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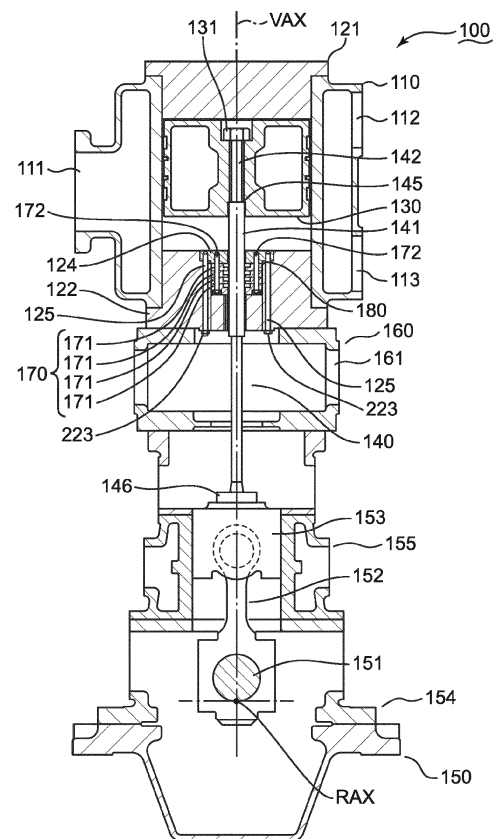
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(54) **RECIPROCATING COMPRESSOR**

(57) A reciprocating compressor with an easily replaceable rod packing is provided. This application discloses a reciprocating compressor including a piston rod coupled to a piston that is accommodated within a cylinder and a crank mechanism, and an annular rod packing having an inner peripheral edge in sliding contact with the outer peripheral surface of the piston rod to prevent gas within the cylinder from leaking around the outer peripheral surface of the piston rod. The piston rod includes a first rod portion with which the rod packing is in sliding contact and a second rod portion provided in a manner extending from the leading end of the first rod portion and inserted through an insertion hole that is formed in the piston. The piston is separable from the second rod portion. The diameter of the second rod portion is equal to or smaller than that of the first rod portion.

FIG. 1



Description

BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] The present invention relates to a reciprocating compressor for gas compression.

(DESCRIPTION OF THE RELATED ART)

[0002] In a reciprocating compressor (hereinafter referred to as "compressor"), a piston reciprocates within a cylinder to compress gas within the cylinder. A piston rod arranged to transmit a torque of a crankshaft to the piston as a force for reciprocation of the piston penetrates through a cylinder head that closes an opening portion formed at the lower end of the cylinder. Generally, an annular rod packing prevents gas leakage through the boundary space between the piston rod and the cylinder head (see JP 2016-153637 A).

SUMMARY OF THE INVENTION

[0003] The rod packing is one of components most likely to be worn in the compressor. In accordance with JP 2016-153637 A, an operator who replaces the rod packing separates a cylindrical adapter fixed to a head case in which a crosshead is accommodated and then uncouples a base end portion of the piston rod from the crosshead. Thereafter, the operator disassembles the upper structure separated from the crosshead and the head case to replace the worn rod packing with a new rod packing. That is, with the conventional compressor structure, the operator has to disassemble various components of the compressor to replace the rod packing. This means that it takes a long period of time to replace the rod packing.

[0004] In a compressor according to another related art, the rod packing may be fixed upward within the compressor. In this case, an operator who replaces the rod packing has to enter the compressor through a maintenance window provided on the exterior surface of the compressor to perform an operation of dismounting the rod packing. Upon this, it is necessary for the operator to dismount the rod packing while receiving the heavy weight of the rod packing, which makes difficult the operation of dismounting the rod packing.

[0005] It is hence an object of the present invention to provide a reciprocating compressor with an easily replaceable rod packing.

[0006] A reciprocating compressor according to an aspect of the present invention includes a piston rod coupled to a piston that is accommodated within a cylinder and a crank mechanism, and an annular rod packing having an inner peripheral edge in sliding contact with the outer peripheral surface of the piston rod to prevent gas within the cylinder from leaking through a gap around the

outer peripheral surface of the piston rod. The piston rod includes a first rod portion with which the rod packing is in sliding contact and a second rod portion provided in a manner extending from the leading end of the first rod portion and inserted through an insertion hole that is formed in the piston. The piston is separable from the second rod portion. The diameter of the second rod portion is equal to or smaller than the diameter of the first rod portion.

[0007] In accordance with the arrangement above, since the piston is separable from the second rod portion that is inserted through the insertion hole of the piston and the diameter of the second rod portion is equal to or smaller than the diameter of the first rod portion, the operator can remove the piston from the second rod portion and then draw out the rod packing from the first rod portion toward the second rod portion. Unlike the structure of a conventional reciprocating compressor that requires disassembling of the crank mechanism and the piston rod, the operator can replace the worn rod packing with a new rod packing while the piston rod and the crank mechanism are still coupled. The above-described reciprocating compressor therefore requires only a smaller number of components to be disassembled than the conventional reciprocating compressor. As a result, the operator can replace the rod packing in a short period of time. In addition, since the operator can remove the piston from the second rod portion and then draw out the worn rod packing toward the second rod portion, there is no need to receive the heavy rod packing. The rod packing can thus be separated easily from the piston rod.

[0008] As for the arrangement above, the reciprocating compressor may further include a nut threadably mounted on a male screw portion that is formed in a leading end portion of the second rod portion protruding from the piston to fix the piston to the second rod portion. The leading end of the first rod portion may include an annular stepped surface defined by the diameter difference between the first rod portion and the second rod portion, which is thinner than the first rod portion. The piston may be held between the stepped surface and the nut in the direction in which the piston rod is provided in an extending manner.

[0009] In accordance with the arrangement above, since the second rod portion is thinner than the first rod portion, the stepped surface is defined at the leading end of the first rod portion by the diameter difference between the first rod portion and the second rod portion. Since the stepped surface is defined in a manner holding the piston in cooperation with the nut in the direction in which the piston rod is provided in an extending manner, the piston, when the operator inserts the second rod portion there-through, is hung and supported on the stepped surface. When the operator then threadably mounts the nut on the male screw portion of the second rod portion, the piston is held between the nut and the stepped surface in the direction in which the piston rod is provided in an extending manner to be fixed stably to the piston rod.

[0010] When the operator loosens the nut, the piston can be separated from the piston rod. Since the second rod portion is thinner than the first rod portion, the rod packing in sliding contact with the first rod portion can then be drawn out toward the second rod portion. During this, since the piston rod and the crank mechanism can still be coupled, the above-described reciprocating compressor requires only a smaller number of components to be disassembled than the conventional reciprocating compressor. As a result, the operator can replace the rod packing easily in a short period of time.

[0011] As for the arrangement above, the reciprocating compressor may further include a nut threadably mounted on a male screw portion that is formed in a leading end portion of the second rod portion to fix the piston to the second rod portion, and a ring member mounted on the piston rod in a manner holding the piston in cooperation with the nut in the direction in which the piston rod is provided in an extending manner. The ring member may have a diameter greater than that of the first rod portion and is dismountable from the piston rod.

[0012] In accordance with the arrangement above, since the ring member has a diameter greater than that of the first rod portion, the piston, when the operator inserts the second rod portion through the insertion hole thereof, is hung on the ring member and positioned in the direction in which the piston rod is provided in an extending manner. When the operator then threadably mounts the nut on the male screw portion that is formed in the leading end portion of the second rod portion protruding from the piston, the piston is held between the nut and the ring member in the direction in which the piston rod is provided in an extending manner to be fixed stably to the piston rod.

[0013] When the operator loosens the nut, the piston can be separated from the piston rod. The operator can then dismount the ring member from the piston rod. Since the diameter of the second rod portion is equal to or smaller than the diameter of the first rod portion, the rod packing can then be drawn out toward the second rod portion. During this, since the piston rod and the crank mechanism can still be coupled, the above-described reciprocating compressor requires only a smaller number of components to be disassembled than the conventional reciprocating compressor. As a result, the operator can replace the rod packing easily in a short period of time.

[0014] As for the arrangement above, the reciprocating compressor may further include a cylinder head penetrated through by the piston rod while closing an opening portion formed at the lower end of the cylinder and formed with an accommodation chamber in which the rod packing is accommodated, and a flange arranged on the cylinder head in a manner penetrated through by the piston rod while closing the accommodation chamber. The flange may be separable upward from the cylinder head with being coupled to the rod packing within the accommodation chamber and penetrated through by the piston rod.

