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(54) **CYLINDER HEAD ASSEMBLY**

(57) The invention relates to a cylinder head assembly (500) for an encapsulated refrigerant compressor (1) comprising
- a valve plate (530) having a suction opening (531) and a discharge opening (532);
- a suction valve spring (520) being mounted to a suction side (530a) of the valve plate (530);
- a discharge valve spring (540) being mounted to a discharge side (530b) of the valve plate(530);
- a suction muffler (600) having a suction connector head (640) which is connecting an outlet section (606) of the suction muffler (600) with the suction opening (531) and the suction valve spring (520);
- a discharge muffler (700) having a discharge connector head (730) which is connecting an inlet section (704) of the discharge muffler (700) with the discharge valve spring (540) and the discharge opening (532);
- a mounting assembly (580) for fixing the cylinder head assembly (500) to a cylinder housing (310) of the refrigerant compressor (1);
- a first sealing element (550) which is located between the discharge connector head (640) as well as the suction connector head (730) and the discharge side (530b) of the valve plate (530).

In order to ensure a simple and safe installation the suction valve spring (520) is welded onto the suction side (530a) of the valve plate (530) and the discharge valve spring (540) is welded onto the discharge side (530b) of the valve plate (530) .

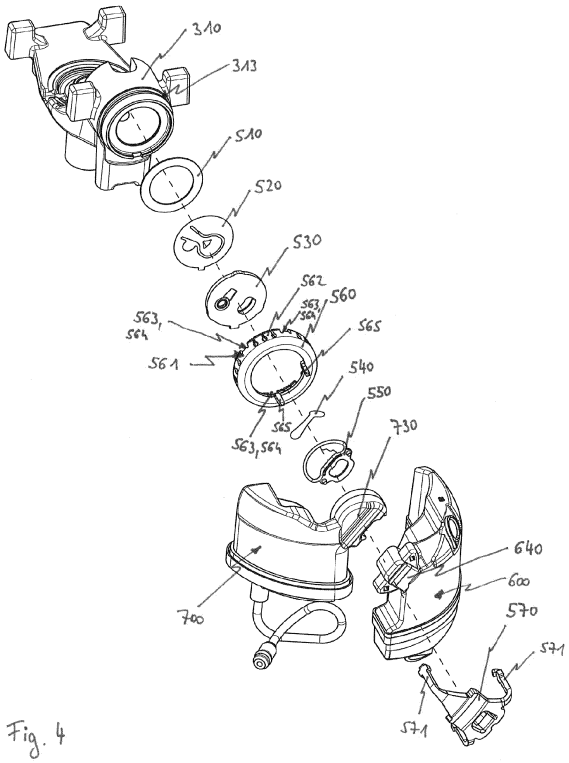

Fig. 4

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a cylinder head assembly for an encapsulated refrigerant compressor comprising

- a valve plate having a suction opening and a discharge opening;
- a suction valve spring being mounted to a suction side of the valve plate;
- a discharge valve spring being mounted to a discharge side of the valve plate;
- a suction muffler having a suction connector head which is connecting an outlet section of the suction muffler with the suction opening and the suction valve spring;
- a discharge muffler having a discharge connector head which is connecting an inlet section of the discharge muffler with the discharge valve spring and the discharge opening;
- a mounting assembly for fixing the cylinder head assembly to a cylinder housing of the refrigerant compressor;
- a first sealing element which is located between the discharge connector head as well as the suction connector head and the discharge side of the valve plate.

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. 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 part of a compression and discharge cycle, 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 assembly. The cylinder head assembly 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 crank-pin 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] All members of the cylinder head assembly, in particular the valve plate, the suction valve spring and the discharge valve spring, have to withstand high levels of pulsation due to refrigerant pumping. These pulsations can propagate and excite other structural components of the refrigerant compressor, ultimately being translated to unwanted noise. Furthermore, the discharge side of

the refrigerant compressor has to withstand high temperature and pressure levels. Therefore, the fixation of these members has to endure these conditions, wherein particular importance is attributed to the fixation of the suction valve spring and the discharge valve spring. It is known from prior art that both the suction valve spring and the discharge valve spring are attached to the valve plate by means of a plug-in connection. A disadvantage of this type of connection is that it is difficult to assemble since both springs tend to slip during assembly. However, a cylinder head assembly that is not assembled to fit accurately results in a lower efficiency of the refrigerant compressor.

OBJECT OF THE INVENTION

[0009] It is therefore an object of the invention to provide a cylinder head assembly which overcomes the disadvantages of the prior art. In particular, the cylinder head assembly shall ensure a simple and safe installation and be economical to manufacture. Furthermore, the compressor should perform efficiently over long operation periods. Also the noise level of the compressor, caused by the cylinder head assembly, shall be as low as possible.

SUMMARY OF THE INVENTION

[0010] In order to achieve at least one of the objects set out above in a cylinder head assembly for an encapsulated refrigerant compressor comprising

- a valve plate having a suction opening and a discharge opening;
- a suction valve spring being mounted to a suction side of the valve plate;
- a discharge valve spring being mounted to a discharge side of the valve plate;
- a suction muffler having a suction connector head which is connecting an outlet section of the suction muffler with the suction opening and the suction valve spring;
- a discharge muffler having a discharge connector head which is connecting an inlet section of the discharge muffler with the discharge valve spring and the discharge opening;
- a mounting assembly for fixing the cylinder head assembly to a cylinder housing of the refrigerant compressor;
- a first sealing element which is located between the discharge connector head as well as the suction connector head and the discharge side of the valve plate,

it is suggested according to the invention that the suction valve spring is welded onto the suction side of the valve plate and the discharge valve spring is welded onto the discharge side of the valve plate.

[0011] The welded joint between the suction valve spring and the valve plate as well as between the discharge valve spring and the valve plate leads to a simple, yet robust, way to assemble these parts of the cylinder head assembly. Due to the welded joint, the suction valve spring and the discharge valve spring always cover the corresponding suction and discharge opening of the valve plate with a perfect fit, even after operations over a long period of time. I.e. even after a long period of operation, the compressor still works efficiently.

[0012] Furthermore, in reducing the assembly-steps and assembly-time on the production line due to welding (the creation of the rather time-consuming plug-in connection is no longer necessary) costs can be avoided. In addition, weight savings due to the elimination of overlapping lugs, as well as no weakening of the springs due to connecting holes are also achieved by the arrangement according to the invention.

[0013] The valve plate can have corresponding indentations and / or grooves located below the suction valve spring and /or the discharge valve spring, which are configured such that a surface of both springs facing away from the valve plate lies in substantially the same plane as a surface of the valve plate. The indentations and / or grooves thus ensure

- on the one hand a good fit of the suction valve spring and / or the discharge valve spring as well as an uniform and even surface of the valve assembly and
- on the other hand prevent dirt / particles from accumulating underneath the springs in such a way that their closing is hindered.

[0014] In order to be able to position the suction valve spring better on the valve plate, in particular above the suction opening of the valve plate, it is provided in an embodiment variant of the invention that the suction valve spring has a suction spring body,

wherein the suction spring body is a flexible metal disk, wherein the suction spring body has a linear first cut-out, which first cut-out separates a suction reed valve section for opening and closing the suction opening of the valve plate from a surrounding static positioning section,
wherein the suction valve spring is welded to the valve plate in the positioning section,
wherein the movable reed valve section and the positioning section are connected by a hinge section of the suction spring body.

