(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 571 336 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.09.2005 Bulletin 2005/36

(51) Int Cl.[7]: **F04B 27/10**, F04B 39/12, F04B 39/08

(21) Application number: **05004432.0**

(22) Date of filing: **01.03.2005**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR LV MK YU

(30) Priority: **03.03.2004 JP 2004059466**

(71) Applicant: **KABUSHIKI KAISHA TOYOTA JIDOSHOKKI**
Aichi-ken 448-8671 (JP)

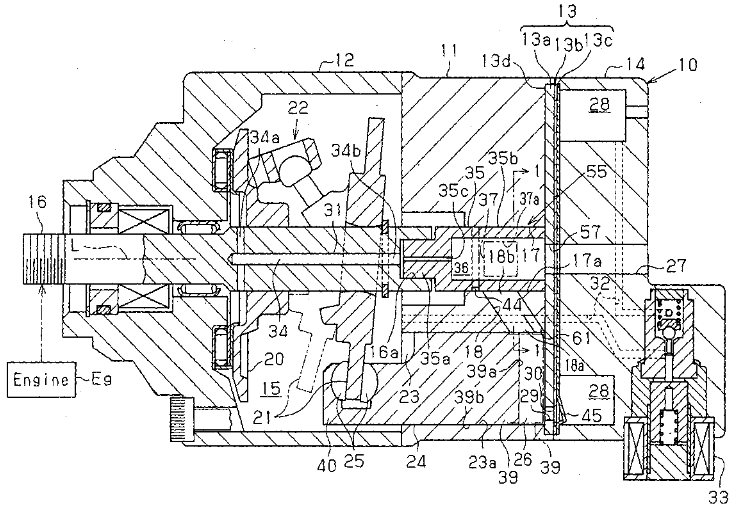
(72) Inventors:
- **Inoue, Yoshinori**
  Kariya-shi Aichi-ken (JP)
- **Kawamura, Hisato**
  Kariya-shi Aichi-ken (JP)
- **Kawachi, Shigeki**
  Kariya-shi Aichi-ken (JP)
- **Masuda, Masanori**
  Kariya-shi Aichi-ken (JP)
- **Kimoto, Yoshio**
  Kariya-shi Aichi-ken (JP)
- **Hibino, Sokichi**
  Kariya-shi Aichi-ken (JP)
- **Hayashi, Shiro**
  Kariya-shi Aichi-ken (JP)
- **Morishita, Atsuyuki**
  Kariya-shi Aichi-ken (JP)
- **Murakami, Tomohiro**
  Kariya-shi Aichi-ken (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **Piston compressor**

(57) A piston compressor includes a rotary valve (35) having a suction guide hole. A plurality of introducing passages are formed in a cylinder block to connect compression chambers to the rotary valve (35). The inner circumferential surface of each cylinder bore has a suction auxiliary recess (61), which is connected to the outlet of the corresponding introducing passage in the circumferential direction of the cylinder bore at the end of the cylinder bore facing a valve assembly. Therefore, the compressor reduces suction resistance of gas at the beginning of the suction stroke without enlarging introducing passages formed in the cylinder block.

Fig.1



EP 1 571 336 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a piston compressor that compresses gas by reciprocation of pistons.

[0002] For example, suction valves, which are reed valves, are generally used in a piston compressor that is used as a refrigerant compressor of a vehicle air-conditioner. When the pressure in a compression chamber becomes less than the pressure in a suction pressure zone during the suction stroke of a piston moving from the top dead center position to the bottom dead center position, refrigerant gas in the suction pressure zone presses open one of the suction valves and flows into the compression chamber. However, the suction valves, which are differential valves such as the reed valves, easily generate noise due to self-excited vibration.

[0003] Therefore, as shown in Fig. 9, a piston compressor has been proposed that uses a rotary valve 88, which does not cause self-excited vibration, instead of the suction valves (see Japanese Laid-Open Patent Publication No. 6-117366).

[0004] That is, cylinder bores 83 (only one is shown in Fig. 9) are arranged about a drive shaft 82 in a cylinder block 81 in a housing of the piston compressor. A piston 84 is accommodated in each cylinder bore 83. In each cylinder bore 83, a compression chamber 86 is defined by the associated piston 84 and a valve assembly 85, which is joined to the cylinder block 81. Although not shown in the drawing, discharge ports and discharge valves are formed on the valve assembly 85 corresponding to the compression chambers 86.

[0005] An accommodation hole 87 is formed at the center of the cylinder block 81. The accommodation hole 87 accommodates the cylindrical rotary valve 88, which is coupled to the end of the drive shaft 82. The rotary valve 88 slides along an inner circumferential surface 87a of the accommodation hole 87. A space in the rotary valve 88 serves as an introduction chamber 89. Low pressure refrigerant gas is introduced into the introduction chamber 89 from an evaporator of an external refrigerant circuit.

[0006] A suction guide hole 90 is formed in the rotary valve 88. The suction guide hole 90 is always connected to the introduction chamber 89 and has an outlet (opening facing the compression chamber) 90a on an outer circumferential surface 88a of the rotary valve 88. Introducing passages 91 are formed through the cylinder block 81 to connect the compression chambers 86 to the rotary valve 88. An outlet (opening facing the compression chamber) 91a, which is the end of each introducing passage 91 facing the compression chamber 86, is formed on an inner circumferential surface 83a of the cylinder bore 83. An inlet (opening facing the rotary valve) 91b, which is the end of each introducing passage 91 facing the rotary valve 88, is formed on the inner circumferential surface 87a of the accommodation hole 87.

[0007] As the rotary valve 88 rotates in synchronization with the drive shaft 82, the outlet 90a of the suction guide hole 90 is sequentially connected to the inlet 91b of each introducing passage 91 corresponding to the compression chamber 86 that is in the suction stroke. This permits refrigerant gas to flow (be drawn) into the compression chamber 86 through the suction guide hole 90 and the introducing passage 91 from the introduction chamber 89.

[0008] However, in the above mentioned piston compressor, as shown by a chain double-dashed line in Fig. 9, when each piston 84 begins the suction stroke, that is, when the piston 84 is in the vicinity of the top dead. center position, the outlet 91a of the corresponding introducing passage 91 is almost completely closed by the outer circumferential surface 84a of the piston 84. In this state, the opening area for refrigerant gas to flow between the introducing passage 91 and the compression chamber 86 is narrow. Therefore, a portion where the opening area becomes narrow functions as a restrictor, thereby increasing the flow resistance (suction resistance) of refrigerant gas that flows from the introduction chamber 89 to the compression chamber 86. This may decrease the suction efficiency of refrigerant gas from the introduction chamber 89 to the compression chamber 86, that is, decrease the volumetric efficiency of the piston compressor.

[0009] The piston compressor shown in Fig. 9 is a swash plate type variable displacement compressor. In the swash plate type piston compressor, the pressure in a swash plate accommodating chamber, which is a crank chamber 92, is adjusted to change the difference between the pressure in the crank chamber 92 and the pressure in the compression chambers 86 with the pistons 84 in between. Accordingly, the inclination angle of a swash plate 93 is changed. As a result, the stroke of each piston 84, or the compressor displacement, is varied. Therefore, when the piston compressor is operating in a minimum displacement, the stroke of piston 84 is far smaller than that in a case where the piston compressor is operating in a maximum displacement. At this time, the bottom dead center position of the piston 84 becomes closest to the top dead center position.

[0010] Therefore, regarding the above-mentioned problem of decrease in the suction efficiency at the beginning of the suction stroke, when the piston compressor is operated in the minimum displacement, refrigerant gas is hardly drawn into the compression chambers 86. That is, the amount of refrigerant gas supplied for compression in each compression chamber 86 is decreased. Thus, the pressure in the compression chamber 86 is hardly increased by the compression of refrigerant gas. Even if the piston compressor attempts to increase the displacement from the minimum displacement, compression reaction force that acts on the swash plate 93 from the compression chambers 86 via the pistons 84 in a direction to increase the inclination angle of the swash plate 93 may be insufficient. In this case, increasing the compressor displacement may be delayed. This may deteriorate the cooling performance.

[0011] To solve this problem, the size of the introducing passages 91 formed in the cylinder block 81 may be increased to enlarge the outlet 91a of each introducing passage 91 in the circumferential direction of the cylinder bore 83. This widens the opening area between each introducing passage 91 and the corresponding compression chamber 86 at the beginning of the suction stroke. However, increasing the size of the introducing passage (through hole) 91 provided per each cylinder bore 83 directly decreases the strength of the cylinder block 81.

[0012] In Fig. 10, the rotary motion of the rotary valve 88 is developed and expressed as a linear motion. Also, rotation of the suction guide hole 90 about the axis of the rotary valve 88 is transformed into the leftward movement of the suction guide hole 90. As shown in Fig. 10, a residual gas bypass groove 94 is formed on the outer circumferential surface 88a of the rotary valve 88. The residual gas bypass groove 94 connects the introducing passage 91 (91A), which communicates with the pressurized compression chamber 86 that has completed the discharge stroke, to the introducing passage 91 (91B), which communicates with the low pressure compression chamber 86.

