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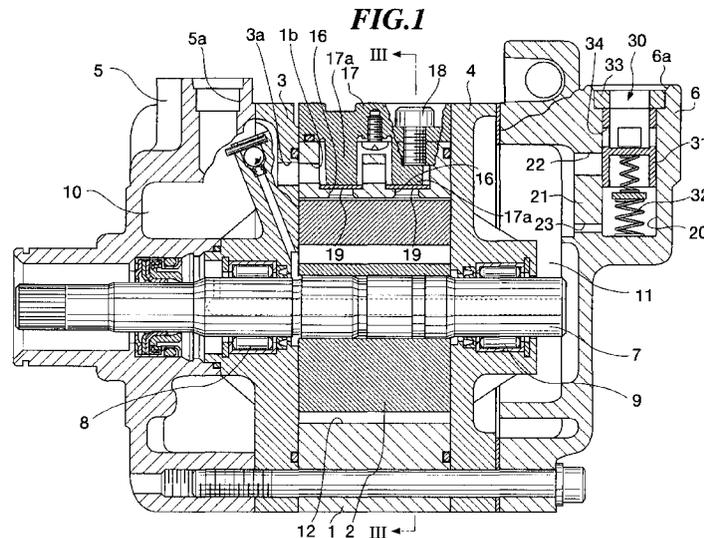
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(54) **Suction valve device for refrigerant compressors**

(57) A suction valve device (30) for a refrigerant compressor, which is capable of varying an open area of an opening of a suction passage (20,22) communicating a suction port (6a) with a suction chamber (11), according to changes in a flow rate of refrigerant gas flowing into the compressor, to thereby reduce or curb the capacity of the compressor only when the compressor is in high-speed operation. A valving element (31) is arranged in the suction passage (20,22), for being moved according to changes in a flow rate of refrigerant gas flowing from the suction port (6a) into the suction passage (20,22), to thereby vary an open area of opening of the suction passage (20,22). An urging member

(32) urges the valving element (31) in a predetermined direction toward a valve-closing position thereof. The urging member is caused to contact by pressure of the refrigerant gas when the flow rate of the refrigerant gas reaches a first predetermined value to thereby shift the valving element (31) to a first position in which the open area of the opening in the suction passage (20,22) is large, and is caused to further contract by increased pressure of refrigerant gas when the flow rate of the refrigerant gas reaches a second predetermined value larger than the first predetermined value to thereby shift the valving element (31) to a second position in which the open area of the opening of the suction passage (20,22) is reduced.



DescriptionBACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a suction valve device for refrigerant compressors, and more particularly to a suction valve device of this kind, which is capable of preventing reverse rotation of a rotor of a vane compressor when the compressor is not in operation, as well as reducing the flow rate of refrigerant gas flowing through the compressor when the compressor is in high-speed operation.

Description of the Prior Art

In a swash plate compressor, a wobble plate compressor and the like, refrigerant gas is drawn into a suction chamber via a suction port opening in a compressor housing and then flows into a compression chamber when a suction valve mounted on a refrigerant inlet port opens.

On the other hand, in a vane compressor, a compression chamber and a suction chamber are permitted to communicate with each other via a refrigerant inlet port only during each suction stroke, more specifically during a time period from the start of each suction stroke to the completion of the same, whereas these chambers are inhibited from communicating with each other during each compression stroke. Therefore, the vane compressor dispenses with a suction valve, without the inconvenience of refrigerant gas in the suction chamber mixing with refrigerant gas to be delivered from the compression chamber.

The vane compressor has no suction valve as described above, so that refrigerant gas can be drawn into the compression chamber with less resistance than in any other type of compressor, which ensures enhanced volumetric efficiency of the vane compressor in high-speed operation. However, when the compressor is in high-speed operation, the refrigerant gas flowing into the compressor becomes so large that the compressor operates at superfluous cooling capacity (i.e. at cooling capacity in excess of heat-exchanging capability of an evaporator), resulting in significant power losses of the whole system.

To overcome this problem, in a fixed capacity vane compressor, a suction port or a refrigerant inlet passage which communicates the suction port with a suction chamber is formed with a restriction for reducing or curbing the cooling capacity of the compressor in high-speed operation.

However, the restriction provided as above not only curbs the cooling capacity of the compressor when the compressor is operating in a high-speed operating region, but also reduces the same over the whole operating speed region.

On the other hand, a variable capacity compressor is free from such a problem, but it requires a complicated mechanism for varying capacity thereof, which results in an increase in manufacturing costs of the compressor.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a suction valve device for a refrigerant compressor, which is capable of varying an open area of an opening of a refrigerant inlet passage according to changes in flow rate of refrigerant gas flowing into the compressor, to thereby reduce the cooling capacity of the compressor only when the compressor is in high-speed operation.

To attain the above object, the invention provides a suction valve device for a refrigerant compressor having a housing, a suction port formed in the housing, a suction chamber defined within the housing, and a suction passage for communicating the suction port with the suction chamber.

The suction valve device according to the invention is characterized by comprising:

a valving element arranged in the suction passage, for being moved according to changes in a flow rate of refrigerant gas flowing from the suction port into the suction passage, to thereby vary an open area of opening of the suction passage; and
 an urging member for urging the valving element in a predetermined direction toward a valve-closing position thereof, the urging member being caused to contract by pressure of the refrigerant gas flowing from the suction port into the suction passage when the flow rate of the refrigerant gas reaches a first predetermined value to thereby shift the valving element to a first position in which the open area of the opening of the suction passage is large, and being caused to further contract by increased pressure of the refrigerant gas when the flow rate of the refrigerant gas reaches a second predetermined value larger than the first predetermined value to thereby shift the valving element to a second position in which the open area of the opening of the suction passage is reduced.

