A scroll type compressor includes a fixed scroll member, a movable scroll member, an inlet, a discharge port, a discharge valve, a first pressure region and a second pressure region. The inlet is formed through the fixed scroll base plate. The discharge port is formed through the movable scroll member. The discharge valve opens and closes the discharge port. The first pressure region and the second pressure region defined at opposite sides of the movable scroll member apply pressure to the movable scroll member. Gas introduced through the inlet is compressed and highly pressurized in accordance with the movable scroll member orbiting with respect to the fixed scroll member. The highly pressurized gas is discharged from a compression region via the discharge port and the discharge valve. The compressor is provided with a communication passage so as to intercommunicate the first pressure region and the second pressure region during a predetermined period of a compression cycle established by the gas. The gas is flowed between both the pressure regions due to a pressure difference between both pressure regions at timing when the thrust force acting on the back surface of the movable scroll member is large.
Fig. 4

ORBIT ANGLE OF A MOVABLE SCROLL MEMBER

Fig. 5

COMMUNICATING WITH INTERMEDIATE PRESSURE CHAMBER

COMPRESSION CURVE IN A COMPRESSION CHAMBER
Fig. 7

Fig. 8
Fig. 9

HIGH COMPRESSION

COMMUNICATING WITH INTERMEDIATE PRESSURE CHAMBER

DISCOMMUNICATING WITH INTERMEDIATE PRESSURE CHAMBER

LOW ORBIT ANGLE

360°

COMPRESSION CURVE IN A COMPRESSION CHAMBER

Fig. 10

HIGH COMPRESSION

COMMUNICATING WITH INTERMEDIATE PRESSURE CHAMBER

DISCOMMUNICATING WITH INTERMEDIATE PRESSURE CHAMBER

LOW ORBIT ANGLE

360°

COMPRESSION CURVE IN A COMPRESSION CHAMBER
**Fig. 14**

Orbit Angle of a Movable Scroll Member

**Fig. 15**

Compression Curve in a Compression Chamber
SCROLL TYPE COMPRESSOR AND METHOD FOR COMpressing GAS

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a scroll type compressor that is a type of a rotary compressor. More particularly, the present invention relates to a device and a method for compressing gas.

[0002] Japanese Unexamined Patent Publication No. 6-280757 discloses a general scroll type compressor. This scroll type compressor compresses refrigerant gas by reducing the volume of the compression chamber as a movable scroll member orbits with respect to a fixed scroll member. An inlet for introducing the refrigerant gas into the compression chamber is formed through a fixed scroll base plate. A movable scroll base plate is provided with a discharge port and a reed-type discharge valve for discharging compressed refrigerant gas at an innermost compression chamber whose volume is the smallest. Further, a crank shaft is coupled to a drive shaft of the movable scroll member, and a bearing member is disposed at a sliding surface between a bushing (at a rotary shaft side) fitted to the crank shaft and a boss of the movable scroll member.

[0003] An unwanted effect of the above-mentioned scroll type compressor is that part of the compressed refrigerant gas discharged from a discharge valve tends to leak between the bushing and the boss, passes through a clearance between the movable scroll member and a housing, and then to an inlet side of the compressor (into a high pressure region). To prevent the refrigerant gas from leaking, various kinds of seal members are disposed between the high pressure region and the low pressure region. Nevertheless, such leakage cannot completely be prevented. This refrigerant gas leakage causes the thrust force acting on a back surface of the movable scroll member to fluctuate and various kinds of problems arise. For example, as the thrust force increases, the force pressing the movable scroll member against the fixed scroll member also increases, with a consequent in deterioration of the durability of the movable scroll member and increased loss of power. On the other hand, a reduction of the thrust force weakens the force pressing the movable scroll member against the fixed scroll member, and tends to increase the amount of refrigerant gas leaking into the low pressure region from the high pressure region.

[0004] The present invention addresses the above-mentioned problems traceable to thrust variations by reducing the fluctuation of thrust force due to variations in the gas pressure differences between the high and low pressure regions in the compressor.

SUMMARY OF THE INVENTION

[0005] In accordance with the present invention, regions of relatively higher and lower pressure within the compressor are intercommunicated through a communication passage during a predetermined period of the compression cycle established by the gas, which permits the gas to flow from the region of relatively higher pressure to the region of relatively lower pressure at predetermined timing due to a pressure difference between the regions. Thereby, the thrust force acting on the movable scroll member can be regulated. Meantime, only if the thrust force acting on the movable scroll member can be changed by moving the gas from the region of relatively higher pressure to the region of relatively lower pressure, various kinds of structure can be selected. For example, a first pressure region and a second pressure region may be defined at opposite sides of the movable scroll member, and are the regions of relatively higher and lower pressure. Both regions may be defined in the vicinity of the back surface of the movable scroll member as well. “Gas” includes not only refrigerant gas used in refrigerators and air-conditioners but also various kinds of gas.

[0006] According to the above-mentioned scroll type compressor in the present invention, the first pressure region and the second pressure region are intercommunicated via a communication passage during the predetermined period. Thereby, the fluctuation of the thrust force acting on the movable scroll member can be prevented as much as possible.

