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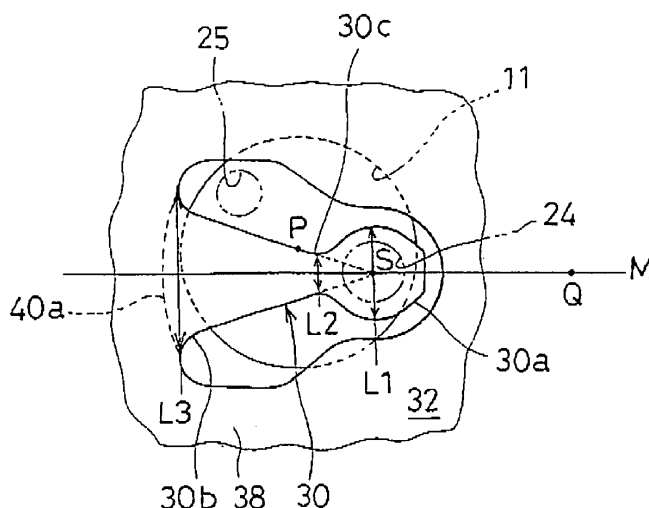
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(54) **RECIPROCATING COMPRESSOR**

(57) The durability of a reed valve is improved by assuring a higher level of resistance to fatigue through distribution of stress that would otherwise concentrate at the base end portion of the reed valve and also better compressor performance is assured. The compressor that includes a valve plate disposed between a cylinder block with cylinder bores formed therein and a cylinder head with a space for temporarily storing a working fluid formed therein, with ports communicating between the

cylinder bores and the space formed at the valve plate and the ports opened/closed by reed valves. The reed valve includes a seat portion 30a located at the front end of a deformation area, which becomes seated at a peripheral edge of the port, and a base end portion 30b fixed to the valve plate and constituting a base end of the deformation area. The modulus of section of the base end portion 30b is set greater than the modulus of section of the seat portion 30a.

Fig. 4



Description

TECHNICAL FIELD

[0001] The present invention relates to a reciprocating compressor and more specifically, it relates to a reciprocating compressor that includes a valve plate disposed between a cylinder block and a cylinder head, with ports formed at the valve plate opened/closed via reed valves.

BACKGROUND ART

[0002] A reciprocating compressor may comprise a cylinder block with cylinder bores formed therein, pistons each engaged in reciprocal linear motion to move inside a cylinder bore, a cylinder head disposed on the side opposite from the side where pistons are inserted at the cylinder block, in which an intake chamber and an outlet chamber where a working fluid is temporarily stored are defined, and a valve plate disposed between the cylinder block and the cylinder head. In a reciprocating compressor adopting such a structure, the cylinder bores are each made to communicate with the intake chamber via an intake port disposed at the valve plate and the intake port is opened/closed via an intake valve constituted with a reed valve.

[0003] The intake valve has a cantilever structure with a deformation area formed so as to range from a base end portion defined by a restricting edge formed at a member facing opposite the valve plate, with a seat portion to become seated on the peripheral edge of the intake port formed at the front end portion of the deformation area.

[0004] The pressure inside the cylinder bore becomes lower than the pressure in the intake chamber as the piston moves during an intake stroke. As a result, the difference between the pressure at the front and the pressure at the rear of the seat portion causes the deformation area at the intake valve to become deformed so as to open up the intake port having been in a closed state and the working fluid in the intake chamber is thus drawn into the cylinder bore via the intake port.

[0005] Intake valves in the related art include an intake valve with a hollowed-out portion formed therein to prevent interference with an outlet port as represented by the intake valve shown in FIGS. 2 and 3 in patent reference literature 1 and an intake valve with no hollowed-out portion as represented by that shown in FIG. 2 in patent reference literature 2.

[0006] At the former type of intake valve, the width gradually increases from a seat portion 30a, which becomes seated at the peripheral edge of an intake port 24 towards a base end portion 30b and a hollowed-out portion 44 is formed over an area further toward the base end portion relative to the center P of a cylinder bore 11, as shown in FIG. 10. The hollowed-out portion 44 is formed as an elongated hole ranging along the axial line of the intake valve 30 so as to face opposite an outlet

port 25 and bridge portions 45, each present on either side of the hollowed-out portion 44, assume widths such that their sum is substantially equal to or less than the width of the seat portion 30a and range so that the inner edges of the two bridge portions extend substantially parallel to each other.

[0007] The base end portion 30b is defined along a restricting edge (indicated by the dotted line near the base end portion 30b of the intake valve shown in FIG. 10) constituted with the circumferential edge of a passing hole in a gasket disposed between the cylinder bore 11 and the valve plate, and the restricting edge 40a at the gasket is formed in the shape of an arc of a circle centered on the center P of the cylinder bore 11.

[0008] As shown in FIG. 11, at the latter type of intake valve 30, the width of the seat portion 30a, which becomes seated at the peripheral edge of the intake port 24 is set greater than the width of the base end portion 30b and its width over the area ranging from the base end portion 30b toward the seat portion 30a is substantially uniform.

Patent reference literature 1: Patent Publication No. 3430486

Patent reference literature 2: Patent Publication No. 3608299

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0009] The extent to which the intake valve is deformed changes in correspondence to the quantity of working fluid passing through the intake port, and as the quantity of working fluid passing through the intake port increases, the pressure applied to the seat portion of the intake valve, too, increases, resulting in a greater extent of deformation at the intake valve. For this reason, if the width at the base portion is equal to or less than the width of the seat portion, as described above, a relatively small modulus of section is assumed at the base end portion and thus, the bending moment, which becomes greater toward the base end portion further away from the seat portion, manifests a lower level of bending stress in the vicinity of the seat portion and a greater level of bending stress near the base end portion as the valve opens. In other words, the level of stress occurring at the base end portion of the intake valve may exceed the allowable stress level.

[0010] In particular, if the restricting edge defining the base end portion is formed at the gasket or the like, as described above, as a circular arc along the edge of the opening of the cylinder bore on the valve plate side, the stress is allowed to concentrate over the two ends of the base end portion at the intake valve, which leads to a concern that the intake valve may become damaged at a high rotation rate or during a high-load operation.

[0011] As a countermeasure to this concern, a stopper recess for regulating the maximum value representing

the maximum extent of lift for the intake valve may be formed at the circumferential edge of the opening of the cylinder boar at the cylinder block so as to keep down the extent of deformation of the intake valve equal to or less than a predetermined value even when a great quantity of working fluid is taken in. However, it is desirable to assume a greater maximum lift quantity in order to reduce the passage resistance at the maximum lift quantity. In other words, it is difficult to assure both good compressor performance and satisfactory intake valve durability.