According to the suction valve device, when the compressor is not in operation, the valving element is pressed in the predetermined direction to the valve-closing position, whereby the suction passage is closed to prevent the suction port and the suction chamber from communicating with each other by way of the suction passage. When the compressor is started and the flow rate of refrigerant gas flowing into the compressor reaches the first predetermined value, the valving element is urged by the pressure of the refrigerant gas flowing into the suction passage, in a direction opposite to the predetermined direction toward the valve closing position, whereby the urging member is caused to contract

to shift the valving element to the first predetermined position in which the open area of the opening of the suction passage is increased, thereby permitting the suction port and the suction chamber to communicate with each other by way of the suction passage. Further, when the flow rate of refrigerant gas flowing into the compressor further increases during high-speed operation of the compressor to reach the second predetermined value larger than the first predetermined value, the valving element is further urged by an increased pressure of the refrigerant gas flowing into the suction passage, in the direction opposite to the predetermined direction, whereby the urging member is caused to further contract to shift the valving element to the second predetermined position to decrease the open area of the opening of the refrigerant inlet passage, which reduces the flow rate of refrigerant gas flowing into the suction chamber. That is, the open area of the opening of the suction passage becomes the maximum during low/medium-speed operation of the compressor, while during high-speed operation of the compressor, it becomes smaller to reduce the flow rate of refrigerant gas flowing into the suction chamber. Therefore, the cooling capacity of the compressor is reduced or curbed to thereby reduce the power consumed by the compressor only when the compressor is in high-speed operation, while the cooling capacity is not reduced or curbed when the compressor is in low/medium-speed operation. This makes it possible to obtain excellent cooling effects in all the operating regions of the compressor ranging from the low/medium-speed operating region to the high-speed operating region. Further, the suction valve device has a simple construction, which contributes to reduction of manufacturing costs of the compressor.

Preferably, the urging member comprises at least two springs having respective spring constants different from each other.

According to this preferred embodiment, the urging member comprises at least two springs having respective spring constants different from each other. Therefore, it is possible to stepwise move the valving element in a manner dependent on the first and second values of the flow rate of the refrigerant gas flowing into the suction passage.

More specifically, it is preferred that the at least two springs include a first spring having a first spring constant according to which the first spring is caused to contract by the pressure of the refrigerant gas flowing into the suction passage at the first predetermined flow rate, and a second spring having a second spring constant according to which the second spring is caused to contract by the increased pressure of the refrigerant gas flowing into the suction passage at the second predetermined flow rate.

According to this preferred embodiment, when the flow rate of refrigerant gas flowing into the compressor reaches the first predetermined value, the first spring alone is caused to contract to shift the valving element,

whereby the suction port and the suction chamber are permitted to communicate with each other by way of the suction passage. Further, when the flow rate of refrigerant gas flowing into the compressor exceeds the first predetermined value and then reaches the second predetermined value, the second spring is also caused to contract to further shift the valving element, whereby the open area of the opening of the suction passage is decreased to reduce the flow rate of refrigerant gas flowing into the suction chamber.

For example, the at least two springs are arranged in series.

Alternatively, the at least two springs are arranged in parallel, one of the at least two springs which has a smaller spring constant being longer than another of the at least two springs which has a larger spring constant.

Preferably, the suction passage comprises a suction valve-receiving chamber communicating with the suction port and receiving the valving element therein, and a passage formed through a wall separating the suction valve-receiving chamber and the suction chamber from each other, the valving element increasing an open area of opening of the passage formed through the wall to the maximum when the valving element is the first position, and decreasing the open area of the opening of the passage formed through the wall when the valving element is in the second position.

More preferably, the valving element is in the form of a hollow cylinder having a peripheral wall, the peripheral wall being formed with a plurality of through holes along a circumference of the hollow cylinder, whereby when the valving element is in the first position, an area of direct communication between any of the through holes and the passage formed through the wall becomes the maximum, and when the valving element is in the second position, the area of direct communication between the any of the through holes and the passage formed through the wall is reduced.

Further preferably, the suction valve device includes a stopper rigidly fitted in the suction port for restricting movement of the valving element toward the suction port, the stopper being formed with at least one through hole, the valving element having a suction port-side end formed with at least one through hole, the valving element being caused to abut the stopper when the compressor is not in operation, by the urging means in a manner such that the at least one hole formed through the stopper and the at least one through hole formed through the suction port-side end of the valving element do not communicate with each other.

Still further preferably, the urging member is arranged within the valving element.

Even more preferably, the valving element has a partition wall integrally formed with the peripheral wall, for separating the valving element into a suction-port side portion and a bottom-side portion, the through holes being formed in the suction-port side portion.

For example, the at least two springs are arranged

in the bottom-side portion.

In this case, it is preferred that the at least two springs are arranged in series with an intermediate member interposed therebetween.

Alternatively, it is preferred that the at least two springs are arranged in parallel, one of the at least two springs which has a smaller spring constant being longer than another of the at least two springs which has a larger spring constant.

In an alternative example, the at least two springs are arranged in the suction-side portion and the bottom-side portion.

The above and other objects, features and advantages of the present invention will become more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view showing the whole arrangement of a refrigerant compressor vane compressor incorporating a suction valve device according to a first embodiment of the invention;

FIGS. 2 A to 2C are enlarged sectional views of the suction valve device which are useful in explaining operation of the suction valve device, in which:

FIG. 2A shows the suction valve device in a state in which the compressor is not in operation;

FIG. 2B shows the suction valve device in a state in which the compressor is in low/medium-speed operation; and

FIG. 2C shows the suction valve device in a state in which the compressor is in high-speed operation;

FIG. 3 is a sectional view of the FIG. 1 vane compressor taken on line III-III of FIG. 1;

FIG. 4 is an enlarged sectional view of a suction valve device according to a second embodiment of the invention; and

FIGS. 5A and 5B are views showing a suction valve device according to a third embodiment of the invention, in which:

FIG. 5A is an enlarged sectional view of the suction valve device according to the third embodiment; and

FIG. 5B is a plan view of a stopper appearing in FIG. 5A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Next, the invention will now be described in detail with reference to drawings showing preferred embodiments thereof.

