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KONDO et al.(10) **Pub. No.: US 2014/0294617 A1**(43) **Pub. Date: Oct. 2, 2014**(54) **PISTON TYPE SWASH PLATE COMPRESSOR**(52) **U.S. Cl.**(71) Applicant: **KABUSHIKI KAISHA TOYOTA**
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ABSTRACT(73) Assignee: **KABUSHIKI KAISHA TOYOTA**
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A piston type swash plate compressor includes a housing, a cylinder block, a cylinder head, a rotary shaft, a plurality of cylinder bores, a plurality of pistons, a swash plate, a plurality of compression chambers, a plurality of head-side discharge chambers, a plurality of block-side discharge chambers, an outlet and a discharge path. The head-side discharge chambers are provided in the cylinder head. The block-side discharge chambers are provided in the cylinder block. The outlet is formed through the housing. The discharge path is formed in the housing and refrigerant gas is flowed through the discharge path from the compression chamber to the outlet through the head-side discharge chamber to the block-side discharge chamber. After refrigerant gas flowed from the compression chamber is flowed through one head-side discharge chamber which communicates with the compression chamber and one block-side discharge chamber, the refrigerant gas is flowed to another head-side discharge chamber.

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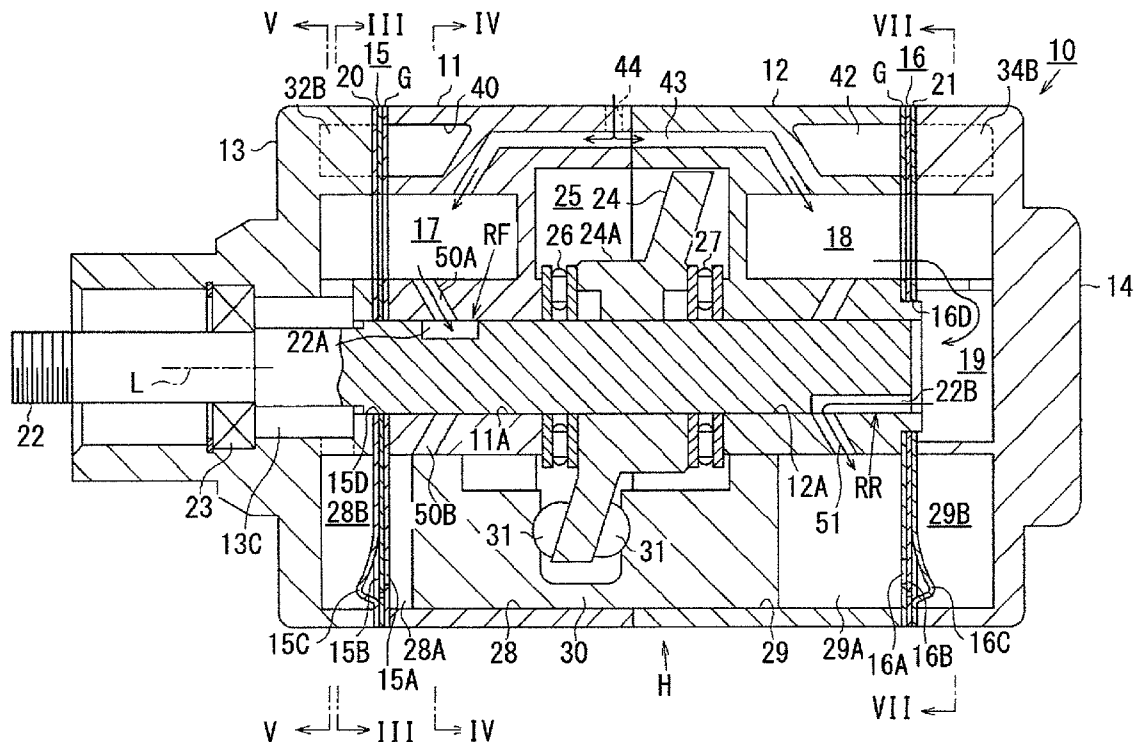


