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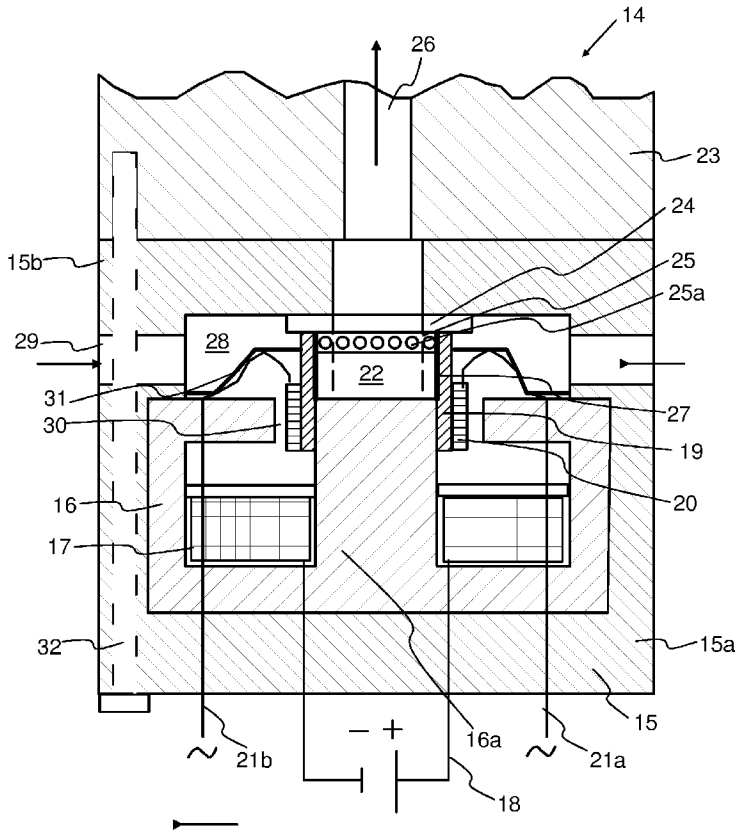
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(54) **Title:** CONTROL VALVE



(57) **Abstract:** A control valve for guiding pressurized medium to an Actuator (23), said actuator (23) being arranged to Dampen the vibrations of a process device connected Thereto. The control valve comprises a control member (19, 60) for controlling the flow of the medium, and at Least one coil (20, 20a, 20b) that is arranged around said Control member (19, 60) for moving the control member (19, 60) in the magnetic field.

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Control valve

Field of the invention

The invention relates to a control valve according to the preamble of the appended claim 1 for guiding pressurized medium to an actuator, said actuator being arranged to dampen the vibrations of the process device connected thereto.

Background of the invention

Oscillation and vibration occurring in paper machines and finishing devices for paper cause quite a significant problem. These devices contain several sources of vibration, the most significant ones being rolls and cylinders that comprise a large mass rotating at considerable speed. The oscillation and vibration of the rolls and cylinders cause marks in the paper that is being manufactured.

The vibration and oscillation occurring in multi-roll calenders used in the finishing process of paper cause a so-called barring phenomenon. Barring may result from various reasons. It may be caused by irregularities in the paper being calendered, the mechanical vibration produced by the calender itself, its actuators or the machines surrounding the same, or the effect of the asymmetry of the roundness of the outer surface of the rolls. Because all rolls of the calender are in contact with each other, the vibration is transferred from one roll to another, and in the end the rolls will repeat a vibration pattern consisting of several waves. The rolls cause MD-oriented variations in the thickness of the paper that is being calendered, wherein the target quality of the paper is generally not reached. Furthermore, the rolls cause additional vibration in the calender as well as noise.

The moving and rotating parts of the paper machine and the finishing devices of paper also cause vibration in the foundations of these devices. These vibrations disturb the running of the devices and may cause permanent changes in their supporting structures. Furthermore,

the vibrations caused by different machine parts/devices placed on the same foundation generate combined effects of vibrations, which results in that the entire machine vibrates periodically or chaotically.