[0015] The suction spring body thus comprises three sections, namely

- the suction reed valve section which is arranged behind the suction opening of the valve plate when seen from the suction muffler in the direction of the cylinder,
- the static positioning section which serves for the connection to the valve plate and for improving the

positioning of the suction valve spring with regard to the valve plate and

- the hinge section which connects the suction reed valve section with the static positioning section, preferably by a small remaining material portion.

[0016] As the suction spring body is a flexible metal disk, the different sections of the suction valve plate can be defined by a linear cut-out, i.e. a cut out that follows a straight and / or curved line. Due to the inherent flexibility of the metal disk, because of its material properties (e.g. its spring constant) and the thickness, the valve reed section is flexible in such a way that it opens and closes the suction opening of the valve plate while being hinged against the hinge section.

[0017] This design of the suction spring body provides a robust element that allows on the one hand an easy connection to the valve plate, while ensuring optimum opening and closing of the suction opening on the other hand.

[0018] In order to be able to arrange the suction spring body easily and precisely on the valve plate, it is provided in a further embodiment variant of the invention that an outer shape of the suction spring body corresponds to an outer shape of the valve plate at least in sections. I. e. the suction spring body and the valve plate can be arranged congruently at least in sections. Preferably all circular sections of the valve plate contour correspond with matching circular sections of the suction spring body.

[0019] In a further embodiment variant of the invention, it is provided that the suction reed valve section has a second cut-out, which second cut-out is located between a segment of the suction reed valve section positioned above the suction opening and the hinge section.

[0020] The use of the second cut-out results in a better flow pattern of the refrigerant in the area of the suction opening with significantly less turbulence, since in addition to the gap between the valve plate and the suction valve spring, which gap is created when the suction valve spring opens, there is another opening, namely the second cut-out, through which refrigerant can flow from the suction muffler into the cylinder.

[0021] To be able to easily arrange the valve plate and the suction valve spring relative to each other as well as to align them against each other, it is provided in a further embodiment variant of the invention that the valve plate has a first positioning protrusion, which first positioning protrusion protrudes from a circumferential surface of the valve plate and that the static mounting section has a second positioning protrusion, which second positioning protrusion of the suction valve spring is matching the first protrusion of the valve plate.

[0022] In order to be able to design the suction spring body in such a way that it can be easily aligned with the valve plate, while not hindering the flow of compressed refrigerant through the discharge opening of the valve plate, it is provided in a further embodiment variant of the invention that the suction spring body has a third cut-out for the discharge opening. This design of the suction spring body ensures that, despite the suction spring body being a flexible metal disk, it has a certain stability and allows a firm connection between the suction spring body and the valve plate as well as precise positioning.

[0023] In a further embodiment variant of the invention, it is provided that the first cut-out and the third cut-out are overlapping, which allows a cost-effective and simple production of the suction valve spring.

[0024] To be able to easily arrange the valve plate with respect to the cylinder as well as to align them against each other and at the same time to ensure a non-rotating mounting of the valve plate in a recess of the cylinder housing, it is provided in a further embodiment variant of the invention that the valve plate has at least one first positioning protrusion for aligning the valve plate with respect to a cylinder of the refrigerant compressor, wherein the at least one first positioning protrusion is configured to interact with a matching positioning recess of a valve plate seat of a cylinder housing of the refrigerant compressor.

[0025] Thus, it is conceivable that the first positioning protrusion of the valve plate interacts with two further elements of the cylinder head assembly of this invention, namely with the second positioning protrusion of the suction valve spring and with the recess of the cylinder housing, and, thereby, allows an easy assembly and relative positioning of these elements. To easily align the valve plate relative to the cylinder and ensure a centered position of the valve plate in a valve plate seat of the cylinder housing, it is provided in a further embodiment variant of the invention that

the valve plate has at least two centring protrusions for centring the valve plate in a valve plate seat of a cylinder housing of the refrigerant compressor, which at least two centring protrusions are located at a circumferential surface of the valve plate. I.e. the centring protrusions contact an inner circumferential surface of the valve plate seat located in the cylinder housing.

[0026] To ensure easy manufacturing of the valve plate and an increased centring effect, it is provided in a further embodiment variant of the invention that the valve plate has three centring protrusions, which are preferably evenly distributed around the circumference of the valve plate.

[0027] In a further embodiment variant of the invention, it is provided that the discharge valve spring is configured as a flat spring,

wherein the discharge valve spring comprises a discharge reed valve section for opening an closing of the discharge opening of the valve plate and a mounting section,

wherein the discharge valve spring is welded to the valve plate in the mounting section.

[0028] In contrast to the suction valve spring, which consists of a disk shaped flexible metal disk, having an

approximately circular outer contour, the discharge valve spring is smaller and has less material compared to the suction valve spring.

[0029] The discharge valve spring thus comprises two sections, namely

- the discharge reed valve section which is arranged behind the discharge opening of the valve plate when seen from the cylinder in the direction of the discharge muffler, and
- the mounting section, wherein the mounting section is also used for positioning the discharge valve spring on the valve plate.

[0030] This design of the discharge valve spring provides a robust element that allows on the one hand an easy connection to the valve plate while ensuring optimum opening and closing of the discharge opening.

[0031] To ensure safe operation of the discharge valve spring, it is provided in a further embodiment variant of the invention that the valve plate has a first recess located on the discharge side,
wherein the first recess is positioned between the discharge opening and the mounting section of the discharge valve spring.

[0032] In particular, the recess ensures that particles, such as chips which may be formed in or transported into the cylinder during operation, can collect therein, whereby the closing of the discharge opening by means of the discharge valve spring is not hindered. This ensures an efficient operation and an increased lifecycle time.

[0033] To press the valve plate against the cylinder housing on the one hand and to press the suction connector head as well as the discharge connector head against the valve plate on the other hand, it is provided in a further embodiment variant of the invention that the mounting assembly comprises a clamping element for clamping the valve plate to the cylinder housing of the refrigerant compressor and a fixing element for pressing the suction connector head and the discharge connector head to the valve plate,
wherein the fixing element is mounted on the clamping element.

[0034] As a result, the clamping element known from the prior art, which is fixed to the cylinder by means of screws, can be replaced by lighter and easier-to-install components with a higher clamping force.

[0035] In addition, the fixing element can have a preload and, therefore, acts like a spring in operation keeping the force to fix the other elements of the cylinder head assembly of the invention over a long time, even when slight creeping effects may occur.

[0036] In order to attach the valve plate particularly securely and firmly to the cylinder housing, it is provided in a further embodiment variant of the invention that the clamping element has an annular clamping section and a plurality of first clamping protrusions, which first clamping protrusions are configured to latch with a circumferential clamping groove of the cylinder housing.

[0037] To be able to arrange both the suction muffler and the discharge muffler easily and safely with respect to the valve plate, it is provided in a further embodiment variant of the invention that the clamping element has two positioning pins for aligning the suction connector head of the suction muffler and the discharge connector head of the discharge muffler with respect to the valve plate,
wherein the positioning pins extend to an opposite side of the annular clamping section than the first clamping protrusions. Preferably both the suction connector head and the discharge connector head have positioning openings matching the cross section of the positioning pins.