FIG. 2

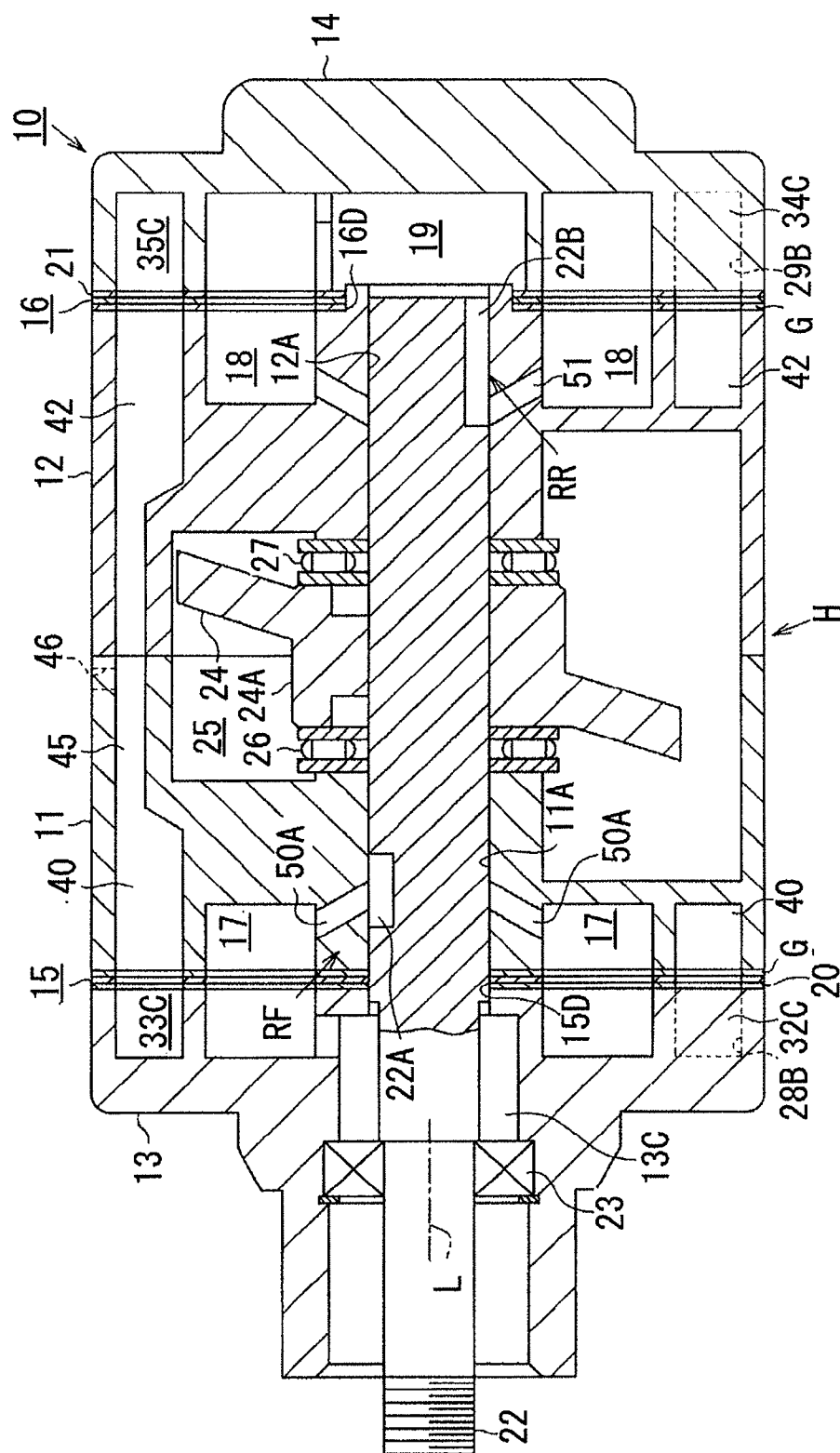


FIG. 3

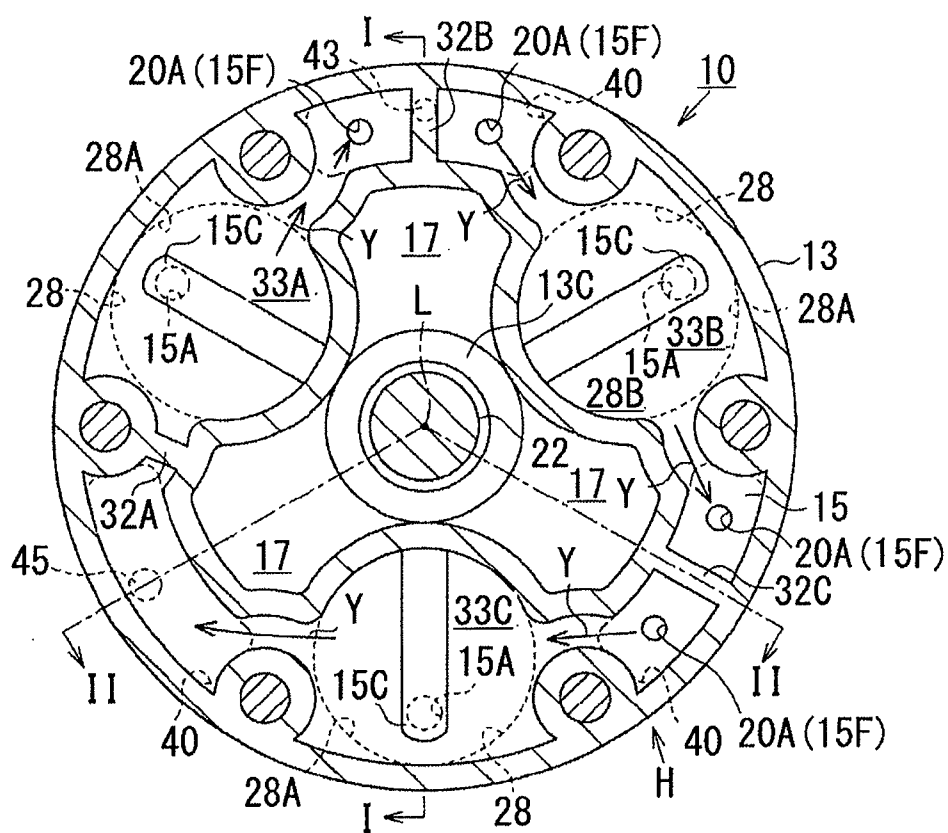


FIG. 4

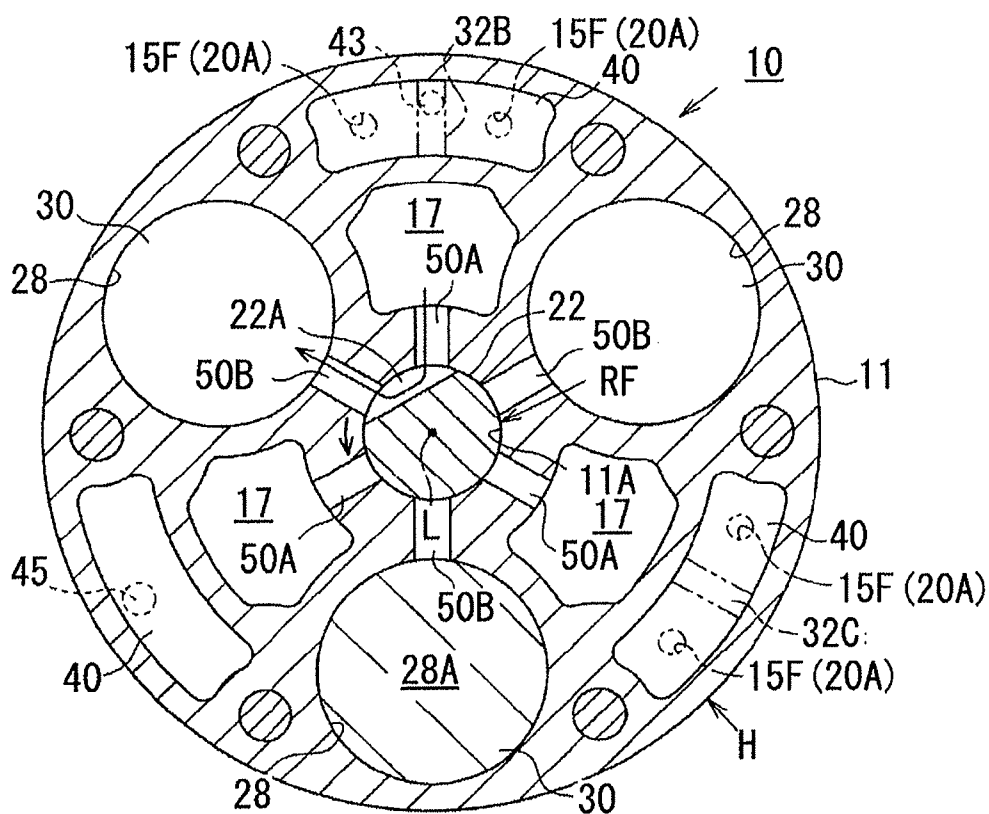
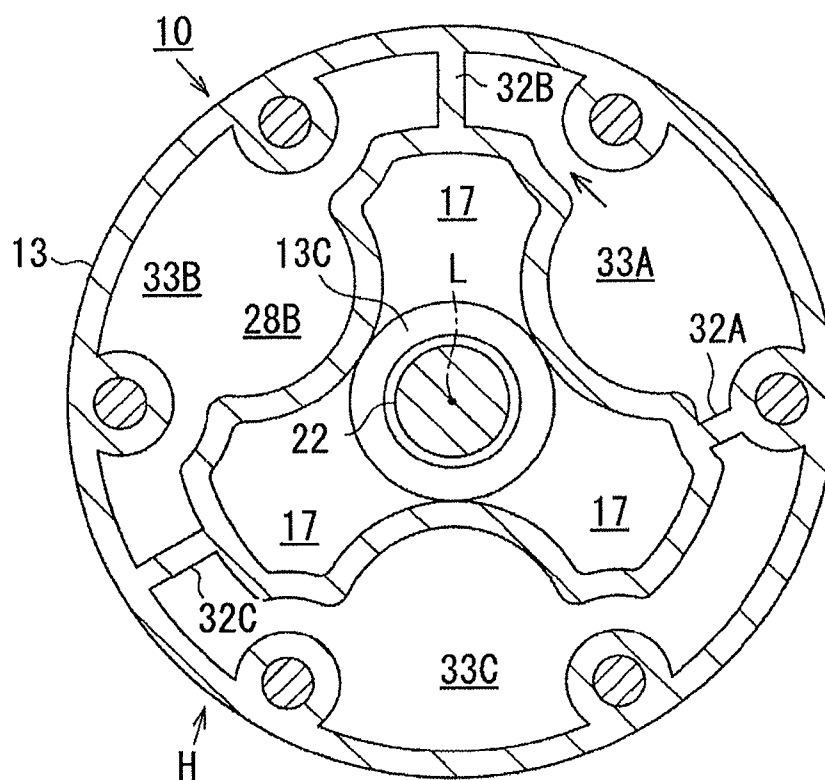


