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

(11) **EP 4 170 164 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.04.2023 Bulletin 2023/17

(21) Application number: **22203373.0**

(22) Date of filing: **24.10.2022**

(51) International Patent Classification (IPC):
F04B 35/04 *(2006.01)* ***F04B 39/00*** *(2006.01)*
F04B 39/02 *(2006.01)* ***F04B 39/12*** *(2006.01)*
F04B 53/10 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04B 35/04; F04B 39/0044; F04B 39/0061; F04B 39/0094; F04B 39/02; F04B 39/128; F04B 53/1047

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **25.10.2021 EP 21204555**

(71) Applicant: **Secop GmbH**
24941 Flensburg (DE)

(72) Inventor: **Da Silva Castro, Mattias**
8042 Graz (AT)

(74) Representative: **KLIMENT & HENHAPEL Patentanwälte OG**
Gonzagagasse 15/2
1010 Wien (AT)

(54) REFRIGERANT COMPRESSOR

(57) The invention relates to an encapsulated refrigerant compressor (1) having
- a compressor shell (100);
- a pump unit (10) located within the compressor shell (100), said pump unit (10) comprising:
-- a cranktrain (200) with a crankshaft (210), a counterweight (225), a crankpin (220), a connecting rod (230) and a piston (240;
-- a crankcase (300) with a cylinder housing (310), wherein a cylinder (320) for reciprocating movement of the piston (240) is located, and wherein the crankshaft (210) is rotatably mounted inside a main bearing section (302),
-- an electric drive unit (400) with a stator (420) and a rotor (410), the rotor (410) being fixed to the crankshaft (210) ;
-- wherein the crankshaft (210) is axially supported by a ball bearing (201) on the crankcase (300).

The crankshaft (210) comprises an upper bearing section (215) and a lower bearing section (217) to form an upper sliding bearing (215b) and a lower sliding bearing (217b), wherein an upper bearing seat (305) as the part of the main bearing section (302) forming the upper sliding bearing (215b) is arranged at an upper end section of the main bearing section (302) of the crankcase (300), and wherein said upper bearing seat (305) is configured to be flexibly bendable in a radial direction (212) of the crankshaft (210).

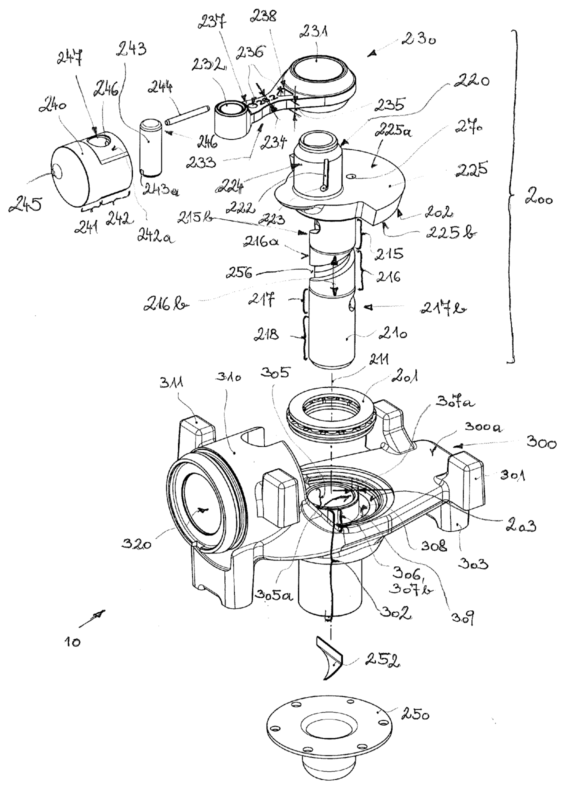


Fig.5

EP 4 170 164 A2

Description

FIELD OF THE INVENTION

[0001] The invention relates to an encapsulated refrigerant compressor having

- a compressor shell with connection openings for a discharge pipe, a suction pipe, and a maintenance pipe each entering the compressor shell;
- a pump unit that is located within the compressor shell and supported via a plurality of support spring assemblies, said pump unit comprising:

  -- a cranktrain having a crankshaft with a counterweight, a crankpin, a connecting rod and a piston, wherein the connecting rod is rotatably mounted on the crankpin of the crankshaft, and wherein the connecting rod connects the crankpin with the piston;
  -- a crankcase with a cylinder housing, wherein a cylinder for reciprocating movement of the piston is located in the cylinder housing, and wherein the crankshaft is rotatably mounted inside a main bearing section of the crankcase that acts as a crankshaft bearing shell;
  -- an electric drive unit having a stator and a rotor, the rotor being fixed to the crankshaft, and wherein the stator is attached to the cylinder crankcase;
  -- wherein the crankshaft is axially supported by a ball bearing on the crankcase, wherein said ball bearing is positioned below the counterweight and is configured to support in an operation state of said compressor an axial load of the rotor and the crankshaft against the crankcase.

PRIOR ART

[0002] Encapsulated, especially hermetically sealed, refrigerant compressors have been known for a long time and are mainly used in refrigeration cabinets, such as refrigerators or refrigerated shelves, but can also be used in mobile appliances, for example as battery-driven refrigerant compressors. The refrigerant process as such has also been known for a long time. Refrigerant is thereby heated by energy absorption from the space to be cooled in an evaporator and finally superheated and pumped to a higher pressure level using the refrigerant compressor having a cylinder and a reciprocating piston. At this higher pressure level the refrigerant is cooled via a condenser and is conveyed back into the evaporator via a throttle, via which throttle the pressure is reduced and the refrigerant is further cooled down, before the cycle starts anew.

[0003] The path of the usually gaseous refrigerant through the compressor can be described as follows: The refrigerant enters a compressor shell of the refrigerant compressor, which compressor shell encapsulates a pump unit of the refrigerant compressor, through a suction pipe, which is in the operating state connected to the evaporator of the refrigerant appliance. During a suction cycle, the refrigerant is sucked through a suction muffler, a suction opening of a valve plate, which suction opening is released by a suction valve spring, into a cylinder of the pump unit of the refrigerant compressor. The suction is caused by linear movement of a piston inside the cylinder. During a compression step of a compression and discharge cycle, while the suction valve is closed, the refrigerant is compressed within the cylinder by the linear movement of the piston until a discharge valve spring releases a discharge opening of the valve plate. During a discharge part of the compression and discharge cycle, the so compressed refrigerant then flows through the discharge opening of the valve plate into a discharge muffler and leaves the compressor shell through a discharge pipe, which is connected to the discharge muffler by a discharge connection tube. The discharge tube is in the operating state connected to the condenser of the refrigerant appliance.

[0004] The pump unit comprises a cranktrain, which includes the piston and is causing the linear movement of the piston inside the cylinder, a crankcase, in which a crankshaft of the cranktrain is mounted, the crankcase also having a cylinder housing, an electric drive unit, which comprises a rotor and a stator, and a cylinder head arrangement. The cylinder head arrangement includes the valve plate, the suction valve spring, the discharge valve spring, the suction muffler and the discharge muffler. The pump unit is supported within the compressor shell on a plurality of support spring assemblies, preferably on four support spring assemblies.

[0005] The shell usually comprises a lower shell part and an upper shell part, which are welded together. The discharge pipe and the suction pipe as well as a maintenance pipe (also known as service pipe) are hermetically connected to the shell. As the refrigerant compressor is a stand-alone product, which is integrated into a refrigerant appliance at some stage of the assembly process, the discharge pipe, the suction pipe and the maintenance pipe are also called discharge connector, suction connector and maintenance connector as they are configured to be connected with respective elements with the refrigerant appliance during assembly and/or in the operation state.

[0006] The movement of the piston is caused by rotation of the crankshaft, wherein the piston is connected to a crankpin of the crankshaft via a connecting rod. The electric drive unit is required to facilitate the rotation of the crankshaft, wherein the rotor is fixed to the crankshaft.

[0007] Usually, an electronic control unit is mounted to an outside surface of the compressor shell, wherein the stator is connected to an electric pass-through element (also known as "fusite") via an inner harness and the electronic control unit is connected to the electric pass-through element via an outer harness. The electronic control unit powers the stator and thereby controls the rotational speed of the pump unit of the refrigerant compressor.

[0008] In general, a refrigerant compressor basic function can be specified as to compress and circulate refrigerant through the refrigeration system. This is usually achieved by a reciprocating movement of a piston inside a cylinder, and a set of valves that open by differential pressures. The reciprocating movement of the piston is a result of the rotative movement of an eccentric crankshaft driven by an electric motor and the parts connecting each other. All those parts need to move or slide between each other during the whole service life of the refrigerant compressor with minimum friction.

[0009] For comparatively bigger refrigerant compressors with bigger moving or sliding parts the configuration of bearings for the crankshaft is usually chosen in such a way that one bearing each is arranged along the crankshaft above and below the level of the connecting rod.

[0010] For comparatively smaller refrigerant compressors like such as used for household refrigerators or mobile refrigerators, especially for battery-driven refrigerators, it is possible to configure the bearings for the crankshaft in a more compact way since loads are normally smaller and size of moving or sliding parts as well. Thus, design of smaller refrigerant compressors allows positioning of both two bearings for the crankshaft below the bearing connection of the connecting rod with the crankpin along the same side of the crankshaft. However, it should be noted that in this way, the reaction forces on the crankshaft and crankcase interface point in opposite directions, resulting in high moment loads acting on the respective components.

[0011] During operation of the compressor, it can therefore happen that the crankshaft bends strongly due to the small distance between the two bearings typical for the design. This bending of the crankshaft is comparable to a loaded beam that is fixed only on one side. Thus, without a specific design of the pump unit, the piston will bend excessively inside the cylinder, making high contact pressure loads acting on the edges of the piston. This common design has at least the disadvantage of high friction and wear, accompanied by a reduced service life as well as bad reliability of such a compressor.

OBJECT OF THE INVENTION

[0012] It is an object of the invention to provide a refrigerant compressor with a compact design, for example a refrigerant compressor that can be battery-driven or be used for mobile applications, which overcomes the disadvantages of the prior art and which provides a pump unit wherein the moving or sliding parts are configured in a way to further reduce friction and wear and to enhance reliability and service life of the compressor. A further object of the invention is to provide a refrigerant compressor where unwanted canting or jamming of the moving or sliding parts within their respective housing can be prevented and that is relatively cheap to produce and easy to assemble.

DESCRIPTION OF THE INVENTION

[0013] In order to achieve at least one of the objects set out above in a refrigerant compressor as defined initially it is suggested according to the invention that the crankshaft comprises a first, upper bearing section and, spaced therefrom in an axial distance, a second, lower bearing section, wherein the upper bearing section is configured to interact with the main bearing section of the crankcase to form a first, upper sliding bearing, and wherein the lower bearing section is configured to interact with the main bearing section of the crankcase to form a second, lower sliding bearing, wherein an upper bearing seat as the part of the main bearing section forming the first, upper sliding bearing is arranged at an upper end section of the main bearing section of the crankcase, wherein said upper end section of the main bearing section is facing towards the counterweight, and wherein said upper bearing seat is configured to be flexibly bendable in a radial direction of the crankshaft to reduce edge loading of the crankshaft relative to the crankcase.

[0014] Due to this specific design according to the invention with a flexibly bendable or hingeable upper bearing seat that is positioned at the upper end section of the main bearing section of the crankcase, it is possible to reduce the edge load on the upper bearing seat and on the upper end of the main bearing section of the crankcase. High edge loads are due to the high bending and rotational forces of the crankshaft that act on the main bearing section mainly in radial direction of the crankshaft. The crankshaft is designed in a way that it has a first, upper bearing section that functions as upper bearing journal and forms together with the respective corresponding section of the main bearing section of the crankcase a first, upper sliding bearing. The first, upper sliding bearing has spaced therefrom in an axial distance a second, lower bearing section, that functions as lower bearing journal and forms together with the respective surrounding section of the main bearing section a second, lower sliding bearing. Thus, the crankshaft is rotatably mounted inside the main bearing section with two spaced sliding bearings. Additionally, the crankshaft is axially supported by a ball bearing on the crankcase, which ball bearing is positioned below the counterweight of the crankshaft and is configured to support in the operation state of the compressor an axial load of the rotor and the crankshaft against the crankcase.