[0038] To be able to connect the fixing element securely and firmly to the clamping element, which itself is firmly attached to the cylinder housing, it is provided in a further embodiment variant of the invention that the clamping element has at least three second clamping protrusions which second are clamping protrusions are configured to latch with a circumferential clamping groove of the cylinder housing, wherein each second clamping protrusion has a fixing recess, wherein the fixing element has at least three fixing legs, wherein each fixing leg is configured to latch with a fixing recess of the clamping element.

[0039] The contours of the fixing recesses of the second protrusions correspond to at least a section of the contours of the fixing legs. On the one hand, this prevents the clamping element from slipping off and, on the other hand, ensures that the clamping force is constantly maintained.

[0040] The invention further relates to an encapsulated refrigerant compressor having

- a compressor shell having a lower shell part and an upper shell part, wherein a discharge pipe, a suction pipe and a maintenance pipe enter the compressor shell,
  wherein an electric pass through element is inserted into the compressor shell;
- a pump unit comprising:

  -- a cranktrain having a crankshaft, a crank pin, a connecting rod and a piston;
  -- an electric drive unit having an inner harness, a stator and a rotor, the rotor being fixed to the crankshaft, wherein the inner harness is connecting the electric pass through element and the stator;
  -- a crankcase with a cylinder housing,

  wherein a cylinder for reciprocating movement of the piston is located in the cylinder housing, wherein the crankshaft is rotatably mounted in the crankcase,
  wherein the stator is attached to the cylinder crankcase;
- a plurality of support spring assemblies for support-

ing the compressor body in the compressor shell,

wherein the pump unit further comprises a cylinder head assembly according to the invention described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] The invention will now be explained in more detail below with reference to one exemplary embodiment. 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 an exploded view of a cylinder head assembly of the refrigerant compressor;
Fig. 5 shows a top view of a suction side of a valve plate of the cylinder head assembly;
Fig. 6 shows a top view of a discharge side of the valve plate of the cylinder head assembly;
Fig. 7 shows a three dimensional view of the valve plate of the cylinder head assembly.

WAYS OF CARRYING OUT THE INVENTION

[0042] 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.

[0043] 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.

[0044] 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).

[0045] 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.

[0046] 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.

[0047] 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.

[0048] 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 damp-

ening element 91, a lining disk 93 and a securing element 94.

[0049] 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.

[0050] 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.

[0051] 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.

[0052] 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.

[0053] The cranktrain 200 comprises a piston 240 and a crankshaft 210, which is rotatably mounted inside a main bearing 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 crank pin 220 on which a connecting rod 230 is mounted, which connecting rod 230 connects the crank pin 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.

[0054] 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.

[0055] 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 310. 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. 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 act 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 an exploded view of the cylinder head assembly 500 of the refrigerant compressor 1, in which a detailed arrangement of the various members of the cylinder head assembly 500 is visible. Seen from the fixing element 570 in the direction of the cylinder housing 310, the following members are arranged between the fixing element 570 and cylinder housing 310: the suction connector head 640, the discharge connector head 730, the first sealing element 550, the discharge valve spring 540, the clamping element 560, the valve plate 530, the suction valve spring 520 and the cylinder gasket 510. Both the suction valve spring 520 and the discharge valve spring 540 are welded onto the valve plate. The welded joint between the suction valve spring 520 and the valve plate 530 as well as the discharge valve spring 540 and the valve plate 530 leads to a simple, yet robust, way to combine these parts of the cylinder head assembly 500 together.

[0064] Both from Fig. 4 as well as from Fig. 5, which shows a top view of the suction side 530a of the valve plate 530 of the cylinder head assembly 500, is visible that the suction valve spring 520 comprises a suction spring body 521, which is a flexible metal disk and which outer shape corresponds to an outer shape of the valve plate 530. The suction spring body 521 has a linear first cut-out 522, which separates a suction reed valve section 521a for opening and closing the suction opening 531 from a surrounding static positioning section 521b. The suction reed valve section 521a and the static positioning section 521b are connected by a hinge section 521c, wherein the suction spring body 521 is welded to the valve plate 530 in the positioning section 521b.

[0065] To improve the flow behavior of the refrigerant, the suction reed valve section 521a comprises a second cut-out 523, which is located between a segment of the suction reed valve section 521a positioned above the suction opening 531 and the hinge section 521c.

[0066] The suction spring body 521 has a third cut-out 524 for the discharge opening 532, which third cut-out 524 overlaps with the first cut-out 522.

[0067] In Fig. 6, which shows a top view of a discharge side 530b of the valve plate 530 of the cylinder head assembly 500, as well as in Fig. 7, which shows a three dimensional view of the valve plate 530 of the cylinder head assembly 500, it can be seen that the discharge valve spring 540 is configured as a flat spring, which comprises a discharge reed valve section 540a for opening an closing of the discharge opening 532 of the valve plate 530 and a mounting section 540b, wherein the discharge valve spring 540 is welded to the valve plate 530 in the mounting section 540b.

[0068] Furthermore Figs. 6 and 7 show that the valve plate 530 has a first positioning protrusion 533, which protrudes from a circumferential surface 530c of the valve plate 530. The static mounting section 521b of the suction spring body 521 comprises a second positioning protrusion 521d, which is matching the first positioning protrusion 533. Both positioning protrusions 533, 521d allow an easy arrangement of the valve plate 530 and the suction valve spring 520 one above the other.

[0069] In addition, the first positioning protrusion 533

serves also for aligning the valve plate 530 with respect to the cylinder 320. Namely, the first positioning protrusion 533 is configured to interact with a matching positioning recess 312a of a valve plate seat 312 of the cylinder housing 310.

[0070] To easy align the valve plate 530 to the cylinder 1, the valve plate 530 has three centring protrusions 534 for centring the valve plate 530 in a valve plate seat 312 of the cylinder housing 310, which centring protrusions 534 are located at the circumferential surface 530c of the valve plate 530 (see Figs. 5, 6 and 7). In Fig. 7 it can be seen that the centring protrusions 534 extend circumferentially over the entire thickness of the valve plate 530.

[0071] A first recess 535 is located on the discharge side 530b of the valve plate 530, which first recess 535 ensures that particles, such as chips, can collect therein, whereby the closing of the discharge opening 532 by means of the discharge valve spring 540 is not hindered. The first recess 535 is positioned between the discharge opening 532 and the mounting section 540b of the discharge valve spring 540.

[0072] For clamping the valve plate 530 to the cylinder housing 310 and for pressing the suction connector head 640 as well as the discharge connector head 730 to the valve plate 530, the cylinder head assembly 500 comprises the mounting assembly 580 (see Fig. 3), which comprises the clamping element 560 for the first purpose mentioned above and the fixing element 570 for the second purpose mentioned above.

