a to communicate with the second supply section 69b from an earlier stage of the compression process of the compression chambers 33a, 33b and 33c, and thereafter to stabilize the pressure in the back pressure space 77 to the high pressure.

[0127] Accordingly, it is possible to start the discharged process of the compression chambers 33a, 33b and 33c at an earlier stage, the open/close valve 37 of the discharge slot 35 is opened at an earlier stage and the high-pressure refrigerant in the compression chambers 33a, 33b and 33c is efficiently and sufficiently discharged, and thereby it is possible to achieve enhancement of refrigerant compression efficiency.

[0128] In addition, in the above-mentioned plurality of embodiments, a description has been made by taking, by way of example, a case of dividing the high-pressure supply groove 69 into two of the first supply section 69a and the second supply section 69b in the rotation direction X in order to prevent the back pressure space 77 of the vane 25 from communicating with the same supply section as that of the back pressure space 77 of the upstream-side vane 25 by way of example. However, the present invention is also widely applicable to a case where the high-pressure supply groove 69 is divided into three or more supply sections in the rotation direction X.

[0129] In that case, it is possible to obtain the similar effects to those of the above-mentioned plurality of embodiments by forming, among the three or more supply sections, one supply section that communicates with the back pressure space 77 that is in a state where the pressure in the back pressure space 77 is in the middle of rising from the intermediate pressure to the high pressure, into a shape in which the two back pressure spaces 77 adjacent to each other in the rotation direction X do not communicate with each other simultaneously.

[0130] Namely, the supply section positioned second from the most upstream side of the rotation direction X becomes at least an object to be formed into a shape in which the two back pressure spaces 77 adjacent to each other in the rotation direction X do not communicate with each other simultaneously. In addition, also each of the third and subsequent supply sections from the most upstream side becomes the object to be formed into a shape in which the two back pressure spaces 77 adjacent to each other in the rotation direction X do not communicate with each other simultaneously, in a case of communicating with the back pressure space 77 when the pressure of the back pressure space 77 is in the middle of rising from the intermediate pressure to the high pressure.

[0131] The above embodiments of the present invention are merely illustrative ones which have been described for facilitating understanding of the present invention and the present invention is not limited to the embodiments concerned. The technical scope of the present invention includes, not limited to specific technical matters disclosed in the above-mentioned embodiments, various modifications, changes, alternative technologies and the like, which can be easily derived therefrom.

[0132] The present application claims the priority based on Japanese Patent Application No. 2014-260491 filed on December 24, 2014, based on Japanese Patent Application No. 2014-260492 filed on December 24, 2014 and based on Japanese Patent Application No. 2014-260500 filed on December 24, 2014, the entire contents of which are incorporated herein by reference.

INDUSTRIAL APPLICABILITY

[0133] According to the present invention, the back pressure space of the vane groove having completed communication with the intermediate-pressure supply section communicates with the first supply section of the high-pressure supply section until the refrigerant pressure in each of the compression chambers having been partitioned by the vane stored in the vane groove reaches the highest pressure, and then the high pressure is supplied from the first supply section. Thereafter, this back pressure space completes communication with the first supply section before the back pressure space of the next vane groove on the upstream side of the rotation direction communicates with the first supply section, and then communicates with the next second supply section that is independent of the first supply section and subsequently the high pressure is again supplied thereto.

[0134] Accordingly, at a time point when the back pressure space having completed communication with the intermediate-pressure supply section communicates with the first supply section of the high-pressure supply section, the preceding back pressure space which is adjacent to the back pressure space on the downstream side in the rotation direction does not communicate with the first supply section simultaneously. Consequently, the pressure in the preceding back pressure space is prevented from being temporarily lowered from the high pressure by the intermediate pressure of the following next back pressure space and the occurrence of chattering of the vane by a temporary reduction in pressure in the back pressure space of the vane can be prevented.

REFERENCE SIGNS LIST

[0135]

1 gas compressor
2 housing
3 compression section
4 motor section
5 inverter section
7 front head
9 rear case
11 suction chamber
13 inner wall
15, 108 discharge chamber
19 compression block
21 oil separator
23, 102 rotor
23a outer peripheral surface
25 (25A, 25B, 25C), 103 vane
27 drive shaft
29, 100 cylinder block
31, 101 side block
31a front-side block
31b rear-side block
33, 105 cylinder chamber
33a, 33b, 33c, 105a, 105b, 105c compression chamber
33d inner peripheral surface
35 discharge slot
37, 109 open/close valve
39 suction slot
41 cylinder-side oil supply path
43 front-side end surface
47 front-side bearing
49 front -side oil supply path
51, 113 intermediate-pressure supply groove
53, 114 high-pressure supply groove
55 front-side annular groove
57 rear-side end surface
59 oil supply hole
59a rear-side oil supply path
59b rear-side oil supply path
61 discharge hole
63 rear-side bearing
65 rear-side communication path
67 intermediate-pressure supply groove (intermediate-pressure supply section)
69 high-pressure supply groove (high-pressure supply section)
69a first supply section (upstream-side supply section)
69b second supply section (downstream-side supply section)
69c interval
71a, 71b high-pressure supply path
73 rear-side annular groove
75, 106 vane groove
77 (77A, 77B, 77C), 107 back pressure space
79 stator
81 motor rotor
110 suction port
O oil
X rotation direction

Claims

1. A gas compressor (1) comprising:

   a tubular cylinder block (29) having therein a cylinder chamber (33) in which a refrigerant is compressed;
   side blocks (31a, 31b) that are attached to side parts of the cylinder block (29) and seal an opening of the cylinder chamber (33) on the side parts ;
   a rotor (23) that rotates in the cylinder chamber (33) and has a plurality of vane grooves (75) opening to an outer peripheral surface (23a) facing an inner peripheral surface (33d) of the cylinder chamber (33) at intervals in a rotation direction (X);
   a plurality of vanes (25) that is respectively stored in the respective vane grooves (75), protrudes and retracts from the outer peripheral surface (23a), comes into sliding contact with the inner peripheral surface (33d) of the cylinder chamber (33), and partitions a space between the inner peripheral surface (33d) and the outer peripheral surface (23a) of the rotor (23) into a plurality of compression chambers (33a, 33b, 33c);
   an intermediate-pressure supply section (67) that is formed in at least one of the side blocks (31a, 31b), communicates with a back pressure space (77) at a groove bottom of each of the vane grooves (75) storing the vanes (25) for partitioning the compression chambers (33a, 33b, 33c) from a suction process to a compression process, and supplies, to the back pressure space (77), an intermediate pressure larger than a refrigerant pressure in each of the compression chambers (33a, 33b, 33c) from the suction process to the compression process; and
   a high-pressure supply section (69) that is formed in at least one of the side blocks (31a, 31b), communicates with the back pressure space (77) in each of the vane grooves (75) storing the vanes (25) for partitioning the compression chambers (33a, 33b, 33c) from the compression process to a discharged process after communication with the intermediate-pressure supply section (67) has been completed, and supplies, to the back pressure space (77), high pressure larger than the refrigerant pressure in each of the compression chambers (33a, 33b, 33c) from the compression process to the discharged process and larger than the intermediate pressure, wherein
   the high-pressure supply section (69) is divided into a plurality of mutually independent supply sections (69a, 69b) in the rotation direction (X), the second supply section (69b) that is positioned at least secondarily from the most upstream side in the rotation direction (X) is formed into a shape in which the second supply section (69b), while communicating with the back pressure space (77) of one vane groove (75), does not simultaneously communicate with the back pressure space (77) of the other vane groove (75) adjacent to the vane groove (75) on the upstream side in the rotation direction (X), and the high-pressure supply section (69) is formed in a range in which it simultaneously communicates with the back pressure space (77) of the one vane groove (75) and the back pressure space (77) of the other vane groove (75) adjacent to the vane groove (75) on the upstream side in the rotation direction (X).

2. The gas compressor (1) according to claim 1, wherein
   the upstream-side supply section (69a) and the downstream-side supply section (69b) which are mutually adjacent in the rotation direction (X) have, in the rotation direction (X), an interval at which, when the back pressure space (77) communicates with the upstream-side supply section (69a) and the downstream-side supply section (69b) in a striding manner, a total of communication cross-sectional areas with the respective supply sections (69a, 69b) becomes at least a minimum path cross-sectional area of high-pressure supply paths (71a, 71b) for supplying high pressures respectively to the respective supply sections (69a, 69b).

3. The gas compressor (1) according to claim 1 or 2, wherein
   the upstream-side supply section (69a) and the downstream-side supply section (69b) arc disposed at an interval (69c) in the rotation direction (X), and the interval (69c) is disposed at a position communicating with the back pressure space (77) at a rotation position of the rotor (23) where a reduction rate of a projection stroke of the vane (25) relative to the vane groove (75) becomes not more than a predetermined threshold value.