FIG. 5



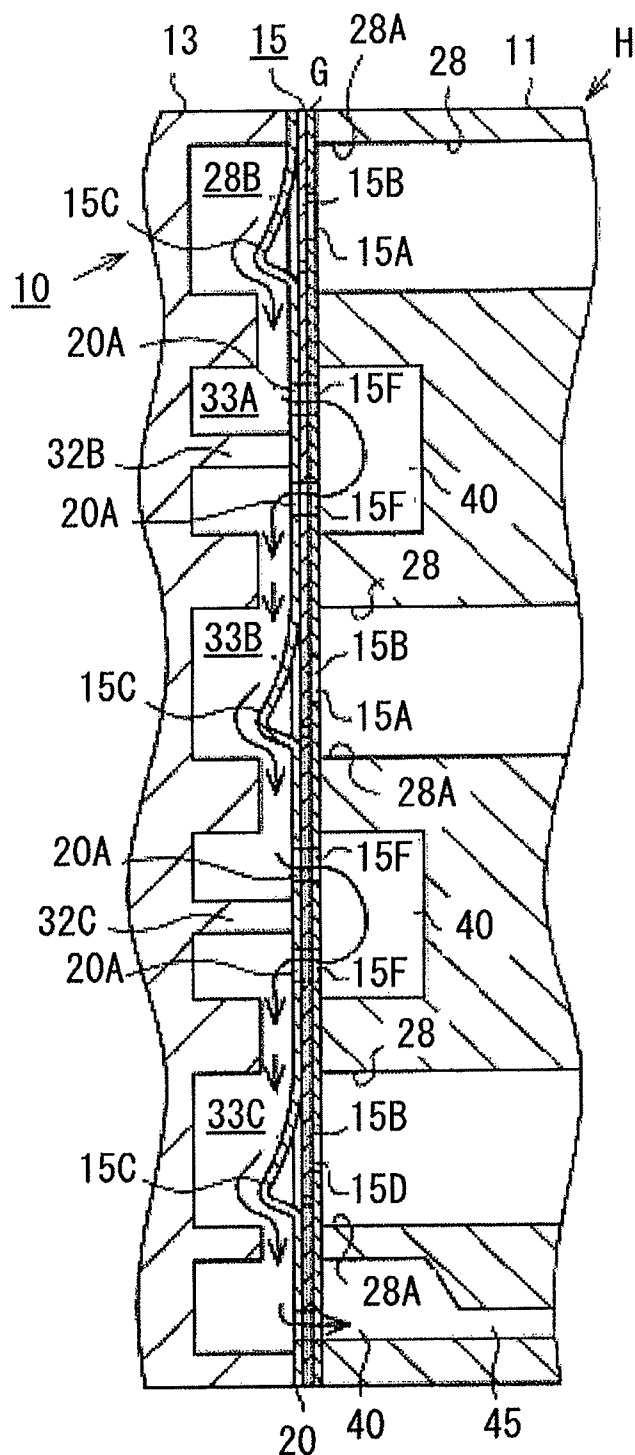
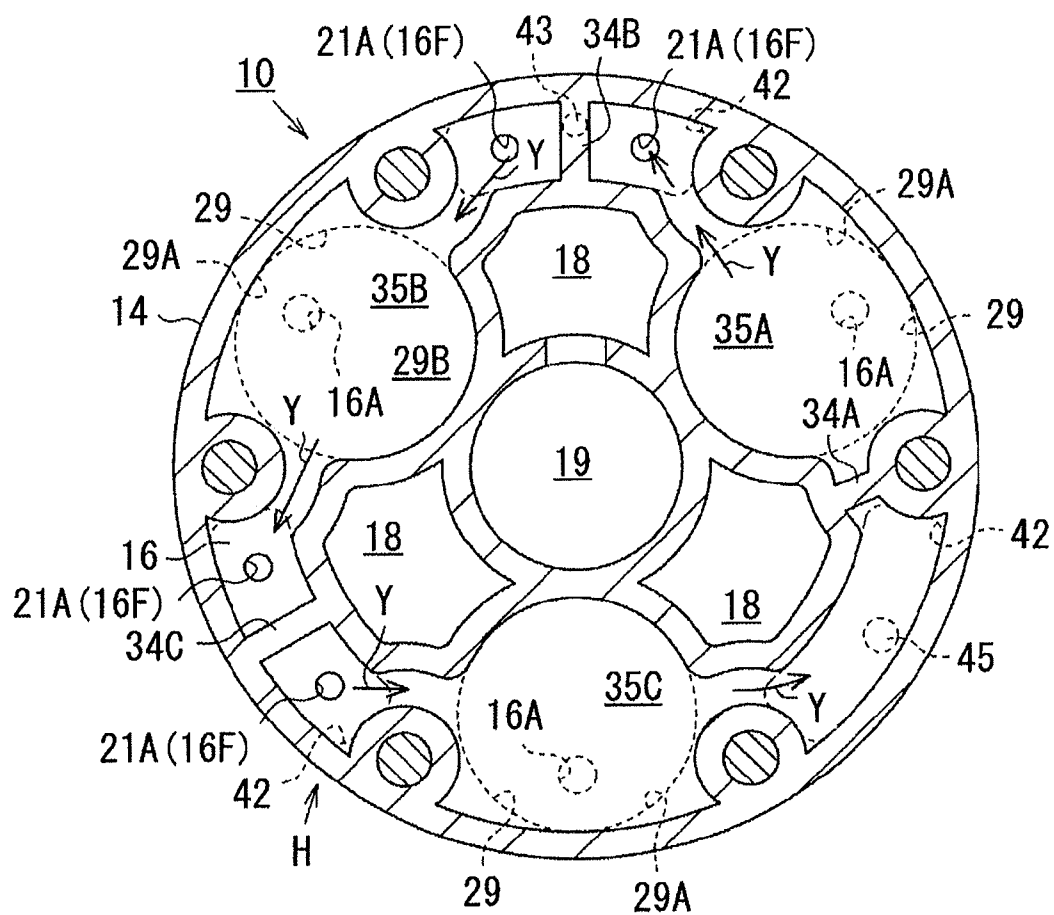


FIG. 7



PISTON TYPE SWASH PLATE COMPRESSOR

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a piston type swash plate compressor.

[0002] In a piston type swash plate compressor, refrigerant gas is introduced into compression chambers and compressed and discharged by reciprocation motion of pistons together with rotation of a swash plate. In the piston type swash plate compressor, vibration and noise development are caused by pulsation of refrigerant gas. There has been proposed a compressor including a muffler for reducing the pulsation. For example, Japanese Patent Application Publication No. 10-89251 discloses a compressor wherein a muffler space is formed in a compressor housing, a compression chamber is connected to the muffler space and a meandering member is provided in the muffler space for defining a passage for meandering discharged gas.

[0003] However, if the muffler space is formed in the piston type swash plate compressor in order to reduce the pulsation as in Japanese Patent Application Publication No. 10-89251, the compressor housing extends outwardly and the size of the piston type swash plate compressor is increased. The present invention, which has been made in light of the above problems, is directed to providing a piston type swash plate compressor which can reduce the pulsation without being large in size.

SUMMARY OF THE INVENTION

[0004] In accordance with the present invention, a piston type swash plate compressor includes a housing, a cylinder block, a cylinder head, a rotary shaft, a plurality of cylinder bores, a plurality of pistons, a swash plate, a plurality of compression chambers, a plurality of head-side discharge chambers, a plurality of block-side discharge chambers, an outlet and a discharge path. The cylinder block is formed in the housing. The cylinder head is formed in the housing and connected to an end of the cylinder block. The rotary shaft is rotatably supported by the cylinder block. A plurality of cylinder bores is arranged around the rotary shaft. A plurality of pistons is respectively accommodated in the cylinder bores. The swash plate integrally rotates with the rotary shaft and is engaged with the pistons. A plurality of the compression chambers is respectively defined in the cylinder bores by the pistons. A plurality of the head-side discharge chambers is provided in the cylinder head. A plurality of the block-side discharge chambers is provided in the cylinder block. The outlet is formed in the housing and compressed refrigerant gas is flowed outside of the housing through the outlet. The discharge path is formed in the housing and refrigerant gas is flowed through the discharge path from the compression chamber to the outlet to the block-side discharge chamber through the head-side discharge chamber. After refrigerant gas flowed from the compression chamber is flowed through one head-side discharge chamber which communicates with the compression chamber and one block-side discharge chamber, the refrigerant gas is flowed to another head-side discharge chamber.

