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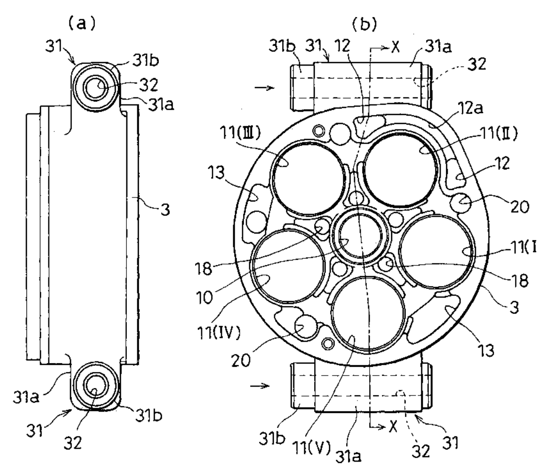
# (54) RECIPROCATING COMPRESSOR

(57) A reciprocating compressor comprising a cylinder block (3) having formed therein a plurality of cylinders (11), a shaft rotatably passing through the cylinder block and pistons engaged in reciprocating movement inside the cylinders (11) as the shaft rotates, which is installed by fastening mounting leg parts (31) disposed at the cylinder block (3) at mounting positions, is **characterized in that** the mounting leg parts are each constituted with a connecting portion (31 a) extending from the cylinder block 3 and a projected portion (31b) formed continuously to the connecting portion to project on one side or both sides of the connecting portion along the tightening direction and that the projected portion (31 b) has a lower level of rigidity compared to the connecting portion (31a). The reciprocating compressor eliminates the need for rigorous management of the piston clearance by assuring firm installation via the mounting leg parts and also assuring smooth movement of the pistons with the extent of cylinder deformation kept within the allowable range.

FIG. 3




EP 1 605 160 A1

## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a reciprocating compressor which is installed by fastening mounting leg parts of the cylinder block at specific positions with mounting bolts or the like.

### BACKGROUND ART

**[0002]** A reciprocating compressor includes a cylinder block having a plurality of cylinders formed therein, a shaft rotatably disposed so as to pass through the cylinder block and pistons engaged in reciprocating movement inside the cylinders as the shaft rotates. It is installed at a specific location such as an engine compartment by fastening and locking mounting leg parts formed at the external circumferential surface of the cylinder block or the like at specific positions with mounting bolts or the like.

**[0003]** While the mounting leg parts formed at the cylinder block or the like may assume any of various structures, it is essential that they be firmly locked at the mounting positions. For this reason, in the structure disclosed in Japanese Unexamined Utility Model Publication No. H2-43478, having mounting leg parts with cylindrical front ends formed at the external circumference of the compressor main unit as an integrated part thereof and bolt insertion holes formed at the cylindrical front ends so as to extend along a direction or perpendicular to the axis of the compressor main unit, the mounting bolts passing through the bolt insertion holes are fastened to mounting brackets locked onto mounting eyes.

**[0004]** Another compressor mounting structure that is widely known in the related art (see Japanese Unexamined Patent Publication No. 2001-182650) is adopted in conjunction with a compressor having a bore housing having a plurality of cylinders formed therein and a side housing having housed therein a piston drive means. Two main mounting portions, each having a mounting hole or a mounting groove at which a main locking bolt means is mounted, are disposed at the external circumferential surface of the side housing and at least one sub-mounting portion having a mounting hole or a mounting groove at which a sub locking bolt means is mounted is disposed at the external circumferential surface of the bore housing so as to allow the compressor to be locked at the main mounting portions while it is held at the sub-mounting portion. This structure allows the compressor to be installed without having to mount the sub-mounting portion with an excessive level of firmness which may cause deformation of the bore housing.

**[0005]** However, the cylinder block of the compressor is often constituted of an aluminum alloy in order to keep down the weight, and there is a problem in that as the mounting leg parts are fastened by tightening mounting bolts as in the structure described above, the tightening pressure occurring while the mounting leg parts are fastened deforms the mounting leg parts and the deformation propagated to the cylinders compromises the shape of the cylinders, which, in turn, prevents smooth movement of the pistons. While the piston clearance may be set to a large value by taking into consideration such cylinder deformation, the quantity of working fluid leaking along the side surfaces of the pistons is bound to increase when the piston clearance is large, which will require more rigorous allowance management. If the management is not rigorous enough, the performance of the compressor will become poorer due to the leakage.

**[0006]** While the problem described above may be solved to some extent by adopting the structure disclosed in the second publication described above, the structure in which the level of the tightening force with which the sub-mounting portion at the cylinder block is fastened is relatively low is not necessarily suited for an application in a compressor installed in a vehicle or the like subjected to a great deal of vibration.

**[0007]** Accordingly, an object of the present invention is to provide a reciprocating compressor that does not require rigorous management of the piston clearance while assuring secure installation via the mounting leg parts and also assuring smooth movement of the pistons by keeping the extent of cylinder deformation occurring during the installation within an allowable range.

### DISCLOSURE OF THE INVENTION

**[0008]** In order to achieve the object described above, a reciprocating compressor according to the present invention comprising a cylinder block having formed therein a plurality of cylinders, a shaft rotatably passing through the cylinder block and pistons engaged in reciprocating movement inside the cylinders as the shaft rotates, which is installed by fastening mounting leg parts disposed at the cylinder block at mounting positions, is characterized in that the mounting leg parts are each constituted with a connecting portion extending from the cylinder block and a projected portion formed continuously to the connecting portion to project on one side or both sides of the connecting portion along the tightening direction and that the projected portion has a lower level of rigidity compared to the connecting portion.

**[0009]** Accordingly, as the mounting leg parts disposed at the cylinder block are fastened onto the mounting positions with mounting bolts or the like to install the compressor at the installation location, the tightening pressure occurring as the mounting bolts are tightened causes deformation of the mounting leg parts, but since the projected portions formed at the mounting leg parts are formed to have a relatively low level of rigidity compared to the connecting portions, the deformation occurring during the tightening process manifests in a concentrated manner at the projected portions. Thus, the deformation of the mounting leg parts occurring during the tightening process can be absorbed at the projected portions, reducing the extent to which the tightening pressure is transmitted to the cylinders via the connecting portions, which makes it possible to ensure that the extent of the cylinder deformation is kept within the allowable range.