[0007] Furthermore, according to the scroll type compressor in the present invention, the first pressure region is a compression region defined between the fixed and movable scroll members, while the second pressure region is a backside region defined in the vicinity of the back surface of the movable scroll member. Moreover, an intermediate pressure region is defined as a high pressure region and a low pressure region in the backside region. Namely, the gas compressed in the compression region is discharged through a discharge port and a discharge valve, the gas discharged from the compression region flows from the high pressure region to the intermediate pressure region, and flows from the intermediate pressure region to the low pressure region. Meanwhile, the compression region and the intermediate pressure region are intercommunicated via the communication passage, which is formed through the movable scroll member during the predetermined period, which permits the gas to flow between the compression region and the intermediate pressure region. Consequently, the thrust force acting on the back surface of the movable scroll member is regulated by moving the gas. For example, the gas in the intermediate pressure region is transferred to the compression region via the communication passage when the thrust force acting on the back surface of the movable scroll member is large. Also, the gas in the compression region is transferred to the intermediate pressure region when the thrust force is small. Thereby, the fluctuation of the thrust force can be prevented as much as possible.

[0008] According to the above-mentioned scroll type compressor in the present invention, the compression region and the intermediate pressure region are intercommunicated during the predetermined period. Thereby, the fluctuation of the thrust force acting on the back surface of the movable scroll member can be prevented as much as possible.

[0009] Preferably, the communication passage is formed through the movable scroll member, which simplifies the structure of the compressor and permits the gas to flow via the passage.

[0010] Furthermore, according to the scroll type compressor in the present invention, the communication passage is designed to intercommunicate the compression region and the intermediate pressure region continuously during the predetermined period, which permits to flow the gas effectively between the compression region and the intermediate pressure region.
Therefore, refrigerant gas in the intermediate pressure chamber is transferred to the compression region due to the pressure difference between the pressure in the compression region and the pressure in the intermediate pressure region at timing when the pressure difference is the largest. Therefore, the thrust force acting on the back surface of the movable scroll member can be reduced.

Consequently, according to the scroll type compressor in the present invention, the compression region and the intermediate pressure region are intercommunicated during the predetermined period. Therefore, the fluctuation of the thrust force acting on the back surface of the movable scroll member can be reduced as much as possible.

Furthermore, according to the scroll type compressor in the present invention, during the predetermined period the communication passage moves between a first position where the compression region and the intermediate pressure region are intercommunicated via the passage and a second position where the communication passage is shut by a seal member. Namely, the gas may flow between the compression region and the intermediate pressure region when the compression region and the intermediate pressure region are intercommunicated via the communication passage. The gas may be stopped flowing between the compression region and the intermediate pressure region when the communication passage is shut by the seal member.

Therefore, when the gas flows from the intermediate pressure region to the compression region via the communication passage due to the pressure difference between the regions, the communication passage is shut by the seal member on the way. Thereby, the thrust force acting on the back surface of the movable scroll member can be prevented from reducing. Meantime, when the pressure in the compression region increases, the communication passage is shut by the seal member on the way. Therefore, a peak of the thrust force acting on the back surface of the movable scroll member is restrained.

Consequently, according to the scroll type compressor in the present invention, oscillation of the thrust force acting on the back surface of the movable scroll member can be diminished.

Furthermore, according to the scroll type compressor in the present invention, during the predetermined period the communication passage moves among the first position where the compression region and the intermediate pressure region are intercommunicated via the passage, the second position where the communication passage is shut by the seal member and a third position where the compression region and the low pressure region are intercommunicated via the passage. Namely, the gas flows between the compression region and the intermediate pressure region when the compression region and the intermediate pressure region are intercommunicated via the communication passage. The gas is stopped flowing between the compression region and the intermediate pressure region when the communication passage is shut by the seal member. Further, the gas flows between the compression region and the low pressure region when the compression region and the low pressure region are intercommunicated via the communication passage.

Therefore, when the pressure in the compression region increases, the communication passage is shut by the seal member and the communication between the compression region and the intermediate pressure region is blocked on the way. Thereby, a peak of the thrust force acting on the back surface of the movable scroll member is restrained. Further, the compression region and the low pressure region are intercommunicated via the communication passage at timing except when the pressure in the compression region increases. Therefore, the thrust force acting on the back surface of the movable scroll member is restrained from increasing.

Consequently, according to the scroll type compressor in the present invention, the thrust force acting on the back surface of the movable scroll member can be maintained at a certain level.

According to a method for compressing gas in the present invention, the step of intercommunicating the first pressure region and the second pressure region is executed during the predetermined period of the compression cycle established by the gas. Thereby, the fluctuation of the thrust force acting on the movable scroll member can be prevented as much as possible.

Furthermore, according to the method for compressing gas in the present invention, the steps of continuously intercommunicating the first pressure region and the second pressure region are executed during the predetermined period. Thereby, the fluctuation of the thrust force acting on the movable scroll member can be prevented as much as possible.

Furthermore, according to the method for compressing gas in the present invention, the steps of intercommunicating the compression region and the intermediate pressure region, and shutting the communication passage by the seal member are executed at predetermined timing. Therefore, the oscillation of the thrust force acting on the movable scroll member can be diminished as much as possible.

