ABSTRACT OF THE DISCLOSURE

A tandem type vane compressor has a housing, a drive shaft, primary and secondary vanes, and primary and secondary vane grooves. A primary backpressure chamber is defined between the bottom surface of each primary vane and the corresponding primary vane groove. A secondary backpressure chamber is defined between the bottom surface of each secondary vane and the corresponding secondary vane groove. The housing includes a shell, first to third side plates, and first and second cylinder blocks. The shell has a common passage, which extends in a longitudinal direction of a drive shaft to communicate with a discharge chamber. At least one of the first side plate and the second side plate has a first supplying passage, which connects the common passage with each primary backpressure chamber. At least one of the second side plate and the third side plate has a second supplying passage, which connects the common passage with each secondary backpressure chamber.

CLAIMS

1. A tandem type vane compressor comprising:

a housing that has a suction chamber, a discharge chamber, and a plurality of compression chambers, wherein the housing rotationally supports a drive shaft; and

a plurality of compression mechanisms including a first compression mechanism and a second compression mechanism, which are coupled to each other in tandem in the housing, wherein

the first and second compression mechanisms each have at least one of the compression chambers,

each compression mechanism is driven by rotation of the drive shaft to perform a suction process, in which each compression mechanism draws low-pressure refrigerant gas into the respective compression chamber from the suction chamber, a compression process, in which each compression mechanism compresses the refrigerant gas in the respective compression chamber, and a discharge process, in which each compression mechanism discharges the high-pressure refrigerant gas in the respective compression chamber to the discharge chamber,

the first compression mechanism includes a first cylinder chamber, which is formed in the housing, a first rotor, which is provided in the first cylinder chamber to rotate when the drive shaft rotates, the first rotor having a plurality of radially extending primary vane grooves, and a plurality of primary vanes, each of which is located in one of the primary vane grooves and is capable of projecting and retracting,

the compression chamber of the first compression mechanism is defined by an inner surface of the first cylinder chamber, an outer surface of the first rotor, and the primary vanes, wherein the compression chamber of the first compression mechanism is located at a position forward of the compression chamber of the second compression mechanism, the second compression mechanism includes a second cylinder chamber, which is formed in the housing, a second rotor, which is provided in the second cylinder chamber to rotate when the drive shaft rotates, the second rotor having a plurality of radially extending secondary vane grooves, and a plurality of secondary vanes, each of which is located in one of the secondary vane grooves and is capable of projecting and retracting, and

the compression chamber of the second compression mechanism is defined by an inner surface of the second cylinder chamber, an outer surface of the second rotor, and the secondary vanes, the tandem type vane compressor being characterized in that

a bottom surface of each primary vane and the corresponding primary vane groove define a primary backpressure chamber,

a bottom surface of each secondary vane and the corresponding secondary vane groove define a secondary backpressure chamber,

the housing includes:

a shell having a suction inlet and a discharge outlet, which are connected to the outside;

a first side plate, which is accommodated in the shell and defines, with the shell, the suction chamber such that the suction chamber communicates with the suction inlet;

a second side plate, which is accommodated in the shell and partitions the first compression mechanism and the second compression mechanism from each other;

a third side plate, which is accommodated in the shell and defines, with the shell, the discharge chamber such that the discharge chamber communicates with the discharge outlet;

a first cylinder block, which is accommodated in the shell and forms the first cylinder chamber while being held between the first side plate and the second side plate; and

a second cylinder block, which is accommodated in the shell while being held between the second plate and the third side plate, thereby forming the second cylinder chamber, wherein

the shell has a common passage, which extends in a longitudinal direction of the drive shaft to communicate with the discharge chamber,

at least one of the first side plate and the second side plate has a first supplying passage, which connects the common passage with each primary backpressure chamber, and

at least one of the second side plate and the third side plate has a second supplying passage, which connects the common passage with each secondary backpressure chamber.

2. The tandem type vane compressor according to claim 1, wherein

the first supplying passage is formed in the second side plate, and

the second supplying passage is formed in the third side plate.

3. The tandem type vane compressor according to claim 1, wherein

the first supplying passage is formed in the first side plate, and

the second supplying passage is formed in the third side plate.

4. The tandem type vane compressor according to claim 1, wherein

the first supplying passage is formed in the first side plate, and

the second supplying passage is formed in the second side plate.

5. The tandem type vane compressor according to claim

1, wherein the first supplying passage and the second supplying passage are formed in the second side plate.

6. The tandem type vane compressor according to any one of claims 1 to 5, wherein

the shell includes a front housing member, which has the suction inlet and defines the suction chamber with the first side plate, and a rear housing member, which has the discharge outlet and defines the discharge chamber with the third side plate,

the first cylinder block and the second cylinder are common components,

the first rotor and the second rotor are common components, and

the primary vanes and secondary vanes are common components.