[0013] Therefore, refrigerant gas that remains undischarged (residual gas) in each compression chamber 86 that has completed the discharge stroke is bypassed (collected) to the low pressure compression chamber 86 through the high pressure-side introducing passage 91A, the residual gas bypass groove 94, and the low pressure-side introducing passage 91B. Accordingly, reexpansion of the residual gas in the compression chamber 86 during the suction stroke becomes smaller, making it possible to reliably draw the refrigerant gas in the introduction chamber 89 into the compression chamber 86. This improves the volumetric efficiency of the piston compressor.

[0014] However, when the residual gas bypass groove 94 is formed on the rotary valve 88, it is necessary to prevent gas from flowing between a high pressure groove 94a of the residual gas bypass groove 94 corresponding to the high pressure-side introducing passage 91A and the outlet 90a of the suction guide hole 90 via the inlet 91b of the introducing passage 91. In other words, in the seal area at the outer circumferential surface 88a of the rotary valve 88, a portion between the high pressure groove 94a of the residual gas bypass groove 94 and the outlet 90a of the suction guide hole 90 needs an area large enough to block the opening 91b of the introducing passage 91. In particular, the portion needs to be large enough in the circumferential direction of the rotary valve 88.

[0015] Therefore, enlarging the size of the introducing passages 91 formed in the cylinder block 81, that is, enlarging each inlet 91b in the circumferential direction of the rotary valve 88 hinders securing the above mentioned seal area. Thus, at this point, it is difficult to provide the residual gas bypass groove 94 while increasing the size of the introducing passages 91 formed in the cylinder block 81 by an amount that effectively reduces the suction resistance at the beginning of the suction stroke.

SUMMARY OF THE INVENTION

[0016] Accordingly, it is an objective of the present invention to provide a piston compressor that reduces suction resistance of gas at the beginning of the suction stroke without enlarging introducing passages formed in a cylinder block.

[0017] To achieve the above-mentioned objective, the present invention provides a piston compressor. The compressor includes a drive shaft and a housing. The housing rotatably supports the drive shaft. The housing includes a cylinder block, which has a plurality of cylinder bores. Each cylinder bore has openings on both axial ends, and the cylinder block has an accommodation hole surrounded by the cylinder bores. Each of a plurality of pistons is accommodated and reciprocates in one of the cylinder bores. A valve assembly is joined to the cylinder block. The pistons and the valve assembly define a plurality of compression chambers in each cylinder bore. The valve assembly has discharge ports and discharge valves. Each set of the discharge port and the discharge valve corresponds to one of the compression chambers. A rotary valve is accommodated in the accommodation hole. The rotary valve has a suction guide hole, which opens on the outer circumferential surface of the rotary valve. A suction pressure zone communicates with the suction guide hole. A plurality of introducing passages are formed in the cylinder block to connect the compression chambers to the rotary valve. Each introducing passage has an inlet, which opens on the inner circumferential surface of the accommodation hole, and an outlet, which opens on the inner circumferential surface of the cylinder bore. When the rotary valve rotates in synchronization with the drive shaft, the suction guide hole sequentially communicates with the inlet of each introducing passage so that gas is drawn into the corresponding compression chamber through the suction guide hole and the introducing passage from the suction pressure zone. The inner circumferential surface of each cylinder bore has a suction auxiliary recess, which is connected to the outlet of the corresponding introducing passage in the circumferential direction of the cylinder bore at the end of the cylinder bore facing the valve assembly.

[0018] Further, the present invention provides a piston compressor including a suction auxiliary portion formed at the end portion of each piston facing the valve assembly. The suction auxiliary portion separates an area of the outer circumferential surface of the end portion that faces the outlet of the corresponding introducing passage from the outlet.

[0019] Further, the present invention provides a piston compressor, wherein a portion of the valve assembly facing the compression chambers has suction auxiliary recesses corresponding to the outlets of the introducing passages.

[0020] 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

[0021] 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 cross-sectional view illustrating a swash plate type variable displacement compressor according a first embodiment of the present invention;

Fig. 2 is a cross-sectional view taken along line 1-1 in Fig. 1;

Fig. 3 is a view showing the rotary motion of the rotary valve incorporated in the compressor of Fig. 1 developed and expressed as a linear motion;

Fig. 4 is a view illustrating the inner circumferential surface of the cylinder bore of the compressor shown in Fig. 1 developed and expressed as a plane form;

Fig. 5 is a partial longitudinal cross-sectional view illustrating a swash plate type variable displacement compressor according to a second embodiment of the present invention;

Fig. 6 is perspective view illustrating the head of the piston incorporated in the compressor shown in Fig. 5;

Fig. 7 is a partial longitudinal cross-sectional view illustrating a swash plate type variable displacement compressor according to a third embodiment of the present invention;

Fig. 8(a) is a partial longitudinal cross-sectional view illustrating a swash plate type variable displacement compressor according to a fourth embodiment of the present invention;

Fig. 8(b) is an enlarged view illustrating the vicinity of the second discharge port of the compressor shown in Fig. 8(a);

Fig. 9 is a partial longitudinal cross-sectional view illustrating a swash plate type variable displacement compressor according to a prior art; and

Fig. 10 is a view showing the rotary motion of the rotary valve incorporated in the compressor of Fig. 9 developed and expressed as a linear motion.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] A piston compressor according to first to fourth embodiments of the present invention will now be described. The piston compressor is embodied in a swash plate type variable displacement compressor for compressing refrigerant used in a vehicle air-conditioner. In the second to fourth embodiments, only the parts different from the first embodiment are explained. Like members are given the like numbers and detailed explanations are omitted.

[0023] The invention of claim 1 according to the first embodiment will now be described. A swash plate type variable displacement compressor 10 will now be described.

[0024] Fig. 1 shows a longitudinal cross-section of the compressor 10. The left end of the compressor 10 in Fig. 1 is defined as the front of the compressor 10, and the right end is defined as the rear of the compressor 10. As shown in Fig. 1, the compressor 10 includes a cylinder block 11, a front housing member 12, a valve assembly 13, and a rear housing member 14. The front housing member 12 is secured to the front end of the cylinder block 11. The rear housing member 14 is secured to the rear end of the cylinder block 11 with the valve assembly 13 in between. The valve assembly 13 includes a port plate 13a, a discharge valve flap plate 13b, and a retainer plate 13c, which are laminated from the cylinder block 11 toward the rear housing member 14 in this order. The cylinder block 11, the front housing member 12, and the rear housing member 14 form a housing of the compressor 10.

[0025] The cylinder block 11 and the front housing member 12 define a crank chamber 15 in between. A drive shaft 16 extends through the crank chamber 15 and is rotatably supported by the front housing member 12 and the cylinder block 11. The drive shaft 16 is coupled to a drive source of the vehicle, which is an engine Eg in the first embodiment. The drive shaft 16 is rotated by power supplied by the engine Eg.

[0026] A lug plate 20 is coupled to the drive shaft 16 and is located in the crank chamber 15. The lug plate 20 rotates integrally with the drive shaft 16. A cam plate, which is a swash plate 21 in the first embodiment, is accommodated in the crank chamber 15. The swash plate 21 slides along and inclines with respect to the drive shaft 16. That is, the swash plate 21 tilts with respect to the drive shaft 16. A hinge mechanism 22 is arranged between the lug plate 20 and the swash plate 21. The swash plate 21 is supported by the drive shaft 16. The lug plate 20 and the swash plate 21 are coupled by the hinge mechanism 22. Therefore, the swash plate 21 integrally rotates with the lug plate 20 and the drive shaft 16. The swash plate 21 also slides along the axis L of the drive shaft 16 while inclining with respect to the drive shaft 16.

[0027] The compressor 10 includes a multi-cylindered piston compressor mechanism. That is, as shown in Figs. 1 and 2, cylinder bores 23, the number of which is five in the first embodiment (only one is shown in Fig. 1), are arranged about the rear end of the drive shaft 16 at equal angular intervals extending through the cylinder block 11. A single-headed piston 24 is accommodated in each cylinder bore 23. Each piston 24 includes a head 39, which is inserted in the associated cylinder bore 23, and a neck 40 located in the crank chamber 15. The head 39 and the neck 40 are coupled to each other along the axis L of the drive shaft 16.

[0028] The front and rear openings of each cylinder bore 23 are closed by a front end face 13d of the valve assembly 13 (more specifically, the port plate 13a) and an end face 39a of the' head 39 of the associated piston 24. A compression chamber 26 is defined in each cylinder bore 23. The volume of the compression chamber 26 changes according to the reciprocation of the corresponding piston 24. Each piston 24 has a pair of shoes 25 arranged in the associated neck 40, and is coupled to the peripheral portion of the swash plate 21 with the shoes 25. The shoes 25 convert rotation of the swash plate 21, which rotates with the drive shaft 16, to linear reciprocation of the pistons 24.

[0029] A suction passage 27 and a discharge chamber 28 are defined in the rear housing member 14. The suction passage 27 functions as a suction pressure zone. The suction passage 27 is defined in a center portion of the rear housing member 14. The discharge chamber 28 is defined between the valve assembly 13 and the rear housing member 14 to surround the suction passage 27. The suction passage 27 is connected to an external pipe connected to an evaporator (not shown) of an external refrigerant circuit. The discharge chamber 28 is connected to an external pipe connected to a gas cooler (not shown) of the external refrigerant circuit. The external refrigerant circuit and the compressor 10 form a refrigerant circuit of the vehicle air-conditioner.