FIG. 1 shows the whole arrangement of a vane compressor incorporating a suction valve device according to a first embodiment of the invention. FIG. 3 is a sectional view taken on line III-III of FIG. 1.

The vane compressor is comprised of a cam ring 1, a front side block 3 and a rear side block 4 closing opposite ends of the cam ring 1, respectively, a rotor 2 rotatably received within the cam ring 1, a front head 5 secured to a front-side end face of the front side block 3, a rear head 6 (housing of the compressor) secured to a rear-side end face of the rear side block 4, and a drive shaft 7 on which is rigidly fitted the rotor 2. The drive shaft 7 is rotatably supported by a pair of radial bearings 8 and 9 arranged in the front and rear side blocks 3 and 4, respectively.

The front head 5 is formed with a discharge port 5a via which refrigerant gas is discharged, while the rear head 6 is formed with a suction port 6a via which refrigerant gas is drawn into the compressor. The discharge port 5a communicates with a discharge chamber 10 which is defined by an inner wall surface of the front head 5 and the front-side end face of the front side block 3. On the other hand, the suction port 6a can communicate with a suction chamber 11 which is defined by an inner wall surface of the rear head 6 and the rear-side end face of the rear side block 4 via a suction valve-receiving chamber 20 and a refrigerant inlet passage 22.

The suction valve-receiving chamber 20 is formed between the suction port 6a and the suction chamber 11 such that it continues from the suction port 6a. The suction chamber 11 and the suction valve-receiving chamber 20 are separated from each other by a partition wall 21. The suction chamber 11 and the suction valve-receiving chamber 20 communicate with each other via a refrigerant inlet passage 22 and a passage 23 formed through the partition wall 21. A suction valve device 30, referred to hereinafter, is received in the suction valve-receiving chamber 20. The suction valve-receiving chamber 20 and the refrigerant inlet passage 22 forms a suction passage for communicating the suction port with the suction chamber.

As best shown in FIG. 3, a pair of compression spaces 12 are defined at diametrically opposite locations between an inner peripheral surface of the cam ring 1 and an outer peripheral surface of the rotor 2 (one of the compression spaces is shown in FIG. 1). The rotor 2 has its outer peripheral surface formed therein with a plurality of axial vane slits 13 at circumferentially equal intervals, in each of which a vane 14 is radially slidably fitted. Each compression space 12 is divided by vanes 14 into compression chambers, the volume of each of which is varied with rotation of the rotor 2.

Two pairs of refrigerant outlet ports 16 are formed through opposite lateral side walls of the cam ring 1 at diametrically opposite locations (only one pair of them is shown in FIG. 1) in a manner corresponding to the two compression spaces 12. The opposite lateral side walls of the cam ring 1 are provided with two discharge valve covers 17, each formed integrally with a valve stopper 17a, and fixed to the cam ring 1 by bolts 18. Discharge valves 19 are mounted respectively between the lateral side walls of the cam ring 1 and the valve

stoppers 17a in a manner held by the valve covers 17. When the refrigerant outlet ports 16 are open, high-pressure refrigerant gas compressed within the compression chambers is delivered via the ports 16, communication passages 1b, 3a, the discharge chamber 10 and the discharge port 5a.

A pair of refrigerant inlet ports (not shown) are formed in the rear side block 4 at upper and lower locations corresponding to the two compression spaces 12 at upper and lower locations, as viewed in FIG. 1, respectively. The suction chamber 11 is communicated via the refrigerant inlet ports with the compression spaces 12.

FIGS. 2A to 2C are enlarged sectional views of the suction valve device 30, which are useful in explaining the construction and operation of the suction valve device 30. FIG. 2A shows the suction valve device 30 in a state in which the compressor is not in operation. FIG. 2B shows the device 30 in a state in which the compressor is in low/medium-speed operation, and FIG. 3 shows the same in a state in which the compressor is in high-speed operation.

The suction valve device 30 includes a valving element 31 slidably received in the suction valve-receiving chamber 20, an urging member 32 for urging the valving element 31 upward (in a predetermined direction) as viewed in FIGS. 2A to 2C, and an annular stopper 33 rigidly fitted in the suction port 6a for restricting the upward movement of the valving element 31.

The valving element 31 is formed by an upper hollow cylindrical portion 31a, a lower hollow cylindrical portion 31c, and a partition plate portion 31b separating the two hollow cylindrical portions 31a and 31c from each other. The upper hollow cylindrical portion 31a has a plurality of openings 34 formed through its wall at intervals along the circumference thereof. The partition plate portion 31b divides the suction valve-receiving chamber 20 into two i.e. upper and lower spaces. The upper space communicates with the suction port 6a, while the lower space communicates with the passage 23.

The urging member 32 is received within the lower hollow cylindrical portion 31c. The urging member 32 is comprised of a coiled spring 35 (first spring) and a coiled spring 36 (second spring), which are connected in series via an intermediate member 37. The coiled springs 35 and 36 have respective spring constants peculiar thereto. The spring constant of the coiled spring 36 is larger than that of the coiled spring 35.

Next, the operation of the vane compressor constructed as above will be described.

As torque is transmitted from an engine, not shown, to the drive shaft 7, the rotor 2 is driven for rotation. When the flow rate of refrigerant gas flowing into the compressor from an evaporator, not shown, via an outlet port thereof exceeds a predetermined value, the valving element 31 is pushed downward as viewed in FIGS. 2B and 2C to thereby cause the urging member 32 to con-

tract. When the valving element 31 is shifted to positions shown in FIGS. 2B and 2C, the suction port 6a communicates with the suction chamber 11 via the suction valve-receiving chamber 20 and the refrigerant inlet passage 22. As a result, refrigerant gas flows into the suction chamber 11 via the suction port 6a and then drawn into the compression spaces 12 via the refrigerant inlet ports. The compression spaces 12 are divided by the vanes 14 into the compression chambers, each of which is varied in capacity with rotation of the rotor 2, as described above, whereby refrigerant gas trapped in each compression chamber is compressed, and the compressed refrigerant gas opens the discharge valve 19 to flow via the refrigerant outlet ports 16 and the communication passages 1b, 3a into the discharge chamber 10, followed by being discharged via the discharge port 5a.