Dated this 27 day of March 2013

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1377 /CHE/ 2013

ORIGINAL

27 MAR 2013

Fig.1

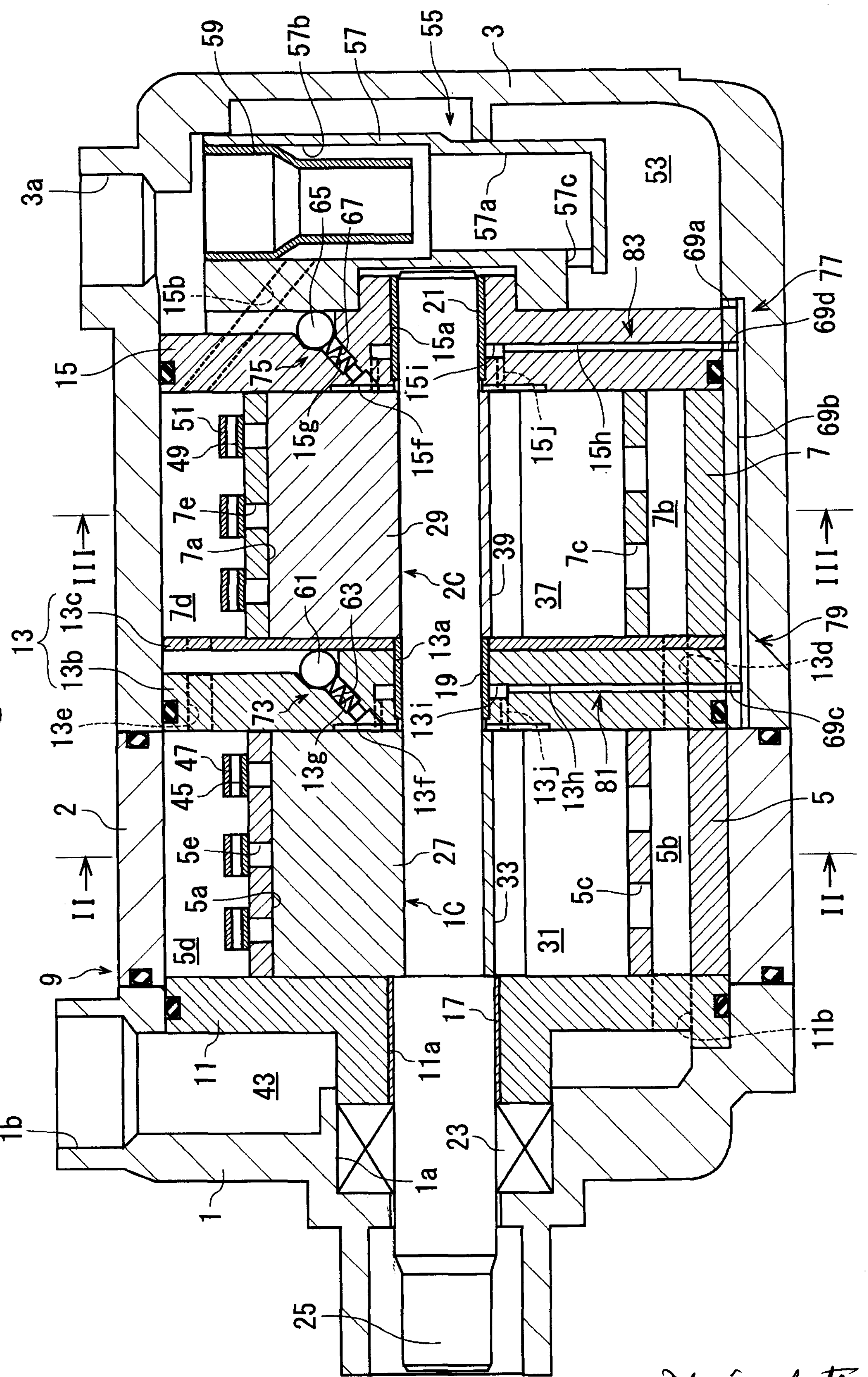

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Fig.2

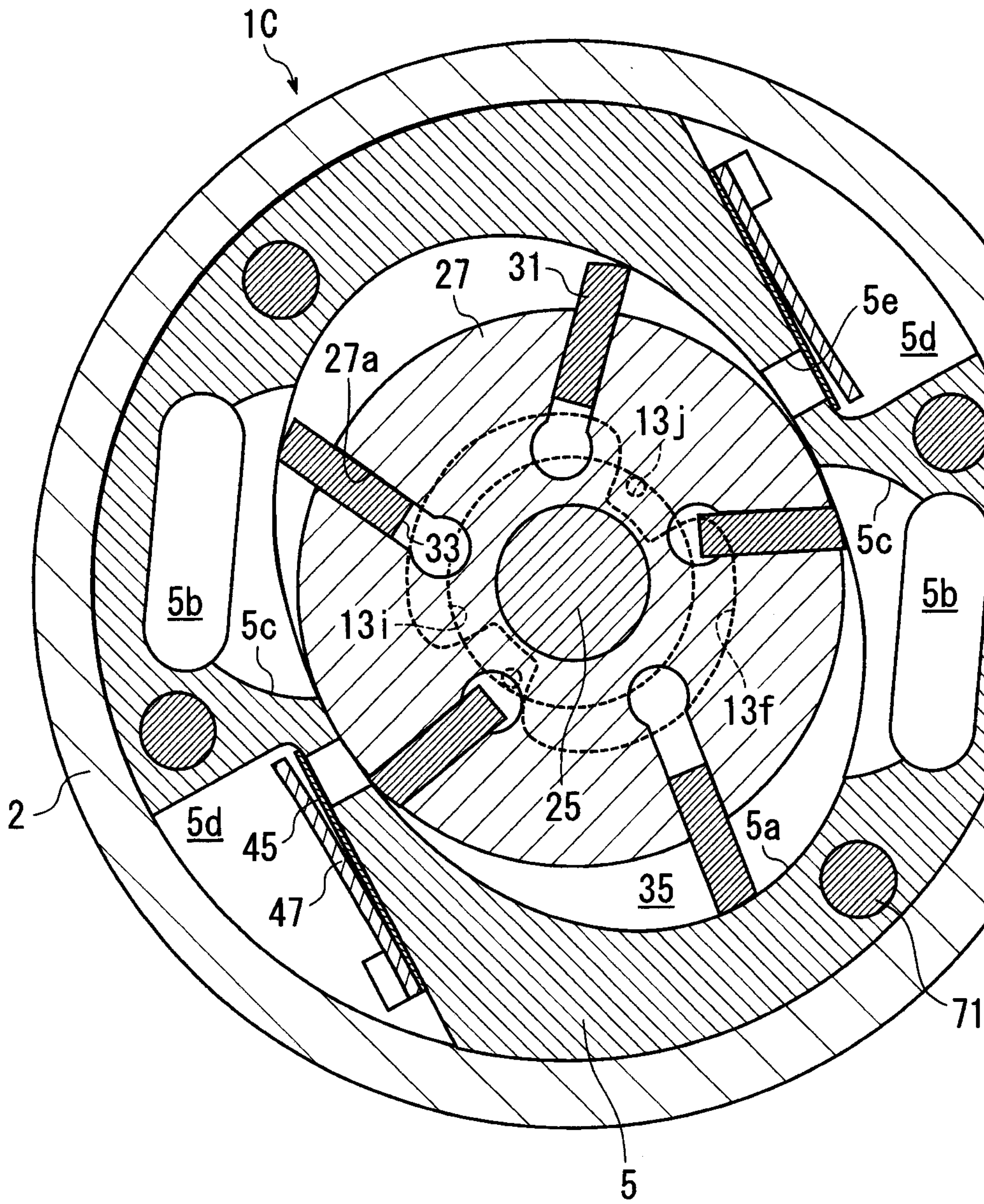

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Fig.3

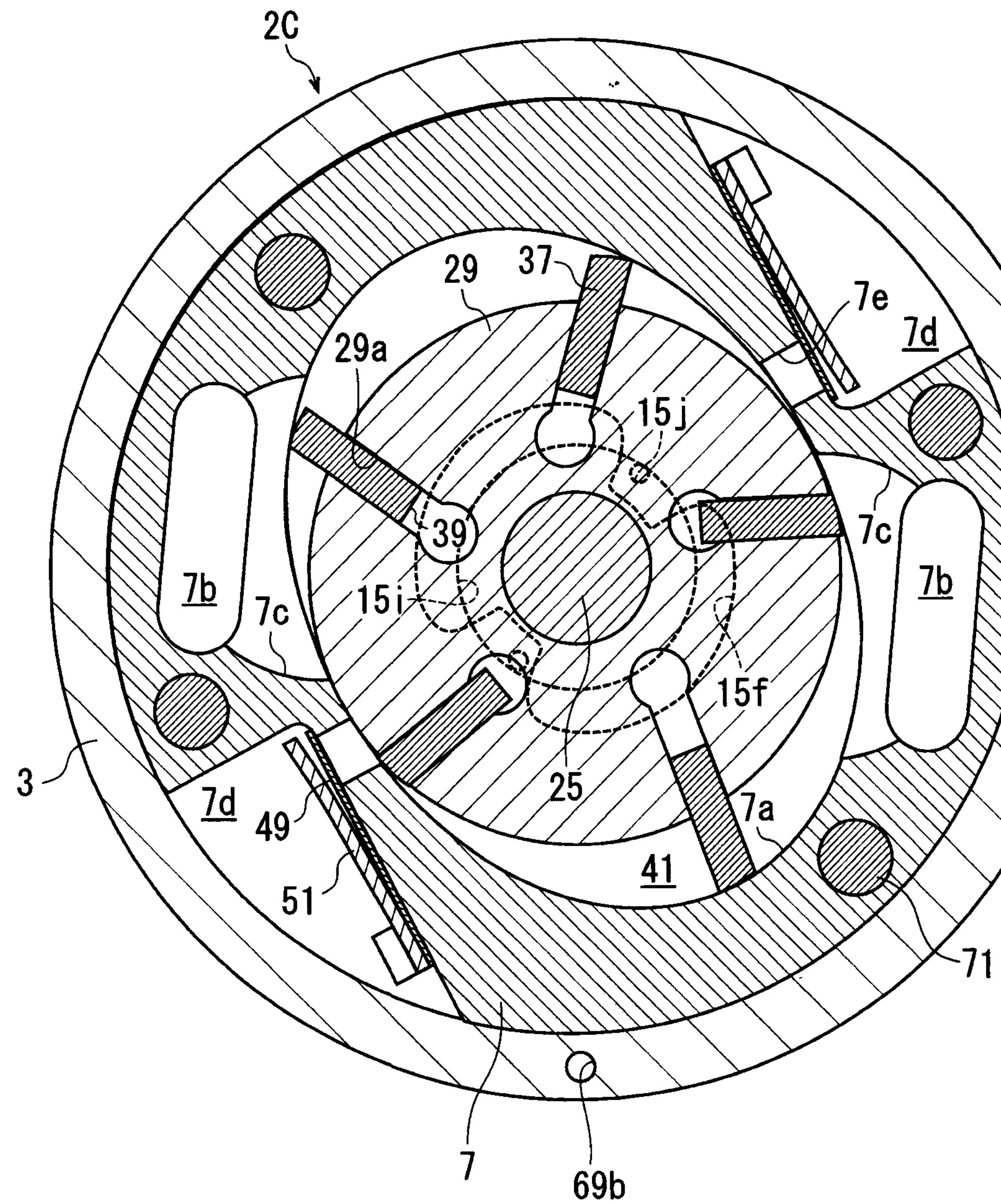

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Fig.4

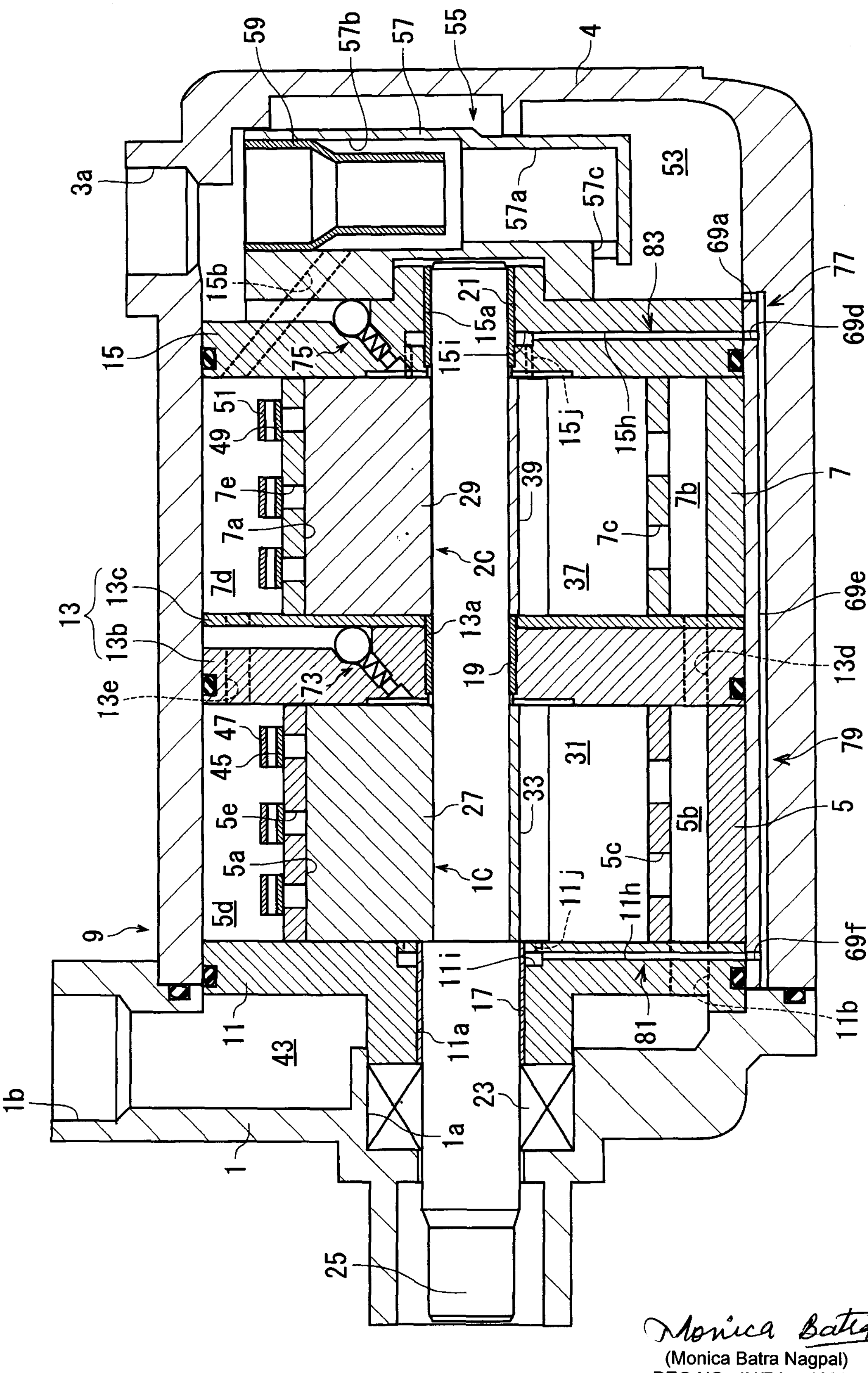

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Fig.5

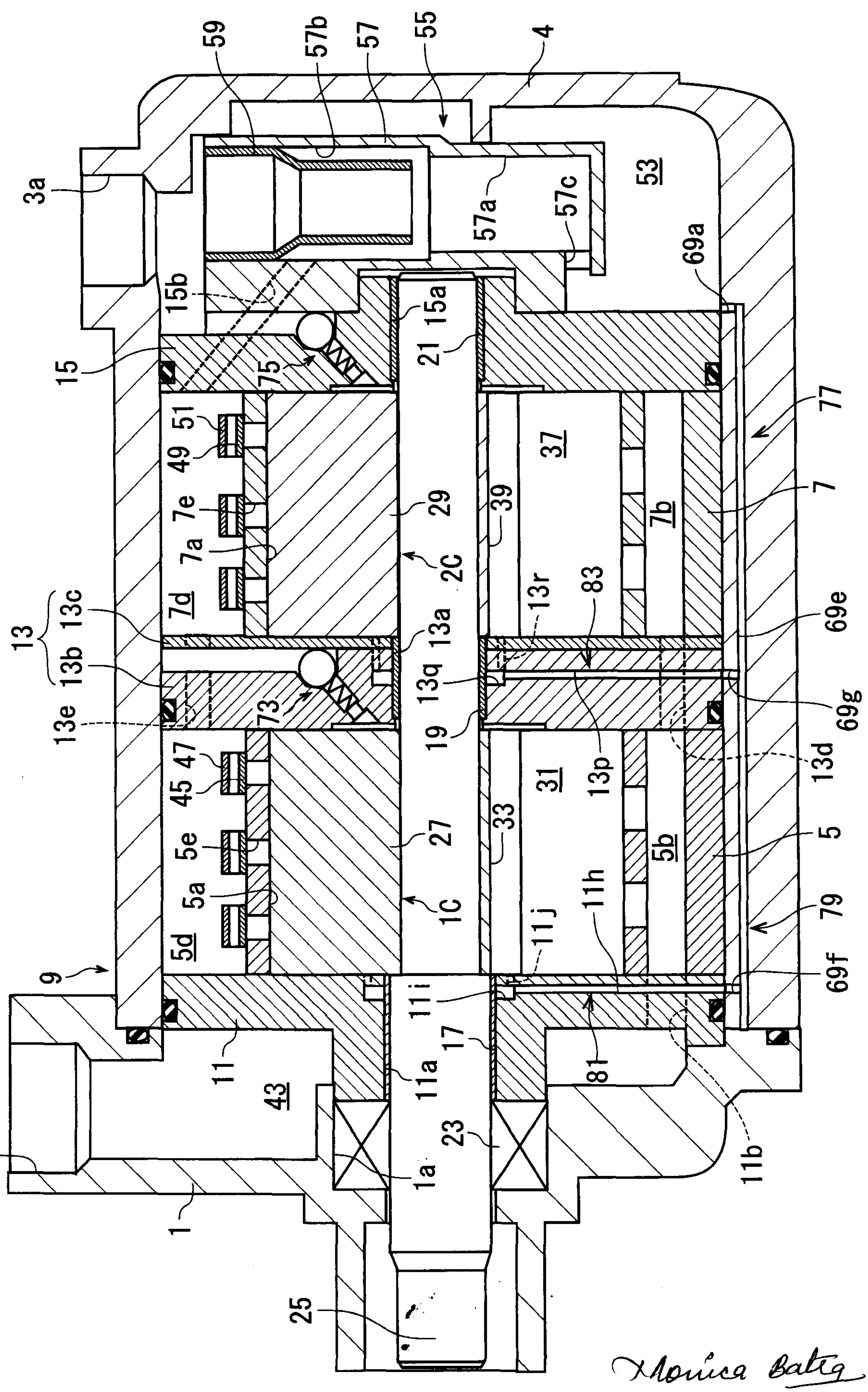

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Fig.6

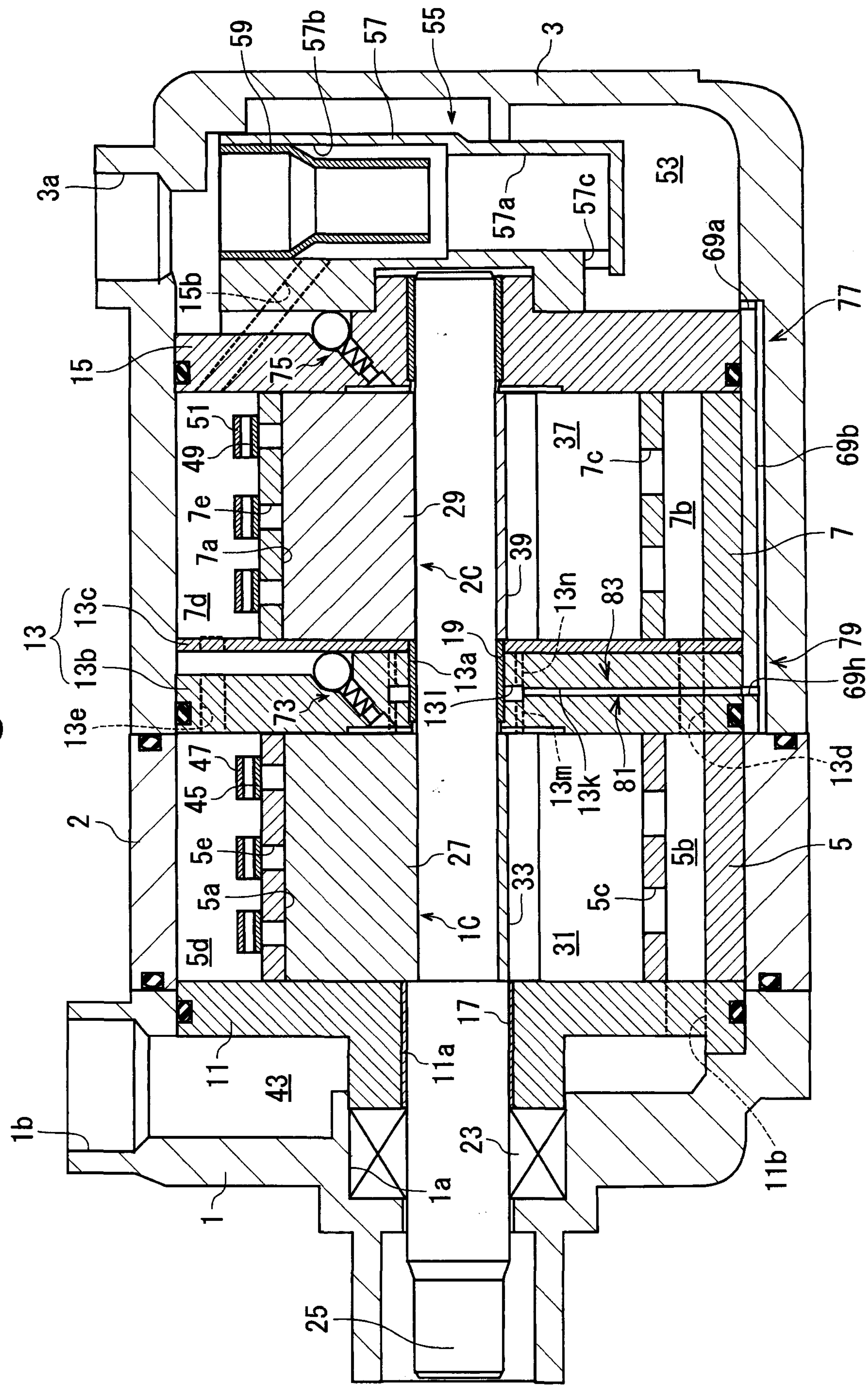

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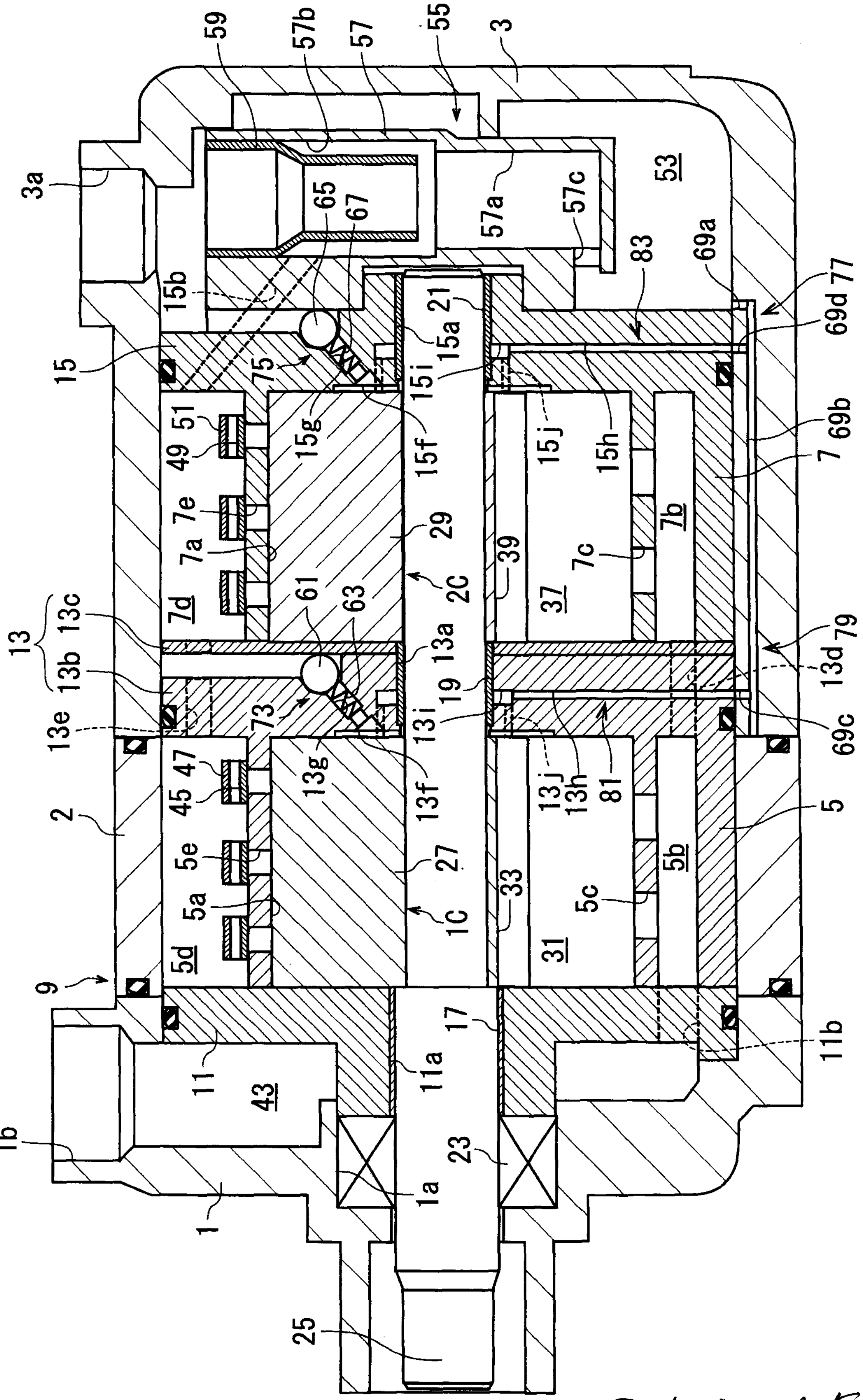
Fig.7



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TANDEM TYPE VANE COMPRESSOR

BACKGROUND OF THE INVENTION

The present invention relates to a tandem type vane compressor.

Japanese Laid-Open Patent Publication No. 59-90086, Japanese Laid-Open Patent Publication No. 58-144687, Japanese Laid-Open Utility Model publication No. 3-102086, Japanese Laid-Open Utility Model Publication No. 60-39793, and Japanese Laid-Open Utility Model Publication No. 3-118294 disclose conventional tandem type vane compressors. These tandem type vane compressors have a suction chamber, a discharge chamber, a compression chamber in a housing, and a rotationally-supported drive shaft. Further, in the