[0015] Thus, due to the inventive design of the refrigerant compressor with a flexible upper bearing seat of the first upper sliding bearing of the crankshaft, reliability of the moving or sliding parts is improved allowing also the use of less viscous oils which is another advantage of the invention.

[0016] In the present application, the term "flexibly bendable" or "flexibly hingeable" is understood by the skilled one to mean a reversible, elastic deformation of the component or section in question, which serves to absorb load peaks due to rotational movements or translational movements of moving components as flexibly as possible. The term "flexibly bendable" thus only includes reversible or non-permanent deformations of the respective components or sections. Furthermore, the positional indications of parts or components used in the following, for example the terms "top", "bottom", "upper", "lower", "front", "rear", "above", "below", "lateral", "in axial direction", "in radial direction" and the like, essentially serve to facilitate understanding of the invention, in particular in conjunction with the following drawings. The positional indications used may possibly refer to certain positions of the compressor during operation or may refer to views in the figures. In any case, the position indications are familiar to those skilled in the art of the invention, but do not limit the present invention.

[0017] In a further advantageous embodiment of the encapsulated refrigerant compressor according to the invention the upper bearing seat of the crankcase for the upper bearing section of the crankshaft can be designed at least partly as a sleeve-shaped cylindrical extension of the crankcase with a wall thickness and an axial height. In this preferred embodiment of the invention the sleeve-shaped cylindrical extension of the crankcase can form an extension of the main bearing section which can protrude from the top side or upper side of the crankcase. The sleeve-shaped cylindrical extension of the crankcase can be the respective upper bearing seat for the total height of the upper sliding bearing. In other words, the sleeve-shaped cylindrical extension of the crankcase can house the entire upper bearing section of the crankshaft. It is also encompassed by the invention that the sleeve-shaped cylindrical extension can accommodate only a height section or part, respectively, of the upper bearing section of the crankshaft.

[0018] The axial height of said sleeve-shaped cylindrical extension is given as the length of the extension parallel to the axial direction of the crankshaft. Or in other words, the axial height corresponds to the lengthwise extent to which the sleeve-shaped cylindrical extension of the upper bearing seat projects freely from the upper side of the crankcase. The sleeve-shaped cylindrical extension of the upper bearing seat is part of the crankcase and is preferably formed integrally in one piece with the crankcase.

[0019] In a further preferred embodiment, the dimensions of the sleeve-shaped cylindrical extension of the crankcase can have a wall thickness that is at least 2 (two) times smaller than the axial height of said sleeve-shaped cylindrical extension. Or in other words the sleeve-shaped cylindrical extension of the crankcase can have an axial height corresponding to at least 2 times the wall thickness, preferably an axial height corresponding 3.5 times the wall thickness, and wherein the wall thickness of said sleeve-shaped cylindrical extension can be chosen between 5% and 20% of the diameter of the crankshaft. Particularly preferable can be to select the wall thickness of said sleeve-shaped cylindrical extension as 10% of the diameter of the crankshaft. In another preferred embodiment of the invention the wall thickness of the sleeve-shaped cylindrical extension of the crankcase is constant along its axial height.

[0020] Surprisingly, it has been found that the indicated ratio of the wall thickness and the axial height of said sleeve-shaped cylindrical extension can particularly be advantageous for flexibly absorbing the high bending forces of the crankshaft during compressor operation. The comparably low wall thickness of the sleeve-shaped cylindrical extension of the crankcase that forms the upper bearing seat for the upper sliding bearing of the crankshaft allows a particularly flexible bearing and flexibility of the crankshaft in radial direction during operation of the compressor.

[0021] According to another practical embodiment of the invention, the upper bearing seat for the upper bearing section of the crankshaft can be formed by a bearing recess within the crankcase. Such a bearing recess can extend from an upper side of the crankcase, wherein said bearing recess runs concentrically around an outer side of the upper bearing seat downwards in axial direction of the crankshaft. Due to the essentially circular bearing recess that runs concentrically around the outsides of the upper bearing seat, the ability of the upper bearing seat to flexibly bend is further increased in order to absorb deflections and edge loads of the crankshaft even more efficiently during operation of the compressor, especially in the radial direction of the crankshaft.

[0022] In a further advantageous embodiment of the invention, the encapsulated refrigerant compressor can have an aforesaid bearing recess running concentrically around the outer sides of the upper bearing seat, which bearing recess has an essentially V-shaped cross-section that tapers in regard to the axial direction of the crankshaft towards the main bearing section. According to this embodiment, this bearing recess thus offers the advantage that the wall of the upper bearing seat can elastically deform more and more in the radial direction of the crankshaft with increasing axial height. High edge loads during operation of the crankshaft are thus absorbed particularly effectively by the flexibly bendable upper bearing seat of the crankcase.

[0023] According also to this embodiment, the upper bearing seat of the crankcase can be designed or shaped as a sleeve-shaped cylindrical extension of the crankcase with a wall thickness and an axial height. In a further preferred embodiment, the essentially V-shaped crosssection of the bearing recess can be shaped in a way that it is tapered downwardly, wherein a first leg of the V-shaped recess, which first leg forms the outer side of the upper bearing seat, extends vertically downwards substantially parallel to the axial direction of the crankshaft. A second leg of the V-shaped recess according to this embodiment can be inclined conically so that the V-shaped recess has its maximum opening width at the upper side of the crankcase.

[0024] To obtain a particularly compact and effective design of the refrigerant compressor according to the invention, the ball bearing can be centered by the outer side of the upper bearing seat. As already explained, according to this embodiment the upper bearing seat serves on the one hand with its inner side as a flexible upper end section of the main bearing section for the bearing of the upper sliding bearing of the crankshaft. On the other hand, according to this preferred design, the upper bearing seat serves with its outer side as a guiding means to center the ball bearing in radial direction. Radial movements and bending of the crankshaft, which must be absorbed by the two sliding bearings, in particular the upper sliding bearing, and which cause flexible bending of the upper bearing seat, are thus also transmitted from the upper bearing seat further to the ball bearing. The upper sliding bearing can thus be coupled in terms of movement with the ball bearing by means of the intermediate upper bearing seat. Thus, a particularly efficient compensation of peak loads of the rotating crankshaft on the crankcase is ensured by the sliding bearings as well as the axial ball bearing, which is why according to this particular design a particularly smooth, quiet operation of the moving parts of the pump unit and its crank train is made possible.

[0025] In order to further improve the compact construction of the encapsulated refrigerant compressor according to the invention, it can be advantageous if an upper axial bearing seat of the ball bearing is positioned on the lower side of the counterweight. On the opposite lower side of the axial bearing a lower axial bearing seat of the ball bearing is positioned on top of the crankcase or can be positioned within a bearing recess of the crankcase. This arrangement ensures particularly smooth running of the rotating counterweight of the crankshaft, as the counterweight rests flat on the ball bearing or axial bearing with an axial bearing seat on its underside. A further advantage of such an arrangement of the counterweight as close as possible to the bearings of the crankshaft is to avoid crankshaft bending. As the ball bearing is in contact with or adjacent to the lower side of the counterweight, axial bearing forces of the rotor and the crankshaft can be absorbed as efficiently as possible.

[0026] A particularly compact design of the inventive refrigerant compressor can be obtained if the ball bearing is positioned at least in sections within the bearing recess of the crankcase. According to this embodiment the concentric bearing recess on the outsides of the sleeve-shaped extension has the advantage to host at least a part of the ball bearing and thus enables a particularly compact design of the crank train.

[0027] Advantageously the encapsulated refrigerant compressor according to the invention can have a crank train wherein the crankpin of the crankshaft protrudes from a first upper side of the counterweight, wherein said crankshaft protrudes from an opposite second lower side of the counterweight with respect to the crankpin, and wherein the longitudinal axis of the crankpin is positioned eccentrically and parallel with respect to the longitudinal axis of the crankshaft. Due to this compact arrangement according to which the crankpin as bearing seat for the connecting rod is positioned as close as possible in regard to the axial direction of the crankshaft to the upper crankshaft end and is only spaced from it by the intervening counterweight, this ensures that the piston runs as evenly as possible.

[0028] According to another advantageous embodiment of the invention the counterweight can be integrally formed in one piece with the crankshaft and with the crankpin. This embodiment has the advantage that manufacture of the crankshaft in one piece with fully integrated counterweight and crankpin can be cheap and efficient, and can be embodied for example as integrally-formed cast component or cast part.

[0029] In a further advantageous embodiment of the invention the encapsulated refrigerant compressor can have an additional second counterweight that is stationary fixed to the crankpin, wherein preferably the connecting rod is arranged between the first counterweight and the additional second counterweight. By means of this additional second counterweight the piston movement can be further evened out to allow a smooth piston run.

[0030] Furthermore, it may be expedient if in a further embodiment of the invention the piston is connected with the connecting rod via a piston pin, wherein the piston pin is fixed to the piston via a clamping sleeve that is inserted into a matching axial opening in the piston and the piston pin. Advantageous the clamping sleeve locks the piston pin into a piston pin bore of the piston without the need of press-fit. That can reduce the deformation on the piston walls. Keeping a better cylindricity and allowing smaller piston cylinder clearances, reducing leakage and improving overall efficiency of the refrigerant compressor. Advantageously the fixation of the head-group can be done without screws, what makes the deformation on the cylinder area smaller, allowing the usage of smaller piston cylinder clearance.

[0031] To provide a flexible connecting rod that can compensate for a high crankshaft bending, the encapsulated refrigerant compressor according to the invention can have a connecting rod that comprises a big eye bearing on its one end and a small eye bearing on its opposite second end, wherein both eye bearings are connected with a flexible connecting rod bar, and wherein said flexible connecting rod bar has at least one damping opening that is oriented in parallel to the big eye bearing and the small eye bearing. Due to the at least one damping opening in the flexible connecting rod bar, flexibility and bendability of the connecting rod can be adjusted.

[0032] According to a further development of the invention, the flexible connecting rod bar has at least one damping opening with a circular cross section and at least one damping opening with a triangular cross section, and wherein the big eye bearing in a lateral view has a barrel shape. By means of two or more damping openings with the same or with different cross sections the flexibility and bendability of the connecting rod can be further adjusted. Such a flexible connecting rod allows the piston run parallel to the cylinder, reducing edge loading and friction, even with lower viscosity oils.

[0033] Advantageously the big eye bearing has a barrel shape as can be seen in a lateral view, preferably in a lateral sectional view. The barrel-shape design of the big eye bearing which results in a height-wise elevation in the axial direction of the big eye bearing upwards as well as downwards in relation to a height of the connecting rod bar, ensures that the loads and torques acting on the connecting rod are transferred as gently and evenly as possible to the crankpin. Thus, the contact surface between the crankpin and the big eye bearing is advantageously increased due to the barrel shape.

[0034] To provide a refrigerant compressor with the function of an integrated oil pump, a lubricant conveying system of the pump unit can comprise an oil pickup for conveying lubricant from a lubricant sump formed in a lower shell part of the compressor shell during operation to the rotating parts of the cranktrain, wherein the oil pickup is positioned on a lower end of the crankshaft, and wherein the oil pickup is configured to distribute lubricant along an oil path upwards within an inner oil supply bore in axial direction of the crankshaft, and further to distribute lubricant via a lower lubrication bore to a helical groove, wherein the lower lubrication bore is positioned at the level of the lower sliding bearing and is in communication to the inner oil supply bore, and wherein the helical groove is arranged along the peripheral surface of a lubrication section of the crankshaft, and further to distribute lubricant via an upper lubrication bore to the ball bearing, wherein the upper lubrication bore is positioned at the level of the upper sliding bearing and is in communication to the inner oil supply bore, and further to distribute lubricant via an crankpin lubrication bore to an oil splash outlet on top of the crankpin, wherein said oil splash outlet is configured to lubricate the piston.

[0035] The crankshaft with the outside helical groove and the lubrication bores together with an oil pickup in form of an oil pump sleeve define the oil pump system. The oil pump on the bottom collects oil or lubricant from the sump and by centrifugal loads during operation of the compressor and a helical blade reaching into the sump the oil is forced to rise to the lower sliding bearing. From there, a helical groove takes the oil to the upper sliding bearing, and from there, a lubricating bore takes the oil to the crankpin and piston via the oil splash outlet.