[0030] As each piston 24 moves from the top dead center position to the bottom dead center position, refrigerant gas in the suction passage 27 is drawn into the corresponding compression chamber 26 through a suction valve mechanism 55 provided in the cylinder block 11. As the piston 24 moves from the bottom dead center position to the top dead center position, refrigerant gas drawn into the compression chamber 26 is compressed to a predetermined pressure. The compressed refrigerant gas is discharged to the discharge chamber 28 through a discharge port 29, which is formed on the port plate 13a of the valve assembly 13, and a discharge valve 30, which is a flapper valve formed on the discharge valve flap plate 13b of the valve assembly 13. The maximum opening degree of the discharge valve 30 is determined by the abutment of the discharge valve 30 on a retainer 45 formed on the retainer plate 13c of the valve assembly 13.

[0031] A bleed passage 31, a supply passage 32, and a control valve 33 are provided in the housing of the compressor 10. The bleed passage 31 connects the crank chamber 15 with the suction passage 27. The bleed passage 31 includes an axial passage 34 formed along the axis L of the drive shaft 16. An inlet 34a of the axial passage 34 is opened to the crank chamber 15 in the vicinity of the lug plate 20. An outlet 34b of the axial passage 34 is opened at the rear end face of the drive shaft 16. The supply passage 32 connects the crank chamber 15 to the discharge chamber 28. The control valve 33, which is a conventional electromagnetic valve, is located in the supply passage 32.

[0032] The opening degree of the control valve 33 is adjusted to control the balance between the flow rate of highly pressurized gas supplied to the crank chamber 15 through the supply passage 32 and the flow rate of gas conducted out of the crank chamber 15 through the bleed passage 31. The pressure in the crank chamber 15 is thus determined. The difference between the pressure in the crank chamber 15 and the pressure in the compression chambers 26 with the pistons 24 in between is changed according to changes in the crank chamber pressure. This alters the inclination angle of the swash plate 21, that is, the angle of the swash plate 21 with respect to a plane perpendicular to the axis L of the drive shaft 16. As a result, the stroke of each piston 24, that is, the displacement of the compressor 10, is controlled.

[0033] For example, when the pressure in the crank chamber 15 is lowered, the inclination angle of the swash plate 21 is increased. This lengthens the stroke of each piston 24 and the compressor displacement is increased accordingly. On the contrary, when the pressure in the crank chamber 15 is increased, the inclination angle of the swash plate 21 is decreased. This shortens the stroke of each piston 24 and the compressor displacement is decreased accordingly.

[0034] The suction valve mechanism 55 will now be described.

[0035] As shown in Figs. 1 and 2, an accommodation hole 17, the transverse cross-section of which is circular, is formed in a center portion of the cylinder block 11 that is surrounded by the cylinder bores 23. A through hole 57, which connects the accommodation hole 17 to the suction passage 27, is formed in the valve assembly 13. Introducing passages 18, the number of which is five in this embodiment, are formed in the cylinder block 11. The introducing passages 18 extend radially from the axis L of the drive shaft 16. Each compression chamber 26 is connected to the accommodation hole 17 by one of the introducing passages 18.

[0036] An end of each introducing passage 18 at the corresponding compression chamber 26, or an outlet (opening facing the compression chamber) 18a of the introducing passage 18, opens in an inner circumferential surface 23a of the cylinder bore 23. An end of each introducing passage 18 at the accommodation hole 17, or an inlet (opening facing the rotary valve) 18b, opens in an inner circumferential surface 17a of the accommodation hole 17. As shown in Figs. 3 and 4, the outlets 18a and the inlets 18b are elongated holes extending along the axis L of the drive shaft 16. The inlets 18b are displaced from the outlets 18a along the axis L. More specifically, the inlets 18b are displaced forward from the outlets 18a. Therefore, the introducing passages 18 incline with respect to the axis L.

[0037] A rotary valve 35 is rotatably accommodated in the accommodation hole 17. The rotary valve 35 substantially has a hollow cylindrical shape with a bottom. The bottom is located at the front end of the rotary valve 35. The inner circumferential surface 17a of the accommodation hole 17 and an outer circumferential surface 35b of the rotary valve 35 closely and slidably contact each other. A communication hole 35c, which extends along the axis L, is formed at the front end of the rotary valve 35. An inside space of the rotary valve 35, which is an introduction chamber 36, is connected to the outlet 34b of the axial passage 34 by the communication hole 35c. The communication hole 35c and the introduction chamber 36 form part of the bleed passage 31.

[0038] The diameter of the front end of the rotary valve 35 is smaller than the other part of the rotary valve 35 and forms a small diameter portion 35a. The rear end face of the drive shaft 16 faces the accommodation hole 17. A mounting hole 16a, which is greater than the outlet 34b of the axial passage 34, is formed on the rear end face of the drive shaft 16. The small diameter portion 35a of the rotary valve 35 is press fitted in the mounting hole 16a. Accordingly, the drive shaft 16 and the rotary valve 35 are arranged coaxially along the axis L and are integrated. The rotary valve 35 rotates in synchronization with rotation of the drive shaft 16, or reciprocation of the pistons 24. The outer circumferential surface 35b of the rotary valve 35 and the inner circumferential surface 17a of the accommodation hole 17 form sliding bearing surfaces that rotatably support the rear end portion of the drive shaft 16 with respect to the cylinder block 11.

[0039] The introduction chamber 36 of the rotary valve 35 communicates with the suction passage 27 via the through hole 57 of the valve assembly 13. A suction guide hole 37 is formed in the circumferential wall of the rotary valve 35. The suction guide hole 37 extends in a predetermined circumferential section and functions as a valve hole that always communicates with the introduction chamber 36. The suction guide hole 37 has an outlet (opening facing the compression chamber) 37a formed at the outer circumferential surface 35b of the rotary valve 35. The suction guide hole 37 sequentially connects the introduction chamber 36 to each introducing passage 18, which extends from the corresponding compression chamber 26, in synchronization with rotation of the rotary valve 35. Part of the outer circumferential surface 35b of the rotary valve 35 other than the outlet 37a functions as a seal area for closing the inlets 18b of the introducing passages 18.

[0040] That is, when each piston 24 begins the suction stroke, the rotary valve 35 connects the outlet 37a of the suction guide hole 37 to the inlet 18b of the introducing passage 18 corresponding to the piston 24. Therefore, refrigerant gas in the suction passage 27 is drawn into each compression chamber 26 via the through hole 57 in the valve assembly 13, the introduction chamber 36 in the rotary valve 35, the suction guide hole 37, and the associated introducing passage 18 in this order.

[0041] When the suction stroke of the piston 24 ends, the outlet 37a of the suction guide hole 37 is completely displaced from the inlet 18b of the introducing passage 18 corresponding to the piston 24 in the circumferential direction of the rotary valve 35. Therefore, suction of refrigerant gas from the introduction chamber 36 to the compression chamber 26 corresponding to the piston 24 is stopped. When the piston 24 proceeds to a compression and discharge stroke, the seal area of the outer circumferential surface 35b of the rotary valve 35 closes the inlet 18b of the corresponding introducing passage 18. Thus, the suction guide hole 37 does not hinder compression of refrigerant gas in the compression chamber 26 and discharge of the compressed refrigerant gas to the discharge chamber 28 from the compression chamber 26.

[0042] A residual gas bypass structure will now be described.

[0043] Fig. 3 is a view showing the rotary motion of the rotary valve 35 developed and expressed as a linear motion. The vertical direction of Fig. 3 corresponds to the axial direction (L) of the rotary valve 35. The lower portion of Fig. 3 corresponds to the front portion of the rotary valve 35. The upper portion of Fig. 3 corresponds to the rear portion of the rotary valve 35. The horizontal direction of Fig. 3 corresponds to the circumferential direction of the rotary valve 35. In Fig. 3, rotation of the suction guide hole 37 about the axis L of the rotary valve 35 is transformed into the leftward movement of the suction guide hole 37. As shown in Fig. 3, a residual gas bypass groove 41 for achieving a residual gas bypass passage is formed on the seal area of the outer circumferential surface 35b of the rotary valve 35. The residual gas bypass groove 41 includes a high pressure groove 42, a low pressure groove 43, and a communication groove 44. The high pressure groove 42 extends along the axis L of the rotary valve 35 (vertical direction of Fig. 3). The low pressure groove 43 also extends along the axis L of the rotary valve 35. The communication groove 44 extends in the circumferential direction of the rotary valve 35 (horizontal direction of Fig. 3) and connects the front ends (lower ends in Fig. 3) of the high pressure groove 42 and the low pressure groove 43 with each other.

[0044] One of the introducing passages 18 connected to the compression chamber 26 that has just completed discharging refrigerant gas is expressed as a high pressure-side introducing passage 18A and one of the introducing passages 18 connected to the compression chamber 26 that has just completed drawing in refrigerant gas is expressed as a low pressure-side introducing passage 18B. The high pressure groove 42 is arranged at a portion of the seal area of the rotary valve 35 that faces the inlet 18b of the high pressure-side introducing passage 18A. The low pressure groove 43 is arranged at a portion of the seal area of the rotary valve 35 that faces the inlet 18b of the low pressure-side introducing passage 18B. In other words, the high pressure groove 42 is located on the leading side of the rotary valve 35 with respect to the suction guide hole 37, that is, on the left side of the suction guide hole 37 as shown in Fig. 3. The low pressure groove 43 is located on the trailing side of the rotary valve 35 with respect to the suction guide hole 37, that is, on the right side of the suction guide hole 37 as shown in Fig. 3.