housing, a plurality of compression mechanisms are coupled in tandem to perform a suction process, in which the compression chamber draws a low-pressure refrigerant gas from the suction chamber, a compression process, in which the refrigerant gas is compressed in the compression chamber, and a discharge process, in which the high-pressure refrigerant gas in the compression chamber is discharged to the discharge chamber.

Each compression mechanism includes a first compression mechanism and a second compression mechanism. The first compression mechanism includes a first cylinder chamber formed in the housing, and a first rotor arranged in the first cylinder chamber to be rotational by the drive shaft. A plurality of radially-extending primary vane grooves is formed in the first rotor. Further, the first compression mechanism includes primary vanes, which are arranged to be capable of projecting and retracting in respective primary vane grooves and form a primary compression chamber with the inner surface of the first cylinder chamber and the outer surface of the first rotor. The primary compression chamber is positioned at the front side.

Similar to the first compression mechanism, the second compression mechanism includes a second cylinder chamber formed in the housing, a second rotor, which is arranged in the second cylinder chamber and rotated by the drive shaft. A plurality of radially-extending secondary vane grooves is formed similarly in the second rotor. Further, the second compression mechanism similarly includes secondary vanes, which are arranged to be capable of projecting and retracting in respective secondary vane grooves and form a secondary compression chamber with the inner surface of the second cylinder chamber and the outer surface of the second rotor. The secondary compression chamber is positioned at the rear side.

In a case where these tandem type vane compressors are used in an air conditioning device of a vehicle and the like, the drive shaft is rotated and driven via an electromagnetic clutch, for example. Due to this, the first and second compression mechanisms are operated. That is, the first and second rotors rotate, and the primary and secondary compression chambers perform the suction process, the compression process, and the discharge process. Due to this, the refrigerant gas is drawn into the primary and secondary compression chambers from the suction chamber, is compressed in the primary and secondary compression chambers, and is discharged to the discharge chamber. The high-pressure refrigerant gas discharged to the discharge chamber is supplied to a refrigeration circuit of the air conditioning device.

Accordingly, in these tandem type vane compressors, since the primary and secondary compression chambers each perform the suction process, the compression process, and the discharge process, the discharge amount per rotation of the drive shaft can be increased.

