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(54) RECIPROCATION PUMP

(57) Reciprocating pump (1), comprising a casing (2) having guide seats (3) extended along a corresponding radial direction (X), heads (4) mounted on the casing (2) at respective guide seats (3) and each defining a pumping chamber (5), and membranes (6) each delimiting a pumping chamber (5).

In addition, the reciprocating pump (1) comprises actuation means (7) housed inside the casing (2) and comprising pistons (8), each of which carrying a membrane (6) fixed thereto and susceptible of sliding in a guide seat (3) between a release position and a compression position, in which the membrane (6) respectively expands and reduces the volume of the pumping chamber (5), and a thrust cam (10) in abutment against the pistons (8) and rotating in order to move them from the release position to the compression position.

In addition, the actuation means (7) comprise one or more rocker arms (11), each of which provided with a first lever arm (13) acting on a corresponding piston (8) and an opposite second lever arm (14), and a return cam (15), which is fixed on the drive shaft (9) and is actuatable to rotate around the rotation axis (Y) in order to move each rocker arm (11) around a corresponding pin (12).

Each rocker arm (11) is also movable between an operative position, in which the return cam (15) acts against the second lever arm (14) in order to return, by means of the first lever arm (13), the piston (8) to slide from the compression position towards the release position, and a non-operative position, in which the return cam (15) releases the second lever arm (14) in order to free the piston (8) to slide from the release position towards the compression position.

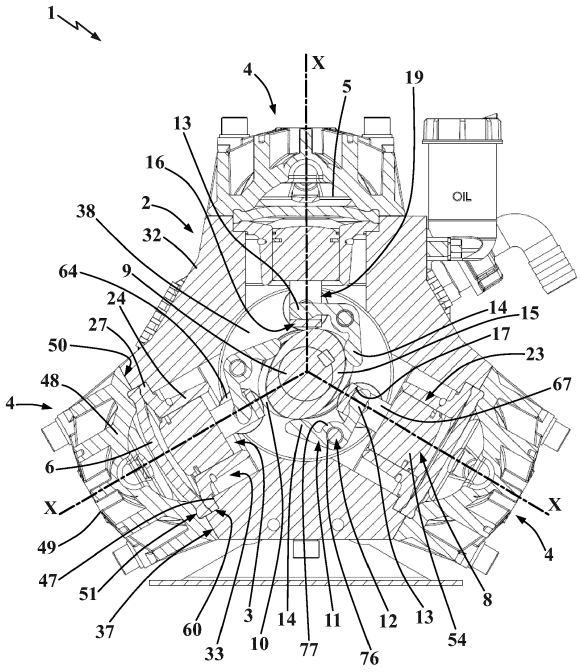

Fig. 5

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Description

Field of application

[0001] The present finding regards a reciprocating pump according to the preamble of the independent claim 1.

[0002] The present pump is intended to be advantageously employed in the attainment of volumetric pumps, in particular of membrane and multiple head type.

[0003] More in detail, the present reciprocating pump is inserted in the industrial field of production of pumps for farming machinery and is in particular intended to be employed for picking up a fluid from a source, for example a cistern transported by the farming machinery, and for conveying the aforesaid fluid under pressure to a plurality of dispensing nozzles, so as to irrigate or disinfesting cultivations.

[0004] The present reciprocating pump is therefore employable for example in the agriculture field for irrigation or disinfestation of the cultivations, or also in any other field of the art where it is necessary to pump large quantities of liquid.

State of the art

[0005] In the field of production of reciprocating pumps, it is known to mount multiple heads on a same casing, in particular so as to process large flows, reducing the discontinuities in fluid dispensing, contrary to what occurs in the single-head reciprocating pumps.

[0006] Generally, on each head of the pump, a pumping chamber closed by a corresponding membrane, which is actuatable in a reciprocating manner in order to expand the volume of the pumping chamber, so as to convey a fluid to be pumped into the same pumping chamber through a corresponding suction channel, and in order to reduce the volume thereof, so as to expel the aforesaid fluid through a corresponding delivery channel.

[0007] More in detail, the membranes of the heads of the reciprocating pump are moved by actuation means housed inside the casing.

[0008] In a known manner, the aforesaid actuation means are provided with a circular cam, mounted eccentric on a shaft that is actuatable in rotation, and with a thrust arm, extended between a first end having an annular connection body rotatably mounted on the cam and an opposite second end connected to a piston slidable in a corresponding guide jacket in order to move the membrane.

[0009] The reciprocating pump of known type briefly described up to now has in practice shown that it does not lack drawbacks.

[0010] The main drawback lies in the fact that the eccentric circular cam and the thrust arm are associable with a mechanism of connecting rod-crank type, which is capable of moving the piston connected to the membrane only and exclusively with harmonic motion along the guide jacket.

[0011] In order to at least partially overcome the problems of the prior art described briefly above, and hence be able to apply a motion law that is different from that of harmonic motion to the piston and to the corresponding membrane, reciprocating pumps are known that are provided with a cam on which a guide channel is made in a depression, and with pistons carrying respective cam followers mounted thereon that are inserted in the aforesaid guide channel, as described for example in the patent CA 2020472.

[0012] More in detail, the guide channel of the cam is provided with a first lateral surface directed in the direction opposite the rotation axis of the cam itself, which is arranged for pushing, through the cam follower, the corresponding piston to reduce the volume of the pumping chamber, and with a second lateral surface facing the first and directed towards the rotation axis, which is arranged in order to return the piston, always through the cam follower thereof, to expand the volume of the pumping chamber.

[0013] In this manner, the first lateral surface of the guide channel is capable of pushing the piston away from the rotation axis of the cam for at least one or more corresponding first angular sections of the cam around the rotation axis thereof and the second lateral surface is capable of returning the piston towards the rotation axis for one or more corresponding second angular sections of the same cam around the rotation axis, and such second angular sections are explementary to the first angular sections. Therefore, the guide channel made in depression on the cam can be shaped in a manner such to impart a particular desired motion law to the pistons, which can be different from the harmonic motion typically conferred by a connecting rod-crank thrust mechanism.

[0014] Nevertheless, also the reciprocating pump with guide channel made in a depression on the cam described briefly up to now has in practice proven that it does not lack drawbacks.

[0015] The main drawback lies in the fact that the cam follower inserted in the guide channel can be easily subjected to breakage. Indeed, the cam follower is provided with a rotary bearing mounted on a corresponding support pin which is extended laterally projecting from the main body of the piston, in a manner such to be inserted between the first and the second lateral surface of the guide channel. Therefore, the forces exerted, during the rotation of the cam, by the first and second lateral surface on the rotary bearing and transmitted by the latter onto the support pin are substantially comparable to the case of a bracket with transverse load applied at the tip or middle and thus cause a bending of the same support pin.

[0016] A further drawback lies in the fact that the reciprocating pump described briefly above is provided with a considerable radial extension starting from its rotation axis since it must be sufficiently large to be able to house the cam follower of the piston in its guide channel. In addition, each piston must project from the correspond-

ing guide jacket by a considerable length, since the portion of the piston that carries the cam follower mounted thereon must be placed alongside the cam across from the guide channel, in a manner such that the cam follower can be inserted in the guide channel during the assembly of the reciprocating pump.

[0017] Also known on the market are other different pump types, such as for example the type described in the patent US 3,433,172.

[0018] More in detail, the reciprocating pump of the aforesaid patent US 3,433,172 comprises a single cam provided with multiple lobes equally distributed around the rotation axis and a rocker arm provided with a first arm, which is mechanically connected with the piston and is placed in contact with the cam, and with an opposite second arm, which is in turn placed in contact with the cam.

[0019] In particular, the aforesaid cam is arranged in order to move the aforesaid piston forward and back through the rocker arm, since, when a lobe thereof is placed at the first arm of the rocker arm, the piston is thrust away from the rotation axis of the cam and, when the same lobe is placed at the second arm of the rocker arm, the aforesaid second arm is thrust away from the rotation axis of the cam in a manner such that the first arm and the piston connected to the latter are driven again close to the rotation axis.