4. The gas compressor (1) according to claim 3, wherein
   the inner peripheral surface (33d) of the cylinder chamber (33) is formed so that:

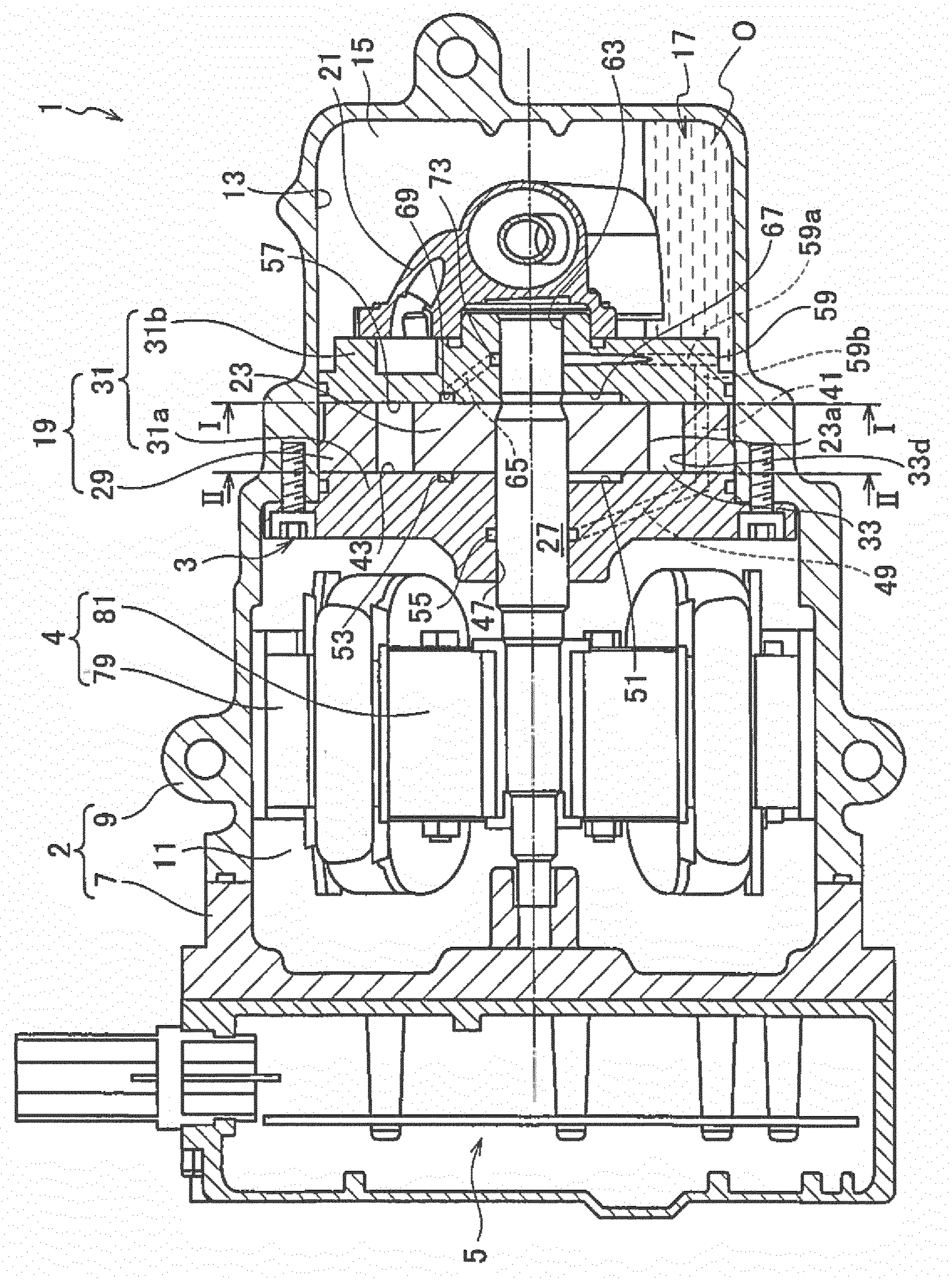
   (a) a region (33e) in which the projection stroke of the vane (25) that is in sliding contact with the inner peripheral surface (33d) from the vane groove (75) is increased along with rotation of the rotor (23) in the rotation direction (X);
   (b) a region (33f) in which the projection stroke of the vane (25) that is in sliding contact with the inner peripheral surface (33d) from the vane

groove (75) is decreased along with rotation of the rotor (23) in the rotation direction (X);
(c) a region (33g) in which the projection stroke of the vane (25) that is in sliding contact with the inner peripheral surface (33d) from the vane groove (75) is decreased along with rotation of the rotor (23) in the rotation direction (X) and in which a reduction rate thereof is smaller than that in the region in (b); and
(d) a region (33f) in which the projection stroke of the vane (25) that is in sliding contact with the inner peripheral surface (33d) from the vane groove (75) is decreased along with rotation of the rotor (23) in the rotation direction (X) and in which a reduction rate thereof is larger than that in the region in (c) and is smaller than that in the region in (b)

are sequentially successive in the rotation direction (X), and wherein
the interval (69c) is disposed at a position communicating with the back pressure space (77) of the vane groove (75) storing the vane (25) when the vane (25) is in sliding contact with the region (33g) in (c) on the inner peripheral surface (33d).

5. The gas compressor (1) according to any one of claims 1 to 4, wherein
the second supply section (69b) has a space of a size that is larger in the rotation direction (X) than a size of the first supply section (69a) positioned on the upstream side of the second supply section (69b) in the rotation direction (X).

FIG. 1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9
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23a
27
29
31
31a
31b
33
33d
41
43
47
49
51
53
55
57
59
59a
59b
63
65
67
69
73
79
81
O
I
II

FIG. 2

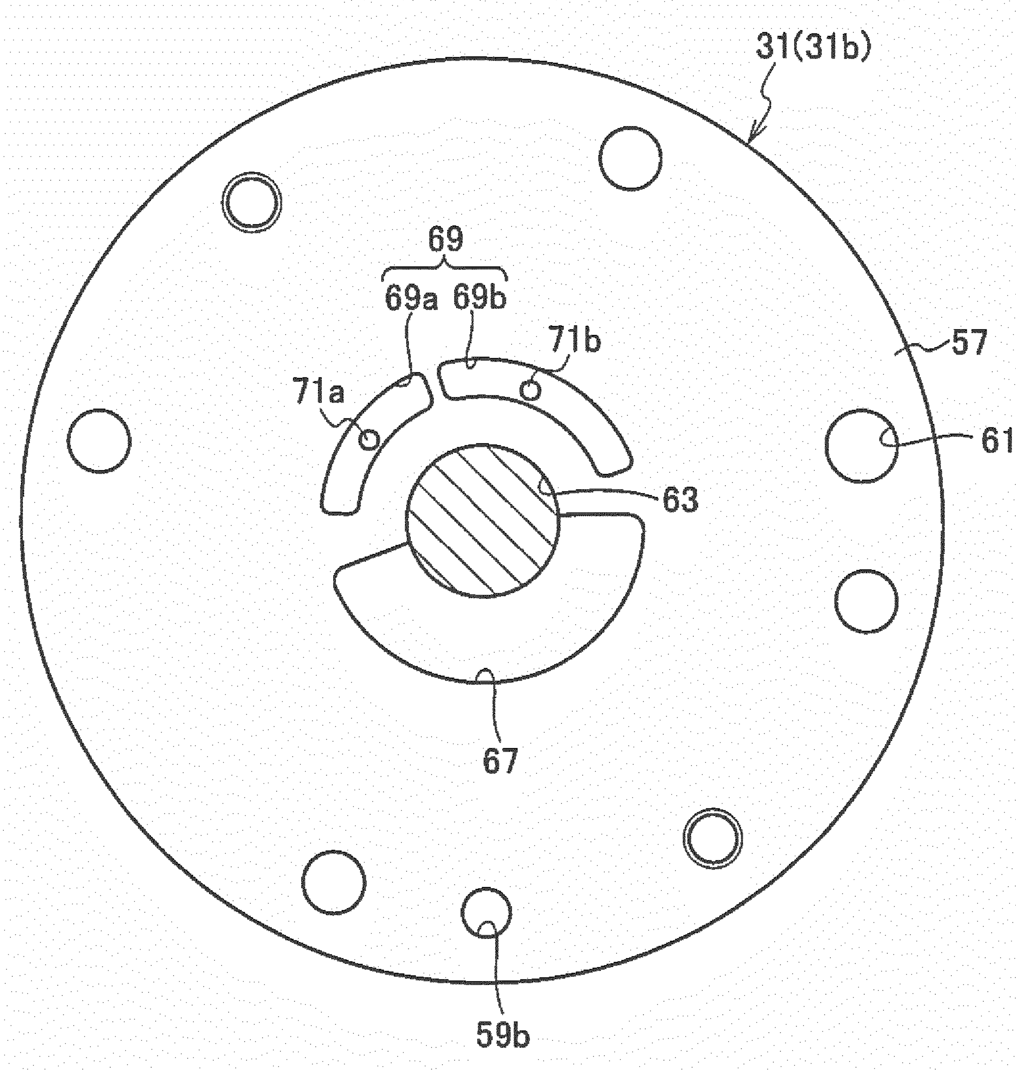
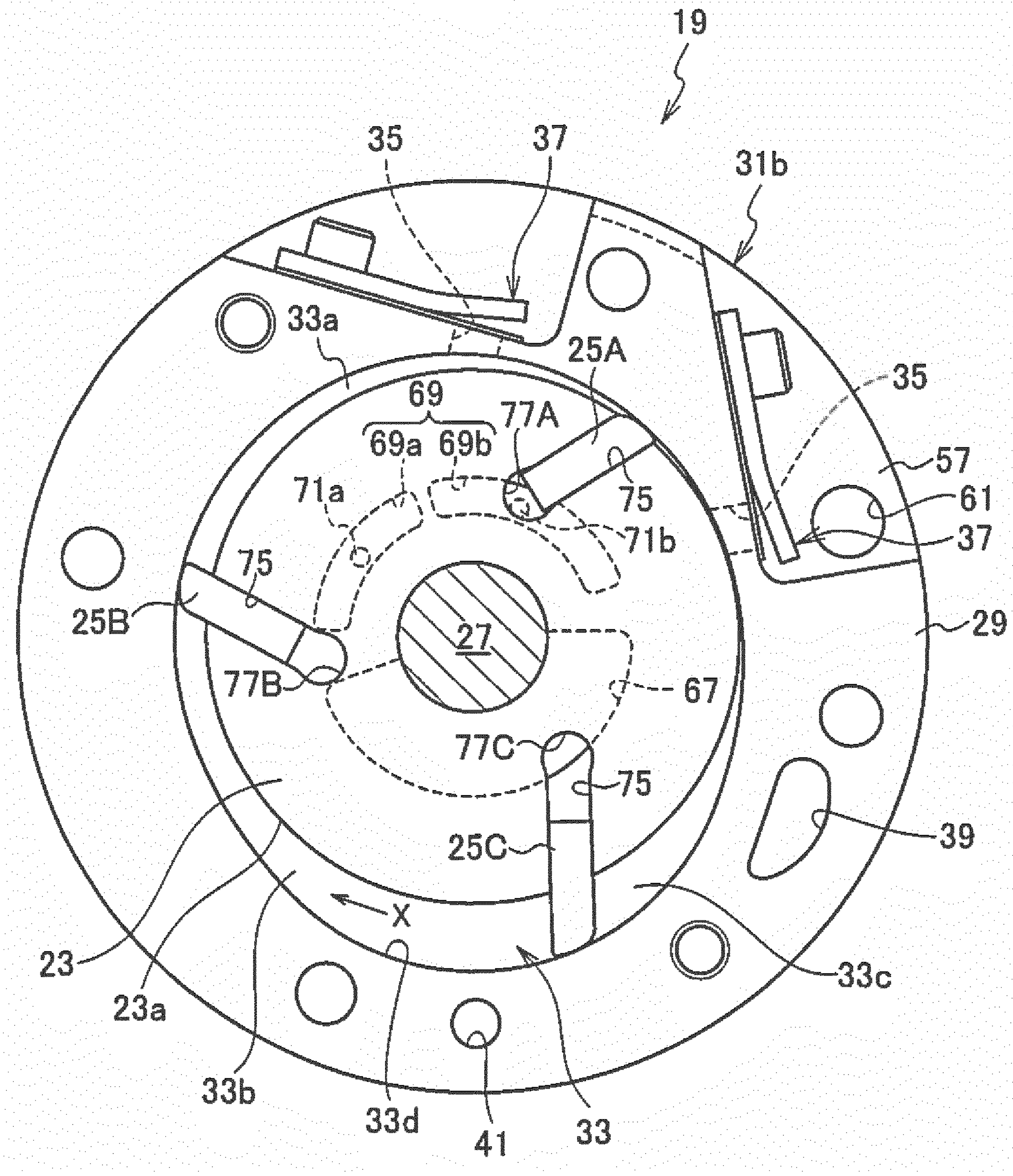