**[0010]** Alternatively, a reciprocating compressor according to the present invention comprising a cylinder block having formed therein a plurality of cylinders, a shaft rotatably passing through the cylinder block and pistons engaged in reciprocating movement inside the cylinders as the shaft rotates, which is installed by fastening mounting leg parts disposed at the cylinder block at mounting positions, is characterized in that the mounting leg parts are each constituted with a connecting portion extending from the cylinder block and a projected portion formed continuously to the connecting portion to project on one side or both sides of the connecting portion along the tightening direction and that the sectional area of the projected portions is set smaller than the sectional area of the connecting portions.

**[0011]** In this structure, while the mounting leg parts are caused to become deformed by the tightening pressure occurring as the mounting bolts are tightened when the mounting leg parts disposed at the cylinder block are fastened at the mounting positions with the mounting bolts to lock the compressor at the installation location, the deformation occurring during the tightening process manifests first and foremost at the projected portions since the sectional area of the projected portions formed at the mounting leg parts is set smaller than the sectional area of the connecting portions. Thus, the deformation of the mounting leg parts occurring during the tightening process can be absorbed at the projected portions, reducing the extent to which the tightening pressure is transmitted to the cylinders via the connecting portions, which makes it possible to ensure that the extent of the cylinder deformation is kept within the allowable range.

**[0012]** In either of the structures described above, a bolt insertion hole at which a mounting bolt is inserted may be formed at the center of each projected portion and thinning out the wall thickness of the connecting portion along the direction running perpendicular to the bolt insertion hole is not required. In such a case, sufficient rigidity of the connecting portions can be assured with an even higher level of reliability.

**[0013]** By forming the projected portions so that they assume a cylindrical shape externally, uniform deformation may be induced at the projected portions around the axes thereof during the tightening process (claim 4). As a further alternative, a bolt insertion hole at which a mounting bolt is inserted may be formed at the center of each projected portion with at least one projected portion disposed on one side or both sides of the corresponding connecting portion along the tightening direction having a length along the axial direction set approximately equal to or greater than the internal diameter of the bolt insertion hole, so as to or allow the deformation manifesting as the bolt is tightened to concentrate at the projected portion.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]**

FIG. 1 is a side elevation of an external view of a reciprocating compressor according to the present invention;

FIG. 2 is a sectional view of the reciprocating compressor according to the present invention taken along line X-X in FIG. 3(b);

FIG. 3 shows the rear-side cylinder block in the compressor shown in FIG. 1, with FIG. 3(a) presenting a side elevation and FIG. 3(b) showing an end surface of the cylinder block, viewed from the side where the rear-side cylinder head is located;

FIG. 4 presents an example of another structure that may be adopted in the mounting leg parts;

FIG. 5 shows a cylinder block that does not include crush zones at the mounting leg parts, with FIG. 5 (a) presenting a side elevation and FIG. 5(b) showing an end surface viewed from the cylinder head side; and

FIG. 6 is a graph provided to facilitate the comparison of the extent of cylinder deformation occurring as the mounting leg portions are fastened in the structure shown in FIG. 5 which does not include crush zones at the mounting leg parts and the extent of deformation occurring as the mounting leg portions are fastened in the structure according to the present invention, which does include crush zones.

## BEST MODE FOR CARRYING OUT THE INVENTION

**[0015]** The following is an explanation of embodiments of the present invention, given in reference to the drawings. A reciprocating compressor 1 shown in FIGS. 1 through 3, which is used in a refrigerating cycle with a coolant used as a working fluid, comprises a front-side cylinder block 2, a rear-side cylinder block 3 mounted at the front-side cylinder block 2, a front-side cylinder head 5 mounted at the front side (the left side in FIGS. 1 and 2) of the front-side cylinder block 2 via a valve plate 4 and a rear-side cylinder head 7 mounted at the rear side (the right side in FIGS. 1 and 2) of the rear-side cylinder block 3 via a valve plate 6. The front-side cylinder head 5, the front-side cylinder block 2, the rear-side cylinder block 3, and the rear-side cylinder head7 are fastened together along the axial direction with a tightening bolt (not shown) and constitute the housing for the whole compressor.

**[0016]** At the cylinder blocks 2 and 3 a shaft support hole 10 that rotatably supports a shaft 9 to be detailed later, a plurality of (5) cylinders 11 extending parallel to the shaft support hole 10 and disposed over equal intervals on a circumference of a circle centered on the shaft 9, two discharge passages 12 extending parallel to the cylinders 11 and intake passages 13 through which a low pressure working fluid flows, are formed. The discharge passages 12 communicate with each other via a guide passage 12a, and individually communicating with a discharge chamber 14 formed at the front-side cylinder head 5 to be detailed later and the other discharge passage communicating with a discharge chamber 14 formed at the rear-side cylinder head 7. In addition, one of the discharge passages 12 is connected to a discharge port 16 through which the working fluid is let out to an external cycle via a passing hole 15 formed at the valve plate 6 or the like. The intake passages 13 are connected to a swashplate housing chamber 21 to be detailed below and they are further connected with a low-pressure passage 18 communicating with intake chambers 17 at the cylinder heads 5 and 7 via the swashplate housing chamber 21. A double-ended piston 19 is slidably inserted at each cylinder 11. It is to be noted that reference numeral 20 in FIG. 3 indicates a bolt insertion hole formed between adjacent cylinders 11, at which a tightening bolt is inserted.

**[0017]** The swashplate housing chamber 21 formed by assembling the front-side cylinder block 2 and the rear-side cylinder block 3 is present inside the cylinder blocks, and the shaft 9 inserted at the shaft support hole 10 formed at the front-side cylinder block 2 and the rear-side cylinder block 3 with one end projecting out through the front-side cylinder head 5 and fixed to the armature of an electromagnetic clutch (not shown) is disposed in the swashplate housing chamber 21.