[0012] The following three approaches have been proposed as means for lowering the stress applied to the base end portion of the intake valve and improving the intake valve strength against fatigue.

- (i) increase the reed length at the intake valve
- (ii) reduce the lift quantity representing the extent of lift of the intake valve
- (iii) increase the radius of curvature of the circular arc at the two ends of the base end portion of the intake valve

[0013] However, the restrictions imposed with regard to the cylinder boar diameter requires the diameter of the intake port to be set to a small value in order to increase the reed length at the intake valve in approach (i). If the diameter of the intake port is reduced, the area through which the working fluid passes becomes smaller, to result in an increase in passage resistance and ultimately lower the compressor performance.

As the lift quantity at the intake valve is reduced in approach (ii), the area through which the working fluid passes becomes smaller, which increases passage resistance and lowers the compressor performance.

If the radius of curvature of the circular arc at the two ends of the base end portion is increased in approach (iii), the area of the intake valve that becomes deformed is reduced. This increases the spring constant at the intake valve and reduces the lift quantity and leads to greater passage resistance.

[0014] The primary object of the present invention, having been completed by addressing the issues discussed above, is to provide a reciprocating compressor with an increased compressor performance level, which also achieves an improvement in durability by assuring the required fatigue resistance through distribution of the stress that would otherwise concentrate at the base end portion of the reed valve.

MEANS FOR SOLVING THE PROBLEMS

[0015] Through concentrated research into an optimal structure that would disperse the stress at the base end portion of the reed valve, the inventor of the present invention et al. learned that the stress occurring at the base end portion can be distributed by modifying the shape of the valve element itself or by modifying the condition in which the valve element is restricted. Based upon these

findings, the present invention has been completed.

[0016] Namely, a reciprocating compressor according to the present invention, which includes a valve plate disposed between a cylinder block having cylinder boars formed therein and a cylinder head having a space formed therein where a working fluid is temporarily stored, with ports through which the cylinder boars and the space communicate formed at the valve plate and the ports opened/closed via reed valves, is characterized in that the reed valve includes a seat portion disposed at a front end portion of a deformation area, which becomes seated at a circumferential edge of the port, and a base end portion which is fixed to the valve plate and functions as a base end of the deformation area and that the modulus of section at the base end portion is set greater than the modulus of section at the seat portion (claim 1).

[0017] In the structure described above, the seat portion assumes strength against a bending force, the level of which is lower relative to the strength achieved at the reed valve base end portion against the bending force. This means that the seat portion is allowed to flex readily so as to disperse the stress occurring at the base end portion toward the seat portion to lower the maximum bending stress that may be applied to the base end portion.

[0018] The advantage of the structure described above may be further enhanced by including a relay portion with a smaller modulus of section than the modulus of section at the seat portion formed within the deformation area where the seat portion transitions to the base end portion (claim 2). The presence of such a relay portion allows the front end of the reed valve to flex even more readily, making it possible for the intake valve to open with greater lift quantity and reduced stress occurring at the base end portion.

[0019] At the reed valve in the structure described above, the width of the seat portion may be set smaller than the width of the base end portion but greater than the width of the relay portion (claim 3). Since this structure makes it possible to achieve the desired advantage simply by assuming varying widths at the different portions of the reed valve, the need to assume varying thicknesses at the different portions of the reed valve and the like is eliminated and the distribution of stress over the various portions can be adjusted with ease.

[0020] In particular, by linearly reducing the width of the reed valve from the base end portion toward the relay portion, with lines extending from the outer edges on the two sides made to intersect near the center of the port (claim 4), the rigidity can be gradually reduced starting at the base end portion toward the relay portion. It can thus be ensured that flexure occurs more readily further away from the base end portion.

[0021] In addition, if the structure includes a hollowed-out portion formed over an area further toward the base end portion relative to the relay portion at the reed valve, bridge portions formed on the two sides of the hollowed-out portion should assume greater widths toward the

base end portion (claim 5). In the structure described above, the reduction in the modulus of section attributable to the presence of the hollowed-out portion can be compensated by increasing the widths of the bridge portions further toward the base end portion. As a result, flexure occurs more readily by reducing the rigidity on the seat portion side while assuring sufficient rigidity on the base end portion side.

[0022] Alternatively, a reciprocating compressor according to the present invention, which includes a valve plate disposed between a cylinder block having cylinder bores formed therein and a cylinder head having a space formed therein where a working fluid is temporarily stored, with ports through which the cylinder bores and the space communicate formed at the valve plate and the ports opened/closed via reed valves, may be characterized in that the reed valve is restricted by a member facing opposite said valve plate and the reed valve includes a base end portion defined by a restricting edge at the member facing opposite the valve plate and that at least part of the restricting edge gradually edges away toward the outside from the circumferential edge of the cylinder bore as the restricting edge extends toward the outside along the widthwise direction (claim 6).

[0023] In the structure described above, the restricting edge is set further outside relative to the circumferential edge of the cylinder bore, assuring a deformation area ranging over a sufficient length from the base end portion even when the reed valve is formed in a fan shape, gradually widening toward the bottom thereof from the seat portion side. In addition, the stress can be dispersed effectively without allowing it to concentrate at the two ends of the base end portion.

[0024] For instance, if the restricting edge is formed in the shape of a circular arc, the center of the curvature of the restricting edge should be offset from the center of the cylinder bore and the radius of curvature of the restricting edge should be set greater than the radius of the cylinder bore (claim 7). The problems discussed earlier cannot be overcome if the center of the curvature of the restricting edge is aligned at the center of the cylinder bore since the stress is allowed to concentrate at the two sides of the base end portion in this state. However, the structure described above allows the deformation area at the reed valve to range over a sufficient length and makes it possible to disperse the stress at the base end portion toward the center by selecting the optimal position for the curvature center and the optimal radius of curvature, thereby effectively preventing concentration of stress in a specific area.

[0025] In addition, it is desirable that the center of curvature of the restricting edge be set on the axial line of the reed valve (claim 8). This structure achieves left/right symmetry in the stress distribution at the base end portion relative to the axial line even when the axial line of the reed valve does not pass through the center of the cylinder bore, and thus, any imbalance in the stress applied during the process of deformation can be prevented.