Various solutions have been suggested to eliminate and reduce the vibrations in paper machines and finishing devices for paper. FI patent 110713 discloses a damper for damping the vibration of a pair of rolls that are in nip contact with each other. The damper is installed between the bearing housings of the rolls, or between the bearing housing and the frame of the machine. The damper comprises two coupling means that intermesh with each other, of and the force with which the coupling means are pressed against each other is directed on the side surfaces of at least one of said coupling means by means of a hydraulic actuator.

Patent FI 85166 discloses a solution for damping the vibrations of a pair of rolls forming a nip, in which the rolls are supported to each other by means of a hydraulic damper. The damper comprises a piston-cylinder device to which pressurized hydraulic medium is supplied and from which it is removed. The rolls of the roll pair produce mutual movement of the piston-cylinder device and the flow of the pressurized medium. The damping of the vibrations takes place by increasing said flow of the pressurized medium and constricting the produced increased flow.

Publication EP 819638 discloses a solution for damping the vibrations of a press roll in a reel-up. In the solution a pressure cylinder is attached to the bearing housing, said pressure cylinder having a choker in its pressure lines for damping the movement of the cylinder. The pressure cylinder can be the loading cylinder of the press roll, which is choked in a suitable manner.

In mineral material processing devices, such as crushers, screens and conveyors, various kinds of vibrations are caused by the operation of these machines. For example the feeding of the material to be crushed to the crusher causes shocks and vibration in the entire crusher. The

oscillation and vibration of mineral material processing devices are currently damped by springs and large-sized hydraulic cylinders.

It is a problem of all the above-mentioned solutions for damping vibrations that they have a long response time to the detected vibrations. Because the vibration damper does not react to vibrations fast enough, the vibrations have time to cause problems in apparatuses and in the manufacturing process before the situation improves. A situation may also occur in which the vibration damper is constantly "late" due to the long response time. Thus, sufficient damping is not attained at any stage, despite of the continuous adjustment of the actuator. The reason for the long response times of the actuators is for example the structure of the actuator and the functional delays caused thereby, but the most important factor is the slow response time of the devices conveying the pressurized medium to the actuators.

It is possible to convey pressurized medium to the actuators by means of different devices, of which various valves are most commonly used. Fig. 1 shows the cross-section of a valve that can be connected to actuators according to the preceding examples to convey the medium producing the movement of the actuator to the actuators.

The control valve comprises a magnet 1 surrounded by the frame 2 of the valve. The cover 3 of the valve is connected to one side of the magnet. A coil 4 is arranged around the core 1a of the magnet and electric current is supplied thereto via a conductor 5 to produce a magnetic field. Concentrically through the cover 3 of the valve and the core 1a of the magnet is produced a boring 6 for a valve control member, i.e. a stem 7 moving in its longitudinal direction. The valve stem 7 is preferably equipped with a suitable set of lugs 8, wherein in the different positions of the stem, the flow of the medium is directed between an inflow channel 9 and an outflow channel 10. A linear actuator, i.e. a speech coil 11 is partly in contact with the magnet 1. The speech coil 11 comprises a frame 11a and a coil 11b wound around the same. Conductors 12 are connected to the speech coil to convey electric current through the coil of the speech coil. A cone-like coupling member

13 having a rigid structure connects the speech coil 11 and the stem 7. The coupling member 13 is connected to the speech coil 11 from its end having a larger diameter and to the stem 7 of the valve from its end having a smaller diameter.

The stem 7 of the valve is moved back and forth in the desired direction in the boring 6, wherein the set of lugs 8 in the stem are positioned in accordance with said movement in relation to the inflow channel 9 and outflow channel 10 of the valve, thus enabling the flow of the pressurized medium in and out of the valve. The movement of the stem 7 is attained by supplying electric current to the coil of the speech coil 11 that produces the linear movement of the speech coil 11. The coupling member 13 moves in accordance with the movement of the speech coil, at the same time moving the stem 7 of the valve. The operation and movement of the speech coil in the magnetic field is known as such for a person skilled in the art, wherein it will not be described in more detail in this context.