[0020] Nevertheless, such pump has in practice shown that it does not lack drawbacks, since, in order to ensure that the first and the second arm of the rocker arm are always in contact with the cam, it is necessary that the equally distributed lobes of the cam are provided with a symmetric shape with respect to a plane containing the rotation axis and that the rocker arm forms, with its two arms, a supplementary angle at half the angle comprised between two adjacent lobes. Such shape of the lobes of the cam and of the rocker arm therefore involves the impossibility to impart different motion laws in the delivery translation and suction of the piston, thus without requiring that the speeds and accelerations imparted to the piston be determined and adapted to the pumping steps.

[0021] In addition, from patent GB 2424455, an internal combustion engine is known that is provided with pistons movable linearly back and forth in order to rotate, through corresponding rocker arms and cams, drive shaft.

[0022] In particular, such motor is provided - for each piston - with a rocker arm comprising a first lever arm, which is mechanically connected to the piston and is placed in contact with a first cam fit on the drive shaft, and a second lever arm, which is opposite the first arm with respect to a pivot point and is also placed in contact with a second cam fit on the drive shaft adjacent to the first cam.

[0023] The arrangement of rocker arms with both of the two arms in contact with a corresponding cam fit on the drive shaft ensures that the risks of jamming of the pistons at their top and bottom dead centers are reduced.

Presentation of the invention

[0024] In this situation, the problem underlying the present invention is therefore that of eliminating the problems of the abovementioned prior art by providing a reciprocating pump, whose membranes can be moved with any one motion law.

[0025] A further object of the present invention is to provide a reciprocating pump, which can be assembled in a quick manner.

[0026] A further object of the present invention is to provide a reciprocating pump, which has a particularly reduced radial size.

[0027] A further object of the present invention is to provide a reciprocating pump, which is simple and inexpensive to attain.

[0028] A further object of the present invention is to provide a reciprocating pump, which is entirely reliable in operation.

Brief description of the drawings

[0029] The technical characteristics of the invention, according to the aforesaid objects, are clearly seen in the contents of the below-reported claims and the advantages thereof will be more evident in the following detailed description, made with reference to the enclosed drawings, which represent a merely exemplifying and non-limiting embodiment of the invention, in which:

- figure 1 shows a sectional view with concurrent planes of a reciprocating pump, object of the present invention, in accordance with a preferred embodiment, in which one concurrent plane passes through a piston for one head and the other concurrent plane passes through a pin carrying, rotatably mounted thereon, a rocker arm acting on a piston for another head;
- figure 2 shows an enlargement of the reciprocating pump, object of the present invention, executed at the frame II of figure 1;
- figure 3 shows an enlargement of the reciprocating pump, object of the present invention, executed at the frame III of figure 1;
- figure 4 shows a sectional view of the reciprocating pump, object of the present invention, attained along the trace IV-IV of figure 1;
- figure 5 shows a sectional view of the reciprocating pump, object of the present invention, attained along the trace V of figure 1.

Detailed description of a preferred embodiment

[0030] With reference to the enclosed figures, reference number 1 overall indicates an reciprocating pump according to the present invention.

[0031] The present invention is in particular inserted in the industrial field of production of volumetric pumps with

multiple heads, which must be capable of pumping large flows of fluid with reduced dispensing discontinuities.

[0032] In particular, the present reciprocating pump 1 has particular application in the farming field of irrigation and disinfestation of cultivations, since it is advantageously intended to be used for pumping herbicide agents, insecticides or fertilizers, for example contained in a cistern mounted on farming machinery, and for dispensing them, for example through a distribution device having multiple dispensing nozzles, on a cultivated terrain.

[0033] The present reciprocating pump 1 comprises a casing 2 provided with one or more guide jackets 23, each of which defining a corresponding guide seat 3 extended along a corresponding radial direction X.

[0034] In addition, the present reciprocating pump 1 is provided with one or more heads 4, each of which mounted on the casing 2 at a respective guide seat 3 and at least partially defining a pumping chamber 5, and with one or more membranes 6, each of which delimiting a corresponding pumping chamber 5.

[0035] Advantageously, each head 4 is provided with a suction channel 34 in fluid connection with the pumping chamber 5, in order to allow the suction of a fluid to be pumped within the same pumping chamber 5, and with a dispensing channel 35 in turn in fluid connection with the pumping chamber 5, in order to allow the delivery dispensing of such fluid to be pumped.

[0036] The reciprocating pump 1 also comprises actuation means 7, which are housed in a containment chamber 38 defined internally by the casing 2 and comprise one or more pistons 8 and a drive shaft 9.

[0037] Each of the pistons 8 carries, fixed thereto, a corresponding membrane 6 and is susceptible of sliding in a guided manner in a corresponding guide seat 3, in particular along its radial direction X, between a release position, in which the corresponding membrane 6 expands the volume of the pumping chamber 5, and a compression position, in which the membrane 6 reduces the volume of the pumping chamber 5.

[0038] In this manner, when the piston 8 translates along the corresponding radial direction X from the compression position to the release position, the membrane 6 expands the volume of the pumping chamber 5 in order to generate reduced pressure within the same and thus suction the fluid to be pumped through the suction channel 34 and, when the piston 8 translates along the corresponding radial direction X from the release position to the compression position, the membrane 6 reduces the volume of the pumping chamber 5 in order to generate an overpressure within the pumping chamber 5 and expel the previously suctioned fluid in delivery through the dispensing channel 35.

[0039] In order to place the suction channels 34 of the heads 4 in fluid communication with a fluid source, e.g. a cistern mounted in farming machinery, the present reciprocating pump 1 preferably comprises an inlet manifold 39 mounted on the heads 4 and provided with at least one inlet mouth, intended to be connected to the aforesaid fluid source in order to receive therefrom the fluid to be pumped, and with multiple supply mouths 41, which are each connected to a corresponding suction channel 34 in order to supply the fluid to be pumped.

[0040] In addition, so as to place the delivery channels 35 of the heads 4 in fluid communication with a distribution device, mounted for example on the same farming machinery and provided with multiple dispensing nozzles for spreading the pumped fluid on a cultivated terrain, the present reciprocating pump 1 preferably comprises a delivery manifold 42 mounted on the heads 4 and provided with multiple reception mouths 43, which are each connected to a corresponding dispensing channel 35 in order to receive the fluid, and with at least one outlet mouth, which is intended to be connected to the aforesaid dispensing device in order to supply the pumped fluid thereto.

[0041] In addition, the drive shaft 9 carries at least one thrust cam 10 fixed thereto, which is in abutment against each piston 8 and is actuatable to rotate around a rotation axis Y thereof, in particular substantially orthogonal to the radial direction X of the guide seats 3, in order to move each piston 8 from the release position to the compression position.

[0042] In particular, the pistons 8 are each provided with a thrust body 54 slidably inserted along the radial direction X in the guide seat 3 of the guide jacket 23.

[0043] In addition, each piston 8 advantageously comprises a tappet element 18 extended along the radial direction X of the corresponding guide seat 3 towards the thrust cam 10 and carrying, associated therewith, at least one cam follower 19 placed in abutment against the thrust cam 10. Preferably, the thrust body 54 of each piston 8 comprises a housing seat extended parallel, and more preferably aligned, with the radial direction X of the corresponding guide seat 3 and carrying the corresponding tappet element 18 at least partially housed at its interior.

[0044] In particular, each tappet element 18 comprises a shaft portion 66, which is inserted in the housing seat made on the thrust body 54 of the corresponding piston 8, and a rear portion 67, which is extended starting from the shaft portion 66, projects with respect to the same thrust body 54 towards the thrust cam 10 and carries the aforesaid cam follower 19 associated therewith.

[0045] More in detail, the housing seat of each thrust body 54 is through, in a manner such that the shaft portion 66 of the corresponding tappet element 18 faces towards the respective head 4 and membrane 6.

[0046] In addition, each housing seat comprises preferably an enlarged section directed towards the thrust cam 10 in order to partially house the rear portion 67 of the corresponding tappet element 18.