[0073] In Figs. 3 and 4 it can be seen that the clamping element 560 has an annular clamping section 561 and a plurality of first clamping protrusions 562, which are configured to latch with a circumferential clamping groove 313 of the cylinder housing 310. In addition, the clamping element 560 has six second clamping protrusions 563, which are configured to latch with the circumferential clamping groove 313, wherein each second clamping protrusion 563 has a fixing recess 564. The fixing element 570 on the contrary has three fixing legs 571, wherein each fixing leg 571 is configured to latch with a fixing recess 564 of the clamping element 560. I.e. the fixing element 570 is mounted on the clamping element 560.

[0074] Furthermore, the above mentioned two positioning pins 565 can be seen also in Fig. 4.

Reference Numerals

[0075]

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
102	Second Connection Opening
103	Third Connection Opening
110	Lower Shell Part
120	Upper Shell Part
140	Mounting pin
160	Supporting Base Plate
164	Opening of the Supporting Base Plate
200	Cranktrain
201	Ball Bearing
210	Crankshaft
220	Crankpin
230	Connecting Rod
240	Piston
243	Piston Pin
244	Clamping Sleeve
250	Oil Pickup
251	Mounting Rivet
300	Crankcase
301	First Protrusion
302	Main Bearing
310	Cylinder Housing
311	Second Protrusion
312	Valve Plate Seat
312a	Positioning Recess
313	Circumferential Clamping Groove
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
521	Suction Spring Body
521a	Suction Reed Valve Section of the Suction Spring Body
521b	Positioning Section of the Suction Spring Body
521c	Hinge Section of the Suction Spring Body
521d	Second positioning protrusion of the Suction Spring Body
522	First cut-out
523	Second cut-out
524	Third cut-out
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	Centring Protrusion
535	First Recess
540	Discharge Valve Spring
540a	Discharge Reed Valve Section of the Discharge Valve Spring
540b	Mounting section of the Discharge Valve Spring
550	First Sealing Element
560	Clamping Element
561	Annular clamping section
562	First clamping protrusions
563	Second clamping protrusions
564	Fixing recess
565	Positioning Pins
570	Fixing Element
571	Fixing leg
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
762	O-Ring Seal
800	Electronic Control Unit
801	Outer Harness
x	Length Direction
y	Width Direction
z	Height Direction

Claims

1. A cylinder head assembly (500) for an encapsulated refrigerant compressor (1) comprising

- a valve plate (530) having a suction opening (531) and a discharge opening (532);
- a suction valve spring (520) being mounted to a suction side (530a) of the valve plate (530);
- a discharge valve spring (540) being mounted to a discharge side (530b) of the valve plate(530);
- a suction muffler (600) having a suction connector head (640) which is connecting an outlet section (606) of the suction muffler (600) with the suction opening (531) and the suction valve spring (520);
- a discharge muffler (700) having a discharge connector head (730) which is connecting an inlet section (704) of the discharge muffler (700) with the discharge valve spring (540) and the discharge opening (532) ;
- a mounting assembly (580) for fixing the cylinder head assembly (500) to a cylinder housing (310) of the refrigerant compressor (1);
- a first sealing element (550) which is located between the discharge connector head (640) as well as the suction connector head (730) and the discharge side (530b) of the valve plate (530),

characterized in that
the suction valve spring (520) is welded onto the suction side (530a) of the valve plate (530) and the discharge valve spring (540) is welded onto the discharge side (530b) of the valve plate (530).

2. The cylinder head assembly (500) according to claim 1, **characterized in that** the suction valve spring (520) has a suction spring body (521),

wherein the suction spring body (521) is a flexible metal disk,
wherein the suction spring body (521) has a linear first cut-out (522), which first cut-out (522) separates a suction reed valve section (521a) for opening and closing the suction opening (531) of the valve plate (530) from a surrounding static positioning section (521b),
wherein the suction valve spring (520) is welded to the valve plate (530) in the positioning section (521b), wherein the movable reed valve section (521a) and the positioning section (521b) are connected by a hinge section (521c) of the suction spring body (521).

3. The cylinder head assembly (500) according to claim 2, **characterized in that** an outer shape of the suction spring body (521) corresponds to an outer shape of the valve plate (530) at least in sections.

4. The cylinder head assembly (500) according to claim 2 or 3, **characterized in that** the suction reed valve section (521a) has a second cut-out (523), which second cut-out (523) is located between a segment of the suction reed valve section (521a) positioned above the suction opening (531) and the hinge section (521c).

5. The cylinder head assembly (500) according to any one of claims 2 to 4, **characterized in that** the valve plate (530) has a first positioning protrusion (533), which first positioning protrusion (533) protrudes from a circumferential surface (530c) of the valve plate (530), and that the static mounting section

(521b) has a second positioning protrusion (521d), which second positioning protrusion (521d) of the suction valve spring (520) is matching the first positioning protrusion (533) of the valve plate (530).

6. The cylinder head assembly (500) according to any one of claims 2 to 5, **characterized in that** the suction spring body (521) has a third cut-out (524) for the discharge opening (532), wherein the first cut-out (522) and the third cut-out (524) are preferably overlapping.

7. The cylinder head assembly (500) according to any one of claims 1 to 6, **characterized in that** the valve plate (530) has at least one first positioning protrusion (533) for aligning the valve plate (530) with respect to a cylinder (320) of the refrigerant compressor (1), wherein the at least one first positioning protrusion (533) is configured to interact with a matching positioning recess (312a) of a valve plate seat (312) of a cylinder housing (310) of the refrigerant compressor (1).

8. The cylinder head assembly (500) according to any one of claims 1 to 7, **characterized in that** the valve plate (530) has at least two centring protrusions (534) for centring the valve plate (530) in a valve plate seat (312) of a cylinder housing (310) of the refrigerant compressor (1), which at least two centring protrusions (534) are located at a circumferential surface (530c) of the valve plate (530),
wherein the valve plate (530) has preferably three centring protrusions (534).

9. The cylinder head assembly (500) according to any one of claims 1 to 8, **characterized in that** the discharge valve spring (540) is configured as a flat spring,

wherein the discharge valve spring (540) comprises a discharge reed valve section (540a) for opening an closing of the discharge opening (532) of the valve plate (530) and a mounting section (540b),
wherein the discharge valve spring (540) is welded to the valve plate (530) in the mounting section (540b).

10. The cylinder head assembly (500) according to claim 9, **characterized in that** the valve plate (530) has a first recess (535) located on the discharge side (530b), wherein the first recess (535) is positioned between the discharge opening (532) and the mounting section (540b) of the discharge valve spring (540).

11. The cylinder head assembly (500) according to any one of claims 1 to 10, **characterized in that** the mounting assembly (580) comprises a clamping element (560) for clamping the valve plate (530) to the cylinder housing (310) of the refrigerant compressor (1) and a fixing element (570) for pressing the suction connector head (640) and the discharge connector head (730) to the valve plate (530),
wherein the fixing element (570) is mounted on the clamping element (560).

12. The cylinder head assembly (500) according to claim 11, **characterized in that** the clamping element (560) has an annular clamping section (561) and a plurality of first clamping protrusions (562), which first clamping protrusions (562) are configured to latch with a circumferential clamping groove (313) of the cylinder housing (310).