**[0018]** A swashplate 22, which rotates as one with the shaft 9 inside the swashplate housing chamber 21, is fixed to the shaft 9. The swashplate 22 is rotatably supported at the front-side cylinder block 2 and the rear-side cylinder block 3 via thrust bearings 23, with the circumferential edge thereof held at shoe pockets 25 formed at the center of the double ended pistons 19 via semispherical shoes 24 disposed along the front/rear direction. Thus, as the shaft 9 rotates causing the swashplate 22 to rotate, the rotating movement is converted to reciprocal linear motion of the double ended pistons 19 via the shoes 24, and then as the double ended pistons 19 engage in the reciprocal motion, the volumetric capacity of the compression space 26 formed inside each cylinder 11 between the piston 19 and the valve plates 4 and 6 is varied.

**[0019]** An intake hole 27 and a discharge hole 28 are formed at each valve plate 4 and 6, in correspondence to each of the cylinders 11. In addition, the intake chambers 17, in which the working fluid to be supplied to the compression spaces 26 is stored, and the discharge chambers 14 in which the working fluid discharged from the compression spaces 26 is stored, are defined. The intake chambers 17 are allowed to communicate with the compression spaces 26 via the intake holes 27 formed at the valve plates 4 and 6, whereas the discharge chambers 14 formed continuously around the intake chambers 17 are allowed to communicate with the compression spaces 26 via the discharge holes 28 formed at the valve plates 4 and 6.

**[0020]** The intake holes 27 are opened/closed with intake valves 29 disposed at the end surfaces of the valve plates 4 and 6 toward the cylinder blocks, whereas the discharge holes 28 are opened/closed with discharge valves 30 disposed at the end surfaces of the valve plates 4 and 6 toward the cylinder heads.

**[0021]** Thus, during an intake stroke in which the volumetric capacity of the compression space 26 increases as the piston 19 moves reciprocally, the working fluid is taken into the compression spaces 26 from the intake chamber 17 via the intake hole 27 and the intake valve 29, whereas during a compression stroke in which the volumetric capacity of the compression space 26 decreases, the working fluid having been compressed in the compression space 26 is discharged via the discharge hole 28 and the discharge valve 30 to the discharge chamber 14 and is forced to the outside of the compressor from the discharge port 16 via the discharge passage 12.

**[0022]** At the external circumferential surfaces of the cylinder blocks 2 and 3 described above, mounting leg parts 31 used when installing the compressor at a specific mounting location in an engine room or the like are formed at positions symmetrical to each other relative to the axis (upper and lower positions in the figure).

**[0023]** The mounting leg parts 31 each include a connecting portion 31a extending from the cylinder block 2 or 3 along a substantially radial direction and a projected portion 31b formed continuous to the connecting portion 31a so as to project on one side of the connecting portion along the tightening direction running perpendicular to the shaft 9. At the center of the projected portion 31b, a bolt insertion hole 32 at which a mounting bolt (not shown) to interlock with a mounting hole formed at the mounting area is inserted, is formed to range over to the connecting portion 31a. In addition, the wall thickness of the connecting portion 31a at the mounting leg part 31 is not thinned out from the direction running perpendicular to the bolt insertion hole 32.

**[0024]** The mounting leg parts 31 are formed as an integrated part of the cylinder blocks 2 and 3 by using an aluminum alloy, with the projected portions 31 b formed to have a lower level of rigidity compared to the connecting portions 31a to form more deformable crush zones. More specifically, the rigidity at each projected portion 31b is set lower than the rigidity at the corresponding connecting portion by setting the area of a section of the projected portion 31b perpendicular to the axial line of the bolt insertion hole 32 smaller than the area of a section of the connecting portion 31a. In this example, the sectional area of the projected portion is reduced by forming the bolt insertion hole 32 to have a uniform internal diameter over the full range and setting the external diameter of the projected portion 31 b to a relatively small value so as to form a stage at the surface over which the connecting portion 31a turns into the projected portion 31 b.

**[0025]** In addition, the projected portion 31b in the structure described above is formed in a cylindrical shape with a uniform thickness, with the length of the projected portion 31b along the axial direction set approximately equal to or greater than the internal diameter of the bolt insertion hole 32.

**[0026]** In the structure described above, as a mounting bolt is inserted at the bolt insertion hole 32 from the side on which the projected portion 31b is formed (from the direction indicated with the arrow in FIG. 3(b)) and the corresponding mounting leg part 31 is fastened by interlocking the mounting bolt at a screw hole formed at a specific mounting position, the mounting leg part 31 becomes deformed due to the tightening pressure. However, since the level of rigidity of the projected portion 31b formed at the mounting leg part 31 is set lower than the rigidity of the connecting portion 31 a and the wall of the connecting portion 31a is not thinned out, the deformation occurring during the tightening process manifests at the projected portion 31b in a concentrated manner. Thus, the deformation of the mounting leg part 31 occurring during the tightening process can be absorbed at the projected portion 31b, which disallows ready transmission of the tightening pressure to the cylinder 11 via the connecting portion 31a. Consequently, the extent of deformation of the cylinder 11 is kept within the allowable range and the circularity of the cylinder can be maintained at a high degree of accuracy, assuring smooth movement of the piston 19. In addition, since the extent of deformation of the cylinder 11 is reduced, a large piston clearance for assuring a comfortable margin for the deformation of the cylinder 11 is not necessary. Moreover, rigorous allowance management for purposes of managing the working fluid leaking past the side surface of the piston 19 is not required.

**[0027]** Furthermore, since the projected portion 31b of the mounting leg part 31 is formed in a cylindrical shape, the projected portion 31b becomes deformed with uniformity around the axis during the tightening process. Thus, with the projected portion 31b allowed to become deformed evenly, the extent to which the cylinder 11 becomes deformed can be reduced. In addition, since the length of the projected portion 31b along the axial direction is set approximately equal to or greater than the diameter of the bolt insertion hole 32, the deformation occurring as the mounting bolt is tightened can be concentrated at the projected portion 31b with an even higher degree of reliability, which also makes it possible to reduce the extent of deformation of the cylinder 11.

**[0028]** While the projected portion 31b is formed only on one side of the connecting portion along the tightening direction in the example described above, the projected portion 31b may be disposed on each side along the tightening direction, as shown in FIG. 4(a). Namely, the mounting leg portion 31 may include projected portions 31b projecting on the two sides along the tightening direction at the connecting portion 31 a extending from the cylinder block 2 or 3 substantially along the radial direction with the bolt insertion hole 32 formed to have a uniform diameter ranging from one of the projected portions 31b through the other projected portion 31b and the sectional area of the projected portions set smaller by setting the external diameter of the projected portions 31 b smaller than the diameter of the connecting portion 31 a so as to form a crush zone with lower rigidity at each end of the bolt insertion hole 32.