Furthermore, according to the method for compressing gas in the present invention, the steps of intercommunicating the compression region and the intermediate pressure region, shutting the communication passage by the seal member, and intercommunicating the compression region and the low pressure region are executed at predetermined timing. Thereby, the thrust force acting on the movable scroll member can be maintained at a certain level.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. 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 longitudinal sectional view of a whole scroll type compressor according to a first embodiment of the present invention;
[0026] FIG. 2 is a cross-sectional view of a scroll type compressor illustrating the state of a compression chamber at the commencement of communication of the compression chamber with a communication passage;

[0027] FIG. 3 is a cross-sectional view of a scroll type compressor illustrating the state of the compression chamber at the conclusion of communication of the compression chamber with the passage;

[0028] FIG. 4 is a figure showing thrust force as a function of an orbital angle of a movable scroll member according to the first embodiment of the present invention;

[0029] FIG. 5 is a figure showing timing that a compression chamber and an intermediate pressure chamber are intercommunicated according to the first embodiment of the present invention;

[0030] FIG. 6 is a longitudinal sectional view of a scroll type compressor according to second and third embodiments of the present invention;

[0031] FIG. 7 is a figure showing thrust force as a function of an orbital angle of a movable scroll member according to the second embodiment of the present invention;

[0032] FIG. 8 is a figure showing thrust force as a function of an orbital angle of a movable scroll member according to the third embodiment of the present invention;

[0033] FIG. 9 is a figure showing timing that a compression chamber and an intermediate pressure chamber are intercommunicated according to the second embodiment of the present invention;

[0034] FIG. 10 is a figure showing timing that a compression chamber and an intermediate pressure chamber are intercommunicated according to the third embodiment of the present invention;

[0035] FIG. 11 is a longitudinal sectional view of a scroll type compressor according to a fourth embodiment of the present invention;

[0036] FIG. 12 is a cross-sectional view of a scroll type compressor illustrating a state of a compression chamber communicating with an intermediate pressure chamber;

[0037] FIG. 13 is an enlarged cross-sectional view of FIG. 12, with part cut away;

[0038] FIG. 14 is a figure showing thrust force as a function of an orbital angle of a movable scroll member according to the fourth embodiment of the present invention;

[0039] FIG. 15 is a figure showing timing that a compression chamber and an intermediate pressure chamber are intercommunicated, and showing timing that a compression chamber and a low pressure chamber are intercommunicated according to the fourth embodiment of the present invention;

[0040] FIG. 16 is a longitudinal sectional view of a scroll type compressor illustrating a flap valve according to the present invention;

[0041] FIG. 17 is an enlarged longitudinal sectional view of FIG. 16, with part cut away; and

[0042] FIG. 18 is a longitudinal sectional view of a scroll type compressor illustrating a plurality of communication passages according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0043] First through fourth embodiments of the present invention will be described as follows with reference to FIGS. 1 through 18. The present embodiments applied the present invention to a scroll type compressor which compresses refrigerant gas closed in a compression chamber defined between a fixed scroll member and a movable scroll member and discharges the refrigerant gas compressed therein.

[0044] [First Embodiment]

[0045] A scroll type compressor according to the first embodiment of the present invention will be described with reference to FIGS. 1 through 5. FIG. 1 is a longitudinal sectional view illustrating the whole scroll type compressor according to the first embodiment. FIG. 2 is a cross-sectional view of the scroll type compressor illustrating a state of the compression chamber at the commencement of communication of the compression chamber with a communication passage. Also, FIG. 3 is a cross-sectional view of the scroll type compressor illustrating a state of the compression chamber at the conclusion of communication of the compression chamber with the passage. FIG. 4 is a figure showing thrust force as a function of an orbital angle of the movable scroll member according to the first embodiment of the present invention. FIG. 5 is a figure showing timing that the compression chamber and the intermediate pressure chamber are intercommunicated according to the first embodiment of the present invention.

[0046] Furthermore, the first embodiment of a scroll type compressor, a compression chamber 32 as a first pressure region and a backside region as a second pressure region are defined in a housing. A backside region is constituted of a high pressure chamber 70 as a high pressure region, an intermediate pressure chamber 77 as an intermediate pressure region and a low pressure chamber 78 as a low pressure region. The compression chamber 32 and an intermediate low pressure chamber 77 are designed to be intercommunicated via a communication passage 60 formed through a movable scroll base plate 24 during a predetermined period of the compression cycle established by the refrigerant gas in the compression chamber 32. Thereby, fluctuation of thrust force generated by the refrigerant gas acting on a back surface of the movable scroll base plate 24 is reduced.

[0047] As shown in FIG. 1, a movable scroll member 20 and its drive mechanism are sealingly accommodated in a housing of a scroll type compressor 1, and the housing is constituted of a fixed scroll member 2, a center housing 4 and a motor housing 6. The center housing 4 is coupled to the fixed scroll member 2 at its front end, and is coupled to the motor housing 6 at its rear end. A drive shaft 8 is rotatably supported by both the center housing 4 and the motor housing 6 via radial bearings 10, 12, and a crank shaft 14 axially offset from the axis of the drive shaft 8 is integrally formed at the front end of the drive shaft 8. The fixed scroll member 2 has a fixed scroll wall 28 extending from the surface of a fixed scroll base plate 26. Likewise, the movable scroll member 20 has a scroll wall 30 extending from the front surface of the disk-shaped movable scroll base plate 24. The scroll walls 28, 30 are arranged so as to be engaged with each other. A scroll tip seal 28a occupies a
groove in the end surface of the fixed scroll wall 28, and a scroll tip seal 30\(x\) occupies a groove in the end surface of the movable scroll wall 30.

[0048] The base plate 26 and spiral wall 28 of the fixed scroll member 2 and the base plate 24 and spiral wall 30 of the movable scroll member 20 form cooperatively compression chambers 32 defined between the scroll walls. The respective walls of the fixed and movable scroll members are aligned to engage on mesh with each other. The movable scroll member 20 orbits (orbital motion) in accordance with the orbital motion of the crank shaft 14, creating traveling points of contact between the two walls. As the movable scroll member 20 orbits, the volumes of the compression chambers 32 are progressively reduced, thus compressing the gas trapped in the volumes between the scroll walls 28, 30. A balance weight 18 cancels centrifugal force generated by orbital motion of the movable scroll member 20. Orbiting mechanism is constituted of the crank shaft 14 which integrally rotates with the drive shaft 8, a bushing 16, and a plane bearing 22 which is interposed between the crank shaft 14 and a boss 24\(x\) of the movable scroll member 20.