[0047] In accordance with the preferred embodiment illustrated in the enclosed figures, the cam follower 19 comprises preferably at least one bearing 64, arranged for rotating in contact with the thrust cam 10.

[0048] In particular, the aforesaid bearing 64 is rotat-

ably mounted on a support pin 65 mechanically connected to the tappet element 18 of the corresponding piston 8.

[0049] More in detail, the rear portion 67 of each tappet element 18 comprises two annular shoulders 68 that face each other, which carry the support pin 65 inserted therein and carry the bearing 64 of the corresponding cam follower 19 interposed therebetween.

[0050] In order to increase the the mechanical strength of the cam follower 19, the same cam follower 19 comprises more than one bearing 64 mounted on the support pin 65, e.g. two bearings 64 placed side-by-side each other, interposed between the annular shoulders 68 and placed in contact with the thrust cam 10.

[0051] Otherwise, in accordance with a further embodiment not illustrated in the enclosed figures, the cam follower 19 is attained directly in a single body with the corresponding tappet element 18 and comprises a sliding surface, which is directed towards the thrust cam 10, is placed in abutment against it and is extended on the rear portion 67 of the corresponding tappet element 18.

[0052] Preferably, each membrane 6 is fixed to the tappet element 18 of the corresponding piston 8, in particular by means of a retention screw 55 having the threaded stem thereof placed to traverse the same membrane 6 and screwed to the shaft portion 66 and by means of a support plate 56 maintained adhered against the face of the membrane 6 directed towards the pumping chamber 5 by the enlarged head of the same retention screw 55.

[0053] In accordance with the preferred embodiment illustrated in the enclosed figures, the present reciprocating pump 1 comprises three heads 4 (and, hence, three corresponding guide jackets 23, three corresponding pistons 8 and three corresponding membrane 6).

[0054] Advantageously, the guide jackets 23 (and hence also the guide seats 3 at which the heads 4 are mounted with their membranes 6 moved by the respective pistons 8) are angularly distributed equidistant from each other, in particular at an angular distance of 120° each from the adjacent one, as illustrated in the enclosed figures 4 and 5.

[0055] Otherwise, in accordance with further embodiments not illustrated in the enclosed figures, the present reciprocating pump 1 can comprise a different number of heads 4, e.g. four heads 4 or two heads 4, and consequently an analogous number of guide jackets 23, pistons 8 and membranes 6.

[0056] In addition, each guide jacket 23 is advantageously provided with a lateral wall 24 placed to delimit the corresponding guide seat 3, so as to increase the precision with which the piston 8 translates between the release position and the compression position within the corresponding guide jacket 23.

[0057] In particular, the thrust body 54 of each piston 8 is slidably inserted substantially to size in the guide seat 3 delimited by the corresponding lateral wall 24.

[0058] More in detail, the lateral wall 24 of each guide jacket 23 has substantially circular extension around the radial direction X and the thrust body 54 of the piston 8 has substantially circular plan shape.

[0059] Preferably, the casing 2 also comprises a central support body 32 delimiting, at least laterally around the rotation axis Y, the containment chamber 38 and provided with at least three lateral openings 33, one for each head 4, which are extended starting from the containment chamber 38 and are each aligned with the radial direction X of a corresponding guide seat 3.

[0060] In accordance with the preferred embodiment illustrated in the enclosed figures, the central support body 32 of the casing 2 has substantially prismatic shape, is extended along a main extension axis Z between two opposite terminal faces 36, is provided with one or more lateral faces 37, one for each head 4, substantially planar (preferably parallel to the main extension axis Z and perpendicular to the terminal faces 36), and on each of which a corresponding lateral opening 33 is made.

[0061] In particular, the rotation axis Y of the drive shaft 9 preferably coincides with the main extension axis Z of the central support body 32 of the casing 2.

[0062] Advantageously, at least the central support body 32 is made of aluminum or or an alloy thereof, in order to make the casing 2 as light as possible, as this is one of the heaviest components of of the present reciprocating pump 1.

[0063] In accordance with the preferred embodiment, each guide jacket 23 comprises a positioning flange 27 extended transversely starting from the lateral wall 24 and retained at least between the corresponding head 4 and the central support body 32 of the casing 2.

[0064] In addition, preferably, the lateral wall 24 of the guide jacket 23 is extended along the radial direction X at least partially within the corresponding lateral opening 33, in a manner such that the guide seats 3 are in turn extended inside the central support body 32 of the casing 2, thus reducing the overall bulk of the present reciprocating pump 1.

[0065] Analogous to the positioning flange 27 of the guide jacket 23, also the membrane 6 of each head 3 is preferably retained between the corresponding head 4 and the central support body 32 of the casing 2.

[0066] In particular, each lateral opening 33 is provided with an enlarged portion 60 at the respective lateral face 37, in order to at least partially house the positioning flange 27 of the corresponding guide jacket 23.

[0067] More in detail, the enlarged portions 60 of each lateral opening 33 define, on the central support body 32, corresponding abutment steps 47 against which the positioning flanges 27 are placed in abutment.

[0068] Preferably, the positioning flanges 27 are completely housed in the enlarged portion 60 of the corresponding lateral openings 33 and placed in abutment against the respective abutment step 47, and the membranes 6 are pressed with pressure against the positioning flanges 27 by the corresponding heads 4 mounted on the casing 2.

[0069] More in detail, the positioning flanges 27 and the enlarged portions 60 of the lateral openings 33 have

shape that is substantially counter-shaped with respect to each other.

[0070] In particular, the positioning flanges 27 and the enlarged portions 60 of the corresponding lateral openings 33 have circular shape, in accordance with the preferred embodiment. Otherwise, the positioning flanges 27 and the enlarged portions 60 can have polygonal shape. Each head 4 advantageously comprises a shaped body 48 provided with a rear face 49, directed in opposite sense with respect to the central support body 32 and hence intended to remain visible, and with a front face 50, which, like the lateral faces 37 of the central support body 32, has substantially planar extension, so as to be mechanically coupled to one of these.

[0071] For such purpose, between the rear face 49 and the front face 50, multiple through holes are preferably made on the shaped body 48 of the head 4, and on each lateral face 37 of the central support body 32, multiple threaded holes are made corresponding to the through holes of the heads 4, in order to attain a bolted connection between each head 4 and the central support body 32.

[0072] Preferably, the pumping chamber 5 of each head 4 is made by means of a substantially cap-shaped concavity on the front face 50 and is closed by a corresponding membrane 6, which is advantageously retained between the head 4 itself and the central support body 32 of the casing 2, in particular between the front face 50 of the head 4 and the positioning flange 27 of the corresponding guide jacket 23 in abutment against the respective abutment step 47, as described above.

[0073] In addition, on the front face 50 of each head 4, a centering seat 51 is advantageously made, around the concavity that at least partially defines the pumping chamber 5, and such centering seat 51 at least partially houses the membrane 6, which is in turn preferably at least partially housed in the enlarged portion 60 of the corresponding lateral opening 33.

[0074] In accordance with an embodiment not illustrated in the enclosed figures, the lateral wall 24 of each guide jacket 23 might not be inserted within a corresponding lateral opening 33, but rather it can be projectingly extended with respect to the corresponding lateral face 37 of the central support body 32, always aligned with the lateral opening 33. In such case, each guide jacket 23 advantageously comprises a first fixing flange, which is extended radially starting from a first terminal end of the lateral wall 24 and is mechanically coupled to the corresponding lateral face 37 of the central support body 32, e.g. by means of screws, and a second fixing flange, which is extended radially starting from an opposite second terminal end of the lateral wall 24 and carries a corresponding head 4 mounted thereon, with the corresponding membrane 6 retained interposed between head 4 and second fixing flange.

[0075] According to the underlying the present invention, the actuation means 7 also comprise one or more rocker arms 11, each of which rotatably connected to the casing 2 by means of a pin 12 and provided with a first lever arm 13 acting on a corresponding piston 8, and a second lever arm 14 opposite the first lever arm 13 with respect to the pin 12, and at least one return cam 15, which is fixed on the drive shaft 9 and is actuatable to rotate around the rotation axis Y in order to move each rocker arm 11 around the corresponding pin 12.