[0026] It is to be noted that the member facing opposite the valve plate, at which the restricting edge is formed, may be a gasket disposed between the cylinder block and the cylinder head (claim 9) or the cylinder block itself.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

FIG. 1 is a sectional view presenting a structural example for a reciprocating compressor;

FIG. 2 is an exploded perspective showing various components disposed between the cylinder block and the cylinder head;

FIG. 3 is a plan view of the intake valve sheet;

FIG. 4 is an enlarged view of an intake valve formed in the intake valve sheet shown in FIG. 3;

FIG. 5 is an enlarged view of an area around a passing hole at the gasket, formed in correspondence to the intake valve shown in FIG. 4;

FIG. 6 is a plan view presenting another structural example that may be adopted in the intake valve sheet;

FIG. 7 is an enlarged view of an intake valve formed in the intake valve sheet shown in FIG. 6;

FIG. 8 is an enlarged view of an area around a passing hole at the gasket, formed in correspondence to the intake valve shown in FIG. 7;

FIG. 9 is a plan view of the layout of the various components disposed between the cylinder block and the cylinder head;

FIG. 10 shows an intake valve in the related art; and FIG. 11 shows another structure adopted in an intake valve in the related art.

EXPLANATION OF REFERENCE NUMERALS

[0028]

1	cylinder block
2	valve plate
3	cylinder head
11	cylinder bore
22	intake chamber
24	intake port
30	intake valve
30a	seat portion
30b	base end portion
30c	relay portion
33	gasket
40a	restricting edge
44	hollowed-out portion

BEST MODE FOR CARRYING OUT THE INVENTION

[0029] The following is a description of embodiments of the present invention given in reference to the drawings.

FIG. 1 shows a reciprocating compressor achieved in an embodiment of the present invention. This reciprocating compressor comprises a cylinder block 1, a cylinder head 3 attached to the rear side of the cylinder block 1 via a valve plate 2 and a front housing 5 attached so as to encase the cylinder block 1 and defining a crankcase 4 on the front side of the cylinder block 1. The front housing 5, the cylinder block 1, the valve plate 2 and the cylinder head 3 are fastened together along the axial direction with a fastening bolt 6.

[0030] The crankcase 4 defined by the front housing 5 and the cylinder block 1 houses therein a drive shaft 7, one end of which projects out from the front housing 5. The one end of the drive shaft 7 is rotatably supported at the front housing 5 via a radial bearing 8, whereas the other end of the drive shaft 7 is rotatably supported at the cylinder block 1 via a radial bearing 9 and a thrust bearing 10.

[0031] At the cylinder block 1, a plurality of cylinder bores 11 are formed with specific intervals along the circumferential direction around the drive shaft 7, with a piston 12 slidably inserted in each cylinder bore 11.

[0032] A thrust flange 15, which rotates as one with the drive shaft 7, is fixed to the drive shaft 7 in the crankcase 4. The thrust flange 15 is rotatably supported via a thrust bearing 16 at the inner wall surface of the front housing 5 ranging substantially perpendicular to the drive shaft 7. A swashplate 18 is linked to the thrust flange 15 via a link member 17.

[0033] The swashplate 18, tiltably held via a hinge ball 19 disposed on the drive shaft 7, is caused to rotate as one with the thrust flange 15 in synchronization with the rotation of the thrust flange 15. An engaging portion 12a of the piston 12 is held at the edge of the swashplate 17 via a pair of shoes 20 holding the engaging portion between them.

[0034] Thus, as the drive shaft 7 rotates, the swashplate 18 also rotates and the rotating motion of the swashplate 18 is converted via the shoes 20 to reciprocal linear motion of the piston 12, thereby altering the volumetric capacity of a compression space 21 defined between the piston 12 and the valve plate 2 inside the cylinder bore 11.

[0035] At the cylinder head 3, an intake chamber 22 and outlet chambers 23 disposed around the intake chamber 22 are defined, whereas intake ports 24, each communicating between the intake chamber 22 and a compression space 21 (cylinder bore 11) via an intake valve 30 and outlet ports 25, each communicating between an outlet chamber 23 and a compression space 21 (cylinder bore 11) via an outlet valve 31, are formed at the valve plate 2 over predetermined intervals along the circumferential direction.

[0036] An intake valve sheet 32 is laid onto an end surface of the valve plate 2 toward the cylinder block 1, and the cylinder block 1 is set on the intake valve sheet 32 via a gasket 33, as shown in FIG. 2. An outlet valve sheet 34 having outlet valves 31 formed therein as an integrated part thereof, is laid on an end surface of the

valve plate 2 toward the cylinder head and the cylinder head 3 is set on the outlet valve sheet 34 via a gasket 35. The cylinder block 1, the gasket 33, the intake valve sheet 32, the valve plate 2, the outlet valve sheet 34 and the gasket 35 are positioned via positioning pins 36 and locked together with a bolt 37, which interlocks with the cylinder block 1, so as to press them against each other.

[0037] As shown in FIG. 3, at the intake valve sheet 32, constituted with a group of intake valves 30 which open/close the intake ports 24, the intake valves 30, the number of which matches the number of the cylinder bores 11, are formed along the circumferential direction over specific intervals, as well as holes 32a and 32b at which the bolts 6 and 37 are inserted and holes 32c at which the positioning pins 36 are inserted.

[0038] As shown in FIG. 4, the intake valves 30 are each constituted with part of the intake valve sheet 32 and they are formed contiguously to a connecting area 38 ranging around the intake valves and connecting adjacent intake valves to each other. The intake valves 30 are cantilevered reed valves with a uniform thickness. At the front end of the deformation area of each intake valve, a seat portion 30a to become seated on an area at the circumferential edge around the corresponding intake port 24 is formed. This seat portion 30a assumes a shape substantially similar to the shape of the intake port 24 and accordingly, if the intake port 24 has a circular section, the seat portion also assumes a circular shape.

[0039] In addition, over the area where the seat portion 30a transitions to a base end portion 30b, which is to constitute the base end of the deformation area, a relay portion 30c with a width L2 smaller than the width of the seat portion 30a is formed, and the width gradually increases from the relay portion 30c toward the base end portion 30b.

[0040] The width L1 of the seat portion 30a is set smaller than the width L3 of the base end portion 30b and over the area where the base end portion 30b transitions to the relay portion 30c, the width of the intake valve 30 becomes linearly smaller, with the lines extending from the outer edges on the two sides over this area made to intersect each other near a center S of the intake port 24 (the extending lines intersect each other at the center S of the intake port 24 in this example).