Next, the operation of the suction valve device 30 will be described.

When the compressor is not in operation, the valving element 31 stays urged upward by the urging force of the urging member 32 as shown in FIG. 2A, with its upper hollow cylindrical portion 31a pressed against the bottom of the stopper 33. At this time, the refrigerant inlet passage 22 is closed by the lower hollow cylindrical portion 31c of the valving element 31, and hence the suction valve-receiving chamber 20 (communicating with the suction port 6a) and the suction chamber 11 are not permitted to communicate with each other. Thus, the suction valve device functions as a check valve as well and thereby prevents reverse rotation of the rotor 2.

When the flow rate of refrigerant gas flowing into the compressor exceeds a first predetermined value after the start of the compressor, the valving element 31 is pushed downward, whereby only the coiled spring 35 of the urging member 32 is caused to contract to shift the valving element 31 to the position shown in FIG. 2B. The first predetermined value is a value corresponding to a very small flow rate of refrigerant gas (i.e. a value close to zero). Therefore, actually, the valving element 31 opens immediately after the start of operation of the compressor. When the valving element 31 is moved downward to the position where the refrigerant inlet passage 22 and the whole opening 34 of the valving element 31 are opposed to each other, the suction valve-receiving chamber 20 (communicating with the suction port 6a) and the suction chamber 11 fully communicate with each other with an open area of the opening of the refrigerant inlet passage 22 at its maximum, to permit refrigerant gas to flow into the suction chamber 11.

When the compressor is in low/medium-speed operation, since the flow rate of refrigerant gas flowing into the compressor is not very large, the coiled spring 35 alone is caused to contract, whereas the coiled spring 36 is scarcely caused to contract. Therefore, the state shown in FIG. 2B (in which the open area of the opening of the refrigerant inlet passage 22 is at the maximum) is maintained, and hence the capability of the vane com-

pressor is not reduced or curbed.

When the compressor is in high-speed operation, the flow rate of refrigerant gas flowing into the compressor is increased. When the flow rate exceeds the first predetermined value and then reaches a second predetermined value, the valving element 31 is further pushed downward from the position shown in FIG. 2B, whereby the coiled spring 36 of the urging member 32 is caused to contract to shift the valving element 31 to the position shown in FIG. 2C. When the valving element 31 is moved to this position, since the opening 34 of the valving element 31 also moved downward from the location where the whole opening 34 was opposed to the opening of the refrigerant inlet passage 22, the open area of the opening of the refrigerant inlet passage 22 is reduced by half, whereby refrigerant gas flowing into the suction chamber 11 is decreased. Therefore, when the vane compressor is in high-speed operation, the capacity of the compressor is reduced or curbed, thereby reducing the power wastefully consumed thereby.

As the operation of the compressor shifts from the high-speed operating region to the low/medium-speed region and further from the low/medium-speed region to the inoperative region, the suction valve device operates following the above process in reverse. That is, the state of operation of the suction valve device shifts from the FIG. 2C state to the FIG. 2B state and further from the FIG. 2B state to the FIG. 2A state.

According to the suction valve device of the first embodiment for a vane compressor, since the open area of the opening of the refrigerant inlet passage 22 is variable, the cooling capacity of the compressor is reduced or curbed for reduction of the power consumed thereby only when the compressor is in high-speed operation, whereas the cooling capacity of the compressor is not reduced when the compressor is in low/medium-speed operation. This makes it possible to obtain excellent cooling effects in all the operating regions of the compressor ranging from the low/medium-speed operating region to the high-speed operating region.

Further, the suction valve device of the first embodiment has a simple construction similarly to a conventional check valve, which makes it possible to manufacture a vane compressor of high performance at a low cost.

FIG. 4 is a sectional view showing a suction valve device according to a second embodiment of the invention. Component parts and elements corresponding to those of the first embodiment are indicated by identical reference numerals, and description thereof is omitted.

The present embodiment is distinguished from the first embodiment in which the coiled springs (first and second springs) 35 and 36 are connected in series to each other via the intermediate member 37, in that the intermediate member 37 is dispensed with, and a coiled spring 135 (first spring) and a coiled spring 136 (second spring) alone are used, as shown in FIG. 4. The longitudinal size and outer diameter of the coiled spring 135

are larger than those of the coiled spring 136, and the coiled spring 136 is arranged inside the coiled spring 135.

However, the second embodiment is similar to the first embodiment in that the springs 135 and 136 have respective spring constants peculiar thereto, and that the spring constant of the coiled spring 136 (second spring) is larger than that of the coiled spring 135 (first spring).

When the compressor is not in operation, the valving element 31 stays urged upward by the urging force of the coiled spring 135, with its upper hollow cylindrical portion 31a pressed against the bottom of the stopper 33. At this time, the refrigerant inlet passage 22 is closed by the lower hollow cylindrical portion 31c of the valving element 31, and hence and the suction valve-receiving chamber 20 (communicating with the suction port 6a) and the suction chamber 11 are not permitted to communicate with each other.

When the compressor is started, the valving element 31 is pushed downward, whereby only the coiled spring 135 is caused to contract to shift the valving element 31 to a position where the refrigerant inlet passage 22 and the whole opening 34 of the valving element 31 are opposed to each other. At this time point, the open area of the opening of the refrigerant inlet passage 22 becomes the maximum, and the suction valve-receiving chamber 20 (communicating with the suction port 6a) and the suction chamber 11 fully communicate with each other.

When the compressor is in high-speed operation, the coiled spring 136 is also caused to contract to shift the valving element 31 further downward. As a result, since the opening 34 of the valving element 31 also moves downward from the location where the whole opening 34 was opposed to the opening of the refrigerant inlet passage 22, the open area of the opening of the refrigerant inlet passage 22 is reduced by half, whereby the flow rate of refrigerant gas flowing into the suction chamber 11 is decreased.