[0005] Other aspects and advantages of the 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

[0006] 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:

[0007] FIG. 1 is a sectional view taken along the line I-I in FIG. 3 showing a double-headed piston type swash plate compressor according to a first preferred embodiment of the present invention;

[0008] FIG. 2 is a sectional view taken along the line II-II in FIG. 3 showing the double-headed piston type swash plate compressor of FIG. 1;

[0009] FIG. 3 is a sectional view taken along the line in FIG. 1 showing front head-side discharge chambers and front suction chambers of the double-headed piston type swash plate compressor of FIG. 1;

[0010] FIG. 4 is a sectional view taken along the line IV-IV in FIG. 1 showing front block-side discharge chambers and the front suction chambers of the double-headed piston type swash plate compressor of FIG. 1;

[0011] FIG. 5 is a sectional view taken along the line V-V in FIG. 1 showing the front head-side discharge chambers and front partition walls of the double-headed piston type swash plate compressor of FIG. 1;

[0012] FIG. 6 is a sectional view showing the front head-side discharge chambers, front compression chambers and the front block-side discharge chambers expanded in a rotating direction of a rotary shaft of the double-headed piston type swash plate compressor of FIG. 1; and

[0013] FIG. 7 is a sectional view taken along the line VII-VII in FIG. 1 showing the rear head-side discharge chambers and rear partition walls of the double-headed piston type swash plate compressor of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] The following will describe a piston type swash plate compressor embodied as a double-headed piston type swash plate compressor according to a preferred embodiment of the present invention with reference to FIGS. 1 through 7. As shown in FIGS. 1 and 2, reference numeral 10 designates a double-headed piston type swash plate compressor (hereinafter simply referred to as "compressor") and the compressor 10 includes a housing H and a pair of front and rear cylinder blocks 11 and 12 connected to each other. In the housing H of the compressor 10, a front cylinder head 13 is disposed on the front side of the compressor 10 (the left side in FIG. 1) and coupled to the front end of the front cylinder block 11 through the front valve plate assembly 15. The front valve plate assembly 15 includes a gasket G for sealing a space between the front cylinder block 11 and the front cylinder head 13 and a valve plate 20 a part of which forms a front discharge valve 15B which will be described later. A rear cylinder head 14 is disposed on a rear side of the compressor 10 (the right side in FIG. 1) and coupled to the rear end of the rear cylinder block 12 through a rear valve plate assembly 16. The rear valve plate assembly 16 includes the gasket G for sealing a space between the rear cylinder block 12 and the rear cylinder head 14 and a rear valve plate 21 a part of which forms a rear discharge valve 16B which will be described later. The front and the rear cylinder heads 13 and 14 and the pair of the front and the rear cylinder blocks 11 and 12 which are interposed between the front and the rear cylinder heads

13 and **14** cooperate to form the housing **H**. The front and the rear cylinder blocks **11** and **12** serve as a cylinder block of the present invention. The front and the rear cylinder heads **13** and **14** serve as a cylinder head of the present invention. The front and the rear valve plate assemblies **15** and **16** serve as a valve plate assembly of the present invention. The front and the rear discharge valves **15B** and **16B** serve as a discharge valve of the present invention. The front and the rear valve plates **20** and **21** serve as a valve plate of the present invention.

[0015] The front and the rear cylinder blocks **11** and **12** include front and rear shaft holes **11A** and **12A**, respectively, and a rotary shaft **22** is inserted through the front and the rear shaft holes **11A** and **12A** so as to be rotatably supported by the inner circumferential surfaces of the front and the rear shaft holes **11A** and **12A** which form a sealing circumferential surface. The front and the rear valve plate assemblies **15** and **16** include front and rear insertion holes **15D** and **16D** formed at the centers thereof, respectively, and the rotary shaft **22** is inserted through the front and the rear insertion holes **15D** and **16D**. A shaft seal **23** of a lip seal type hermetically seals a space between the outer circumferential surface of the front end of the rotary shaft **22** extending out of the front valve plate assembly **15** and the inner circumferential surface of the front cylinder head **13**. The shaft seal **23** is provided in an accommodation chamber **13C** formed between the inner circumferential surface of the front cylinder head **13** and the outer circumferential surface of the rotary shaft **22**. The front and the rear shaft holes **11A** and **12A** serve a shaft hole of the present invention. The front and the rear insertion holes **15D** and **16D** serve an insertion hole of the present invention.

[0016] A swash plate **24**, which integrally rotates with the rotary shaft **22**, is firmly fixed to the rotary shaft **22**. The swash plate **24** is disposed in a crank chamber **25** formed between the front and the rear cylinder blocks **11** and **12**. A front thrust bearing **26** is interposed between the rear end surface of the front cylinder block **11** and an annular base portion **24A** of the swash plate **24**. A rear thrust bearing **27** is interposed between the front end surface of the rear cylinder block **12** and the base portion **24A** of the swash plate **24**. The front and the rear thrust bearings **26** and **27** hold the swash plate **24** and regulate the movement of the swash plate **24** along the center axis **L** of the rotary shaft **22**. The front and the rear thrust bearings **26** and **27** serve as a thrust bearing of the present invention.

[0017] As shown in FIG. 4, three front cylinder bores **28** are arranged around the rotary shaft **22** in the front cylinder block **11**. As shown in FIG. 1, three rear cylinder bores **29** are arranged around the rotary shaft **22** in the rear cylinder block **12**. The paired front and rear cylinder bores **28** and **29** formed to extend along the center axis **L** of the rotary shaft **22** (in the longitudinal direction of the compressor **10**). Double-headed pistons **30** are received in the front and the rear cylinder bores **28** and **29**, respectively. The front cylinder bore **28** is closed by the front valve plate assembly **15** and the double-headed piston **30** and the rear cylinder bore **29** is closed by the rear valve plate assembly **16** and the double-headed piston **30**. The front and the rear cylinder bores **28** and **29** serve as a cylinder bore of the present invention.

[0018] The rotating movement of the swash plate **24** which integrally rotates with the rotary shaft **22** is transmitted to the double-headed pistons **30** through a pair of shoes **31** which hold the swash plate **24** from opposite sides thereof. The double-headed pistons **30** are reciprocally moved in the front and the rear cylinder bores **28** and **29**. A front compression

chamber **28A** is defined in the front cylinder bore **28** by the double-headed piston **30** and the front valve plate assembly **15** and a rear compression chamber **29A** is defined in the rear cylinder bore **29** by the double-headed piston **30** and the rear valve plate assembly **16**. The front and the rear compression chambers **28A** and **29A** serve as a compression chamber of the present invention.

[0019] As shown in FIGS. 1 and 4, three front suction chambers **17** and three rear suction chambers **18** are formed surrounding the rotary shaft **22** and extending through the front and the rear valve plate assemblies **15** and **16** in the front and the rear cylinder heads **13** and **14** and the front and the rear cylinder blocks **11** and **12**. Each front suction chamber **17** is located between any two adjacent front cylinder bores **28** and each rear suction chamber **18** is located between any two adjacent rear cylinder bores **29**. The front and the rear suction chambers **17** and **18** are arranged at equal intervals on the outer circumference side of the front and the rear shaft holes **11A** and **12A**, respectively. One front suction chamber **17** has a length in the axial direction of the rotary shaft **22** and a volume larger than the length and the volume of the other front suction chamber **17** and one rear suction chamber **18** has a length in the axial direction of the rotary shaft **22** and a volume larger than the length and the volume of the other rear suction chamber **18**. The front and the rear suction chambers **17** and **18** serve as a suction chamber of the present invention.

[0020] As shown in FIGS. 1 and 3, in the front cylinder head **13**, each of the three front suction chambers **17** communicates with the accommodation chamber **13C** and three front suction chambers **17** communicate with each other through the accommodation chamber **13C**. Thus, the three front suction chambers **17** and the accommodation chamber **13C** form one space.

[0021] As shown in FIGS. 1, 3 and 7, three first through third front head-side discharge chambers **33A** through **33C** are located so as to surround the rotary shaft **22** between the front cylinder head **13** and the front valve plate assembly **15** and three first through third rear head-side discharge chambers **35A** through **35C** are located so as to surround the rotary shaft **22** between the rear cylinder head **14** and the rear valve plate assembly **16**. Refrigerant gas flowed from the front and the rear compression chambers **28A** and **29A** is discharged to the first through the third front head-side discharge chambers **33A** through **33C** and the first through the third rear head-side discharge chambers **35A** through **35C**, respectively. A front space **28B** is formed around the rotary shaft **22** in the front cylinder head **13** and partitioned to the first through the third front head-side discharge chambers **33A** through **33C**. A rear space **29B** is formed around the rotary shaft **22** in the rear cylinder head **14** and partitioned to the first through the third rear head-side discharge chambers **35A** through **35C**. The size of the openings of the first through the third front head-side discharge chambers **33A** through **33C** and the first through the third rear head-side discharge chambers **35A** through **35C** at positions facing the front and the rear compression chambers **28A** and **29A** through the front and the rear valve plate assemblies **15** and **16** is the same as the circular section of the front and the rear compression chambers **28A** and **29A** (the front and the rear cylinder bores **28** and **29**). The first through the third front head-side discharge chambers **33A** through **33C** and the first through the third rear head-side discharge chambers **35A** through **35C** serve as a

head-side discharge chamber of the present invention. The front and the rear spaces 28B and 29B serve as a space of the present invention.