FIG. 3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35
37
31b
33a
25A
35
69
69a
69b
77A
57
71a
75
61
71b
37
75
25B
27
29
77B
67
77C
75
39
25C
X
23
33c
23a
33b
33d
41
33

FIG. 4

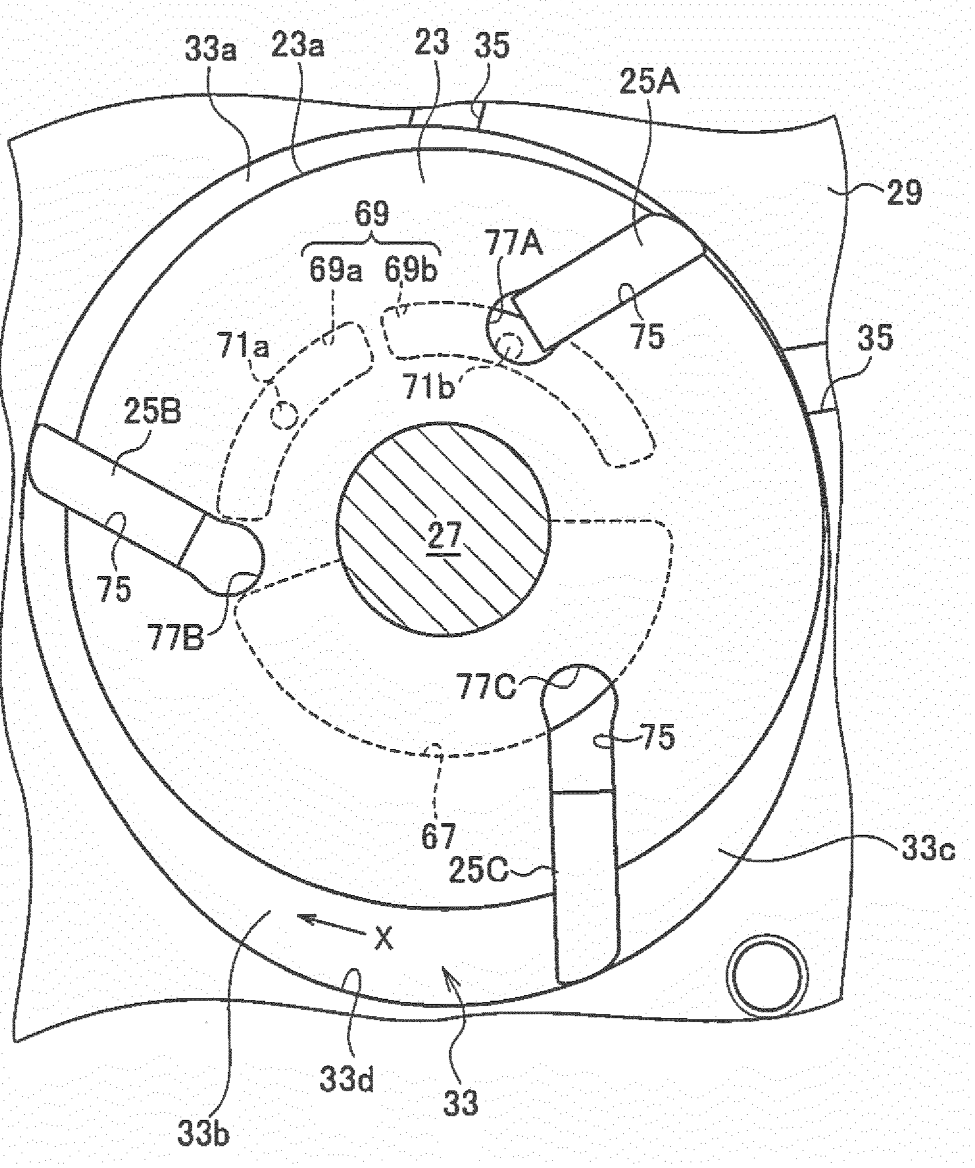

33a
23a
23
35
25A
29
69
69a
69b
77A
75
35
71a
71b
25B
27
75
77B
77C
75
67
25C
33c
X
33d
33
33b

FIG. 5

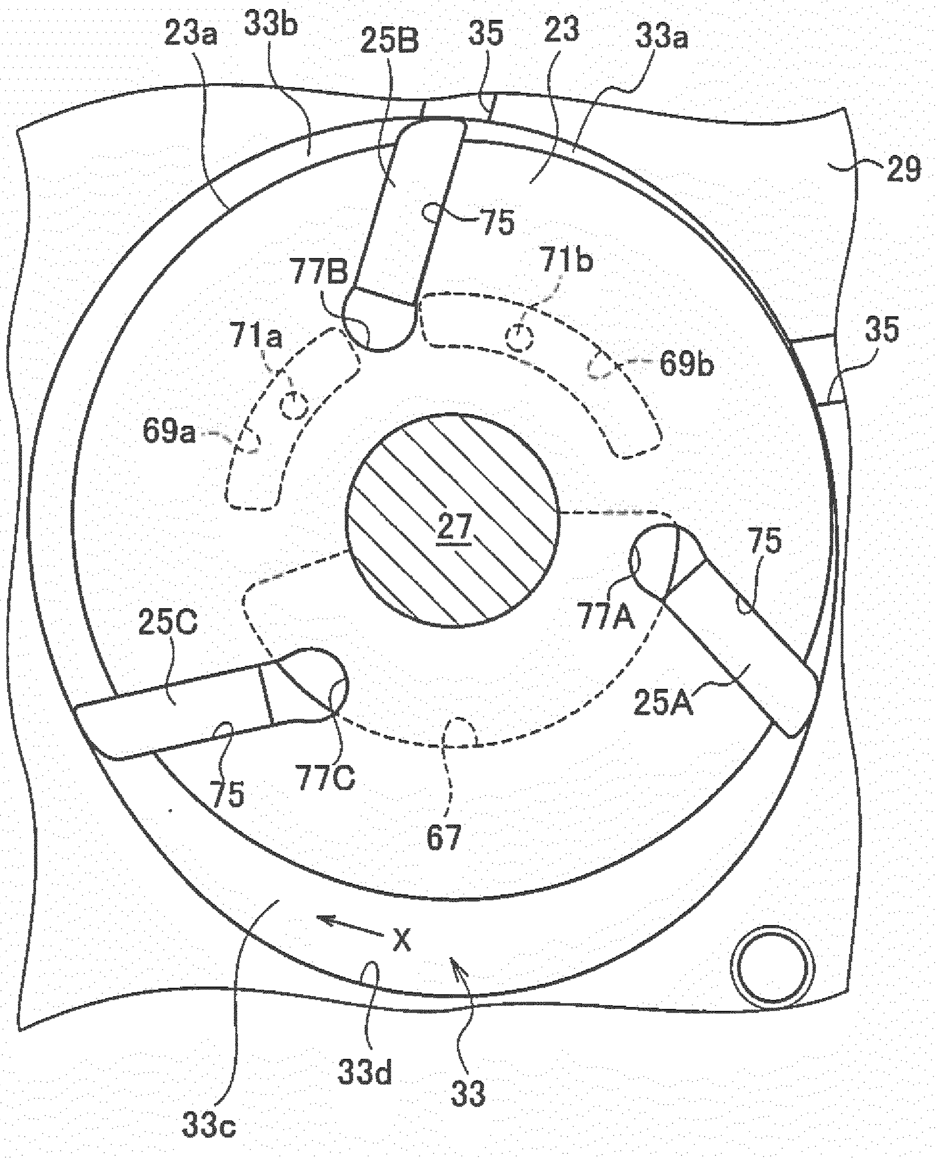

23a
33b
25B
35
23
33a
29
75
77B
71b
71a
35
69b
69a
27
75
77A
25C
25A
75
77C
67
X
33d
33
33c