[0015] In accordance with the arrangement above, since the cylinder head closes the opening portion that is formed at the lower end of the cylinder, gas within the cylinder is confined within the cylinder not to leak through the opening portion that is formed at the lower end of the cylinder. The rod packing is accommodated in the accommodation chamber of the cylinder head to prevent gas leakage through a gap between the cylinder head and the piston rod. The flange, which is arranged on the cylinder head in a manner closing the accommodation chamber, is in proximity to the rod packing within the accommodation chamber. Since the flange is coupled to the rod packing, the operator who replaces the rod packing can integrally handle the flange and the rod packing. Since the flange is separable upward from the cylinder head with being penetrated through by the piston rod, the operator can integrally draw up and out the flange and the rod packing from the second rod portion after the piston is removed therefrom. That is, the operator can separate the flange and the rod packing from the piston rod without supporting the flange and the rod packing. During this, since the piston rod and the crank mechanism can still be coupled, the above-described reciprocating compressor requires only a smaller number of components to be disassembled than the conventional reciprocating compressor. As a result, the operator can replace the rod packing easily in a short period of time.

[0016] As for the arrangement above, the reciprocating compressor may further include a cylindrical member surrounding the piston rod below the cylinder and mounted in the cylinder head, and a fastener for fastening the flange to the cylinder head. The fastener may include a head portion arranged to receive an operation for releasing the fastening between the flange and the cylinder head. The head portion may be exposed to the internal space of the cylindrical member and accessible through an opening window formed in the cylindrical member.

[0017] In accordance with the arrangement above, the operator can fasten the flange to the cylinder head using the fastener. Since the head portion of the fastener surrounds the piston rod below the cylinder and is exposed to the internal space of the cylindrical member that is mounted in the cylinder head, the operator can access the head portion of the fastener through the opening window that is formed in the cylindrical member to perform an operation of releasing the fastening between the flange and the cylinder head. As above, the operator can then separate the flange and the rod packing upward from the cylinder head with the piston rod penetrating therethrough. That is, the operator can separate the flange and the rod packing from the piston rod without supporting the flange and the rod packing. During this, since the piston rod and the crank mechanism can still be coupled, the above-described reciprocating compressor requires only a smaller number of components to be disassembled than the conventional reciprocating compressor. As a result, the operator can replace the rod packing easily in a short period of time.

[0018] As for the arrangement above, the reciprocating compressor may further include an annular gasket arranged to prevent the gas from leaking through the boundary between the cylinder head and the flange. The gasket may be mounted on the flange.

[0019] In accordance with the arrangement above, since the annular gasket is arranged to prevent the gas from leaking through the boundary between the cylinder head and the flange, the gas can be confined within the cylinder not to leak through the boundary between the cylinder head and the flange. Since the piston reciprocates within the cylinder, the gas confined within the cylinder is compressed by the piston.

[0020] Since the gasket is mounted on the flange, when the flange is separated upward from the cylinder head with the piston rod penetrating therethrough, the gasket can be separated upward from the cylinder integrally with the flange. No dedicated operation is needed for taking the gasket out of the reciprocating compressor, whereby the operator can replace the gasket and the rod packing easily in a short period of time.

[0021] The above-described reciprocating compressor can have a structure in which the rod packing can be replaced easily.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

FIG. 1 is a schematic cross-sectional view of a reciprocating compressor according to a first embodiment.

FIG. 2 is a schematic front view of a piston rod of the reciprocating compressor shown in FIG. 1.

FIG. 3A is a schematic cross-sectional view of a flange of the reciprocating compressor shown in FIG. 1.

FIG. 3B is a schematic bottom view of the flange shown in FIG. 3A.

FIG. 4 is a schematic front view of an alternative piston rod (second embodiment).

FIG. 5 is a schematic cross-sectional view of a compressor according to a third embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

<First Embodiment>

[0023] FIG. 1 is a schematic cross-sectional view of a reciprocating compressor (hereinafter referred to as "compressor 100") according to a first embodiment. The compressor 100 will be described with reference to FIG. 1.

[0024] The compressor 100 includes a cylinder 110 having an approximately cylindrical shape. The cylinder 110 is an approximately cylindrical component. The vertical axis VAX shown in FIG. 1 is drawn to approximately coincide with the center axis of the cylinder 110. The

vertical axis VAX is orthogonal to opening portions formed at the upper end and the lower end of the cylinder 110.

[0025] The peripheral wall of the cylinder 110 is formed with an intake port 111 through which gas flows and two discharge ports 112, 113 through which gas compressed within the cylinder 110 is discharged. The intake port 111 and the discharge ports 112, 113 are in communication with the internal space surrounded by the cylinder 110 through flow paths formed in the peripheral wall of the cylinder 110.

[0026] The compressor 100 includes two cylinder heads 121, 122. The cylinder head 121 closes an opening portion formed at the upper end of the cylinder 110. The cylinder head 122 closes an opening portion formed at the lower end of the cylinder 110. The cylinder 110 and the cylinder heads 121, 122 define the internal space in which gas is compressed. Gas is taken into the internal space surrounded by the cylinder 110 and the cylinder heads 121, 122 through the intake port 111 to undergo compression processing in the internal space. The compressed gas is then discharged through the discharge ports 112, 113.

[0027] The compressor 100 includes a piston 130, a piston rod 140, a crank mechanism 150, and a flange 146. The crank mechanism 150 is arranged to generate a drive force for reciprocation of the piston 130 arranged within the cylinder 110 along the vertical axis VAX. The drive force generated by the crank mechanism 150 is transmitted to the piston 130 by the piston rod 140, which is coupled to the crank mechanism 150 and the piston 130. This allows the piston 130 to reciprocate within the cylinder 110 along the vertical axis VAX. The flange 146 is used to couple the piston rod 140 to the crank mechanism 150.

[0028] The piston 130 is an approximately columnar member having a center axis approximately coinciding with the vertical axis VAX. The internal space surrounded by the cylinder 110 and the cylinder heads 121, 122 is divided by the piston 130 into two compression chambers. One of the two compression chambers is a space surrounded by the upper surface of the piston 130, the lower surface of the upper cylinder head 121, and the inner peripheral surface of the cylinder 110. The piston 130 shown in FIG. 1 is at the top dead center, so that the space surrounded by the upper surface of the piston 130, the lower surface of the upper cylinder head 121, and the inner peripheral surface of the cylinder 110 is minimized. The other of the two compression chambers is a space surrounded by the lower surface of the piston 130, the upper surface of the lower cylinder head 122, and the inner peripheral surface of the cylinder 110. Since the piston 130 shown in FIG. 1 is at the top dead center as described above, so that the space surrounded by the lower surface of the piston 130, the upper surface of the lower cylinder head 122, and the inner peripheral surface of the cylinder 110 is maximized. In this case, gas is taken into the space surrounded by the lower surface of the

piston 130, the upper surface of the lower cylinder head 122, and the inner peripheral surface of the cylinder 110 through the intake port 111. Thereafter, when the piston 130 is lowered, the space surrounded by the lower surface of the piston 130, the upper surface of the lower cylinder head 122, and the inner peripheral surface of the cylinder 110 is reduced and thereby the gas is compressed. The compressed gas is discharged through the discharge ports 112, 113.

[0029] The crank mechanism 150 is arranged below the piston 130. The crank mechanism 150 can include a crankshaft 151, a connecting rod 152, a crosshead 153, a hollow crankcase 154, and an approximately cylindrical head case 155. The crankshaft 151 is accommodated within the crankcase 154 that is provided in a manner extending along a predetermined rotation axis RAX orthogonal to the vertical axis VAX. The crankshaft 151 is double-supported by the crankcase 154 and arranged to rotate about the rotation axis RAX. The lower end of the connecting rod 152 is coupled to the crankshaft 151. The portion at which the crankshaft 151 and the connecting rod 152 are coupled is arranged to revolve around the rotation axis RAX. The head case 155 has a center axis approximately coinciding with the vertical axis VAX. The head case 155 is fixed to the upper surface of the crankcase 154. The crosshead 153 is an approximately columnar member accommodated within the head case 155 and having a center axis approximately coinciding with the vertical axis VAX. The crosshead 153 is coupled to the upper end of the connecting rod 152. Since the outer peripheral surface of the crosshead 153 is in proximity to the inner peripheral surface of the head case 155, the horizontal displacement of the crosshead 153 is limited by the head case 155. On the other hand, the head case 155 allows the vertical displacement of the crosshead 153. While the crankshaft 151 rotates about the rotation axis RAX, the connecting rod 152 changes its posture to absorb the horizontal displacement component, so that only the vertical displacement component is transmitted to the crosshead 153. As a result, the crosshead 153 can reciprocate within the head case 155 along the vertical axis VAX.