**[0029]** In addition to advantages similar to the previous structural example, this structure, which allows the deformation occurring during the tightening process to be dispersed onto the two sides of the connecting portion 31a, makes it possible to reduce the extent to which the tightening force is communicated to the cylinder 11 via the connecting portion 31a with an even higher degree of reliability.

**[0030]** While the rigidity at the projected portions 31 b is set smaller relative to the rigidity at the connecting portions by setting the external diameter of the projected portions 31b to a smaller value in the structures described above, the rigidity of the projected portions may be set smaller by adopting structures other than those explained above.

**[0031]** For instance, in a structure having a projected portion 31c formed on each side along the tightening direction at each mounting leg part 31, the projected portions 31c may be formed so that their exteriors range uniformly to the external contour of the connecting portions 31a without creating stages between the projected portions and the connecting portion 31 a, and the internal diameter of the bolt insertion hole 32 may be set larger than the areas where the projected portions 31c are present relative to the internal diameter in the area over which the connecting portion 31a is present. In this case, with the sectional area of the projected portions 31c set smaller than the sectional area of the connecting portion 31 a, a crush zone with lower rigidity is formed at each end of the bolt insertion hole 32. It is to be noted that since other structural features such as the projected portions 31c each formed in a cylindrical shape with a uniform thickness and the length of the projected portions 31b[1] along the axial direction set substantially equal to or greater than the internal diameter of the bolt insertion hole 32 are identical to those of the previous structural examples, their explanation is omitted.

**[0032]** This structure, too, makes it possible to concentrate the deformation occurring during the tightening process at the projected portions 31c, which, in turn, reduces the extent to which the mounting bolt tightening force is transmitted to the cylinder 11 via the connecting portion 31a, thereby achieving advantages similar to

[1] check number

those of the previous structural examples.

**[0033]** Alternatively, crush zones with lower rigidity than the connecting portion may be formed by using a different material to constitute the projected portions, as shown in FIG. 4(c). Namely, in a structure having a projected portion on each side along the tightening direction at the connecting portion 31a of the mounting leg part 31, which extends from the cylinder block 2 or 3 substantially along the radial direction, the connecting portion 31a may be constituted of an aluminum alloy, as are the cylinder blocks 2 and 3, the projected portions 31d may be formed by using a synthetic resin with a lower level of rigidity compared to the aluminum alloy, and the connecting portion and the projected portions may be coupled by an appropriate means such as press fitting or bonding so as to form low-rigidity crush zones at the two ends of the bolt insertion hole 32. It is to be noted that since other structural features such as the projected portions 31d each formed in a cylindrical shape with a uniform thickness and the length of the projected portions 31d along the axial direction set substantially equal to or greater than the internal diameter of the bolt insertion hole 32 are identical to those of the previous structural examples, their explanation is omitted.

**[0034]** This structure, too, makes it possible to concentrate the deformation occurring during the tightening process at the projected portions 31d constituted of a synthetic resin, which, in turn, reduces the extent to which the mounting bolt tightening force is transmitted to the cylinder 11 via the connecting portion 31a, thereby achieving advantages similar to those of the previous structural examples. In addition, in this structure, the projected portions 31d may be formed with their exteriors ranging uniformly and continuously to the external contour of the connecting portion 31a without creating stages between the projected portions 31d and the connecting portion 31a with the bolt insertion hole 32 formed to have a uniform internal diameter ranging from one of the projected portions 31d through the other projected portion 31d, and since the connecting portion 31a and the projected portions 31d can be machined separately, the mounting leg part 31 can be formed with greater ease.

**[0035]** A comparison of the extent of deformation occurring at cylinders 11 when the mounting leg parts 31 are fastened with mounting bolts by using the cylinder blocks 2 and 3 having the projected portions 31b, 31c or 31d forming crush zones at the mounting leg parts 31 as described above and by using a cylinder block 36 shown in FIG. 5 with no projected portions to form crush zones included at the mounting leg parts 31 and the wall thickness reduced over an area 35 from the direction running perpendicular to the bolt insertion holes 32 provided the results presented in FIG. 6. The bore numbers in FIG. 6 were assigned to identify the individual cylinders, with "No. V" assigned to the cylinder 11 located closest to the bottom where the mounting leg parts 31 are present in FIGS. 3 and 5, and "No. IV", "No. III", "No. II" and "No. I" sequentially assigned to the remaining cylinders 11 by moving clockwise from the cylinder No. V. The extents of deformation occurring as the mounting bolts inserted at the bolt insertion holes 32 from the left side in FIGS. 3 and 5 were tightened were compared.

**[0036]** As the results of the comparison clearly indicate, the extent of deformation of the cylinders 11 that occurred as the mounting bolts were tightened in either of the structures, was lessened when crush zones were formed at the mounting leg parts 31, compared to the extent of deformation at the cylinders 11 in the structure that did not include any crush zones. The greatest difference in the extent of deformation manifested at the cylinders (V) closest to the mounting leg parts 31.

**[0037]** It is to be noted that while the rigidity of the projected portions is lessened relative to the rigidity of the connecting portions by setting the sectional area of the projected portions smaller than the sectional area of the connecting portions or by forming the projected portions with a material different from the material used to form the connecting portions in the structural examples described above, the features of the structural examples described above may be adopted in combination as appropriate. In addition, as an alternative to or as an additional feature to the structural examples described above, different levels of rigidity may be achieved chemically through a heat treatment or the like.

## INDUSTRIAL APPLICABILITY

**[0038]** As described above, the reciprocating compressor according to the present invention comprising a cylinder block having a plurality of cylinders formed therein, a shaft rotatably passing through the cylinder block and pistons engaged in reciprocal motion in the cylinders as the shaft rotates, which is installed by fastening mounting leg parts disposed at the cylinder block at mounting positions, is characterized in that the mounting leg parts each include a connecting portion extending from the cylinder block and a projected portion formed continuous to the connecting portion and projecting on one side or both sides of the connecting portion along the tightening direction. Since the projected portions are formed so as to have a lower level of rigidity compared to the connecting portions, the deformation occurring as the mounting bolts are tightened can be concentrated at the projected portions, which makes it possible to assure smooth movement of the pistons by keeping down the extent of cylinder deformation within the allowable range while assuring firm installation of the compressor via the mounting leg parts. As a result, rigorous management of the piston clearance is no longer required and a greater tolerance can be assumed for the piston clearance.