Further, since the tandem type vane compressors may have the same shell diameter as the single-cylinder type vane compressors, they are relatively compact; that is, it is relatively easy to mount such compressors in a crowded engine compartment.

However, the conventional tandem type vane compressors as above are not configured to supply high-pressure lubricant oil to a primary backpressure chamber formed between the bottom surface of each primary vane and each primary vane groove and to a secondary backpressure chamber formed between the bottom surface of each secondary vane and each secondary vane groove. Thus, in the tandem type vane compressors, while the first and second compression mechanisms respectively perform the compression process and the discharge process, each of the primary and secondary vanes is not pressed against the inner surfaces of the first and second cylinder chambers. Therefore, the refrigerant gas may leak from the primary and secondary compression chambers. Due to this, it is difficult to reliably exhibit the high mechanical efficiency in the tandem type vane compressors.

Further, in the tandem type vane compressors, when the drive shaft is not rotated by the electromagnetic clutch, the refrigerant gas within the discharge chamber and the lubricant oil contained in the refrigerant gas to the compression chambers, so that the drive shaft may be rotated reversely. In this case, since an evaporator is heated by the high-temperature refrigerant gas flowing back to the suction side of the refrigerant circuit, the temperature of air flowing into the passenger compartment upon restarting the rotation of the drive shaft is increased. This causes a decrease in refrigerating efficiency. Further, a decrease in durability is caused by the occurrence of liquid compression when the compressor is started again. Noise also is generated upon the reverse rotation. Due to this, if an on-off valve is provided in the tandem type vane compressor, or a check valve is provided in the discharge chamber or the suction chamber, spaces for the on-off valve and the check valve need to be provided therein. This is likely to increase the size of the tandem type vane compressor.

An objective of the present invention is to provide a tandem type vane compressor that increases the discharge amount per rotation of a drive shaft, is reliably compact and efficient, and has good mounting characteristics.

SUMMARY OF THE INVENTION

To achieve the foregoing objective and in accordance with one aspect, a tandem type vane compressor is provided that includes a housing and a plurality of compression mechanisms. The housing has a suction chamber, a discharge chamber, and a plurality of compression chambers. The housing rotationally supports a drive shaft. The compression mechanisms include a first compression mechanism and a second compression mechanism, which are coupled to each other in tandem in the housing. The first and second compression mechanisms each have at least one of the compression chambers. Each compression mechanism is driven by rotation of the drive shaft to perform a suction process, in which each compression mechanism draws low-pressure refrigerant gas into the respective compression chamber from the suction chamber, a compression process, in which each compression mechanism compresses the refrigerant gas in the respective compression chamber, and a discharge process, in which each compression mechanism discharges the high-pressure refrigerant gas in the respective compression chamber to the discharge chamber. The first compression mechanism includes a first cylinder chamber, which is formed in the housing, a first rotor, which is provided in the first cylinder chamber to rotate when the drive shaft rotates, and a plurality of primary vanes. The first rotor has a plurality of radially extending primary vane grooves. Each primary vane is located in one of the primary vane grooves and is capable of projecting and retracting. The compression chamber of the first compression mechanism is defined by an inner surface of the first cylinder chamber, an outer surface of the first rotor, and the primary vanes. The compression chamber of the first compression mechanism is located at a position forward of the compression chamber of the second compression mechanism. The second compression mechanism includes a second cylinder chamber, which is formed in the housing, a second rotor, which is provided in the second cylinder chamber to rotate when the drive shaft rotates, and a plurality of secondary vanes. The second rotor has a plurality of radially extending secondary vane grooves. Each secondary vane is located in one of the secondary vane grooves and is capable of projecting and retracting. The compression chamber of the second compression mechanism is defined by an inner surface of the second cylinder chamber, an outer surface of the second rotor, and the secondary vanes. A bottom surface of each primary vane and the corresponding primary vane groove define a primary backpressure chamber. A bottom surface of each secondary vane and the corresponding secondary vane groove define a secondary backpressure chamber. The housing includes a shell having a suction inlet and a discharge outlet, which are connected to the outside, a first side plate, which is accommodated in the shell and defines, with the shell, the suction chamber such that the suction chamber communicates with the suction inlet, a second side plate, which is accommodated in the shell and partitions the first compression mechanism and the second compression mechanism from each other, a third side plate, which is accommodated in the shell and defines, with the shell, the discharge chamber such that the discharge chamber communicates with the discharge outlet, a first cylinder block, which is accommodated in the shell and forms the first cylinder chamber while being held between the first side plate and the second side plate, and a second cylinder block, which is accommodated in the shell while being held between the second plate and the third side plate, thereby forming the second cylinder chamber. The shell has a common passage, which extends in a longitudinal direction of the drive shaft to communicate with the discharge chamber. At least one of the first side plate and the second side plate has a first supplying passage, which connects the common passage with each primary backpressure chamber. At least one of the second side plate and the third side plate has a second supplying passage, which connects the common passage with each secondary backpressure chamber.

The tandem type vane compressor of the present invention has a structure in which high-pressure lubricant oil can be supplied to both of the primary backpressure chamber formed between the bottom surface of each primary vane and the corresponding primary vane groove and the secondary backpressure chamber formed between the bottom surface of each secondary vane and the corresponding secondary vane groove. That is, the high-pressure lubricant oil in the discharge chamber is supplied to the respective primary backpressure chambers via the common passage formed in the shell and the first supplying passage formed in at least one of the first side plate and the second side plate. Further, the high-pressure lubricant oil in the discharge chamber is supplied to the respective secondary backpressure chambers via the common passage formed in the shell and the second supplying passage formed in at least one of the second side plate and the third side plate.

Due to this, in the tandem type vane compressor, each of primary and secondary vanes is suitably pressed against the inner surfaces of first and second cylinder chambers while the first and second compression mechanisms respectively perform the compression process and the discharge process. As a result, leakage of the refrigerant gas from the primary and secondary compression chambers is reduced. Due to this, the tandem type vane compressor has high mechanical efficiency. Further, in the tandem type vane compressor, each primary backpressure chamber and each secondary backpressure chamber do not need to be connected to the discharge chamber separately. This reduces the production costs.

Thus, with the tandem type vane compressor, the discharge amount per rotation of the drive shaft is increased, and the compactness and efficiency are favorable.

Further, in the tandem type vane compressor of the invention, the arrangement of the passages for supplying backpressure is simplified by forming the common passage. This reduces the production costs.

In the tandem type vane compressor of the invention, the compression mechanisms may include another compression mechanism other than the first compression mechanism and the second compression mechanism. Further, the shell may be configured of a front housing member and a rear housing member. A cylindrical center housing member may be provided between the front housing member and the rear housing member.

Other aspects and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a cross-sectional view of a tandem type vane compressor of a first embodiment;

Fig. 2 is a cross-section view taken along line II-II of Fig. 1, illustrating the tandem type vane compressor of the first embodiment;

Fig. 3 is a cross-section view taken along line III-III of Fig. 1, illustrating the tandem type vane compressor of the first embodiment;

Fig. 4 is a cross-sectional view of a tandem type vane compressor of a second embodiment;

Fig. 5 is a cross-sectional view of a tandem type vane compressor of a third embodiment;

Fig. 6 is a cross-sectional view of a tandem type vane compressor of a fourth embodiment; and

Fig. 7 is a cross-sectional view of a tandem type vane compressor of a modification.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, first to fourth embodiments of the present invention will be described with reference to the drawings.

(First Embodiment)

As shown in Fig. 1, a tandem type vane compressor of the first embodiment has a first side plate 11, a first cylinder block 5, a second side plate 13, a second cylinder block 7, and a third side plate 15, which are fixed in a state of being housed in a front housing member 1, a center housing member 2, and a rear housing member 3, which are coupled to each other. The front housing member 1, the center housing member 2, and the rear housing member 3 form a shell 9. The diameter of the shell 9 is the same as that of a single-cylinder type vane compressor. Further, the first and second cylinder blocks 5, 7 have an identical outer shape.

As shown in Fig. 2 also, a first cylinder chamber 5a of elliptical shape in a direction orthogonal to the axis is formed in the first cylinder block 5. As shown in Fig. 3 also, a second cylinder chamber 7a having the identical shape as the first cylinder chamber 5a is formed in the second cylinder block 7. The first and second cylinder blocks 5, 7 are fixed such that the first and second cylinder chambers 5a, 7a have an identical phase.