FIG. 6

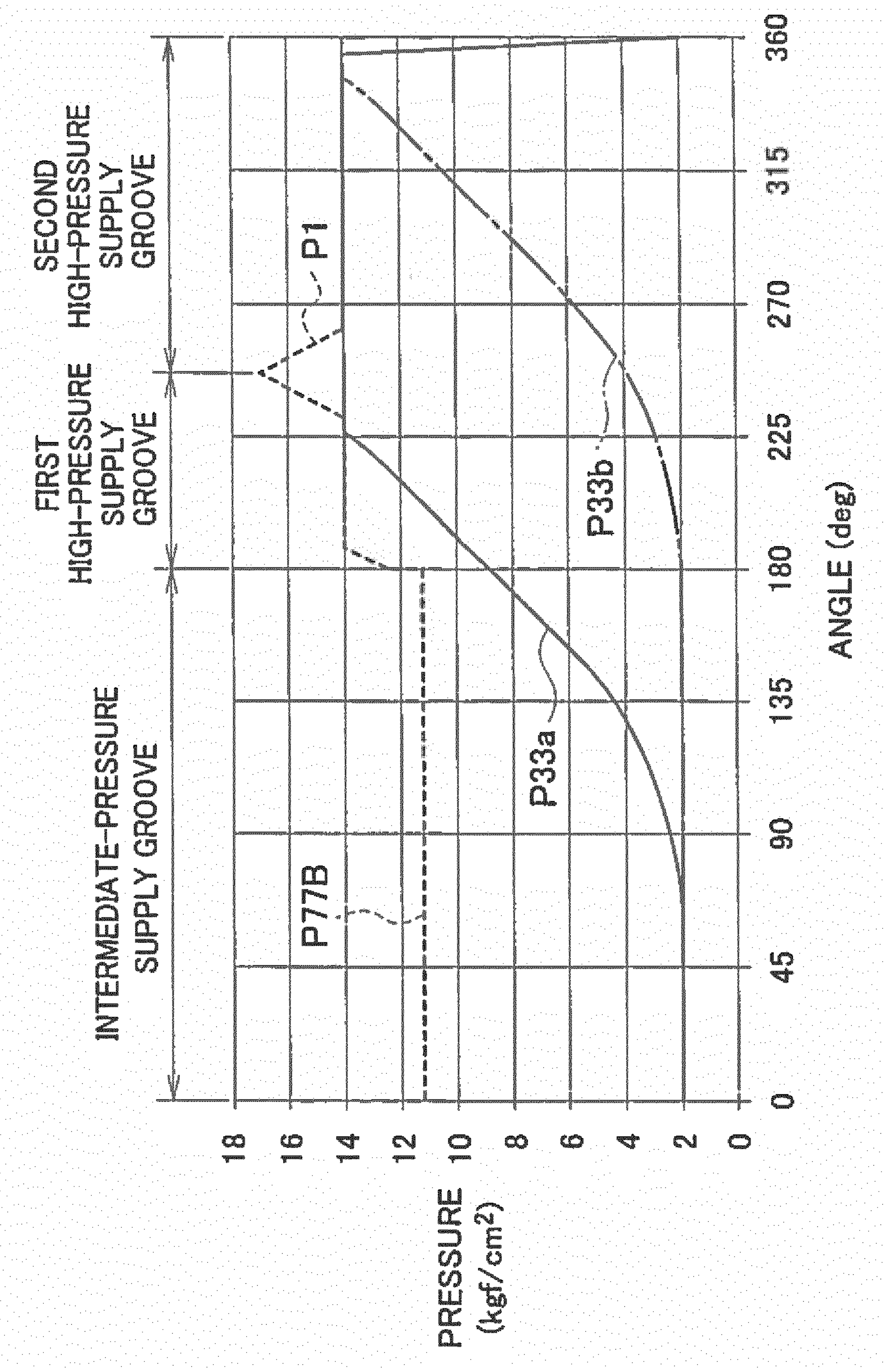

INTERMEDIATE-PRESSURE SUPPLY GROOVE
FIRST HIGH-PRESSURE SUPPLY GROOVE
SECOND HIGH-PRESSURE SUPPLY GROOVE
P1
P77B
P33a
P33b
PRESSURE (kgf/cm2)
18
16
14
12
10
8
6
4
2
0
0
45
90
135
180
225
270
315
360
ANGLE (deg)

FIG. 7

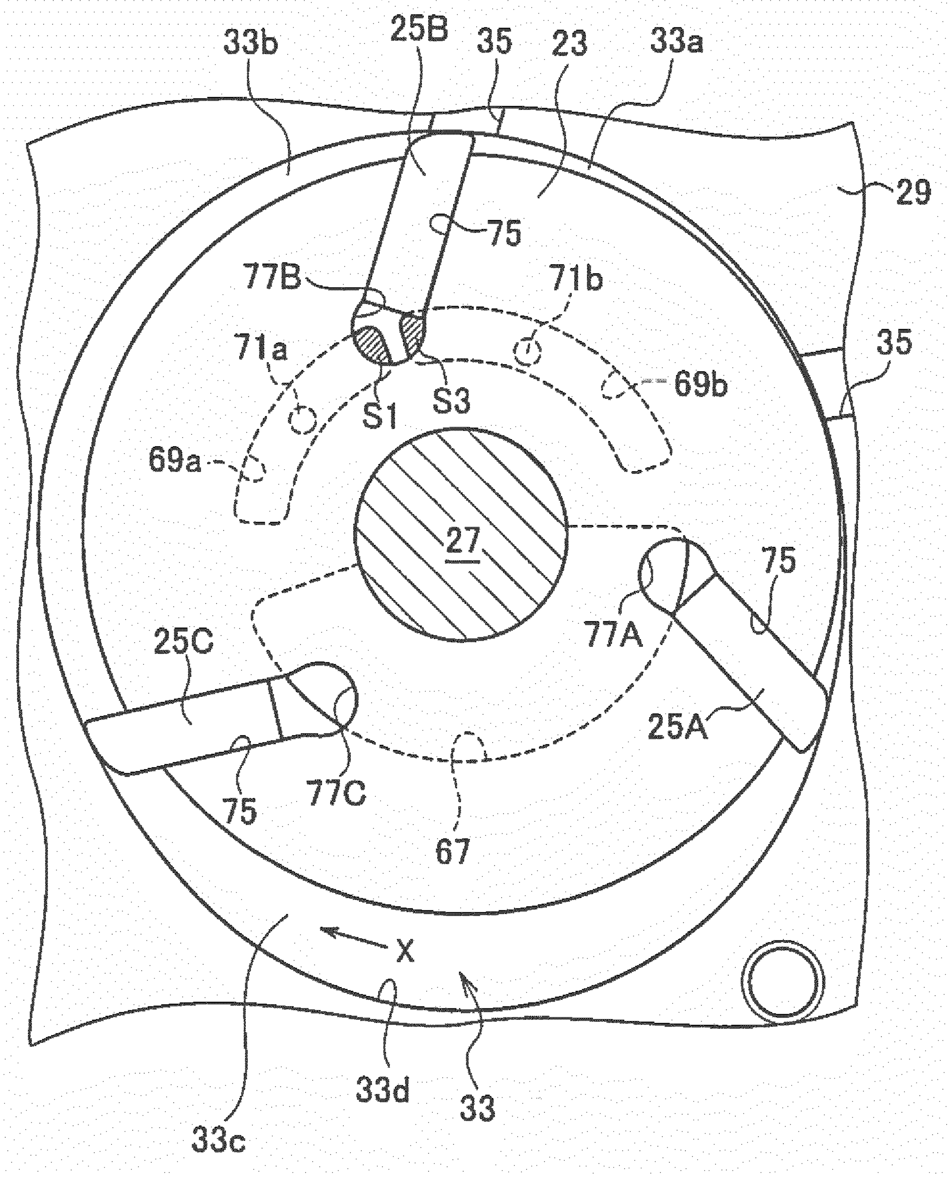

33b
25B
35
23
33a
29
75
77B
71b
35
71a
S1
S3
69b
69a
27
75
77A
25C
25A
75
77C
67
X
33d
33
33c