[0045] Therefore, refrigerant gas that remains undischarged in the compression chamber 26 that has just completed the discharge stroke is bypassed (collected) to the compression chamber 26 that has just completed the suction stroke via the high pressure-side introducing passage 18A, the high pressure groove 42, the communication groove 44, the low pressure groove 43, and the low pressure-side introducing passage 18B in this order. Accordingly, reexpansion of the residual gas in the compression chamber 26 during the suction stroke becomes smaller, making it possible to reliably draw the refrigerant gas in the introduction chamber 36 into the compression chamber 26. This improves the volumetric efficiency of the compressor 10.

[0046] Next, a structure for reducing the suction resistance of refrigerant gas that flows into the compression chamber 26 at the beginning of the suction stroke will be now described with reference to Figs. 1, 2, and 4. In Fig. 4, the inner circumferential surface 23a of the cylinder bore 23 is developed and expressed as a plane form. The upper side of Fig. 4 corresponds to the upper side of Fig. 3. The lower side of Fig. 4 corresponds to the lower side of Fig. 3. That is, the upper side of Fig. 4 corresponds to the rear end of the introducing passage 18, which faces the valve assembly 13, and the lower side of Fig. 4 corresponds to the front end of the introducing passage 18, which faces the crank chamber 15.

[0047] Suction auxiliary recesses 61 are formed on the inner circumferential surface 23a of each cylinder bore 23. A pair of the suction auxiliary recesses 61 are connected to the rear portion (the end facing the valve assembly 13) of the outlet 18a of each introducing passage 18. The pair of suction auxiliary recesses 61 are arranged on both sides of the rear end of the outlet 18a in the circumferential direction of cylinder bore 23. The suction auxiliary recesses 61 are designed to widen the outlet 18a of the introducing passage 18 toward the valve assembly 13 in the circumferential direction of the cylinder bore 23. That is, the suction auxiliary recesses 61 are substantially inverted triangles as viewed in Fig. 4.

[0048] As shown in Figs. 1 and 4, a state in which the suction stroke of refrigerant gas begins, that is, a state in which each piston 24 is in the vicinity of the top dead center position, or more specifically, a state in which the head 39 of the piston 24 is arranged as shown by a chain double-dashed line will now be described. In this state, most part of the outlet 18a of the introducing passage 18 is closed by the outer circumferential surface 39b of the head 39 of the piston 24. However, in this state, the suction auxiliary recesses 61 are open to the corresponding compression chamber 26 and are connected to (communicate with) the outlet 18a of the corresponding introducing passage 18 in the circumferential direction of the cylinder bore 23. This is because the suction auxiliary recesses 61 widen the rear end of the outlet 18a (end of the outlet 18a facing the valve assembly 13) in the circumferential direction of the cylinder bore 23.

[0049] Therefore, even at the beginning of the suction stroke, a wide opening area for refrigerant gas to flow is secured between the introducing passage 18 and the compression chamber 26. This reduces the suction resistance of refrigerant gas that flows into the compression chamber 26. This improves the volumetric efficiency of the compressor 10.

[0050] As described above, the suction auxiliary recesses 61 are recesses formed on the inner circumferential surface 23a of each cylinder bore 23. In other words, recesses (suction auxiliary recesses 61) are merely formed on the inner circumferential surface 23a of each cylinder bore 23 to improve the volumetric efficiency of the compressor 10. That is, the introducing passages 18 located at a portion of the cylinder block 11 between the cylinder bores 23 and the accommodation hole 17 need not be enlarged to obtain the above advantage improving the volumetric efficiency of the compressor 10. This prevents the strength of the cylinder block 11 from being decreased.

[0051] The illustrated embodiment has the following advantages.

[0052] (1) The suction auxiliary recesses 61 are formed to widen the outlet 18a of each introducing passage 18 toward the valve assembly 13 in the circumferential direction of the cylinder bore 23. To reduce the suction resistance of refrigerant gas flowing into each compression chamber 26 at the beginning of the suction stroke, a portion of the outlet 18a corresponding to the vicinity of the top dead center position of the corresponding piston 24, that is, the vicinity of the end portion of the outlet 18a facing the valve assembly 13 is merely widened in the circumferential direction of the cylinder bore 23. Therefore, a portion of the outlet 18a apart from the valve assembly 13, i.e., the front end of the outlet 18a need not be widened in the circumferential direction.

[0053] For example, if the suction auxiliary recesses 61 also widen a portion of the outlet 18a apart from the valve assembly 13 in the circumferential direction of the cylinder bore 23, the volume of the suction auxiliary recesses 61 is increased. As the volume is increased, the dead volume (the volume of the compression chamber 26 when the piston 24 is at the top dead center position) of the corresponding compression chamber 26 is increased. This may decrease the volumetric efficiency of the compressor 10. However, the suction auxiliary recesses 61 of the first embodiment suppresses the outlet 18a from widening opposite toward the valve assembly 13 in the circumferential direction of the cylinder bore 23 . That is, the suction auxiliary recesses 61 suppress increase of the dead volume of the compression chamber 26 and decrease the suction resistance of refrigerant gas flowing into the compression chamber 26 at the beginning of the suction stroke.

[0054] (2) The suction auxiliary recesses 61 are formed on both sides of the outlet 18a of each introducing passage 18 in the circumferential direction of the cylinder bore 23. Therefore, the suction auxiliary recesses 61 are easily formed on the inner circumferential surface 23a of the cylinder bore 23.

[0055] That is, for example, assume that the suction auxiliary recess 61 is formed in the cylinder bore 23 to be arranged on only one side of the outlet 18a of each introducing passage 18 in the circumferential direction of the cylinder bore 23. In this case, the depth of the suction auxiliary recess 61 needs to be increased to secure the opening area for refrigerant gas to flow between the introducing passage 18 and the corresponding compression chamber 26 by only one suction auxiliary recess 61. As a result, machining of the suction auxiliary recesses 61 becomes complicated.

[0056] However, in the first embodiment, the suction auxiliary recesses 61 are formed on both sides of each outlet 18a in the circumferential direction of the cylinder bore 23. Therefore, each suction auxiliary recess 61 forms part of the opening area for refrigerant gas to flow between the compression chamber 26 and the introducing passage 18. This decreases the depths of the suction auxiliary recesses 61 and facilitates machining of the suction auxiliary recesses 61.

[0057] (3) As is described in the BACKGROUND OF THE INVENTION, increase of the suction resistance at the beginning of the suction stroke of the variable displacement compressor 10 delays restoration of the compressor 10 from the minimum displacement state, or delays increasing the displacement of the compressor 10. The variable displacement compressor 10 according to the first embodiment of the present invention reduces the suction resistance at the beginning of the suction stroke. This is advantageous for promptly restoring the compressor 10 from the minimum displacement state.

[0058] (4) The residual gas bypass groove 41 is formed in the rotary valve 35. The residual gas bypass groove 41 connects the high pressure-side introducing passage 18A, which communicates with the pressurized compression chamber 26'that has completed the discharge stroke, to the low pressure-side introducing passage 18B, which communicates with the low pressure compression chamber 26. In the first embodiment, the size of the introducing passages 18 formed in the cylinder block 11 need not be increased to reduce the suction resistance at the beginning of the suction stroke. That is, the inlet 18b of each introducing passage 18 need not be widened in the circumferential direction of the cylinder bore 23. Therefore, in the first embodiment, the structure for reducing the suction resistance at the beginning of the suction stroke may be applied with the residual gas bypass groove 41, which was difficult in the conventional compressor (such as a compressor that simply enlarges the introducing passages 18).

[0059] Figs. 5 and 6 illustrate the invention of claim 4 according to the second embodiment. The second embodiment is different from the first embodiment in that the suction auxiliary recesses 61 are omitted. To reduce the suction resistance at the beginning of the suction stroke, a suction auxiliary portion 64 is formed at the end of the head 39 of each piston 24 that faces the valve assembly 13.

[0060] The suction auxiliary portion 64 is a cut-off surface where part of the periphery of the end face 39a of the piston 24 is removed (chamfered). The suction auxiliary portion 64 separates an area 64a of the outer circumferential surface 39b of the head 39 facing the outlet 18a of the corresponding introducing passage 18 from the outlet 18a, that is, from the inner circumferential surface 23a of the cylinder bore 23. A chamfered portion 39c is formed on the periphery of the end face 39a to prevent the edge of the piston 24 from hitting the inner circumferential surface 23a of the cylinder bore 23 and the valve assembly 13. The portion of each piston 24 that is cut off to form the suction auxiliary portion 64 (chamfered size) is larger than the chamfered portion 39c.

[0061] Each suction auxiliary portion 64 secures the opening area between the corresponding compression chamber 26 and the corresponding introducing passage 18 at the beginning of the suction stroke. Therefore, the suction auxiliary portion 64 prevents the outlet 18a of the introducing passage 18 from being closed by the outer circumferential surface 39b of the head 39 of the piston 24 by a large amount at the beginning of the suction stroke, thereby decreasing the suction resistance of refrigerant gas that flows from the introducing passage 18 into the compression chamber 26. To achieve this advantage, the suction auxiliary portion 64 is formed by simply chamfering each piston 24. It is not necessary to enlarge the introducing passages 18 formed in the cylinder block 11 between the cylinder bores 23 and the accommodation hole 17. This prevents decrease of the strength of the cylinder block 11 by forming the introducing passages 18.