As shown in Fig. 1, the first cylinder block 5 is housed in the shell 9 while being sandwiched by the first side plate 11 and the second side plate 13. The second side plate 13 is formed of a second side plate main body 13b positioned on the front side and a second side plate cover 13c positioned on the rear side of the second side plate main body 13b. Front and rear ends of the first cylinder chamber 5a are respectively closed by the first side plate 11 and the second side plate main body 13b.

Further, the second cylinder block 7 is housed in the shell 9 while being sandwiched by the second side plate cover 13c and the third side plate 15. Front and rear ends of the second cylinder chamber 7a are respectively closed by the second side plate cover 13c and the third side plate 15. The shell 9, the first and second cylinder blocks 5, 7, and the first to third side plates 11, 13, 15 correspond to a housing.

Axial holes 11a, 13a, 15a are formed respectively to extend through the first to third side plates 11, 13, 15, and slide bearings 17, 19, 21 are press-fitted into the respective axial holes 11a, 13a, 15a. An axial hole 1a is formed to extend through the front housing member 1 also, and a shaft sealing device 23 is press-fitted into the axial hole 1a. A drive shaft 25 is rotationally retained by the shaft sealing device 23 and the slide bearings 17, 19, 21. An electromagnetic clutch or pulley (neither is shown) is fixed to the distal end of the drive shaft 25 exposed from the front housing member 1. Driving force of an engine or a motor of a vehicle is configured to be transmitted to the electromagnetic clutch or pulley.

Further, first and second rotors 27, 29 having a circular cross section are press-fitted about the drive shaft 25. The first rotor 27 is arranged within the first cylinder chamber 5a, and the second rotor 29 is arranged within the second cylinder chamber 7a.

As shown in Fig. 2, five radially-extending primary vane grooves 27a are formed on the outer circumferential surface of the first rotor 27, and a primary vane 31 is housed in each primary vane groove 27a to be able to project and retract. A space between the bottom surface of each primary vane 31 and the corresponding primary vane groove 27a is a primary backpressure chamber 33. Five primary compression chambers 35 are each formed by two adjacent primary vanes 31, 31, the outer circumferential surface of the first rotor 27, the inner circumferential surface of the first cylinder block 5, the back surface of the first side plate 11, and the front surface of the second side plate main body 13b.

Further, as shown in Fig. 3, five radially-extending secondary vane grooves 29a are formed on an outer circumferential surface of the second rotor 29 also, and a secondary vane 37 is housed in each secondary vane groove 29a to be able to project and retract. A space between the bottom surface of each secondary vane 37 and a corresponding secondary vane groove 29a is a secondary backpressure chamber 39. Five secondary compression chambers 41 are each formed by two adjacent secondary vanes 37, 37, the outer circumferential surface of the second rotor 29, the inner circumferential surface of the second cylinder block 7, the back surface of the second side plate cover 13c, and the front surface of the third side plate 15.

The first rotor 27 and the second rotor 29 are identical components. Further, the primary vanes 31 and the secondary vanes 37 are identical components. These are employed in the single-cylinder type vane compressor.

As shown in Fig. 1, a suction chamber 43 is formed between the front housing member 1 and the first side plate 11. A suction inlet 1b for connecting the suction chamber 43 to the outside is opened upward in the front housing member 1. Two suction holes 11b for communicating with the suction chamber 43 are formed to extend through the first side plate 11, and each of the suction holes 11b communicates with a corresponding suction space 5b of the first cylinder block 5. As shown in Fig. 2, the respective suction spaces 5b are configured to communicate with the primary compression chambers 35 in a suction process through suction ports 5c.

Further, two discharge spaces 5d are formed between the first cylinder block 5 and the center housing member 2. The compression chambers 35 in a discharge process and the respective discharge spaces 5d are connected through discharge ports 5e. A discharge valve 45, which closes the discharge port 5e, and a retainer 47, which restricts the lifting amount of the discharge valve 45, are provided in each discharge space 5d. Components such as the drive shaft 25, the first cylinder block 5, the first rotor 27, the respective primary vanes 31, the discharge valves 45, and the retainers 47 configure a first compression mechanism 1C.

As shown in Fig. 1, two suction holes 13d for communicating with the respective suction spaces 5b of the first cylinder block 5 are formed to extend through the second side plate 13, and the suction holes 13d communicate with suction spaces 7b of the second cylinder block 7, respectively. As shown in Fig. 3, the respective suction spaces 7b are configured to communicate with the secondary compression chambers 41 in the suction process through suction ports 7c.

Further, as shown in Fig. 1, two discharge holes 13e for communicating with the respective discharge spaces 5d are formed to extend through the second side plate 13. Further, two discharge spaces 7d are formed between the second cylinder block 7 and the rear housing member 3. The discharge holes 13e communicate with the discharge spaces 7d, respectively. As shown in Fig. 3, the compression chambers 41 in the discharge process and the respective discharge spaces 7d communicate with each other through discharge ports 7e. A discharge valve 49, which closes the discharge port 7e, and a retainer 51, which restricts the lifting amount of the discharge valve 49, are provided in each discharge space 7d. A second compression mechanism 2C is configured by components such as the drive shaft 25, the second cylinder block 7, the second rotor 29, the respective secondary vanes 37, the discharge valve 49, and the retainer 51.

As shown in Fig. 1, two discharge holes 15b for communicating with the respective discharge spaces 7d are formed to extend through the third side plate 15. Further, a discharge chamber 53 is formed between the third side plate 15 and the rear housing member 3. In the discharge chamber 53, a centrifugal-type separator 55 is fixed by being sandwiched by the third side plate 15 and the rear housing member 3. The separator 55 is configured by an end frame 57 and a cylindrical member 59 fixed in the end frame 57 and extending in the up-down direction.

An oil separation chamber 57a extending in the up-down direction in a columnar shape is formed in the end frame 57. The cylindrical member 59 is press-fitted into the upper end of the oil separation chamber 57a. Due to this, a part of the oil separation chamber 57a functions as a guiding surface 57b that swirls the refrigerant gas around an outer circumferential surface of the cylindrical member 59. The discharge holes 15b opens to the space between the cylindrical member 59 and the guiding surface 57b. Further, a communication hole 57c is formed at the lower end of the end frame 57, which allows communication of the bottom surface of the oil separation chamber 57a with the discharge chamber 53. Further, a discharge outlet 3a for connecting the upper end of the discharge chamber 53 to the outside is formed in the rear housing member 3. The discharge outlet 3a is positioned above of the cylindrical member 59.

As shown in Figs. 1 and 2, a pair of oil drain grooves 13f of sectoral shape is formed at a front surface of the second side plate main body 13b. The respective drain grooves 13f are configured to communicate with primary backpressure chambers 33 in the suction process and the like by rotation of the first rotor 27. Further, as shown in Figs. 1 and 5, a valve chamber 13g for communicating between the discharge holes 13e and the respective drain grooves 13f is formed to extend through the second side plate main body 13b, and a ball-shaped valve body 61 is housed in the valve chamber 13g. The valve body 61 is urged in a direction that opens the valve chamber 13g by a spring 63 housed in the valve chamber 13g. The valve body 61 is prevented from escaping by the second side plate cover 13c. The drain grooves 13f, the valve chamber 13g, the valve body 61, and the spring 63 configure a first chatter preventing valve 73, which prevents chattering of the first compression mechanism 1C.

As shown in Figs. 1 and 3, a pair of oil drain grooves 15f of sectoral shape is formed at a front surface of the third side plate 15 also. The respective drain grooves 15f are configured to communicate with secondary backpressure chambers 39 in the suction process and the like by a rotation of the second rotor 29. Further, as shown in Fig. 1, a valve chamber 15g for communicating between the discharge chamber 53 and the respective oil drain grooves 15f is formed to extend through the third side plate 15, and a ball-shaped valve body 65 is housed in the valve chamber 15g also. The valve body 65 is urged in a direction that opens the valve chamber 15g by a spring 67 housed in the valve chamber 15g. The valve body 65 is prevented from escaping by the end frame 57 of the separator 55. The drain grooves 15f, the valve chamber 15g, the valve body 65, and the spring 67 configure a second chatter preventing valve 75, which prevents chattering of the second compression mechanism 2C.

The first rotor 27 and the second rotor 29 are fixed to the drive shaft 25 such that the primary and secondary vane grooves 27a, 29a, the drain grooves 13f, 15f, and the first and second chatter preventing valves 73, 75 have the same phase.

One primary upstream passage 13h is formed in the second side plate main body 13b to extend upward from the lower end.

Further, as shown in Fig. 2, an annular primary intermediate passage 13i, which surrounds the axial hole 13a is formed in the second side plate main body 13b. The upper end of the primary upstream passage 13h communicates with the primary intermediate passage 13i. Further, in the second side plate main body 13b, two primary downstream passages 13j for communicating with the primary intermediate passage 13i extend frontward in the axial direction. The respective primary downstream passages 13j are configured to communicate with the primary backpressure chambers 33 in the compression process and the discharge process by rotation of the first rotor 27.