[0076] Each rocker arm 11 is movable between an operative position, in which the return cam 15 acts against the second lever arm 14 in order to return, by means of the corresponding first lever arm 13, the corresponding piston 8 to slide from the compression position towards the release position, and a non-operative position, in which the return cam 15 releases the second lever arm 14 in order to free the corresponding piston 8 to slide from the release position towards the compression position.

[0077] Advantageously, each rocker arm 11 is provided with an enlarged central portion 77 interposed between first lever arm 13 and second lever arm 14.

[0078] Preferably, on the enlarged central portion 77 of each rocker arm 11, a mounting opening is made that is traversed by the corresponding pin 12.

[0079] In addition, between the enlarged central portion 77 and the pin 12, a slide bushing 76 is advantageously interposed, so as to reduce the friction with the rotation between enlarged central portion 77 of each rocker arm 11 and the corresponding pin 12.

[0080] More in detail, each rocker arm 11 is movable around the corresponding pin 12 in a first rotation direction from the non-operative position to the operative position, in which the return cam 15 acts against the second lever arm 14 in order to push, by means of the corresponding first lever arm 13, the corresponding piston 8 to slide along the respective radial direction X with a return travel from the compression position towards the release position.

[0081] In addition, each rocker arm 11 is preferably movable in a second rotation direction, opposite the first, from the operative position to the non-operative position, in which the return cam 15 releases the second lever arm 14 in order to free the corresponding piston 8 to slide along the respective radial direction X with a delivery travel from the release position towards the compression position.

[0082] In this manner, the thrust cam 10 actuates each piston 8 to translate in the corresponding guide seat 3 along the radial direction X with a delivery travel from the release position to the compression position and the return cam 15 actuates, by means of the rocker arms 11, each piston 8 to translate with a return travel from the compression position to the release position. More in detail, as is better described hereinbelow, providing for two separate cams - i.e. the thrust cam 10 arranged for acting directly on the pistons 8, pushing them from the release position to the compression position and the return cam 15 arranged for acting on the pistons 8 through the corresponding rocker arms 11, returning them from the compression position to the release position - allows impart-

ing to the pistons 8 different speeds and accelerations in their motion from the release position to the compression position and in their motion from the compression position to the release position, and such different speeds and accelerations are preferably sized as a function of the different operative parameters of the pump, such as for example the characteristics of the fluid that must be pumped, the pressure of the plant in which the pump is intended to be installed downstream or upstream of the pump itself, the loads and the stresses that are developed during the suction of the liquid into the pumping chamber 5 and during the dispensing of the aforesaid liquid to be pumped and the like.

[0083] Advantageously, the thrust cam 10 is shaped in a manner such to impart, during the rotation of the drive shaft 9, a first motion law (i.e. a first speed law and a first acceleration law) to the pistons 8 and, in addition, the return cam 15 is shaped in a manner such to impart, through the rocker arms 11, during the rotation of the drive shaft 9, a second motion law (i.e. a second speed law and a second acceleration law) to the pistons 8 which is different than the aforesaid first motion law.

[0084] In particular, the thrust cam 10 is provided with a first lateral abutment surface arranged for receiving the pistons 8 in abutment, and more particularly their corresponding cam followers 19, and the return cam 15 is provided with a second lateral abutment surface for receiving in abutment the second lever arms 14 of the rocker arms 11.

[0085] More in detail, the first lateral abutment surface of the thrust cam 10 is provided with at least one thrust point, which is placed at a first radial distance from the rotation axis Y and determines the compression position of the pistons 8, and the second lateral abutment surface of the return cam 15 is provided with at least one release point, which is placed at a second radial distance from the rotation axis Y and determines the non-operative position of the rocker arms 11.

[0086] Preferably, the thrust point of the thrust cam 10 and the release point of the return cam 15 are angularly spaced around the rotation axis Y in a manner such that, with the thrust point placed at a piston 8, the release point is placed at the second lever arm 14 of the rocker arm 11 corresponding to the aforesaid piston 8.

[0087] In addition, advantageously, the second lateral abutment surface of the return cam 15 is provided with at least one return point, which is placed at a third radial distance from the rotation axis Y greater than the second radial distance and determines the operative position of the rocker arms 11, and the first lateral abutment surface of the thrust cam 10 is provided with at least one release point, which is placed at a fourth radial distance lower than the first radial distance and determines the release position of the pistons 8.

[0088] Preferably, the return point of the return cam 15 and the release point of the thrust cam 10 are equally spaced around the rotation axis Y such that, with the return point placed at the second thrust arm 14 of a rocker arm 11, the release point is placed at the piston 8 corresponding to the aforesaid rocker arm 11.

[0089] In addition, the first lateral abutment surface of the thrust cam 10 is advantageously provided, with reference to the rotation direction of the same thrust cam 10 around the rotation axis Y, with a thrust section, which is extended from the release point to the thrust point, and with a release section, which is extended from the thrust point to the release point.

[0090] More in detail, the thrust profile and the release profile can have angular shape and/or size with respect to the rotation axis Y that are different from each other.

[0091] Analogously, the second lateral abutment surface of the return cam 15 is advantageously provided, with reference to the rotation direction of the same return cam 15 around the rotation axis Y, with a return profile, which is extended from the release point to the return point, and with a release profile, which is extended from the return point to the release point.

[0092] More in detail, the return profile and the release profile can have angular shape and/or size with respect to the rotation axis Y that are different from each other.

[0093] In this manner, it is possible to move the pistons 8 to translate from the release position towards the compression position (delivery travel) and from the compression position towards the release position (return travel) with different accelerations and sized on the basis of the loads that are developed respectively during the dispensing of the liquid to be pumped from the pumping chamber 5 and during the suction of the aforesaid liquid into the same pumping chamber 5.

[0094] More in detail, the first lever arm 13 does not abut against the (and in particular is separated from the) first lateral abutment surface of the thrust cam 10 and against the second lateral abutment surface from the return cam 15, in particular both in the operative position and in the non-operative position of the rocker arm 11.

[0095] Advantageously, the second lever arm 14, which abuts against the second lateral abutment surface of the return cam 15, never abuts against the first lateral abutment surface of the thrust cam 10.

[0096] Preferably, the thrust cam 10 and the return cam 15 are attained in a single body and are fit on the drive shaft 9.

[0097] Otherwise the thrust cam 10 and the return cam 15 can be made separately and both be fit on the drive shaft 9, preferably adjacent to each other.

[0098] Still otherwise, the thrust cam 10 and the return cam 15 can be made in a single body with the same drive shaft 9.

[0099] In accordance with the preferred embodiment, each piston 8 comprises at least one abutment portion 16 extended substantially transverse to the radial direction X of the corresponding guide seat 3 and provided with a retention face 17 directed in the opposite direction with respect to the return cam 15, and preferably parallel to the rotation axis Y of the drive shaft 9.

[0100] More in detail, the first lever arm 14 of each

rocker arm 11 is placed in abutment against the retention face 17 of the abutment portion 16 of the corresponding piston 8 at least with the corresponding piston 8 sliding from the compression position towards the release position (i.e. in particular in the return travel).

[0101] Preferably, the first lever arm 14 of each rocker arm 11 is placed in abutment against the retention face 17 of the abutment portion 16 of the corresponding piston 8 both with the corresponding piston 8 sliding from the compression position towards the release position and with the corresponding piston 8 sliding from the release position towards the compression position (i.e. in particular both in the return travel and in the delivery travel).

[0102] Advantageously, the abutment portion 16 of each piston 8 is laterally extended starting from the corresponding tappet element 18.

[0103] Preferably, as illustrated in particular in figure 2, the abutment portion 16 is extended projecting from the rear portion 67 of the corresponding tappet element 18, i.e. in particular from at least one of the annular shoulders 68 which carry, inserted therein, the support pin 65 on which the bearing 64 is mounted.