[0062] The second embodiment provides the same advantages as the advantages (3) and (4) of the first embodiment.

[0063] Fig. 7 shows the invention of claim 6 according to the third embodiment. The third embodiment is different from the first embodiment in that the suction auxiliary recesses 61 are omitted. To achieve the structure for reducing the suction resistance at the beginning of the suction stroke, suction auxiliary recesses 67 are formed on the front end face 13d of the valve assembly 13 (port plate 13a) facing the compression chambers 26. That is, a portion of the valve assembly 13 facing the compression chambers 26 has the suction auxiliary recesses 67 corresponding to the outlets 18a of the introducing passages 18. A communication groove 68 is formed in the cylinder block 11 at the opening edge of each cylinder bore 23 facing the valve assembly 13. More specifically, each communication groove 68 is formed by cutting off the edge of the outlet 18a of the introducing passage 18. The outlet 18a of the introducing passage 18 is connected to one of the suction auxiliary recesses 67 through the corresponding communication groove 68.

[0064] Therefore, even if the outlet 18a of each introducing passage 18 is almost completely closed by the outer circumferential surface 39b of the head 39 of the corresponding piston 24 at the beginning of the suction stroke, refrigerant gas is introduced into the corresponding compression chamber 26 from the introducing passage 18 via the associated communication groove 68 and the associated suction auxiliary recess 67. Therefore, even at the beginning of the suction stroke, a wide opening area is secured for refrigerant gas to flow between each introducing passage 18 and the corresponding compression chamber 26. This reduces the suction resistance of refrigerant gas. The suction auxiliary recesses 67 are achieved by simply forming recesses in the valve assembly 13 and the communication grooves 68 are achieved by simply forming grooves in the cylinder block 11 at part of the introducing passages 18. Therefore, it is not necessary to enlarge the introducing passages 18 formed in the cylinder block 11 between the cylinder bores 23 and the accommodation hole 17. As a result, decrease of the strength of the cylinder block 11 is prevented.

[0065] The third embodiment provides the same advantages as the advantages (3) and (4) of the first embodiment.

[0066] The fourth embodiment according to the present invention 5 will now be described with reference to Figs. 8(a) and 8(b). This embodiment is an alternative embodiment, which is similar to the third embodiment.

[0067] The fourth embodiment is different from the third embodiment in that the suction auxiliary recesses 67 are omitted. Second discharge ports 51 are formed on the port plate 13a of the valve assembly 13 in addition to the discharge ports (first discharge ports) 29. The second discharge ports 51 are arranged on the valve assembly 13 radially inward of the first discharge ports 29. Each first discharge port 29 is selectively opened and closed by the distal end of the corresponding discharge valve 30. Each second discharge port 51 is selectively opened and closed by the proximal end of the discharge valve 30.

[0068] Since the compressor 10 of the fourth embodiment includes the discharge ports 29, 51 for each compression chamber 26, refrigerant gas is smoothly discharged to the discharge chamber 28 from the compression chamber 26. Therefore, excess compression of refrigerant gas is prevented and power loss of the compressor 10 is reduced. The two discharge ports 29, 51 are selectively opened and closed by one discharge valve 30. Specifically, each second discharge port 51 is selectively opened and closed by the proximal end of the corresponding discharge valve 30. Flow of refrigerant gas is thus generated at the proximal portion of the discharge valve 30 during the discharge stroke, which prevents clogging of a foreign object in the second discharge port 51. Accordingly, during the suction stroke and the compression stroke, the first and second discharge ports 29, 51 are reliably closed by the corresponding discharge valve 30. This improves the efficiency of the compressor 10.

[0069] In the fourth embodiment, the end portion of each second discharge port 51 facing the corresponding compression chamber 26 functions as a suction auxiliary recess 51a. In other words, each second discharge port 51 has an opening connected to the corresponding compression chamber 26. The opening also serves as the suction auxiliary recess 51a. Part of each suction auxiliary recess 51a communicates with the outlet 18a of the corresponding introducing passage 18. Therefore, the suction auxiliary recesses 51a function in the same manner as the suction auxiliary recesses 67 of the third embodiment.

[0070] The fourth embodiment provides the same advantages as the advantages of the third embodiment. Furthermore, the end (opening) of each discharge port 51 facing the corresponding compression chamber 26 is used to achieve the suction auxiliary recess 51a. Thus, as compared to a case in which the special suction auxiliary recesses are provided, the structure of the compressor 10 is simplified. In addition, since flow of refrigerant gas is generated at each discharge port 51 during the discharge stroke as described above, accumulation of foreign objects in the suction auxiliary recess 51a, which utilizes part of the discharge port 51, is prevented.

[0071] The invention may be embodied in the following forms.

[0072] In the first embodiment, the suction auxiliary recesses 61 are formed to widen the outlet 18a of each introducing passage 18 toward the valve assembly 13 in the circumferential direction of the cylinder bore 23 (see Fig. 4). That is, each suction auxiliary recess 61 is an inverted triangle as viewed in Fig. 4. However, suction auxiliary portions (suction auxiliary recesses) may be formed such that the vicinity of the end of the outlet 18a facing the valve assembly 13 has a constant width in the circumferential direction of the cylinder bore 23 along a direction to approach and separate from the valve assembly 13 (along the axis L). That is, each suction auxiliary recess may be rectangular in Fig. 4.

[0073] In the first embodiment, the suction auxiliary recesses 61 are formed on the both sides of the outlet 18a of each introducing passage 18 in the circumferential direction of the cylinder bore 23 (see Fig. 4). However, the suction auxiliary recess may be formed on only one of the both sides of the outlet 18a of each introducing passage 18 in the circumferential direction of the cylinder bore 23.

[0074] In the second embodiment, the suction auxiliary portion 64 is formed by cutting off part of the periphery of the end face 39a of each piston 24 (see Fig. 6). This is possible since the compressor 10 has a structure for preventing rotation of each piston 24 about its own axis by the abutment between the neck 40 of the piston 24 and the swash plate 21 or the abutment between the neck 40 and the housing (for example, the front housing member 12). That is, each suction auxiliary portion 64 will not be displaced from the outlet 18a of the corresponding introducing passage 18 by a large amount about the axis of the piston 24.

[0075] However, in a case with a piston compressor that does not have the structure for preventing rotation of the pistons 24 (such as a wobble type compressor), the entire periphery of the end face 39a of each piston 24 is cut off (chamfered) to form the suction auxiliary portion 64 so that the suction auxiliary portion 64 faces the outlet 18a of the corresponding introducing passage 18 even if the piston 24 is rotated about its own axis. In this case, the suction auxiliary portion 64 also serves as the chamfered portion 39c for preventing the edge of the piston 24 from hitting the inner circumferential surface 23a of the cylinder bore 23 and the valve assembly 13.

[0076] In each of the illustrated embodiments, the residual gas bypass groove 41 may be omitted.

[0077] The present invention may be applied to fixed displacement piston compressors.

[0078] The present invention may be applied to a piston compressor that uses double-headed pistons.

[0079] The present invention may be applied to a wobble-type piston compressor that is equipped with a wobble plate, which functions as a cam plate.

[0080] The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A piston compressor, comprising:

a drive shaft;
a housing, which rotatably supports the drive shaft, wherein the housing includes a cylinder block, which has a plurality of cylinder bores, each cylinder bore having openings on both axial ends, and the cylinder block has an accommodation hole surrounded by the cylinder bores;
a plurality of pistons, each of which is accommodated and reciprocates in one of the cylinder bores;
a valve assembly joined to the cylinder block, the pistons and the valve assembly define a plurality of compression chambers in each cylinder bore, the valve assembly has discharge ports and discharge valves, and each set of the discharge port and the discharge valve corresponds to one of the compression chambers;
a rotary valve accommodated in the accommodation hole, the rotary valve having a suction guide hole, which opens on the outer circumferential surface of the rotary valve;
a suction pressure zone, which communicates with the suction guide hole; and
a plurality of introducing passages formed in the cylinder block to connect the compression chambers to the rotary valve, each introducing passage has an inlet, which opens on the inner circumferential surface of the accommodation hole, and an outlet, which opens on the inner circumferential surface of the cylinder bore, when the rotary valve rotates in synchronization with the drive shaft, the suction guide hole sequentially communicates with the inlet of each introducing passage so that gas is drawn into the corresponding compression chamber through the suction guide hole and the introducing passage from the suction pressure zone,
the compressor being **characterized in that**:

the inner circumferential surface of each cylinder bore has a suction auxiliary recess, which is connected to the outlet of the corresponding introducing passage in the circumferential direction of the cylinder bore at the end of the cylinder bore facing the valve assembly.

2. The compressor according to claim 1, **characterized in that** the suction auxiliary recess is formed to widen the outlet of each introducing passage toward the valve assembly in the circumferential direction of the cylinder bore.

3. The compressor according to claim 1 or 2, **characterized in that** the suction auxiliary recess is one of suction auxiliary recesses formed on both sides of the outlet of each introducing passage in the circumferential direction of the cylinder bore.