[0049] Two mutually parallel planes (a pair of planes) 14\(a\) are formed on a circumferential surface of the crank shaft 14, and the crank shaft 14 is fitted in the bushing 16 so that the bushing 16 can integrally rotate with the crank shaft 14 through the planes. The balance weight 18 is coupled to the rear end of the bushing 16 so as to rotate integrally with the bushing 16, while the movable scroll member 20 is coupled to the bushing 16 so as to face the fixed scroll member 2 so that the movable scroll member 20 can relatively rotate with the bushing 16 via the plane bearing 22. Also, the plane bearing 22 is accommodated in a cylindrical boss 24\(a\) which is formed on the back surface (right hand in FIG. 1) of the base plate 24 of the movable scroll member 20 so as to protrude therefrom.

[0050] This plane bearing 22 functions not only as a bearing but also as a seal. In other words, the plane bearing 22 functions so as to prevent the refrigerant gas from leaking from the high pressure chamber 70 into the rest of the backside region adjacent to the back surface of the movable scroll base plate 24 via a clearance between the movable scroll member 20 and the center housing 4 as much as possible.

[0051] An annular seal 80 is arranged at the front end of the center housing 4 (at an annular recess) facing to the movable scroll base plate 24. The refrigerant gas leaks from the high pressure chamber 70 into the rest of the backside region adjacent to the back surface of the movable scroll base plate 24, and the rest of the backside region is divided into an intermediate pressure chamber 77 and a low pressure chamber. Also, the low pressure chamber 78 communicates with an inlet side. Accordingly, the refrigerant gas in the high pressure chamber 70 leaks into the rest of the backside region adjacent to the back surface of the movable scroll base plate 24 by way of the intermediate pressure chamber 77 and the low pressure chamber 78 in order. Besides, the plane bearing 22 having a seal function is disposed between the high pressure chamber 70 and the intermediate pressure chamber 77 so as to define the chambers 70, 77, and the seal 80 is disposed between the intermediate pressure chamber 77 and the low pressure chamber 78 so as to define the chambers 77, 78. Therefore, sealing efficiency is reinforced and the amount of the refrigerant gas leaking into the rest of the backside region adjacent to the back surface of the movable scroll base plate 24 is reduced.

[0052] A reed-type discharge valve mechanism 52, which opens and closes a discharge port 50, is affixed to the movable scroll base plate 24 at its back surface (an opposed surface relative to the crank shaft 14). This discharge valve mechanism 52\(15\) has a reed valve 54 at the discharge port 50, a retainer 56 supporting the reed valve 54 and a bolt 58 fixing the reed valve 54 and the retainer 56 to the movable scroll base plate 24, and is accommodated in a discharge valve chamber 25 which is bored at the back surface of the movable scroll base plate 24.

[0053] The reed valve 54 opens and closes due to a pressure difference between the compression chamber 32 and the intermediate pressure chamber 77. Namely, when the pressure in the compression chamber 32 is greater than the pressure in the high pressure chamber 70, the reed valve 54 opens. When the pressure in the compression chamber 32 is lower than the pressure in the high pressure chamber 70, the reed valve 54 closes. Also, the retainer 56 is not only designed to retain the reed valve 54 but also designed to regulate the maximum opening amount of the reed valve 54.

[0054] As shown in FIGS. 1 through 3, a communication passage 60, which intercommunicates the compression chamber 32 and the intermediate pressure chamber 77, is formed through the base plate 24 of the movable scroll member 20 which orbits with respect to the fixed scroll member 2 (the center of which is 2\(a\)). The communication passage 60 intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 until the refrigerant gas enclosed in the compression chamber 32, or the compression chamber 32, one of the compression chambers is compressed from a state shown in FIG. 2 (at the commencement of communication of the compression chamber 32 with the communication passage 60) to a state shown in FIG. 3 (at the conclusion of communication of the compression chamber 32 with the communication passage 60). That is, as shown in FIG. 5, the compression chamber 32 and the intermediate pressure chamber 77 are preferably designed to be continuously intercommunicated during a complete orbit of the movable scroll member 20 (360 degrees) (corresponding to the predetermined period according to the present invention) in a compression cycle established by the refrigerant gas is compressed in the compression chamber 32. Also, the communication passage 60 describes a locus of rotation P1 (A1 → B1 → C1 → D1) during a complete orbit of the movable scroll member 20 as shown in FIG. 4.

[0055] FIGS. 2 and 3 show the range of the orbital angles during which the compression chamber 32 communicates with the communication passage 60. Substantially, the range is less than 360 degrees because the fixed scroll wall 28 blocks the communication passage 60, but as a matter of convenience, in the present embodiment (FIGS. 4 and 5, etc.), a period during which the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated via the communication passage 60 may be described as a period during which the movable scroll member 20 and the communication passage 60 orbit 360 degrees with respect to the fixed scroll member 2.
A plurality of concave portions 41 (e.g. four concave portions) is formed in an equiangular position on an identical circumference of the front end surface of the center housing 4. Movably pins 40 fixed to the movable scroll base plate 24 are loosely fitted into the associated concave portions so that the movable pins can contact with fixed pins 42 fixed to the center housing 4. The concave portions 41, the movable pins 40 and the fixed pins 42 prevent the movable scroll member 20 from rotating. The movable scroll member 20 is prevented from rotating by the concave portions 41, the fixed pins 42 and the movable pins 40 even if the crank shaft 14 rotates. Namely, rotation preventing mechanism is constituted of the concave portions 41, the fixed pins 42 and the movable pins 40.

