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Pompe linéaire

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Description

[0001] The present invention relates to a fluid pump for usage in a massage system in a vehicle seat comprising a housing with a front wall at a front side and a rear wall at a rear side, a first actuator element which is movable forwards and backwards, and a second actuator element which is configured to be counter-directionally movable with respect to the first actuator element.

[0002] The limited space within a vehicle seat, especially those seats equipped with air cell based support systems requires that any integrated component must be as small as possible. Especially, the extension towards a passenger's body is very limited such that a component should be as flat as possible. Additionally, pressure to reduce fuel consumption has led vehicle manufacturers to lower the weight of the vehicle's inherent components. A low weight fluid pump is therefore needed. Further, the pump must effectively and timely manage the filling of a multitude of air cells that comprise a vehicle seat support system. Thus, the pump needs to have a large volume flow rate. At the same time, the pump needs to be silent and should create a minimum of vibrations only, because this would have a negative effect on the vehicle driver's comfort and safety. Finally, during a continuous use of the pump over long periods, the pump should create a minimum of heat only. Thus, reducing internal friction in the pump is of essence.

[0003] A pump type known in the art is the so-called diaphragm pump, one example of which is described in EP 0 743 452 B1. Therein, the volume of a cylindrically shaped pump's multitude of pumping chambers is defined on one side by a deformable diaphragm. These volumes are cyclically set to vary as an eccentric crank connected to diaphragms is rotated in order to deform the diaphragms. During this process, air flows into the pumping chamber and is channelled to a common outlet port causing a pumping effect.

[0004] Unfortunately, such a diaphragm pump using a rotating crank is physically large and the rotating movement itself creates vibration, noise and heat due to the resulting constant displacement of its centre of mass.

[0005] A second type of diaphragm pump is known from US 6,589,028 B1. That pump's objective is to reduce vibrations and is therefore caused to generate oscillations through the influence of two counter-directional electric coils. The cylindrically shaped pump contains two chambers divided by a partition wall, each with a corresponding diaphragm. For each side, in a diaphragm unit a diaphragm, a shaft and a coil are the only parts that move during oscillation. They move in mutually opposite directions to reduce vibration.

[0006] WO 2007/103384 A1 discloses a relatively flat oscillating electro-actuated pump using bellows formed by upper and lower diaphragms. Actuators, such as electro-active actuators drive the oscillating movement of the diaphragms/pistons when being powered which causes the diaphragms to vibrate in opposite vertical directions. Diaphragms have inlet and outlet reed valves to allow the compression chamber to receive the fluid.

[0007] That relatively flat electro-actuated oscillating pump has the disadvantage that it only allows one exhaust peak per pump cycle, consequently limiting the possible continuous flow rate of the pump. WO 2007/103384 A1 proposes to place additional bellows on top of each other in order to increase the possible maximum volume capability having the negative effect that the height of the pump is increased.

[0008] A further solution known from the art is described in US 4,585,397 and relates to a voice coil based pump having no movable parts in frictional contact. In essence, this cylindrically shaped pump consists of two moving coils with a metal bellow attached, two fixed permanent magnets concentric with the coils, and two corresponding fluid chambers. As alternating current is provided the two coils and bellows oscillate in phase and in the same axial direction. Thus, as one bellow is performing an exhaust stroke, the other one is performing an intake stroke.

[0009] Similarly, US 5,693,991 describes a cylinder compressor solution including two movable permanent magnets symmetrically structured about their axis, connected to two counter reciprocating pistons that are set to reciprocate axially relative to the cylinder to create a pressure therein. The reciprocating force is created as a result of the magnetic field generated from symmetrical cylinder stator assemblies being excited with alternating current.

[0010] It is the drawback of such voice coil pump solutions with a symmetrical shape including counter-moving magnets in order to reduce vibrations that they are physically large. They extend in radial and linear directions. Further, these pumps have the drawback that they only provide one exhaust peak per pump cycle due to the synchronous movement of the diaphragm units, thus leading to a reduced flow rate.

[0011] WO 2008/135186 provides a solution for a fluid valve with a simple, small design having the effect that the pressure in an air chamber, i.e. an air bladder, is held constant over a certain period of time.

[0012] GB 2 356 024 A discloses a fluid pump comprising two actuator elements which are counter-directionally movable along a linear axis. The actuator elements are coupled to four pistons which perform pumping strokes in such a way that two pistons arranged at the front side of a housing are movable backwards during an intake stroke and forwards during an exhaust stroke while the remaining two pistons arranged at the rear side of the housing are movable forwards during an intake stroke and backwards during an exhaust stroke. Each actuator element is coupled to two opposite pistons. The actuator elements known from this document carry permanent magnets which are driven by stationary coils wound around field cores between which the actuator elements are linearly and counter-directionally movable.

[0013] US 2,815,901 describes a compressor having first and second actuator elements which are counter-directionally movable, further having four pistons, wherein first and second pistons are movable backwards during an intake stroke and forwards during an exhaust stroke and third and fourth pistons are movable forwards during an intake stroke and backwards during an exhaust stroke. The actuator elements are driven by a bidirectionally rotating driving axle which is connected to the actuator elements by means of driving arms.

[0014] DE 199 04 350 A1 discloses a fluid pump comprising first and second actuator elements which are movable counter-directionally to one another and which are connected to four pistons to initiate movement of the pistons in a way that first and second pistons are movable backwards during an intake stroke and forwards during an exhaust stroke and third and fourth pistons are movable forwards during an intake stroke and backwards during an exhaust stroke. The actuator elements are driven by a rotating crank axis.

[0015] WO 96/02760 discloses a fluid pump having two wobbling discs mounted on a rotating driving axis and initiating linear movement of four pistons in a way that opposite pistons are moved forwards at the same time and backwards at the same time. The first wobbling disc is coupled to the first and second pistons and the second wobbling disc is coupled to the third and fourth piston.

[0016] US 2,732,124 describes a compressor comprising first and second actuator elements and four pistons, wherein each two opposite pistons are moved by one actuator element which is driven by a lever arm which in turn is moved by an electromagnet.

[0017] In summary, there is no small pump known from the prior art that has effectively combined low vibration, noise and heat generation with a continuously high flow rate.

[0018] It is therefore the object of the present invention to provide a fluid pump that overcomes the disadvantages of the pumps known from the prior art, i.e. to provide a small sized, light and low-cost fluid pump that generates as little sound, vibrations and heat as possible, that is easily integrated in a vehicle seat, and that is suitable for continuous massaging in a vehicle seat, namely having a continuously high flow rate.

[0019] This object is solved according to the present invention by a fluid pump with the features of claim 1. Preferred embodiments of the invention are subject of the dependent claims.

[0020] According to the present invention the fluid pump further comprises

a first piston and a second piston arranged at the front side, wherein the first piston and the second piston are movable backwards during an intake stroke and forwards during an exhaust stroke, and

a third piston and a fourth piston arranged at the rear side, wherein the third piston and the fourth piston are movable forwards during an intake stroke and backwards during an exhaust stroke,

wherein

the first actuator element is coupled to the first piston and the third piston such that

the first piston performs an intake stroke and the third piston performs an exhaust stroke when the first actuator element moves backwards, and such that

the first piston performs an exhaust stroke and the third piston performs an intake stroke when the first actuator element moves forwards,

wherein

the second actuator element is coupled to the second piston and to the fourth piston such that

the second piston performs an exhaust stroke and the fourth piston performs an intake stroke when the second actuator element moves forwards, and such that

the second piston performs intake stroke and the fourth piston performs an exhaust stroke when the second actuator element moves backwards, and

wherein

a coil (69, 71) is mounted on the first actuator element (65) and/or the second actuator element (67),

a permanent magnet (55) is located in a sandwich configuration between the first actuator element (65) and the second actuator element (67), and

at least one rolling element (89, 91, 93) having an axis of rotation perpendicular to the linear axis of motion of the actuator elements (65, 67) is provided between the first actuator element (65) and the second actuator element (67) such that both the first actuator element (65) and the second actuator element (67) are in driving contact with the rolling element (89, 91, 93) from opposite sides with respect to the axis of rotation of the rolling element.

[0021] Typically, the inventive fluid pump is an air pump. However, the fluid pump may also be used to pump another gas or liquid such as water or oil, or any other suitable fluid.

[0022] The housing may be closed or partially open and may comprise vents or ventilation slots through which air may pass in order to provide a cooling effect for inner components.

[0023] The movable actuator elements of the fluid pump define a linear axis of motion, which runs from the front side to the rear side in the backward direction and from the rear side to the front side in the forward direction.

[0024] The inventive fluid pump comprises at least four pistons of which two are arranged at the front side and two at the rear side. Herein, the term "piston" shall refer to any movable component that is adapted and arranged to cause a pressure in an associated compression chamber in order generate a pumping effect. A piston may for example be a rigid piston in a cylinder or a flexible rubber diaphragm sealing a compression chamber or a combination of both, wherein a rigid piston is connected to a flexible diaphragm sealing a compression chamber.

[0025] All pistons are adapted and arranged to perform an outward exhaust stroke, i.e. the front pistons forwards and the rear pistons backwards, in order to cause a pressure in their respective compression chamber. Analogously, the intake stroke is an inward movement for all pistons, i.e. backwards for the front pistons and forwards for the rear pistons. Thereby, the actuator elements always push for an exhaust stroke and pull for an intake stroke.

[0026] The inventive fluid pump allows for a simultaneous exhaust stroke of two pistons whilst the other two pistons are performing an intake stroke. This is achieved by a single one-directional movement of an actuator element. The actuator element pushes the first piston and pulls the opposite third piston whilst the other actuator element moves counter-directionally to pull the second piston and push the opposite fourth piston. Then, the actuator element moves in the other direction such that the first piston is pulled and the opposite third piston is pushed whilst the other actuator element pushes the second piston and pulls the opposite fourth piston. Thereby, the flow rate is continuously doubled compared to ordinary pumps usually used in a massage system in a vehicle seat.

[0027] In operation, the actuator elements oscillate with a phase shift of 180° to each other which ensures that the common centre of mass is substantially stationary and does not oscillate. Thereby, noise and vibrations are minimized.

[0028] The inventive fluid pump can be designed in a small, flat shape in an uncomplicated way and allows for a high flow rate in combination with minimal noise, vibrations and generation of heat. The length of a stroke may be designed to be as small as 5 mm. Therefore, the inner volume of the housing may be used to almost full capacity with only little forward and backward moving space.

[0029] According to the invention, a coil is mounted on the first actuator element and/or the second actuator element. Thereby, at least one actuator element can be driven by an alternating current through the coil(s) when they are located within a magnet field. Preferably, each actuator element is equipped with a coil in order to achieve a maximum of pumping power. The magnet field is provided by a permanent magnet that is fixed within the housing. The permanent magnet may have a flat shape and a horizontal orientation with a forward pole and a backward pole. The coil(s) may also be arranged horizontally parallel and in close vicinity to the permanent magnet such that the coil(s) move through an essentially vertical magnetic field. Thereby, those sections of the coil(s) through which an electric current has a transverse component drive the coil(s) in a longitudinal direction. Preferably, the diameter of the coil(s) is large enough such that there is one of those sections in the vicinity of the north pole and the other of those sections in vicinity of the south pole. When a current is applied to the coil(s) both of those sections drive the coil(s) in the same longitudinal direction. In case a four-pole magnet is used, e.g. in form of two flat two-pole magnets sandwiched to each other with opposite poles, and the four-pole magnet is located between the actuator elements, the mutually opposite current through the coils of the actuator elements drives the actuator elements into mutually opposite directions.

[0030] A printed circuit board (PCB) may be arranged at one lateral side of the housing and connected to the movable coil(s) via a flexible electric conductor within a band of biaxially-oriented polyethylene terephthalate (boPET).

[0031] In a preferred space-saving configuration, the permanent magnet may be located in a sandwich configuration between the first actuator element and the second actuator element. Except for the couplings to the respective pistons, the actuator elements may have a very similar design in this configuration. On the one hand, the space between the actuator elements is effectively used with this configuration. On the other hand, both actuator elements are symmetrically located with respect to the magnet field of the permanent magnet. Thereby, in case both actuator elements are equipped with identical coils, the very same amount of current may be applied to both coils in order to achieve the same driving force. Advantageously, the actuator elements with the mounted coils can be manufactured in a substantially identical way, except for the couplings to the respective pistons. The flexible conductor band for one actuator element may be arranged at the forward free moving space and the flexible conductor band for other actuator element may be arranged at the backward free moving space.