13. The cylinder head assembly (500) according to claim 12, **characterized in that** the clamping element (560) has two positioning pins (565) for aligning the suction connector head (640) of the suction muffler (600) and the discharge connector head (730) of the discharge muffler (700) with respect to the valve plate (530),
wherein the positioning pins (565) extend to an opposite side of the annular clamping section (561) than the first clamping protrusions (562).

14. The cylinder head assembly (500) according to any one of claims 11 to 13, **characterized in that** the clamping element (560) has at least three second clamping protrusions (563) which second clamping protrusions (563) are configured to latch with a circumferential clamping groove (313) of the cylinder housing (310), wherein each second clamping protrusion (563) has a fixing recess (564),
wherein the fixing element (570) has at least three fixing legs (571), wherein each fixing leg (571) is configured to latch with a fixing recess (564) of the clamping element (560).

15. An encapsulated refrigerant compressor (1) having

- a compressor shell (100) having a lower shell part (110) and an upper shell part (120), wherein a discharge pipe (20), a suction pipe (30) and a maintenance pipe (40) enter the compressor shell (100), wherein an electric pass through element (50) is inserted into the compressor shell (100);
- a pump unit (10) comprising:

-- a cranktrain (200) having a crankshaft (210), a crank pin (220), a connecting rod (230) and a piston (240);
-- an electric drive unit (400) having an inner harness (430), a stator (420) and a rotor (410), the rotor (410) being fixed to the

crankshaft (210), wherein the inner harness (430) is connecting the electric pass through element (50) and the stator (420);
-- 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), wherein the crankshaft (210) is rotatably mounted in the crankcase (300),

wherein the stator (420) is attached to the cylinder crankcase (300);
- a plurality of support spring assemblies (60) for supporting the compressor body (10) in the compressor shell (100),

wherein the pump unit (10) further comprises a cylinder head assembly (500) according to any one of claims 1 to 14.