## Claims

**1.** A reciprocating compressor comprising:

a cylinder block (3) having formed therein a plurality of cylinders (11), a shaft (9) rotatably passing through said cylinder block (3) and pistons (19) engaged in reciprocating movement inside said cylinders (11) as said shaft (9) rotates, which is installed by fastening mounting leg parts (31) disposed at said cylinder block (3) at mounting positions (19),

**characterized in:**

**that** said mounting leg parts (31) are each constituted with a connecting portion extending from said cylinder block (3) and a projected portion (31b) formed continuously to said connecting portion (31a) to project on one side or both sides of said connecting portion (31a) along the tightening direction; and
**that** said projected portion (31b) has a lower level of rigidity compared to said connecting portion (31a).

**2.** A reciprocating compressor comprising:

a cylinder block (3) having formed therein a plurality of cylinders (11), a shaft (9) rotatably passing through said cylinder block (3) and pistons (19) engaged in reciprocating movement inside said cylinders (11) as said shaft (9) rotates, which is installed by fastening mounting leg parts (31) disposed at said cylinder block (3) at mounting positions (19),

**characterized in:**

**that** said mounting leg parts (31) are each constituted with a connecting portion extending from said cylinder block (3) and a projected portion (31 b) formed continuously to said connecting portion (31a) to project on one side or both sides of said connecting portion (31a) along the tightening direction; and
**that** the sectional area of said projected portions (31b) is set smaller than the sectional area of said connecting portion (31a).

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

**that** a bolt insertion hole (32) at which a mounting bolt is inserted is formed at the center of each projected portion (31b) and the wall thickness of said connecting portion (31a) is not thinned out along a direction running perpendicular to said bolt insertion hole (32).

**4.** A reciprocating compressor according to any of claims 1 through 3,
**characterized in:**

**that** the external shape of said projected portion (31 b) is cylindrical.

**5.** A reciprocating compressor according to any of claims 1 through 4,
**characterized in:**

**that** a bolt insertion hole (32) at which a mounting bolt is inserted is formed at the center of each projected portion (31b), with at least one projected portion (31b) disposed on one side or both sides of said connecting portion (31 a) having a length along the axial direction set approximately equal to or greater than the internal diameter of said bolt insertion hole (32).