[0032] In order to save as much space as possible in the direction towards a passenger sitting on the vehicle seat, it is advantageous if the housing and the actuator elements have a substantially flat shape. The pistons may be arranged side-by-side and not on top of each other.

[0033] Further, at least one, preferably two, most preferably three, rolling element(s) having an axis of rotation perpendicular to the linear axis of motion of the actuator elements are provided between the first actuator element and the second actuator element such that both the first actuator element and the second actuator element are in driving contact with the rolling element(s) from opposite sides with respect to the axis of rotation of the rolling element(s).

[0034] Preferably the driving contact between the rolling element or at least one of the rolling elements and the first and second actuator elements is a meshing contact. A meshing contact, in contrast to a purely frictional contact, is meant to be a form-locking or positively fitting engagement as in the case of gear wheels and gear racks. Such meshing contact between the actuators and the roller element ensures the coordinated opposite movement of the two actuator elements. In principle, however, also driving contact based on purely frictional forces are possible, for example created by a spherical ball as a roller element running along a planar linear surface elements on the actuator elements, wherein frictional forces between the surface elements and the ball surface establish the driving contact.

[0035] In case of more than one rolling element, the rolling elements may be separately movable elements, coupled to a common axle or parts of a common axle. The most advantageous configuration comprises a forward axle and a backward axle, wherein both axles have a transverse axis. One axle has a central rolling element in form of an increased diameter portion and the other two rolling elements are located at each end of the other axle. Thereby, an always-stable three-point suspension of the actuator elements to each other is achieved.

[0036] The rolling element(s) may be suspended rotatably (and stationary) to a stationary bracket which is located in a sandwich configuration between the first and the second actuator element and configured to hold the permanent magnet. Thereby, the actuator elements are safely guided along a defined path of motion during oscillation.

[0037] In order to securely couple the actuator elements to each other mechanically such that they can only move counter-directionally, at least one of the rolling element(s) may be a pinion of a rack-and-pinion mechanism, wherein the actuator elements comprise associated rack portions extending along the linear axis of motion of the actuator elements such that the teeth of the pinion engage the teeth of the rack portions. In a configuration with two transversal axles one of them may be a roller axle having a radial extension at its centre as a first roller element. The other one may be a spur axle having at each end a roller element in form of a pinion engaging associated rack portions in the actuator elements.

[0038] Preferably, the fluid pump may comprise an integrated microcontroller for controlling the current through a coil mounted on the first actuator element and/or a coil mounted on the second actuator element. Such a microcontroller may be located on a printed circuit board (PCB) that may be arranged at one lateral side within the housing.

[0039] Furthermore, the fluid pump may comprise a position sensor for detecting the position of the first actuator element and/or second actuator element. Such a position sensor may include an optical path in vertical direction defined by optical elements such as an LED and a photodiode on a printed circuit board (PCB) that may be arranged at one lateral side within the housing. The actuator elements may comprise lateral light blocking extensions, which cross the optical path during oscillation of the actuator elements. Thereby, the exact position of the actuator elements may be detected and inputted to the microcontroller as a feedback and/or trigger value for controlling the current through the coil(s). Such a feedback and/or triggered controlling allows for a more economic operation of the fluid pump.

[0040] In a preferred embodiment of the inventive fluid pump the pistons are connected to a common air channel system having one or more inlet openings at an inner wall of the housing such that air is pumped from the inner volume of the housing towards a common outlet when the pistons are in motion. This has two advantages. Firstly, the inner inlet openings produce less suction noise, because it is acoustically shielded by the housing. Secondly, fresh air is transported through the housing such that those parts are cooled which generate heat during operation due to electric current and frictional motion.

[0041] In order to achieve the necessary pumping effect by simple means, an inlet valve and an outlet valve may be associated to each piston, wherein the inlet valve is open and the outlet valve is closed during an intake stroke of the associated piston, and wherein the inlet valve is closed and the outlet valve is open during an exhaust stroke of the associated piston. Preferably, the valves are simple reed valves with a flexible flap that covers an air passage in one direction and deforms to open in the other direction.

[0042] It is further preferred that an inlet channel is associated to each piston, wherein the inlet channel connects a compression volume of the associated piston via the corresponding inlet valve with the inner volume of the housing, and wherein an outlet channel is associated to each piston, wherein the outlet channel connects a compression volume of the associated piston via the corresponding outlet valve with a common outlet.

[0043] The housing may comprise two piston apertures at the front wall and two piston apertures at the rear wall, two outer inlet apertures connected to inner inlet openings at the front wall and two outer inlet apertures connected to inner inlet openings at the rear wall. Furthermore, a common gallery may be connected to the common outlet and sealed from the inlet openings and from the inner volume of the housing and having two outlet apertures at the outer front wall and two outlet apertures at the outer rear wall. Such a configuration has the advantage that a front channel cover and a rear channel cover may be sealingly attached to the front side and the rear side, respectively, wherein the channel cover defines the inlet and outlet channels. It is a very simple and cost-effective setup in which the inlet and outlet channels are defined by the channel covers, which are simply attachable to the outer front wall and outer rear wall of the housing.

[0044] Moreover, the first piston, the second piston, and the flexible flaps of the associated inlet and outlet valves may be integrated parts of a front piston element that may be arranged between the front wall of the housing and the front channel cover. Analogously, the third piston, the fourth piston, and the flexible flaps of the associated inlet and outlet valves may be integrated parts of a backward piston element that may be arranged between the rear wall of the housing and the rear channel cover.

[0045] Such a configuration ensures a very simple and cost-effective manufacturing of the fluid pump, because the number of parts is heavily reduced. The piston elements are placed at the front side and rear side, respectively, sandwiched between the front channel cover and the front wall and the rear channel cover and rear wall, respectively, wherein the piston elements serve as a sealing layer. Finally, the actuator system is inserted comprising the actuator elements and the bracket with a permanent magnet, the rolling element(s) and the PCB, wherein the actuator elements are coupled to the pistons and the bracket is fixed to the housing.

[0046] In the following, a preferred embodiment of the invention is described in detail with references to the accompanying figures, where:

Figure 1 shows a perspective view of a preferred embodiment of the fluid pump according to the present invention, wherein the front side of the fluid pump is shown in an exploded view.

Figure 2A shows a top view of a preferred embodiment of the fluid pump according to the present invention.

Figure 2B shows a front view of a preferred embodiment of the fluid pump according to the present invention.

Figure 3 shows a perspective exploded view of the parts comprised in a preferred embodiment of the fluid pump according to the present invention.

Figure 4 shows a detailed sectional view inside a preferred embodiment of the fluid pump according to the present invention without lid and cut through the xz-plane A-A indicated in Figure 2A.

Figure 5 shows a perspective sectional view inside a preferred embodiment of the fluid pump according to the present invention cut through the xy-plane B-B indicated in Figure 2B.

Figure 6 shows a perspective sectional view of a preferred embodiment of the fluid pump according to the present invention without housing and lid cut through the xz-plane C-C displayed in Figure 2A.

Figure 7A shows a perspective view of a preferred embodiment of the fluid pump according to the present invention without housing, lid, and upper inner parts.

Figure 7B shows a perspective detailed view of a preferred embodiment of the fluid pump according to the present invention without housing and lid.

[0047] The fluid pump 1 shown in Fig. 1 comprises a housing 3 essentially having the shape of a flat rectangular box. The height of the housing 3 is designed to be as small as possible and amounts to approximately 20 mm. The flat shape results from the fact that the height is designed to be less than a third of the length (about 85 mm) and the width (about 60 mm). The compact design of the fluid pump 1 further results in a weight of about 125 grams or less.

[0048] For the sake of a better understanding of the present invention, a suitable coordinate system is provided to define a forward axis x, a lateral axis y and a vertical axis z. However, any other suitable coordinate system may be defined to describe an embodiment of the invention. For the embodiment shown, the positive x-axis is defined to be the forward direction and the negative x-axis is defined to be the backward direction. Analogously, the positive y-axis is the left direction and the negative y-axis is the right direction. Finally, the positive z-axis is the upward direction and the negative z-axis is the downward direction.

[0049] Consequently, the fluid pump 1 in form of an essentially rectangular box has a front side, a rear side, a left side, a right side, a bottom side and a top side. The housing 3 comprises a bottom wall 3a, a left side wall 3b, a right side wall 3c, a front wall 3d, and a rear wall 3e defining an inner volume of the housing 3. On top, the housing 3 is covered by a removable or permanently fixed lid 5. In the lid an air inlet 6 is provided which communicates with a system of air distribution channels in the interior of the housing which serves both the purpose of cooling and of supplying air to be pumped as will be described in more detail below. A further corresponding air inlet is provided in the bottom wall of the housing 3 opposite to the lid 5.

[0050] The housing comprises an aperture 7 through which cables extend from the exterior to the interior of the housing 3 to be connected there to connectors as on a printed circuit board. This allows supply of electrical power and communication of control signals.

[0051] The housing 3 is further provided with attachment means 9 suitable for attaching the fluid pump 1 to the back of a vehicle seat.

[0052] The front wall 3d of the housing 3 comprises a left circular piston aperture 11 and a right circular piston aperture 13, which are arranged side-by-side with a relatively short distance to each other. The left circular piston aperture 11 and the right circular piston aperture 13 have an identical diameter in order to receive pistons 15, 17 having a slightly smaller diameter. The front wall 3d of the housing 3 further comprises a bottom circular outlet aperture 19 and a top circular outlet aperture 21, which are arranged between the piston apertures 11, 13. Furthermore, the front wall 3d of the housing 3 comprises a left circular inlet aperture 23 and a right circular inlet aperture 25, which are arranged to the left of the left piston aperture 11 and to the right of the right piston aperture 13, respectively. Moreover, a common outlet 27 in form of a spigot extends forwardly out of the left portion of front wall 3d. The outlet spigot 27 is provided with an outer profile in order to be air-tightly attachable to a fluid tube (not shown), which may connect the fluid pump with one or more inflatable air bladders of a massage system within a vehicle seat (not shown). Furthermore, eight hook pins 28 extend forwardly out of the front wall 3d of the housing 3, four of which are distributed at the top portion of the front wall 3d and four of which are distributed at the bottom portion of the front wall 3d.

[0053] The pistons 15, 17 are integral parts of a front piston element 29 which is arranged to be sandwiched between the front wall 3d of the housing 3 and an outer front channel cover 31 which comprises eight reception means 33 adapted to receive the eight hook pins 28 extending forwardly out of the front wall 3d of the housing 3.

[0054] The front piston element 29 is comprised of a flexible material, such as rubber, which provides an air-tight sealing contact with the front wall 3d of the housing 3 and the front channel cover 31. The pistons 15, 17 are moulded formations of the flexible material in form of collapsible bellows each of which defines a variable tubular compression volume extending into the backward direction. At their rear end, the pistons 15, 17 comprise male coupling means 35 for a coupling to actuator elements 65, 67 (not visible in Fig. 1) which drive the pistons 15, 17 forward and backward, respectively, wherein the flexible lateral walls of the pistons 15, 17 are folded and unfolded, respectively, such that the compression volume of the pistons is decreased and increased, respectively.

[0055] Both an inlet valve and an outlet valve is provided for each piston 15, 17. These inlet valves and outlet valves are designed as reed valves with a flexible flap 37, 39, 41, 43 which is an integral part of the front piston element 29. At the positions corresponding to the positions of the inlet apertures 23, 25 and outlet apertures 19, 21 in the front wall 3d of the housing 3, the front piston element 29 is provided with a left inlet flap 41, a right inlet flap 43, a bottom outlet flap 37, and a top outlet flap 39. The flaps are moulded, cut or punched out of the front piston element 29 in such a way that the inlet flaps 41, 43 may bend open forward (outward) in order to allow a fluid flow into the compression volumes of the pistons and that the outlet flaps 37, 39 may bend open backward (inward) in order to allow a fluid flow out of the compression volume of the pistons. The inlet flaps 41, 43 abut air-tightly against an annular stop at the outlet apertures 23, 25 in order to block a fluid flow out of the compression volume of the pistons. Analogously, the outlet flaps 37, 39 abut air-tightly against an annular stop at the front channel cover 31 in order to block a fluid flow into the compression volume of the pistons. At the left portion of the front piston element 29 a clearance is provided through which the outlet spigot 27 protrudes. Moreover, eight clearances are provided in the front piston element 29 through which the eight hook pins 28 of the front wall 3d protrude.