A stator 46 is fixed on an inner circumferential surface of the motor housing 6, and a rotor 48 is fixed to the drive shaft 8. The motor is constituted of the stator 46 and the rotor 48. The rotor 48 and the drive shaft 8 integrally rotate through energizing the stator 46.

As the crank shaft 14 of the drive shaft 8 rotates, the movable scroll member 20 orbits 20 orbits in the compression chamber 32, the intermediate pressure chamber 77, and the refrigerant gas (corresponding to the gas according to the present invention) is introduced through an inlet 44 which is formed through the fixed scroll member 2, and the refrigerant gas flows from a peripheral side of both the scroll members 2, 20 in between the fixed scroll base plate 26 and the movable scroll base plate 24. Also, as the movable scroll member 20 orbits, the movable pins 40 slide along outer circumferential surfaces of the associated fixed pins 42.

When the crank shaft 14 rotates, the movable scroll member 20 which can relatively rotate with respect to the crank shaft 14 via the plane bearing 22 orbits about the axis of the drive shaft 8 without rotating.

As the movable scroll member 20 orbits, the refrigerant gas is introduced through the inlet 44, and is closed in the compression chamber 32. As the compression chamber 32 moves to the center, the refrigerant gas accordingly is inwardly led to the center of the movable scroll member 20 in parallel with compressing and highly pressurizing the refrigerant gas. The highly pressurized refrigerant gas flows into the discharge port 50 which is communicated with the compression chamber 32, the pressure of which is the highest among the compression chambers 32, defined at the center of the movable scroll base plate 24.

The compressed refrigerant gas passing through the discharge port 50 and the discharge valve 52 is discharged into the high pressure chamber 70 inside the boss 24a. This high pressure chamber 70 communicates with an inside of the motor housing 6 via a first axial passage 72 formed within the drive shaft 8 (including the crank shaft 14), and the refrigerant gas flowed into the motor housing 6 is discharged from a second axial passage 74 formed within the drive shaft 8 to an external refrigerant circuit via an outlet 76 which is formed through a wall of the motor housing 6.

The motor is designed to be cooled by the refrigerant gas while the refrigerant gas flows from the first axial passage 72 to the second axial passage 74.

Meanwhile, the refrigerant gas leaking from the high pressure chamber 70 into the intermediate pressure chamber 77 by the plane bearing 22 and the refrigerant gas in the compression chamber 32 during the compression cycle flow between the compression chamber 32 and the intermediate compression chamber 77 due to the pressure difference between the chambers 32, 77 via the communication passage 60 during a complete orbit of the communication passage 60 (360 degrees) along the locus P1 (A1 → B1 → C1 → D1). In such a state, the thrust force acting on the back surface of the movable scroll base plate 24 varies, as shown in FIG. 4. FIG. 4 shows that an introduction of the refrigerant gas into the compression chamber 32 is finished just before A1, and that the pressure difference between the compression chamber 32 and the intermediate pressure chamber 77 is the greatest (pressure in the compression chamber 32-pressure in the intermediate pressure chamber 77). Thereby, the refrigerant gas in the intermediate pressure chamber 77 flows into the compression chamber 32 immediately due to the pressure difference between the chambers. Accordingly, the thrust force acting on the back surface of the movable scroll base plate 24 reduces.

The above-mentioned scroll type compressor and a method for compressing gas according to the first embodiment, the refrigerant gas is effectively moved between the compression chamber 32 and the intermediate pressure chamber 77 due to the pressure difference between the chambers 32, 77 and the fluctuation of the thrust force acting on the back surface of the movable scroll base plate 24 can be prevented as much as possible because the communication passage 60 continuously intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 during a complete orbit of the movable scroll member 20 (360 degrees) during the compression cycle established by the refrigerant gas in the compression chamber 32.

[Second and Third Embodiments]

A scroll type compressor according to the second and the third embodiments will now be described with reference to FIGS. 6 through 10. FIG. 6 is a longitudinal sectional view illustrating the scroll type compressor according to the second and the third embodiments. FIG. 7 is a figure showing thrust force as a function of the orbital angle of the movable scroll member according to the second embodiment. FIG. 8 is a figure showing thrust force as a function of the orbital angle of the movable scroll member according to the third embodiment. FIG. 9 is a figure showing timing that the compression chamber and the intermediate pressure chamber are intercommunicated according to the second embodiment. Besides, since main structure of the scroll type compressor according to the second and the third embodiments is same as the scroll type compressor according to the first embodiment, different structure from the scroll type compressor of the first embodiment will be described in particular. Furthermore, the same reference numerals denote the same components in FIGS. 6 through 10 as compared with FIGS. 1 through 5.

The scroll type compressor according to the second and the third embodiments, in the compression cycle established by the refrigerant gas in the compression chamber 32, the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated via the communication passage 62 which is formed through the movable base plate 24 and the communication passage 62 is shut by the seal 80 so as to block communication between the compression chamber 32 and the intermediate pressure chamber 77.
Thereby, the fluctuation of the thrust force acting on the back surface of the movable scroll base plate 24 generated by the refrigerant gas may be further prevented as compared with the scroll type compressor according to the first embodiment.