4. A piston compressor, comprising:

a drive shaft;

a housing, which rotatably supports the drive shaft, wherein the housing includes a cylinder block, which has a plurality of cylinder bores, each cylinder bore having openings on both axial ends, and the cylinder block has an accommodation hole surrounded by the cylinder bores;

a plurality of pistons, each of which is accommodated and reciprocates in one of the cylinder bores;

a valve assembly joined to the cylinder block, the pistons and the valve assembly define a plurality of compression chambers in each cylinder bore, the valve assembly has discharge ports and discharge valves, and each set of the discharge port and the discharge valve corresponds to one of the compression chambers;

a rotary valve accommodated in the accommodation hole, the rotary valve having a suction guide hole, which opens on the outer circumferential surface of the rotary valve;

a suction pressure zone, which communicates with the suction guide hole; and

a plurality of introducing passages formed in the cylinder block to connect the compression chambers to the rotary valve, each introducing passage has an inlet, which opens on the inner circumferential surface of the accommodation hole, and an outlet, which opens on the inner circumferential surface of the cylinder bore, when the rotary valve rotates in synchronization with the drive shaft, the suction guide hole sequentially communicates with the inlet of each introducing passage so that gas is drawn into the corresponding compression chamber through the suction guide hole and the introducing passage from the suction pressure zone,

the compressor being **characterized by:**

a suction auxiliary portion formed at the end portion of each piston facing the valve assembly, the suction auxiliary portion separates an area of the outer circumferential surface of the end portion that faces the outlet of the corresponding introducing passage from the outlet.

5. The compressor according to claim 4, **characterized in that** each suction auxiliary portion is formed by cutting off the area of the corresponding piston.

6. A piston compressor, comprising:

a drive shaft;

a housing, which rotatably supports the drive shaft, wherein the housing includes a cylinder block, which has a plurality of cylinder bores, each cylinder bore having openings on both axial ends, and the cylinder block has an accommodation hole surrounded by the cylinder bores;

a plurality of pistons, each of which is accommodated and reciprocates in one of the cylinder bores;

a valve assembly joined to the cylinder block, the pistons and the valve assembly define a plurality of compression chambers in each cylinder bore, the valve assembly has discharge ports and discharge valves, and each set of the discharge port and the discharge valve corresponds to one of the compression chambers;

a rotary valve accommodated in the accommodation hole, the rotary valve having a suction guide hole, which opens on the outer circumferential surface of the rotary valve;

a suction pressure zone, which communicates with the suction guide hole; and

a plurality of introducing passages formed in the cylinder block to connect the compression chambers to the rotary valve, each introducing passage has an inlet, which opens on the inner circumferential surface of the accommodation hole, and an outlet, which opens on the inner circumferential surface of the cylinder bore, when the rotary valve rotates in synchronization with the drive shaft, the suction guide hole sequentially communicates with the inlet of each introducing passage so that gas is drawn into the corresponding compression chamber through the suction guide hole and the introducing passage from the suction pressure zone,

the compressor being **characterized in that**:

a portion of the valve assembly facing the compression chambers has suction auxiliary recesses corresponding to the outlets of the introducing passages.

7. The compressor according to claim 6, **characterized in that** the cylinder block has communication grooves, each of which connects the outlet of one of the introducing passages to the corresponding suction auxiliary recess, and each communication groove is located at the opening edge of one of the cylinder bores facing the valve assembly.

8. The compressor according to claim 6 or 7, **characterized in that** each discharge port has an opening connected to the corresponding compression chamber, and the opening also serves as the suction auxiliary recess.

9. The compressor according to claim 6 or 7, **characterized in that** the discharge ports are first discharge ports,

the valve assembly has a plurality of second discharge ports, each of which corresponds to one of the compression chambers, the second discharge ports are located closer to the rotary valve than the first discharge ports, each second discharge port has an opening connected to the corresponding compression chamber, and the opening also serves as the suction auxiliary recess.

10. The compressor according to any one of claims 1 to 9, **characterized by:**

a crank chamber defined in the housing;
a cam plate accommodated in the crank chamber, the cam plate being coupled to the drive shaft to rotate integrally with and tilt with respect to the drive shaft, and the pistons are coupled to the cam plate; and
wherein rotation of the drive shaft is converted into reciprocation of the pistons via the cam plate, and adjusting the pressure in the crank chamber changes the difference between the pressure in the crank chamber and the pressure in the compression chambers with the pistons in between, which alters the inclination angle of the cam plate, thereby adjusting the displacement of the compressor.

11. The compressor according to any one of claims 1 to 10,
characterized in that the rotary valve includes a residual gas bypass passage, the residual gas bypass passage connects the introducing passage corresponding to the pressurized compression chamber that has completed a discharge stroke to the introducing passage corresponding to the low pressure compression chamber.

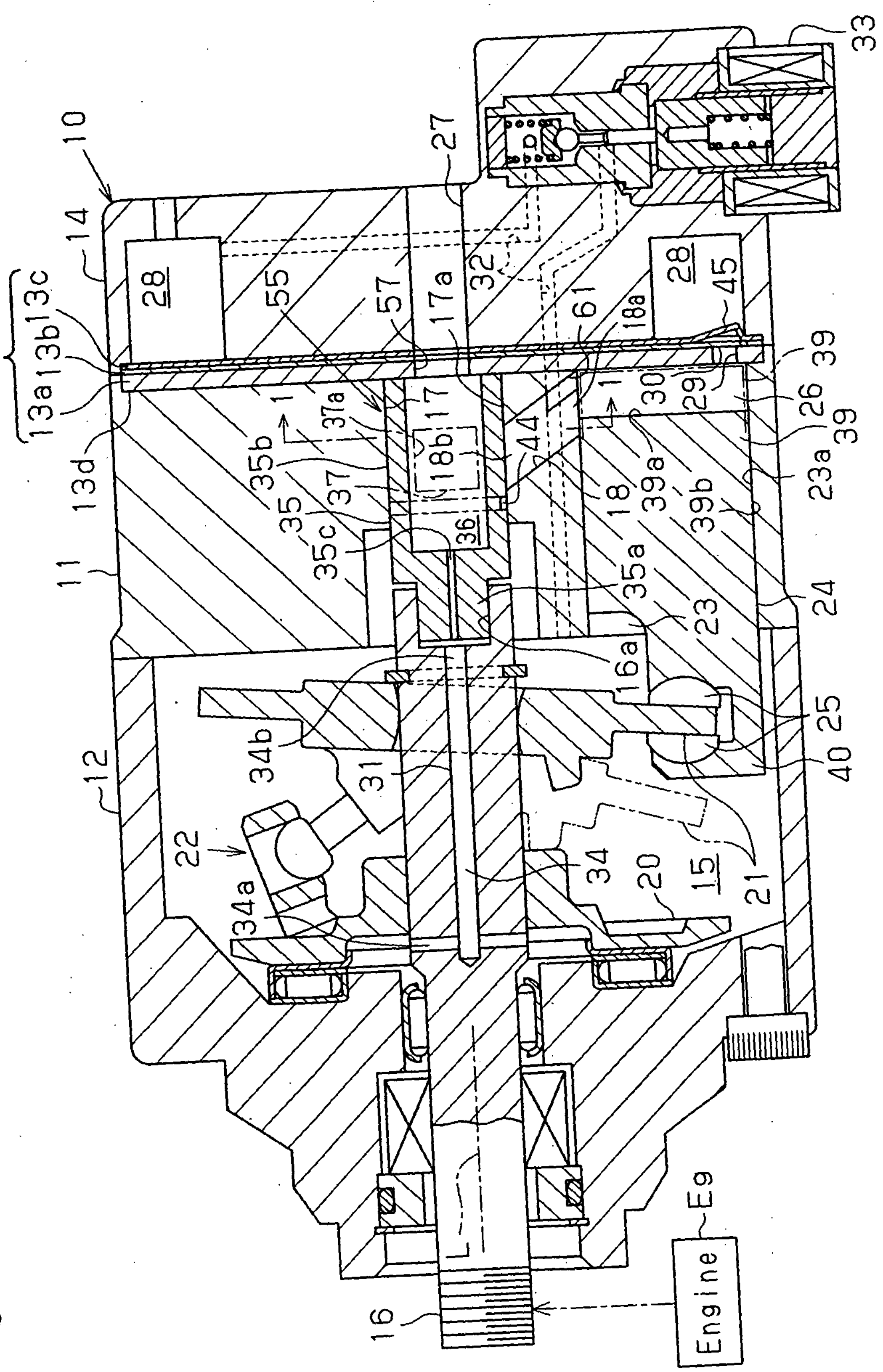

10
11
12
13
13a
13b
13c
13d
14
15
16
16a
17
17a
18
18a
18b
20
21
22
23
23a
24
25
26
27
28
29
30
31
32
33
34
34a
34b
35
35a
35b
35c
36
37
37a
39
39a
39b
40
44
45
55
57
61
Engine
Eg
L