FIG. 8

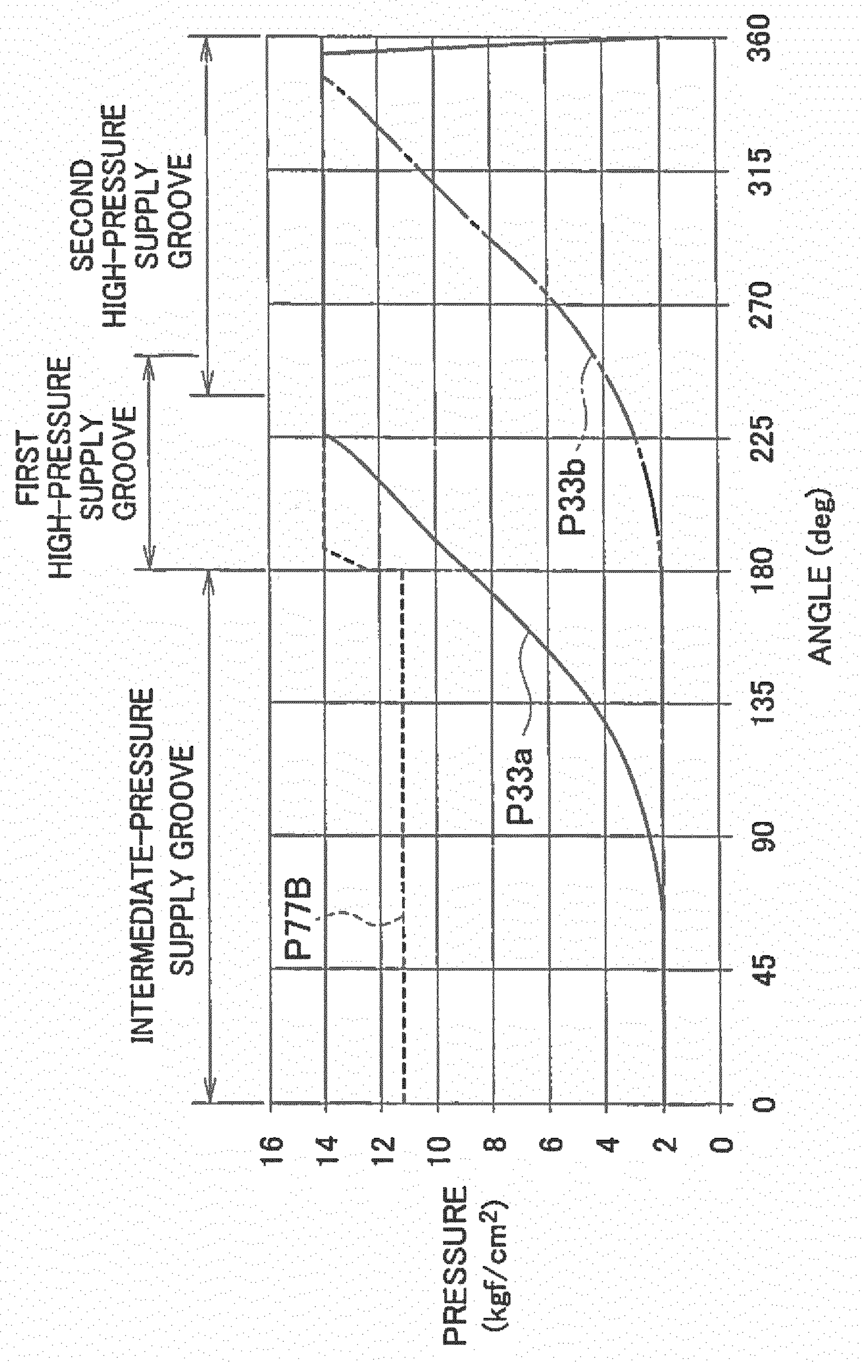

INTERMEDIATE-PRESSURE SUPPLY GROOVE
FIRST HIGH-PRESSURE SUPPLY GROOVE
SECOND HIGH-PRESSURE SUPPLY GROOVE
P77B
P33a
P33b
PRESSURE (kgf/cm²)
16
14
12
10
8
6
4
2
0
0
45
90
135
180
225
270
315
360
ANGLE (deg)

FIG. 9

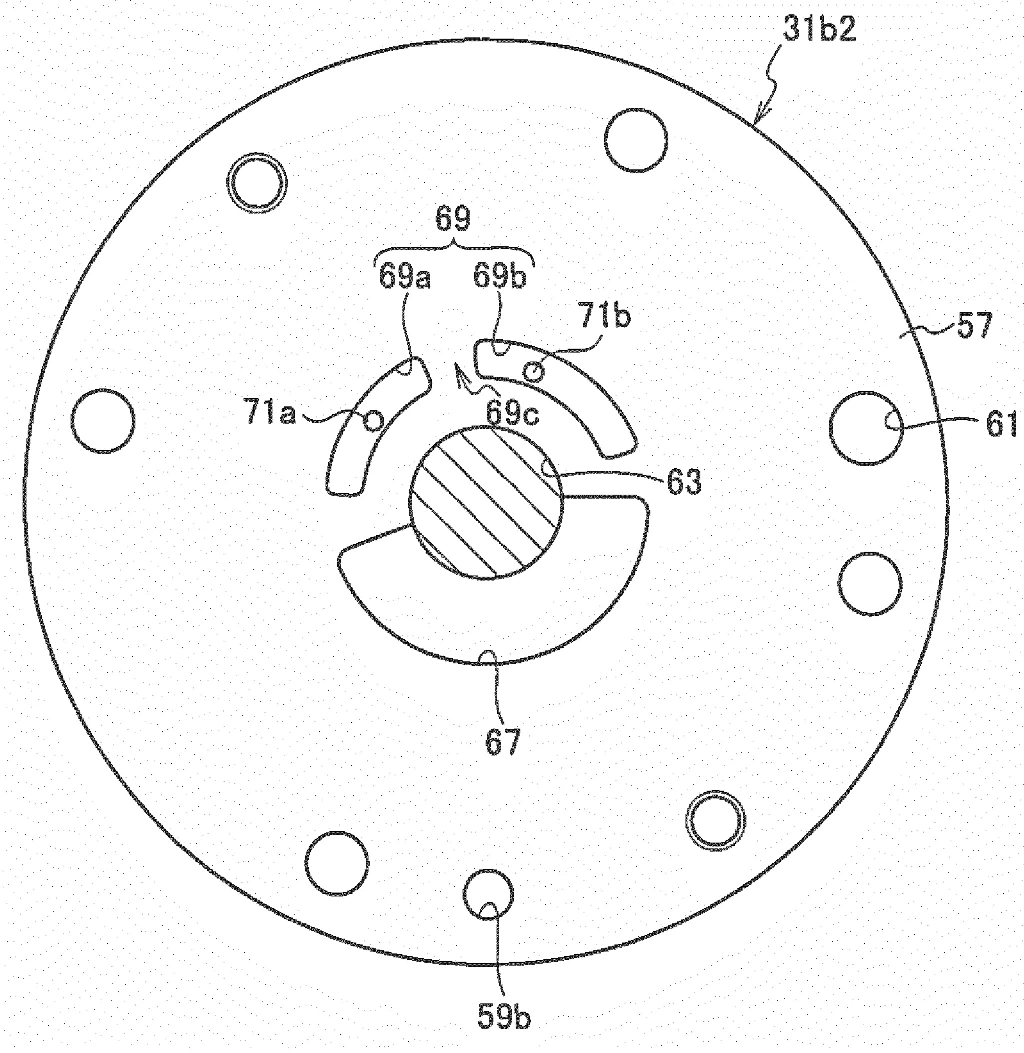
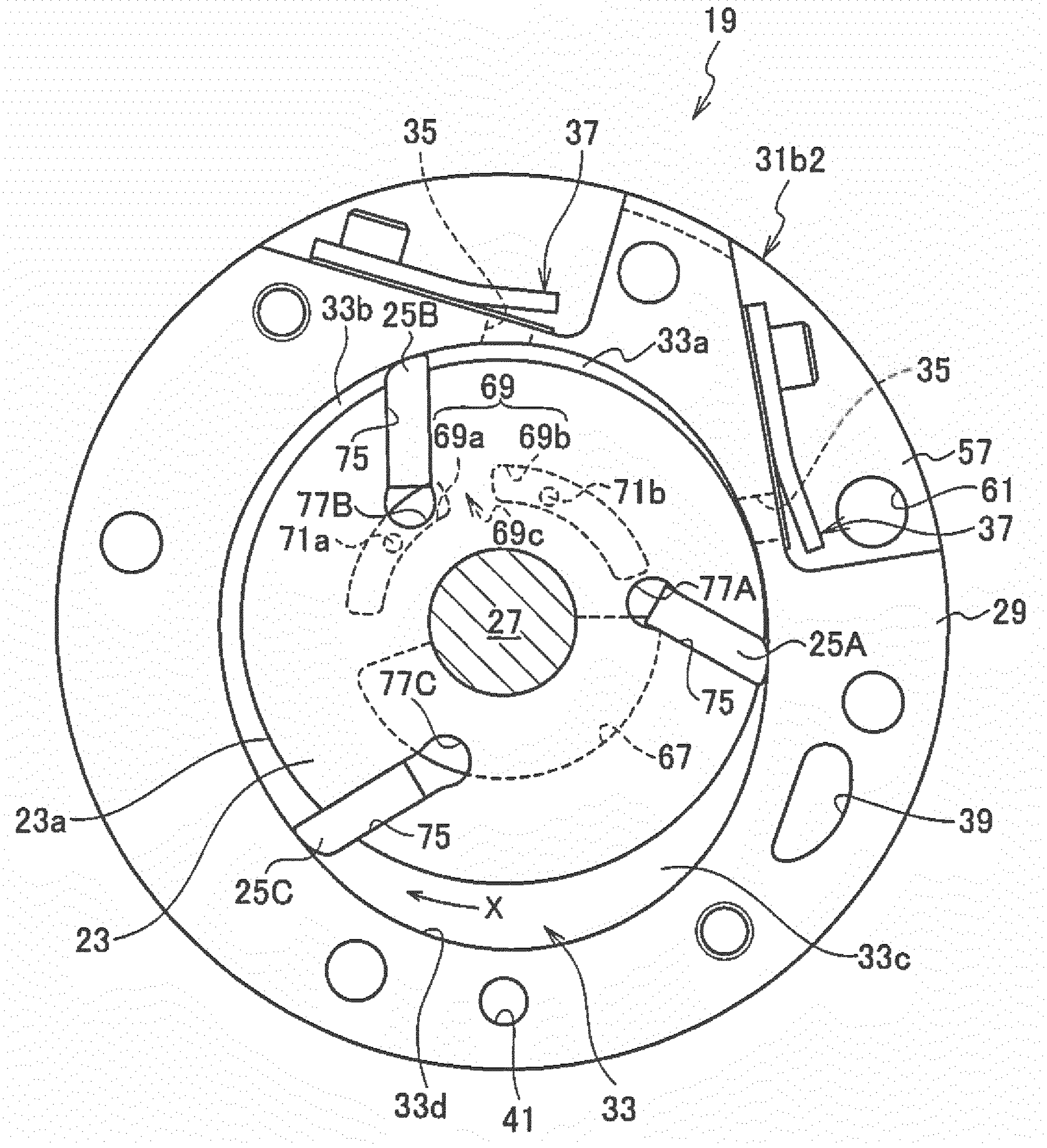