[0041] Thus, the base end portion 30b is formed so as to have a modulus of section greater than the modulus of section at the seat portion in the intake valve 30. In addition, the relay portion 30c is formed so as to have a modulus of section smaller than the modulus of section at the seat portion 30a in the intake valve 30.

[0042] Passing holes 40 to communicate with the cylinder bores 11, the quantity of which matches the number of cylinder bores 11, are formed over equal intervals along the circumferential direction and also, holes 42a and 42b, through which the bolts 6 and 37 are inserted, as well as holes 42c (see FIG. 2) at which the positioning pins 36 are inserted, are formed at the gasket 33.

[0043] The state of restriction on the intake valves 30

is determined by the shape of the passing holes 40 formed at the gasket 33. As shown in FIG. 5, the circumferential edge of each passing hole 40 at the gasket 33 forms a restricting edge 40a constituting an edge at which the corresponding intake valve 30 is restricted and the base end portion 30b of the intake valve 30 is defined by the restricting edge 40a.

[0044] The restricting edge 40a at the gasket 33 is formed so as to gradually move away toward the outside from the circumferential edge of the cylinder boar 11 as it ranges outward along the widthwise direction. In this example, the restricting edge 40a is formed in a circular arc shape and the center Q of curvature of the restricting edge 40a is set on the axial line of the intake valve 30 without being aligned with the center P of the cylinder boar 11, with the radius of curvature of the restricting edge 40a set greater than the radius of the cylinder boar 11. In addition, the axial line M of the intake valve 30 does not pass through the center P of the cylinder boar 11 but extends further toward one side with an outlet port 25 formed on the side opposite from the side toward which the axial line extends in the example.

It is to be noted that reference numeral 50 indicates a pressure control valve with which the piston stroke, i.e., the outlet capacity, is controlled by adjusting the crankcase pressure.

[0045] In the structure described above, the modulus of section of the base end portion 30b is set greater than the modulus of section of the seat portion 30a at the intake valve 30 so as to reduce the strength of the seat portion 30a against a bending force relative to the strength at the base end portion 30b. In other words, the seat portion 30a is allowed to flex readily and the stress occurring at the base end portion 30b is distributed, reducing the maximum bending stress applied to the base end portion 30b.

[0046] As a result, the lift quantity at the intake valve 30 can be increased and, at the same time, the stress applied to the base end portion 30b can be reduced, thereby improving the performance of the compressor. In addition, since a sufficient level of resistance to fatigue can be assured by distributing the stress applied to the base end portion 30b of the intake valve 30, the durability of the intake valve 30 is improved.

[0047] Furthermore, the structure described above includes the relay portion 30c with a smaller modulus of section than the seat portion 30a, formed over the area where the seat portion 30a transitions to the base end portion 30b. The presence of the relay portion 30c allows the front end portion of the intake valve 30 to flex even more easily. Thus, the intake valve is allowed to open with a greater lift quantity and the stress applied to the base end portion 30b is reduced.

[0048] In particular, since the various portions are formed with a uniform thickness and the moduli of section of the individual portions are adjusted by adjusting their widths, the stress distribution at each portion can be adjusted with ease in the structure described above.

[0049] In addition, the width of the intake valve 30 is

reduced linearly, starting from the base end portion 30b toward the relay portion 30c and the lines extending from the outer edges on the two sides are made to intersect each other in the vicinity of the center S of the intake port 24. As a result, the rigidity can be gradually reduced over the area ranging from the base end portion 30b toward the relay portion 30c, which allows a portion further away from the base end portion 30b to flex more readily.

[0050] Furthermore, the center Q of curvature of the restricting edge 40a is offset from the center P of the cylinder boar 11 and the radius of curvature of the restricting edge 40a is set greater than the radius of the cylinder boar 11, so that the restricting edge 40a formed at the gasket 33 ranges gradually further away (gradually edges away) toward the outside from the circumferential edge (the opening edge toward the valve plate) of the cylinder boar 11 as it extends outward along the widthwise direction. Consequently, even if the intake valve 30 is formed in a fan shape, widening toward the bottom from the seat portion 30a, a sufficient reed length can be assured and the stress occurring at the base end portion 30b can be effectively distributed without being allowed to concentrate on the two sides of the base end portion 30b. As a result, the durability of the intake valve 30 can be improved by assuring sufficient resistance to fatigue at the base end portion 30b of the intake valve 30, and since the front end portion of the intake valve is allowed to flex more easily, a greater lift quantity is assured so as to satisfy the needs for both higher compressor performance and better intake valve durability.

[0051] Moreover, the center Q of curvature of the restricting edge 40a is set on the axial line of the intake valve 30. Thus, even when the axial line M of the intake valve 30 does not pass through the center P of the cylinder boar 11 as in the example described above, left/right symmetry relative to the axial line M can be achieved with regard to the stress distribution at the base end portion 30b, which effectively prevents any imbalance in the stress applied as the intake valve becomes deformed.

[0052] FIGS. 6 and 7 show another structural example that may be adopted in the intake valve 30 in the compressor according to the present invention. The intake valves 30 formed at the intake valve sheet 32 are each formed so that the axial line M passes through the center P of the cylinder boar 11 in this example. Accordingly, a hollowed-out portion 44 is formed further toward the base end portion 30b relative to the relay portion 30c at the intake valve 30. An outlet port 25 is formed at the valve plate 2 so as to face opposite the hollowed-out portion 44 and interference that might otherwise occur between the intake valve 30 and the outlet port 25 is thus prevented via the hollowed-out portion.

[0053] On the two sides of the hollowed-out portion 44, bridge portions 45 extending from the base end portion 30b through the relay portion 30c are formed. The widths of the bridge portions 45 gradually increase toward the base end portion 30b. In this particular example, the lines extending from the inner edges of the bridge portions 45

are made to intersect each other near the center S of the intake port 24 (intersect at the center S of the intake port 24 in the example)

[0054] In addition, as in the previous structural example, a relay portion 30c with a width thereof set smaller than the width of the seat portion 30a is formed at the intake valve 30 over the area where the seat portion 30a transitions to the base end portion 30b constituting the base end of the deformation. The width of the intake valve 30 gradually increases from the relay portion 30c toward the base end portion 30b. The seat portion 30a has a width smaller than the sum L of the widths L4 of base end portions 45a of the two bridge portions 45. The width of the intake valve 30 is linearly reduced over the area where the base end portion 30b transitions to the relay portion 30c, with the lines extending from the outer edges of the two sides over this area made to intersect each other near the center S of the port (intersect at the center S of the intake port 24 in this example).