Fig.1

Fig.2

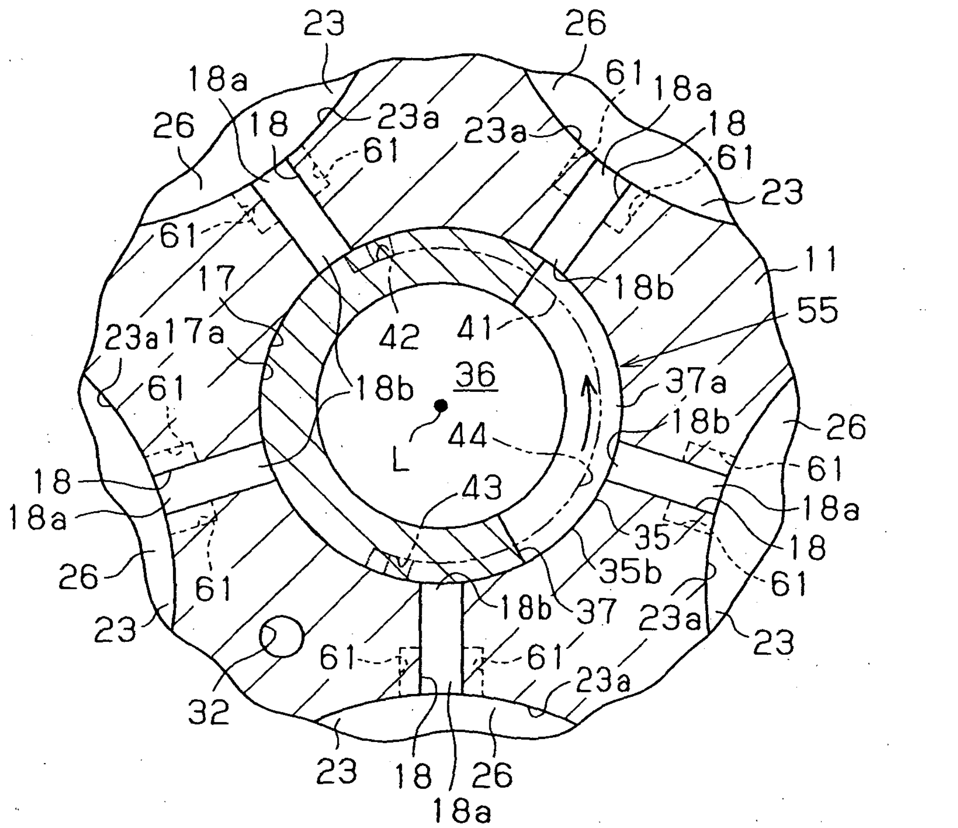

23
26
18a
23a
61
18a
26
18
23a
18
61
61
23
61
11
17
18b
55
23a
17a
42
41
61
18b
36
37a
18b
26
L
44
18
61
18a
43
18a
35
18
26
61
35b
61
18b
37
23a
23
23
61
61
23a
32
23
18
26
18a

Fig.3

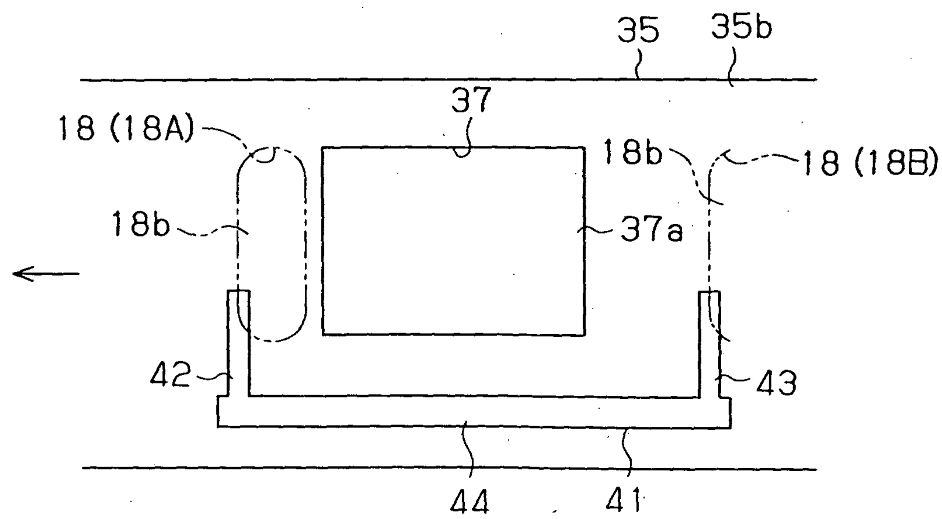

35
35b
37
18 (18A)
18b
18 (18B)
18b
37a
42
43
44
41

Fig.4

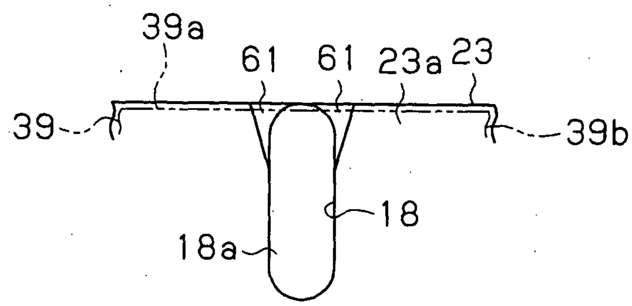

39a
61
61
23a
23
39
39b
18
18a

Fig.5

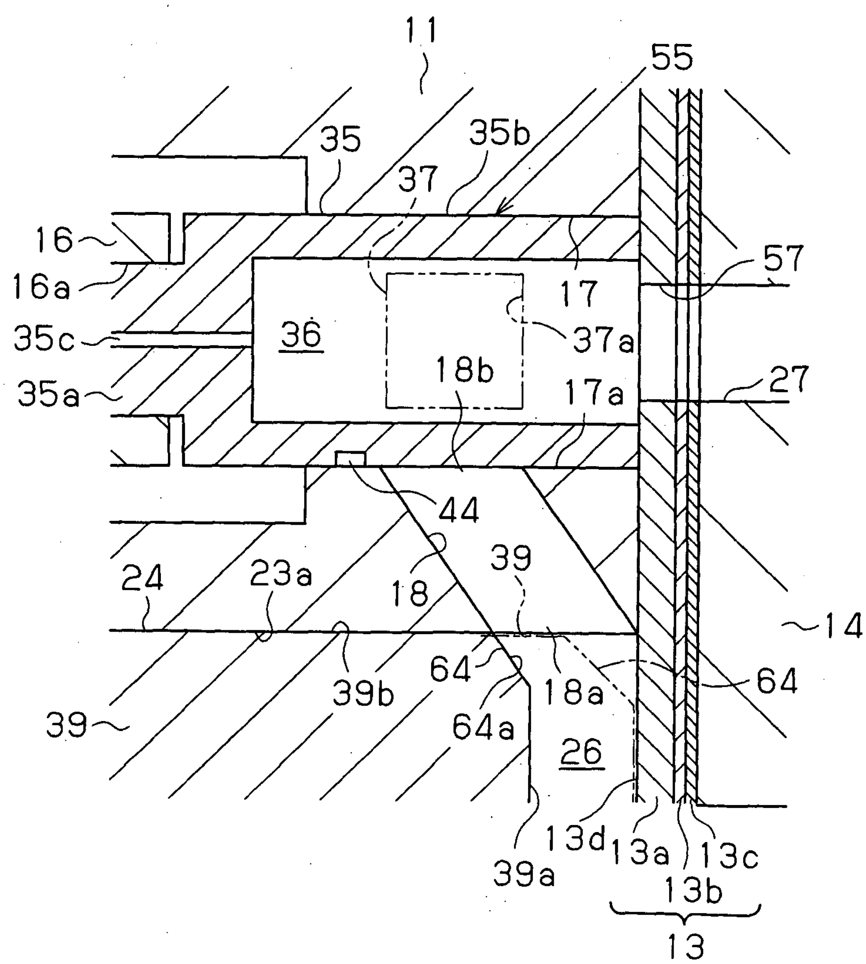

11
55
35
35b
37
16
16a
57
17
37a
35c
36
18b
27
35a
17a
44
39
24
23a
18
14
64
64
39b
18a
39
64a
26
13d
13a
13c
39a
13b
13