[0056] The front channel cover 31, preferably made of the same rigid plastic material the housing 3 is made of, comprises eight distributed female connector means 45 for catching the eight hook pins 28 of the front wall 3d in order to achieve an air-tight planar contact between the front wall 3d, the front piston element 29, and the front channel cover 31. The outlet spigot 27 protrudes through an opening at the left portion of the front channel cover 31. The front channel cover 31 further comprises four channels in form of moulded elongate convexities. Two of these channels serve as outlet channels 47 extending diagonally and parallel to each other in order to connect the bottom outlet valve 19 with the volume of the left first piston 15 and the top outlet valve 21 with the volume of the right second piston 17. The other two of the channels serve as inlet channels 49 extending horizontally in order to connect the left inlet valve 23 with the volume of the left first piston 15 and the right inlet valve 25 with the volume of the right second piston 17.

[0057] The top view of Fig. 2A shows that the fluid pump 1 has, except for the outlet spigot 27, an essentially symmetric design with respect to a central xz-plane, spanned by the x-axis and the z-axis, and with respect to a central yz-plane, spanned by the y-axis and the z-axis. Although not visible in Fig. 2A, it will be appreciated that the rear side of the fluid pump 1 has an identical setup like the front side shown in Fig. 1. For the purpose of cost-effective manufacture of the fluid pump 1, it is advantageous if the rear piston element 51 is identical to the front piston element 29 and if the rear channel cover 53 is identical to the front channel cover 31. The present embodiment of the fluid pump 1 is only provided with one outlet spigot 27 at the front side. However, it is appreciated that the outlet spigot 27 may be arranged at any side and/or that there may be more of them. The front view of Fig. 2B gives a detailed view in particular on the front channel cover 31 with its moulded outlet channels 47 and inlet channels 49. A rear view on the fluid pump 1 would look identical, except for the missing outlet spigot 27.

[0058] The perspective exploded view of Fig. 3 also shows most of the inner parts of the fluid pump 1. The inner parts of the fluid pump 1 have a sandwiched structure in which a four-pole permanent magnet 55 having a flat shape with a front upper south-pole 55a, a rear upper north-pole 55b, a front lower north-pole 55c, and a rear lower south-pole 55d takes a central position. The four-pole permanent magnet 55 is fixed in its central position by a magnet holder 57 in form of a bracket framing the four-pole permanent magnet 55 peripherically. The magnet holder 57 further comprises suspension points for two rotatable axles, namely a roller axle 59 and a spur axle 61. The axles 59, 61 are arranged in parallel having a transverse axis of rotation, wherein the roller axle 59 is located at the forward portion of the magnet holder 57 and the spur axle 61 is located at the backward portion of the magnet holder 57. The axles 59, 61 are secured to the magnet holder 57 at their suspension points by means of linear axle retainer springs 63 extending each at one side of the magnet holder 57 in a forward direction over the length of the magnet holder 57.

[0059] The fluid pump 1 further comprises an upper first actuator element 65 and a lower second actuator element 67 between which the magnet holder 57 with the four-pole permanent magnet 55 is sandwiched. The actuator elements 65, 67 have a flat shape and a very similar design. They act as driving wagons, which are movable forwards and backwards. Each actuator element 65, 67 is configured to retain a coil 69, 71 with essentially horizontal windings. The shape of the coils 69, 71 is oval, wherein the upper coil 69 has a front section in the vicinity of the front upper south-pole 55a of the permanent magnet 55 and a rear section in the vicinity of the rear upper north-pole 55b, wherein an electric current may flow in a transverse direction through these front and rear sections of the upper coil 65. Analogously, the lower coil 71 has a front section in the vicinity of the front lower north-pole 55c of the permanent magnet 55 and a rear section in the vicinity of the rear lower south-pole 55d, wherein an electric current may flow in a transverse direction through these front and rear sections of the lower coil 65.

[0060] When an electric current flows through the front section of the upper coil 69 with a direction to the left within the magnetic field of the permanent magnet 55 near the front upper south-pole 55a, where it has an essentially downward direction, this results in a Lorentz force on the upper coil 69 into the backward direction. Simultaneously, the electric current through the rear section of the upper coil 69 is consequently directed to the right within the magnetic field of the permanent magnet 55 near the rear upper north-pole 55b, where it has an essentially upward direction, and results in an additional Lorentz force on the upper coil 69 into the backward direction. A current through the upper coil 65 in the other direction results in a corresponding Lorentz force on the upper coil 69 into the forward direction.

[0061] Analogously, when an electric current flows through the front section of the lower coil 71 with a direction to the right within the magnetic field of the permanent magnet 55 near the front lower north-pole 55c, where it has an essentially downward direction, this results in a Lorentz force on the lower coil 71 into the forward direction. Simultaneously, the electric current through the rear section of the lower coil 71 is consequently directed to the left within the magnetic field of the permanent magnet 55 near the rear lower south-pole 55d, where it has an essentially upward direction, and results in an additional Lorentz force on the lower coil 71 into the forward direction. A current through the lower coil 71 in the other direction results in a corresponding Lorentz force on the lower coil 71 into the backward direction.

[0062] Applying an alternating current to the coils 69, 71 results in a corresponding forward-backward oscillation of the upper first actuator element 65 retaining the upper coil 69 and of the a lower second actuator element 67 retaining the lower coil 71. If the alternating current through the upper coil 69 is phase-shifted by 180° with respect to the alternating current through the lower coil 71, a counter-directional forward-backward movement of the first actuator element 65 and the second actuator element 67 may be achieved. Alternatively or in addition to this, a suitable mechanical coupling between the actuator elements 65, 67 may ensure a counter-directional forward-backward movement of the actuator elements 65, 67 as described below.

[0063] At its front side, the upper first actuator element 65 comprises a front female coupling means 73 providing a coupling with the male coupling means 35 of the left forward first piston 15. At its rear side, the upper first actuator element 65 comprises a rear female coupling means 75 providing a coupling with the male coupling means 35 of the left rear third piston 107 (not shown in Fig. 3). Analogously, the lower second actuator element 67 comprises a front female coupling means 77 providing a coupling with the male coupling means 35 of the right forward second piston 17. At its rear side, the lower second actuator element 67 comprises a rear female coupling means 79 providing a coupling with the male coupling means 35 of the right rear fourth piston 99 (not shown in Fig. 3).

[0064] The magnetic field of the upper coil 69 retained in the upper first actuator element 65 is shielded from above by an upper steel shim 81 which is hold by an upper magnet screen 83 in form of a bracket. Analogously, the magnetic field of the lower coil 71 retained in the lower second actuator element 67 is shielded from below by a lower steel shim 85 which is hold by a lower magnet screen 87 in form of a bracket. The upper and lower magnet screens 83, 87 are stationary and fixed to the magnet holder from a above and below, respectively, whereas the upper first actuator element 65 and the lower second actuator element 65 are movable forward and backward in between.

[0065] The roller axle 59 has a central radial extension acting as a rolling element 89 in form of a reel which has frictional contact with its upper running surface to the lower surface of the upper first actuator element 65 and frictional contact with its lower running surface to the upper surface of the lower second actuator element 67. Therefore, the rolling element 89 rotates forward/backward about the transverse axis of rotation of the roller axle when the upper first actuator element 65 moves forward/backward and the lower second actuator element 67 moves backward/forward.

[0066] Similarly, the spur axle 61 comprises at its end portions radial extensions acting as rolling elements 91, 93 in form of pinions of a rack-and-pinion mechanism. The upper first actuator element 65 has associated rack portions 94 (not visible in Fig. 3) located laterally at its lower surface such that the teeth of the pinions 91, 93 engage the teeth of the associated rack portions. Analogously, the lower second actuator element 67 has associated rack portions 94 located laterally at its upper surface such that the teeth of the pinions 91, 93 engage the teeth of the associated rack portions 94. This rack-and-pinion mechanism provides a meshing contact as the driving contact to establish the opposed movement of the first and second actuator elements in opposite directions.

[0067] By means of the three rolling elements 89, 91, 93 an always-stable three-point suspension of the actuator elements 65, 67 to each other is achieved. Thereby, the actuator elements 65, 67 are mechanically coupled to each other in order to allow counter-directional movements only. With such a mechanical coupling, it will be appreciated that only one of the actuator elements 65, 67 may be provided with a driving coil 69, 71. However, for the purpose of maximum pumping performance, it is preferred that each of the actuator elements 65, 67 is equipped with a driving coil 69, 71.

[0068] The fluid pump 1 further comprises an integrated microcontroller for controlling the alternating current through the coils 69, 71. The microcontroller is implemented on a printed circuit board (PCB) assembly 95, which is located at the right side wall 3c inside the inner volume of the housing 3. The PCB assembly 95 is arranged in parallel to the right side wall 3c of the housing 3c. Flexible electric conductors 97 are further provided, for instance in form of a mylar band comprising biaxially-oriented polyethylene terephthalate (boPET), in order to establish an electric connection between the coils 69, 71 retained by the oscillating actuator elements 65, 67 and the stationary PCB assembly 95.

[0069] Fig. 4 gives a detailed view on the rack-and-pinion mechanism which couples the actuator elements 65, 67 via the rotatable spur axle 61 such that only a counter-directional movement of the actuator elements 65, 67 is possible. The lower second actuator element 67, which is coupled at its rear end with the right rear fourth piston 99, is shown in its rearmost position, whereas the upper first actuator element 65 is in its foremost position. Therefore, the lower second actuator element 67 has just moved backwards and pushed the coupled fourth piston 99 backward in order to fulfil an exhaust stroke during which air is pushed out of the compression chamber through the associated outlet channel 104 and open outlet valve into a common gallery 101 which is connected to the outlet spigot 27, whereas the inlet valve blocks the associated inlet channel 103. Afterwards, the lower second actuator element 67 will move forward and pull the coupled fourth piston forward in order to fulfil an intake stroke during which fluid is sucked into the compression chamber through the associated inlet channel 103 and open inlet valve, whereas the outlet valve blocks the associated outlet channel 104 (see Fig. 6).

[0070] Fig. 5 gives an impression of the assembled inner parts of the fluid pump 1 and their coordinated interaction. The common gallery 101 is integrated in the rear wall 3e, the left side wall 3b and the front wall 3d of the housing 3 connecting all four outlet channels 47, 104 with each other and with the outlet spigot 27. The four inlet channels 49, 103, however, have separate tubular connections via inner inlet openings 105 with the inner volume of the housing 3. Thereby, the fluid pump pumps air from the inner volume of the housing 3 towards the outlet spigot 27. The air in the inner volume of the housing is replaced by an inflow of ambient air through one or more air passages 6 in the housing 3 (see Figs. 1 and 3) . This inflow of ambient air is used to cool inner parts, which tend to produce heat due to friction or electric current such as the PCB assembly 95. In order to maximise the cooling effect, the air passage 6 is located in the vicinity of the PCB assembly 95 (see Fig. 1), and the inflowing air is passed through a system of air distribution channels (not shown in the Figs.) which distributes the inflowing air into the interior of the housing such that cool air is directly guided also to parts in further distance from the air passage 6, i.e. some channels of the air distribution channel system directly lead to parts of the interior further distant from the air passage 6. Such system of air distribution channels may be realized by a number of channels extending below the air passage 6 parallel to lid 5 and having outlets in all areas of the interior of the housing for which efficient cooling is desired. A corresponding system of air distribution channels is located on top of the bottom wall of the housing 6 in order to efficiently distribute the inflowing cool air which flows through the air passage provided in the bottom wall of the housing. In this manner the air inflow is used for two purposes, firstly for cooling the components within the housing, by virtue of the distribution channel system including those distant from the air inflow passage 6, in particular the coils, and secondly for providing an air supply for air to be pumped.

[0071] Fig. 5 also shows all four pistons: the first piston 15 located at the front left, the second piston 17 located at the front right, the third piston 107 located at the rear left, and the fourth piston 99 located at the rear right. The first piston 15 and the third piston 107 are coupled to the upper first actuator element 65 of which only the female coupling means 73, 75 are visible in the cut view of Fig. 5. The second piston 17 and the fourth piston 99 are coupled to the lower second actuator element 67 by the female coupling means 77, 79. The first piston 15 and the second piston 17 are movable backwards during an intake stroke and forwards during an exhaust stroke, whereas the third piston 107 and the fourth piston 99 are movable forwards during an intake stroke and backwards during an exhaust stroke.