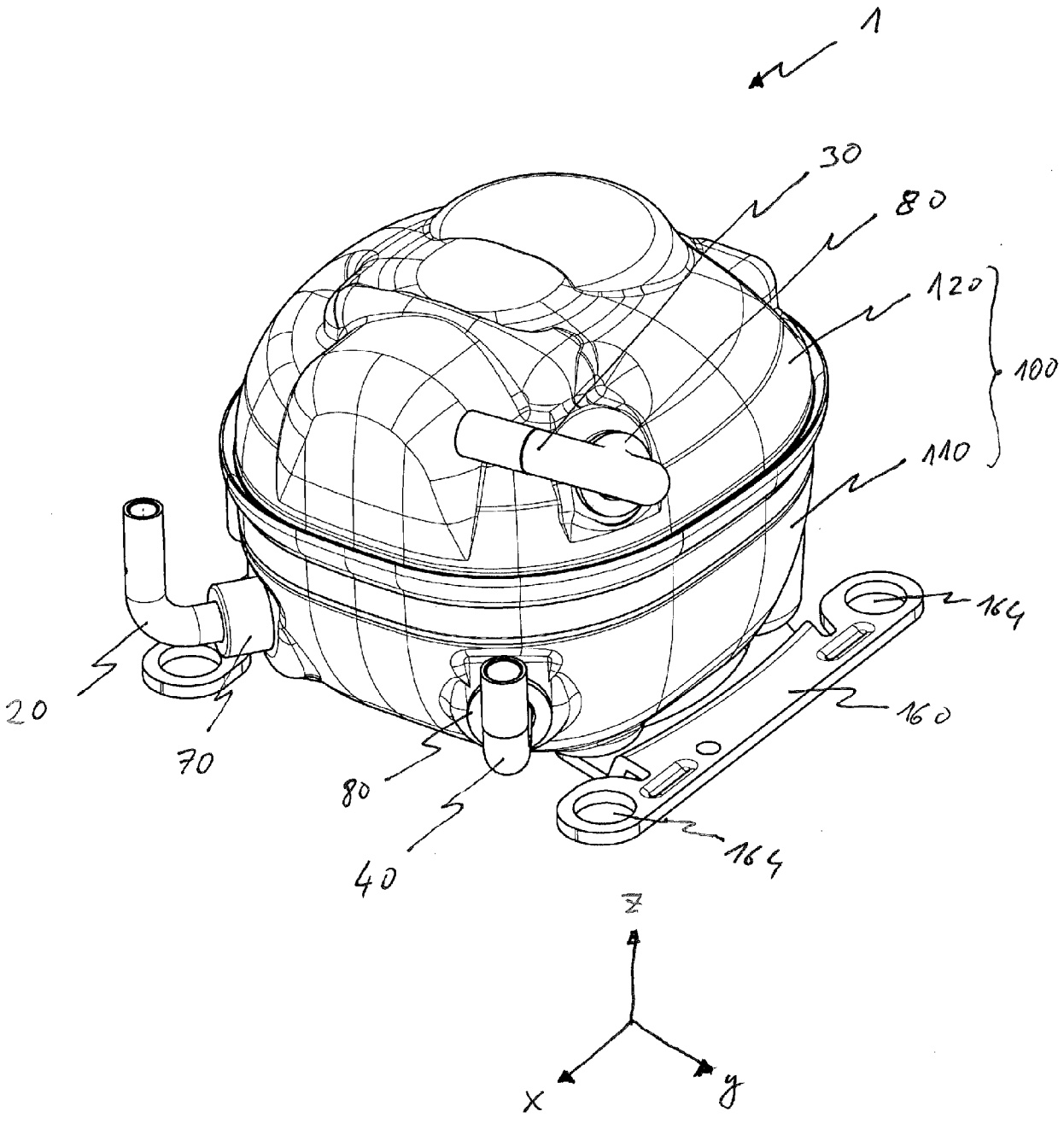

Fig. 1

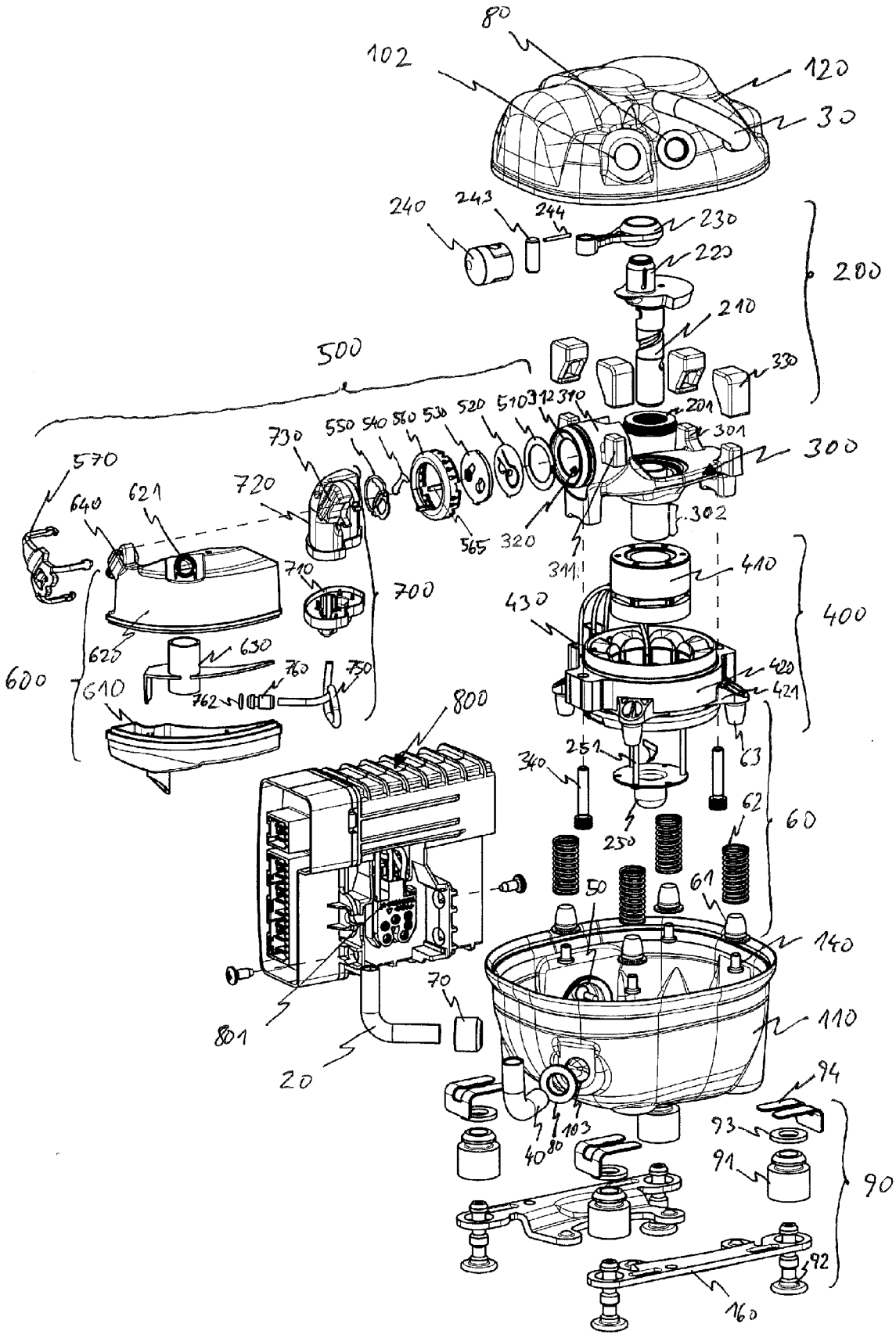
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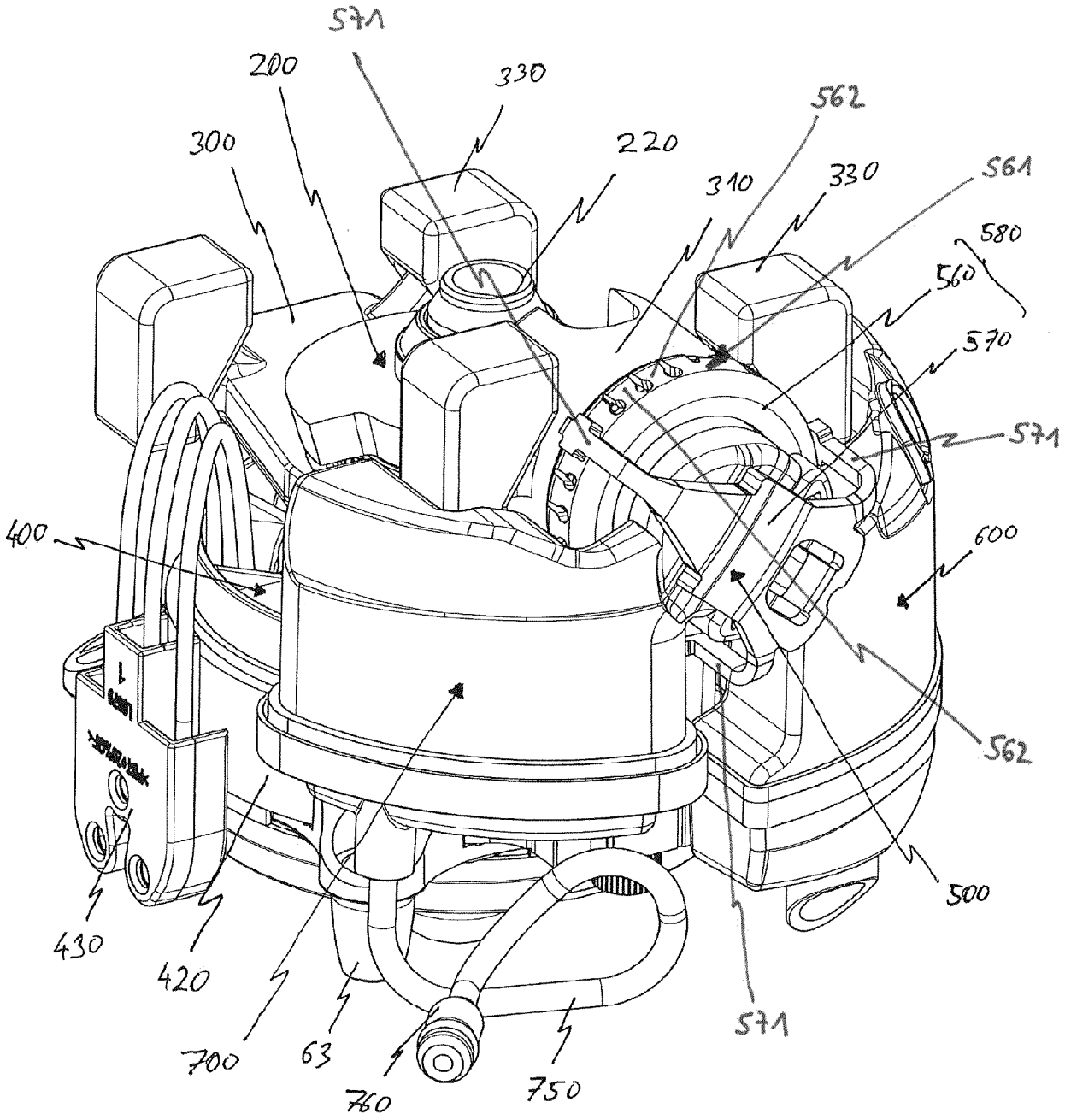
Fig. 2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571