[0036] In a further development of the invention, it may be advantageous if the oil pickup is mounted to the rotor, and wherein a helical blade within the oil pickup is configured to distribute lubricant upwards within the inner oil supply bore. This design provides a very compact build-up of the pump unit. Due to a helical blade that reaches into the oil pickup the lubricant is advantageously diverted upwards within the inner oil supply bore of the crankshaft during operation of the compressor.

[0037] According to another appropriate embodiment of the invention, the inner oil supply bore in axial direction of the crankshaft can have a crankshaft degassing bore on its upper end, wherein the crankshaft degassing bore leads through the counterweight and ends on its upper side. Due to this design degassing effects are enhanced within the oil pump system and unwanted dry running of the moving or sliding parts of the compressor can be avoided.

[0038] Also an inlet of the oil pump sleeve may have a degassing bore, preferably an elongated degassing bore, to improve degassing effects, making it easier for gas bubbles to disappear.

[0039] According to even another advantageous embodiment of the invention, the encapsulated refrigerant compressor can comprise a cylinder head assembly that is mounted to the cylinder housing of the crankcase, the cylinder head assembly comprising a valve plate, a suction valve spring, a discharge valve spring, a suction muffler and a discharge muffler, wherein the discharge muffler has a discharge connection tube being connected to the discharge pipe. Due to this design, cylinder head assembly is particularly easy and possible without tools as far as possible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] The invention will now be explained in more detail below with reference to exemplary embodiments. The drawings are provided by way of example and are intended to explain the concept of the invention, but shall in no way restrict it or even render it conclusively, wherein:

- Fig. 1 shows a three-dimensional view of a refrigerant compressor from the outside;
- Fig. 2 shows an exploded view of the refrigerant compressor;
- Fig. 3 shows a three-dimensional view of an assembled pump unit of the refrigerant compressor;
- Fig. 4 shows a lateral sectional view of the structure of an assembled pump unit of the refrigerant compressor;
- Fig. 5 shows an exploded view of the pump unit as depicted in Fig. 4;
- Fig. 6 shows in detail a connecting rod and piston connected thereto in a three-dimensional sectional view according to embodiment as depicted in Fig. 5;
- Fig. 7 shows in a three-dimensional view a connecting rod according to the invention;
- Fig. 8 shows a three-dimensional view of a first embodiment of a crank train of the refrigerant compressor;
- Fig. 9 shows a three-dimensional view of a second embodiment of a crank train of the refrigerant compressor.

DETAILED DESCRIPTION

[0041] Fig. 1 shows an outside view of an, in particular hermetically, encapsulated refrigerant compressor 1 which extends along a length direction x, a width direction y and a height direction z. Length direction x, width direction y and height direction z form an orthogonal reference system. In general, the length dimension of the refrigerant compressor measured along the length direction x is greater than the width dimension measured along the width direction y.

[0042] In the following reference will occasionally be made to (usually gaseous) refrigerant, which flows through the refrigerant compressor 1. It is self evident that these remarks refer to an operating state of the refrigerant compressor 1, but that usually no refrigerant is present in the refrigerant compressor 1 when the refrigerant compressor 1 is produced or sold as a stand-alone product.

[0043] The refrigerant compressor 1 comprises a compressor shell 100, which in this embodiment consists of a lower shell part 110 and an upper shell part 120. The upper shell part 120 and the lower shell part 110 are welded together. On both sides of the lower shell part 110, which extend mainly in the length direction x, a supporting base plate 160 is fixed to the compressor shell 100. Each supporting base plate 160 has two openings 164 for mounting support damper assemblies 90 (see Fig. 2).

[0044] A suction pipe 30, which is connectable to a low pressure side of a refrigerant appliance, enters the upper shell part 120 on a lateral side of the refrigerant compressor 1. During operation refrigerant is sucked into the refrigerant compressor 1 through the suction pipe 30, mainly during a suction cycle of a pump unit 10 (see Fig. 3) of the refrigerant compressor 1. Therefore, in an operating state, the suction pipe 30 is connected directly or indirectly, e.g. through piping of the low pressure side of the refrigerant appliance, to an evaporator of the refrigerant appliance. With regard to the compressor shell 100, the suction pipe 30 is entering the upper shell part 110 through a second connector element 80, which second connector element 80 is hermetically connected to the upper shell part 120 on the one hand and to the suction pipe 30 on the other hand, for example by welding and/or soldering.

[0045] A discharge pipe 20 as well as a maintenance pipe 40 enters the lower shell part 110 on a front side of the refrigerant compressor 1. The discharge pipe 20 enters the lower shell part 110 through a first connector element 70, which first connector element 70 is hermetically connected to the lower shell part 110 on the one hand and to the discharge pipe 20 or maintenance pipe 40 respectively on the other hand, for example by welding and/or soldering. During operation, refrigerant compressed by the pump unit 10 can escape the refrigerant compressor 1 through the discharge pipe 20, mainly during a compression and discharge cycle of the pump unit 10. Therefore, the discharge pipe 20 is connectable to a high pressure side of the refrigerant appliance to allow compressed refrigerant to be fed to a high pressure side of the refrigerant appliance. In the operation state the discharge pipe 20 is connected directly or indirectly, e.g. through piping of the high pressure side of the refrigerant appliance, to a condenser of the refrigerant appliance.

[0046] The maintenance pipe 40 can be used to insert lubrication oil and/or refrigerant into the refrigerant compressor 1 during assembly of the refrigerant application or during maintenance operations. The maintenance pipe 40 is, similar to the suction pipe 30, connected to the lower shell part 110 by a second connector element 80, which is hermetically connected to the lower shell part 110 on the one hand and to the maintenance pipe 40 on the other hand, for example by welding and/or soldering.

[0047] With regard to Fig. 2 all main components of the refrigerant compressor 1 as well as their functions will be briefly described. The refrigerant compressor 1 comprises the shell 100, an electronic control unit 800, which is detachably mounted to the compressor shell 100, and the pump unit 10 (see Fig. 3), which is located inside the compressor shell 100 and supported by four support spring assemblies 60. The refrigerant compressor 1 is mounted on four support damper assemblies 90, which are connected to the respective openings of the two supporting base plates 160. Each support damper assembly 90 includes a damper pin 92, an outer dampening element 91, a lining disk 93 and a securing element 94.

[0048] As can be seen in Fig. 2, the suction pipe 30 enters the upper shell part 120 through a second connection opening 102, whereas the maintenance pipe 20 enters the lower shell part 110 through a third connection opening 103. Even though not visible in Fig. 2, the discharge pipe 20 enters the lower shell part 110 through a first connection opening 101.

[0049] The pump unit 10 comprises an electric drive unit 400, a cranktrain 200, a crankcase 300 and a cylinder head assembly 500, which includes a suction muffler 600 and a discharge muffler 700.

[0050] Each support spring assembly 60 comprises a mounting pin 140, which is fixed, preferably welded, to the lower shell part 110, a lower spring pin 61, which is mounted on the respective mounting pin 140, and a support spring 62, which is supported on the lower spring pin 61.

[0051] The electric drive unit 400 comprises a stator 420, a rotor 410 and an inner harness 430. The stator 420 has a lower end element 421 made of plastic, which lower end element 421 comprises four upper spring holders 63 for the respective support springs 62. The stator 420 is fixed to the crankcase 300 via two stator mounting screws 340. The inner harness 430 connects the stator 420 with an electric pass-through element 50, which is located in the compressor shell 100. On the outside of the compressor 1 the electronic control unit 800 is connected to the electric pass-through element 50 via an outer harness 801, in order to control the rotation speed of the pump unit 10.

[0052] The cranktrain 200 comprises a piston 240 and a crankshaft 210, which is rotatably mounted inside a main bearing section 302 of the crankcase 300 on the one hand and axially supported on the crankcase 300 by a ball bearing 201. The crankshaft 210 has a crankpin 220 on which a connecting rod 230 is mounted, which connecting rod 230 connects the crankpin 220 with a piston pin 243 of the piston 240. The piston pin 243 is fixed to the piston 240 via a clamping sleeve 244 that is inserted into a matching axial opening in the piston 240 and the piston pin 243. On a lower end of the crankshaft 210, opposite the end with the crankpin 220, the rotor 410 is mounted to the crankshaft 210, preferably via press fitting. Further an oil pickup 250 for conveying lubricant from a lubricant sump formed in the lower shell part 110 during operation into a lubricant conveying system of the cranktrain 200 is mounted to the rotor 410 via three mounting rivets 251.

[0053] The crankcase 300 includes a cylinder housing 310, in which a cylinder 320 is formed. The piston 240 reciprocates within the cylinder 320 during operation of the refrigerant compressor 1 in order to suck refrigerant into the cylinder 320 during a suction cycle and to compress and discharge the compressed refrigerant during a compression and discharge cycle. On the crankcase 300 a set of two first protrusions 301 is located on the side opposite of the cylinder housing 310 and a set of two second protrusions 311 is located on the cylinder housing 310 itself. Inner dampening elements 330 are attached to each of the first protrusions 301 and second protrusions 311, which inner dampening elements 330 interact with respective regions of an inner surface of the upper housing part 120 in order to dampen vibrations of the pump unit 10 during operation and to prevent damages during transport.

[0054] In order to establish a suction path and a discharge path for the refrigerant from the suction pipe 30 via the cylinder 320 to the discharge pipe 20, the cylinder head assembly 500 is mounted onto a cylinder head section of the cylinder housing 510. The cylinder head assembly 500 comprises a cylinder gasket 510, a suction valve spring 520, a valve plate 530 and a discharge valve spring 540, wherein the valve plate 530 has a suction opening 531 and a discharge opening 532. The cylinder gasket 510 and the suction valve spring 520 are located on a suction side 530a of the valve plate 530, which suction side faces towards the piston 240.

[0055] The discharge valve spring 540 is located on a discharge side 530b of the valve plate 530, which faces in the opposite direction of the piston 240. When assembled, the valve plate 530, the suction valve spring 520 and the cylinder gasket 510 are pressed into a valve plate seat 312 of the cylinder housing 310, as will be described below in detail.

[0056] A suction connector head 640 of the suction muffler 600 and a discharge connector head 730 of the discharge muffler 700 are pressed onto the discharge side 530b of the valve plate 530, wherein a first sealing element 550 is placed between the valve plate 530 and the suction connector head 640 as well as the discharge connector head 730, respectively.

[0057] During the suction cycle of the pump unit 10, the piston 240 inside the cylinder 320 moves away from the valve plate 530, so that a negative pressure builds up in the cylinder 320, because the suction valve spring 520 keeps the suction opening 531 of the valve plate 530 closed due to its spring force, while the discharge valve spring 540 closes the discharge opening 532 of the valve plate 530. When the negative pressure exceeds a certain threshold, the suction valve spring 520, which at least has a section configured as a reed valve, opens the suction opening 531 to allow refrigerant to flow from the suction pipe 30 through the suction muffler 600 into the cylinder 320.

[0058] During the compression cycle of the pump unit 10, the piston 240 inside the cylinder 320 moves in the direction of the valve plate 530, so that the refrigerant in the cylinder 320 is compressed, because the discharge valve spring 540 keeps the discharge opening 532 of the valve plate 530 closed due to its spring force, while the suction valve spring 520 keeps the suction opening 531 of the valve plate 530 closed. Once the pressure of the compressed refrigerant exceeds a predefined threshold, the discharge valve spring 540, which is configured as a reed valve, opens the discharge opening 532 of the valve plate 530 to allow refrigerant to flow from the cylinder 320 through the discharge muffler 700 to the discharge tube 20.

[0059] The suction muffler 600 includes a lower housing part 610, an upper housing part 620 and an inner housing element 630, which is inserted into a suction muffler volume 601 defined by the lower housing part 610 and the upper housing part 620 of the suction muffler 600. Refrigerant is sucked into the suction muffler 600 via an inlet opening 621 located in the upper housing part 620 mainly during the suction cycle of the pump unit 10. The suction muffler 600 dampens sound based on the well-known Helmholtz principle when refrigerant flows through it, i.e. by chambers formed within the suction muffler 600 which acts as resonators that absorb sound. The refrigerant escapes the suction muffler 600 through the suction connector head 640, which is placed above the suction opening 531 of the valve plate 530 and is located on the upper housing part 620 of the suction muffler 600.