[0055] Thus, the base end portion 30b is formed so as to have a modulus of section greater than the modulus of section at the seat portion 30a in the intake valve 30. The relay portion 30c present over the area where the seat portion 30a transitions to the base end portion 30b is formed so as to have a modulus of section smaller than the modulus of section at the seat portion 30a.

[0056] In addition, while the restricting edge 40a formed at the gasket 33 in this example is similar to that in the previous structural example in that it is formed in a circular arc shape so as to gradually range further away toward the outside from the circumferential edge of the cylinder boa 11 as it extends outward along the widthwise direction, as shown in FIG. 8, it differs from the restricting edge in the previous example in that the center Q of curvature of the restricting edge 40a is set on the axial line M of the intake valve 30 passing through the center P of the cylinder boa 11.

It is to be noted that other structural features are similar to those in the previous example and accordingly, a detailed explanation is omitted by assigning the same reference numerals to identical components.

[0057] The structure described above achieves advantages similar to those of the previous example. In addition, by forming the hollowed-out portion 44 at the intake valve 30, too, the intake valve is allowed to flex with ease on the seat portion side and, at the same time, the stress can be distributed effectively on the base end portion side. As a result, the need for both higher compressor performance and greater intake valve durability are satisfied.

[0058] It is to be noted that the center of the seat portion 30a at the intake valve 30 (the center S of the intake port 24) in each of the structural examples described above should be set on the line connecting a center D of the drive shaft 7 and a center C of the outlet port 25, as shown in FIG. 9 (intake chambers are formed around an outlet chamber in the example presented in the figure). Such a structure allows a partitioning wall 51, separating the

intake chamber 22 from the outlet chambers 23 formed at the cylinder head 3 to assume a cylindrical shape, which will contribute to a further improvement in the compressor efficiency (in FIG. 9, E indicates a bead formed by partially raising the surface of the gasket 33, which assumes a ring shape ranging substantially along the edge of the passing whole 40 to surround the cylinder boa 11 around its circumferential edge).

[0059] While no special mention is made in the description of the embodiment of the present invention provided above with regard to specific applications in which the compressor may be utilized, the present invention is particularly effective in applications in CO2 compressors with cylinder boas having a small diameter. In addition, while the member at which the restricting edges 40a are formed in the gasket 33 disposed between the cylinder block 1 and the valve plate 2 in the examples described above, restricting edges may be formed at the cylinder block 1 instead of the gasket 33.

In addition, while the structural features characterizing the present invention are adopted in the intake valves in the description provided above, a similar structure may also be adopted in the outlet valves.

Claims

1. A reciprocating compressor that includes a valve plate (2) disposed between a cylinder block (1) having cylinder boas (11) formed therein and a cylinder head (3) having a space formed therein where a working fluid is temporarily stored, with ports through which said cylinder boas (11) and said space communicate formed at said valve plate (2) and said ports opened/closed by reed valves, **characterized in:**

that said reed valve includes a seat portion (30a) disposed at a front end portion of a deformation area, which becomes seated at a circumferential edge of said port, and a modulus of section of a base end portion defining a base end of said deformation area is set greater than a modulus of section at said seat portion (30a).

2. A reciprocating compressor according to claim 1, **characterized in:**

that a relay portion (30c) with a smaller modulus of section than the modulus of section at said seat portion (30a) is formed within said deformation area where said seat portion (30a) transitions to said base end portion (30b).

3. A reciprocating compressor according to claim 2, **characterized in:**

that the width of said seat portion (30a) is set smaller than the width of said base end portion

(30b) but greater than the width of said relay portion (30c).

4. A reciprocating compressor according to claim 3, **characterized in:**

that the width of said reed valve is linearly reduced from said base end portion (30b) toward said relay portion (30c) with lines extending from outer edges on the two sides made to intersect each other near the center of said port.

5. A reciprocating compressor according to claim 1, **characterized in:**

that a hollowed-out portion (44) is formed at said reed valve over an area further toward said base end portion (30b) relative to said relay portion (30c) and bridge portions formed on the two sides of said hollowed-out portion (44) assume greater widths toward said base end portion.

6. A reciprocating compressor that includes a valve plate (2) disposed between a cylinder block (1) having cylinder bores (11) formed therein and a cylinder head (3) having a space formed therein where a working fluid is temporarily stored, with ports through which said cylinder bores (11) and said space communicate formed at said valve plate (2) and said ports opened/closed by reed valves, **characterized in:**

that said reed valve is restricted by a member facing opposite said valve plate (2) and the reed valve includes a base end portion (30b) defined by a restricting edge of said member facing opposite said valve plate (2) and at least part of said restricting edge (40a) gradually edges away toward the outside from the circumferential edge of said cylinder bore (11) as said restricting edge extends outward along the width-wise direction.

7. A reciprocating compressor according to claim 6, **characterized in:**

that said restricting edge (40a) is formed in a circular arc shape and the center of curvature thereof is set so as not to be aligned with the center of said cylinder bore (11) and the radius of curvature of said restricting edge (40a) is set greater than the radius of the cylinder bore (11).