The suction valve device according to the second embodiment provides the same effects as obtained by the device according to the first embodiment.

FIGS. 5A and 5B shows a suction valve device according to a third embodiment of the invention. FIG. 5A shows the suction valve device in cross section, and FIG. 5B is a plan view of a stopper incorporated in the device. Component parts and elements corresponding to those of the above embodiments are indicated by identical reference numerals, and description thereof is omitted.

The suction valve device 230 according to the third embodiment is compressed of a valving element 231 in the form of hollow cylinder bottomed or having a suction port-side end wall and slidably received in the suction valve-receiving chamber 20, an urging member 232 for urging the valving element 231 upward (in a predetermined direction) as viewed in FIG. 5A, a stopper 233

rigidly fitted in the suction port 6a for restricting the upward movement of the valving element 231, and a movable member 50 fitted in the valving element 231 in a manner slidable along an inner wall surface of the valving element 231 and dividing the inner space of the valving element 231 into upper and lower spaces.

The urging member 232 is formed by a coiled springs 235 (first spring) and a coiled spring 236 (second spring) which are connected in series to each other via the movable member 50.

The coiled springs 235 and 236 have respective spring constants peculiar thereto, and the spring constant of the coiled spring 236 is larger than that of the coiled spring 235.

The coiled spring 235 functions similarly to the coiled spring 35 of the first embodiment and the coiled spring 135 of the second embodiment, and the coiled spring 236 functions similarly to the coiled spring 36 of the first embodiment and the coiled spring 136 of the second embodiment.

The valving element 231 has its outer peripheral wall formed therethrough with a plurality of openings 234 at intervals along the circumference thereof. Further, the valving element 231 has its bottom or suction port-side end wall formed with a round through hole 238 in its center.

The stopper 233 has a plurality of openings 233a formed therethrough at intervals along the circumference thereof.

When the valving element 231 is shifted downward, refrigerant gas is drawn into the suction chamber 11 via the openings 233a of the stopper 233, the round through hole 238 of the valving element 231, and the opening 234 of the valving element 231.

The suction valve device of the third embodiment provides the same effects as obtained by the device of the first embodiment. In addition, an area in which the valving element 231 is seated on the stopper is increased, which improves the sealing characteristics of the suction valve device.

Although in the above embodiments, each urging member is formed by two springs (e.g. the coiled springs 35, 36), more than two springs may be used to form the urging member. Alternatively, one spring (such as a non-linear spring) alone may be used for the same purpose.

Further, when more than two springs are used, the linear arrangement of the springs exemplified in FIGS. 1 and 5 and the parallel arrangement of the same are both possible. When the springs are arranged in parallel, it is also possible to arrange one spring inside another as exemplified in FIG. 4. In the parallel arrangement, a spring having a smaller spring constant should be longer than another spring having a larger spring constant. Assigning of functions to respective springs or setting operations of the respective springs is easier when the springs are arranged in parallel than when they are arranged in series.

It is further understood by those skilled in the art

that the foregoing is the preferred embodiments of the invention, and that various changes and modification may be made without departing from the spirit and scope thereof.

Claims

1. A suction valve device (30) for a refrigerant compressor having a housing (6), a suction port (6a) formed in the housing (6), a suction chamber (11) defined within the housing (6), and a suction passage (20,22) for communicating the suction port (6a) with the suction chamber (11), the suction valve device (30) comprising:

a valving element (31) arranged in the suction passage (20,22) and movable according to changes in a flow rate of refrigerant gas flowing from the suction port (6a) into the suction passage (20,22) to thereby vary an open area of opening of the suction passage (20,22); and an urging member (32) for urging the valving element (31) in a predetermined direction toward a valve-closing position thereof, the urging member (32) being arranged to be caused to contract by pressure of refrigerant gas flowing from the suction port (6a) into the suction passage (20,22) when the flow rate of refrigerant gas reaches a first predetermined value, to thereby shift the valving element (31) to a first position in which the open area of the opening of the suction passage (20,22) is large, and being arranged to be caused to further contract by increased pressure of refrigerant gas when the flow rate of refrigerant gas reaches a second predetermined value larger than the first predetermined value, to thereby shift the valving element (31) to a second position in which the open area of the opening of the suction passage (20,22) is reduced.

2. A suction valve device (30) according to claim 1, wherein the urging member (32) comprises at least two springs (35,36) having respective spring constants different from each other.

3. A suction valve device (30) according to claim 2, wherein said at least two springs (35,36) include a first spring (35) having a first spring constant according to which the first spring (35) is arranged to be caused to contract by the pressure of refrigerant gas flowing into the suction passage (20,22) at the first predetermined flow rate, and a second spring (36) having a second spring constant according to which the second spring (36) is arranged to be caused to contract by said increased pressure of refrigerant gas flowing into the suction passage

(20,22) at the second predetermined flow rate.

4. A suction valve device (30) according to claim 2 or 3, wherein said at least two springs (35,36) are arranged in series.
5. A suction valve device (30) according to claim 2 or 3, wherein said at least two springs (35,36) are arranged in parallel, one (36) of said at least two springs (35,36) which has a smaller spring constant, being longer than another (35) of said at least two springs (35,36) which has a larger spring constant.
6. A suction valve device (30) according to any preceding claim, wherein the suction passage (20,22) comprises a suction valve-receiving chamber (20) communicating with the suction port (6a) and receiving the valving element (31) therein, and a passage (22) formed through a wall (21) separating the suction valve-receiving chamber (20) and the suction chamber (11) from each other, the valving element (31) being arranged to increase an open area of opening of the passage (22) formed through the wall (21) to the maximum when the valving element (31) is in its first position, and being arranged to decrease the open area of the opening of the passage (22) formed through the wall (21) when the valving element (31) is in its second position.
7. A suction valve device (30) according to any preceding claim, wherein the valving element (31) is in the form of a hollow cylinder (31a,31c) having a peripheral wall formed with a plurality of through holes (34) along a circumference of the hollow cylinder (31a,31c), whereby when the valving element (31) is in its first position, an area of direct communication between any of the through holes (34) and the passage (22) formed through the wall (21) becomes the maximum, and when the valving element (31) is in its second position, the area of direct communication between any of the through holes (34) and the passage (22) formed through the wall (21) is reduced.
8. A suction valve device (30) according to any preceding claim, including a stopper (33) fitted rigidly in the suction port (6a) and arranged to restrict movement of the valving element (31) toward the suction port (6a), the stopper (33) being formed with at least one through hole, the valving element (31) having a suction port-side end formed with at least one through hole and being arranged to be caused to abut the stopper (33) when the device (30) is fitted to a compressor which is not in operation, by the urging member (32) in a manner such that said at least one hole formed through the stopper (33) and said at least one through hole formed through