[0072] To give a better view on the movable parts of the fluid pump 1, the housing 3 is not shown in Figs. 6 and 7A. Due to the coupling between the first actuator element 65 and the first piston 15 and third piston 107, respectively, the first piston 15 performs an intake stroke and the third piston 107 performs an exhaust stroke when the first actuator element 65 moves backwards. Vice versa, the first piston 15 performs an exhaust stroke and the third piston 107 performs an intake stroke when the first actuator element moves 65 forwards. Analogously, due to the coupling between the second actuator element 67 and the second piston 17 and fourth piston 99, respectively, the second piston 17 performs an exhaust stroke and the fourth piston 99 performs an intake stroke when the second actuator element 67 moves forwards. Conversely, the second piston 17 performs intake stroke and the fourth piston 99 performs an exhaust stroke when the second actuator element 67 moves backwards.

[0073] Given a certain oscillation length, mass, friction and mechanical interaction of the movable parts of the fluid pump 1, an optimal shape of the alternating current is required in order to achieve a certain oscillation frequency within a range of feasible oscillation frequencies at a minimal power consumption. The microcontroller on the PCB assembly 95 may be configured to apply such alternating current with an optimal shape to the coils 69, 71. However, the optimal shape of the alternating current may change during usage of the fluid pump 1 due to wear, abrasion and/or dust/dirt at the movable parts of the fluid pump 1. In order to continuously provide the optimal shape of the alternating current for a desired oscillation frequency at a minimum of power consumption, the fluid pump 1 may be equipped with a position sensor for detecting the position of the first actuator element 65 and/or the second actuator element 67.

[0074] As shown in Fig. 7B, two vertical light beams 109 may be produced each between a light source 111 and a photo sensor 113, all of which are installed on the PCB assembly 95 (see Fig. 7A). Both the first actuator element 65 and the second actuator element 67 comprise at least one blocking element 115 which crosses the path of the vertical light beams 109 during movement of the actuator elements 65, 67. Thereby, the photo sensors 113 may quickly detect the moment when an actuator element 65, 67 has reached a certain position. Typically, this is the reversal point when the actuator elements 65, 67 should change the direction of motion. Thereby, one of the photo sensors 113 may trigger a change of sign of the current applied to the coils 69, 71 at the reversal point. Due to the forced counter-directional motion of the actuator elements 65, 67 it would suffice to have only one position sensor either for the first actuator element 65 or the second actuator element 67. However, it is advantageous to have a position sensor for both the first actuator element 65 and the second actuator element 67. This is because the blocking elements 115 may be arranged at different positions at the first actuator element 65 and the second actuator element 67. In the shown embodiment for example, the distance between the blocking elements 115 at the first actuator element 65 is larger than the distance between the blocking elements 115 at the second actuator element 67. This means that the microcontroller may be configured to use either the upper or the lower photo sensor 113 as trigger in order to be able to run the fluid pump 1 in two different modes. If the lower photo detector 113 is used, the stroke length and the achieved swept volume of the pistons 15, 17, 107, 99 is smaller, whereas the oscillation frequency may be higher. If the upper photo detector 113 is used, the stroke length and the achieved swept volume of the pistons 15, 17, 107, 99 is larger, whereas the oscillation frequency may be lower.

[0075] The inventive fluid pump 1 can be designed in a small, flat shape in an uncomplicated way and allows for a high flow rate in combination with minimal noise, vibrations, power consumption and generation of heat. Having a dimension of approximately 85 x 60 x 20 mm and a weight of about 125 grams, the fluid pump 1 performs a flow rate of 6 litres per minute at an average power consumption of 3 Watts and a peak power consumption of 8 Watts. The maximal achieved pressure amounts to 0.7 bar. A plurality of such fluid pumps 1 may be installed in parallel as a pressure supply for a massage system within a vehicle seat.

Claims

1. A fluid pump (1) for usage in a massage system in a vehicle seat comprising

- a housing (3) with a front wall (3d) at a front side and a rear wall (3e) at a rear side,
- a first actuator element (65) which is movable forwards and backwards, and
- a second actuator element (67) which is configured to be counter-directionally movable with respect to the first actuator element (65),
- a first piston (15) and a second piston (17) arranged at the front side, wherein the first piston (15) and the second piston (17) are movable backwards during an intake stroke and forwards during an exhaust stroke, and
- a third piston (107) and a fourth piston (99) arranged at the rear side, wherein the third piston (107) and the fourth piston (99) are movable forwards during an intake stroke and backwards during an exhaust stroke,

wherein
the first actuator element (65) is coupled to the first piston (15) and the third piston (107) such that the first piston (15) performs an intake stroke and the third piston (107) performs an exhaust stroke when the first actuator element (65) moves backwards, and such that the first piston (15) performs an exhaust stroke and the third piston (107) performs an intake stroke when the first actuator element (65) moves forwards, and
the second actuator element (67) is coupled to the second piston (17) and to the fourth piston (99) such that the second piston (17) performs an exhaust stroke and the fourth piston (99) performs an intake stroke when the second actuator element (67) moves forwards, and such that the second piston (17) performs intake stroke and the fourth piston (99) performs an exhaust stroke when the second actuator element (67) moves backwards,
characterized in that
a coil (69, 71) is mounted on the first actuator element (65) and/or the second actuator element (67),
a permanent magnet (55) is located in a sandwich configuration between the first actuator element (65) and the second actuator element (67), and
at least one rolling element (89, 91, 93) having an

axis of rotation perpendicular to the linear axis of motion of the actuator elements (65, 67) is provided between the first actuator element (65) and the second actuator element (67) such that both the first actuator element (65) and the second actuator element (67) are in driving contact with the rolling element (89, 91, 93) from opposite sides with respect to the axis of rotation of the rolling element.

2. A fluid pump according to Claim 1, wherein the permanent magnet (55) is a four-pole magnet.

3. A fluid pump according to any of the preceding Claims, wherein the housing (3) and the actuator elements (65, 67) have a substantially flat shape, the first piston (15) and the second piston (17) are arranged side-by-side, and the third piston (107) and the fourth piston (99) are arranged side-by-side.

4. A fluid pump according to any of the preceding Claims, wherein two or preferably three, rolling elements (89, 91, 93) having an axis of rotation perpendicular to the linear axis of motion of the actuator elements (65, 67) are provided between the first actuator element (65) and the second actuator element (67) such that both the first actuator element (65) and the second actuator element (67) are in driving contact with the rolling elements (89, 91, 93) from opposite sides with respect to the axis of rotation of the rolling elements.

5. A fluid pump according to any of the preceding Claims, wherein preferably the driving contact is a meshing contact for at least one of the rolling elements or for the rolling element in case of one single rolling element.

6. A fluid pump according to any of the preceding Claims, wherein the rolling element(s) (89, 91, 93) is/are rotatably suspended to a stationary magnet holder (57) in form of a bracket which is located in a sandwich configuration between the first (65) and the second actuator element (67) and configured to hold a permanent magnet (55).

7. A fluid pump according to any of the preceding Claims, wherein at least one of the rolling element(s) (89, 91, 93) is a pinion (91, 93) of a rack-and-pinion mechanism, wherein the actuator elements (65, 67) comprise associated rack portions (94) extending along the linear axis of motion of the actuator elements (65, 67) such that the teeth of the pinion(s) (91, 93) engage the teeth of the rack portions (94).

8. A fluid pump according to any of the preceding Claims, further comprising an integrated microcontroller for controlling the current through a coil (69) mounted on the first actuator element (65) and/or a coil (71) mounted on the second actuator element (67).

9. A fluid pump according to any of the preceding Claims, further comprising a position sensor for detecting the position of the first actuator element (65) and/or the second actuator element (67).

10. A fluid pump according to any of the preceding Claims, wherein the pistons (15, 17, 107, 99) are connected to a common fluid channel system having one or more inlet openings (105) at an inner wall of the housing (3) such that fluid is pumped from the inner volume of the housing (3) towards a common outlet (27) when the pistons (15, 17, 107, 99) are in motion.

11. A fluid pump according to any of the preceding Claims, wherein an inlet valve and an outlet valve is associated to each piston (15, 17, 107, 99), wherein the inlet valve is open and the outlet valve is closed during an intake stroke of the associated piston (15, 17, 107, 99), and wherein the inlet valve is closed and the outlet valve is open during an exhaust stroke of the associated piston (15, 17, 107, 99).

12. A fluid pump according to Claim 11, wherein an inlet channel (49, 103) is associated to each piston (15, 17, 107, 99), wherein the inlet channel (49, 103) connects a compression volume of the associated piston (15, 17, 107, 99) via the corresponding inlet valve with the inner volume of the housing (3), and wherein an outlet channel (47, 104) is associated to each piston (15, 17, 107, 99), wherein the outlet channel (47, 104) connects a compression volume of the associated piston (15, 17, 107, 99) via the corresponding outlet valve with a common outlet (27).

13. A fluid pump according to Claim 12, wherein
the housing (3) comprises two piston apertures (11, 13) at the front wall (3d) and two piston apertures at the rear wall (3e), two outer inlet apertures (23, 25) connected to inner inlet openings (105) at the front wall (3d) and two outer inlet apertures connected to inner inlet openings (105) at the rear wall (3e), and a common gallery (101) connected to the common outlet (27) and sealed from the inlet openings (105) and from the inner volume of the housing 3, and having two outlet apertures (19, 21) at the outer front wall (3d) and two outlet apertures at the outer rear wall (3e), and
wherein a front channel cover (31) and a rear channel cover (53) are sealingly attached at the front wall (3d) and the rear wall (3e), respectively, wherein the channel cover (31, 53) defines the inlet and outlet channels (47, 49, 103, 104).

14. A fluid pump according to Claim 13, wherein the first piston (15), the second piston (17) and flaps (37, 39, 41, 43) of the associated inlet and outlet valves are integrated parts of a front piston element (29) that is arranged between the front wall (3d) of the housing (3) and the front channel cover (31), and wherein the third piston (107), the fourth piston (99) and flaps of the associated inlet and outlet valves are integrated parts of a backward piston element (51) that is arranged between the rear wall (3e) of the housing (3) and the rear channel cover (53).

Patentansprüche

1. Fluidpumpe (1) zur Verwendung in einem Massagesystem in einem Fahrzeugsitz, wobei die Fluidpumpe aufweist

- ein Gehäuse (3) mit einer Vorderwand (3d) an einer Vorderseite und einer Hinterwand (3e) an einer Rückseite,
- ein erstes Aktuator-Element (65), das vorwärts und rückwärts beweglich ist, und
- ein zweites Aktuator-Element (67), das dazu ausgestaltet ist, um in Bezug auf das erste Aktuator-Element (65) gegenläufig gerichtet beweglich zu sein,
- einen ersten Kolben (15) und einen zweiten Kolben (17), die an der Vorderseite angeordnet sind, wobei der erste Kolben (15) und der zweite Kolben (17) rückwärts beweglich sind während eines Aussaughubs und vorwärts beweglich sind während eines Ausstoßhubs, und
- einen dritten Kolben (107) und einen vierten Kolben (99), die an der Hinterseite angeordnet sind, wobei der dritte Kolben (107) und der vierte Kolben (99) vorwärts beweglich sind während eines Ansaughubs und rückwärts beweglich sind während eines Ausstoßhubs,

wobei
das erste Aktuator-Element (65) mit dem ersten Kolben (15) und dem dritten Kolben (107) gekoppelt ist, so dass der erste Kolben (15) einen Ansaughub durchführt und der dritte Kolben (107) einen Ausstoßhub durchführt, wenn das erst Aktuator-Element (65) sich rückwärts bewegt, und so dass der erste Kolben (15) einen Ausstoßhub durchführt und der dritte Kolben (107) einen Ansaughub durchführt, wenn sich das erste Aktuator-Element (65) vorwärts bewegt, und
das zweite Aktuator-Element (67) mit dem zweiten Kolben (17) und dem vierten Kolben (99) gekoppelt ist, so dass der zweite Kolben (17) einen Ausstoßhub durchführt und der vierte Kolben (99) einen Ansaughub durchführt, wenn das zweite Aktuator-Element (67) sich vorwärts bewegt, und so dass der zweite Kolben (17) einen Ansaughub durchführt und der vierte Kolben (99) einen Ausstoßhub durchführt, wenn das zweite Aktuator-Element (67) sich rückwärts bewegt,
dadurch gekennzeichnet, dass
eine Spule (69, 71) an dem ersten Aktuator-Element (65) und/oder an dem zweiten Aktuator-Element (67) angebracht ist,
ein Permanentmagnet (55) sandwichartig zwischen dem ersten Aktuator-Element (65) und dem zweiten Aktuator-Element (67) angeordnet ist und
wenigstens ein Abrollelement (89, 91, 93) mit einer Drehachse senkrecht zu der linearen Bewegungsachse der Aktuator-Elemente (65, 67) zwischen dem ersten Aktuator-Element (65) und dem zweiten Aktuator-Element (67) vorgesehen ist, so dass sowohl das erste Aktuator-Element (65) als auch das zweite Aktuator-Element (67) in Antriebskontakt mit dem Abrollelement (89, 91, 93) von gegenüberliegenden Seiten aus in Bezug auf die Drehachse des Abrollelements stehen.