[0060] The discharge muffler 700 includes a lower housing part 710, an upper housing part 720 and the discharge connector head 730, which is connected to the upper housing part 720 of the discharge muffler 700. During the discharge cycle of the pump unit 10, compressed refrigerant coming from the discharge opening 532 of the valve plate 530 enters the discharge muffler 700 though the discharge connector head 730. The discharge muffler

700 dampens sound based on the well-known Helmholtz principle when refrigerant flows through it, i.e. by chambers formed within the discharge muffler 700 which chambers act as resonators that absorb sound and or by pulsation filtering. The compressed refrigerant escapes the discharge muffler 700 through a discharge connection tube 750, which is connected to the discharge tube 20 via connection sleeve 760 and an O-ring seal 762.

[0061] The mounting of the cylinder head assembly 500 to the cylinder housing 310 is facilitated by a mounting assembly 580 (see Fig. 3), which comprises a clamping element 560 for clamping the valve plate 530 to the valve plate seat 312 and a fixing element 570, which presses the suction connector head 640 and the discharge connector head 730 onto the valve plate 530. The fixing element 570 is latched onto the clamping element 560. The clamping element 560 further comprises two positioning pins 565 (see Fig. 2), which are used for aligning the discharge connector head 730 with the discharge opening 532 and the suction connector head 640 with the suction opening 531 respectively.

[0062] Fig. 3 shows the pump unit 10 of the refrigerant compressor 1 in an assembled state. The suction muffler 600 and the discharge muffler 700 are fixed to the cylinder housing 210 via the clamping element 560 and the fixing element 570 of the mounting assembly 580, while the crankshaft 210 is inserted into the crankcase 300 and the stator 420 is surrounding the rotor 410.

[0063] Fig. 4 shows the structure or build-up of an assembled pump unit 10 of the refrigerant compressor 1. Reference is made also to Fig. 5 that shows an exploded view of the pump unit 10 as depicted in Fig. 4. The cranktrain 200 comprises a piston 240 and a crankshaft 210, which is rotatably mounted inside a main bearing section 302 of the crankcase 300 on the one hand and axially supported on the crankcase 300 by a ball bearing 201.

[0064] The crankshaft 210 has a crankshaft axis 211 that indicates the axial direction of the crankshaft 210. Perpendicular to the crankshaft axis 211 is depicted in Fig. 4 via arrows a radial direction 212 of said crankshaft 210.

[0065] As can be seen in Fig. 5, in axial direction of the crankshaft 210 starting on top with the crankpin 220 and the counterweight 225 are several regions formed in downward direction along its outside: an upper bearing section 215, thereupon below a lubrication section 216, further downstream of it a lower bearing section 217, and even further downwards a rotor fixation section 218 where the rotor 410 of the electric drive unit 400 is mounted to the crankshaft 210, preferably via press fitting.

[0066] The crankshaft 210 transfers the rotating movement from the electric drive unit 400 to the connecting rod 230 and further to the piston 240. It has two bearing sections 215 and 217 which interact with a corresponding main bearing section 302 that acts as a crankshaft bearing shell of the crankcase 300. The two bearing sections 215 and 217 are both arranged in axial direction 211 below the connecting rod 230. Furthermore, a crankpin bearing 223 interacts with the connecting rod 230. The rotor 410 is fixed to the bottom side of the crankshaft 210 below the lower bearing section 217 by press-fit.

[0067] The lubrication unit 216 further comprises a lubrication recess 216a that forms a thin lubrication gap in communication with the main bearing section 302 of the crankcase 300. An axial length 216b of the lubrication recess 216a corresponds to the axial length of said lubrication section 216 that is positioned between the upper bearing section 215 and the lower bearing section 217.

[0068] On top of the counterweight 225a, respectively on its upper side 225a, there is the crankpin 220 positioned. A crankpin axis 221 runs in parallel with the crankshaft axis 211, wherein the crankpin axis 221 is arranged eccentrically to the crankshaft axis 211. The crankpin 221 has a crankpin lubrication recess 222, wherein lubricant that is supplied from a crankpin lubrication bore 223 that is in communication with said crankpin lubrication recess 222, is distributed to lubricate the crankpin sliding bearing 224.

[0069] The crankpin 220 of the crankshaft 210 protrudes from a first upper side 225a of the counterweight 225. The crankshaft 210 protrudes from an opposite second lower side 225b of the counterweight 225 with regard to the crankpin 220. The longitudinal axis 221 of the crankpin 220 is positioned eccentrically and parallel with regard to the longitudinal axis 211 of the crankshaft 210.

[0070] The crankcase 300 has two crankcase legs 303 connected to the stator 420, resulting in a light weight and small component build-up. The crankcase 300 has a groove in the back of the cylinder housing 310 to facilitate the assembly of the connecting rod 230 into the crankshaft 210 and following the piston pin 243 and clamping sleeve 244.

[0071] The main bearing section 302 of the crankcase 300 acts as a crankshaft bearing shell, within which the crankshaft 210 is slidably mounted. As said before, the crankshaft 210 has a first, upper bearing section 215 and has spaced therefrom in an axial distance 216b a second, lower bearing section 217. The upper bearing section 215 is configured to interact with the main bearing section 302 as upper bearing journal to form a first, upper sliding bearing 215b. The lower bearing section 217 is configured to interact with the main bearing section 302 of the crankcase 300 as lower bearing journal to form a second, lower sliding bearing 217b. An upper bearing seat 305 for said upper bearing section 215 of the crankshaft 210 is positioned at an upper end section of the main bearing section 302 of the crankcase 300. Said upper end section of the main bearing section 302 is facing towards the counterweight 225 and facing towards an upper side 300a of the crankcase 300. The upper bearing seat 305 is configured to be flexibly bendable in a radial direction 212 of the crankshaft 210 to reduce edge loading of the crankshaft 210 relative to the crankcase 300.

[0072] The upper bearing seat 305 has an inner side 305a and an outer side 305b. The inner side 305a faces towards the crankshaft 210. The outer side 305b of the upper bearing seat 305 faces towards a bearing recess 308 as can be seen in Fig. 5. According to this embodiment as shown in Fig. 5, the upper bearing seat 305 of the crankcase 300 for the upper bearing section 215 of the crankshaft 210 is designed as a sleeve-shaped cylindrical extension 306 of the crankcase 300 with a wall thickness 307a and an axial height 307b.

[0073] The wall thickness 307a is here for example selected such that the wall thickness 307a is approximately 10% of the diameter of the crankshaft 210. The ratio between the axial height 307b and the wall thickness 307a of the sleeve-shaped cylindrical extension 306 is here for example selected as an axial height 307b corresponding 3.5 times the wall thickness 307a. In other words, the axial height 307b is chosen here as 3.5 times the wall thickness 307a to allow a flexible bending of the sleeve-shaped cylindrical extension 306. The wall thickness 307a is here constant along the axial height 307b of the sleeve-shaped cylindrical extension 306.

[0074] Due to the flexibly bendable configuration of the upper bearing seat 305, it is possible to reduce the edge load on the upper sliding bearing 215b due to the high bending of the crankshaft 210.

[0075] The upper bearing seat 305 for the upper bearing section 215 of the crankshaft 210 is formed by a bearing recess 308 within the crankcase 300 that extends from the upper side 300a of the crankcase 300. The bearing recess 308 runs concentrically around the outer side 305b of the upper bearing seat 305 downwards in axial direction 211 of the crankshaft 210.

[0076] According to Figures 4 and 5, the bearing recess 308 has an essentially V-shaped cross-section 309 that tapers in regard to the axial direction 211 of the crankshaft 210 towards the main bearing section 302.

[0077] The ball bearing 201 that functions as axial bearing supports the axial load of the rotor 410 and the crankshaft 210 against the crankcase 300. The ball bearing is positioned below the counterweight 225, wherein an upper axial bearing seat 202 of the ball bearing 201 is positioned on the lower side 225b of the counterweight 225. As the ball bearing 201 is positioned here at least in sections within the bearing recess 308, a lower axial bearing seat 203 of the ball bearing 201 is positioned within said bearing recess 308. According to this embodiment, the ball bearing 201 is advantageously centered in radial direction 212 of the crankshaft 210 by the outer side 305b of the upper bearing seat 305.

[0078] As can be seen in Figures 6 and 7 in detail, the connecting rod 230 is designed to be flexible for defined compressor operating conditions to compensate for the high crankshaft 210 bending, making the piston 240 run parallel to the cylinder housing 310, and reducing edge loading and friction, even with lower viscosity oils. The connecting rod 230 comprises a big eye bearing 231 on its one end and a small eye bearing 232 on its opposite second end. Both eye bearings 231, 232 are connected with a flexible connecting rod bar 233 that is positioned between both eye bearings 231, 232. The flexible connecting rod bar 233 has here two separate damping openings 236 that are oriented in parallel to the big eye bearing 231 and the small eye bearing 232. A first damping opening 236 has a circular cross section 237 and a second damping opening 236 has a triangular cross section 238. The big eye bearing 231 in a lateral view has a barrel shape 239.

[0079] Within the small eye bearing 232 there is a lubrication slot 232a that lubricates the sliding bearing of the piston pin 243 in interaction with the small eye bearing 232. The lubrication slot 232a functions to receive oil from crankshaft splash and lubricate the small eye bearing 232.

[0080] The flexible connecting rod bar 233 has a rod width 234 and a rod height 235. Flexibility of the connecting rod 230 or the flexible connecting rod bar 233, respectively, can be adjusted via selecting the rod width 234 and/or rod height 235 in combination by appropriate positioning of damping openings 236.

[0081] As can be seen in Figures 5 and 6, the piston 240 has two regions: a first region as piston top 241 that defines the sealing area of the piston 240 towards the cylinder housing 310. The entire perimeter of the piston top 241 is in sliding contact with the cylinder housing 310. A second region of the piston 240 is a piston skirt 242, wherein the piston skirt 242 has material on its sides and one piston skirt recess 242a on its upper side as well as another one piston skirt recess 242a on its lower side. By means of the piston skirt recesses 242a, the contact area along this region of the piston skirt 242 towards the cylinder housing 310 can be reduced. Thus, also friction can be reduced. Furthermore, the piston has a protrusion 245 on its top that goes inside the valve plate 530 to reduce the noxious space, increasing the compressor efficiency.

[0082] The piston pin 243 has a piston pin recess 243 to receive oil splashed by the crankshaft 210 to the back of the piston 240 and make it slide down through the piston pin 243 to the small eye lubrication slot 232a of the connecting rod 230, lubricating the small eye bearing 232.

[0083] The connecting rod 230 connects the crankpin 220 with a piston pin 243 of the piston 240. The piston pin 243 is fixed to the piston 240 via a clamping sleeve 244 that is inserted into a matching axial opening 246 in the piston 240 and the piston pin 243. Thus, the clamping sleeve 244 locks the piston pin 243 into a piston pin bore 247 without the need of press-fit. That reduces the deformation on the piston walls, keeping a better cylindricity and allowing smaller piston cylinder clearances, reducing leakage, and improving efficiency.

[0084] With reference to Figures 4 and 5, in the following the oil pump system or lubricant conveying system, respectively, of the inventive refrigerant compressor is described in more detail: The lubricant conveying system of the pump unit 10 comprises an oil pickup 250 for conveying lubricant from a lubricant sump formed in a lower shell part 110 of the compressor shell 100 during operation to the rotating parts of the cranktrain 200. The oil pickup 250 is positioned on a lower end of the crankshaft 210. The oil pickup 250 is configured to distribute lubricant along an oil path 260 upwards within an inner oil supply bore 254 in axial direction 211 of the crankshaft 210. From there the oil or lubricant is further distributed via a lower lubrication bore 255 to a helical groove 256 that is arranged on an outside of the crankshaft 210 along the peripheral surface of the lubrication section 216, even more precisely that is arranged along the length 216b of the lubrication recess 216a along the lubrication section 216 of the crankshaft 210. The lower lubrication bore 255 is positioned at the level of the lower sliding bearing 217b and is in communication to the inner oil supply bore 254.

[0085] From there the oil or lubricant is distributed further via an upper lubrication bore 265 to the ball bearing 201, wherein the upper lubrication bore 265 is positioned at the level of the upper sliding bearing 215b and is in communication to the inner oil supply bore 254. Lubricant can be further upwards distributed via a crankpin lubrication bore 275 to an oil splash outlet 280 on top of the crankpin 220. The oil splash outlet 280 is configured to lubricate the piston 240.