The above-described valve is functional as such, but it contains certain significant drawbacks. As the description above shows, said valve has a complex structure. Therefore it is difficult to manufacture. This increases the manufacturing costs of the valve and makes it an expensive component for the end user. Due to the complex structure, it is difficult or even impossible to maintain the valve and replace the parts when they have been broken.

The step response of the valve is slow, i.e. the stem of the valve reacts to control commands slowly. This results from the fact that the stem of the valve is heavy, which slows down its movement. This also decelerates the flow of the pressurized medium from the outlet port of the valve. The flow of the medium will not comply with the control command until the stem has had the time to move to the correct position, which in the worst case may take several milliseconds. The slow step response of the valve causes slowness in the reactions of the actuator.

Brief description of the invention

Therefore, the purpose of the present invention is to provide a control valve for supplying pressurized medium to an actuator, which control valve avoids the above-presented problems and enables faster and more accurate positioning of the valve than before.

To attain this purpose, the control valve according to the invention is primarily characterized in what will be presented in the characterizing part of the independent claim 1.

The other, dependent claims will present some preferred embodiments of the invention.

The invention is based on the idea that a control valve is used for supplying pressurized medium to an actuator, in which control valve at least one coil is arranged around a control member for moving the control member in a magnetic field. The control member controls the volume flow of the pressurized medium. In other words, an element moving the control member is directly connected thereto.

The control member is formed as a cylindrical piece that is at least partly hollow inside. The valve contains at least one outflow chamber for the pressurized medium. The medium flows to the outflow chamber either from an inflow chamber or an inflow channel through a flow guide. The control member is positioned in such a manner in relation to the flow guide that it is capable of controlling the volume flow of the medium through the flow guide. The at least one coil arranged on the outer surface of the control member is at least partly surrounded by the pressurized medium.

The valve contains at least one magnet to which electric current is supplied to form a magnetic field. The magnet used in the valve is designed in such a manner and the at least one coil arranged on the outer surface of the control member is positioned in relation to magnet/magnets so that the density of the magnetic flux is the highest pos-

sible in the surroundings of the coil of the control member. This results in that the movements of the control member are fast and precise, and correct positioning of the control member is easy and rapid.

The magnets can be either permanent magnets or electric magnets. If an electric magnet is used, it is possible to supply either direct current or alternating current thereto.

To move the control member in the magnetic field, electric current is supplied to at least one coil arranged around the control member. Alternating current is supplied to the coil, wherein the direction of movement of the control member with respect to the flow guide can be guided to both directions.

If desired, it is possible to attach at least one spring to the control member, said spring holding the control member in its place when it is not being controlled. More than one spring is connected to the control member, and they have been positioned symmetrically around the control member. It is also possible to use the spring as a supporting structure for the conductors supplying electric current to the coil, wherein the durability of the conductors improves.

By means of the rigidity of the spring it is possible to affect the speed of the step response of the valve. If a fast step response is required, a slack spring with a low natural oscillation frequency is selected. For a slower step response, a rigid spring is selected whose natural oscillation frequency is high. Less power is required to control a rigid spring than a slack spring. It is possible to select a spring suitable for the application in question by calculation by means of amplitude resonance in the following way:

$$f = \tfrac{1}{2}\pi\sqrt{\frac{k}{m} - \frac{B^2}{2m^2}} \qquad (1)$$

in which f = frequency
k = spring constant
m = total mass of the stem and the spring
B = damping factor

The spring is not absolutely necessary for the function of the control valve. However, the force produced by the spring is considerably smaller when compared to the force produced by the speech coil.

The pressurized medium controlled by the control valve can be a liquid or gaseous medium. For controlling the valve it is advantageous to use feedback control, but it is also possible to control the actuator connected to the valve proportionally, without feedback.

Depending on the application, the number of outflow channels may vary, and there may be 1 to 20 outflow channels. Advantageously there are 2 to 5 of them.