[0022] Three front block-side discharge chambers 40 are formed in the front cylinder block 11 and three rear block-side discharge chambers 42 are formed in the rear cylinder block 12. The front compression chambers 28A, the first through the third front head-side discharge chambers 33A through 33C and the front block-side discharge chambers 40 communicate with one another and the rear compression chambers 29A, the first through the third rear head-side discharge chambers 35A through 35C and the rear block-side discharge chambers 42 communicate with one another. The three front block-side discharge chambers 40 are located around the rotary shaft 22 and each front block-side discharge chamber 40 is located between any two adjacent front cylinder bores 28. The three rear block-side discharge chambers 42 are located around the rotary shaft 22 and each rear block-side discharge chamber 42 is located between any two adjacent rear cylinder bores 29. The front block-side discharge chambers 40 are formed on the outer circumference side of the front suction chambers 17 in the radial direction of the front cylinder block 11 and the rear block-side discharge chambers 42 are formed on the outer circumference side of the rear suction chambers 18 in the radial direction of the rear cylinder block 12. The front and the rear block-side discharge chambers 40 and 42 serve as a block-side discharge chamber of the present invention.

[0023] Front discharge ports 15A are formed in the front valve plate assembly 15 at positions facing the corresponding front cylinder bores 28 and rear discharge ports 16A are formed in the rear valve plate assembly 16 at positions facing the corresponding rear cylinder bores 29. Front discharge valves 15B are formed in the front valve plate 20 at positions facing the corresponding front discharge ports 15A and rear discharge valves 16B are formed in the rear valve plate 21 at positions facing the corresponding rear discharge ports 16A. Front retainers 15C are formed in the front valve plate assembly 15 to regulate the opening degrees of the front discharge valves 15B, respectively and rear retainers 16C are formed in the rear valve plate assembly 16 to regulate the opening degrees of the rear discharge valves 16B, respectively. The front discharge ports 15A communicate with the first through the third front head-side discharge chambers 33A through 33C, respectively, and the rear discharge ports 16A communicate with the first through the third rear head-side discharge chambers 35A through 35C, respectively. Refrigerant gas flowed from the front compression chamber 28A is flowed to the first through the third front head-side discharge chambers 33A through 33C and refrigerant gas flowed from the rear compression chamber 29A is flowed to the first through the third rear head-side discharge chambers 35A through 35C. The front and the rear discharge ports 15A and 16A serve as a discharge port of the present invention. The front and the rear retainer 15C and 16C serve as a retainer of the present invention.

[0024] As shown in FIG. 1, a suction passage 43 is formed in the front and the rear cylinder blocks 11 and 12. The opening of the front end of the suction passage 43 communicates with the front suction chambers 17 with the largest volume among three front suction chambers 17. The opening of the rear end of the suction passage 43 communicates with the rear suction chamber 18 with the largest volume among three rear suction chambers 18. An inlet 44 is formed in the

front cylinder block 11. One end of the inlet 44 is opened through the front cylinder block 11 and the other end of the inlet 44 is opened to the suction passage 43. An external refrigerant circuit disposed outside of the compressor 10 is connected to the opening of the one end of the inlet 44.

[0025] The suction passage 43 is formed to communicate the front and the rear suction chambers 17 and 18 each of which has the largest volume on the front and the rear sides among the front and the rear suction chambers 17 and 18. Therefore, the suction passage 43 is interposed in the axial direction between the front and the rear block-side discharge chambers 40 and 42 located on the outer circumference side of the front and the rear suction chambers 17 and 18.

[0026] As shown in FIG. 2, a discharge passage 45 is formed in the front and the rear cylinder blocks 11 and 12. The opening of the front end of the discharge passage 45 communicates with one of three front block-side discharge chambers 40 and the opening of the rear end of the discharge passage 45 communicates with one of three rear block-side discharge chambers 42. Further, an outlet 46 is formed through the front cylinder block 11, or housing H. One end of the outlet 46 is opened through the front cylinder block 11 (the housing H) and the other end of the outlet 46 is opened to the discharge passage 45. The external refrigerant circuit provided outside of the compressor 10 is connected to the outlet 46. As shown in FIG. 3, the discharge passage 45 is formed in the front and the rear cylinder blocks 11 and 12 at a position shifted in the rotating direction of the front and the rear cylinder blocks 11 and 12 from the suction passage 43. The front compression chambers 28A communicate with the discharge passage 45 through the first through the third front head-side discharge chambers 33A through 33C and the front block-side discharge chambers 40. The rear compression chambers 29A communicate with the discharge passage 45 through the rear head-side discharge chambers 35A through 35C and the rear block-side discharge chambers 42. Therefore, a discharge path extending from the front and the rear compression chambers 28A and 29A to the outlet 46 through the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C, the front and the rear block-side discharge chambers 40 and 42 and the discharge passage 45 is formed in the housing H.

[0027] In a case that the compressor 10 is used in a refrigerant circuit for a vehicle air-conditioner, the external refrigerant circuit connects the outlet 46 with the inlet 44 of the compressor 10. The external refrigerant circuit includes a condenser, an expansion valve and an evaporator, which are arranged in the external refrigerant circuit in this order from the outlet 46 of the compressor 10.

[0028] The following will describe a suction structure in the compressor 10. As shown in FIGS. 1 and 4, communication passages 50A are formed in the front cylinder blocks 11 for respectively communicating the front suction chambers 17 with the front shaft hole 11A. One ends of the communication passages 50A are opened to the front suction chambers 17 and the other ends of the communication passages 50A are opened to the front shaft hole 11A at the sealing circumferential surface thereof. The communication passages 50A are formed in the front cylinder block 11 so as to extend while slightly tilting in the radial direction of the front cylinder block 11.

[0029] Introducing passages 50B are formed in the front cylinder block 11 for respectively communicating the front

shaft hole 11A with the front cylinder bores 28. One ends of the introducing passages 50B are opened to the front shaft hole 11A at the sealing circumferential surface thereof and the other ends of the introducing passages 50B are opened to the front cylinder bores 28. The communication passages 50A and the introducing passages 50B are alternately arranged in the rotating direction of the rotary shaft 22. The communication passages 50A and the introducing passages 50B are opened to the front shaft hole 11A at the same position in the axial direction of the front shaft hole 11A.

[0030] A front groove 22A is formed on the circumferential surface of the rotary shaft 22 on the front side. The front groove 22A is recessed on the circumferential surface of the rotary shaft 22 on the front cylinder head 13 side. The front groove 22A is opened to the front shaft hole 11A at the sealing circumferential surface and communicable with the communication passage 50A and the introducing passage 50B. In accordance with the rotation of the rotary shaft 22, the position of the front groove 22A is changed to mechanically switch communication paths between communication passage 50A and the introducing passage 50B and the front groove 22A.

[0031] Therefore, a portion of the rotary shaft 22 surrounded by the sealing circumferential surface is a front rotary valve RF which is integrally formed with the rotary shaft 22. The front groove 22A is configured to communicate one communication passage 50A with one introducing passage 50B located adjacent to the communication passage 50A in the rotating direction of the rotary shaft 22. The communication passage 50A communicates with the introducing passage 50B through the front groove 22A in accordance with the rotation of the rotary shaft 22, so that the refrigerant gas is flowed from the front suction chamber 17 into the front cylinder bore 28 adjacent to the front suction chamber 17.