[0086] In Fig. 4 the oil path 260 is symbolised via a dotted line 260 with arrows. The oil pickup 250 is mounted to the rotor 410, and a helical blade 252 is positioned within the oil pickup 250 and is configured to distribute lubricant that is provided within an oil pump sleeve 253 of the oil pickup 250. Due to a helical blade 252 that reaches into the oil pickup the lubricant is advantageously diverted upwards within the inner oil supply bore 254 of the crankshaft 210 during operation of the compressor 1.

[0087] An inlet of the oil pump sleeve 253 has a degassing bore, here in a preferred embodiment an elongated degassing bore 253a, to improve degassing effects, making it easier for gas bubbles to disappear.

[0088] Usually the rotor 410 is a press-fit fixed to the crankshaft 210. Additionally, the oil pump can be press-fit to the crankshaft 210 as a second process step. In this case, the oil pump is integrated to the rotor 210 making possible to assembly both in one step, simplifying assembly and reducing cost.

[0089] The inner oil supply bore 254 of the crankshaft 210 in axial direction 211 of the crankshaft 210 has a crankshaft degassing bore 270 on its upper end, wherein the crankshaft degassing bore 270 leads through the counterweight 225 and ends on its upper side 225a. Due to this design, degassing effects are enhanced within the lubricant conveying system. Thus, unwanted dry running of the moving or sliding parts of the compressor 1 can be avoided.

[0090] Fig. 8 shows a three-dimensional view of a first embodiment of a crank train 200 of the refrigerant compressor 1. This embodiment of the crank train 200 has been described before and comprises one counterweight 225 that is positioned between the crankpin 220 for the connecting rod 230 and the crankshaft 210 below. Here the counterweight 225 is fully integrated in the crankshaft 210.

[0091] Fig. 9 refers to a second embodiment of a crank train 200 of the refrigerant compressor 1, that has besides a first counterweight 225 an additional second counterweight 226. This additional second counterweight 226 is stationary fixed onto the tip of the crankpin 220, wherein the connecting rod 230 is arranged between the first counterweight 225 and the additional second counterweight 226 above the connecting rod 230. The additional second counterweight 226 has a degassing bore 227 to improve degassing effects, making it easier for gas bubbles to disappear.

LIST OF REFERENCE NUMBERS

[0092]

1	refrigerant compressor
10	pump unit
20	discharge pipe
30	suction pipe
40	maintenance pipe
50	electric pass-through element
60	support spring assembly
61	lower spring pin
62	support spring
63	upper spring holder
70	first connector element
80	second connector element
90	support damper assembly
91	outer dampening element
92	damper pin
93	lining disk
94	securing element
100	compressor shell
101	first connection opening
102	second connection opening
103	third connection opening
104	oil pocket
110	lower shell part
120	upper shell part
160	supporting base plate
164	opening of the supporting base plate
200	cranktrain
201	ball bearing
202	upper axial bearing seat of ball bearing
203	lower axial bearing seat of ball bearing
210	crankshaft
211	crankshaft axis, axial direction of crankshaft
212	radial direction of crankshaft (arrow)
215	upper bearing section of crankshaft
216	lubrication section of crankshaft
216a	lubrication recess of crankshaft
216b	length of lubrication recess of crankshaft
217	lower bearing section of crankshaft
218	rotor fixation section of crankshaft
220	crankpin

221 crankpin axis
222 crankpin lubrication recess
223 crankpin lubrication bore
224 crankpin bearing
225 counterweight
225a upper side of counterweight
225b lower side of counterweight
226 additional second counterweight
227 degassing bore of second counterweight
230 connecting rod
231 big eye bearing
232 small eye bearing
232a lubrication slot within small eye bearing
233 connecting rod bar
234 rod width
235 rod height
236 damping opening
237 damping opening with circular cross section
238 damping opening with triangular cross section
240 piston
241 piston top
242 piston skirt
242a piston skirt recess
243 piston pin
243a piston pin recess
244 clamping sleeve
245 protrusion
246 axial opening
247 piston pin bore
250 oil pickup
251 mounting rivet
252 helical blade
253 oil pump sleeve
253a elongated degassing bore
254 oil supply bore
255 lower lubrication bore
256 helical groove
260 oil path (arrow)
265 upper lubrication bore
270 crankshaft degassing bore
275 crankpin lubrication bore
280 oil splash outlet
300 crankcase
300a upper side of crankcase
301 first protrusion
302 main bearing section
303 crankcase leg
305 upper bearing seat
305a inner side of upper bearing seat
305b outer side of upper bearing seat
306 cylindrical extension
307a wall thickness of upper bearing seat
307b axial height of upper bearing seat
308 bearing recess
309 cross section of bearing recess
310 cylinder housing
311 second protrusion
312 valve plate seat
320 cylinder
330 inner dampening elements
340 stator mounting screw
400 electric drive unit
410 rotor
420 stator
421 lower end element
430 inner harness
500 cylinder head assembly
510 cylinder gasket
520 suction valve spring
530 valve plate
530a suction side of the valve plate
530b discharge side of the valve plate
530c circumferential surface of the valve plate
531 suction opening
532 discharge opening
533 first positioning protrusion
534 centering protrusion
535 first recess
540 discharge valve spring
550 first sealing element
560 clamping element
565 positioning pins
570 fixing element
580 mounting assembly
600 suction muffler
601 suction muffler volume
610 lower housing part of the suction muffler
620 upper housing part of the suction muffler
621 inlet opening
630 inner housing element
640 suction connector head
700 discharge muffler
710 lower housing part of the discharge muffler
720 upper housing part of the discharge muffler
730 discharge connector head
750 discharge connection tube
760 connection sleeve
800 electronic control unit
801 outer harness
802 main housing of electronic control unit
803 cover of housing of electronic control unit
x length direction
y width direction
z height direction
h horizontal plane
v_1 first vertical plane
v_2 second vertical plane
C_1 first centre point
C_2 second centre point

Claims

1. An encapsulated refrigerant compressor (1) having

- a compressor shell (100) with connection open-

ings (101, 102, 103) for a discharge pipe (20), a suction pipe (30), and a maintenance pipe (40) each entering the compressor shell (100);
- a pump unit (10) that is located within the compressor shell (100) and supported via a plurality of support spring assemblies (60), said pump unit (10) comprising:

-- a cranktrain (200) having a crankshaft (210) with a counterweight (225), a crankpin (220), a connecting rod (230) and a piston (240), wherein the connecting rod (230) is rotatably mounted on the crankpin (220) of the crankshaft (210), and wherein the connecting rod (230) connects the crankpin (220) with the piston (240);
-- a crankcase (300) with a cylinder housing (310), wherein a cylinder (320) for reciprocating movement of the piston (240) is located in the cylinder housing(310), and wherein the crankshaft (210) is rotatably mounted inside a main bearing section (302) of the crankcase (300) that acts as a crankshaft bearing shell;
-- an electric drive unit (400) having a stator (420) and a rotor (410), the rotor (410) being fixed to the crankshaft (210), and wherein the stator (420) is attached to the cylinder crankcase (300);
-- wherein the crankshaft (210) is axially supported by a ball bearing (201) on the crankcase (300), wherein said ball bearing (201) is positioned below the counterweight (225) and is configured to support in an operation state of said compressor (1) an axial load of the rotor (410) and the crankshaft (210) against the crankcase (300),

characterised in that

the crankshaft (210) comprises a first, upper bearing section (215) and, spaced therefrom (215) in an axial distance (216b), a second, lower bearing section (217), wherein the upper bearing section (215) is configured to interact with the main bearing section (302) to form a first, upper sliding bearing (215b), and wherein the lower bearing section (217) is configured to interact with the main bearing section (302) to form a second, lower sliding bearing (217b), wherein an upper bearing seat (305) as the part of the main bearing section (302) forming the first, upper sliding bearing (215b) is arranged at an upper end section of the main bearing section (302) of the crankcase (300), wherein said upper end section of the main bearing section (302) is facing towards the counterweight (225), and wherein said upper bearing seat (305) is configured to be flexibly bendable in a radial direction (212) of the crankshaft (210) to reduce edge loading of the crankshaft (210) relative to the crankcase (300).

2. The encapsulated refrigerant compressor (1) according to claim 1, **characterized in that** the upper bearing seat (305) of the crankcase (300) for the upper bearing section (215) of the crankshaft (210) is designed at least partly as a sleeve-shaped cylindrical extension (306) of the crankcase (300) with a wall thickness (307a) and an axial height (307b).

3. The encapsulated refrigerant compressor (1) according to claim 2, **characterized in that** the sleeve-shaped cylindrical extension (306) of the crankcase (300) has an axial height (307b) corresponding to at least 2 times the wall thickness (307a), and wherein the wall thickness (307a) is between 5% and 20% of the diameter of the crankshaft (210).

4. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 3, **characterized in that** the upper bearing seat (305) for the upper bearing section (215) of the crankshaft (210) is formed by a bearing recess (308) within the crankcase (300), wherein the ball bearing (201) is preferably positioned at least in sections within the bearing recess (308).

5. The encapsulated refrigerant compressor (1) according to claim 4, **characterized in that** the bearing recess (308) has an essentially V-shaped cross-section (309) that tapers in regard to the axial direction (211) of the crankshaft (210) towards the main bearing section (302).

6. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 5, **characterized in that** the ball bearing (201) is centered by the outer side (305b) of the upper bearing seat (305).

7. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 6, **characterized in that** an upper axial bearing seat (202) of the ball bearing (201) is positioned on the lower side (225b) of the counterweight (225) .

8. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 7, **characterized in that** the crankpin (220) of the crankshaft (210) protrudes from a first upper side (225a) of the counterweight (225), wherein said crankshaft (210) protrudes from an opposite second lower side (225b) of the counterweight (225) with respect to the crankpin (220), and wherein the longitudinal axis (221) of the crankpin (220) is positioned eccentrically and parallel with respect to the longitudinal axis (211) of the crankshaft (210), wherein the counterweight (225) is preferably integrally formed in one piece with the crankshaft (210) and with the crankpin (220).

9. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 8, **characterized in that** an additional second counterweight (226) is stationary fixed to the crankpin (220), wherein preferably the connecting rod (230) is arranged between the first counterweight (225) and the additional second counterweight (226).

10. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 9, **characterized in that** the piston (240) is connected with the connecting rod (230) via a piston pin (243), wherein the piston pin (243) is fixed to the piston (240) via a clamping sleeve (244) that is inserted into a matching axial opening in the piston (240) and the piston pin (243).

11. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 10, **characterized in that** the connecting rod (230) comprises a big eye bearing (231) on its one end and a small eye bearing (232) on its opposite second end, wherein both eye bearings (231, 232) are connected with a flexible connecting rod bar (233), and wherein said flexible connecting rod bar (233) has at least one damping opening (236), wherein the at least one damping opening (236) is oriented in parallel to the big eye bearing (231) and the small eye bearing (232).

12. The encapsulated refrigerant compressor (1) according to claim 11, **characterized in that** the flexible connecting rod bar (233) has at least one damping opening (236) with a circular cross section (237) and at least one damping opening (236) with a triangular cross section (238), and wherein the big eye bearing (231) in a lateral view has a barrel shape (239).

13. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 12, **characterized in that** a lubricant conveying system of the pump unit (10) comprises an oil pickup (250) for conveying lubricant from a lubricant sump formed in a lower shell part (110) of the compressor shell (100) during operation to the rotating parts of the cranktrain (200), wherein the oil pickup (250) is positioned on a lower end of the crankshaft (210), and wherein the oil pickup (250) is configured to distribute lubricant along an oil path (260) upwards within an inner oil supply bore (254) in axial direction (211) of the crankshaft (210), and further to distribute lubricant via a lower lubrication bore (255) to a helical groove (256), wherein the lower lubrication bore (255) is positioned at the level of the lower sliding bearing (217b) and is in communication to the inner oil supply bore (254), and wherein the helical groove (256) is arranged along the peripheral surface of a lubrication section (216) of the crankshaft (210), and further to distribute lubricant via an upper lubrication bore (265) to the ball bearing (201), wherein the upper lubrication bore (265) is positioned at the level of the upper sliding bearing (215b) and is in communication to the inner oil supply bore (254), and further to distribute lubricant via an crankpin lubrication bore (275) to an oil splash outlet (280) on top of the crankpin (220), wherein said oil splash outlet (280) is configured to lubricate the piston (240).