FIG. 1

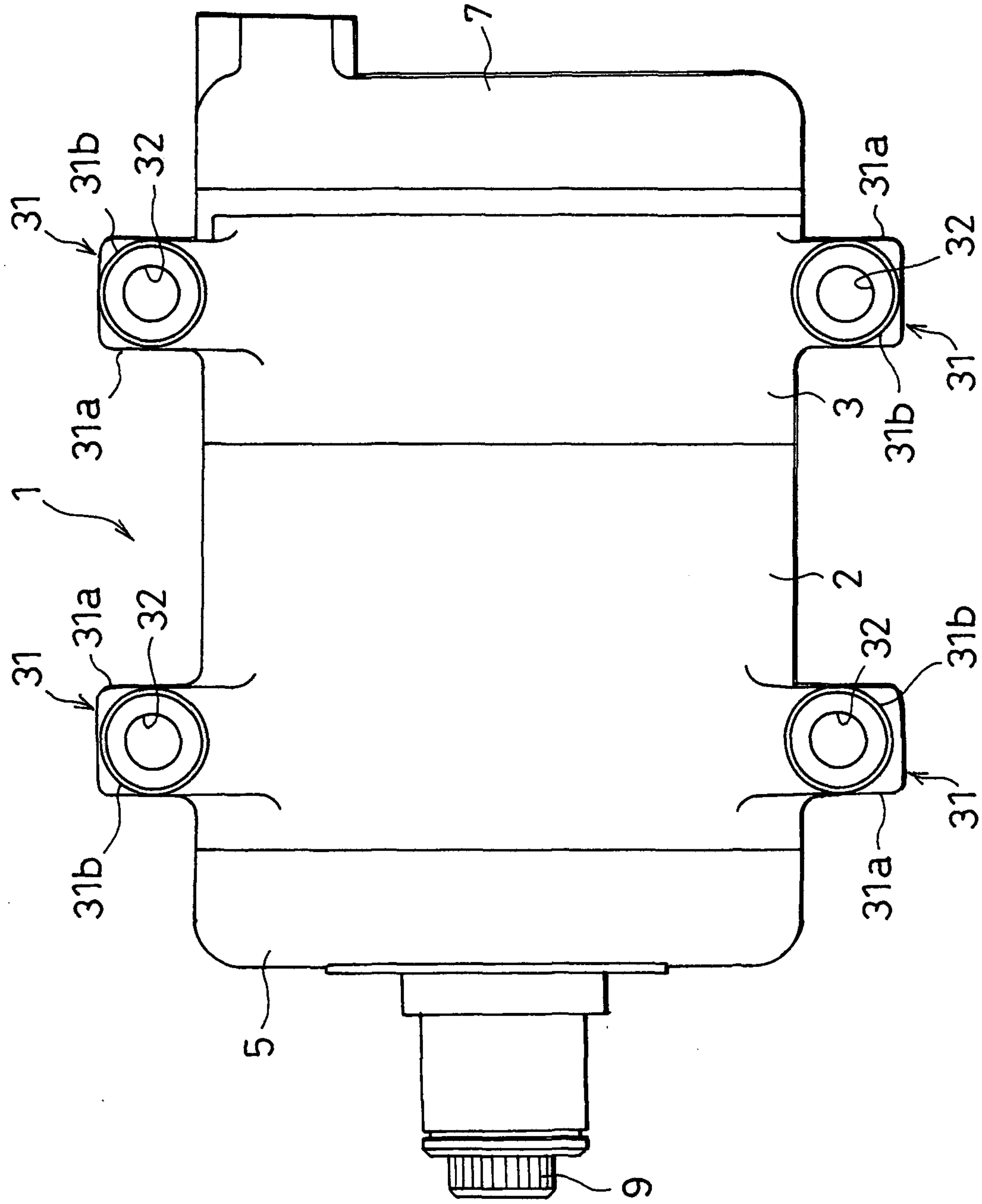


FIG. 2

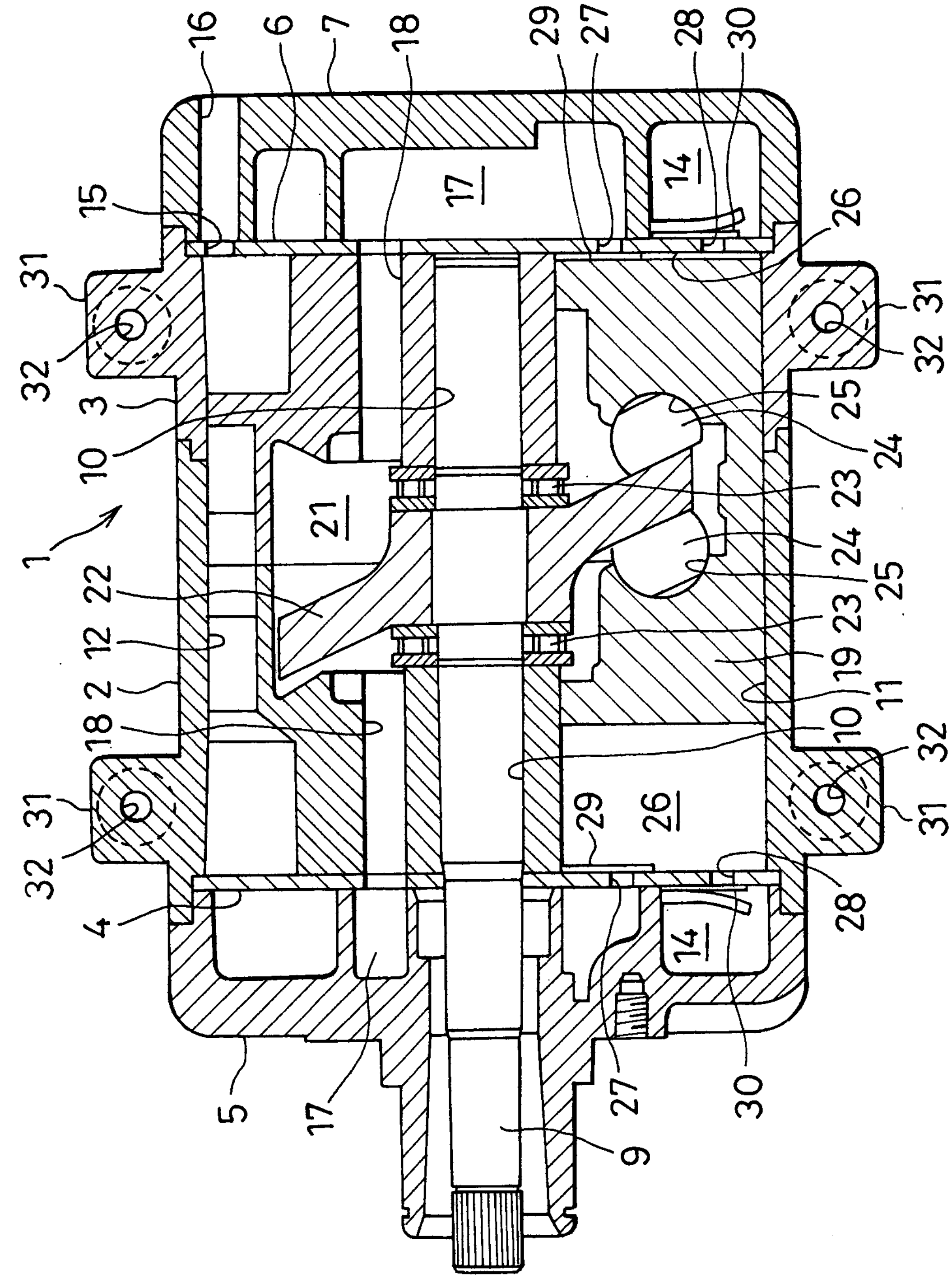


FIG. 3

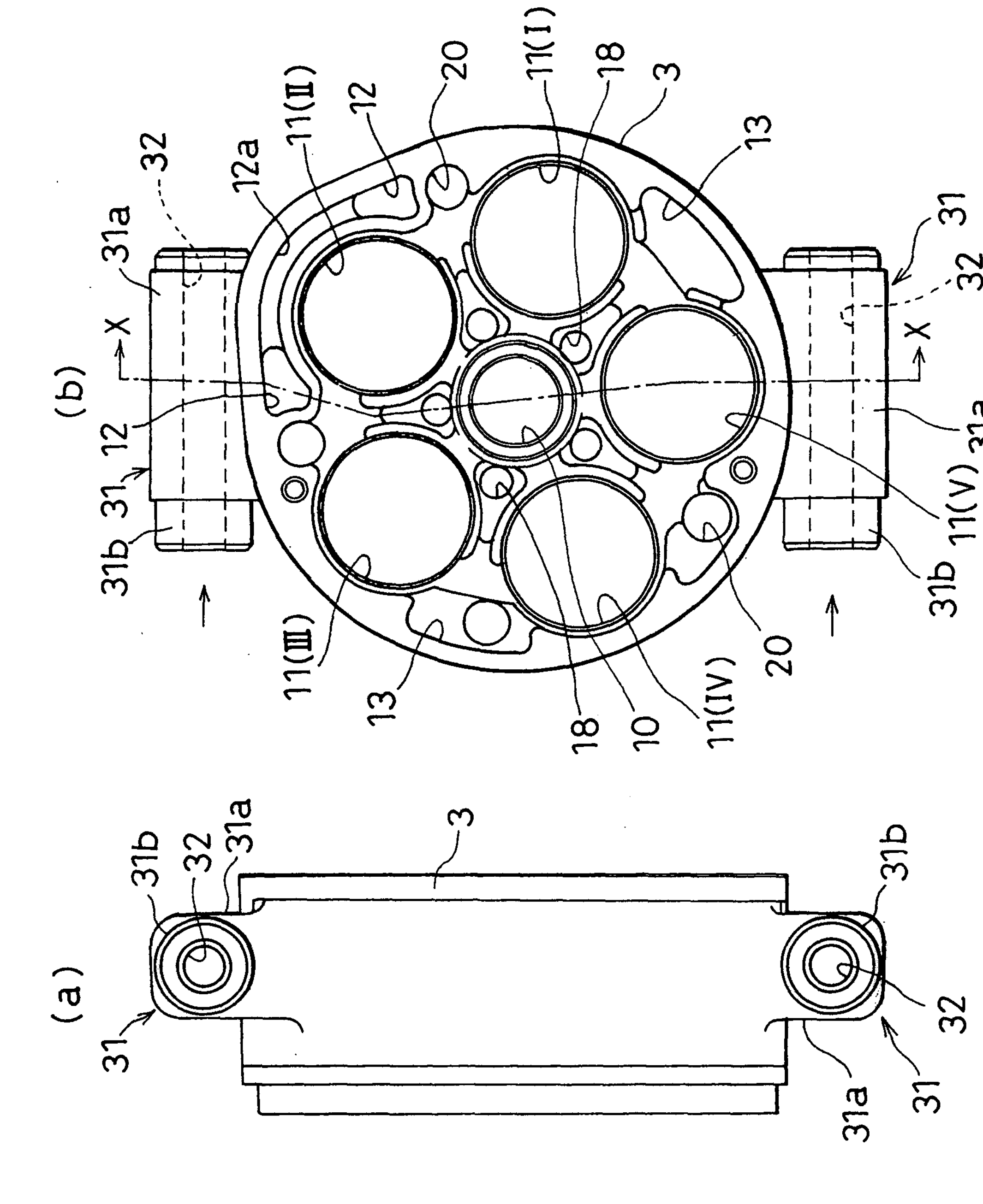
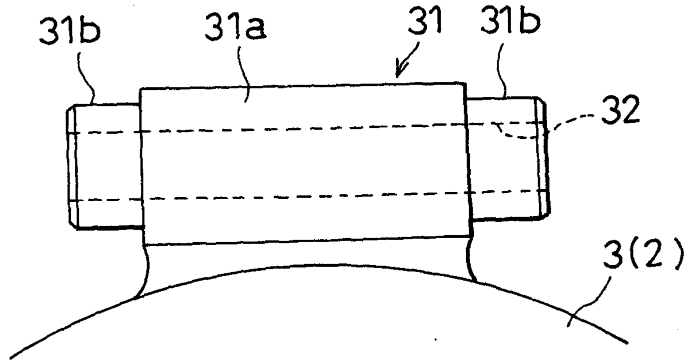


FIG. 4