[0068] As shown in FIG. 6, the communication passage 62 according to the second and the third embodiments intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 at the same as the communication passage 60 according to the first embodiment.

[0069] The communication passage 62 according to the second embodiment, as shown in FIG. 9, is designed to move between a first position where the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated and a second position where the compression chamber 32 and the intermediate pressure chamber 77 are discommunicated with each other by the seal 80 during a complete orbit of the movable scroll member 20 (corresponding to the predetermined period according to the present invention) of the compression cycle established by the refrigerant gas in the compression chamber 32. That is, during a complete orbit of the movable scroll member 20 (360 degrees), the communication passage 62 describes a locus of rotation P2 (A2→B2→C2→D2) as shown in FIG. 7.

[0070] Then, the refrigerant gas leaking from the high pressure chamber 70 into the intermediate pressure chamber 77 by the plane bearing 22, and the refrigerant gas during the compression cycle in the compression chamber 32 flows between the compression chamber 32 and the intermediate pressure chamber 77 via the communication passage 62 while the seal 80 is not sealing the passage 62 during a complete orbit of the passage 62 (360 degrees) along the locus P2 (A2→B2→C2→D2). In such a state, the thrust force acting on the back surface of the movable scroll base plate 24 varies, as shown in FIG. 7. FIG. 7 shows that introduction of the refrigerant gas into the communication chamber 32 is finished just before A2, and that the pressure difference between the compression chamber 32 and the intermediate pressure chamber 77 is the greatest (pressure in the communication chamber 32-pressure in the intermediate pressure chamber 77). Thereby, the refrigerant gas in the intermediate pressure chamber 77 flows into the communication chamber 32 immediately due to the pressure difference between the chambers 32, 77, but the thrust force acting on the back surface of the movable scroll base plate 24 stops reducing because the communication passage 62 is shut by the seal 80 at A2 to C2. Accordingly, oscillation of the thrust force can be diminished as compared with the scroll type compressor according to the first embodiment.

[0071] Furthermore, the communication passage 62 according to the third embodiment, as shown in FIG. 10, is designed to move between a first position where the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated and a second position where communication between the compression chamber 32 and the intermediate pressure chamber 77 are blocked by the seal 80 during a complete orbit of the movable scroll member 20 (corresponding to a predetermined period according to the present invention) of the compression cycle established by the refrigerant gas in the compression chamber 32. Namely, during a complete orbit of the movable scroll member 20 (360 degrees), the communication passage 62 describes a locus of rotation P3 (A3→B3→C3) as shown in FIG. 8.

[0072] Also, the refrigerant gas leaking from the high pressure chamber 70 into the intermediate pressure chamber 77 by the plane bearing 22 and the refrigerant gas during the compression cycle in the scroll compression chamber 32 flows between the compression chamber 32 and the intermediate pressure chamber 77 due to the pressure difference between the chambers 32, 77 via the communication passage 62 while the seal 80 is not sealing the passage 62 during a complete orbit of the passage 62 (360 degrees) along the locus P3 (A3→B3→C3→D3). In such a state, the thrust force acting on the back surface of the movable scroll base plate 24 varies, as shown in FIG. 8. FIG. 8 shows that on the way to increase the refrigerant gas pressure in the compression chamber 32, and that a peak of the thrust force acting on the back surface of the movable scroll base plate 24 at A3 is less than that of the scroll type compressor according to the first embodiment, and that a curve of the thrust force may be flat at A3 to B3 while the communication passage 62 intercommunicating the compression chamber 32 and the intermediate pressure chamber 77 is shut by the seal 80. Also, the refrigerant gas in the intermediate pressure chamber 77 flows into the compression chamber 32 due to the pressure difference between the chambers 32, 77 at B3. Thus, the thrust force acting on the back surface of the movable scroll base plate 24 reduces. Accordingly, the peak of the thrust force can be restrained as compared with the scroll type compressor according to the first embodiment.

[0073] The above-mentioned scroll type compressor and methods for compressing gas according to the second and the third embodiments, the refrigerant gas is effectively moved between the compression chamber 32 and the intermediate pressure chamber 77 due to the pressure difference between the chambers 32, 77, and the fluctuation of the thrust force acting on the back surface of the movable scroll base plate 24 can be prevented as much as possible because the communication passage 62 which is formed through the movable scroll base plate 24 intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 and the compression chamber 32 and the intermediate pressure chamber 77 are discommunicated with each other during a complete orbit of the movable scroll member 20 (360 degrees) in the compression cycle established by the refrigerant gas in the compression chamber 32.

[0074] [Fourth Embodiment]

[0075] A scroll type compressor according to the fourth embodiment will now be described with reference to FIGS. 11 through 15. Then, FIG. 11 is a longitudinal sectional view illustrating the scroll type compressor according to the fourth embodiment. FIG. 12 is a cross-sectional view of FIG. 11 illustrating a state of the compression chamber communicating with the intermediate pressure chamber. FIG. 13 is an enlarged cross-sectional view of FIG. 12, with part cut away. FIG. 14 is a figure showing thrust force as a function of the orbital angle of the movable scroll member according to the fourth embodiment. FIG. 15 is a figure showing timing that the compression chamber and the intermediate pressure chamber are intercommunicated according to the fourth embodiment. Besides, since main structure of the scroll type compressor according to the fourth embodiment is same as the scroll type compressor
according to the first embodiment, different structure from the scroll type compressor according to the first embodiment will be described in particular. Furthermore, the same reference numerals denote the same components in FIGS. 11 through 15 as compared with FIGS. 1 through 5.