[0032] The following will describe a suction structure on the rear side of the compressor 10. As shown in FIGS. 1 and 2, introducing passages 51 are formed in the rear cylinder block 12 for respectively communicating the rear cylinder bores 29 with the rear shaft hole 12A. One ends of the introducing passages 51 are opened to the rear cylinder bores 29, respectively, and the other ends of the introducing passages 51 are opened to the rear shaft hole 12A at the sealing circumferential surface. A rear supply passage 22B is formed on the circumferential surface of the rear end of the rotary shaft 22. One end of the rear supply passage 22B is opened to a cylinder suction chamber 19 formed in the rear cylinder head 14 and the other end of the rear supply passage 22B is communicable with the other end of the introducing passages 51. In accordance with the rotation of the rotary shaft 22, the position of the rear supply passage 22B is changed to mechanically switch communication paths between the introducing passages 51 and the rear supply passage 22B. Therefore, a portion of the rotary shaft 22 surrounded by the sealing circumferential surface is a rear rotary valve RR which is integrally formed with the rotary shaft 22. The cylinder suction chamber 19 serves as the suction chamber of the present invention.

[0033] The following will describe a muffler structure in the compressor 10. As shown in FIGS. 2, 3, and 5, the front space 28B is recessed on the front cylinder head 13 so as to annularly surround the rotary shaft 22. First through third front partition walls 32A through 32C are provided in the front cylinder head 13 for dividing the front space 28B into the first through the third front head-side discharge chambers

33A through 33C. The first through the third front partition walls 32A through 32C extend from the bottom surface of the front cylinder head 13 toward the front block-side discharge chambers 40. The first front partition wall 32A is provided at a position adjacent to the front block-side discharge chamber 40, which communicates with the discharge passage 45, in the rotating direction of the rotary shaft 22.

[0034] The first and the second front partition walls 32A and 32B are disposed adjacent to each other so as to interpose one front cylinder bore 28 in the rotating direction of the rotary shaft 22. The front space 28B includes the first front head-side discharge chamber 33A which is formed by the first and the second front partition walls 32A and 32B. The first front head-side discharge chamber 33A communicates with one front cylinder bore 28 (the front compression chamber 28A) through one front discharge port 15A.

[0035] The second and the third front partition walls 32B and 32C are disposed adjacent to each other so as to interpose another front cylinder bore 28 in the rotating direction of the rotary shaft 22. The front space 28B includes the second front head-side discharge chamber 33B formed by the second and the third front partition walls 32B and 32C. The second front head-side discharge chamber 33B communicates with one front cylinder bore 28 (the front compression chamber 28A), which is different from the front cylinder bore 28 communicating with the first front head-side discharge chamber 33A, through one front discharge port 15A. The front space 28B includes the third front head-side discharge chamber 33C formed by the first and the third front partition walls 32A and 32C. The third front head-side discharge chamber 33C communicates with the remaining one front cylinder bore 28 (the front compression chamber 28A) through one front discharge port 15A. The third front head-side discharge chamber 33C communicates with the discharge passage 45 through the front block-side discharge chamber 40.

[0036] As shown in FIGS. 2 and 7, a rear space 29B is recessed on the rear cylinder head 14 so as to annularly surround the rotary shaft 22. First through third rear partition walls 34A through 34C are provided in the rear cylinder head 14 for dividing the rear space 29B into three spaces. The first through the third rear partition walls 34A through 34C extend from the bottom surface of the rear cylinder head 14 toward the rear block-side discharge chamber 42. The first rear partition wall 34A is provided at a position adjacent to the rear block-side discharge chamber 42, which communicates with the discharge passage 45, in the rotating direction of the rotary shaft 22.

[0037] The first and the second rear partition walls 34A and 34B are provided adjacent to each other so as to interpose one rear cylinder bore 29 in the rotating direction of the rotary shaft 22. The rear space 29B includes the first rear head-side discharge chamber 35A formed by the first and the second rear partition walls 34A and 34B. The first rear head-side discharge chamber 35A communicates with one rear cylinder bore 29 (the rear compression chamber 29A) through one rear discharge port 16A.

[0038] The second and the third rear partition walls 34B and 34C are provided adjacent to each other so as to interpose another rear cylinder bore 29 in the rotating direction of the rotary shaft 22. The rear space 29B includes the second rear head-side discharge chamber 35B formed by the second and the third rear partition walls 34B and 34C. The second rear head-side discharge chamber 35B communicates with one rear cylinder bore 29 (the rear compression chamber 29A)

which is different from the rear cylinder bore 29 communicating with the first rear head-side discharge chamber 35A through one rear discharge port 16A. The rear space 29B further includes the third rear head-side discharge chamber 35C formed by the first and the third rear partition walls 34C and 34A. The third rear head-side discharge chamber 35C communicates with the remaining one rear cylinder bore 29 (the rear compression chamber 29A) through one rear discharge port 16A. The third rear head-side discharge chamber 35C communicates with the discharge passage 45 through the rear block-side discharge chamber 42.

[0039] As shown in FIGS. 3 and 7, two pairs of first front throttles 15F are formed in the gasket G of the front valve plate assembly 15 so as to interpose the second front partition wall 32B and the third front partition wall 32C, respectively. Two pairs of first rear throttles 16F are formed in the gasket G of the rear valve plate assembly 16 so as to interpose the second and the third rear partition walls 34B and 34C, respectively. Two pairs of second front throttles 20A are formed in the front valve plate 20 for communicating with the first front throttles 15F, respectively. Two pairs of second rear throttles 21A are formed in the rear valve plate 21 for communicating with the first rear throttles 16F, respectively. Pairs of the first front throttles 15F and the second front throttles 20A which interpose the second front partition wall 32B communicate with one front block-side discharge chamber 40. Pairs of the first rear throttles 16F and the second rear throttles 21A which interpose the second rear partition wall 34B communicate with one rear block-side discharge chamber 42. Pairs of the first front throttles 15F and the second front throttles 20A which interpose the third front partition wall 32C communicate with the other front block-side discharge chamber 40. Pairs of the first rear throttles 16F and the second rear throttles 21A which interpose the third rear partition wall 34C communicate with the other rear block-side discharge chamber 42. The first and the second front head-side discharge chambers 33A and 33B communicate through one front block-side discharge chamber 40 with the pairs of first and second front throttles 15F and 20A which interpose the second front partition wall 32B. The first and the second rear head-side discharge chambers 35A and 35B communicate through one rear block-side discharge chamber 42 with the pairs of first and the second rear throttles 16F and 21A which interpose the second rear partition wall 34B. The second and the third front head-side discharge chambers 33B and 33C communicate through the other front block-side discharge chamber 40 with the pairs of the first and the second front throttles 15F and 20A which interpose the third front partition wall 32C. The second and the third rear head-side discharge chambers 35B and 35C communicate through the other rear block-side discharge chamber 42 with the pairs of the first and the second rear throttles 16F and 21A which interpose the third rear partition wall 34C. The first and the third front head-side discharge chambers 33A and 33C are separated by the first front partition wall 32A and do not communicate with each other. The first and the third rear head-side discharge chambers 35A and 35C are separated by the first rear partition wall 34A and do not communicate with each other. In the front space 28B, refrigerant gas flows in the rotating direction of the rotary shaft 22 from the first front head-side discharge chamber 33A to the second front head-side discharge chamber 33B and then to the third front head-side discharge chamber 33C, as indicated by the arrows Y in FIG. 3. In the rear space 29B, refrigerant gas flows in the rotating direction of the rotary

shaft 22 from the first rear head-side discharge chamber 35A to the second rear head-side discharge chamber 35B and then to the third rear head-side discharge chamber 35C, as indicated by the arrows Y in FIG. 7. The first front throttle 15F and the first rear throttle 16F serve as a first throttle of the present invention. The second front throttle 20A and the second rear throttle 21A serve as a second throttle of the present invention.

[0040] The following will describe the operation of the compressor 10 as constructed above. The refrigerant gas is flowed into the suction passage 43 through the inlet 44 and supplied to the front and the rear suction chambers 17 and 18. When the front cylinder bores 28 shift to a suction stroke, one communication passage 50A and the introducing passage 50B adjacent to the communication passage 50A communicate with each other through the front groove 22A of the front rotary valve RF. Then, the refrigerant gas is flowed into the front cylinder bores 28 from the front suction chamber 17 through the front rotary valve RF.

[0041] In accordance with the rotation of the rotary shaft 22, the front groove 22A is disconnected from the communication passage 50A, the communication of the communication passage 50A and the introducing passage 50B is blocked, and the front cylinder bores 28 are shut off. Thus, the front cylinder bores 28 shift to a compression stroke and a discharge stroke.