FIG. 10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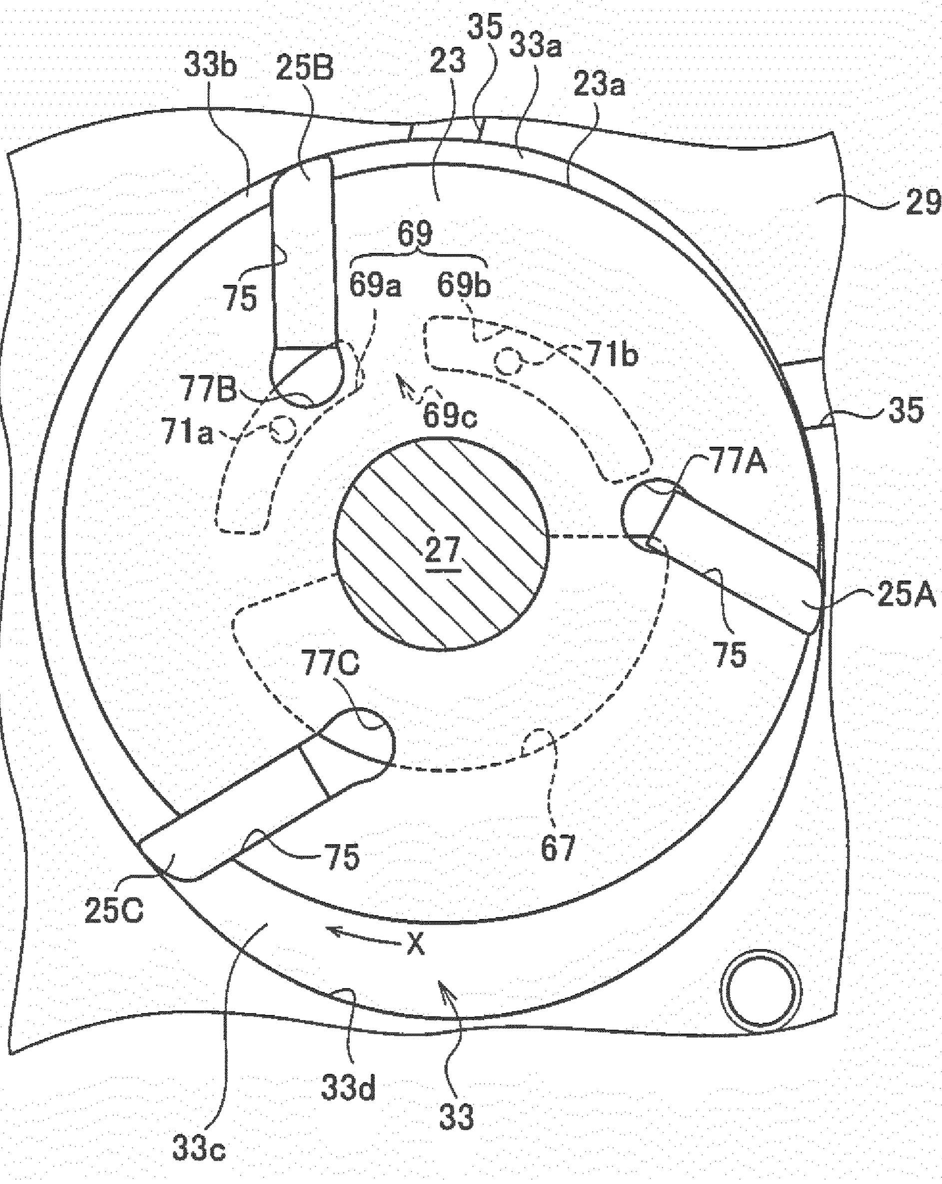
37
31b2
33b
25B
33a
69
35
69a
69b
57
75
61
77B
71b
37
71a
69c
77A
29
27
25A
77C
75
67
23a
75
39
25C
X
23
33c
33d
41
33

FIG. 11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33a
23
33b
25B
23a
29
69
75
69a
69b
71b
77B
69c
71a
35
77A
27
25A
75
77C
67
75
25C
X
33d
33
33c