(a)

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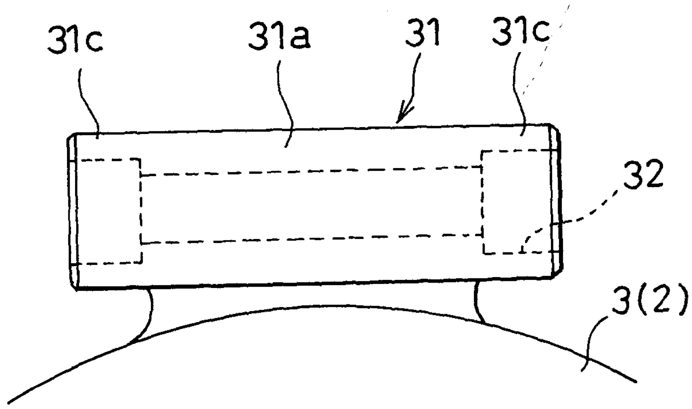


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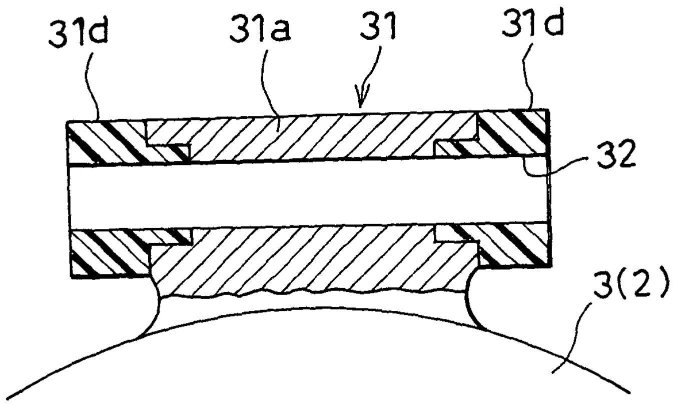