An individual valve according to an embodiment of the invention functions like a 2/2 valve containing two ports and two stem positions. According to another embodiment it is also possible to form an individual valve as a 4/2 valve. It is also possible to connect valves to each other, wherein several different operating alternatives can be attained.

The fact that the control member and the element moving the same have been connected brings about several advantages.

It is not necessary to provide the valve with a separate, heavy stem, wherein the entire valve is smaller in size and lighter, wherein it can be installed in connection with actuators more easily. The control member itself is naturally lighter as well, wherein it can be moved faster, and

thus the flow of the medium can also be controlled faster. In tests response times of 0.1 ms have been measured as the reaction time of the control member. Furthermore, it has been noted that increasing the flow from zero to full flow or closing of the same from the full flow may be reached even in approximately 1 ms. As a consequence of all this the positioning of the actuator to the desired operating state is fast.

Because of the simpler structure, the valve is also less expensive than the valves currently in the market that are capable of almost the same action.

The valve has been designed in such a manner that it can be easily maintained and the parts that wear can be easily replaced. The inner calibration of the valve can be carried out easily by using a pressure sensor. Furthermore, the parts used in the valve, especially the at least one coil arranged around the control member is very durable. This results from the fact that it is at least partly surrounded by the pressurized medium that cools down the coil when it is controlled with high currents.

Especially in view of damping the vibrations, it is very advantageous that the step response of the actuator becomes faster. Furthermore, by means of the valve it is also possible to attain other than sine wave.

Brief description of the drawings

In the following, the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 shows the cross-section of a valve according to prior art,

Fig. 2 shows the cross-section of a control valve according to the invention,

Fig. 3a shows a way of coupling a control valve according to the invention,

Fig. 3b shows another way of coupling a valve according to the invention,

Fig. 3c shows a hydraulic circuit diagram of a valve series having two valves coupled to each other,

Fig. 3d shows the control of an actuator by means of two valve series,

Fig. 4 shows a second control valve according to the invention,

Fig. 5 shows a finishing device for paper in which vibrations are damped with a separate actuator, and

Fig. 6 shows a third control valve according to the invention.

Detailed description of the invention

In this description the term process device refers to papermaking devices or finishing devices for paper, processing devices for mineral materials and their parts, components, subassemblies and foundations.

Fig. 2 shows an embodiment of the invention as a 2/2 valve. The control valve 14 shown in the figure comprises a valve frame 15 which is designed to be hollow inside for positioning the parts of the valve inside the frame 15. The frame can be formed of a uniform, housing-like element 15a that forms the bottom and end walls, and of a cover part 15b attached thereto, as in the embodiment of Fig. 2. The frame of the valve can also be composed of separate bottom and cover parts, and side walls attached thereto. If desired, the valve can also be produced without the cover. The valve is attached to the actuator 23 by a fastening member 32 in such a manner that the cover of the valve 15b is in contact with the actuator 23.

A magnet 16 is arranged inside the frame, which is preferably an electric magnet, but a permanent magnet can also be used. The coil 17 of the magnet is wound around the core 16a of the magnet. Electric current is supplied to the coil 17 of the magnet via a conductor 18 in order to produce a magnetic field.

A control member 19 is at least partly in contact with the magnet 16, said control member being designed as a cylindrical piece that is at least partly hollow inside. There is a coil 20 arranged around the control member 19. Electric current is supplied to or discharged from the coil 20 via conductors 21a, 21b. The volume flow of the medium supplied by the valve 14 to the actuator is controlled by adjusting the quantity and direction of the control current supplied to the coil 20.

As an extension of the core 16a of the magnet there is an outflow chamber 22 separated from an inflow chamber 28 by means of a cylindrical wall 22a. The control member 19 is arranged around the core 17a of the magnet and the wall 27 of the outflow chamber in such a manner that it extends over the entire length of the wall 17 and partly around the core 16a of the magnet. In this section the inner surface of the stem is in contact with the outer surface of the core 16a of the magnet.