[0030] The piston rod 140 is a bar-shaped member provided in a manner extending along the vertical axis VAX. That is, the piston rod 140 has a center axis approximately coinciding with the vertical axis VAX. The lower end of the piston rod 140 is fixed to the upper surface of the crosshead 153, while an upper portion of the piston rod 140 is coupled to the piston 130. Accordingly, the reciprocation of the crosshead 153 along the vertical axis VAX is transmitted through the piston rod 140 to the piston 130. This allows the piston 130 to reciprocate within the cylinder 110 along the vertical axis VAX.

[0031] The compressor 100 includes a cylindrical member 160 formed between the lower cylinder head 122 and the head case 155 in a manner surrounding the piston rod 140. The cylinder head 122 and the head case 155 are fixed to the cylindrical member 160. The cylin-

drical member 160 defines a storage space arranged to temporarily store gas unintentionally leaking out of the internal space of the cylinder 110. Non-flammable purge gas (e.g. nitrogen gas) for discharging gas leaking into the cylindrical member 160 may be supplied into the storage space of the cylindrical member 160. This allows gas unintentionally leaking out of the internal space of the cylinder 110 to be discharged from the cylindrical member 160.

[0032] The lower cylinder head 122 is arranged between the piston 130 and the crosshead 153 and therefore formed in a manner penetrated through by the piston rod 140. The compressor 100 includes a rod packing portion 170 arranged to prevent gas leakage through a gap between the cylinder head 122 and the piston rod 140.

[0033] The rod packing portion 170 is formed in an annular shape and mounted in the cylinder head 122. The rod packing portion 170 is one of components most likely to be worn in the compressor 100 because it is penetrated through by the piston rod 140 such that the inner peripheral edge of the rod packing portion 170 is in sliding contact with the outer peripheral surface of the piston rod 140 that is mounted on the cylinder head 122. It is therefore necessary to replace the rod packing portion 170 at a frequency higher than the other components.

[0034] FIG. 2 is a schematic front view of the piston rod 140. The piston rod 140 will be described with reference to FIGS. 1 and 2.

[0035] The piston rod 140 includes a first rod portion 141 and a second rod portion 142 extending upward from the leading end (i.e. upper end) of the first rod portion 141. The first rod portion 141 is a component with which the inner peripheral edge of the rod packing portion 170 is in sliding contact. The first rod portion 141 is arranged to transmit the reciprocation of the crosshead 153 to the second rod portion 142 and the piston 130. The second rod portion 142 is used to couple the piston 130 to the piston rod 140.

[0036] The first rod portion 141 has an outer peripheral surface with which the inner peripheral edge of the rod packing portion 170 is in sliding contact. The length of the first rod portion 141 can be set to have a value larger than the stroke length of the piston 130 and the piston rod 140 (i.e. the positional difference between their top dead center and bottom dead center). While the piston 130 and the piston rod 140 reciprocates between the top dead center and the bottom dead center, the outer peripheral surface of the first rod portion 141 continues to be in sliding contact with the inner peripheral surface of the rod packing portion 170. This results in preventing gas leakage from the cylinder 110 while the piston 130 and the piston rod 140 reciprocates between the top dead center and the bottom dead center.

[0037] A leading end portion of the first rod portion 141 is inserted in a recessed portion provided in a manner recessed upward in the lower surface of the piston 130. This results in that a lower portion of the piston 130 is

coupled to the first rod portion 141.

[0038] The flange 146 is mounted on a base end portion (i.e. lower end portion) of the first rod portion 141 opposite to the leading end portion. The first rod portion 141 is coupled to the crosshead 153 via the flange 146.

[0039] The second rod portion 142 is a bar-shaped component protruding upward from the leading end face (i.e. upper end) of the first rod portion 141 and inserted through an insertion hole that penetrates through the piston 130 along the vertical axis VAX. Unlike the first rod portion 141, the second rod portion 142 is entirely accommodated in the piston 130.

[0040] The second rod portion 142 has a diameter smaller than that of the first rod portion 141. Accordingly, an annular stepped surface 145 surrounding the base end of the second rod portion 142 (i.e. an end portion of the second rod portion 142 coupled to the first rod portion 141) is defined by the diameter difference between the first rod portion 141 and the second rod portion 142 as a leading end face (i.e. upper end face) of the first rod portion 141. The piston 130 is hung on the stepped surface 145 and positioned in the direction in which the vertical axis VAX is provided in an extending manner.

[0041] The compressor 100 includes a nut 131 mounted on a leading end portion of the second rod portion 142. The nut 131 is embedded in a recessed portion formed in the upper surface of the piston 130 and threadably mounted on a male screw portion 144 formed on the outer peripheral surface of the leading end portion (i.e. upper end portion) of the second rod portion 142. The male screw portion 144 is formed at a position away upward from the stepped surface 145.

[0042] When the nut 131 is fastened on the male screw portion 144, a tensile stress occurs on the second rod portion 142. The tensile stress on the second rod portion 142 acts on the piston 130 as a compressive force between the nut 131 and the stepped surface 145. That is, the piston 130 is to be held firmly between the nut 131 and the stepped surface 145 in the direction in which the vertical axis VAX is provided in an extending manner. This results in that the piston 130 can be coupled firmly to the piston rod 140.

[0043] As shown in FIG. 1, the rod packing portion 170 is accommodated in an accommodation chamber formed within the lower cylinder head 122. A recessed portion having a diameter greater than that of the accommodation chamber and continuing to the upper end of the accommodation chamber is formed within the cylinder head 122. The compressor 100 includes an annular flange 124 fitted in the recessed portion that is formed in the cylinder head 122 and closing the accommodation chamber in a manner preventing the rod packing portion 170 from jumping upward out of the cylinder head 122.

[0044] The flange 124 is an annular plate member having a diameter greater than that of the rod packing portion 170. The shapes of the flange 124 and the rod packing portion 170 continuing downward from the flange 124 are complementary with the shapes of the recessed portion

formed in the cylinder head 122 and the accommodation chamber provided in a manner recessed downward from the recessed portion. The diameter difference between the recessed portion in which the flange 124 is fitted and the accommodation chamber in which the rod packing portion 170 is accommodated results in that the stepped surface is defined between the recessed portion in which the flange 124 is fitted and the accommodation chamber in which the rod packing portion 170 is accommodated. An outer peripheral portion of the flange 124 is hung on the stepped surface that is defined by the diameter difference between the recessed portion and the accommodation chamber at the boundary between the recessed portion and the accommodation chamber so that the flange 124 can be held within the recessed portion.

[0045] The rod packing portion 170 includes multiple rod packings 171. The rod packings 171 are provided in series downward from the flange 124 along the vertical axis VAX.

[0046] The compressor 100 includes multiple coupling screws 172 integrally coupling the multiple rod packings 171 of the rod packing portion 170 (see FIG. 1). The coupling screws 172 penetrate through the multiple rod packings 171 approximately in parallel with the vertical axis VAX to be threadably mounted in a female screw hole formed in the flange 124. As a result, the multiple rod packings 171 are integrated with the flange 124.

[0047] In addition to the multiple coupling screws 172, the compressor 100 includes multiple fasteners 125 provided in a manner extending approximately in parallel with the vertical axis VAX in the vicinity of the outer peripheral edge of the rod packing portion 170. The multiple fasteners 125 penetrate through the cylinder head 122 to be threadably mounted in the respective multiple female screw holes formed in the flange 124 at sites where they protrude outward from the outer peripheral edge of the rod packing portion 170. This causes the flange 124 to be fastened to the cylinder head 122. Standard screw members may be used as the multiple fasteners 125.

[0048] The multiple fasteners 125 each include a head portion 223 arranged to receive an operation for releasing the fastening between the flange 124 and the cylinder head 122. The head portions 223 of the multiple fasteners 125 appear in the internal space of the cylindrical member 160. An opening window 161 allowing for access to the head portions 223 of the fasteners 125 is formed in the peripheral wall of the cylindrical member 160.

(Flange)

[0049] As shown in FIG. 1, since the flange 124 is fitted in a recessed portion formed in the upper surface of the cylinder head 122 around the vertical axis VAX, gas leakage may occur at the boundary between the flange 124 and the cylinder head 122. The compressor 100 preferably has a structure for preventing gas leakage through the boundary between the flange 124 and the cylinder head 122.

[0050] FIG. 3A is a schematic cross-sectional view of the flange 124. FIG. 3B is a schematic bottom view of the flange 124. The structure for preventing gas leakage through the boundary between the flange 124 and the cylinder head 122 will be described with reference to FIGS. 1, 3A, and 3B.