2. Fluidpumpe nach Anspruch 1, wobei der Permanentmagnet (55) ein vierpoliger Magnet ist.

3. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei das Gehäuse (3) und die Aktuator-Elemente (65, 67) eine im Wesentlichen flache Form haben, der erste Kolben (15) und der zweite Kolben (17) Seite an Seite zueinander angeordnet sind und der dritte Kolben (107) und der vierte Kolben (99) Seite an Seite zueinander angeordnet sind.

4. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei zwei oder vorzugsweise drei Abrollelemente (89, 91, 93) mit einer Drehachse senkrecht zu der linearen Bewegungsachse der Aktuator-Elemente (65, 67) zwischen dem ersten Aktuator-Element (65) und dem zweiten Aktuator-Element (67) vorgesehen sind, so dass sowohl das erste Aktuator-Element (65) als auch das zweite Aktuator-Element (67) in Antriebskontakt mit den Abrollelementen (89, 91, 93) von gegenüberliegenden Seiten in Bezug auf die Drehachse der Abrollelemente stehen.

5. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei der Antriebskontakt ein kämmender Kontakt für wenigstens eines der Abrollelemente oder für das Abrollelement im Falle nur eines einzigen vorhandenen Abrollelements ist.

6. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei das (die) Abrollelement (e) (89, 91, 93) drehbar an einem stationären Magnethalter (57) in Form eines Bügels aufgehängt ist(sind), der sandwichartig zwischen dem ersten (65) und dem zweiten Aktuator-Element (67) angeordnet ist und dazu ausgestaltet ist, um einen Permanentmagneten (55) zu halten.

7. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei wenigstens eines von dem(den) Abrollelement(en) (89, 91, 93) ein Ritzel (91, 93) eines Ritzel-ZahnstangenMechanismus ist, wobei die Aktuator-Elemente (65, 67) zugeordnete Zahnstangenbereiche (94) aufweisen, die sich entlang der linearen Bewegungsachse der Aktuator-Elemente (65, 67) erstrecken, so dass die Zähne des(der) Ritzels(Ritzel) (91, 93) mit den Zähnen der Zahnstangenbereiche (94) eingreifen.

8. Fluidpumpe nach einem der vorhergehenden Ansprüche, die weiter einen integrierten Mikrokontroller zum Steuern des Stroms durch eine Spule (69), die an dem ersten Aktuator-Element (65) angebracht ist, und/oder einer Spule (71), die an dem zweiten Aktuator-Element (67) angebracht ist, aufweist.

9. Fluidpumpe nach einem der vorhergehenden Ansprüche, die weiter einen Positionssensor zum Erfassen der Position des ersten Aktuator-Elements (65) und/oder des zweiten Aktuator-Elements (67) aufweist.

10. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei die Kolben (15, 17, 107, 99) mit einem gemeinsamen Fluidkanalsystem verbunden sind, das eine oder mehrere Einlassöffnungen (105) an einer Innenwand des Gehäuses (3) aufweist, so dass Fluid aus dem Innenvolumen des Gehäuses (3) zu einem gemeinsamen Auslass (27) gepumpt wird, wenn die Kolben (15, 17, 107, 99) in Bewegung sind.

11. Fluidpumpe nach einem der vorhergehenden Ansprüche, wobei jedem Kolben (15, 17, 107, 99) ein Einlassventil und ein Auslassventil zugeordnet ist, wobei das Einlassventil geöffnet und das Auslassventil geschlossen ist während eines Ansaughubs des zugeordneten Kolbens (15, 17, 107, 99), und wobei das Einlassventil geschlossen und das Auslassventil geöffnet ist während eines Ausstoßhubs des zugeordneten Kolbens (15, 17, 107, 99).

12. Fluidpumpe nach Anspruch 11, wobei jedem Kolben (15, 17, 107, 99) ein Einlasskanal (49, 103) zugeordnet ist, wobei der Einlasskanal (49, 103) ein Kompressionsvolumen des zugeordneten Kolbens (15, 17, 107, 99) über das entsprechende Einlassventil mit dem Innenvolumen des Gehäuses (3) verbindet, und wobei jedem Kolben (15, 17, 107, 99) ein Auslasskanal (47, 104) zugeordnet ist, wobei der Auslasskanal (47, 104) ein Kompressionsvolumen des zugeordneten Kolbens (15, 17, 107, 99) über das entsprechende Auslassventil mit einem gemeinsamen Auslass (27) verbindet.

13. Fluidpumpe nach Anspruch 12, wobei
das Gehäuse (3) zwei Kolbenöffnungen (11, 13) an der Vorderwand (3d) und zwei Kolbenöffnungen an der Rückwand (3e), zwei äußere Einlassöffnungen (23, 25) verbunden mit inneren Einlassöffnungen (105) an der Vorderwand (3d) und zwei äußere Einlassöffnungen verbunden mit inneren Einlassöffnungen (105) an der Hinterwand (3e) und einen gemeinsamen Durchlass (101) aufweist, der mit dem gemeinsamen Auslass (67) verbunden ist und gegenüber den Einlassöffnungen (105) und dem Innenvolumen des Gehäuses (3) abgedichtet ist und zwei Auslassöffnungen (19, 21) an der äußeren Vorderwand (3d) und zwei Auslassöffnungen an der äußeren Hinterwand (3e) aufweist, und
wobei eine vordere Kanalabdeckung (31) bzw. eine hintere Kanaldeckung (53) abgedichtet an der Vorderwand (3d) bzw. an der Hinterwand (3e) angebracht sind, wobei die Kanalabdeckung (31, 53) die Einlass- und Auslasskanäle (47, 49, 103, 104) definiert.

14. Fluidpumpe nach Anspruch 13, wobei der erste Kolben (15), der zweite Kolben (17) und Klappen (37, 39, 41, 43) der zugeordneten Einlass- und Auslassventile integrierte Bestandteile eines vorderen Kolbenelements (29) sind, das zwischen der Vorderwand (3d) des Gehäuses (3) und der vorderen Kanalabdeckung (31) angeordnet ist, und wobei der dritte Kolben (107), der vierte Kolben (99) und die Klappen der zugeordneten Einlass- und Auslassventile integrierte Bestandteile eines hinteren Kolbenelements (51) sind, das zwischen der Rückwand (3d) des Gehäuses (3) und der hinteren Kanalabdeckung (53) angeordnet ist.

Revendications

1. Pompe à fluide (1) destinée à être utilisée dans un système de massage dans un siège de véhicule comprenant :

- un logement (3) avec une paroi avant (3d) à un côté avant et une paroi arrière (3e) à un côté arrière,
- un premier élément actionneur (65) qui est mobile vers l'avant et vers l'arrière, et
- un deuxième élément actionneur (67) qui est configuré pour être mobile dans le sens inverse du premier élément actionneur (65),
- un premier piston (15) et un deuxième piston (17) agencés au côté avant, dans laquelle le premier piston (15) et le deuxième piston (17) sont mobiles vers l'arrière pendant une course d'admission et vers l'avant pendant une course d'échappement, et
- un troisième piston (107) et un quatrième pis-

ton (99) agencés au côté arrière, dans laquelle le troisième piston (107) et le quatrième piston (99) sont mobiles vers l'avant pendant une course d'admission et vers l'arrière pendant une course d'échappement,
dans laquelle
le premier élément actionneur (65) est couplé au premier piston (15) et au troisième piston (107) de sorte que le premier piston (15) effectue une course d'admission et le troisième piston (107) effectue une course d'échappement lorsque le premier élément actionneur (65) se déplace vers l'arrière, et de sorte que le premier piston (15) effectue une course d'échappement et le troisième piston (107) effectue une course d'admission lorsque le premier élément actionneur (65) se déplace vers l'avant, et
le deuxième élément actionneur (67) est couplé au deuxième piston (17) et au quatrième piston (99) de sorte que le deuxième piston (17) effectue une course d'échappement et le quatrième piston (99) effectue une course d'admission lorsque le deuxième élément actionneur (67) se déplace vers l'avant, et de sorte que le deuxième piston (17) effectue une course d'admission et le quatrième piston (99) effectue une course d'échappement lorsque le deuxième élément actionneur (67) se déplace vers l'arrière,
caractérisée en ce que
une bobine (69, 71) est montée sur le premier élément actionneur (65) et/ou sur le deuxième élément actionneur (67),
un aimant permanent (55) est situé dans une configuration en sandwich entre le premier élément actionneur (65) et le deuxième élément actionneur (67), et
au moins un élément roulant (89, 91, 93) ayant un axe de rotation perpendiculaire à l'axe de mouvement linéaire des éléments actionneurs (65, 67) est prévu entre le premier élément actionneur (65) et le deuxième élément actionneur (67) de sorte que le premier élément actionneur (65) et le deuxième élément actionneur (67) soient en contact d'entraînement avec l'élément roulant (89, 91, 93) depuis des côtés opposés par rapport à l'axe de rotation de l'élément roulant.

2. Pompe à fluide selon la revendication 1, dans laquelle l'aimant permanent (55) est un aimant quadripolaire.

3. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle le logement (3) et les éléments actionneurs (65, 67) ont une forme sensiblement plate, le premier piston (15) et le deuxième piston (17) sont agencés côte à côte, et le troisième piston (107) et le quatrième piston (99) sont agencés côte à côte.

4. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle deux ou de préférence trois éléments roulants (89, 91, 93) ayant un axe de rotation perpendiculaire à l'axe de mouvement linéaire des éléments actionneurs (65, 67) sont prévus entre le premier élément actionneur (65) et le deuxième élément actionneur (67), de sorte que le premier élément actionneur (65) et le deuxième élément actionneur (67) soient en contact d'entraînement avec les éléments roulants (89, 91, 93) depuis des côtés opposés par rapport à l'axe de rotation des éléments roulants.

5. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle le contact d'entraînement est de préférence un contact d'engrènement pour au moins l'un des éléments roulants ou pour l'élément roulant dans le cas d'un élément roulant unique.

6. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle le ou les éléments roulants (89, 91, 93) sont suspendus, de manière à pouvoir tourner, à un porte-aimant immobile (57) sous la forme d'un support qui est situé dans une configuration en sandwich entre le premier élément actionneur (65) et le deuxième élément actionneur (67) et configuré pour porter un aimant permanent (55).

7. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle au moins l'un des éléments roulants (89, 91, 93) est un pignon (91, 93) d'un mécanisme de crémaillère et de pignon, dans laquelle les éléments actionneurs (65, 67) comprennent des portions de crémaillère associées (94) s'étendant le long de l'axe de mouvement linéaire des éléments actionneurs (65, 67) de sorte que les dents du ou des pignons (91, 93) se mettent en prise avec les dents des portions de crémaillère (94).

8. Pompe à fluide selon l'une quelconque des revendications précédentes, comprenant en outre un microcontrôleur intégré pour commander le courant à travers une bobine (69) montée sur le premier élément actionneur (65) et/ou une bobine (71) montée sur le deuxième élément actionneur (67).

9. Pompe à fluide selon l'une quelconque des revendications précédentes, comprenant en outre un capteur de position pour détecter la position du premier élément actionneur (65) et/ou du deuxième élément actionneur (67).

10. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle les pistons (15, 17, 107, 99) sont raccordés à un système de canal de fluide commun comportant une ou plusieurs ouvertures d'entrée (105) à une paroi intérieure du logement (3) de sorte qu'un fluide soit pompé depuis le volume intérieur du logement (3) vers une sortie commune (27) lorsque les pistons (15, 17, 107, 99) sont en mouvement.