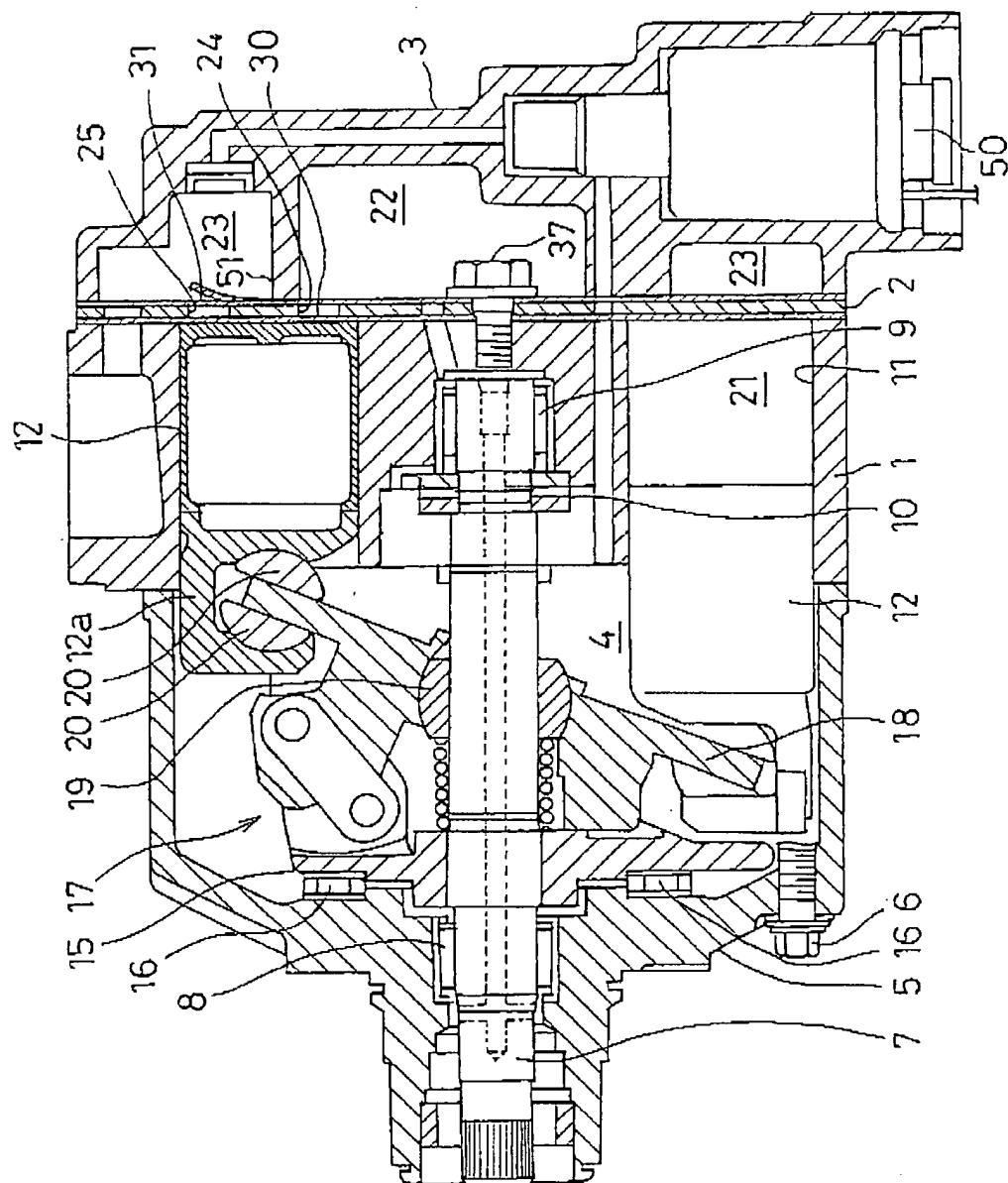
8. A reciprocating compressor according to claim 7, **characterized in:**

that the center of curvature of said restricting edge (40a) is set on the axial line of said reed valve.

9. A reciprocating compressor according to claim 6, **characterized in:**

that said member facing opposite said valve plate (2) is a gasket (33) disposed between said cylinder block (1) and said cylinder head (3).