[0051] The flange 124 is generally divided into an upper portion 126, a lower portion 127, and a middle portion 128. The upper portion 126 is fitted in the recessed portion formed in the upper surface of the cylinder head 122 to define an upper surface exposed to the internal space of the cylinder 110. The lower portion 127 is a thin disk-shaped component positioned below the upper portion 126. The lower portion 127 has a diameter smaller than that of the upper portion 126. The lower portion 127 defines a lower surface to be brought into compressive contact with the upper surface of the rod packing portion 170. Multiple female screw holes 129 into which the multiple coupling screws 172 are threadably mounted are provided in a manner bored upward in the lower portion 127. The middle portion 128 is a thin disk-shaped component positioned between the upper portion 126 and the lower portion 127. The middle portion 128 has a diameter greater than that of the lower portion 127 and smaller than that of the upper portion 126. Multiple female screw holes 221 into which the multiple fasteners 125 are threadably mounted are formed in an outer peripheral portion of the upper portion 126 projecting radially outward from the middle portion 128.

[0052] The lower portion 127 of the flange 124 is generally divided into a thin upper disk component 225 coupled to the middle portion 128 and a lower disk component 226 under the upper disk component 225. The upper disk component 225 has a diameter smaller than that of the lower disk component 226. Consequently, an annular groove portion 222 is formed between the lower disk component 226 and the lower surface of the middle portion 128.

[0053] In FIGS. 3A and 3B is shown an annular gasket 180 arranged to prevent gas leakage through the boundary between the flange 124 and the cylinder head 122. The gasket 180 includes an annular seal ring portion 181 and multiple protruding pieces 182. The seal ring portion 181 is a component arranged to prevent gas leakage through the boundary between the flange 124 and the cylinder head 122. The multiple protruding pieces 182 are used to keep the gasket 180 and the flange 124 in a connected state when the flange 124 is displaced upward.

[0054] The seal ring portion 181 is an approximately annular flat plate. As shown in FIG. 3B, the seal ring portion 181 is disposed along the annular lower surface of the middle portion 128 appearing radially outside of the lower portion 127. The seal ring portion 181 is held between the annular lower surface of the middle portion 128 and a stepped surface 224 defined by the diameter difference between the accommodation chamber in which the rod packing portion 170 is accommodated and

the recessed portion in which the flange 124 is fitted. When the multiple fasteners 125 are threadably mounted in the multiple female screw holes 221, the seal ring portion 181 is compressed by the annular lower surface of the middle portion 128 and the stepped surface 224 of the cylinder head 122 to prevent gas leakage through the boundary between the flange 124 and the cylinder head 122.

[0055] The multiple protruding pieces 182 protrude from the inner peripheral edge of the seal ring portion 181 toward the vertical axis VAX. The multiple protruding pieces 182 are fitted into the groove portion 222, and the gasket 180 is engaged with the flange 124. The dotted circle shown in FIG. 3B indicates the outer peripheral profile of the upper disk component 225 forming the bottom of the groove portion 222.

[0056] As shown in FIG. 3B, multiple notched portions complementary with the multiple protruding pieces 182 are formed in the lower disk component 226. The operator brings the gasket 180 into contact with the lower surface of the middle portion 128 such that the multiple protruding pieces 182 coincide in position with the multiple notched portions. The operator then rotates the gasket 180 about the vertical axis VAX. This causes the protruding pieces 182 to be fitted into the groove portion 222.

[0057] A method for taking out the rod packing portion 170 will hereinafter be described.

[0058] The operator with a tool can access the head portions 223 of the fasteners 125 through the opening window 161 to loosen the fasteners 125. After dismounting the multiple fasteners 125 from the cylinder head 122, the operator dismounts the cylinder head 121 from the upper end of the cylinder 110 (i.e. one of the end portions of the cylinder 110 farther from the crank mechanism 150). The operator can then loosen the nut 131 mounted on the upper end of the piston rod 140 to separate the piston 130 from the piston rod 140. After removing the piston 130, the operator can draw the flange 124 upward along the piston rod 140. As above, since the rod packing portion 170 is integrated with the flange 124 using the multiple coupling screws 172, when the flange 124 is drawn upward, the rod packing portion 170 can also be drawn upward together with the flange 124. The gasket 180, which is engaged with the flange 124 as above, is also to be drawn up together with the flange 124. Since the second rod portion 142 of the piston rod 140 is thinner than the first rod portion 141 and the cylinder head 121, the nut 131, and the piston 130 are removed, the portion of the second rod portion 142 above the first rod portion 141 has a diameter equal to or smaller than the inside diameter of the flange 124, the rod packing portion 170, and the gasket 180. The flange 124, the rod packing portion 170, and the gasket 180 can thus be drawn up smoothly and out of the upper end of the second rod portion 142.

[0059] Since the compressor 100 is arranged such that the rod packing portion 170 is taken out through a smaller number of disassembling steps, the operator can replace

the rod packing portion 170 in a short period of time. In addition, since the gasket 180 is mounted on the flange 124 to which the rod packing portion 170 is coupled, the operator can also take out the gasket 180 simultaneously with the flange 124. No dedicated operation is needed for taking out the gasket 180, whereby the rod packing portion 170 can be replaced efficiently.

[0060] The flange 124, which is hung on the cylinder head 122 as above, cannot fall off the cylinder head 122 even after the multiple fasteners 125 are removed. It is therefore possible for the operator to safely accomplish a disassembling operation for replacing the rod packing portion 170.

[0061] As for mounting of the gasket 180 according to this embodiment, the operator aligns the protruding pieces 182 of the gasket 180 with the notched portions formed in the flange 124 and then rotates the gasket 180 about the vertical axis VAX to fit the protruding pieces 182 into the groove portion 222 formed in the flange 124. However, the operator may snap-fit the protruding pieces 182 into the groove portion 222 without aligning the protruding pieces 182 with the notched portions formed in the flange 124. Accordingly, the notched portions may not be formed in the gasket 180.

[0062] As for mounting of the gasket 180 according to this embodiment, the protruding pieces 182 each have a fan shape. However, the protruding pieces may have another shape. For example, the protruding pieces may be an annular portion protruding inward from the seal ring portion 181 that is held between the cylinder head 121 and the flange 124. In this case, the gasket 180 may entirely be formed in an annular shape.

[0063] As for mounting of the gasket 180 according to this embodiment, the groove portion 222 into which the protruding pieces 182 of the gasket 180 are fitted is formed in the flange 124. However, the groove portion may be formed in the peripheral edge of the gasket, while a protrusion complementary with the groove portion may be formed on the flange. The gasket is integrated with the flange through engagement between the groove portion and the protrusion and can be drawn out of the piston rod 140 together with the flange.

<Second Embodiment>

[0064] In the first embodiment, the piston is positioned by the stepped surface that is defined by the diameter difference between the first rod portion and the second rod portion in the direction in which the piston rod is provided in an extending manner. However, the piston may be positioned by a positioning member mounted on the piston rod in the direction in which the piston rod is provided in an extending manner. In the second embodiment, a reciprocating compressor having such a positioning member mounted on the piston rod will be described.

[0065] FIG. 4 is a schematic front view of the piston rod 140A. The piston rod 140A can be substituted for the

piston rod 140 described with reference to FIG. 1. The piston rod 140A will be described with reference to FIGS. 1 and 4.

[0066] FIG. 4 shows not only the piston rod 140A, but also the rod packing portion 170, the flanges 124, 146, and the nut 131. The description in the first embodiment is incorporated in that of these elements by reference.

[0067] The piston rod 140A includes a first rod portion 141A and a second rod portion 142A extending upward from the leading end (i.e. upper end) of the first rod portion 141A along the vertical axis VAX. As is the case in the first embodiment, the rod packing portion 170 is in sliding contact with the first rod portion 141A. The first rod portion 141A has an approximately constant diameter throughout its length. This is different from the first rod portion 141 (see FIG. 1), which has an upper portion with a larger diameter and a lower portion with a smaller diameter. As is the case in the first embodiment, the second rod portion 142A is thinner than the first rod portion 141A, and an annular stepped surface 145 is defined by the diameter difference between the first rod portion 141A and the second rod portion 142A as a leading end face of the first rod portion 141A. A male screw portion 144 is formed on the outer peripheral surface of the leading end portion of the second rod portion 142A. Unlike the first embodiment, an additional male screw portion 147 is formed on the outer peripheral surface of the base end portion of the second rod portion 142A.

[0068] FIG. 4 shows a ring member 190 serving as the above-described positioning member. The ring member 190, through which the second rod portion 142A is inserted, is threadably mounted on the male screw portion 147 in the based end portion of the second rod portion 142A.