[0104] In accordance with a different embodiment not illustrated in the enclosed figures, the first lever arm 13 of each rocker arm 11 carries, mounted thereon, a corresponding rotary bearing, arranged for rotating in contact with the retention face 17 of the abutment portion 16, so as to reduce the friction between the first lever arm 13 and the retention face 17 and hence limit the wear thereof.

[0105] Otherwise, on each tappet element 18, i.e. in particular on its rear portion 67, a connection seat can be made and the first lever arm 13 of each rocker arm 11 is inserted in the connection seat of the corresponding tappet element 18.

[0106] In order to reduce the radial bulk of the return cam 15 as much as possible starting from the rotation axis Y, the first lever arm 13 and the second lever arm 14 of each rocker arm 11 preferably form an angle between them that is substantially comprised between 75° and 125° and, still more preferably comprised between 85° and 115°, e.g. equal to 90° (as illustrated for example in figures 4 and 5).

[0107] Advantageously, the pin 12 of each rocker arm 11 is extended within the containment chamber 38 substantially parallel to the drive shaft 9.

[0108] Therefore, each rocker arm 11 is preferably actuatable to rotate around a direction substantially parallel to the rotation axis Y of the thrust cam 10 and of the return cam 15.

[0109] In addition, the casing 2 advantageously comprises at least one first closure wall 20 and a second closure wall 21 of the containment chamber 38, which face each other and placed to delimit the containment chamber 38 on opposite sides along the rotation axis Y.

[0110] More in detail, the pin 12 of each rocker arm 11 is extended between a first end 44 thereof mechanically connected to the first closure wall 20 and a second end 45 mechanically connected to the second closure wall 21.

[0111] Preferably, the first closure wall 20 comprises one or more threaded holes 69, one for each pin 12, and the first end 44 of each pin 12 is threaded, in a manner such that the pins 12 are coupled via screwing to the first closure wall 20 at the threaded holes 69.

[0112] In addition, the second closure wall 21 preferably comprises one or more blind holes 70, one for each pin 12, and the second end 45 of each pin 12 is inserted substantially to size in a corresponding blind hole 70, in a manner such that the first and the second closure wall 20, 21 maintain the substantially aligned pins 12 parallel to the rotation axis Y, even under the loads exerted by the return cam 15 on the second lever arm 14 of the corresponding rocker arm 11.

[0113] In accordance with the preferred embodiment illustrated in the enclosed figures, on the terminal faces 36 of the central support body 32, corresponding access openings 52 to the containment chamber 38 are made, so as to allow an easy assembly of the actuation means 7.

[0114] Advantageously the first and the second closure wall 20, 21 respectively comprise a first and a second cover 53, 53', which are coupled to the terminal faces 36 and are placed to close the aforesaid access openings 52.

[0115] In particular, the first cover 53 is advantageously provided with a blind seat 58, in which a terminal portion of the same drive shaft 9 is inserted (rotatably around the rotation axis Y) and the second cover 53' is provided with a through opening 57 traversed by the drive shaft 9 of the actuation means 7.

[0116] Otherwise, in accordance with an embodiment not illustrated in the enclosed figures, usually on one of the two terminal faces 36 of the central support body 32, a corresponding access opening 52 is made and only one between the first and the second closure wall 20, 21 comprises a first or second cover 53, 53' placed to close the aforesaid access opening 52, while the other between the second and the first closure wall 21, 20 is made in a single body with the central support body 32 and thus itself defines one of the terminal faces 36 of the central support body 32.

[0117] Advantageously, each pin 12 comprises at least one first section 61 and a second section 62, which has smaller diameter than the first section 61.

[0118] The first section 61 and the second section 62 are advantageously connected by a positioning shoulder 63, substantially aligned at the return cam 10.

[0119] In addition, in order to maintain each rocker arm 11 precisely in position with respect to the return cam 15 and at least partly limit possible translations of the rocker arms 11 along the corresponding pins 12, preferably, each rocker arm 11 is rotatably mounted on the second section 62 of the corresponding pin 12 in abutment against the positioning shoulder 63. Preferably, each pin 12 carries, mounted on its second section 62, a spacer element 71 interposed between rocker arm 11 and first or second closure wall 20, 21 in order to maintain the

corresponding rocker arm 11 against the positioning shoulder 63.

[0120] In particular, if the first end 44 is placed at the end of the first section 61 of the pin 12 and the second end 45 is placed at the end of the second section 62, as illustrated in particular in figures 1 and 3, the spacer element 71 is preferably interposed between the corresponding rocker arm 11 and the second closure wall 21.

[0121] Otherwise, if the first end 44 is placed at the end of the second section 62 of the pin 12 and the second end 45 is placed at the end of the first section 61, the spacer element 71 is interposed between the corresponding rocker arm 11 and the first closure wall 20.

[0122] In order to at least partly limit the possible rotation of the pistons 8 within their guide seat 3 around the radial direction X, the lateral wall 24 of each guide jacket 23 is advantageously provided with at least one longitudinal opening 25 extended parallel to the radial direction X of the corresponding guide seat 3 and the respective piston 8 comprises at least one projecting element 26 slidably inserted in the longitudinal opening 25.

[0123] Preferably, each projecting element 26 comprises at least one alignment screw 72 provided with a threaded connection stem 73, which is inserted in a corresponding threaded seat made on the thrust body 54 of the corresponding piston 8 and is extended transversely with respect to the radial direction X, and with a projecting head 74, which is extended laterally projecting with respect to the thrust body 54 of the corresponding piston 8 and is slidably inserted in the longitudinal opening 25 of the corresponding guide jacket 23.

[0124] More in detail, the threaded seat is extended through up to the housing seat for the tappet element 18 (in particular up to the enlarged portion of the housing seat for the rear portion 67 of the tappet element 18).

[0125] Advantageously, the tappet element 18 (i.e. in particular its rear portion 67) is provided with an alignment hole substantially aligned with the threaded seat and the alignment screw 72 of the projecting element 26 comprises an alignment section 75, which is extended starting from the threaded connection stem 73 and is inserted in the alignment hole, so as to prevent the rotation of the tappet element 18 within the housing seat on the corresponding thrust body 54 around the radial direction X.

[0126] Otherwise, in accordance with an embodiment not illustrated in the enclosed figures, the thrust body 54 of each piston 8 has substantially polygonal plan shape, e.g. rectangular, and the lateral wall 24 of the guide jacket 23 delimits a corresponding guide seat 3 substantially counter-shaped with respect to the thrust body 54, always in order to prevent the rotation of the piston 8 around the radial direction X.

[0127] Preferably, in order to prevent the guide jackets 23 from being able to rotate around the radial direction X (in particular, for example, if the positioning flanges 27 and the enlarged portions 60 in which they are inserted have substantially circular shape), the casing 2 comprises centering elements 28 each connected to the central support body 32 and to the positioning flange 27 of a corresponding guide jacket 23 and configured for blocking the rotation of the aforesaid positioning flange 27, with respect to the central support body 32, around the radial direction X. In this manner, in accordance with the preferred embodiment, since the rotation of each piston 8 around the radial direction X thereof is blocked by the projecting element 26 slidably inserted in the longitudinal opening 25 on the lateral wall 24 of the guide jacket 23 and since the rotation of each guide jacket 23 around the aforesaid radial direction X is blocked by a suitable centering element 28 connected to the central support body 32 of the casing 2 and to the corresponding positioning flange 27, it is possible to prevent the bearing 64 of each cam follower 19 from modifying its own tilt around the radial direction X with respect to the thrust cam 10.

[0128] In accordance with an embodiment not illustrated in the enclosed figures, the centering element 28 advantageously comprises multiple retention pins extended projecting from the central support body 32 of the casing 2 and/or from the positioning flange 27 of the respective guide jackets 23 and inserted in corresponding seats made on the positioning flanges 27 and/or on the central support body 32.

[0129] Advantageously, as illustrated in particular in figure 2, the central support body 32 of the casing 2, at each head 4, comprises at least one first centering hole 29 and the positioning flange 27 of each guide jacket 23 comprises at least one corresponding second centering hole 30.