FIG. 12

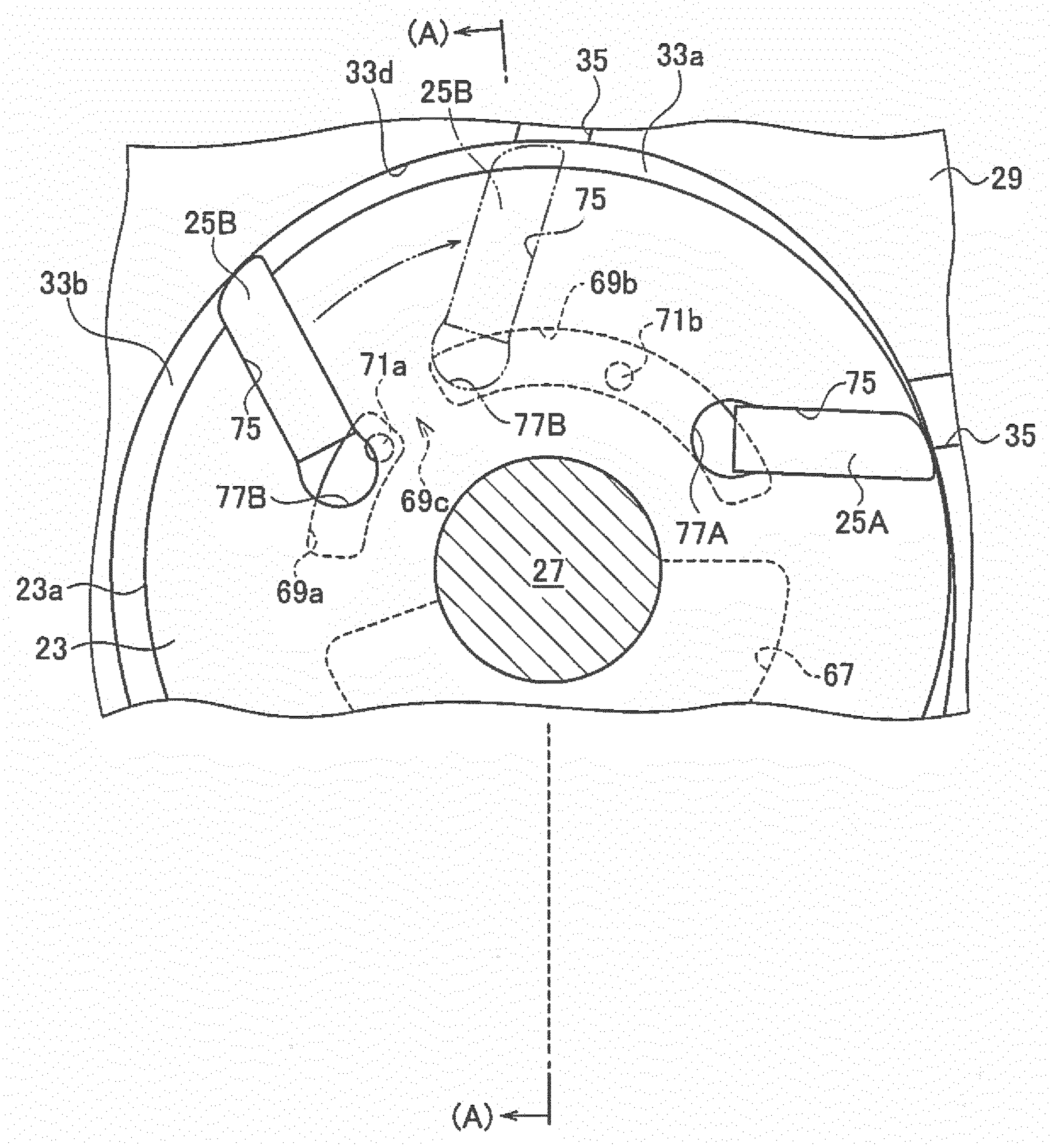
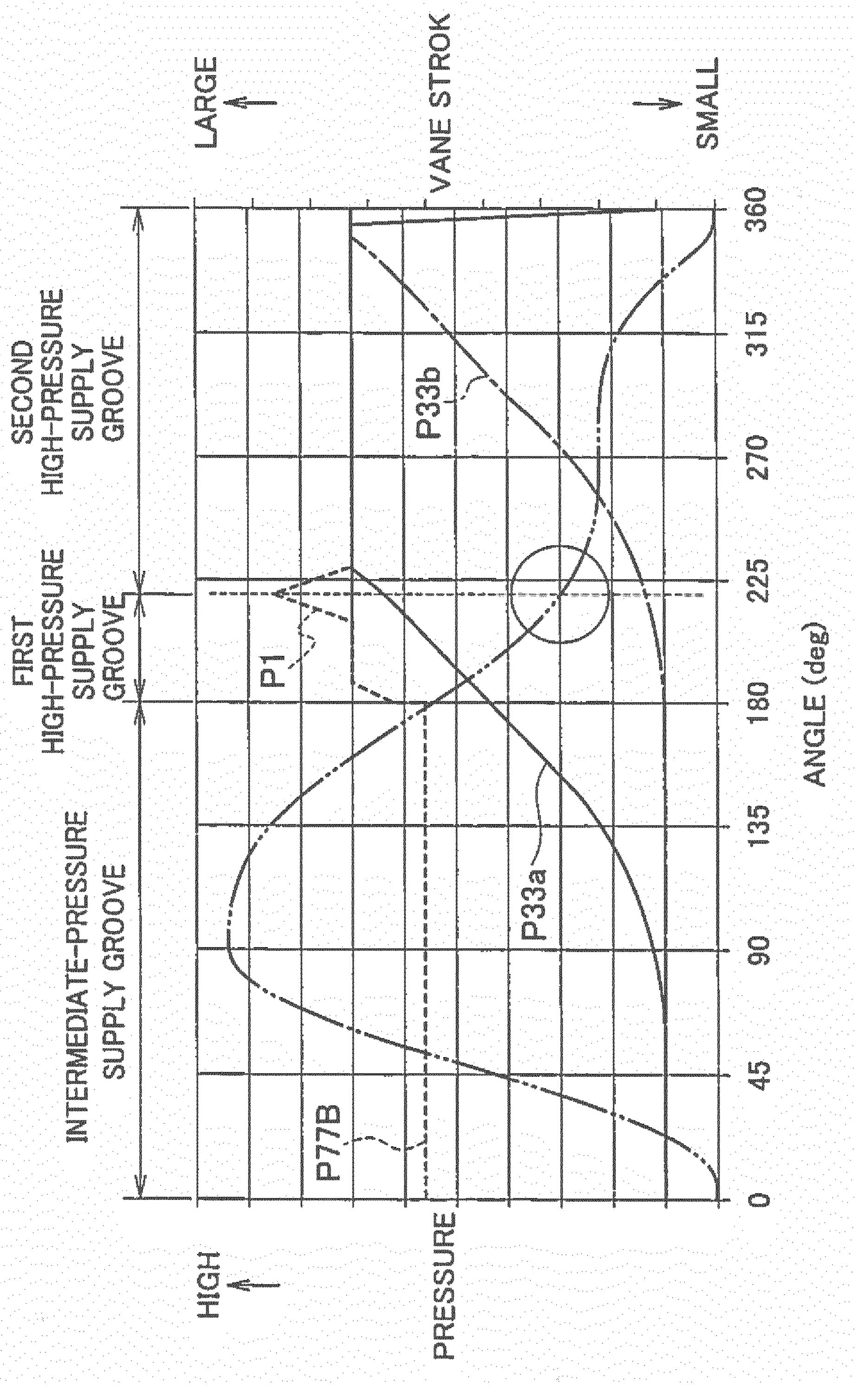
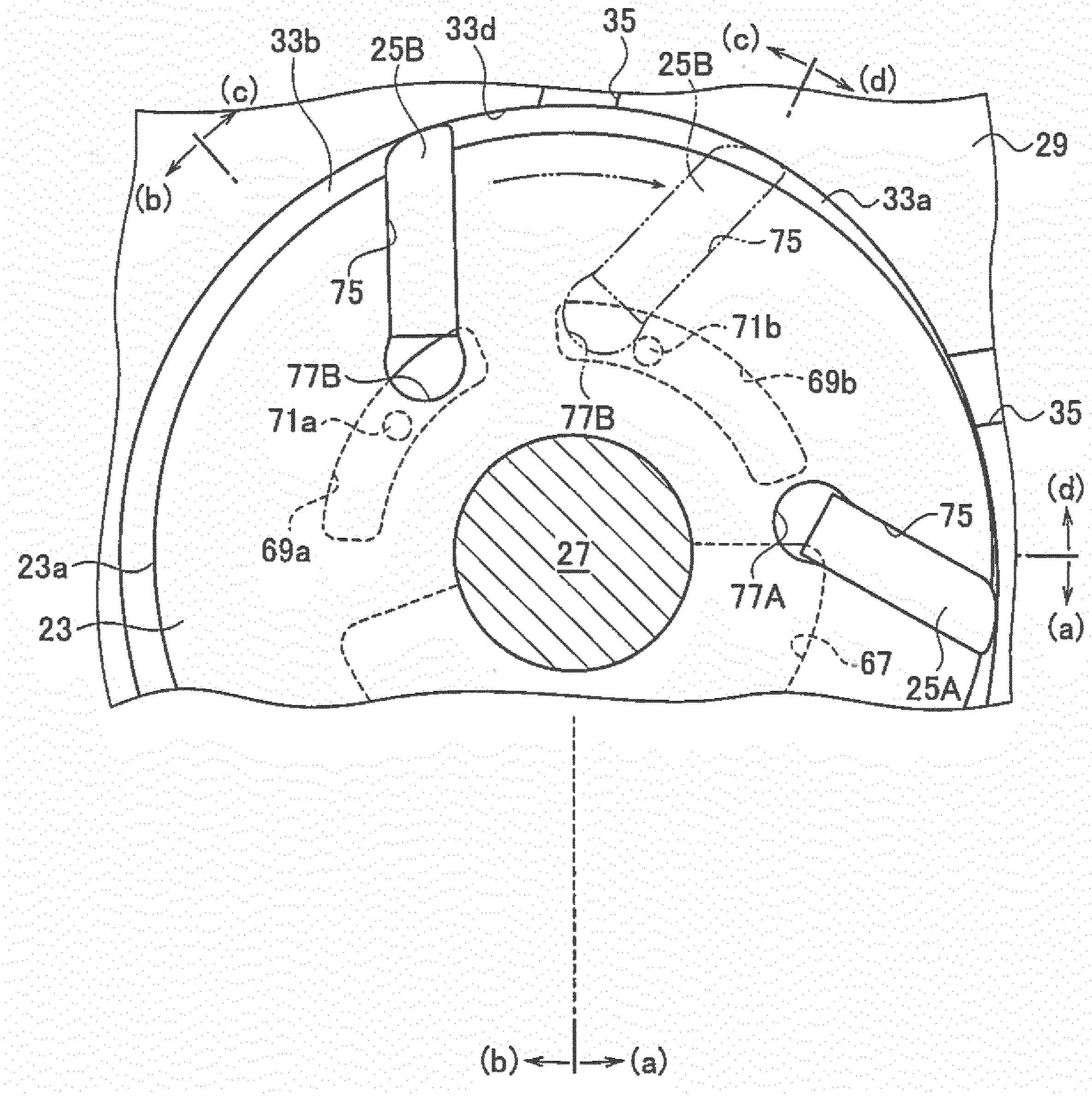

(A)
33d
25B
35
33a
29
75
25B
33b
69b
71b
71a
75
75
77B
35
77B
69c
77A
25A
27
23a
69a
23
67
(A)

FIG. 13



LARGE
VANE STROK
SMALL
SECOND HIGH-PRESSURE SUPPLY GROOVE
FIRST HIGH-PRESSURE SUPPLY GROOVE
INTERMEDIATE-PRESSURE SUPPLY GROOVE
P33b
P1
P33a
P77B
HIGH
PRESSURE
0
45
90
135
180
225
270
315
360
ANGLE (deg)

FIG. 14



33b
25B
33d
35
(c)
25B
(d)
(c)
29
(b)
33a
75
75
71b
77B
69b
71a
77B
35
(d)
75
69a
27
77A
23a
(a)
23
67
25A
(b)
(a)