FIG. 5

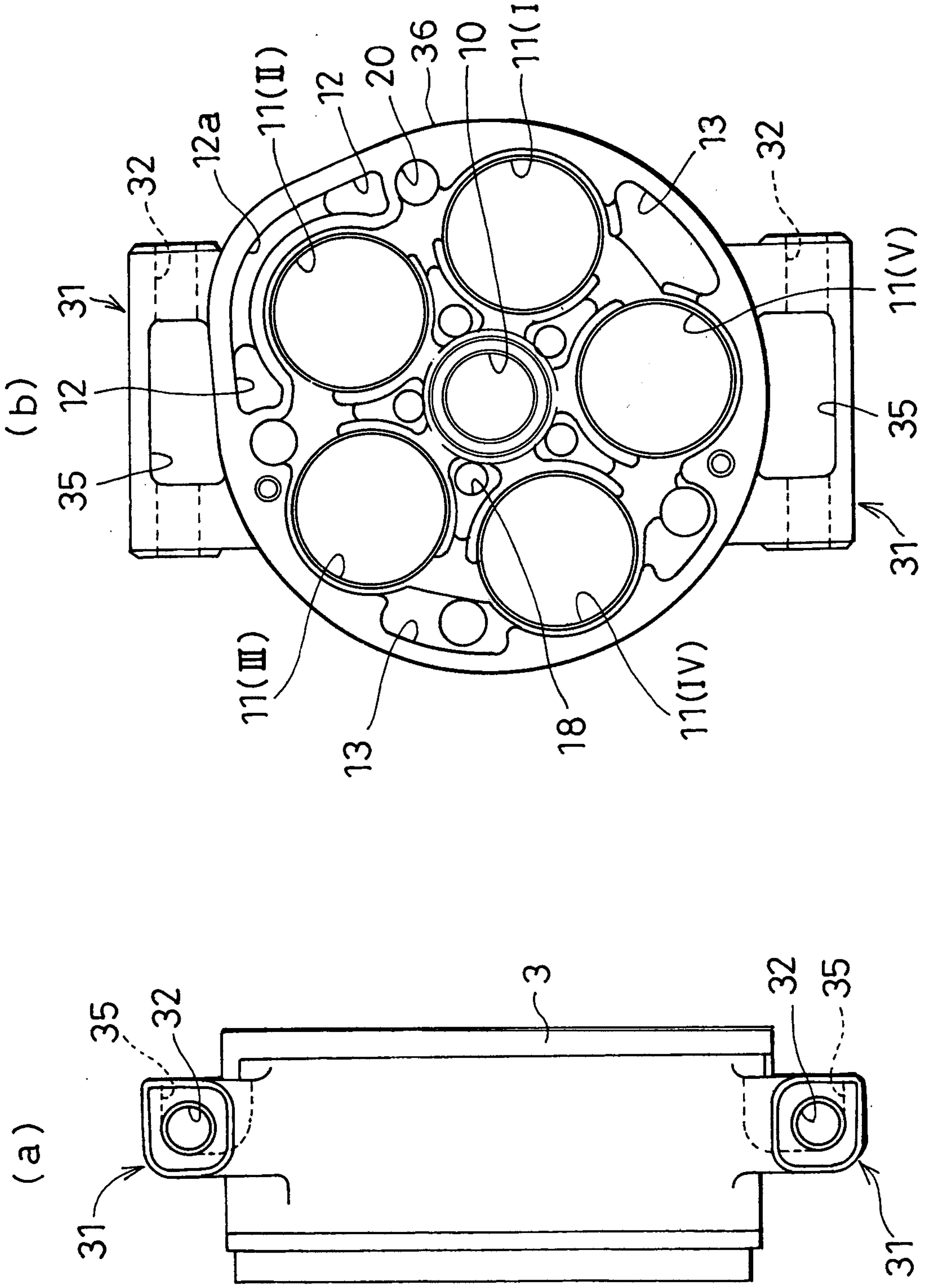
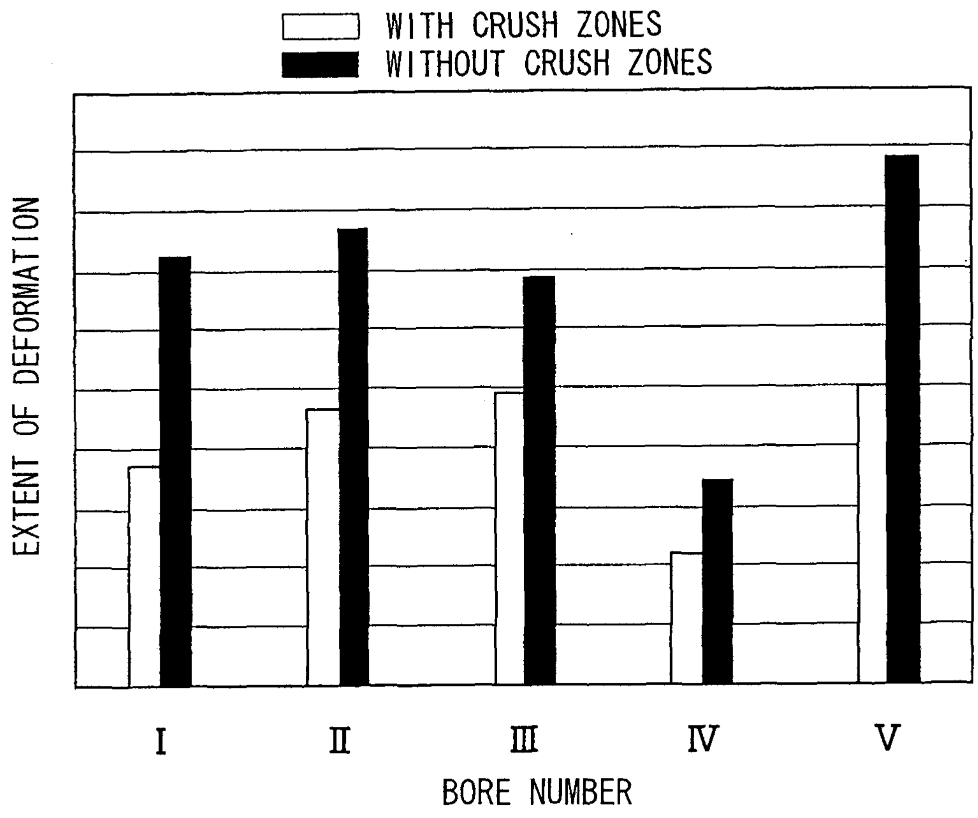


FIG. 6


WITH CRUSH ZONES
WITHOUT CRUSH ZONES
EXTENT OF DEFORMATION
I
II
III
IV
V
BORE NUMBER

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/14564

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl$^7$ F04B27/08

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)
Int.Cl$^7$ F04B27/08

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 | 1996-2004 |
| Kokai Jitsuyo Shinan Koho | 1971-2004 | Toroku Jitsuyo Shinan Koho | 1994-2004 |

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. |
|---|---|---|
| Y | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 104896/1988(Laid-open No. 43478/1990) (Atsugi Unisia Corp.), 26 March, 1990 (26.03.90), (Family: none) | 1-5 |
| Y | JP 2001-182650 A (Toyoda Automatic Loom Works, Ltd.), 06 July, 2001 (06.07.01), (Family: none) | 1-5 |
| Y | JP 7-158563 A (Toyoda Automatic Loom Works, Ltd.), 20 June, 1995 (20.06.95), Column 3 (Family: none) | 1-5 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| | |
|---|---|
| Date of the actual completion of the international search<br>17 February, 2004 (17.02.04) | Date of mailing of the international search report<br>02 March, 2004 (02.03.04) |
| Name and mailing address of the ISA/<br>Japanese Patent Office | Authorized officer |
| Facsimile No. | Telephone No. |

Form PCT/ISA/210 (second sheet) (July 1998)