[0076] The scroll type compressor according to the fourth embodiment, the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated with the movable scroll base plate 24, the communication passage 64 is shut by the seal 80 so as not to intercommunicate the compression chamber 32 and the intermediate pressure chamber 77, and the compression chamber 32 and the low pressure chamber 78 are intercommunicated via the communication passage 64 during the compression cycle established by the refrigerant gas in the compression chamber 32. Thereby, the fluctuation of the thrust force acting on the back surface of the movable scroll base plate 24 generated by the refrigerant gas can be prevented as much as possible.

[0077] The communication passage 64 according to the fourth embodiment shown in FIGS. 11 through 14, as shown in FIG. 15, is designed to move between a first position where the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated, a second position where the compression chamber 32 and the intermediate pressure chamber 77 are disconnected with each other by the seal 80 and a third position where the compression chamber 32 and the low pressure chamber 78 are intercommunicated during a complete orbit of the movable scroll member 20 (corresponding to the predetermined period according to the present invention) in the compression cycle established by the refrigerant gas in the compression chamber 32. That is, during a complete orbit of the movable scroll member 20 (360 degrees), the communication passage 64 describes a locus of rotation P4 (A4→B4) as shown in FIGS. 13 and 14.

[0078] Then, the refrigerant gas leaking from the high pressure chamber 70 into the intermediate pressure chamber 77 by the plane bearing 22, and the refrigerant gas during the compression cycle in the compression chamber 32 flows between the compression chamber 32 and the intermediate compression chamber 77 due to the pressure difference between the chambers 32, 77 via the communication passage 64, during a complete orbit of the communication passage 64 (360 degrees) along the locus P4 (A4→B4), except while the seal 80 blocks the passage 64, and except while the compression chamber 32 and the low pressure chamber 78 are intercommunicated via the communication passage 64. In such a state, the thrust force acting on the back surface of the movable scroll base plate 24 varies, as shown in FIG. 14. FIG. 14 shows that a peak of the thrust force acting on the back surface of the movable scroll base plate 24 at A4 is restrained, and that a curve of the thrust force may be flat because the communication passage 64 intercommunicating the compression chamber 32 and the intermediate pressure chamber 77 is shut by the seal 80 on the way to increase the refrigerant gas pressure in the compression chamber 32. Also, the refrigerant gas in the intermediate pressure chamber 77 flows into the compression chamber 32 due to the pressure difference between the chambers 32, 77. Thus, the thrust force acting on the back surface of the movable scroll base plate 24 reduces. Also, an increase of the thrust force may be restrained because the compression chamber 32 communicates with the low pressure chamber 78 via the communication passage 64 at A4 to B4. Accordingly, the thrust force may be kept constant.

[0079] The above mentioned scroll type compressor and a method for compressing gas according to the fourth embodiment, the communication passage 64 formed through the movable scroll base plate 24 intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 during one certain period, the compression chamber 32 and the intermediate pressure chamber 77 are disconnected with each other during another period, and the communication passage 64 intercommunicates the compression chamber 32 and the low pressure chamber 78 during the other period during a complete orbit of the movable scroll member 20 (360 degrees) in the compression cycle established by the refrigerant gas in the compression chamber 32. Thereby, the refrigerant gas is effectively flowed between the compression chamber 32 and the intermediate pressure chamber 77, and the thrust force acting on the back surface of the movable scroll base plate 24 may be kept constant.

[0080] The present invention is not limited to the embodiments described above, but may be modified into examples as follows.

[0081] (A) The embodiments described above are cases that the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated via the communication passage during a complete orbit of the movable scroll member 20 in the compression cycle established by the refrigerant gas in the compression chamber 32. However, timing when the compression chamber 32 and the intermediate pressure chamber 77 are intercommunicated and communication time are not limited to the embodiments, but can be modified diversely for the occasion that arises.

[0082] (B) The embodiments described above are cases that the communication passage which intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 is formed through the movable scroll base plate 24. However, for example, the communication passage which intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 can be formed through another portion outside the movable scroll base plate 24.

[0083] (C) Furthermore, the embodiments described above are cases that the intermediate pressure chamber 77 is defined between the high pressure chamber 70 and the low pressure chamber 78 by the seal 80. However, for example, a sliding surface between the back surface of the movable scroll base plate 24 and the center housing 4 has the seal function, by which the intermediate pressure chamber 77 is accordingly defined between the high pressure chamber 70 and the low pressure chamber 78. This case is also applicable.

[0084] (D) Furthermore, the embodiments described above are cases that the scroll type compressor is provided with the plane bearing 22 which features both the bearing function and the seal function. However, a kind of bearing member is not limited to the embodiments, but can be modified diversely for the occasion that arises. For example, needle bearings, which have the bearing function but do not sufficiently have the seal function, are employed, and another seal member is disposed downstream to the needle bearings. This case is also applicable. Thereby, the interme-
The second through fourth embodiments described above are cases that the communication passage intercommunicating the compression chamber 32 and the intermediate pressure chamber 77 is shut by the seal 80. However, the method for blocking communication between the compression chamber 32 and the intermediate pressure chamber 77 is not limited to the seal 80. As shown in FIGS. 16 and 17, a flap valve chamber 96 is formed at the movable scroll base plate 24 at its front side, a flap valve 90 and a flap valve retainer 92 are fixed to the movable scroll base plate 24 by a bolt 96. A cover 98 is fixed to the movable scroll base plate 24. The cover 98 has a hole bored through the cover 98, and a diameter of the hole is less than a thickness of corresponding fixed scroll wall 28 so as not to intercommunicate coadjacent compression chambers. Consequently, the flap valve 90 is disposed between the compression chamber 32 and the intermediate pressure chamber 77 so as to open and close the communication passage which intercommunicates the compression chamber 32 and the intermediate pressure chamber 77 due to the pressure difference therebetween. Thereby, the flap valve 90 functions as a seal member instead of the seal 80 so as to switch the communication between the compression chamber 32 and the intermediate pressure chamber 77.