FIG. 15

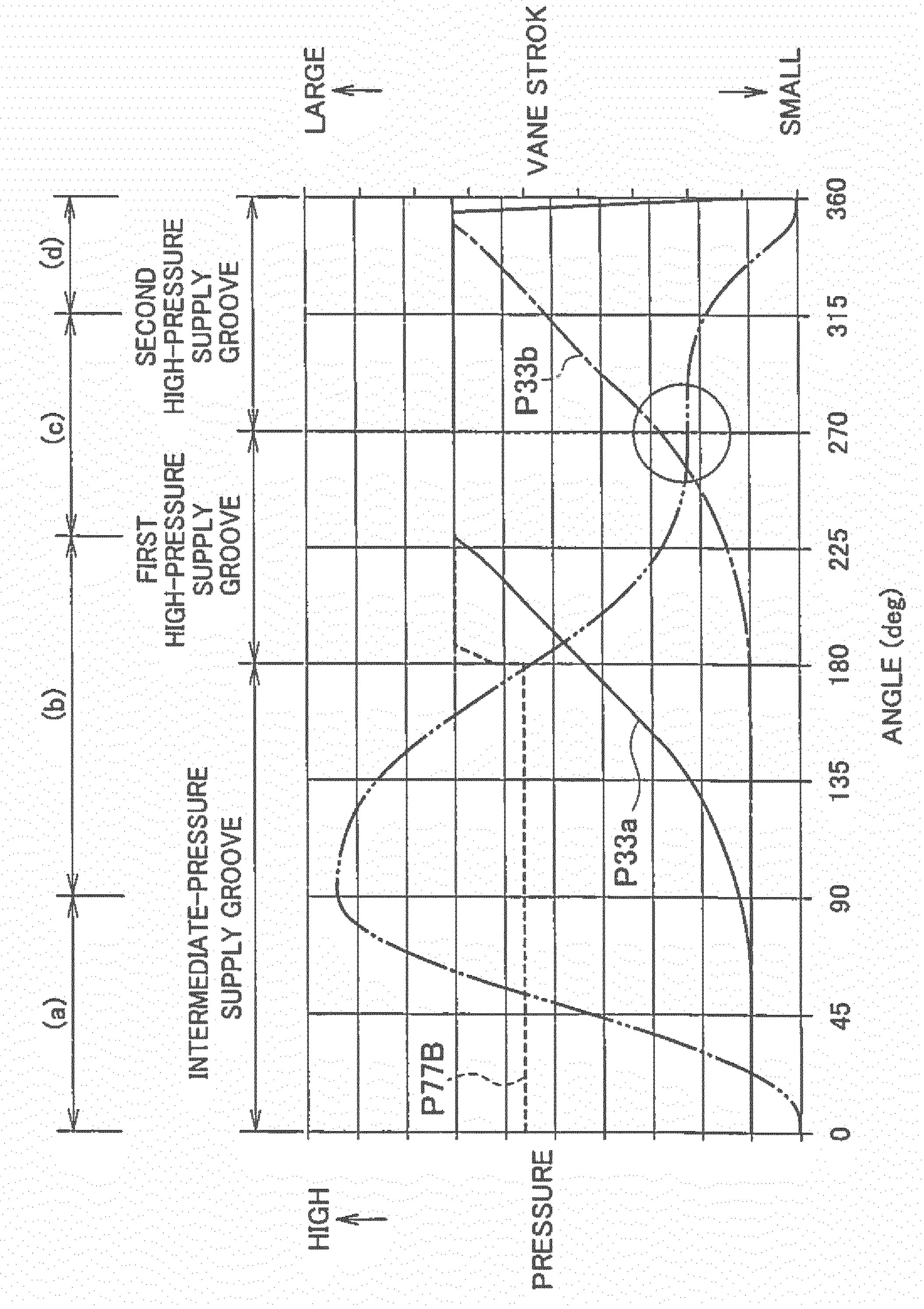
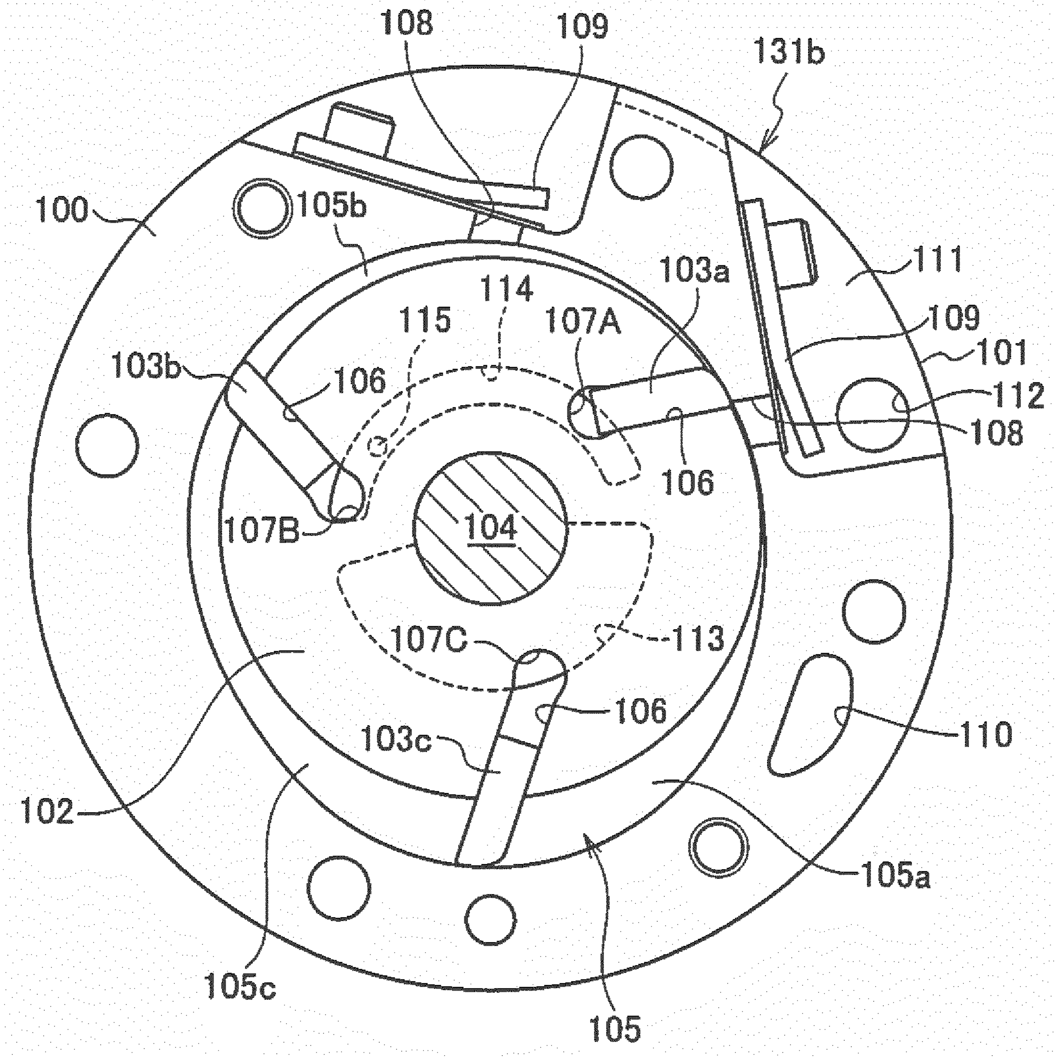

(a)
(b)
(c)
(d)
INTERMEDIATE-PRESSURE SUPPLY GROOVE
FIRST HIGH-PRESSURE SUPPLY GROOVE
SECOND HIGH-PRESSURE SUPPLY GROOVE
P77B
P33a
P33b
HIGH
PRESSURE
LARGE
VANE STROK
SMALL
0
45
90
135
180
225
270
315
360
ANGLE (deg)

FIG. 16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107B
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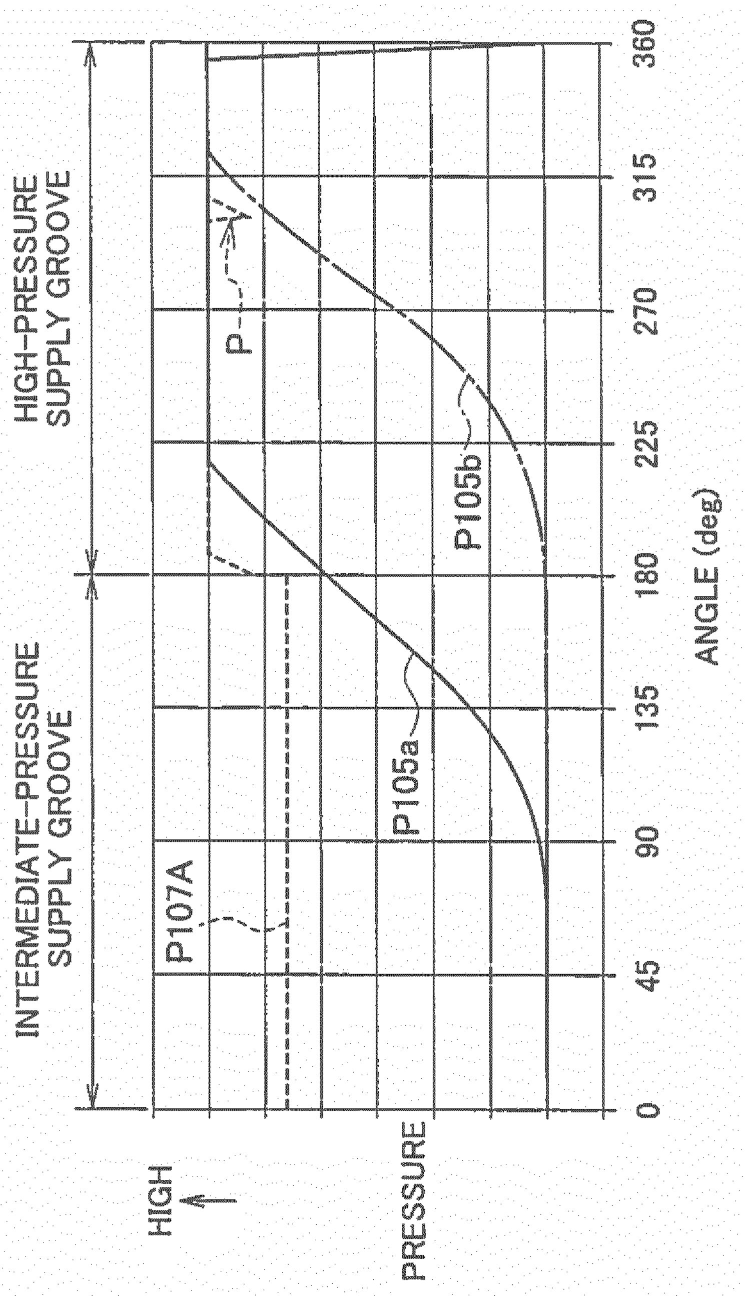
107C
113
106
110
103c
102
105a
105c
105

FIG. 17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HIGH-PRESSURE SUPPLY GROOVE
P107A
P105a
P105b
P
HIGH
PRESSURE
0
45
90
135
180
225
270
315
360
ANGLE (deg)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/085193

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/344(2006.01)i, *F04C27/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04C18/344, F04C27/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 37834/1988(Laid-open No. 141391/1989) (Diesel Kiki Co., Ltd.), 28 September 1989 (28.09.1989), page 11, line 9 to page 12, line 11 (Family: none)	1-5
A	JP 2004-92494 A (Calsonic Compressors Manufacturing Inc.), 25 March 2004 (25.03.2004), paragraphs [0029] to [0033] & US 2004/0136841 A1 paragraphs [0047] to [0051]	1-5

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
03 March 2016 (03.03.16)

Date of mailing of the international search report
15 March 2016 (15.03.16)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3,Kasumigaseki,Chiyoda-ku,
Tokyo 100-8915,Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/085193

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-204557 A (Toyota Industries Corp.), 07 October 2013 (07.10.2013), paragraphs [0024] to [0031] & CN 103362811 A	1-5
A	JP 2006-112331 A (Matsushita Electric Industrial Co., Ltd.), 27 April 2006 (27.04.2006), paragraphs [0015] to [0017] (Family: none)	1-5

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Patent documents cited in the description

- JP 2013194549 A **[0011]**
- JP 2014260491 A **[0132]**
- JP 2014260492 A **[0132]**
- JP 2014260500 A **[0132]**