[0130] In particular, the centering element 28 comprises at least one pin 31 at least partially inserted in the first centering hole 29 of the central support body 32 and in the second centering hole 30 of the positioning flange 27.

[0131] More in detail, the first centering holes 29 are advantageously made on the abutment steps 47 inside the lateral openings 33 of the central support body 32 of the casing 2.

[0132] The invention thus conceived therefore attains the pre-established objects.

Claims

1. Reciprocating pump (1), which comprises:

- a casing (2) provided with one or more guide jackets (23), each of which defines a corresponding guide seat (3) extended along a corresponding radial direction (X);
- one or more heads (4), each of which is mounted on said casing (2) at a respective said guide seat (3) and at least partially defines a pumping chamber (5),
- one or more membranes (6), each of which delimits one said pumping chamber (5);
- actuation means (7), which are housed in a containment chamber (38) defined internally by

said casing (2) and comprise:

- one or more pistons (8), each of which carries fixed thereto a corresponding said membrane (6) and is susceptible of guidedly sliding in a corresponding said guide seat (3) between a release position, in which the corresponding said membrane (6) expands the volume of the pumping chamber (5) and a compression position, in which said membrane (6) reduces the volume of said pumping chamber (5);
- a drive shaft (9) carrying fixed thereto at least one thrust cam (10), which is in abutment against each said piston (8) and is actuatable to rotate around a rotation axis (Y) thereof in order to move each said piston (8) from said release position to said compression position;

said reciprocating pump being **characterized in that** said actuation means (7) also comprise:

- one or more rocker arms (11), each of which is rotatably connected to said casing (2) by means of a pin (12) and is provided with a first lever arm (13) acting on a corresponding said piston (8) and a second lever arm (14) opposite said first lever arm (13) with respect to said pin (12);
- at least one return cam (15), which is fixed on said drive shaft (9) and is actuatable to rotate around said rotation axis (Y) in order to move each said rocker arm (11) around the corresponding said pin (12);

each said rocker arm (11) being movable between an operative position, in which said return cam (15) acts against said second lever arm (14) in order to return, by means of the corresponding said first lever arm (13), said piston (8) to slide from said compression position towards said release position, and a non-operative position, in which said return cam (15) releases said second lever arm (14) in order to free said piston (8) to slide from said release position towards said compression position.

2. Reciprocating pump (1) according to claim 1, **characterized in that** each said piston (8) comprises at least one abutment portion (16) extended substantially transverse to the radial direction (X) of the corresponding said guide seat (3) and provided with a retention face (17) directed in the direction opposite said return cam (15);
the first lever arm (13) of each said rocker arm (11) being placed in abutment against the retention face (17) of the abutment portion (16) of the corresponding said piston (8) at least with the corresponding said piston (8) sliding from said compression position towards said release position.

3. Reciprocating pump (1) according to claim 1 or 2, **characterized in that** each said piston (8) comprises a tappet element (18) extended along the radial direction (X) of the corresponding said guide seat (3) towards said thrust cam (10) and carrying, associated therewith, at least one cam follower (19) placed in abutment against said thrust cam (10).

4. Reciprocating pump (1) according to claims 2 and 3, **characterized in that** the abutment portion (16) of each said piston (8) is laterally extended starting from the corresponding said tappet element (18).

5. Reciprocating pump (1) according to any one of the preceding claims, **characterized in that** the pin (12) of each said rocker arm (11) is extended within said containment chamber (38) substantially parallel to said drive shaft (9).

6. Reciprocating pump (1) according to any one of the preceding claims, **characterized in that** said casing (2) comprises at least one first closure wall (20) and a second closure wall (21) of said containment chamber (38), which face each other and are placed to delimit said containment chamber (38) on opposite sides along said rotation axis (Y);
the pin (12) of each said rocker arm (11) being extended between a first end (44) mechanically connected to said first closure wall (20) and a second end (45) mechanically connected to said second closure wall (21).

7. Reciprocating pump (1) according to any one of the preceding claims, **characterized in that** each said pin (12) comprises at least one first section (61) and one second section (62) with smaller diameter with respect to said first section (61), which are connected by a positioning shoulder (63) substantially aligned at said return cam (10);
each said rocker arm (11) being rotatably mounted on the second section (62) of the corresponding said pin (12) in abutment against said positioning shoulder (63).

8. Reciprocating pump (1) according to any one of the preceding claims, **characterized in that** each said guide jacket (23) is provided with a lateral wall (24) placed to delimit the corresponding said guide seat (3);
the lateral wall (24) of said guide jacket (23) being provided with at least one longitudinal opening (25) extended parallel to the radial direction (X) of the corresponding said guide seat (3) and said piston (8) comprising at least one projecting element (26) slidably inserted in said guide seat (25).

9. Reciprocating pump (1) according to claim 8, **characterized in that** said casing (2) comprises a central support body (32) delimiting, at least laterally around said rotation axis (Y), said containment chamber (38) and provided with one or more lateral openings (33), one for each head (4), which are extended starting from said containment chamber (38) and are each aligned with the radial direction (X) of the corresponding said guide seat (3);

each said guide jacket (23) comprising a positioning flange (27) extended transversely starting from the lateral wall (24) and retained at least between the corresponding said head (4) and the central support body (32) of said casing (2); said casing (2) comprising centering elements (28), each connected to said central support body (32) and to the positioning flange (27) of a corresponding said guide jacket (23) and each configured for blocking the rotation of the corresponding said positioning flange (27), with respect to said central support body (32), around said radial direction (X).

10. Reciprocating pump (1) according to claim 9, **characterized in that** the central support body (32) of said casing (2), at each head (4), comprises at least one first centering hole (29) and the positioning flange (27) of each guide jacket (23) comprises at least one corresponding second centering hole (30); the centering element (28) comprising at least one pin (31) at least partially inserted in the first centering hole (29) of the central support body (32) of said casing (2) and in the second centering hole (30) of said positioning flange (27).

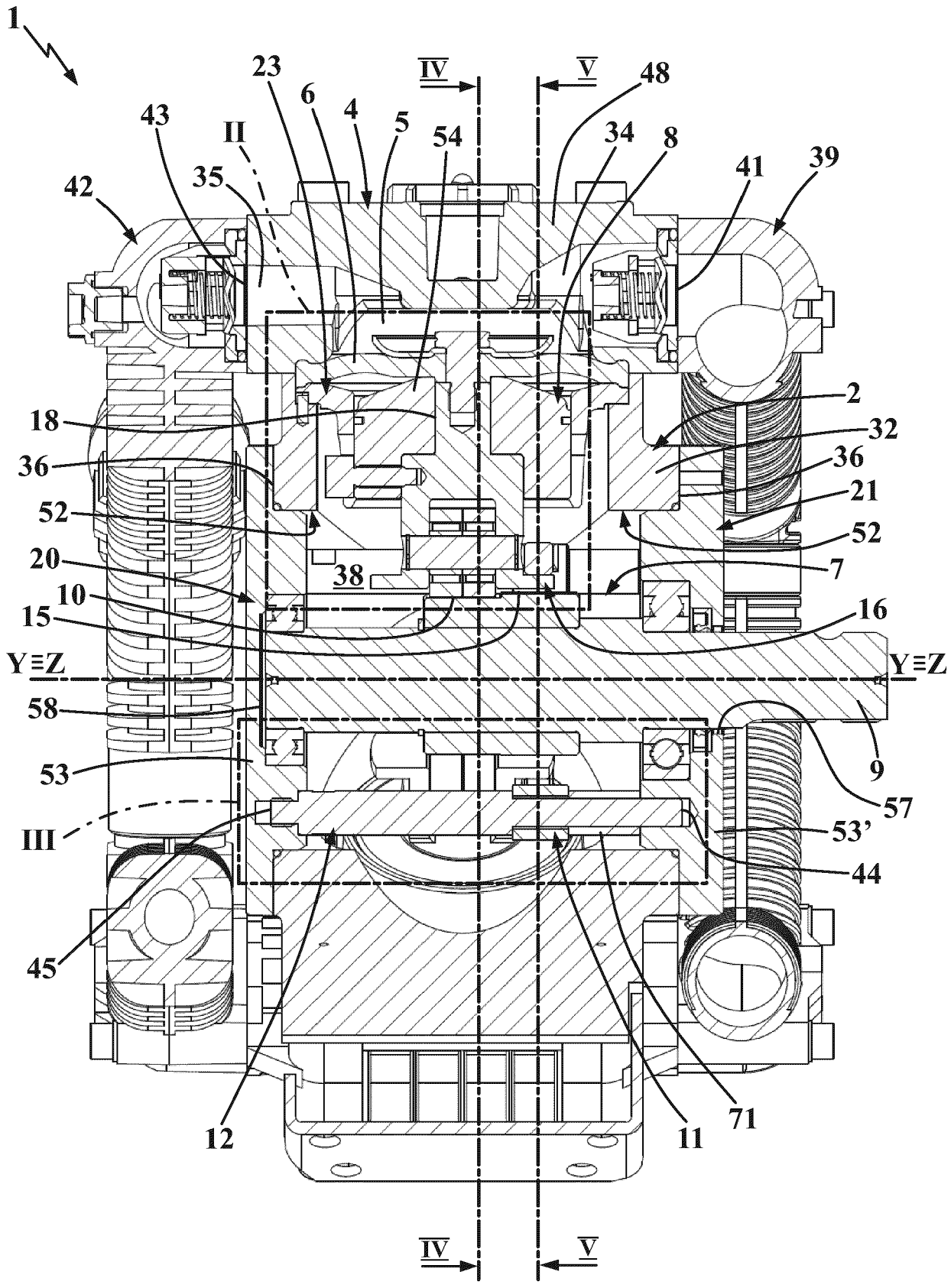
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Fig. 1