The embodiments described above are cases that the refrigerant gas is compressed and is highly pressurized. However, the present invention can also be applied to a compressor that compresses gas except the refrigerant gas.

A communication passage is shown in FIGS. 1 through 17, but a plurality of communication passages 66 may be formed through the movable scroll base plate 24 as shown in FIG. 18.

The above described scroll type compressor according to the present invention, rational gas compressing devices and methods for preventing as much as possible the fluctuation of the thrust force acting on the movable scroll member due to the fluctuation of gas pressure can be performed.

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 of the appended claims.

What is claimed is:

1. A scroll type compressor comprising:
   a fixed scroll member;
   a movable scroll member facing to the fixed scroll member;
   a compression region defined between the fixed scroll member and the movable scroll member to compress the gas by orbiting the movable scroll member relative to the fixed scroll member;
   an inlet to introduce gas into the compression region;
   a discharge port for discharging the pressurized gas from the compression region via the discharge port;
   a discharge valve opening and closing the discharge port;
   a first pressure region applying pressure to the movable scroll member;
   a second pressure region applying pressure to the movable scroll member; and
   a communication passage intercommunicating said first pressure region and said second pressure region during a predetermined period of a compression cycle established by the gas.

2. A scroll type compressor according to claim 1, wherein the inlet is formed through the fixed scroll member, and

3. A scroll type compressor according to claim 1, wherein a plurality of said communication passages is formed.

4. A scroll type compressor according to claim 1, wherein said predetermined period corresponds to approximately a single orbit of the movable scroll member.

5. A scroll type compressor according to claim 1, wherein the first pressure region is a compression region defined between the scroll members, wherein said second pressure region is a backside region defined in the vicinity of a back surface of the movable scroll member, wherein the backside region includes a high pressure region defined downstream to the discharge valve, a low pressure region communicating with the inlet side and an intermediate pressure region defined between the high pressure region and the low pressure region, and

6. A scroll type compressor according to claim 5, wherein the communication passage continuously intercommunicates the compression region and the intermediate pressure region during said predetermined period.

7. A scroll type compressor according to claim 5 further comprising:
   a seal member disposed between the intermediate pressure region and the low pressure region; and
   wherein during said predetermined period the communication passage moves between a first position where the compression region and the intermediate pressure region are intercommunicated and a second position where the communication passage is shut by said seal member.

8. A scroll type compressor according to claim 5 further comprising:
   a seal member disposed between the intermediate pressure region and the low pressure region; and
   wherein during said predetermined period said communication passage moves among a first position where the compression region and the intermediate pressure region are intercommunicated, a second position where the communication passage is shut by said seal member.
and a third position where the compression region and the low pressure region are intercommunicated.

9. A scroll type compressor according to claim 5 further comprising:
   a flap valve disposed between the compression region and the intermediate pressure region; and
   wherein said flap valve opens and closes said communication passage due to a pressure difference between the compression region and the intermediate pressure region during said predetermined period.

10. A method for compressing gas in a scroll type compressor comprising:
   a fixed scroll member;
   a movable scroll member facing to the fixed scroll member;
   a compression region defined between the fixed scroll member and the movable scroll member to compress the gas by orbiting the movable scroll member relative to the fixed scroll member;
   an inlet to introduce gas into the compression region;
   a discharge port for discharging the pressurized gas from the compression region via the discharge port;
   a discharge valve opening and closing the discharge port;
   a first pressure region applying pressure to the movable scroll member;
   a second pressure region applying pressure to the movable scroll member;
   wherein the method comprises the steps of:
   introducing gas from the inlet;
   compressing and highly pressurizing the gas;
   intercommunicating the compression region and the second pressure region during the predetermined period of a compression cycle established by the gas; and
   discharging the highly pressurized gas from the compression region via the discharge port and the discharge valve.

14. A method for compressing gas in a scroll type compressor according to claim 13, wherein the method comprises the step of continuously intercommunicating the compression region and the intermediate pressure region during the predetermined period.

15. A method for compressing gas in a scroll type compressor according to claim 13,
   wherein a seal member is disposed between the intermediate pressure region and the low pressure region, and
   wherein the method further comprises the step of:
   shutting communication between the compression region and the intermediate pressure region by the seal member during the predetermined period.

16. A method for compressing gas in a scroll type compressor according to claim 13,
   wherein a seal member is disposed between the intermediate pressure region and the low pressure region, and
   wherein the method further comprises the steps of:
   shutting communication between the compression region and the intermediate pressure region by the seal member during the predetermined period; and
   intercommunicating the compression region and the low pressure region during the predetermined period.

17. A method for compressing gas in a scroll type compressor according to claim 13,
   wherein a flap valve is disposed between the compression region and the intermediate pressure region,
   wherein the method further comprises the step of:
   opening and closing the communication passage by the flap valve due to a pressure difference between the compression region and the intermediate pressure region during the predetermined period.