11. Pompe à fluide selon l'une quelconque des revendications précédentes, dans laquelle une vanne d'entrée et une vanne de sortie sont associées à chaque piston (15, 17, 107, 99), dans laquelle la vanne d'entrée est ouverte et la vanne de sortie est fermée pendant une course d'admission du piston associé (15, 17, 107, 99), et dans laquelle la vanne d'entrée est fermée et la vanne de sortie est ouverte pendant une course d'échappement du piston associé (15, 17, 107, 99).

12. Pompe à fluide selon la revendication 11, dans laquelle un canal d'entrée (49, 103) est associé à chaque piston (15, 17, 107, 99), dans laquelle le canal d'entrée (49, 103) raccorde un volume de compression du piston associé (15, 17, 107, 99) par l'intermédiaire de la vanne d'entrée correspondante au volume intérieur du logement (3), et dans laquelle un canal de sortie (47, 104) est associé à chaque piston (15, 17, 107, 99), dans laquelle le canal de sortie (47, 104) raccorde un volume de compression du piston associé (15, 17, 107, 99) par l'intermédiaire de la vanne de sortie correspondante à une sortie commune (27).

13. Pompe à fluide selon la revendication 12, dans laquelle
le logement (3) comprend deux ouvertures de piston (11, 13) à la paroi avant (3d) et deux ouvertures de piston à la paroi arrière (3e), deux ouvertures d'entrée extérieures (23, 25) raccordées à des ouvertures d'entrée intérieures (105) à la paroi avant (3d) et deux ouvertures d'entrée extérieures raccordées à des ouvertures d'entrée intérieures (105) à la paroi arrière (3e), et une galerie commune (101) raccordée à la sortie commune (27) et scellée des ouvertures d'entrée (105) et du volume intérieur du logement (3), et comportant deux ouvertures de sortie (19, 21) à la paroi avant extérieure (3d) et deux ouvertures de sortie à la paroi arrière extérieure (3e), et
dans laquelle un couvercle de canal avant (31) et un couvercle de canal arrière (53) sont attachés de manière hermétique respectivement à la paroi avant (3d) et à la paroi arrière (3e), dans laquelle le couvercle de canal (31, 53) définit les canaux d'entrée et de sortie (47, 49, 103, 104).

14. Pompe à fluide selon la revendication 13, dans laquelle le premier piston (15), le deuxième piston (17) et des clapets (37, 39, 41, 43) des vannes d'entrée et de sortie associées sont des parties intégrées d'un élément de piston avant (29) qui est agencé entre la paroi avant (3d) du logement (3) et le couvercle de canal avant (31), et dans laquelle le troisième piston (107), le quatrième piston (99) et des clapets des vannes d'entrée et de sortie associées sont des parties intégrées d'un élément de piston vers l'arrière (51) qui est agencé entre la paroi arrière (3e) du logement (3) et le couvercle de canal arrière (53).

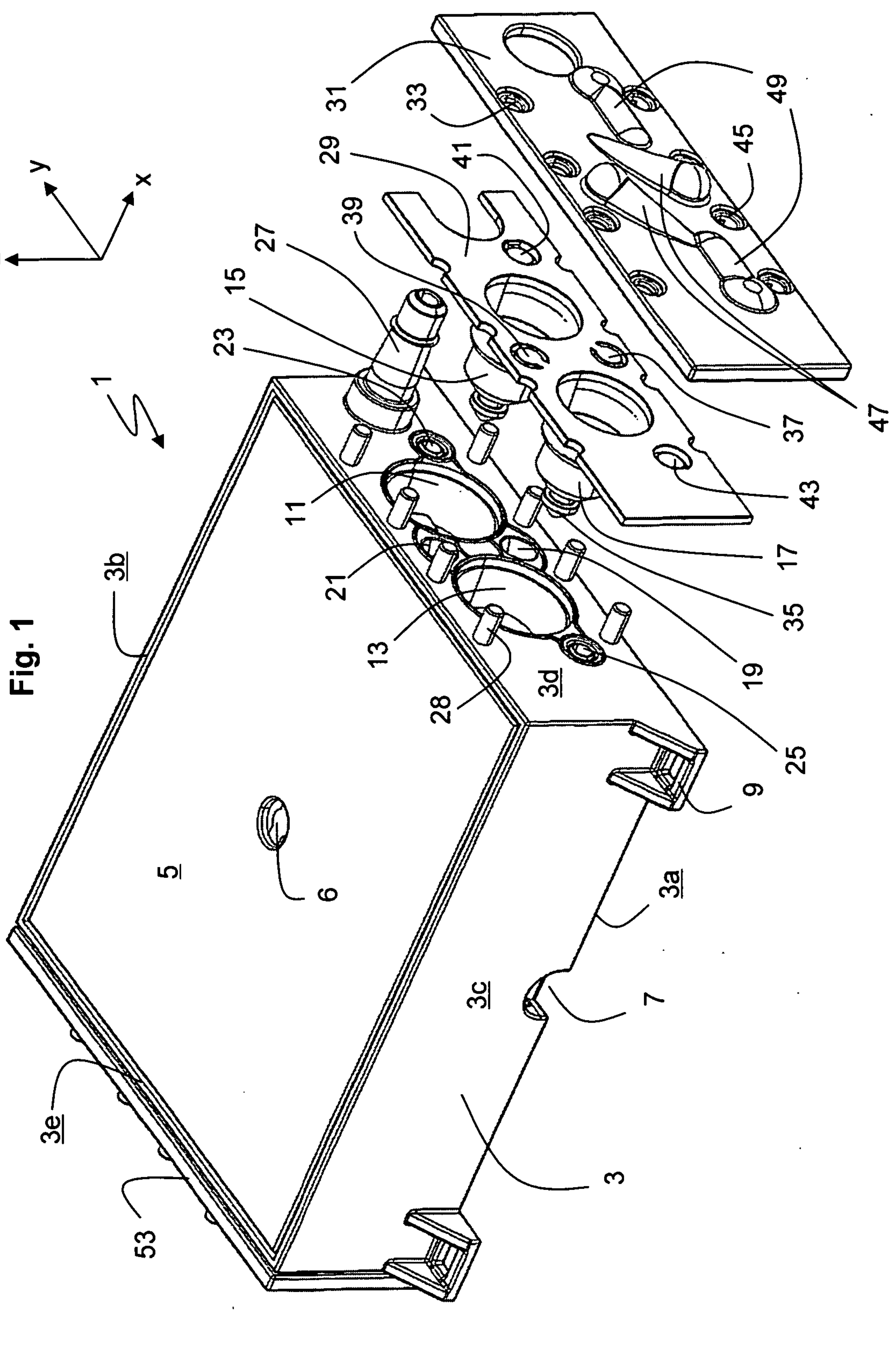
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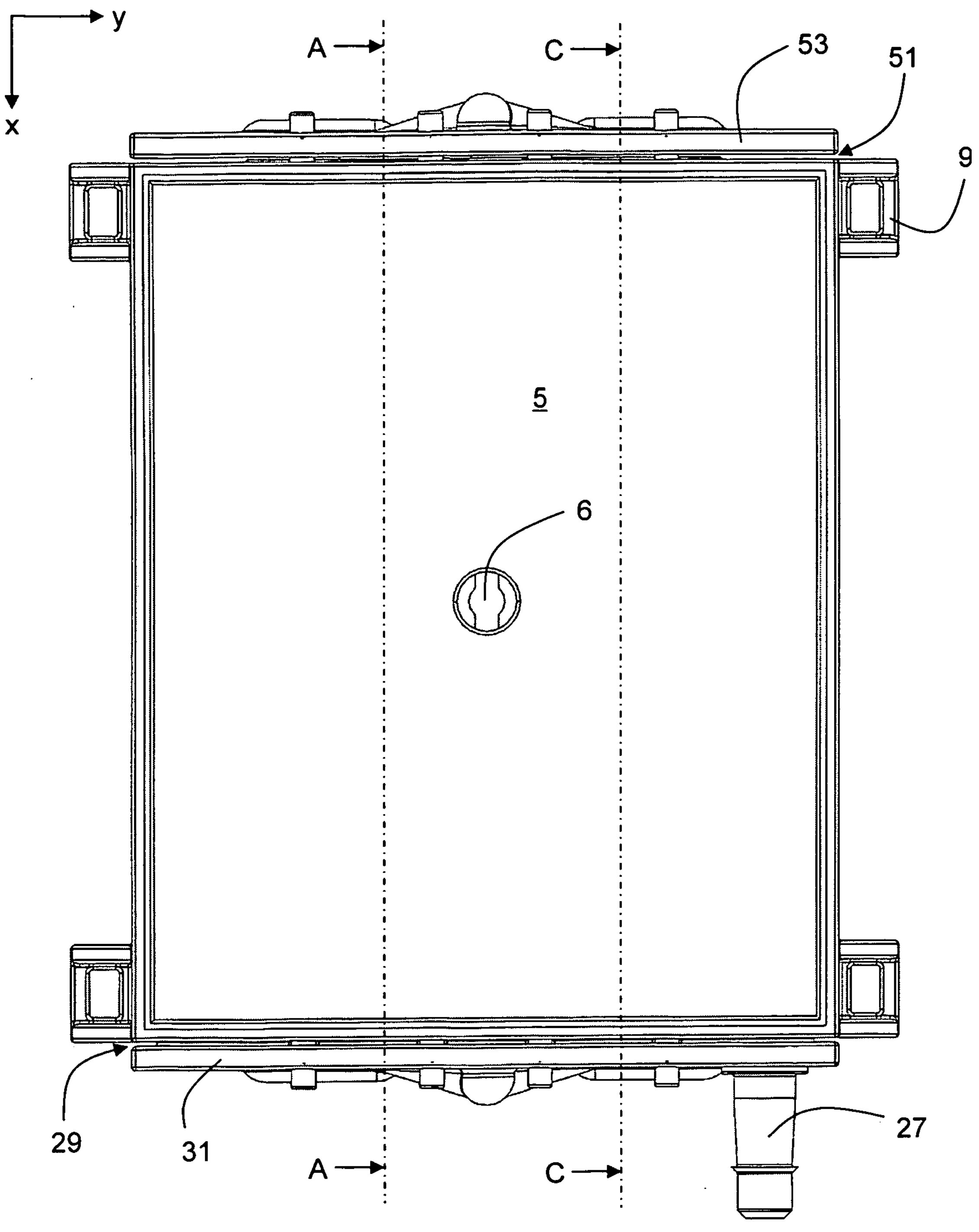
Fig. 1