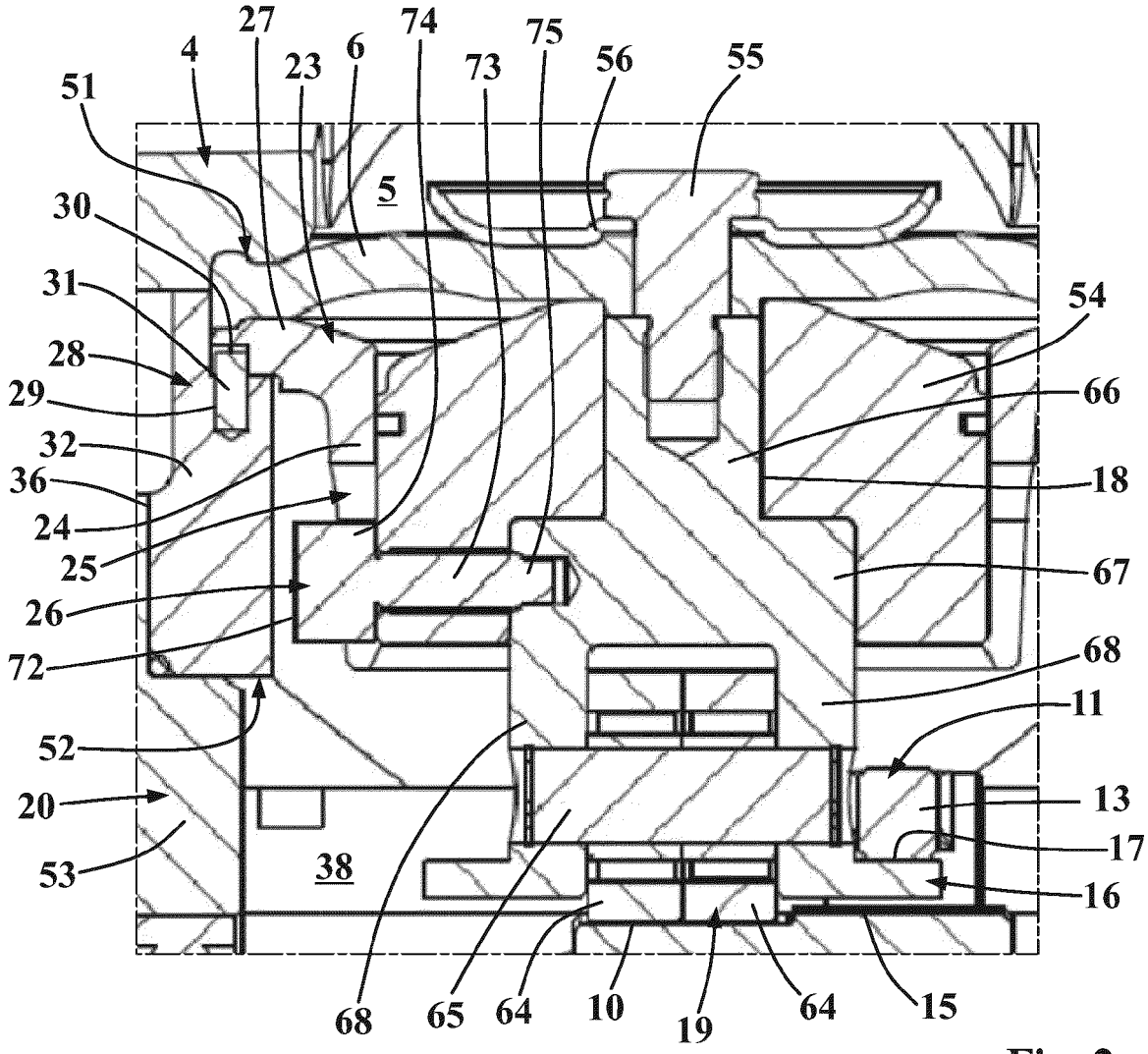
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Fig. 2

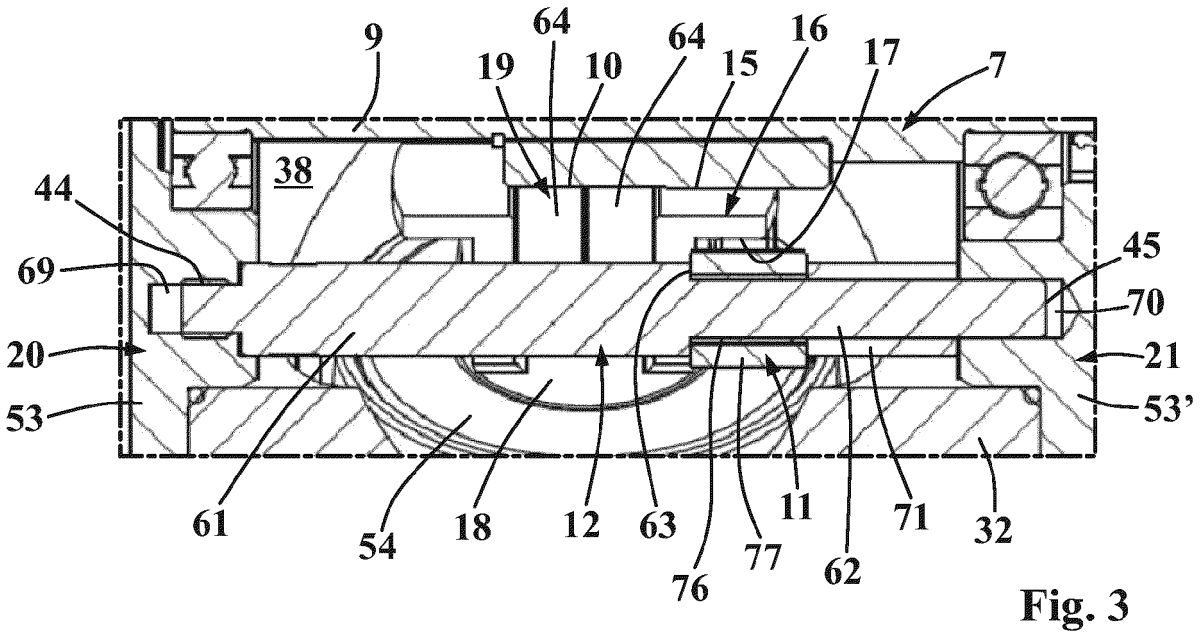
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Fig. 3