Fig. 1



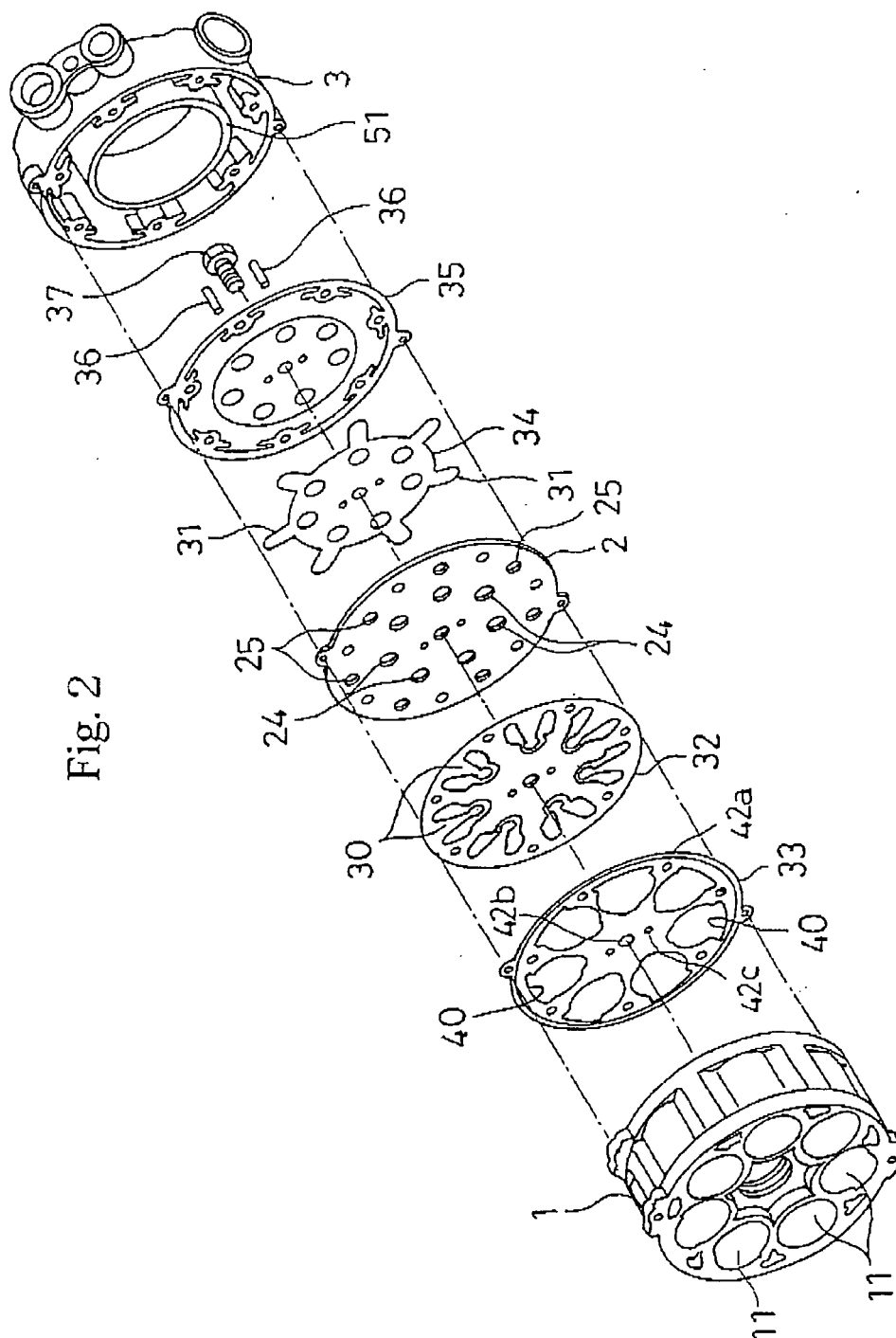


Fig. 3

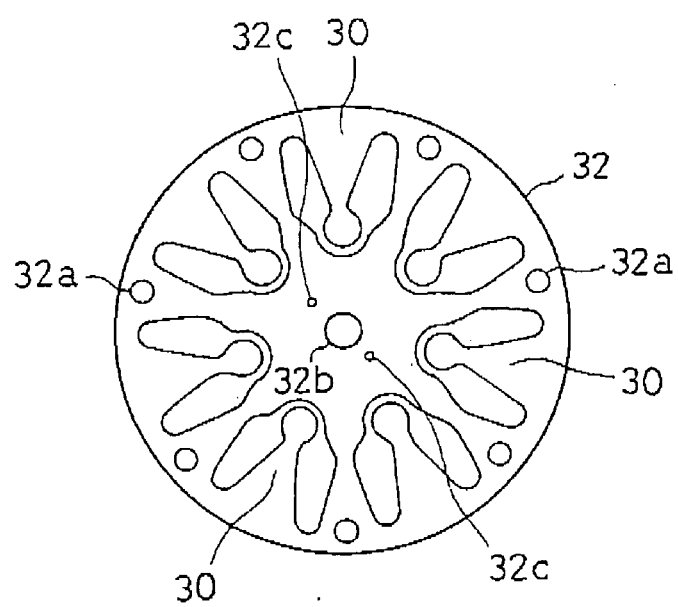


Fig. 4

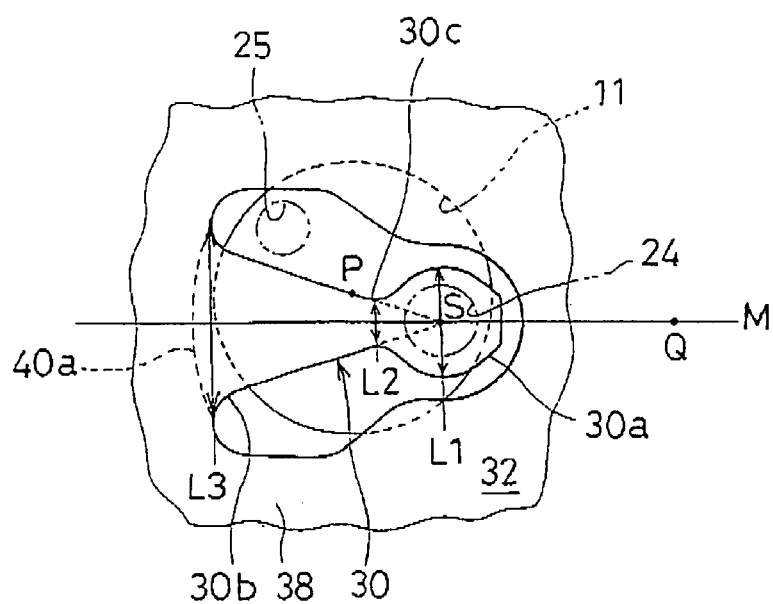


Fig. 5

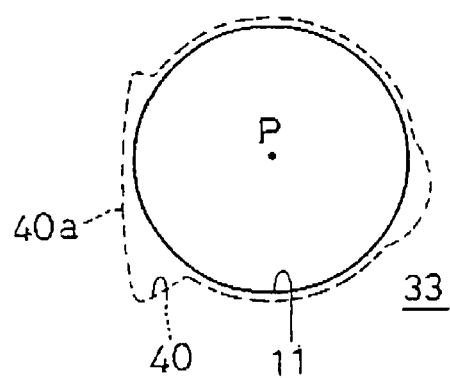


Fig. 6

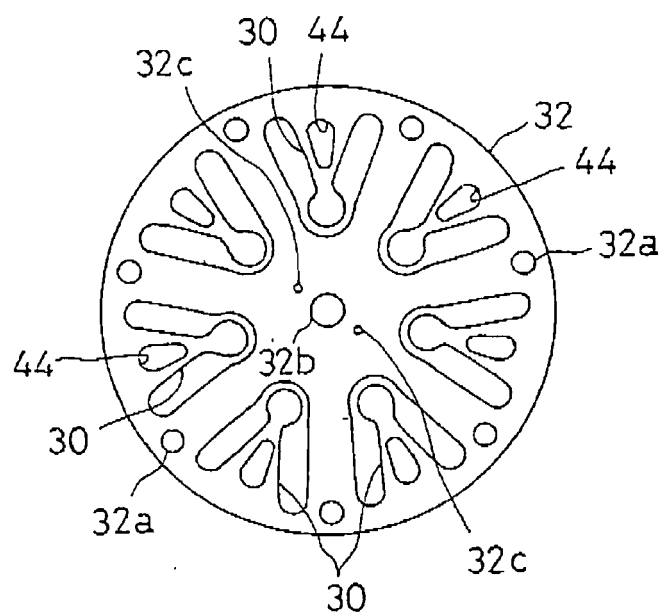


Fig. 7

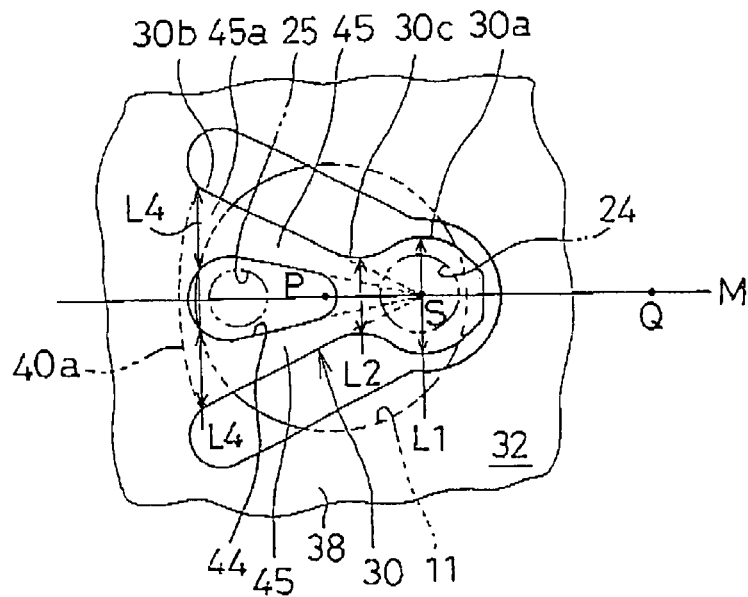


Fig. 8

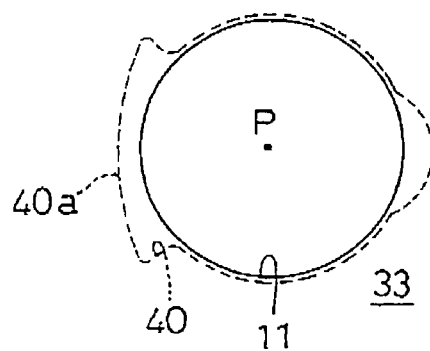


Fig. 9

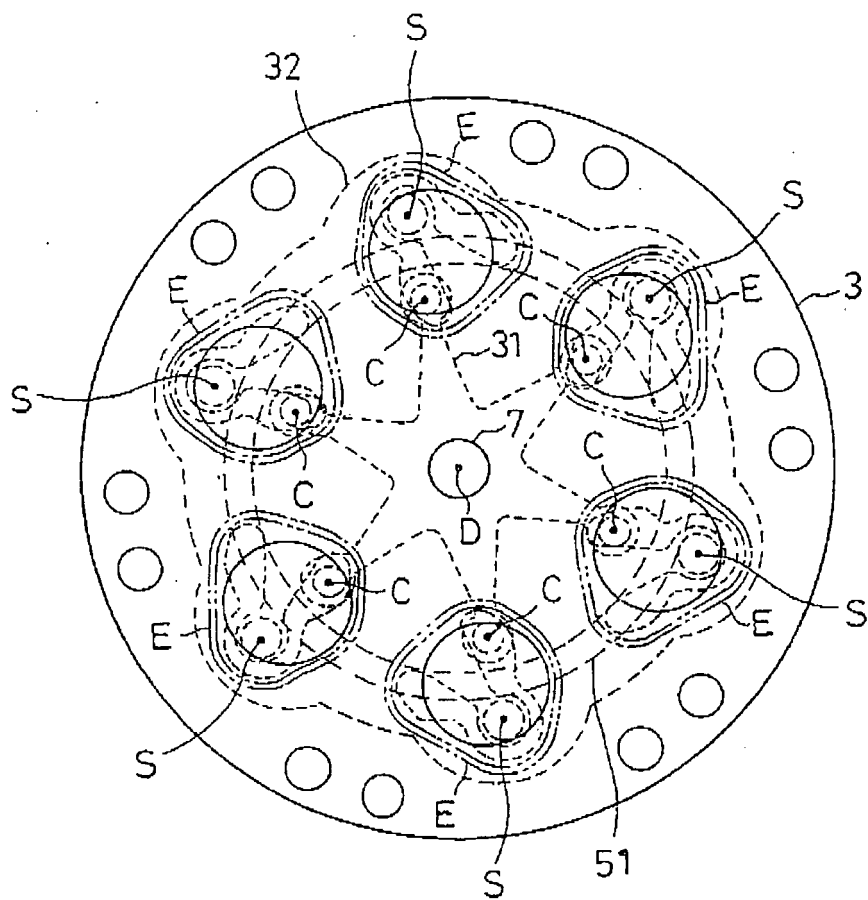


Fig. 1 0

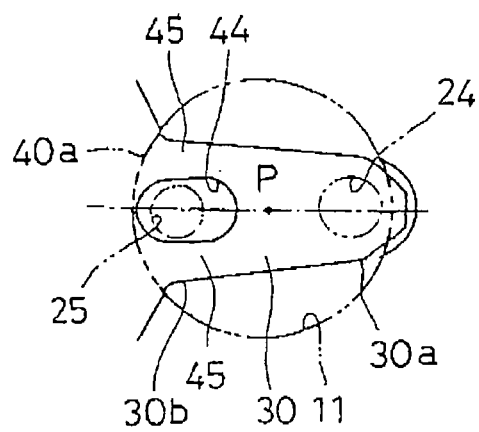
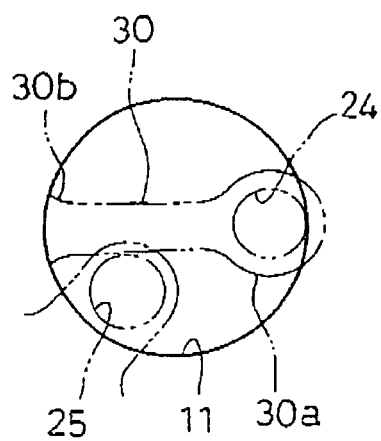


Fig. 1 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/306203

A. CLASSIFICATION OF SUBJECT MATTER F04B39/10 (2006.01)		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) F04B39/10 (2006.01) , F16K15/16 (2006.01)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006 Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 8-277779 A (Sanyo Electric Co., Ltd.), 22 October, 1996 (22.10.96), Par. No. [0014]; Fig. 3 (Family: none)	1-5
X	JP 2001-193648 A (Hitachi, Ltd.), 17 July, 2001 (17.07.01), Fig. 2 (Family: none)	1-5
X Y	JP 2000-54961 A (Toyoda Automatic Loom Works, Ltd.), 22 February, 2000 (22.02.00), Par. No. [0022]; Fig. 5 & EP 962655 A2	6-8 9
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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Date of the actual completion of the international search 15 June, 2006 (15.06.06)		Date of mailing of the international search report 27 June, 2006 (27.06.06)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/306203

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 5-223058 A (Sanyo Electric Co., Ltd.), 31 August, 1993 (31.08.93), Par. Nos. [0013] to [0020]; Figs. 2, 3 (Family: none)	9 6-8
A	JP 2000-291559 A (Matsushita Refrigeration Co.), 17 October, 2000 (17.10.00), Full text; Fig. 2 (Family: none)	1-5
A	JP 62-162780 A (Toyoda Automatic Loom Works, Ltd.), 18 July, 1987 (18.07.87), Full text; Fig. 1 & US 4764091 A	6-9

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REFERENCES CITED IN THE DESCRIPTION

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- WO 3608299 A [0008]