Fig. 2A



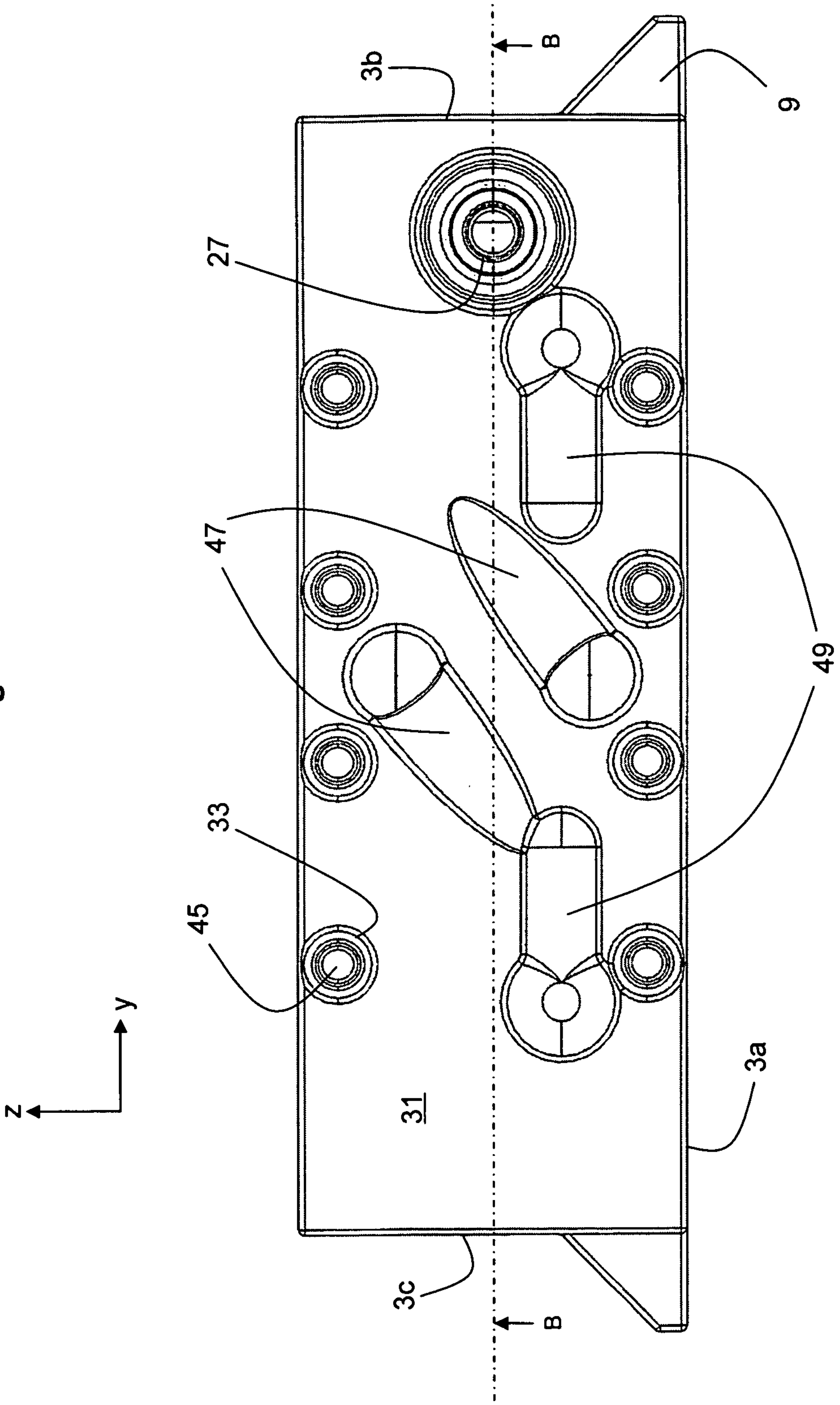
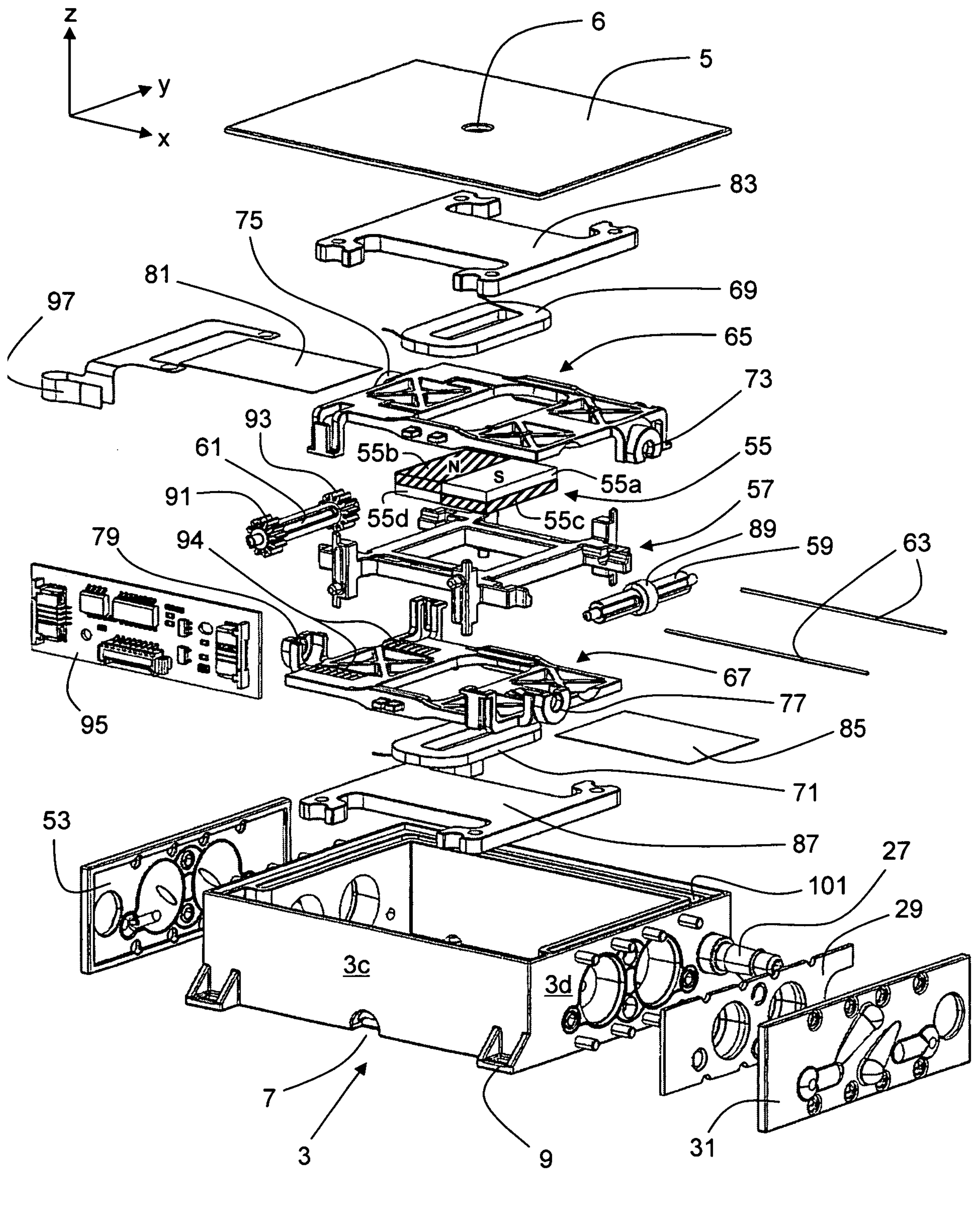


Fig. 2B

Fig. 3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97
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73
93
55b
N
S
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55c
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89
79
94
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3
9
31