[0042] Referring to FIG. 6, on the front side of the compressor 10, the refrigerant gas discharged to the first front head-side discharge chamber 33A passes through one second front throttle 20A and one first front throttle 15F formed across the second front partition wall 32B along the axial direction of the rotary shaft 22 and flows into the front block-side discharge chamber 40. Then, the refrigerant gas passes through the other first front throttle 15F and the other second front throttle 20A along the axial direction of the rotary shaft 22 and flows to the second front head-side discharge chamber 33B different from the first front head-side discharge chamber 33A.

[0043] The refrigerant gas discharged from the front compression chamber 28A facing the second front head-side discharge chamber 33B passes through one pair of the second front throttle 20A and the first front throttle 15F formed across the third front partition wall 32C in the axial direction of the rotary shaft 22 and flows into the front block-side discharge chamber 40 together with the refrigerant gas flowed from the first front head-side discharge chamber 33A. Then, the refrigerant gas passes through the other first front throttle 15F and the other second front throttle 20A from the front block-side discharge chamber 40 in the axial direction of the rotary shaft 22 and flows to the third front head-side discharge chamber 33C different from the second front head-side discharge chamber 33B.

[0044] The refrigerant gas discharged from the front compression chamber 28A facing the third front head-side discharge chamber 33C into the third front head-side discharge chamber 33C is flowed into the front block-side discharge chamber 40 and, then, flowed out to the external refrigerant circuit through the discharge passage 45 and the outlet 46 together with the refrigerant gas flowed from the second front head-side discharge chamber 33B.

[0045] On the rear side of the compressor 10, in a state in which refrigerant gas is supplied to the cylinder suction chamber 19, when the rear cylinder bores 29 shift to the suction stroke, the rear supply passage 22B communicating

with the cylinder suction chamber 19 in the rear rotary valve RR communicates with one introducing passage 51. Then, the refrigerant gas is supplied to the introducing passage 51 from the cylinder suction chamber 19 through the rear rotary valve RR and flowed into the rear cylinder bore 29 communicating with the introducing passage 51.

[0046] In accordance with the rotation of the rotary shaft 22, the rear supply passage 22B is disconnected from the introducing passage 51, the communication between the introducing passage 51 and the cylinder suction chamber 19 is blocked, and the rear cylinder bores 29 is shut off. Thus, the rear cylinder bores 29 shift to the compression stroke and the discharge stroke.

[0047] Referring to FIG. 7, on the rear side of the compressor 10, the refrigerant gas discharged to the first rear head-side discharge chamber 35A passes through one second rear throttle 21A and one first rear throttle 16F formed across the second rear partition wall 34B in the axial direction of the rotary shaft 22 and is flowed into the rear block-side discharge chamber 42. Then, the refrigerant gas in the rear block-side discharge chamber 42 passes the other first rear throttle 16F and the other second rear throttle 21A in the axial direction of the rotary shaft 22 and flows into the second rear head-side discharge chamber 35B different from the first rear head-side discharge chamber 35A.

[0048] The refrigerant gas discharged from the rear compression chamber 29A facing the second rear head-side discharge chamber 35B passes through one second rear throttle 21A and one first rear throttle 16F formed across the third rear partition wall 34C in the axial direction of the rotary shaft 22 and flows into the rear block-side discharge chamber 42 together with the refrigerant gas flowing from the first rear head-side discharge chamber 35A. Then, the refrigerant gas in the rear block-side discharge chamber 42 passes through the other first rear throttle 16F and the other second rear throttle 21A in the axial direction of the rotary shaft 22 and flows into the third rear head-side discharge chamber 35C which is different from the second rear head-side discharge chamber 35B. The refrigerant gas discharged to the third rear head-side discharge chamber 35C flows into the rear block-side discharge chamber 42, flows through the discharge passage 45, and is discharged from the outlet 46 together with the refrigerant gas flowing from the second rear head-side discharge chamber 35B.

[0049] Therefore, on the front and the rear sides of the compressor 10, the refrigerant gas discharged from the front and the rear compression chambers 28A and 29A may be reciprocated for a plurality of times by using the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C and the front and the rear block-side discharge chambers 40 and 42. Therefore, the refrigerant gas is made to meander until the discharged refrigerant gas is discharged from the outlet 46. Since the refrigerant gas has viscosity, energy is reduced by moving the refrigerant gas along the inner surfaces of the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C and the inner surfaces of the front and the rear block-side discharge chambers 40 and 42.

[0050] According to the preferred embodiment of the present invention, the following advantageous effects are obtained.

[0051] (1) On the front side of the compressor 10, the front block-side discharge chambers 40 may be communicable with the different two of the front head-side discharge chambers 33A through 33C and, on the rear side of the compressor 10, the rear block-side discharge chambers 42 may be communicable with the different two of the third through the third rear head-side discharge chambers 35A through 35C. Therefore, the refrigerant gas may be reciprocated in the discharge path through which the discharged refrigerant gas is flowed to the outlet 46. As a result, the refrigerant gas may be made to meander. Accordingly, the distance of the flow of the discharged refrigerant gas to the outlet 46 may be increased to reduce pulsation. Therefore, in order to reduce pulsation, a muffler chamber that projects from the housing H may not need to be provided. Moreover, pulsation may be reduced in a limited volume without providing the muffler chamber.

[0052] (2) The outlet 46 is formed in the front cylinder block 11. Therefore, the refrigerant gas flowed from the front and the rear compression chambers 28A and 29A is discharged in a direction away from the outlet 46 and, then, the refrigerant gas collides against the front and the rear head-side discharge chambers 33A through 33C and 35A through 35C, flows into the front and the rear block-side discharge chambers 40 and 42, and flows out to the external refrigerant circuit through the outlet 46. Therefore, the compressed refrigerant gas may be reciprocated at least once until the refrigerant gas reaches the outlet 46.

[0053] (3) In the front and the rear cylinder heads 13 and 14, the front and the rear spaces 28B and 29B are respectively annularly formed around the rotary shaft 22. Therefore, while the refrigerant gas flows in the rotating direction of the rotary shaft 22, the refrigerant gas flowing into the front and the rear spaces 28B and 29B meanders in the axial direction and reaches the outlet 46. Accordingly, a distance that the discharged refrigerant gas flows to the outlet 46 may be increased to reduce pulsation.

[0054] (4) In the front and the rear cylinder heads 13 and 14, the front and the rear spaces 28B and 29B are respectively annularly formed around the rotary shaft 22. Accordingly, the front and the rear spaces 28B and 29B may be easily partitioned into the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C by the first through the third front partition walls 32A through 32C and the first through the third rear partition walls 34A through 34C. Further, the front and the rear spaces 28B and 29B are formed using the front and the rear cylinder heads 13 and 14 widely to surround the rotary shaft 22. Since the annular front and the annular rear spaces 28B and 29B are partitioned by the first through the third front partition walls 32A through 32C and the first through the third rear partition walls 34A through 34C, the volume of the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C may be increased as much as possible to effectively reduce pulsation.

[0055] (5) The plurality of the front and the rear block-side discharge chambers 40 and 42 are provided around the rotary shaft 22. Therefore, the refrigerant gas may be made to be flowed into the plurality of the front and the rear block-side discharge chambers 40 and 42 from the first through the third front head-side discharge chambers 33A

through 33C and the first through the third rear head-side discharge chambers 35A through 35C and reciprocated therethrough for a plurality of times. Accordingly, a long distance that the discharged gas flows to the outlet 46 may be secured to reduce pulsation.

[0056] (6) The outlet 46 communicates with one of the three front block-side discharge chambers 40 and one of the three rear block-side discharge chambers 42. Therefore, the refrigerant gas flowed into the front block-side discharge chambers 40 from the first through the third front head-side discharge chambers 33A through 33C may be prevented from directly flowing out through the outlet 46 from the front block-side discharge chambers 40. Similarly, the refrigerant gas flowed into the front and the rear block-side discharge chambers 42 from the first through the third rear head-side discharge chambers 35A through 35C may be prevented from directly flowing out through the outlet 46 from the rear block-side discharge chambers 42. As a result, a distance that the discharged refrigerant gas flows to the outlet 46 may be secured to reduce pulsation.