[0069] A recessed portion provided in a manner recessed upward is formed in the lower surface of the ring member 190. When the ring member 190 is threadably mounted completely on the male screw portion 147 of the second rod portion 142A, the upper end of the first rod portion 141A is fitted in the recessed portion formed in the lower surface of the ring member 190. As a result, the piston rod 140A is reinforced by the ring member 190 over a section from a position below the stepped surface 145 to the upper end of the male screw portion 147 above the stepped surface 145. Since the ring member 190 can receive a force from the piston 130A, the piston rod 140A cannot receive an excessively strong force around the stepped surface 145.

[0070] FIG. 4 shows a piston 130A substituted for the piston 130 in the first embodiment. As is the case in the first embodiment, an insertion hole extending along the vertical axis VAX is formed in the piston 130A. When the second rod portion 142A is inserted through the insertion hole of the piston 130A, the piston 130A is hung on the ring member 190 threadably mounted on the male screw portion 147 in the based end portion of the second rod portion 142A to be positioned in the direction in which the vertical axis VAX is provided in an extending manner.

Upon this, the ring member 190 is immersed partially into the recessed portion (complementary with the ring member 190) formed in the lower surface of the piston 130A. The operator can then fasten the nut 131 mounted on the male screw portion 144 that is formed in the leading end portion of the second rod portion 142A to mount the piston 130A on the second rod portion 142A.

[0071] Before the piston 130A is mounted on the piston rod 140A, the nut 131 is dismounted from the male screw portion 144 in the leading end portion of the second rod portion 142A, while the ring member 190 is threadably mounted on the male screw portion 147 in the based end portion of the second rod portion 142A. The operator then inserts the second rod portion 142A through the insertion hole of the piston 130A. Consequently, the upper end face of the ring member 190 comes into contact with the top surface of the recessed portion of the piston 130A so that the piston 130A is positioned in the direction in which the vertical axis VAX is provided in an extending manner. The operator then threadably mount the nut 131 on the male screw portion 144. When the nut 131 is fastened on the male screw portion 144 that is formed at a position away upward from the ring member 190, a tensile stress occurs on the second rod portion 142A. The tensile stress on the second rod portion 142A acts on the piston 130A as a compressive force between the nut 131 and the ring member 190. That is, the piston 130A is to be held firmly between the nut 131 and the ring member 190 in the direction in which the vertical axis VAX is provided in an extending manner. This results in that the piston 130A can be coupled firmly to the piston rod 140A.

[0072] As for dismounting of the rod packing portion 170, the operator with a tool can access the head portions 223 of the fasteners 125 through the opening window 161 of the cylindrical member 160 to loosen the fasteners 125, as is the case in the first embodiment. After dismounting the multiple fasteners 125 from the cylinder head 121, the operator may dismount the upper cylinder head 121 from the upper end of the cylinder 110. The operator can then loosen the nut 131 mounted on the upper end of the piston rod 140A to separate the piston 130A from the piston rod 140A. After removing the piston 130A, the operator can loosen and draw the ring member 190 out of the second rod portion 142A. After removing the ring member 190 from the second rod portion 142A, the operator can draw the flange 124 upward along the piston rod 140A. As above, since the rod packing portion 170 is integrated with the flange 124 using the multiple coupling screws 172, when the flange 124 is drawn upward, the rod packing portion 170 can also be drawn upward together with the flange 124. Since the second rod portion 142A of the piston rod 140A is thinner than the first rod portion 141A and the cylinder head 121, the nut 131, the piston 130A, and the ring member 190 are removed, the portion of the second rod portion 142A above the first rod portion 141A has a diameter equal to or smaller than the inside diameter of the flange 124 and the rod packing portion 170. The flange 124 and the rod

packing portion 170 can thus be drawn up smoothly and out of the upper end of the second rod portion 142A.

[0073] In this embodiment, the stepped surface 145 is defined between the first rod portion 141A and the second rod portion 142A. However, the boundary between the first rod portion 141A and the second rod portion 142A may have a tapered shape narrowed from the first rod portion 141A toward the second rod portion 142A. The ring member may be formed in a manner fitted on the tapered shape between the first rod portion 141A and the second rod portion 142A. Accordingly, in the above-described embodiments, the boundary between the first rod portion and the second rod portion is not limited to have a particular shape.

[0074] In this embodiment, the ring member 190 is immersed in the recessed portion that is formed in the lower surface of the piston 130A. This causes the opening edge of the insertion hole appearing on the lower surface of the piston 130A to come into contact with the peripheral surface of the ring member 190, whereby the ring member 190 can receive a strong force from the opening edge of the insertion hole, while the piston rod 140A cannot receive a strong force from the opening edge of the insertion hole directly. That is, the piston rod 140A can be protected by the ring member 190 against the piston 130A. However, the opening edge of the insertion hole may be in direct contact with the piston rod 140A as long as the piston rod 140A has a sufficient mechanical strength. If the ring member is mounted on the piston rod 140A such that the upper surface of the ring member is coplanar with the stepped surface 145, the opening edge of the insertion hole is in contact with the base end portion of the second rod portion 142A. In this case, the piston 130A can be supported on the stepped surface 145 and the upper surface of the ring member 190.

[0075] In this embodiment, the lower surface of the ring member 190 is approximately coplanar with the lower surface of the piston 130A. However, the lower surface of the ring member 190 may be at a position higher than that of the lower surface of the piston 130A. In this case, the opening edge of the insertion hole appearing on the lower surface of the piston 130A can be spaced away from the peripheral surface of the ring member 190. Accordingly, the piston rod 140A becomes less likely to receive an excessively large load from the opening edge of the insertion hole.

[0076] In this embodiment, the ring member 190 is threadably mounted on the male screw portion 147 that is formed in the base end portion of the second rod portion 142A. However, the ring member may be threadably mounted on the male screw portion that is formed in the leading end portion of the first rod portion.

<Third Embodiment>

[0077] FIG. 5 is a schematic cross-sectional view of a compressor 100B according to a third embodiment. The compressor 100B will be described with reference to

FIGS. 1 and 5.

[0078] The compressor 100B differs from the compressor 100 according to the first embodiment only in the arrangement position of the gasket. The description in the first embodiment is therefore incorporated in that of the compressor 100B by reference except for the gasket.

[0079] The compressor 100B includes a gasket 180B arranged at a position different from that of the gasket 180 described in relation to the first embodiment. The gasket 180 according to the first embodiment is compressed by the lower surface of the flange 124 and the upper surface of the cylinder head 122 within the recessed portion formed in the cylinder head 122, while the gasket 180B according to the third embodiment is compressed by the lower surface of the rod packing portion 170 and the upper surface of the cylinder head 122 within the accommodation chamber in which the rod packing portion 170 is accommodated.

[0080] The gasket 180B is an annular thin plate. The piston rod 140 penetrates through an opening region at the center of the gasket 180B to be surrounded circumferentially by the gasket 180B. The gasket 180B prevents gas flowing through the boundary between the flange 124 and the cylinder head 122 into the accommodation chamber in which the rod packing portion 170 is accommodated from flowing into the thin annular space between the outer peripheral surface of the piston rod 140 and the inner peripheral surface of the cylinder head 122 and the internal space of the cylindrical member 160 that is arranged below the cylinder head 122.

[0081] In the above-described embodiments, the piston rods 140, 140A have the respective first rod portions 141, 141A and the respective second rod portions 142, 142A having their respective different diameters. However, the second rod portions may have the same thickness as the respective first rod portions. In this case, the ring member for supporting each piston 130, 130A thereon is mounted at a middle position of the piston rod. The mounting position of the ring member is at the boundary between each first rod portion and each second rod portion. That is, the portion of the piston rod located higher than the ring member corresponds to the second rod portion. The portion of the piston rod located lower than the ring member corresponds to the first rod portion. As is the case with the ring member 190 described in relation to the second embodiment, the ring member arranged at the boundary between the first rod portion and the second rod portion is formed to be dismountable from the piston rod. For example, the ring member may be formed in a manner threadably mounted on a male screw portion formed at the boundary between the first rod portion and the second rod portion. The operator can dismount the piston and the ring member in this order from the piston rod and draw up the rod packing mounted on the first rod portion toward the second rod portion.

[0082] In the above-described embodiments, the cylinder 110 may not necessarily extend vertically.

[0083] The embodiments disclosed herein are illustrative in all aspects and should not be construed as being restrictive. The scope of the present invention is defined by the appended claims rather than by the description made above, and all modifications within the meaning and scope equivalent to the claims are intended to be encompassed therein.

[0084] The compressors 100, 100B are preferably applicable to various technical fields in which compressed gas is needed. For example, such a compressor may be loaded on a marine vessel that carries liquid natural gas. As above, the reciprocating compressors according to the above-described embodiments each have a structure in which the rod packing portion is less likely to fall, and the rod packing portion is separated from the reciprocating compressor in a manner drawn upward, whereby the operator can safely replace the heavy rod packing portion incorporated in such a large reciprocating compressor.