Thus, the control member 19 restricts the outflow chamber 22 of the valve and its walls inside itself. Correspondingly, the inflow channel 28 of the valve is outside the control member. The coil wound on the outer surface of the control member 19 is thus located inside the inflow chamber 28, surrounded by the medium contained therein.

At the valve cover end of the wall 27 of the outflow chamber is arranged a flow guide 25 guiding the flow of medium from the inflow chamber 28 to the outflow chamber 22 when the control member 19 has been moved to a position in which it does not prevent the flow. In the embodiment of Fig. 2 the flow guide 25 is formed of holes 25a arranged in the wall of the outflow chamber.

In the operating state of the valve 14 shown in Fig. 2, the other end of the control member 19 is in contact with a damping plate attached to the valve cover 15a. Thus, the control member covers the holes 25a of the flow guide 25 and prevents the medium from flowing from the inflow chamber 28 to the outflow chamber 22 and further via the outflow chamber 26 to the actuator 23 connected to the valve.

The frame 15a, the cover 15b, the magnet 16 and the stem 19 of the valve define the inflow chamber 28 of the valve, to which an inflow channel 29 is connected for supplying pressurized medium to the inflow chamber 28.

As the figure shows, the magnet 3 is designed in such a manner that a magnetic gap 30 is formed therein. The magnetic gap 30 has a narrow shape. This design produces an efficient magnet whose magnetic flux is even in the magnetic circuit. The length of the control member 19 and the location of the coil 20 in relation to the length of the control member are arranged in such a manner that the coil is positioned substantially in the magnetic gap 30, wherein the movements of the control member 19 are rapid and precise.

Two springs 31 are attached symmetrically around the control member 19 in such a manner that the first end of the spring is attached to the control member 19. The second end of the springs is attached to the wall of the inflow chamber 28. The springs press the control member 19 against the damping plate when the control member is not being controlled. It is also possible to use the spring as a supporting structure for the conductors 21a and 21b of the coil 20, wherein the durability of the conductors improves.

The control valve according to Fig. 2 functions in the following manner: By means of the electric current supplied to the coil 17 of the magnet via the conductor 18 a magnetic field is generated with the magnet 16. Pressurized medium is constantly supplied to the inflow chamber 28 of the valve via an inlet port 29. When the valve is not being controlled, i.e. current is not supplied to the coil 20 arranged around the control

member 19, the spring 31 presses the control member 19 against the baffle plate 23. Thus, the control member covers the holes 25a arranged in the flow guide 25 and closes the flow path of the medium from the inflow chamber 28 to the outflow chamber 22.

When control current is supplied to the coil 20 arranged around the control member, said control current moving the control member 19 away from the damping plate, a flow path is opened for the medium via the holes of the flow guide 25 to the outflow chamber 22 and through the same via the outflow channel 26 to the actuator 27 connected to the valve. When the flow of the medium is reduced, the control member 19 is moved towards the damping plate by means of the control current supplied to the coil 20. The springs 31 boost this movement.

Fig. 3a shows an alternative for coupling the control valve shown in Fig. 2 to the actuator. Said actuator is connected further to a process device (not shown) to dampen its vibrations. The coupling in question is a so-called 2/2 coupling. The control valve 14 is connected to an actuator 23, which in this embodiment is a motor. The actuator can also be a pump or a hydraulic cylinder functioning as a damper of the vibrations. The valve 14 is coupled to a control unit 33 via a line 34, said control unit controlling the quantity and direction of the electric current supplied to the coil arranged around the control member of the valve. This brings about the desired movement of the control member and a volume flow of the pressurized medium via a line 35 to the motor. The outlet of the motor has a feedback to the control unit. For this purpose the outlet of the motor 23 is provided with a measuring sensor 36 measuring the flow, pressure, speed or acceleration of the medium, and the measurement result obtained therefrom is transmitted via a line 37 to the control unit 33.