14. The encapsulated refrigerant compressor (1) according to claim 13, **characterized in that** the oil pickup (250) is mounted to the rotor (410), and wherein a helical blade (252) within the oil pickup (250) is configured to distribute lubricant upwards within the inner oil supply bore (254)
and/or that the inner oil supply bore (254) in axial direction (211) of the crankshaft (210) has a crankshaft degassing bore (270) on its upper end, wherein the crankshaft degassing bore (270) leads through the counterweight (225) and ends on its upper side (225a).

15. The encapsulated refrigerant compressor (1) according to any one of claims 1 to 14, **characterized in that** a cylinder head assembly (500) is mounted to the cylinder housing (310) of the crankcase (300), the cylinder head assembly (500) comprising a valve plate (530), a suction valve spring (520), a discharge valve spring (540), a suction muffler (600) and a discharge muffler (700), wherein the discharge muffler (700) has a discharge connection tube (750) being connected to the discharge pipe (20).

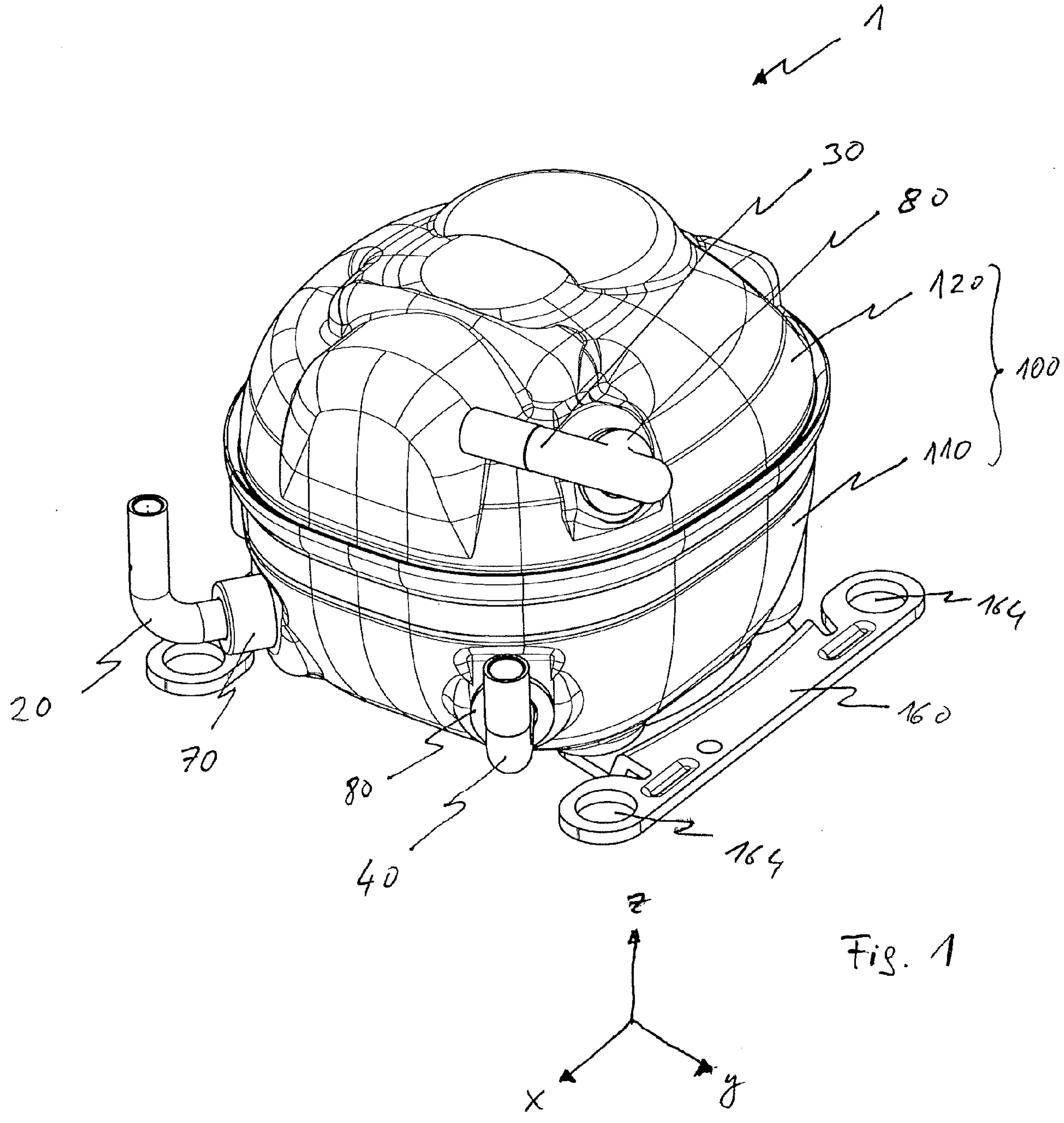


Fig. 1

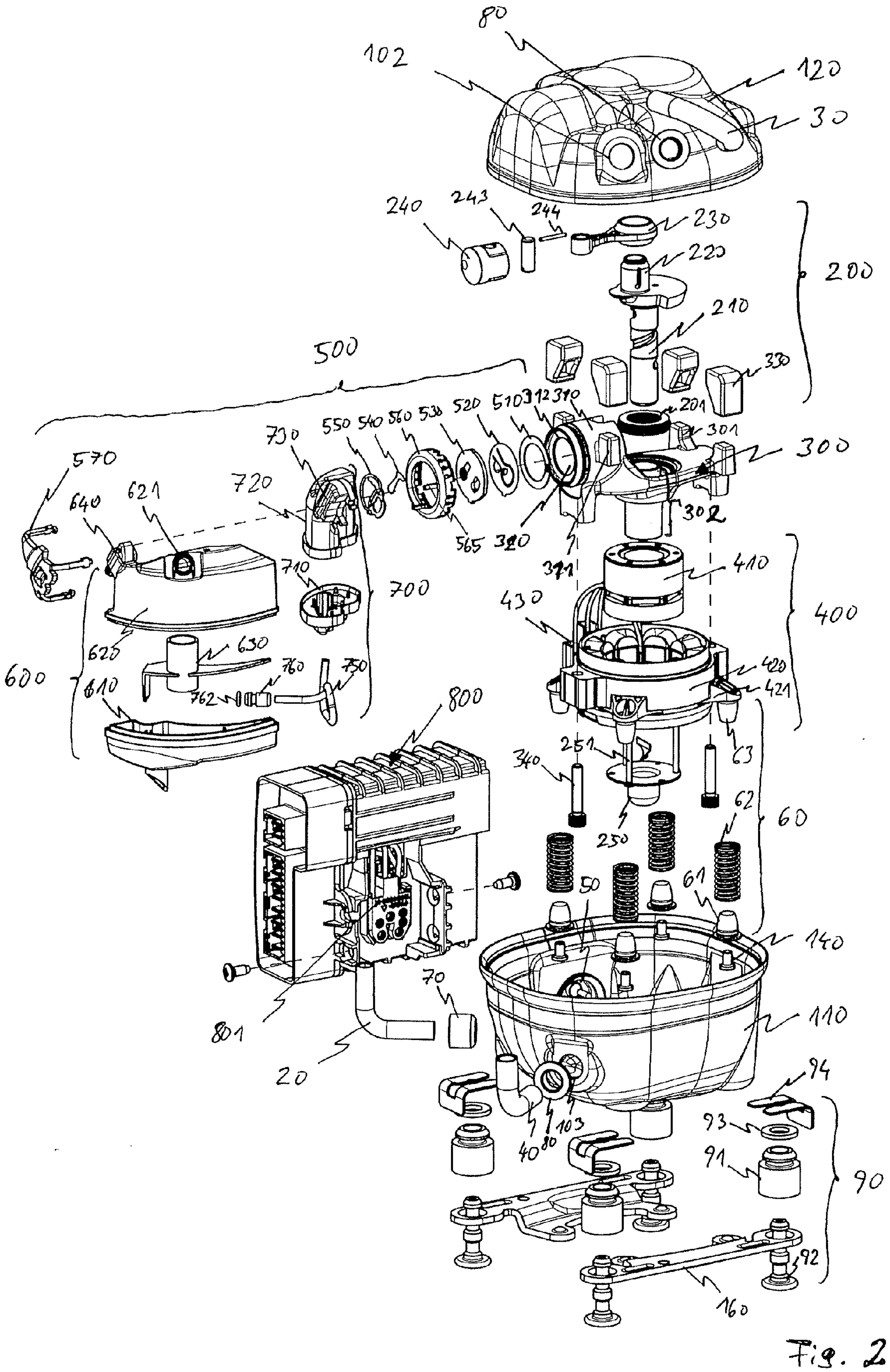

80
102
120
30
240
243
244
230
220
200
210
500
330
510
312
310
520
530
560
540
550
730
201
301
300
570
720
302
640
621
565
320
311
410
710
700
400
430
620
630
600
610
760
762
750
420
421
800
251
63
340
62
60
250
50
61
140
70
801
110
20
94
93
91
90
40
80
103
92
160