Further, as shown in Fig. 1, one secondary upstream passage 15h is formed in the third side plate 15 to extend upward from the lower end. Further, as shown in Fig. 3 also, an annular secondary intermediate passage 15i, which surrounds the axial hole 15a, is formed in the third side plate 15. The upper end of the secondary upstream passage 15h communicates with the secondary intermediate passage 15i. Further, in the third side plate 15, two secondary downstream passages 15j for communicating with the secondary intermediate passage 15i extend frontward in the axial direction. The respective secondary downstream passages 15j are configured to communicate with the secondary backpressure chambers 39 in the compression process and the discharge process by rotation of the second rotor 29.

As shown in Fig. 1, in the rear housing member 3, a first passage 69a, which extends downward from the bottom of the discharge chamber 53, a second passage 69b, which communicates with the first passage 69a and extends in the front-rear direction (the longitudinal direction of the drive shaft 25), a third passage 69c, which connects the second passage 69b and the primary upstream passage 13h with each other, and a fourth passage 69d, which connects the second passage 69b and the secondary upstream passage 15h with each other, are formed. The first passage 69a and a part of the second passage 69b up to the branching position into the secondary upstream passage 15h form a common passage 77. The remainder of the second passage 69b forms a single passage 79 for communicating with the primary upstream passage 13h. The single passage 79, the third passage 69c, the primary upstream passage 13h, the primary intermediate passage 13i, and the primary downstream passages 13j form a first supplying passage 81. Further, the fourth passage 69d, the secondary upstream passage 15h, the secondary intermediate passage 15i and the secondary downstream passages 15j form a second supplying passage 83.

The drive shaft 25, the slide bearings 17, 19, 21, the first side plate 11, the first cylinder block 5, the respective primary vanes 31, the discharge valves 45, the retainers 47, the second side plate 13, the first chatter preventing valve 73, the second cylinder block 7, the respective secondary vanes 37, the discharge valve 49, the retainer 51, the third side plate 15, the second chatter preventing valve 75, and the separator 55 are assembled as a sub assembly SA.

An O-ring is attached to the sub assembly SA, another O-ring is attached to the center housing member 2, and the sub assembly SA is inserted into the rear housing member 3. Next, the center housing member 2 is brought into contact with the rear housing member 3, and the front housing member 1 is covered thereon. Further, a plurality of bolts 71 shown in Figs. 2 and 3 is tightened. Accordingly, the tandem type vane compressor of the first embodiment is assembled.

Although not shown, in this tandem type vane compressor, the discharge outlet 3a is connected to a condenser by a pipe, the condenser is connected to an expansion valve by a pipe, the expansion valve is connected to the evaporator by a pipe, and the evaporator is connected to the suction inlet 1b by a pipe. The tandem type vane compressor, the condenser, the expansion valve, the evaporator, and the pipes form a refrigeration circuit. The refrigeration circuit is part of an air conditioning device for a vehicle.

In the tandem type vane compressor, when the drive shaft 25 is driven by an engine and the like, the first and second compression mechanisms 1C, 2C respectively repeat the suction process, the compression process, and the discharge process.

That is, the first and second rotors 27, 29 rotate in synchrony with the drive shaft 25, and a volume change is generated in the primary and secondary compression chambers 35, 41. Due to this, the refrigerant gas from the evaporator is drawn into the suction chamber 43 through the suction inlet 1b. The refrigerant gas in the suction chamber 43 is drawn into the primary compression chambers 35 via the suction holes 11b, the suction spaces 5b, and the suction ports 5c. Further, the refrigerant gas in the suction spaces 5b is drawn into the secondary compression chambers 41 via the suction holes 13d, the suction spaces 7b, and the suction ports 7c.

Then, the refrigerant gas that has been compressed in the primary compression chambers 35 is discharged to the discharge spaces 5d via the discharge ports 5e. The high-pressure refrigerant gas in the discharge spaces 5d reaches the discharge spaces 7d via the discharge holes 13e. Further, the refrigerant gas that has been compressed in the secondary compression chambers 41 is discharged to the discharge spaces 7d via the discharge ports 7e. The high-pressure refrigerant gas in the discharge spaces 7d is discharged toward the guiding surface 57b of the separator 50 via the discharge holes 15b. Due to this, the refrigerant gas is circulated on the guiding surface 57b, and thereby the lubricant oil is centrifugally separated. Then, the refrigerant gas from which the lubricant oil has been separated is discharged toward the condenser from the discharge outlet 3a. Accordingly, in the tandem type vane compressor, a discharge amount per rotation of the drive shaft 25 is doubled compared to the single-cylinder type vane compressor.

Further, in the tandem type vane compressor, since respective ones of the primary and secondary vanes 31, 37 have a short axial length as employed in the single-cylinder type vane compressor, they are unlikely to be tilted with respect to the front-rear direction. Due to this, leakage of the refrigerant gas from the primary and secondary compression chambers 35, 41 is small, and the sliding characteristics of the respective ones of the primary and secondary vanes 31, 37 are excellent.

The lubricant oil that has been separated is stored in the discharge chamber 53 by being guided from inside the oil separation chamber 57a via the communication hole 57c. The lubricant oil in the discharge chamber 53 is supplied to the second passage 69b from the first passage 69a, due to the discharge chamber 53 being under a high pressure. The lubricant oil in the single passage 79 of the second passage 69b is supplied to the primary downstream passages 13j via the third passage 69c, the primary upstream passage 13h, and the primary intermediate passage 13i in the first compression mechanism 1C. Due to this, the high-pressure lubricant oil is supplied to the respective primary backpressure chambers 33 in the compression process and the discharge process.

Further, the lubricant oil in the second passage 69b flows from the common passage 77 into both of the single passage 79 and the fourth passage 69d. Then, the lubricant oil in the fourth passage 69d is supplied to the secondary downstream passages 15j via the secondary upstream passage 15h and the secondary intermediate passage 15i in the second compression mechanism 2C. Due to this, the high-pressure lubricant oil is supplied to the respective secondary backpressure chambers 39 in the compression process and the discharge process.

Due to this, in the tandem type vane compressor, while the first and second compression mechanisms 1C, 2C respectively perform the compression process, the respective primary and secondary vanes 31, 37 are suitably pressed against the inner surfaces of the first and second cylinder chambers 5a, 7a. Thus, leakage of the refrigerant gas from the primary and secondary compression chambers 35, 41 is small. Due to this, high mechanical efficiency is reliably exhibited. Further, in the tandem type vane compressor, since the respective primary backpressure chambers 33 and the respective secondary backpressure chambers 39 do not need to communicate with the discharge chamber 53 separately. Thus, the production costs are reduced.

Further, the above described tandem type vane compressor has the same shell diameter as the single cylinder type vane compressors, thus the mounting characteristics are excellent.

Notably, the lubricant oil supplied to the respective primary backpressure chambers 33 contributes for lubricating sliding parts between the primary vanes 31 and the primary vane grooves 27a, sliding parts between the first rotor 27 and each of the first side plate 11 and the second side plate main body 13b, sliding parts between the slide bearings 17, 19 and the drive shaft 25, and the like. Further, the lubricant oil supplied to the respective secondary backpressure chambers 39 contributes for lubricating sliding parts between the secondary vanes 37 and the secondary vane grooves 29a, sliding parts between the second rotor 29 and each of the second side plate cover 13c and the third side plate 15, sliding parts between the slide bearings 19, 21 and the drive shaft 25, and the like.

Thus, with the above described tandem type vane compressor, the discharge amount per rotation of the drive shaft 25 is increased, and the efficiency and size characteristics (compactness) are excellent.

Further, in the tandem type vane compressor, both of the first and second compression mechanisms 1C, 2C provide the backpressure at positions close to the discharge chamber 53. Due to this, the distance from the discharge chamber 53 to the backpressure chambers 33, 39 is short. This reduces the pressure loss. Further, since the second passage 69b is short, the number of manufacturing steps can also be reduced.

Moreover, in the tandem type vane compressor, the backpressure is unlikely to leak into the suction chamber 43. This reduces the power loss.

Further, in the tandem type vane compressor, a common component is used respectively for the first cylinder block 5 and the second cylinder block 7, for the first rotor 27 and the second rotor 29, and for the primary vanes 31 and the secondary vanes 37. The component commonality reduces production costs.