Fig. 3

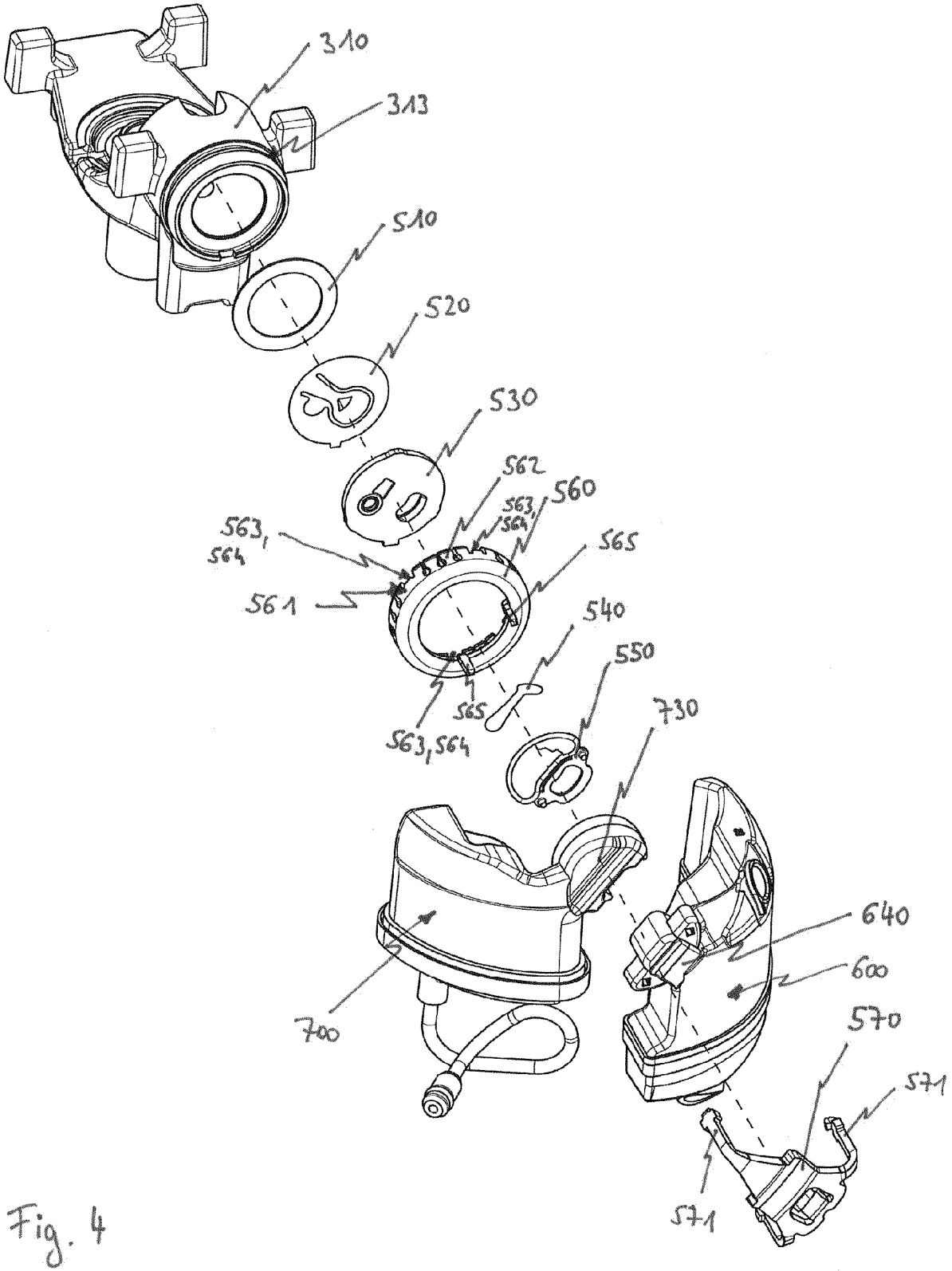
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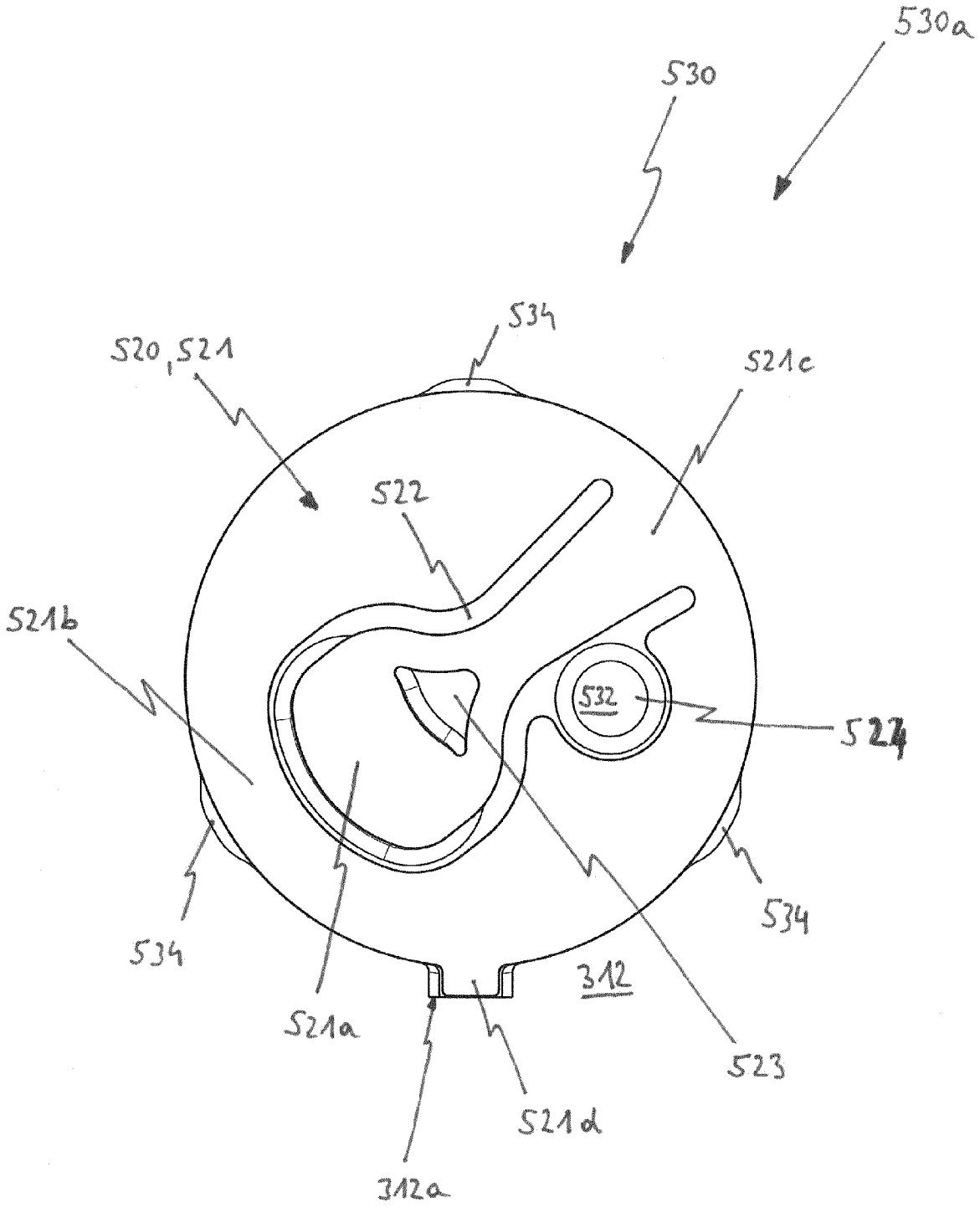
Fig. 4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521b
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521d
312a