the suction port-side end of the valving element 31 do not communicate with each other.

9. A suction valve device (30) according to any preceding claim, wherein the urging member (32) is arranged within the valving element (31).
10. A suction valve device (30) according to claim 7 or claim 8 or 9 when dependent upon claim 7, wherein the valving element (31) has a partition wall (31b) formed integrally with the peripheral wall, for dividing the valving element (31) into a suction port-side portion and a bottom-side portion, the through holes (34) being formed in the suction port-side portion.
11. A suction valve device (30) according to claim 10, wherein the urging member (32) is arranged in the bottom-side portion of the valving element (31).
12. A suction valve device (30) according to claim 9, 10 or 11, wherein the urging member (32) comprises at least two springs (35,36) arranged in series with an intermediate member (37) interposed therebetween.
13. A suction valve device (30) according to claim 9, 10 or 11, wherein the urging member (32) comprises at least two springs (35,36) arranged in parallel, one (36) of said at least two springs (35,36) which has a smaller spring constant being longer than another (35) of said at least two springs (35,36) which has a larger spring constant.
14. A suction valve device according to claim 12 or 13, wherein said at least two springs (35,36) are arranged in the suction-side portion and bottom-side portion of the valving element (31).
15. A refrigerant compressor comprising a housing (6), a suction port (6a) formed in the housing (6), a suction chamber (11) defined within the housing (6), and a suction passage (20,22) for communicating the suction port (6a) with the suction chamber (11), characterised by a suction valve device (30) comprising:

a valving element (31) arranged in the suction passage (20,22) and movable according to changes in a flow rate of refrigerant gas flowing from the suction port (6a) into the suction passage (20,22) to thereby vary an open area of opening of the suction passage (20,22); and an urging member (32) arranged to urge the valving element (31) in a predetermined direction toward a valve-closing position thereof, the urging member (32) being arranged to contract by pressure of refrigerant gas flowing from the suction port (6a) into the suction passage

(20,22) when the flow rate of refrigerant gas reaches a first predetermined value, to thereby shift the valving element (31) to a first position in which the open area of the opening of the suction passage (20,22) is large, and being arranged to further contract by increased pressure of refrigerant gas when the flow rate of refrigerant gas reaches a second predetermined value larger than the first predetermined value, to thereby shift the valving element (31) to a second position in which the open area of the opening of the suction passage (20,22) is reduced.

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16. A refrigerant compressor comprising a housing (6), a suction port (6a) formed in the housing (6), a suction chamber (11) defined within the housing (6), a suction passage (20,22) for communicating the suction port (6a) with the suction chamber (11) and a suction valve device (30) according to any of claims 1 to 14.