[0057] (7) The front and the rear block-side discharge chambers 40 and 42 are arranged one by one in the gaps among the front cylinder bores 28 adjacent to one another and among the rear cylinder bores 29 adjacent to one another in the rotating direction of the rotary shaft 22. Therefore, the gaps of the front and the rear cylinder bores 28 and 29 adjacent to one another are effectively used for the front and the rear block-side discharge chambers 40 and 42. An increase in size of the compressor 10 in the axial direction may be suppressed.

[0058] (8) The first front throttles 15F and the first rear throttles 16F are provided in the gaskets G of the front and the rear valve plate assemblies 15 and 16. The second front throttles 20A and the second rear throttles 21A are provided in the front and the rear valve plates 20 and 21. The first front throttles 15F and the first rear throttles 16F and the second front throttles 20A and the second rear throttles 21A communicate the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C with the front and the rear block-side discharge chambers 40 and 42. Therefore, when the refrigerant gas flows between the first through the third front head-side discharge chambers 33A through 33C and the first through the third rear head-side discharge chambers 35A through 35C and the front and the rear block-side discharge chambers 40 and 42, pulsation occurred by the first front throttles 15F and the first rear throttles 16F and the second front throttles 20A and the second rear throttles 21A may be reduced.

[0059] The above preferred embodiment may be modified into various alternative embodiments, as exemplified below. The diameter of the first front throttles 15F and the first rear throttles 16F and the second front throttles 20A and the second rear throttles 21A may be changed.

[0060] The front and the rear discharge ports 15A and 16A may be formed in other than the front and the rear valve plate assemblies 15 and 16.

[0061] Only the gaskets G may be provided between the front and the rear cylinder blocks 11 and 12 and the front and the rear cylinder heads 13 and 14, respectively, and the front

and the rear discharge ports 15A and 16A and the first front throttles 15F and the first rear throttles 16F may be provided in the gaskets G, respectively.

[0062] The front and the rear block-side discharge chambers 40 and 42 do not have to be provided one by one in the gaps of the front and the rear cylinder bores 28 and 29 adjacent to one another. In some of the gaps, the front and the rear block-side discharge chambers 40 and 42 may be not provided.

[0063] Four or more partition walls may be provided in each of the front and the rear cylinder heads 13 and 14 and four or more front block-side discharge chambers 40 and four or more rear block-side discharge chambers 42 may be provided to increase the number of times of the reciprocation of the refrigerant gas. On the other hand, two partition walls may be provided in each of the front and the rear cylinder heads 13 and 14 and two or more front block-side discharge chambers 40 and two or more rear block-side discharge chambers 42 may be provided to reduce the number of times of reciprocation of the refrigerant gas.

[0064] According to the preferred embodiment, the outlet 46 is opened through the front cylinder block 11. Alternatively, an outlet may be formed to be opened through the rear cylinder block 12, or the front and the rear cylinder heads 13 and 14.

[0065] According to the preferred embodiment, the rotary valves are adapted to suctioning on the front and the rear sides of the compressor 10. Alternatively, suction valves may be adapted to suctioning on the front and the rear sides in stead of the rotary valves.

[0066] According to the preferred embodiment, on the rear side of the compressor 10, the refrigerant gas in the front suction chambers 18 is collected in the cylinder suction chamber 19 and is flowed into the rear cylinder bores 29 from the cylinder suction chamber 19 through the rear rotary valve RR. Alternatively, on the rear side of the compressor 10, as in the front side, the rear suction chambers 18 and the rear shaft hole 12A may communicate through communication passages and introducing grooves, the rear shaft hole 12A and the rear cylinder bores 29 may separately communicate through introducing passages, respectively. Thus, the refrigerant gas may be flowed into the rear cylinder bores 29 from the rear suction chambers 18 through the communication passages, the introducing grooves of the rear rotary valve RR and the introducing passages.

[0067] According to the preferred embodiment, the refrigerant gas passed through the inlet 44 is supplied to the front and the rear compression chambers 28A and 29A through the front groove 22A and the rear supply passage 22B formed on the surface of the rotary shaft 22. Alternatively, a rotary shaft may be formed to include an inner passage therein as a hollow shaft. Thus, after refrigerant gas flowed through the inlet 44 may be guided to the inside of the front and the rear cylinder heads 13 or 14, the refrigerant gas is supplied to the front and the rear compression chambers 28A and 29A through the inner passage.

[0068] According to the preferred embodiment, the refrigerant gas flowed through the inlet 44 is supplied to the front and the rear suction chambers 17 and 18 through the suction passage 43 formed in the front and the rear cylinder blocks 11 and 12. Alternatively, the refrigerant gas flowed through the inlet 44 may be supplied to the front and the rear suction chambers 17 and 18 through the crank chamber 25.

[0069] According to the preferred embodiment, the volume of one front suction chamber 17 and one rear suction chamber 18 which communicate with the suction passage 43 is set larger than the volume of the other two front suction chambers 17 and the other two rear suction chambers 18. Alternatively, the volume of the other two front suction chambers 17 and the other two rear suction chambers 18 may be set larger than the volume of the front and the rear suction chambers 17 and 18 which communicate with the suction passage 43.

[0070] The three front suction chambers 17 may have the same volume and also three rear suction chambers 18 may have the same volume.

[0071] Only one front block-side discharge chamber 40 may be provided and each front space 28B may be partitioned into two front head-side discharge chambers. Only one rear block-side discharge chamber 42 may be provided and each rear space 29B may be partitioned into two rear head-side discharge chambers.

[0072] The number of the front and the rear cylinder bores 28 and 29 may be changed.

[0073] According to the preferred embodiment, the compressor 10 is a double-headed piston type swash plate compressor including the double-headed pistons 30. Alternatively, the piston type swash plate compressor may be a single-headed piston type swash plate compressor including a single-headed piston.

What is claimed is:

1. A piston type swash plate compressor comprising:

- a housing;
- a cylinder block formed in the housing;
- a cylinder head formed in the housing, the cylinder head connected to an end of the cylinder block;
- a rotary shaft rotatably supported by the cylinder block;
- a plurality of cylinder bores arranged around the rotary shaft;
- a plurality of pistons respectively accommodated in the cylinder bores;
- a swash plate integrally rotating with the rotary shaft, the swash plate engaged with the pistons;
- a plurality of compression chambers respectively defined in the cylinder bores by the pistons;
- a plurality of head-side discharge chambers provided in the cylinder head;
- a plurality of block-side discharge chambers provided in the cylinder block;

an outlet formed through the housing, the outlet through which compressed refrigerant gas is flowed outside the housing; and

a discharge path formed in the housing, the discharge path through which refrigerant gas is flowed from the compression chamber to the outlet through the head-side discharge chamber and the block-side discharge chamber,

wherein, after refrigerant gas flowed from the compression chamber is flowed through one head-side discharge chamber which communicates with the compression chamber and one block-side discharge chamber, the refrigerant gas is flowed to another head-side discharge chamber.

2. The piston type swash plate compressor according to claim 1, wherein a plurality of the head-side discharge chambers is formed by dividing a space formed annularly around the rotary shaft in a rotating direction of the rotary shaft by partition walls.

3. The piston type swash plate compressor according to claim 1, wherein a plurality of the block-side discharge chambers is formed around the rotary shaft, after refrigerant gas flowed from the compression chamber is flowed through the discharge path from one block-side discharge chamber to one head-side discharge chamber, the refrigerant gas is flowed to another block-side discharge chamber.

4. The piston type swash plate compressor according to claim 3, wherein each block-side discharge chamber is located between any two adjacent cylinder bores.

5. The piston type swash plate compressor according to claim 1, wherein a gasket is provided between the cylinder block and the cylinder head, a first throttle is formed through the gasket, at least one of the block-side discharge chambers communicates with at least one of the head-side discharge chambers through the first throttle.

6. The piston type swash plate compressor according to claim 1, wherein a valve plate is provided between the cylinder block and the cylinder head, a part of the valve plate forms a discharge valve, a second throttle is formed in the valve plate and at least one of the block-side discharge chamber communicates with at least one of the head-side discharge chamber through the second throttle.

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