Fig. 2

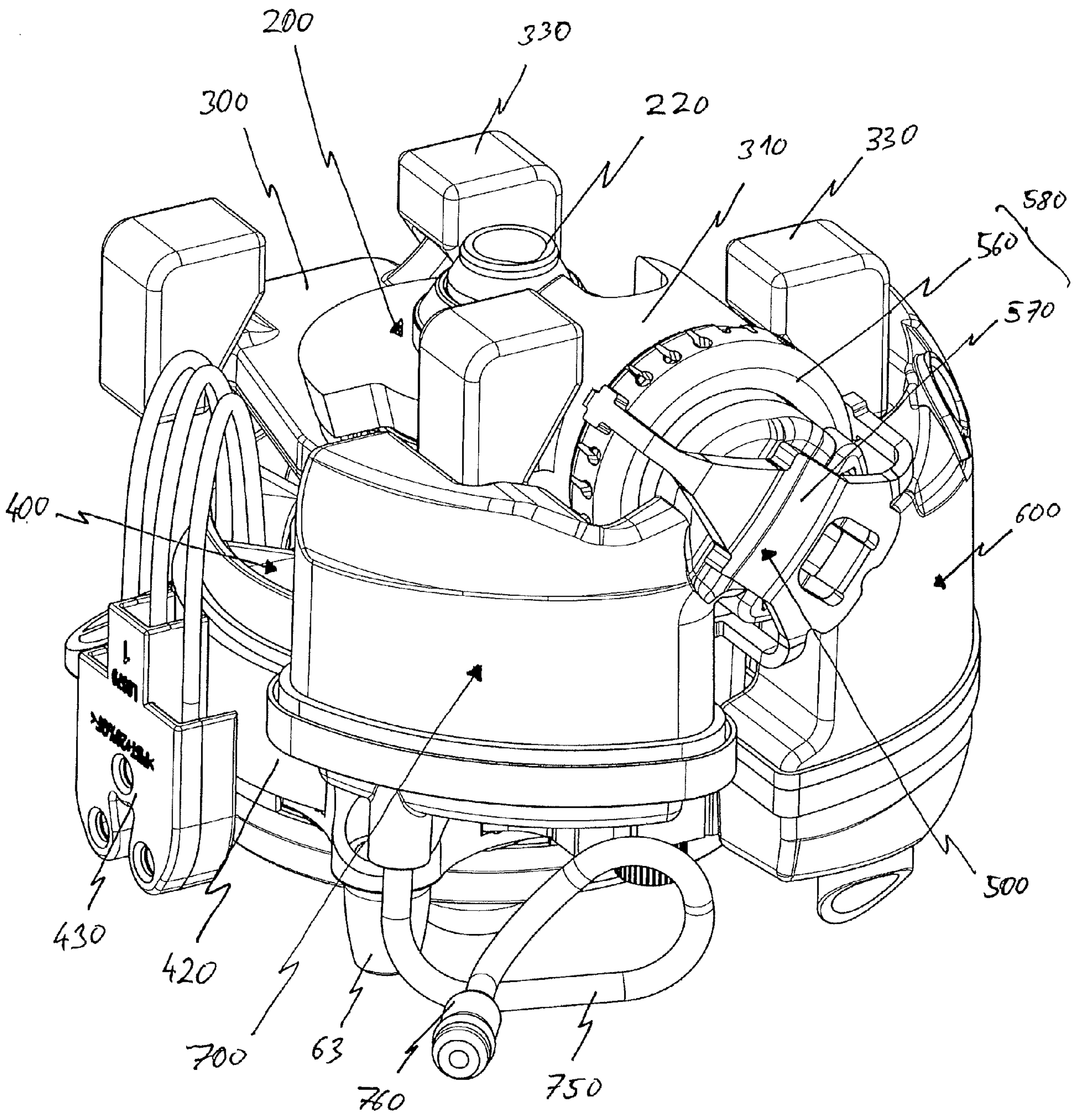

200
330
300
220
310
330
580
560
570
400
600
500
430
420
700
63
760
750

Fig. 3

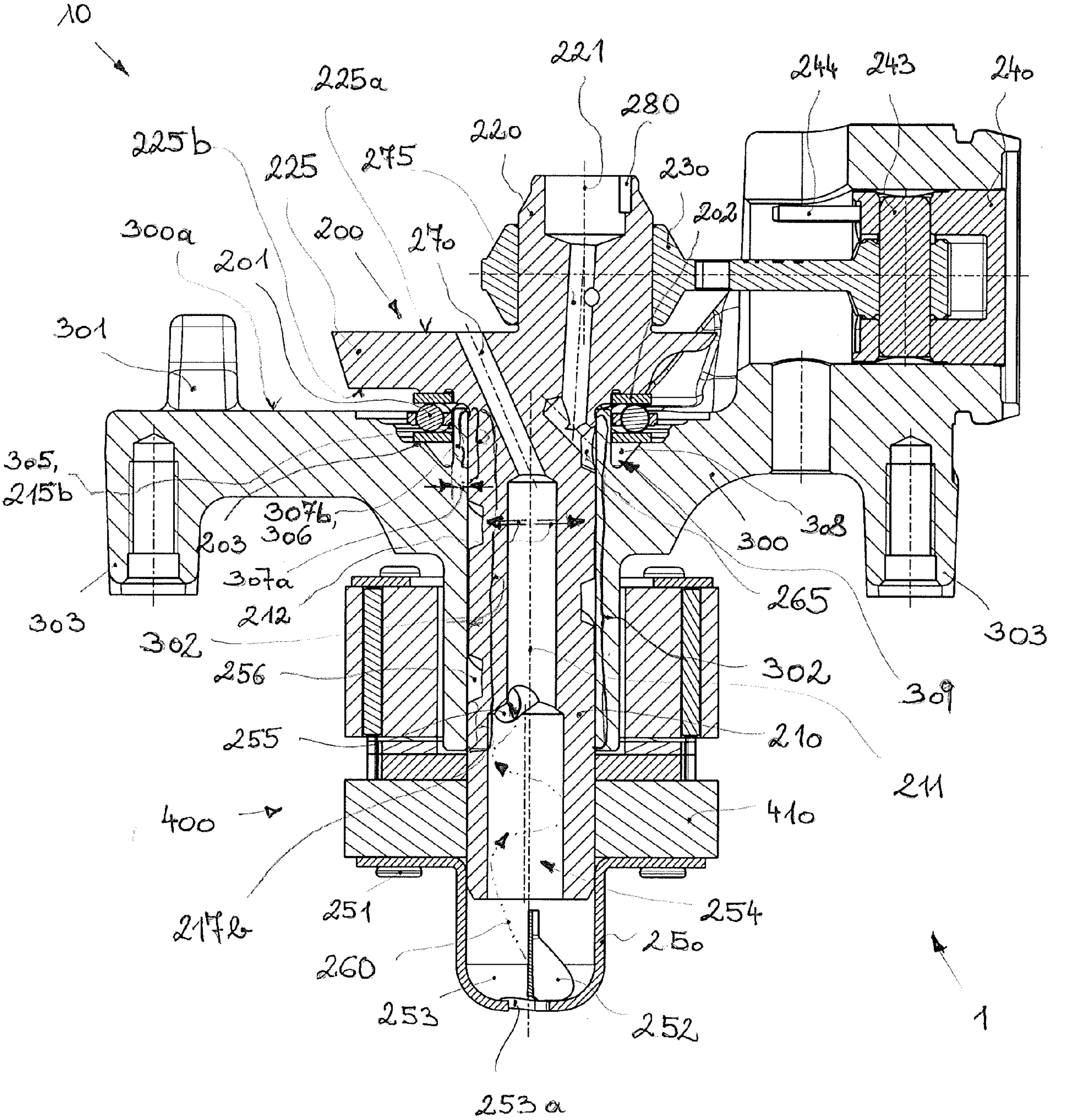

10
221
225a
280
244
243
240
225b
220
225
275
230
202
300a
200
270
201
301
305,
215b
307b,
306
203
300
308
307a
265
303
212
303
302
302
256
309
255
210
211
400
410
217b
251
254
250
260
253
252
1
253a