[0085] A reciprocating compressor with an easily replaceable rod packing is provided. This application discloses a reciprocating compressor including a piston rod coupled to a piston that is accommodated within a cylinder and a crank mechanism, and an annular rod packing having an inner peripheral edge in sliding contact with the outer peripheral surface of the piston rod to prevent gas within the cylinder from leaking around the outer peripheral surface of the piston rod. The piston rod includes a first rod portion with which the rod packing is in sliding contact and a second rod portion provided in a manner extending from the leading end of the first rod portion and inserted through an insertion hole that is formed in the piston. The piston is separable from the second rod portion. The diameter of the second rod portion is equal to or smaller than that of the first rod portion.

Claims

1. A reciprocating compressor comprising:

a piston rod coupled to a piston that is accommodated within a cylinder and a crank mechanism; and

an annular rod packing having an inner peripheral edge in sliding contact with the outer peripheral surface of the piston rod to prevent gas within the cylinder from leaking through a gap around the outer peripheral surface of the piston rod, wherein

the piston rod includes a first rod portion with which the rod packing is in sliding contact and a second rod portion provided in a manner extending from the leading end of the first rod portion and inserted through an insertion hole that is formed in the piston,

the piston is separable from the second rod portion, and

the diameter of the second rod portion is equal to or smaller than the diameter of the first rod

portion.

2. The reciprocating compressor according to claim 1, further comprising a nut threadably mounted on a male screw portion that is formed in a leading end portion of the second rod portion protruding from the piston to fix the piston to the second rod portion, wherein the leading end of the first rod portion includes an annular stepped surface defined by the diameter difference between the first rod portion and the second rod portion, which is thinner than the first rod portion, and the piston is held between the stepped surface and the nut in the direction in which the piston rod is provided in an extending manner. 5 10 15
3. The reciprocating compressor according to claim 1, further comprising: 20
 - a nut threadably mounted on a male screw portion that is formed in a leading end portion of the second rod portion to fix the piston to the second rod portion; and
 - a ring member mounted on the piston rod in a manner holding the piston in cooperation with the nut in the direction in which the piston rod is provided in an extending manner, wherein the ring member has a diameter greater than that of the first rod portion and is dismountable from the piston rod. 25 30
4. The reciprocating compressor according to any one of claims 1 to 3, further comprising: 35
 - a cylinder head penetrated through by the piston rod while closing an opening portion formed at the lower end of the cylinder and formed with an accommodation chamber in which the rod packing is accommodated; and 40
 - a flange arranged on the cylinder head in a manner penetrated through by the piston rod while closing the accommodation chamber, wherein the flange is separable upward from the cylinder head with being coupled to the rod packing within the accommodation chamber and penetrated through by the piston rod. 45
5. The reciprocating compressor according to claim 4, further comprising: 50
 - a cylindrical member surrounding the piston rod below the cylinder and mounted in the cylinder head; and
 - a fastener for fastening the flange to the cylinder head, wherein the fastener includes a head portion arranged to receive an operation for releasing the fasten- 55

ing between the flange and the cylinder head, and the head portion is exposed to the internal space of the cylindrical member and accessible through an opening window formed in the cylindrical member.

6. The reciprocating compressor according to claim 4 or 5, further comprising an annular gasket arranged to prevent the gas from leaking through the boundary between the cylinder head and the flange, wherein the gasket is mounted on the flange.