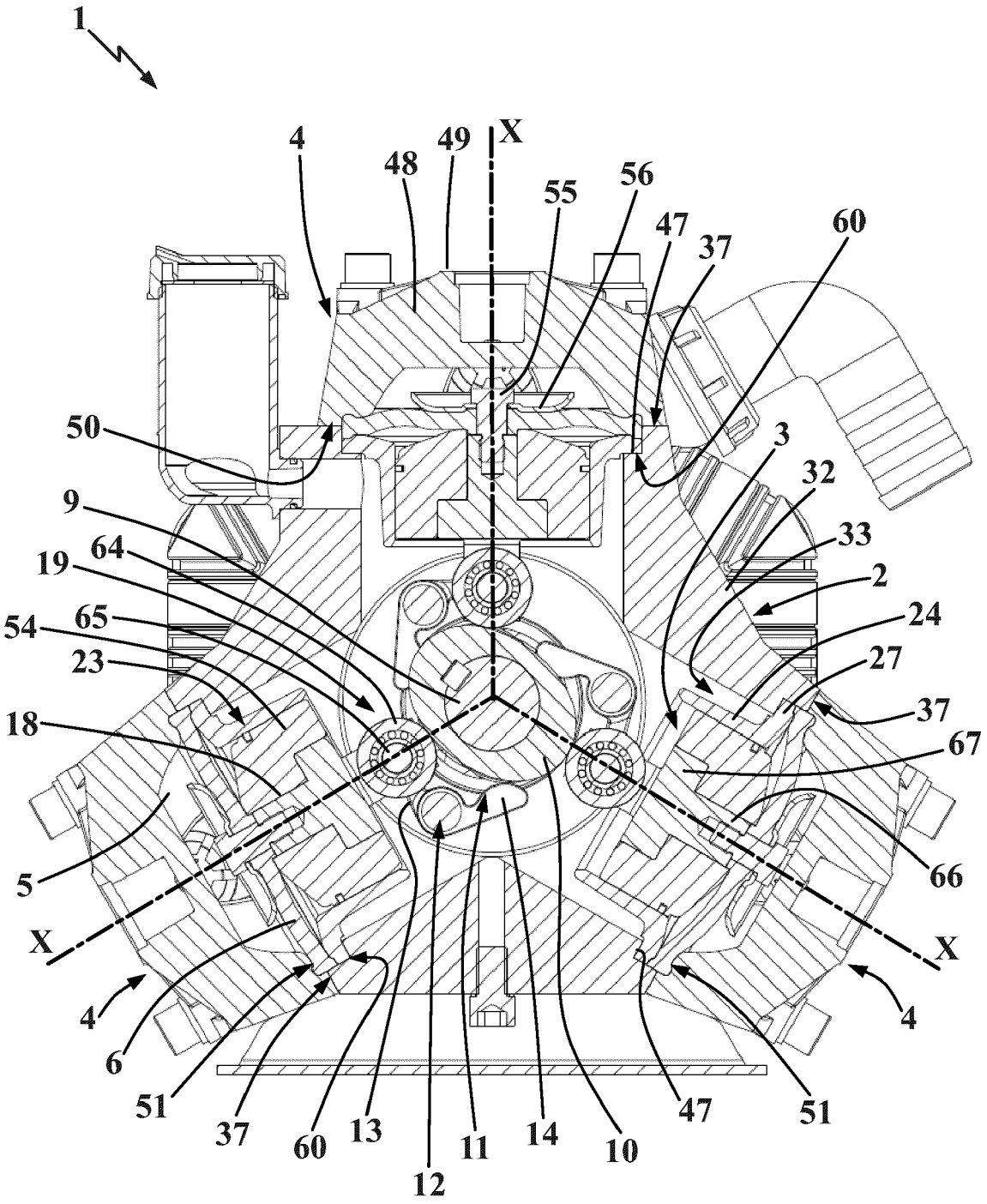
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Fig. 4

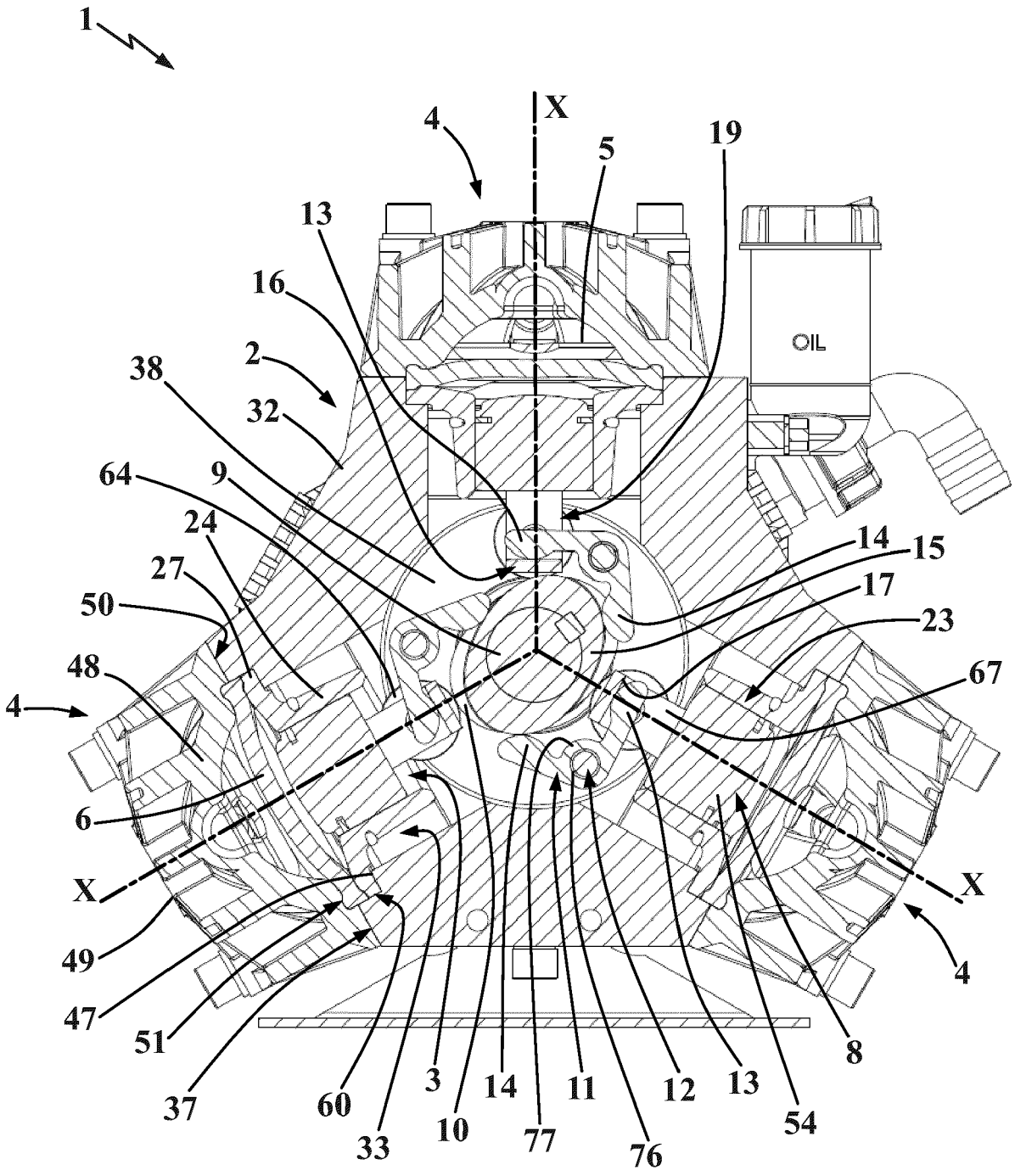
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Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 8558

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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	29 November 2022	Pinna, Stefano

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