(Second Embodiment)

In a tandem type vane compressor of the second embodiment, as shown in Fig. 4, one primary upstream passage

11h is formed in a first side plate 11 to extend upward from the lower end. Further, an annular primary intermediate passage 11i, which surrounds an axial hole 11a, is formed in the first side plate 11. The upper end of the primary upstream passage 11h communicates with the primary intermediate passage 11i. Further, in the first side plate 11, two primary downstream passages 11j for communicating with the primary intermediate passage 11i extend rearward in an axial direction. The respective primary downstream passages 11j are configured to communicate with primary backpressure chambers 33 in a compression process and a discharge process by rotation of a first rotor 27.

Further, similar to the first embodiment, a secondary upstream passage 15h, a secondary intermediate passage 15i, and secondary downstream passages 15j are formed in a third side plate 15.

Further, a front housing member 1 and a rear housing member 4 define a shell 9. In the rear housing member 4, a first passage 69a similar to the first embodiment, a second passage 69e, which communicates with the first passage 69a and extends in the front-rear direction (the longitudinal direction of the drive shaft 25) longer than the second passage 69b of the first embodiment, a third passage 69f, which connects the second passage 69e and the primary upstream passage 11h with each other, and a fourth passage 69d, which connects the second passage 69e and the secondary upstream passage 15h with each other, are formed. The first passage 69a and a part of the second passage 69e up to the branching position to the secondary upstream passage 15h form a common passage 77. The remainder of the second passage 69e is a single passage 79 for communicating with the primary upstream passage 11h. The single passage 79, the third passage 69f, the primary upstream passage 11h, the primary intermediate passage 11i, and the primary downstream passages 11j form a first supplying passage 81. Further, similar to the first embodiment, the fourth passage 69d, the secondary upstream passage 15h, the secondary intermediate passage 15i and the secondary downstream passages 15j form a second supplying passage 83.

Other configuration is similar to the first embodiment. Due to this, as for the components similar to the first embodiment, same reference numerals as the first embodiment will be given, and a detailed description thereof will be omitted.

In the tandem type vane compressor, since a backpressure is supplied from the front side to the primary backpressure chambers 33 positioned on the front side, and is supplied from a rear side to the secondary backpressure chambers 39 positioned on the rear side, the backpressure can easily be exerted onto primary and secondary vanes 31, 37 with good balance. Due to this, the primary and secondary vanes 31, 37 are unlikely to tilt within the primary and secondary vane grooves 27a, 29a upon starting. Thus, a smooth start-up can be expected.

Further, in the tandem type vane compressor, since a drive shaft 25 can be supported by a reaction of the backpressure at the front and rear sides spaced by a large spacing, the long drive shaft 25 can be expected to be rotated with low vibration. Further, in the tandem type vane compressor, lubricant oil can easily be supplied to a slide bearing 17 on the front side. Thus, the rotation of the drive shaft 25 is likely to be smooth. Other advantages are similar to the first embodiment.

(Third Embodiment)

In a tandem type vane compressor of the third embodiment, as shown in Fig. 5, one secondary upstream passage 13p is formed in a second side plate 13 to extend upward from the lower end. Further, an annular secondary intermediate passage 13q, which surrounds an axial hole 13a, is formed in the second side plate 13. The upstream end of the secondary upstream passage 13p communicates with the secondary intermediate passage 13q. Further, in the second side plate 13, two secondary downstream passages 13r for communicating with the secondary intermediate passage 13q extend rearward in an axial direction. The respective secondary downstream passages 13r are configured to communicate with secondary backpressure chambers 39 in a compression process and a discharge process by rotation of a second rotor 29.

Further, similar to the second embodiment, a first supplying passage configured of a primary upstream passage 11h, a primary intermediate passage 11i, and a primary downstream passage 11j is formed in a first side plate 11.

Further, similar to the second embodiment, a front housing member 1 and a rear housing member 4 define a shell 9. In the rear housing member 4, a first passage 69a similar to the first embodiment, a second passage 69e, which communicates with the first passage 69a and extends long in the front-rear direction (the longitudinal direction of the drive shaft 25), a third passage 69f, which connects the second passage 69e and the primary upstream passage 11h with each other, and a fourth passage 69g, which connects the second passage 69e and the secondary upstream passage 13p with each other, are formed. The first passage 69a and a part of the second passage 69e up to a branching position into the secondary upstream passage 13p form a common passage 77. The remainder of the second passage 69e is a single passage 79 for communicating with the primary upstream passage 11h. Similar to the second embodiment, the single passage 79, the third passage 69f, the primary upstream passage 11h, the primary intermediate passage 11i, and the primary downstream passages 11j form a first supplying passage 81. Further, the fourth passage 69g, the secondary upstream passage 13p, the secondary intermediate passage 13q and the secondary downstream passage 13r form a second supplying passage 83.

Other configuration is similar to the first and second embodiments. Due to this, as for the components similar to the first and second embodiments, same reference numerals as the first and second embodiments will be given, and a detailed description thereof will be omitted.

In the tandem type vane compressor, lubricant oil can easily be supplied to a slide bearing 17 on the front side, and thereby rotation of a drive shaft 25 is likely to be smooth. Other advantages are similar to the first embodiment.

(Fourth Embodiment)

In a tandem type vane compressor of the fourth embodiment, as shown in Fig. 6, one upstream passage 13k is formed in a second side plate 13 to extend upward from the lower end. Further, an annular intermediate passage 13l, which surrounds an axial hole 13a, is formed in the second side plate 13. The upstream end of the upstream passage 13k communicates with the intermediate passage 13l. Further, in the second side plate 13, two primary downstream passages 13m for communicating with the intermediate passage 13l extend frontward in an axial direction, and two secondary downstream passages 13n for communicating with the intermediate passage 13l extend rearward in the axial direction. The respective primary downstream passages 13m are configured to communicate with primary backpressure chambers 33 in a compression process and a discharge process by rotation of a first rotor 27. Further, the respective secondary downstream passages 13n are configured to communicate with secondary backpressure chambers 39 in the compression process and the discharge process by rotation of a second rotor 29.

Further, similar to the first embodiment, a front housing member 1, a center housing 2, and a rear housing member 3 define a shell 9. In the rear housing member 3, a first passage 69a similar to the first embodiment, a second passage 69b similar to the first embodiment, and a third passage 69h for communicating between the second passage 69b and the upstream passage 13k are formed. The first passage 69a and the second passage 69b are a common passage 77. The second passage 69b extends in the longitudinal direction of the drive shaft 25. The third passage 69h, the upstream passage 13k, the intermediate passage 13l, and the primary downstream passages 13m form a first supplying passage 81. Further, the third passage 69h, the upstream passage 13k, the intermediate passage 13l, and the secondary downstream passages 13n form a second supplying passage 83.

Other configuration is similar to the first embodiment. Due to this, as for the components similar to the first embodiment, same reference numerals as the first embodiment will be given, and a detailed description thereof will be omitted.

In the tandem type vane compressor, a number of manufacturing steps can be reduced since only the upstream passage 13k and the like have to be formed in the second side plate 13. Other advantages are similar to the first embodiment.

Note that, in the tandem type vane compressor, the upstream passage 13k and the intermediate passage 131 can be regarded as a common passage.

In the above, the invention has been described with reference to the first to fourth embodiments, the invention is not limited to the above first to fourth embodiments, and can be adapted by being suitably modified within the scope of the invention.

For example, the shape of the housing is not limited to those in the first to fourth embodiments. For example, as shown in Fig. 7, one of first and second side plates 11, 13 may be integrated with a first cylinder block 5, and one of second and third side plates 13, 15 may be integrated with a second cylinder block 7. A common passage, a first supplying passage, and a second supplying passage may be similar to those in Figs. 4 to 6.

In the tandem type vane compressors of the first, third, and fourth embodiments, the discharge chamber 53 may be connected with the primary and secondary upstream passages 13h, 13p and the upstream passage 13k by causing the shell 9 to be bulged and a lower portion of the discharge chamber 53 to extend to the position of the second side plate 13.

A third compression mechanism may be provided in addition to the first compression mechanism 1C and the second compression mechanism 2C.

Further, although the first compression mechanism 1C and the second compression mechanism 2C are operated under the same phase in the first to fourth embodiments, the first compression mechanism 1C and the second compression mechanism 2C may be operated under different phases depending on a purpose, such as reducing a discharge pulsation.

Further, the refrigerant gas compressed by the first compression mechanism 1C may be drawn into the second compression mechanism 2C and further compressed by the second compression mechanism 2C, providing multiple level compression.

Further, the second side plate 13 may be configured without the second side plate cover 13c, and the valve body 61 of the chatter preventing valve 73 may be retained by the second rotor 29.

By changing a passage diameter depending on a position of the common passage, lubricant oil can optimally be supplied to the primary and secondary backpressure chambers and the like.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.