Fig.6

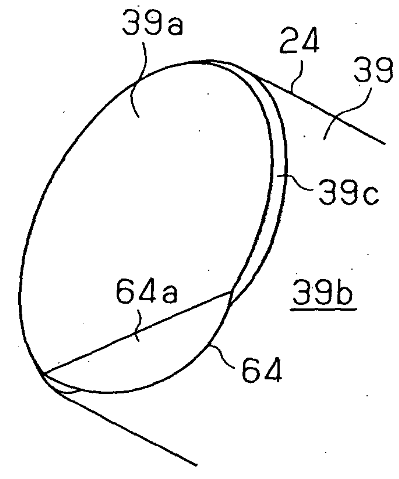

39a
24
39
39c
64a
39b
64

Fig.7

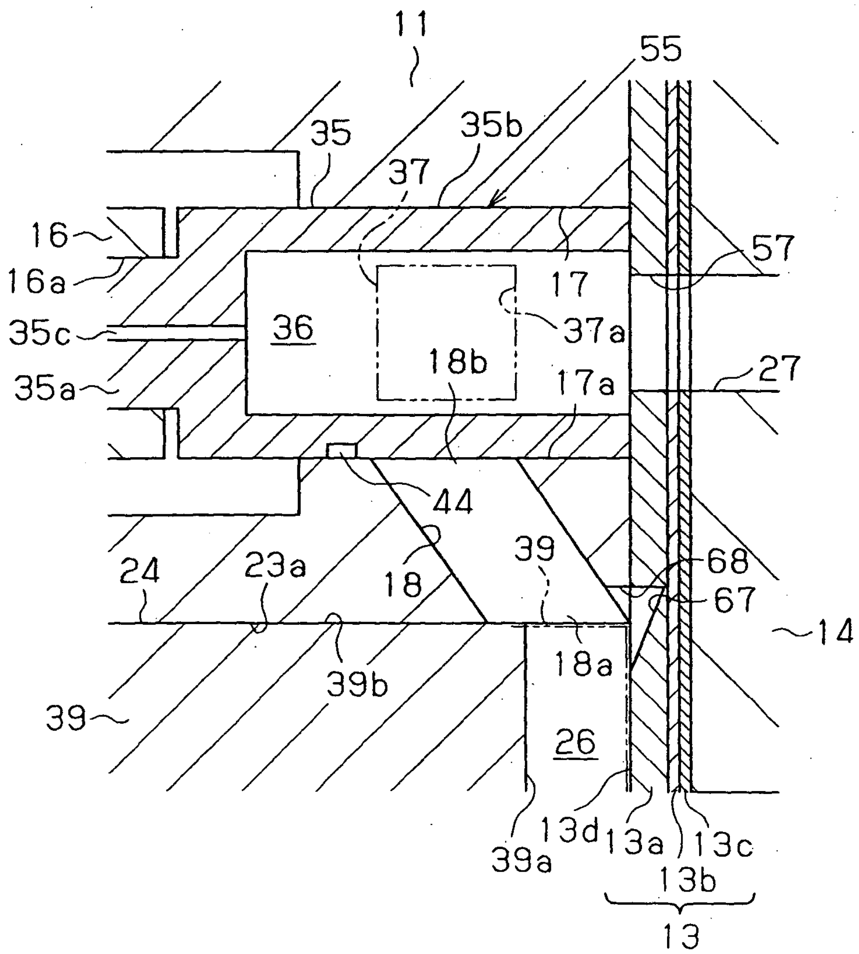

11
55
35
35b
37
16
16a
57
17
35c
36
37a
18b
27
35a
17a
44
68
39
24
23a
18
67
14
18a
39b
39
26
13d
13a
13c
39a
13b
13

Fig.8(a)

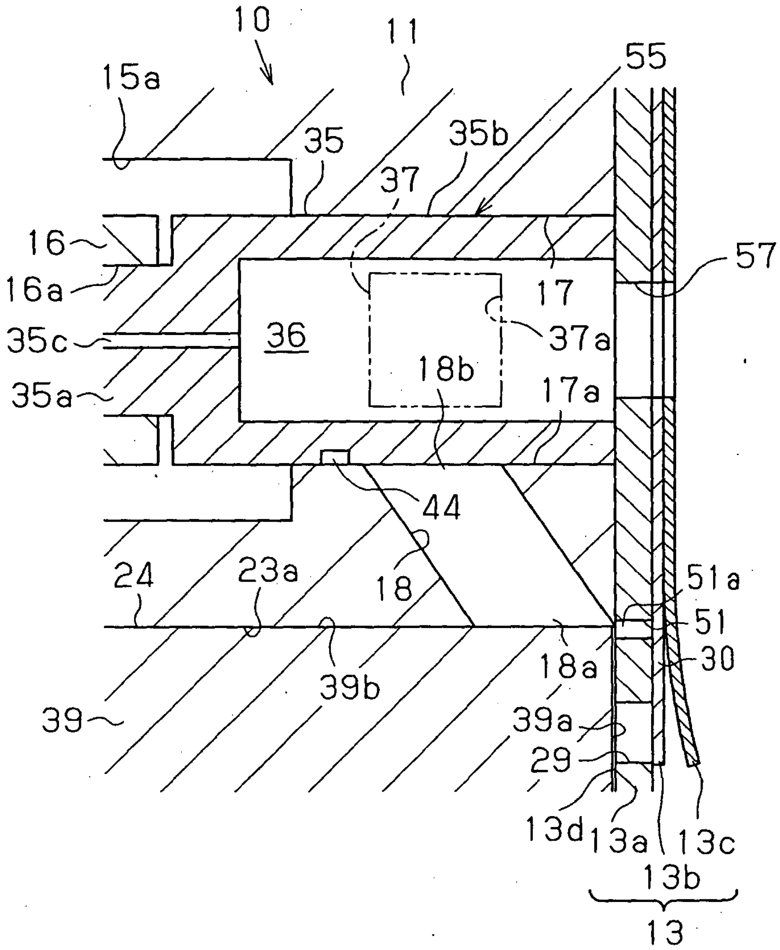

10
11
55
15a
35
35b
37
16
16a
35c
36
35a
57
17
37a
18b
17a
44
24
23a
18
51a
51
30
18a
39b
39
39a
29
13d
13a
13c
13b
13

Fig.8(b)

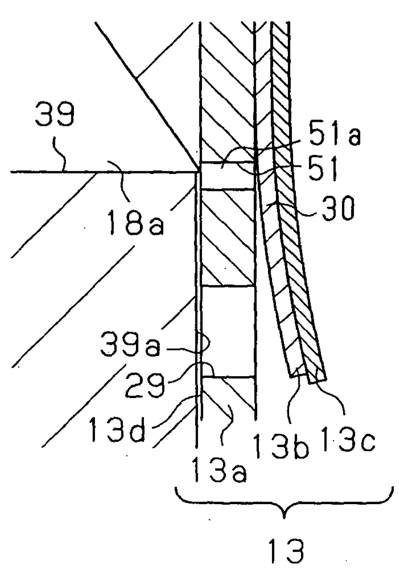

39
51a
51
30
18a
39a
29
13d
13a
13b
13c
13

Fig.9

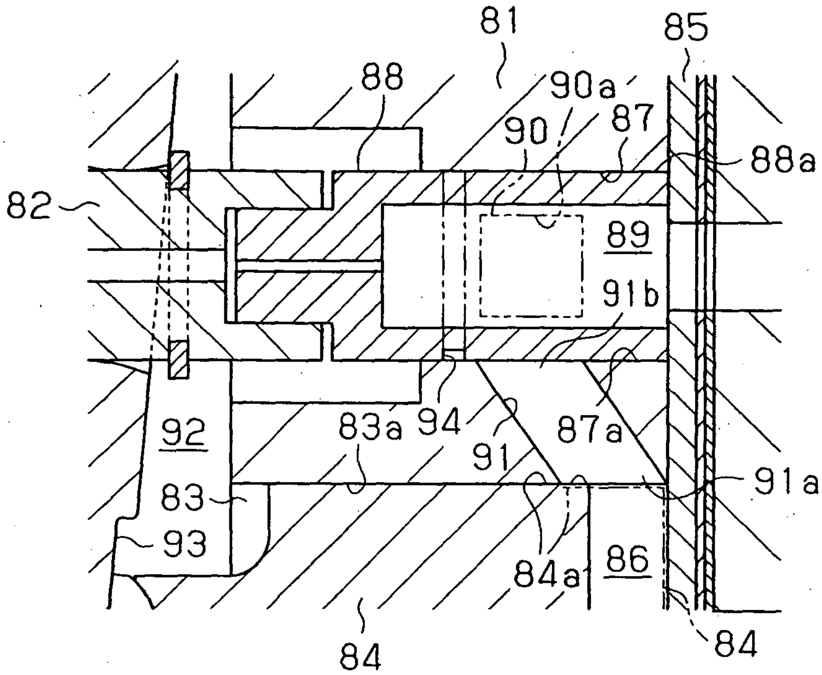
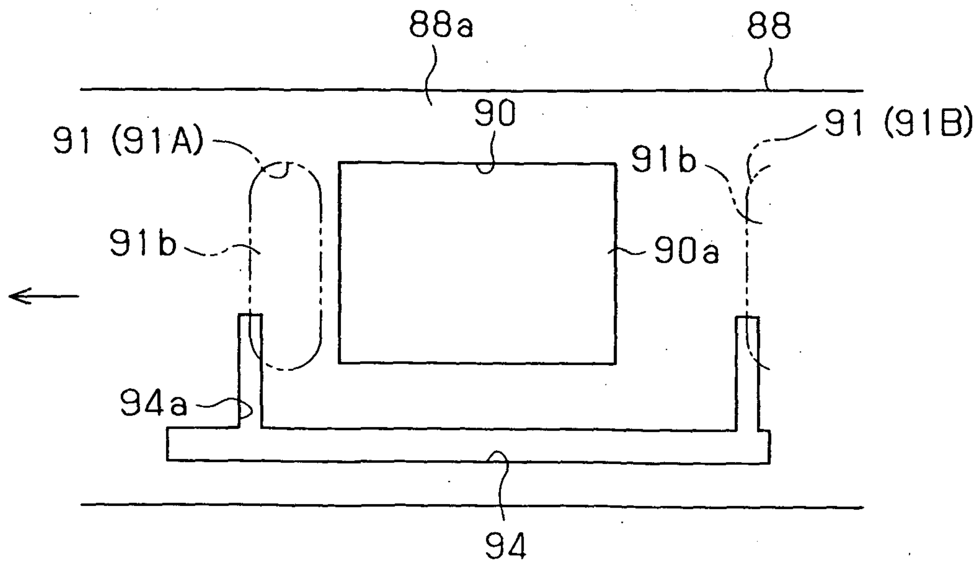

81
85
88
90a
90
87
88a
82
89
91b
92
83a
94
91
87a
91a
83
93
84a
86
84
84

Fig.10


88a
88
90
91 (91A)
91b
91 (91B)
91b
90a
94a
94