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FIG. 1

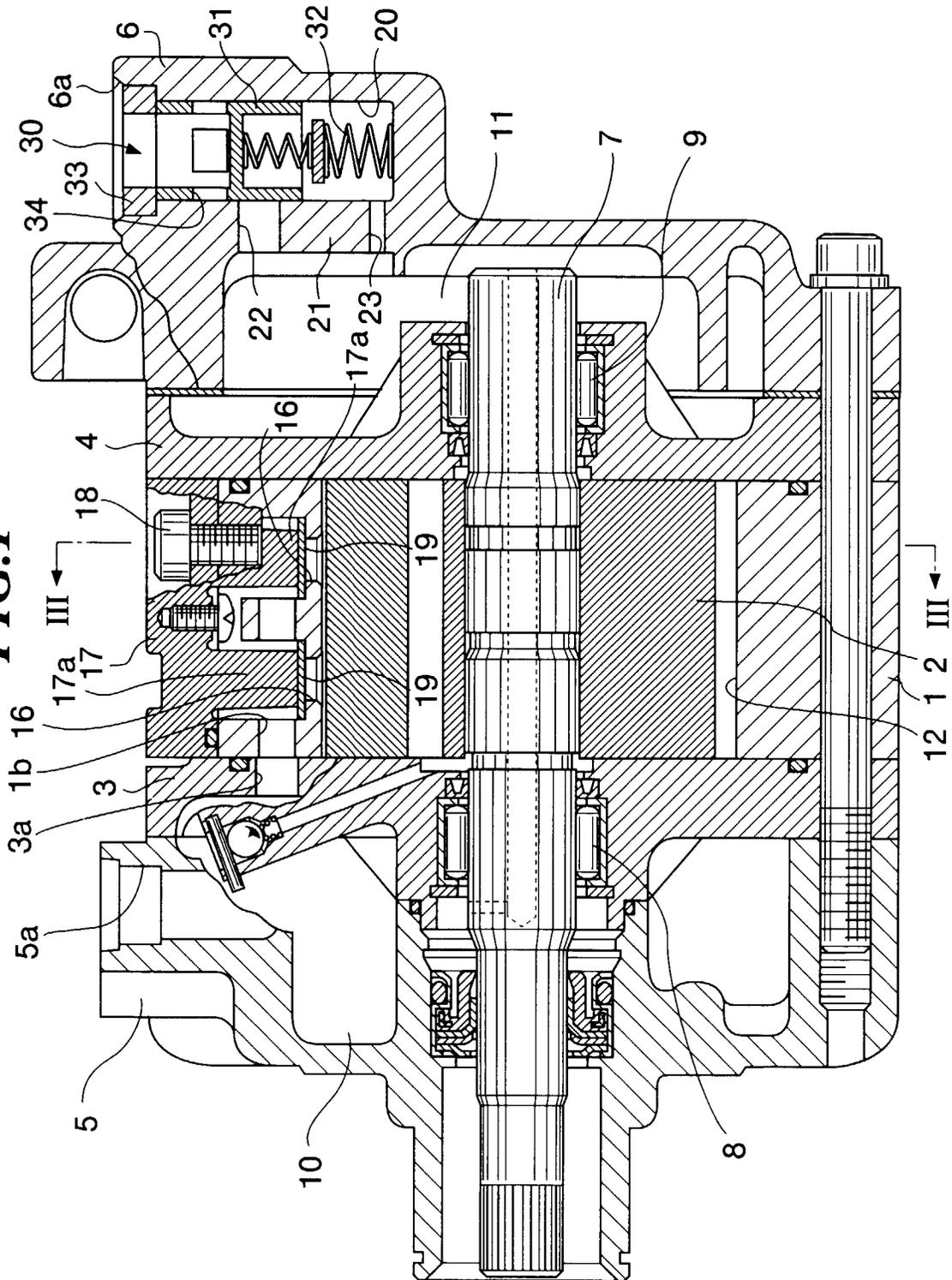


FIG.2C

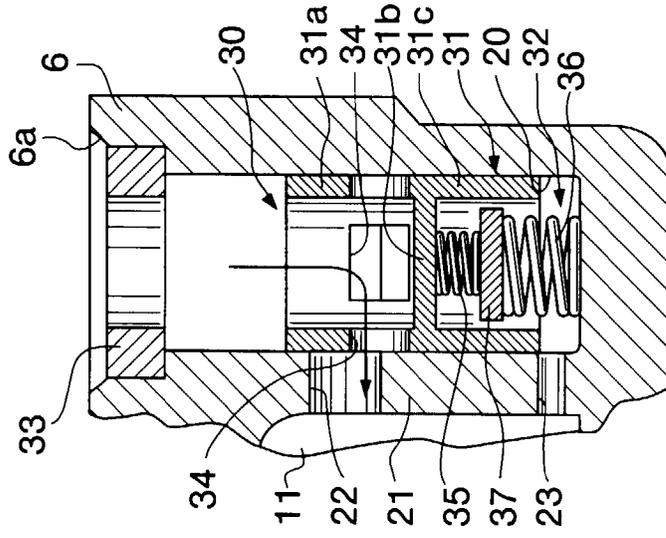


FIG.2B

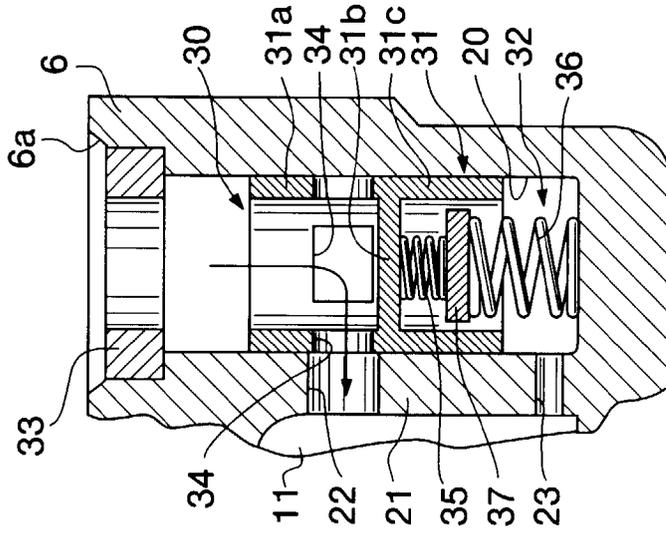


FIG.2A

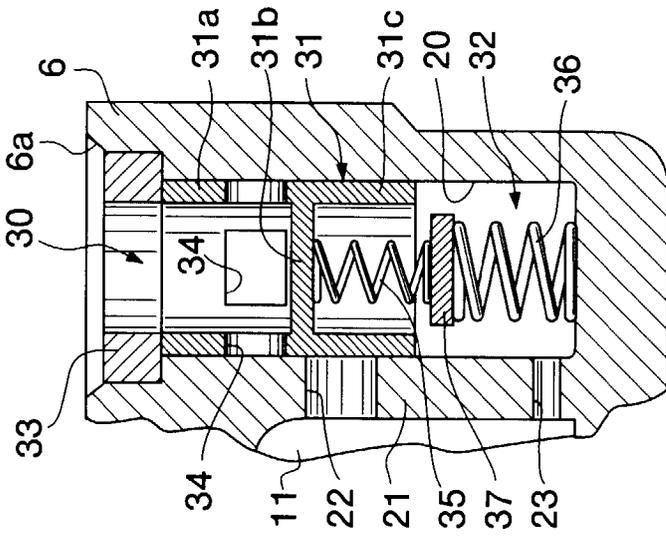


FIG.3

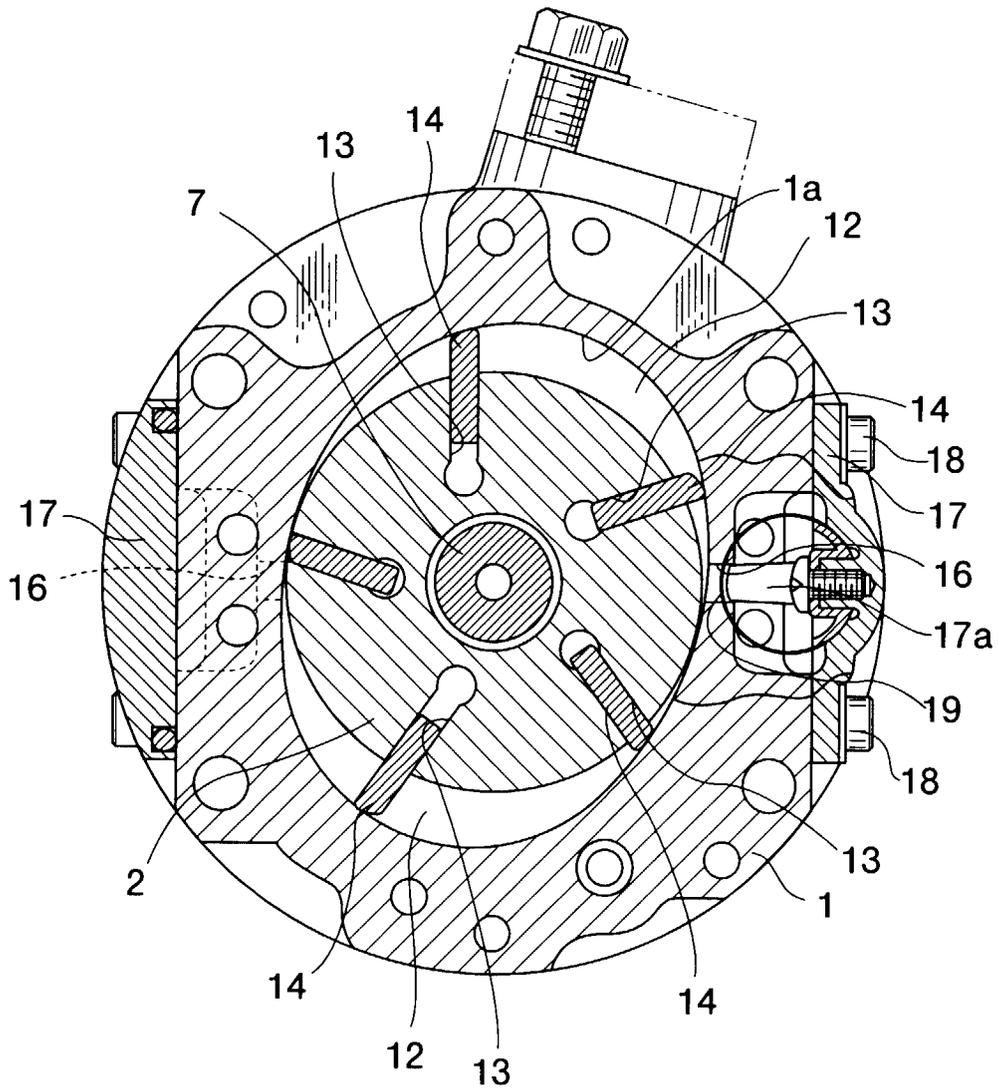


FIG.4

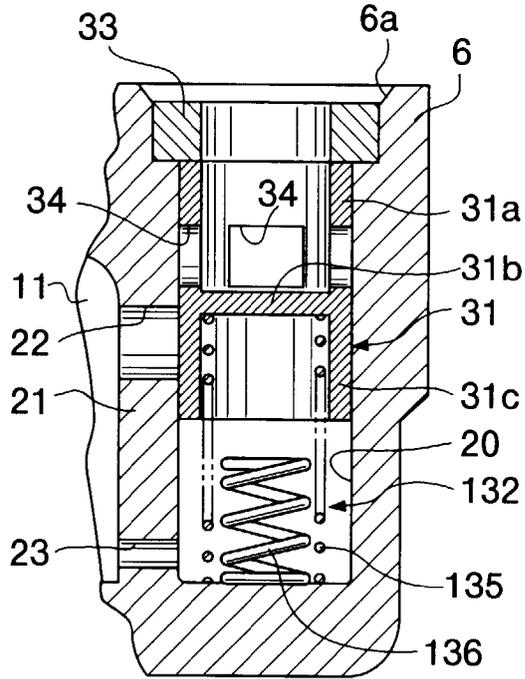


FIG.5A

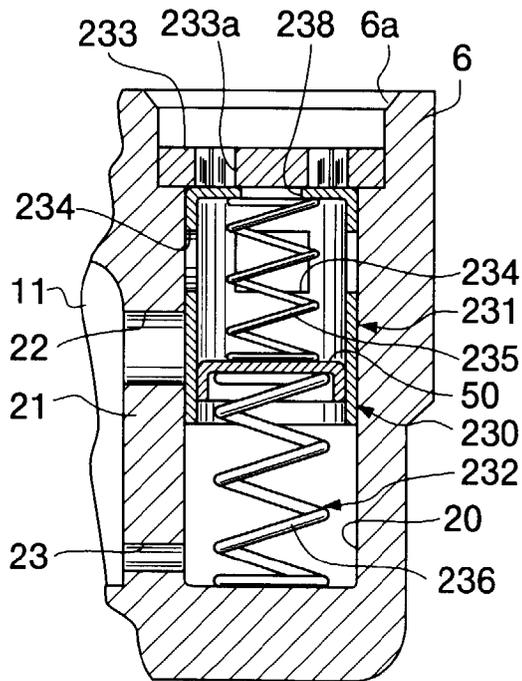
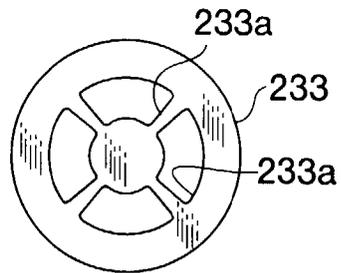


FIG.5B





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 9680

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	DE 34 28 254 A (SEIKO SEIKI KK) * page 3, line 1 - page 4, line 31 * * page 5, line 29 - page 7, line 25; figures 1-3 * ---	1	F04C29/10 F04B49/22
A	US 4 580 950 A (SEIJI SUMIKAWA) * column 1, line 14 - column 2, line 33 * * column 3, line 7 - column 5, line 19; figures 1-3 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F04C F04B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 26 March 1998	Examiner Kapoulas, T
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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