FIG. 1

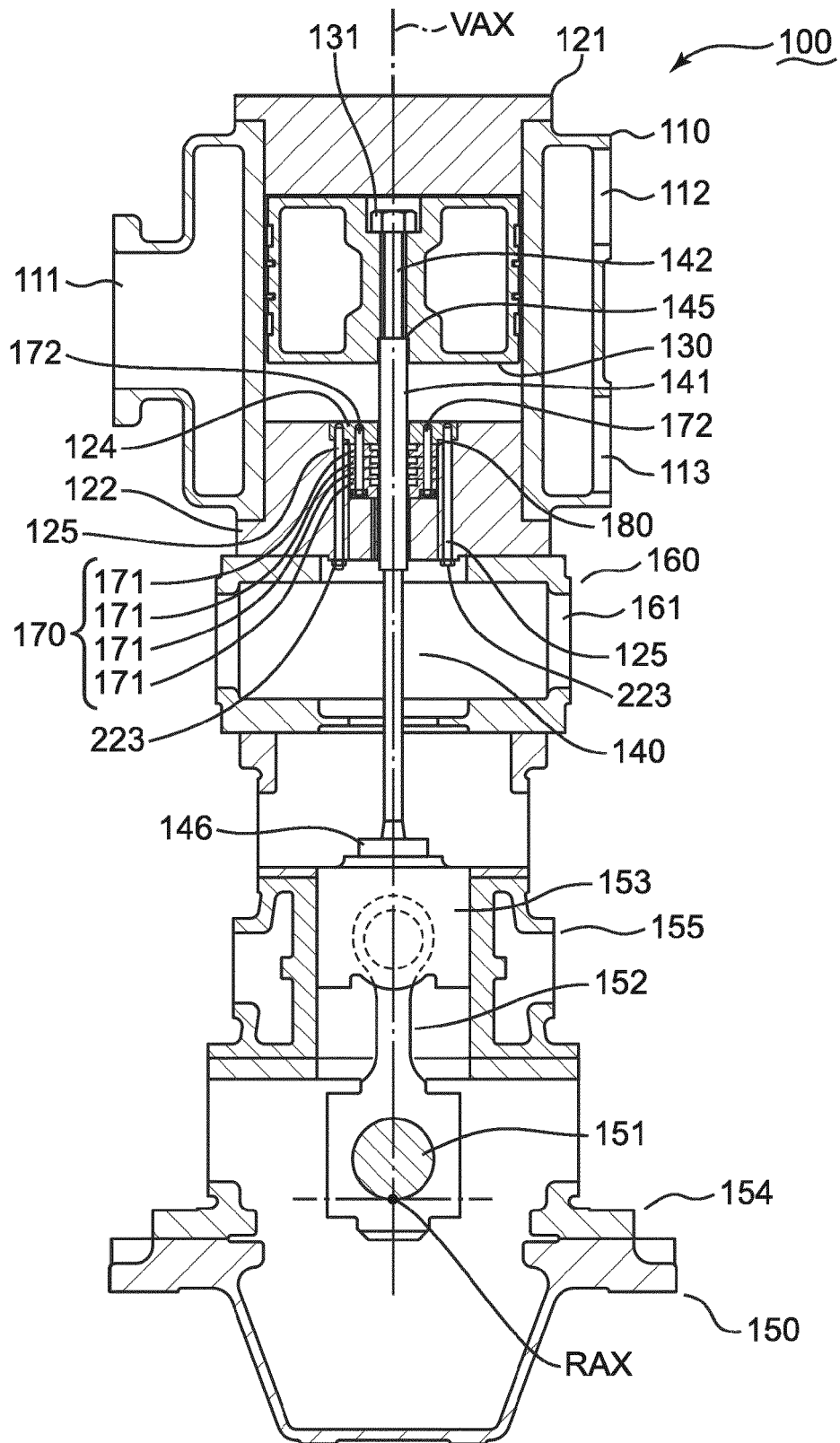


FIG. 2

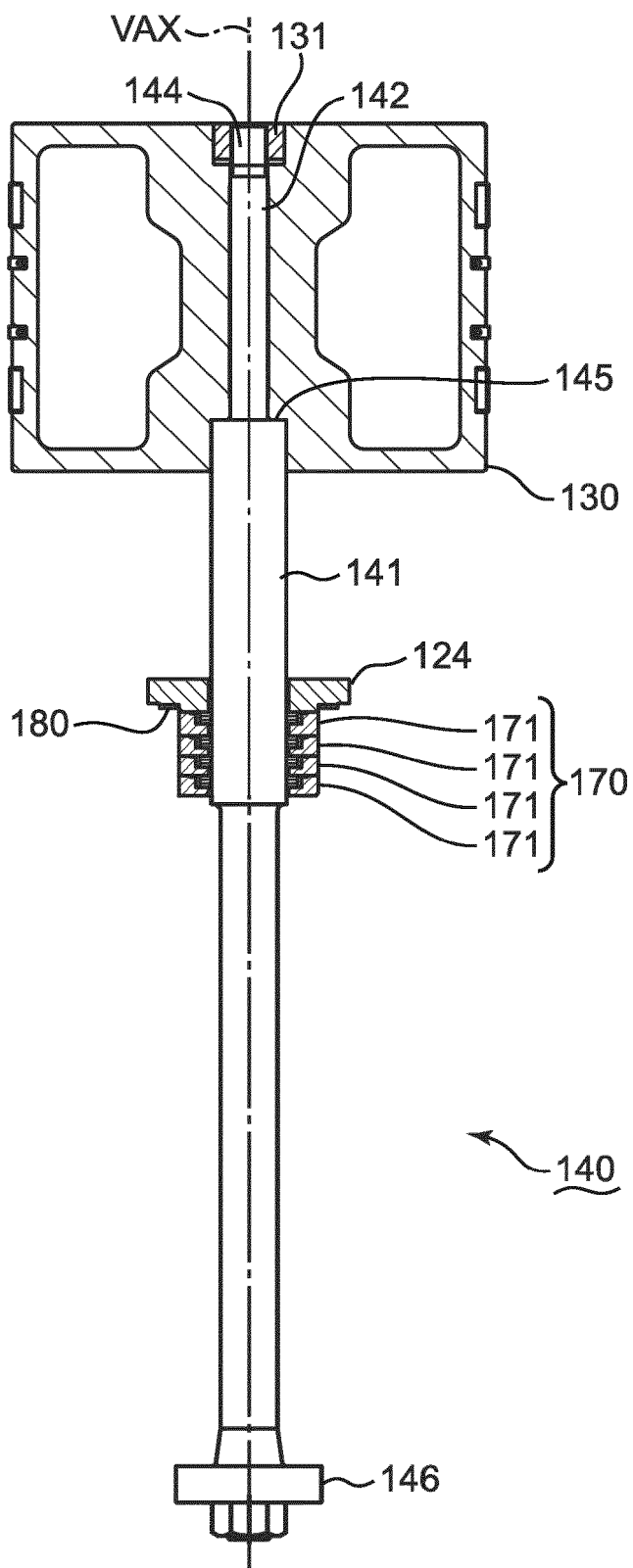


FIG. 3A

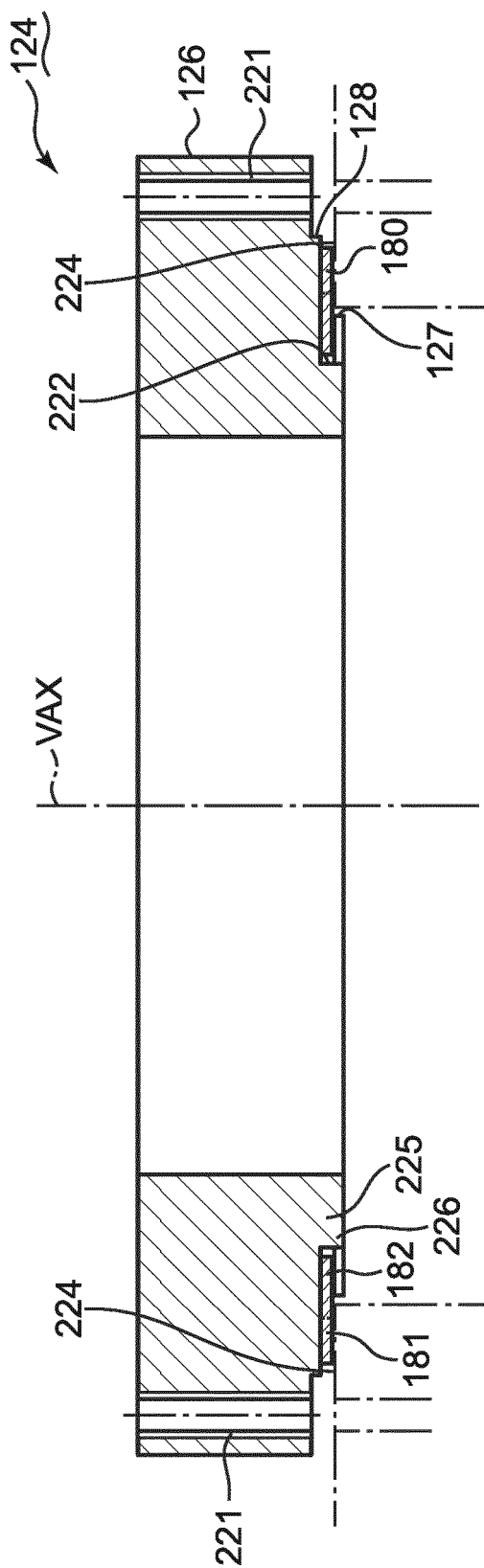


FIG. 3B

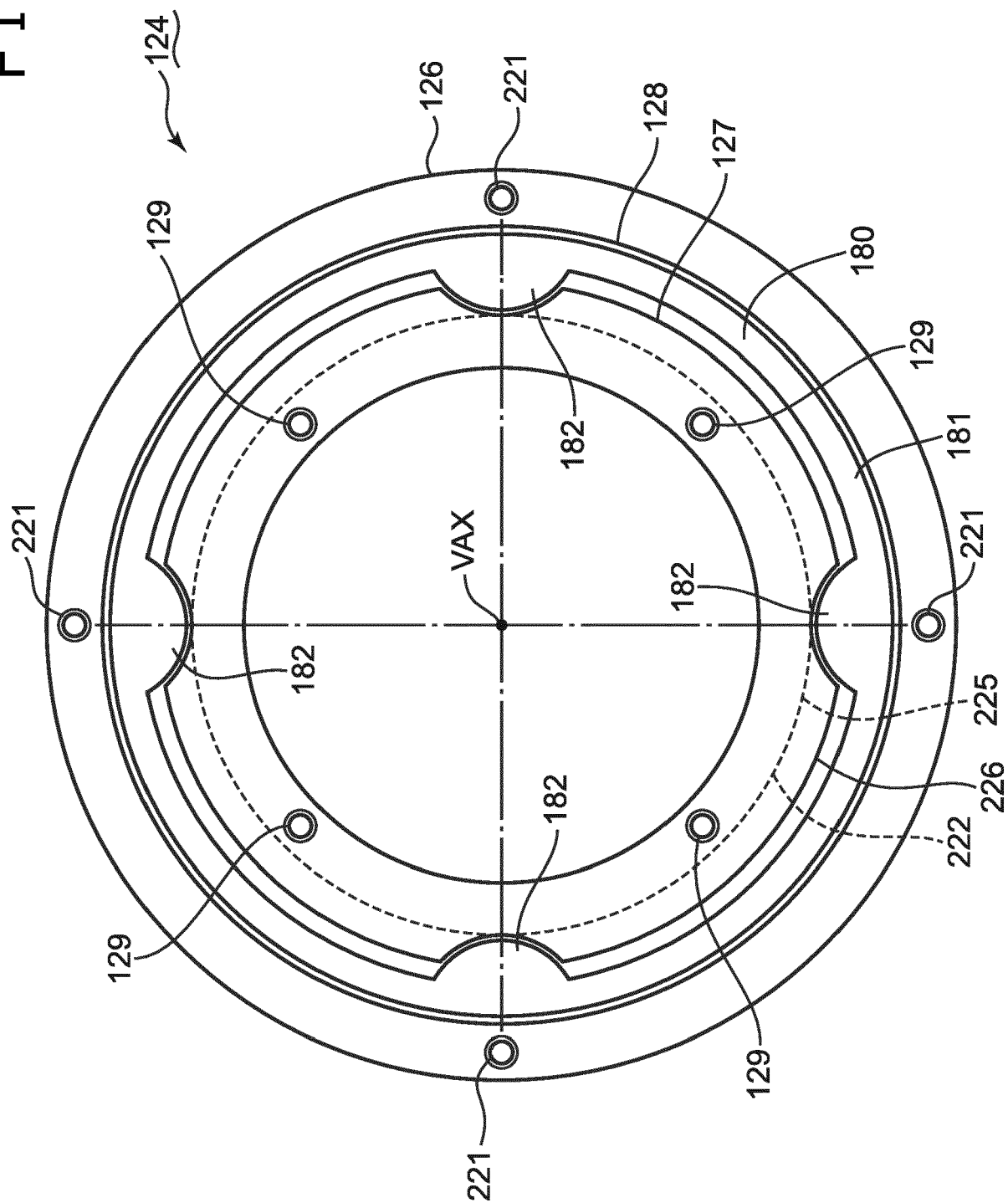


FIG. 4

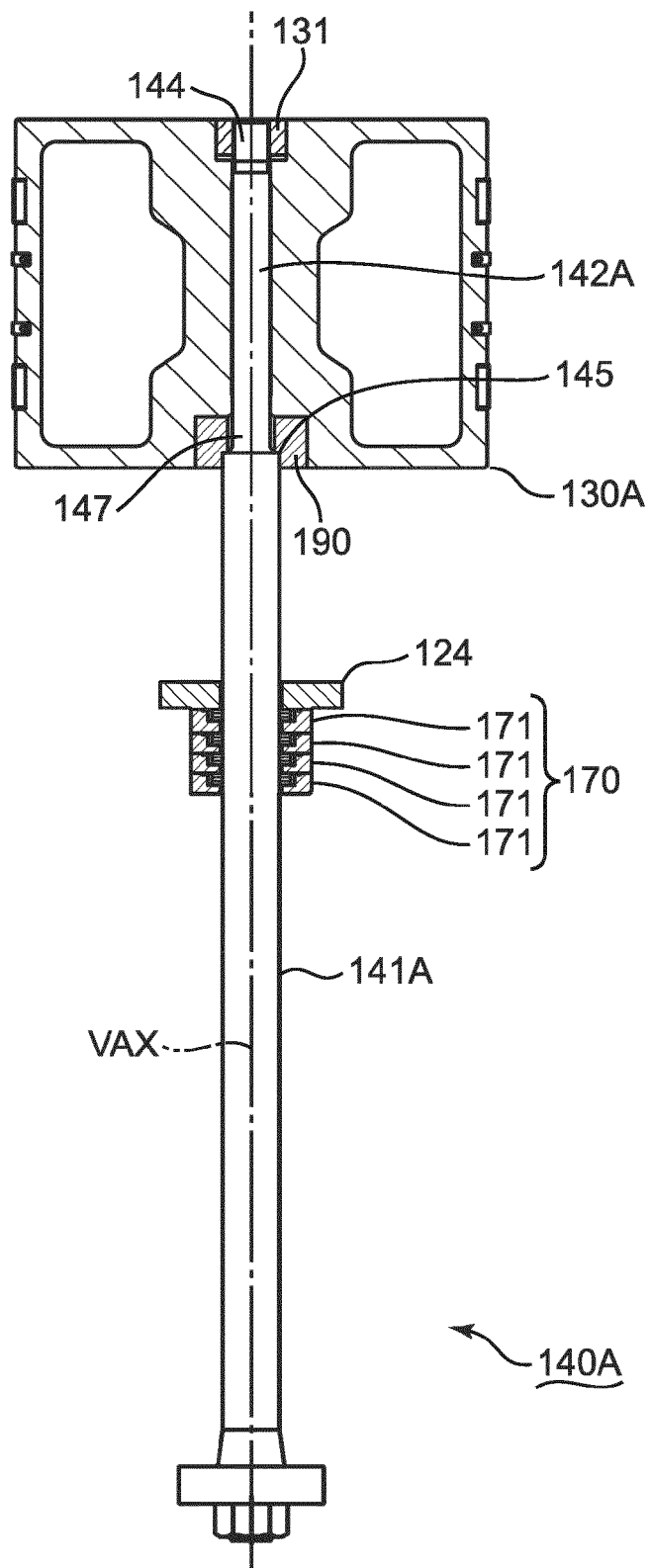
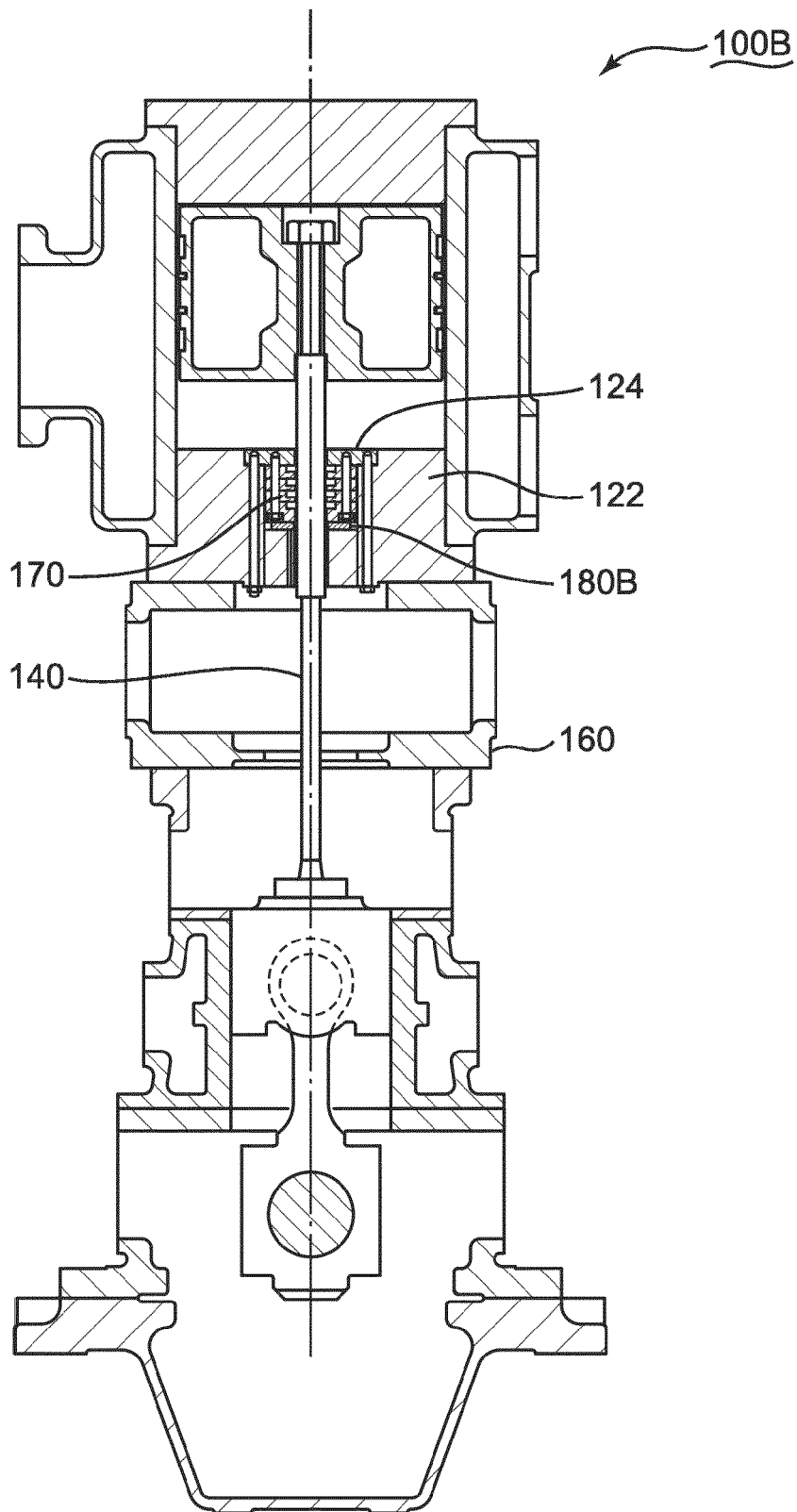


FIG. 5





EUROPEAN SEARCH REPORT

 Application Number
 EP 18 20 4807

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 1 526 909 A (HILLER NICOLAI H) 17 February 1925 (1925-02-17) * page 1, column 2, lines 87-99; figure * -----	1-6	INV. F04B53/00 F04B53/02 F04B53/14 F04B53/16 F04B53/22
X	WO 99/18354 A2 (BASIL INTERNATIONAL INC [US]; TURIANSKY BASIL [US]) 15 April 1999 (1999-04-15) * abstract *; figures 2,3 * -----	1-6	
X	US 3 282 218 A (BAUERS ARTHUR A) 1 November 1966 (1966-11-01) * claims; figures * -----	1-6	
A	CA 820 745 A (CHICAGO PNEUMATIC TOOL CO) 19 August 1969 (1969-08-19) * claims; figures 1,2 * -----	1-6	
			TECHNICAL FIELDS SEARCHED (IPC)
			F04B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 February 2019	Examiner Pinna, Stefano
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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 EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 20 4807

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-02-2019

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 1526909	A	17-02-1925	NONE

WO 9918354	A2	15-04-1999	AU 9669398 A 27-04-1999
			US 6164935 A 26-12-2000
			US 2001000318 A1 19-04-2001
			US 2001000319 A1 19-04-2001
			US 2002005615 A1 17-01-2002
			WO 9918354 A2 15-04-1999

US 3282218	A	01-11-1966	FR 1422486 A 24-12-1965
			GB 1034066 A 29-06-1966
			NL 6500452 A 16-07-1965
			US 3282218 A 01-11-1966

CA 820745	A	19-08-1969	NONE

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016153637 A [0002] [0003]