Fig. 5

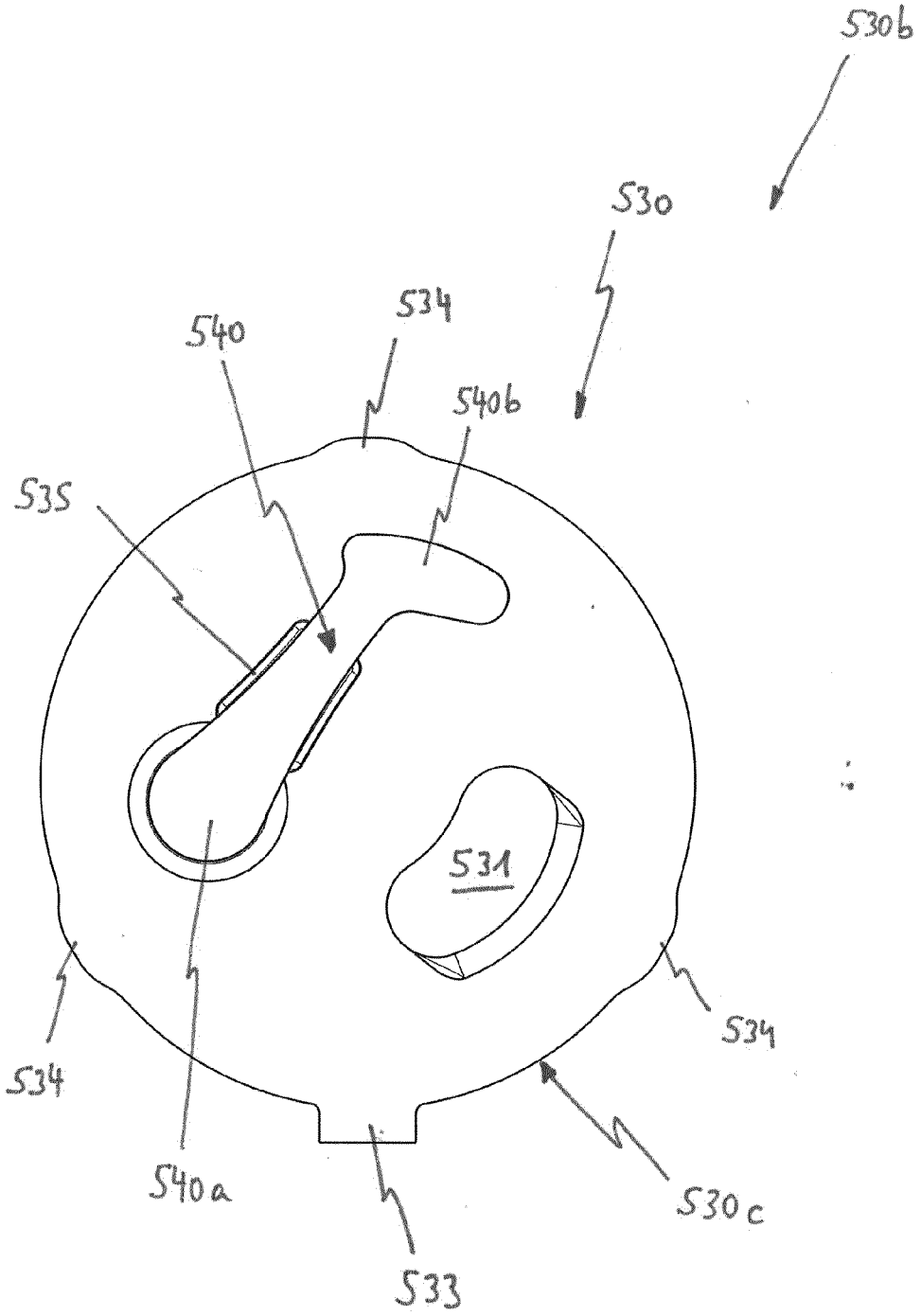

Fig. 6

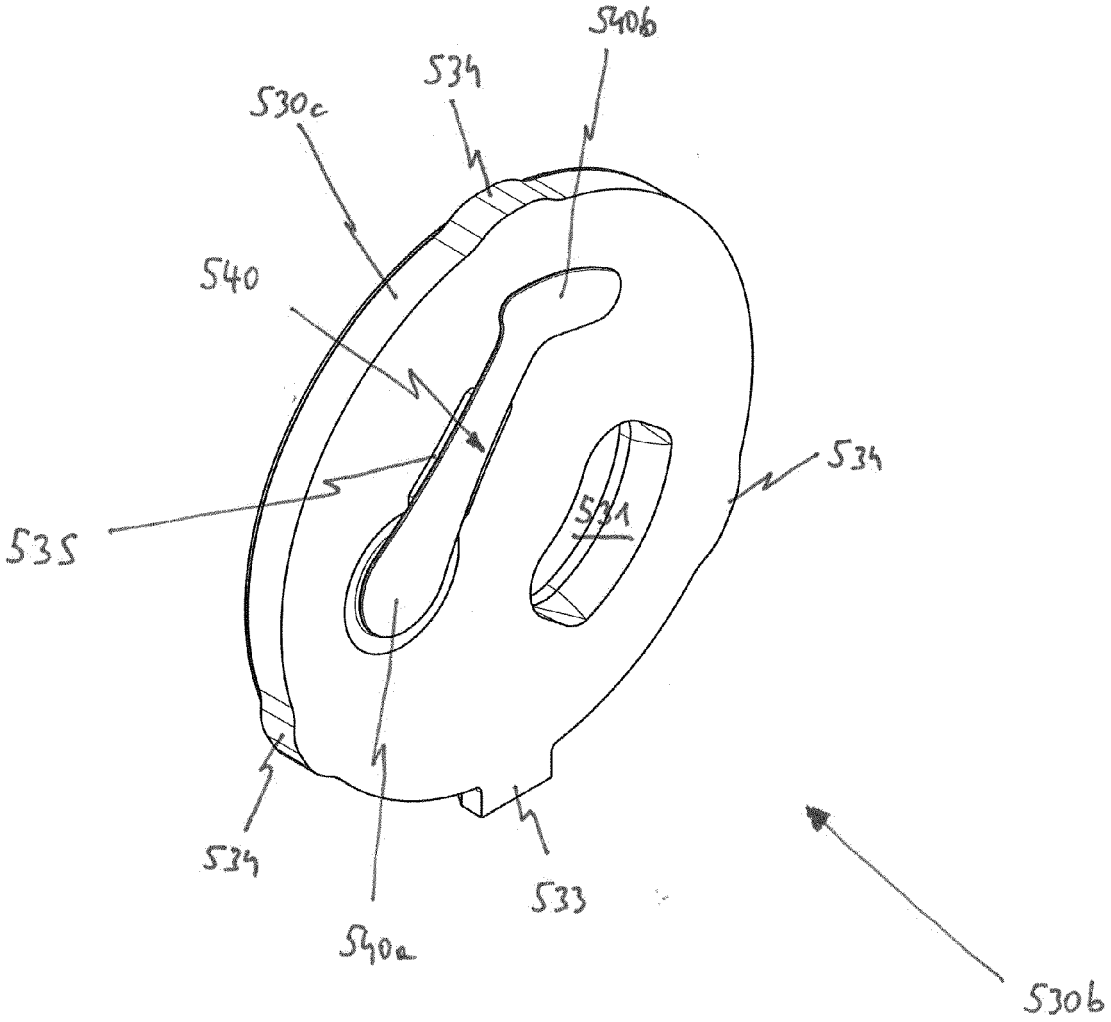

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 3371

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 January 2023	Ricci, Saverio

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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