Fig. 4

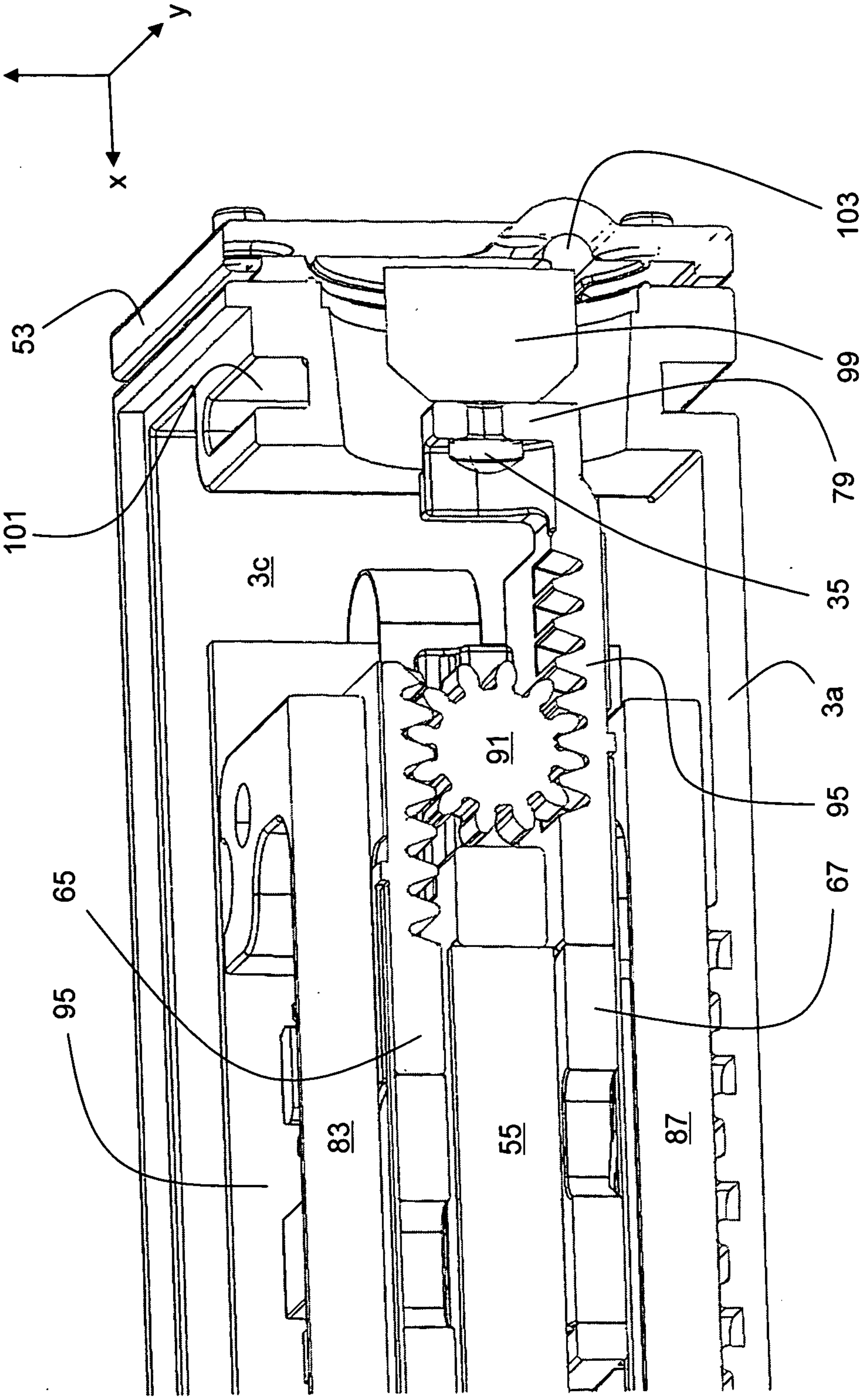


Fig. 5

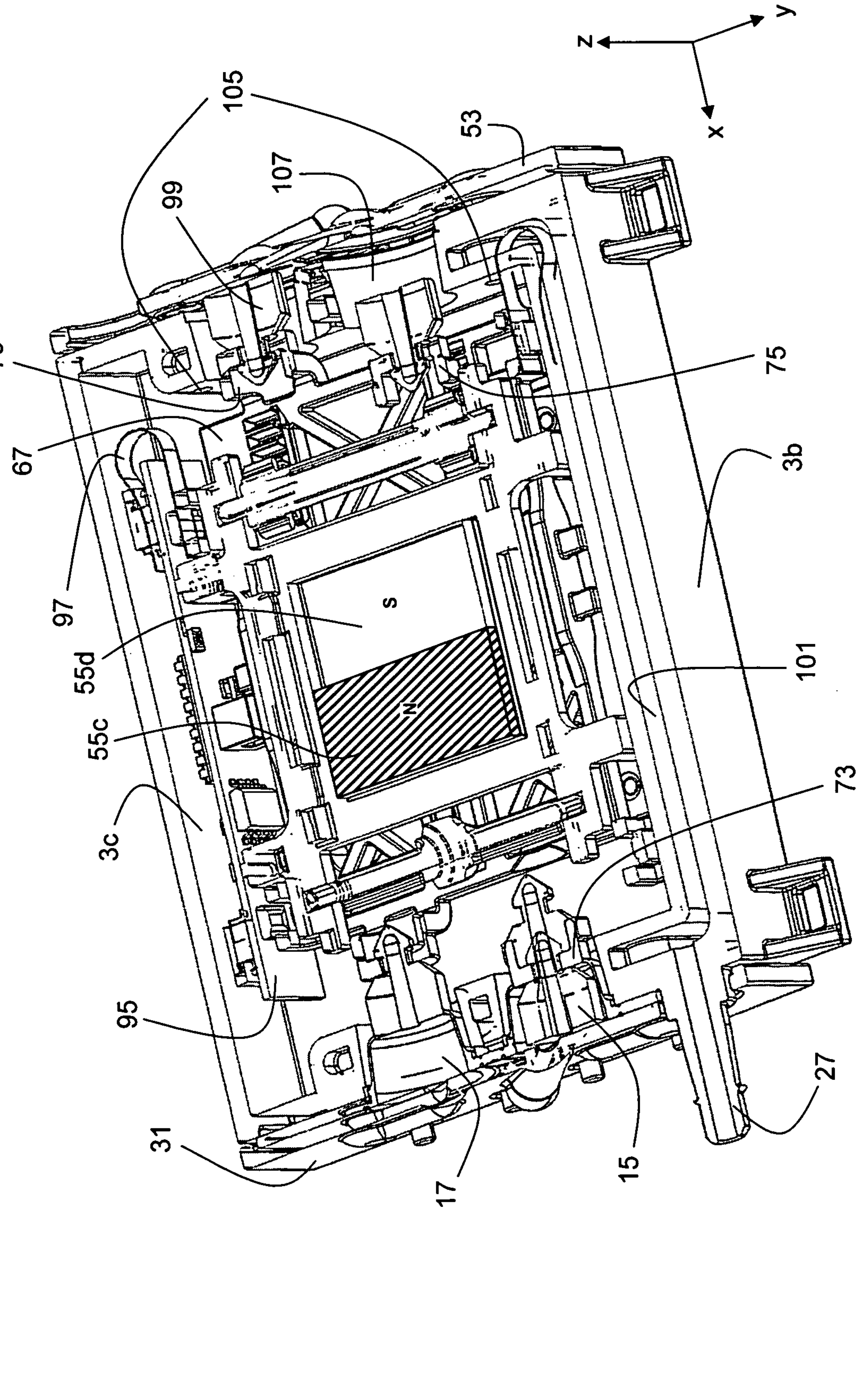
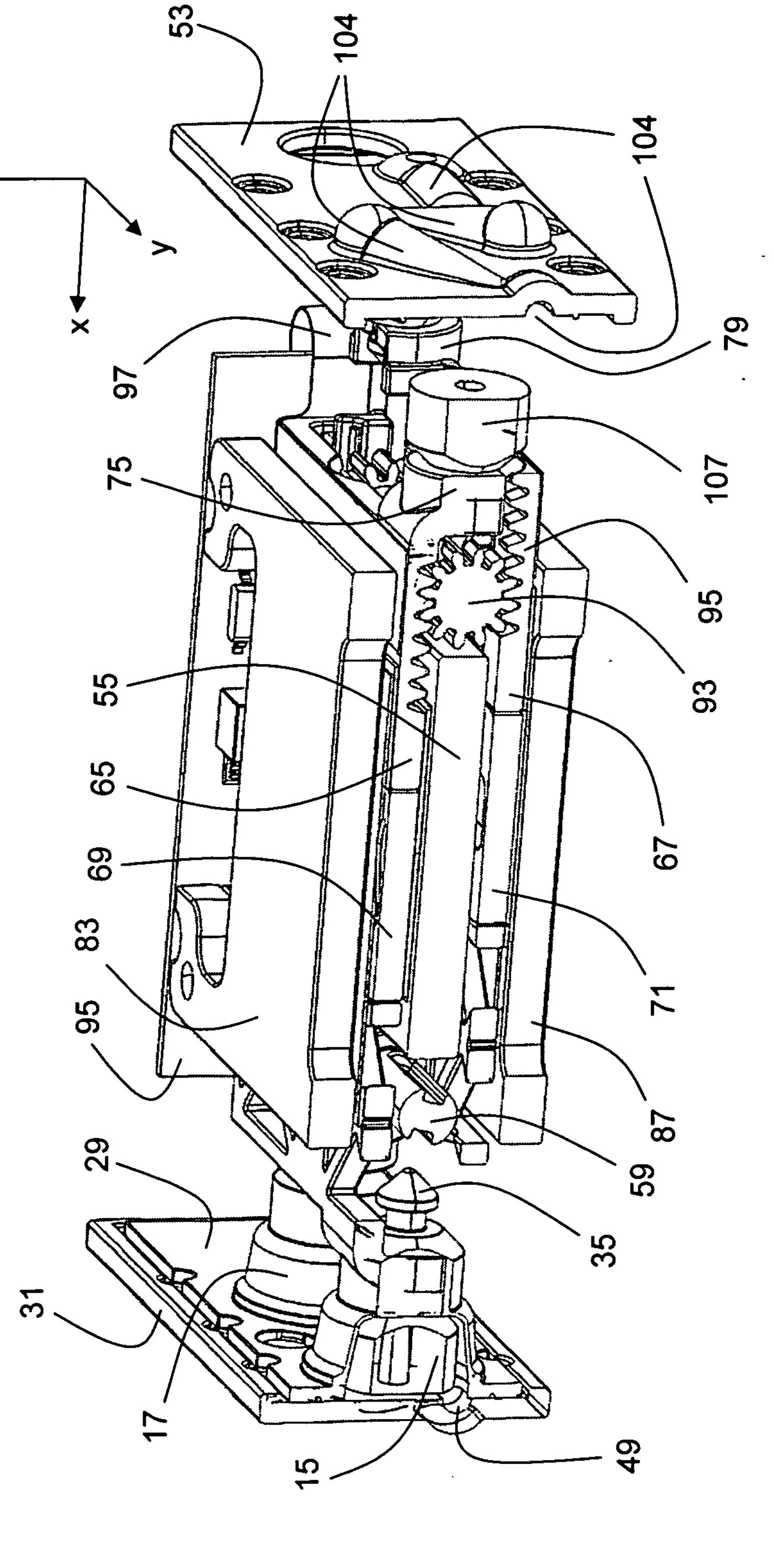


Fig. 6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59
29
35
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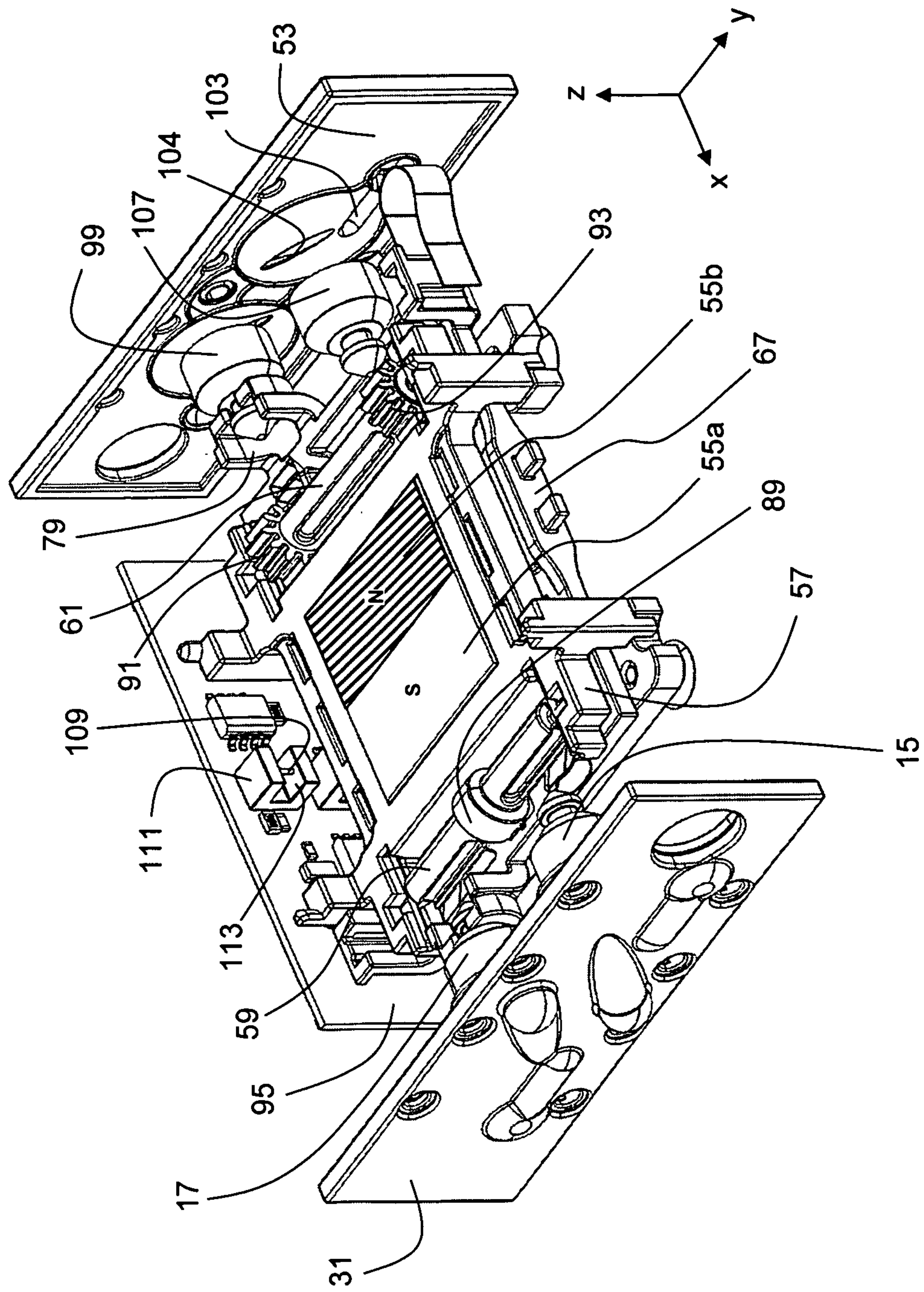
17
15
49

Fig. 7A



53
103
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55b
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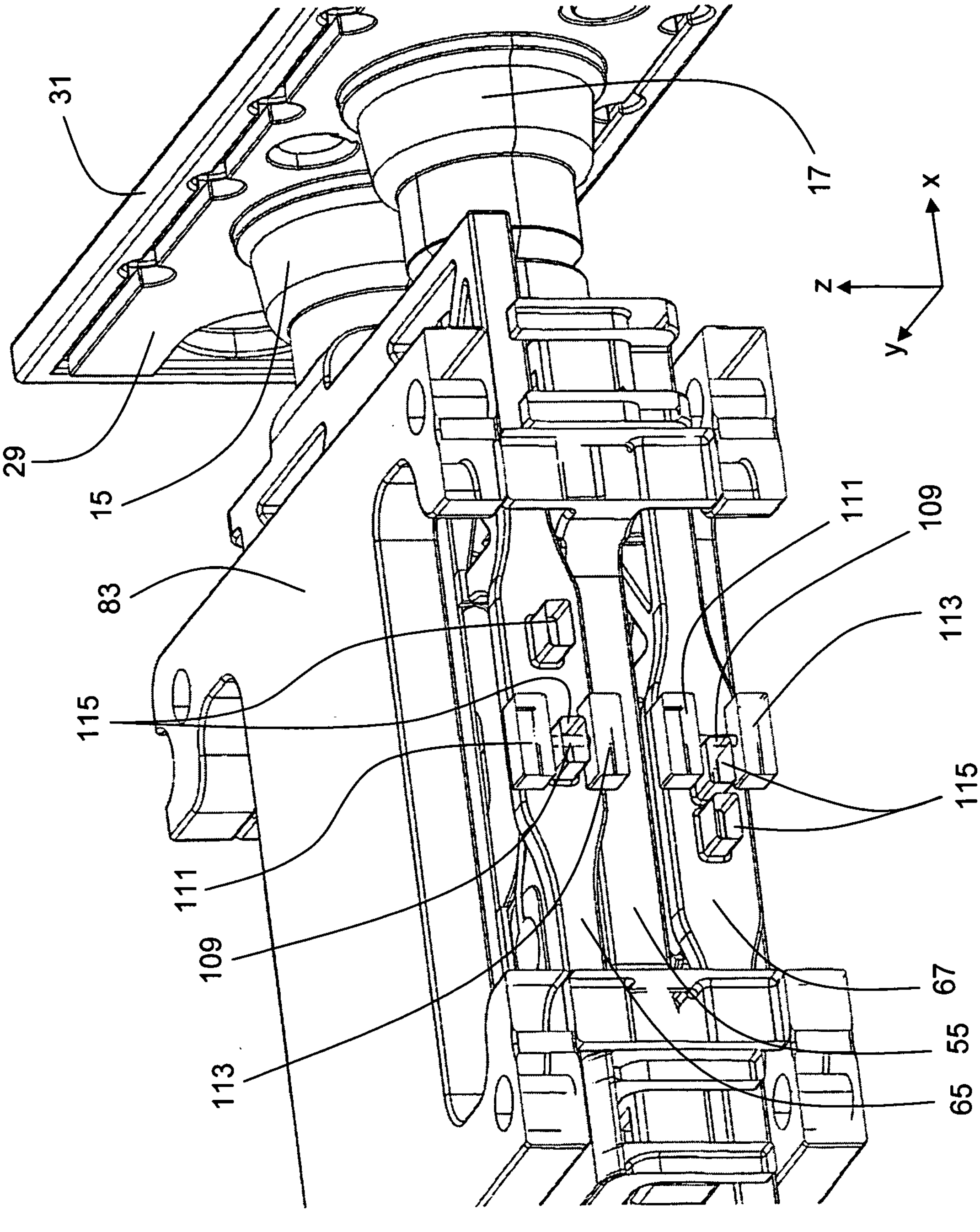
Fig. 7B



REFERENCES CITED IN THE DESCRIPTION

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