Fig.4

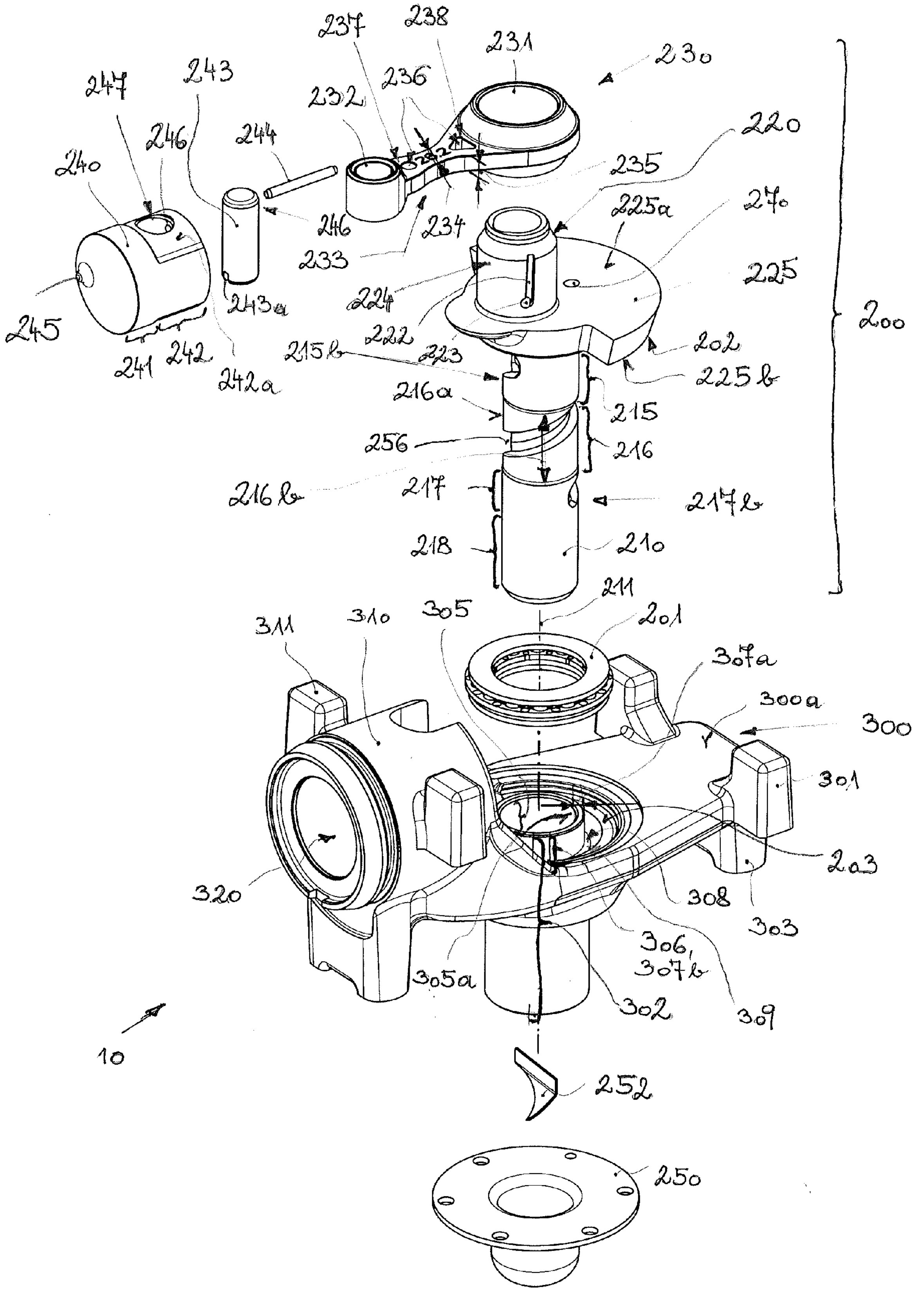
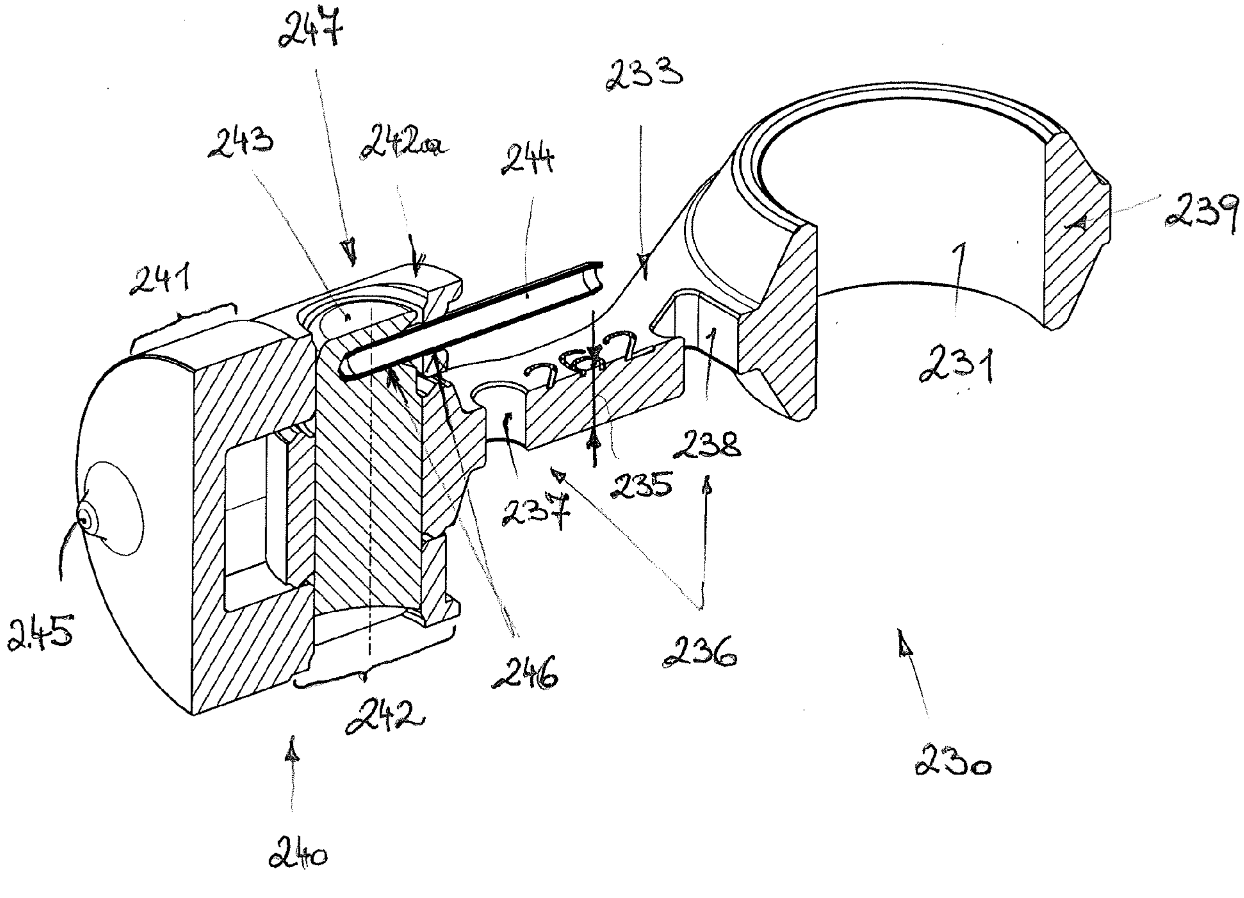
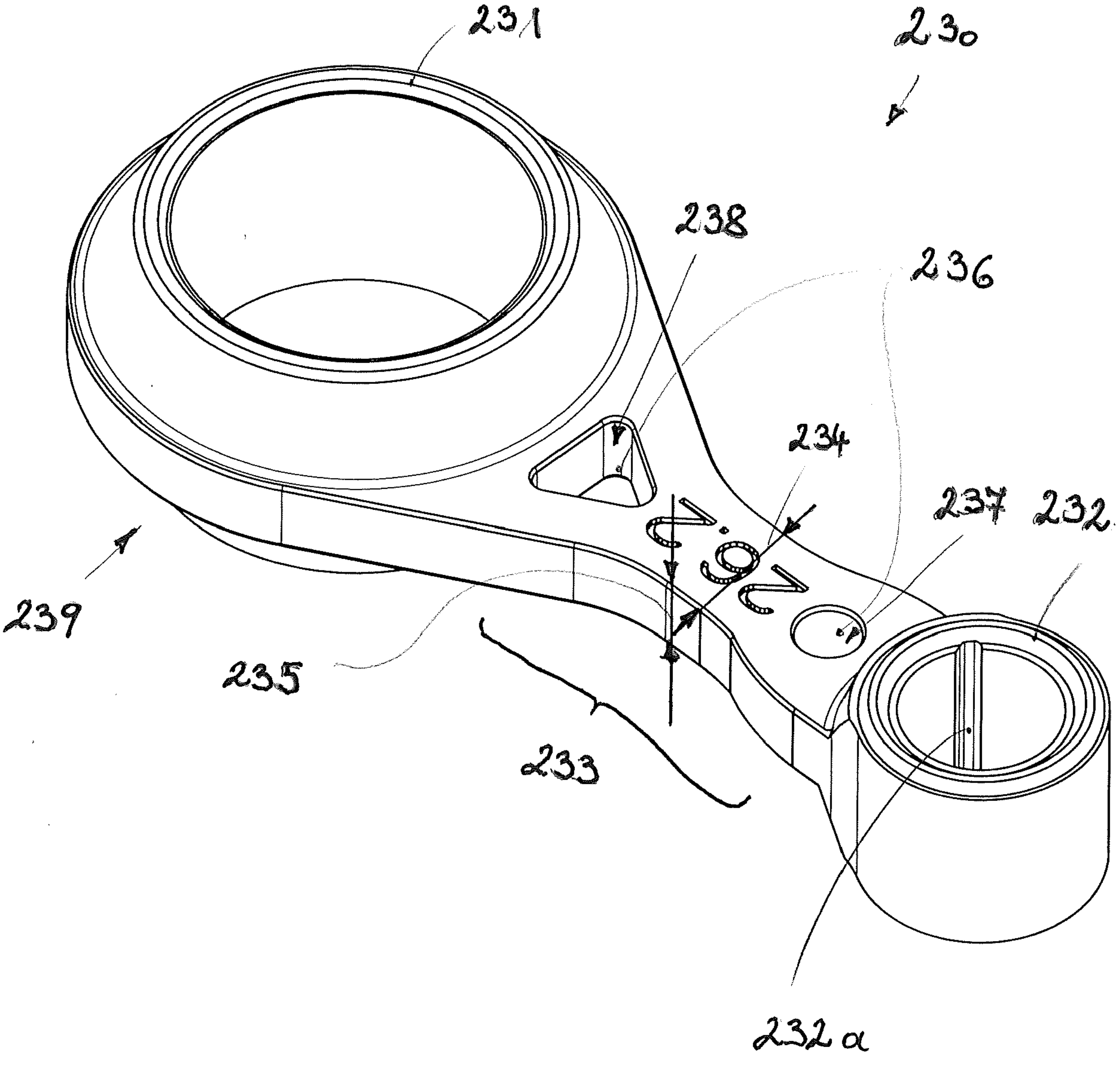
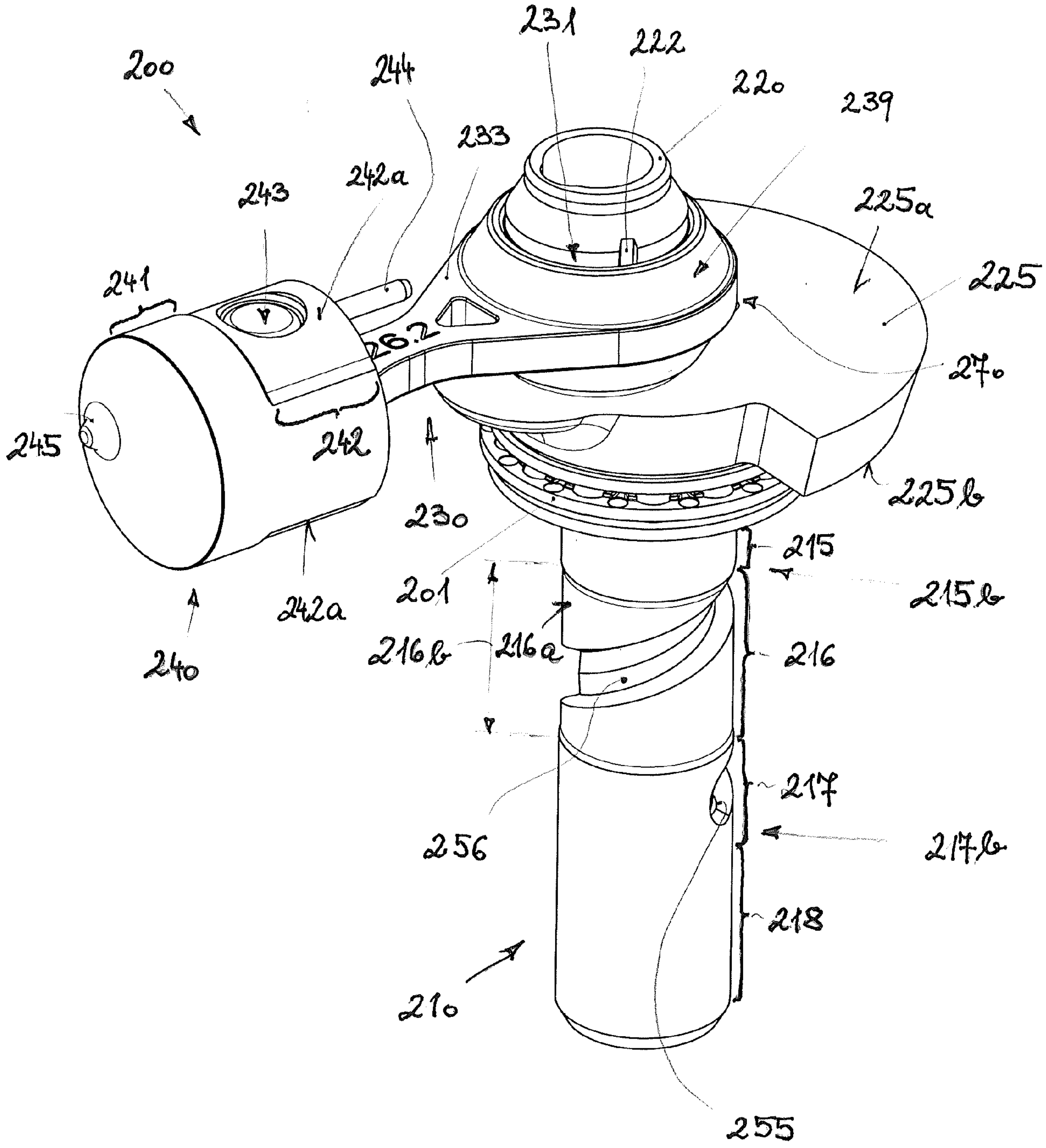
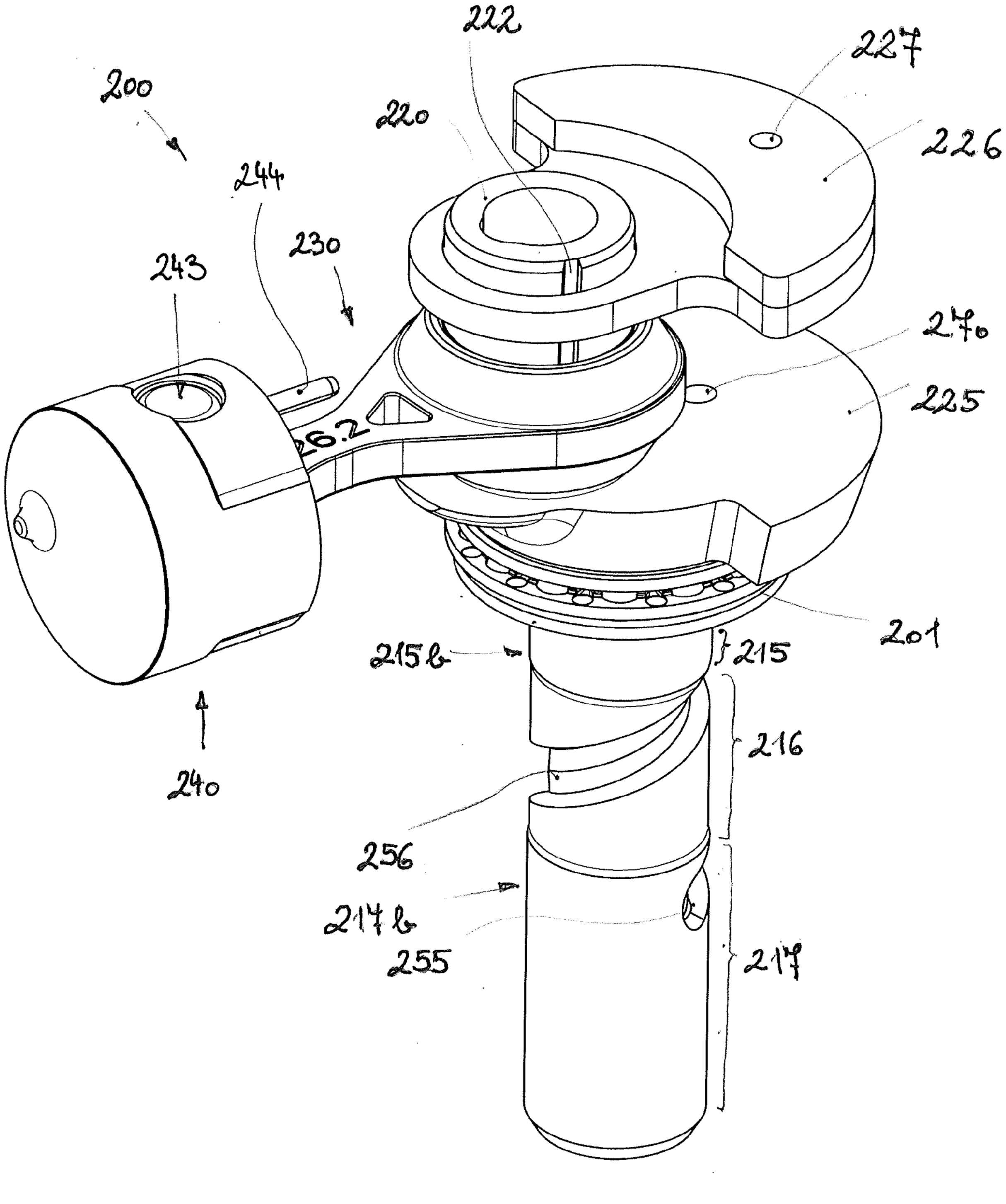

230
200
220
270
225a
225
202
225b
215b
216a
215
256
216
216b
217
217b
218
210
211
201
231
238
237
236
232
235
234
233
244
243
247
246
240
243a
245
241
242
242a
222
223
224
311
310
305
307a
300a
300
301
203
308
303
306, 307b
309
302
305a
320
10
252
250

Fig. 5


247
233
243
242a
244
241
239
231
238
235
237
236
245
246
242
240
230


231
230
238
236
234
237
232
239
235
233
232a


200
244
231
222
220
239
233
242a
243
225a
241
225
262
270
245
242
230
225b
215
201
215b
242a
216a
216b
216
240
217
256
217b
218
210
255


222
227
200
220
226
244
230
243
270
225
26.2
201
215b
215
216
240
256
214b
255
217