Fig. 3b shows an alternative for coupling the control valve shown in Fig. 2 to the actuator. The coupling in question is a so-called 2/2 leakage flow coupling. The control valve 14 is coupled to a control unit 33 via a line 34, said control unit controlling the movements of the control member of the valve in the above-described manner and producing

the desired flow of pressurized medium via a line 38 to the actuator 23. In this example the actuator 23 is a hydraulic cylinder. A choker 40 has been installed in the leakage coupling 39 to control the leakage flow. From the outlet of the actuator there is a feedback to the control unit. For this purpose a measuring sensor 41 is arranged in connection with the hydraulic cylinder 23, which measuring sensor can be a linear sensor or force transducer, and the measurement result obtained therefrom is conducted via the line 37 to the control unit 33.

Fig. 3c shows a valve series comprising two control valves 14 coupled together. This coupling method is a so-called 3/2 coupling in which one control valve controls the incoming flow P of the pressurized medium and the other control valve controls the flow T of the pressurized medium discharged from the valve series. The 3/2 coupling is known to anyone skilled in the art, and therefore it will not be described in more detail in this context. Both valves 14 are coupled to the control unit 33 via the line 34, said control unit controlling the movements of the control members of both valves in the above-described manner and produces the desired flow of pressurized medium via a line 38 to the actuator 23. In this example the actuator 23 is a hydraulic cylinder. From the outlet of the actuator there is a feedback to the control unit. For this purpose a measuring sensor 41 is arranged in connection with the stem of the hydraulic cylinder 23, which measuring sensor can be a linear sensor or force transducer, and the measurement result obtained therefrom is transmitted via the line 37 to the control unit 33.

Fig. 3d shows a valve series comprising four control valves 14 coupled together as a so-called 4/3 coupling. This coupling is also known to anyone skilled in the art, and therefore it will not be described in more detail in this context. All control valves are coupled to the control unit 33 via the lines 34, said control unit controlling the movement of the control members 19 of each valve in the above-described manner. The control valves 14 are coupled to each other in pairs in such a manner that two control valves 14 are coupled together. One pair A guides the pressurized medium via a line 42 to the chamber at the actuator 23 side, i.e. the piston side of the hydraulic cylinder, and the other pair B

guides the pressurized medium via a line 43 to the chamber at the piston rod side of the hydraulic cylinder. From the outlet of the actuator there is a feedback to the control unit. For this purpose a measuring sensor 41 is arranged in connection with the stem of the hydraulic cylinder 23, and the measurement result obtained therefrom is transmitted via the line 37 to the control unit 33.

Hereinabove, only a few examples of coupling the valves have been disclosed. It is also possible to implement other couplings, such as 4/2 or 5/2 couplings.

The couplings described in connection with Figs. 3a and 3b can also be implemented without the control unit and the feedback from the actuator thereto. If several valves have been coupled together, the control unit is necessary to be able to control the valves synchronically in the desired manner, for example in 3/2, 4/2 or 5/2 way. By means of the control unit it is also possible to implement the control of the valve/valves in the desired manner, for example proportionally, in a servo-type manner or on/off manner.

Fig. 4 shows an embodiment of the invention as a 4/2 valve. The control valve 14 shown in the figure comprises a valve frame 15. Inside the frame a magnet 16 has been arranged, around which the coil 17 of the magnet has been wound. Electric current is supplied to the magnet via a conductor 18. A control member 19 is at least partly in contact with the magnet, and a coil 20 is arranged around the same. For the electric current necessary for the coil, conductors 21a and 21b are connected thereto. The volume flow of the medium supplied by the valve 14 to the actuator is controlled by adjusting the quantity and direction of the control current supplied by the control member 19 to the coil 20.

For supplying pressurized medium to the valve 14, it is provided with a lead-through for the flow channel 29. It extends continuously through the entire valve, and it is divided into an inflow channel 29a and an outflow channel 29b by means of a blocking plug 46. The inflow channel

29a is partly surrounded by a magnet 16. The outflow channel 29b is surrounded by the frame.

Apart from the flow channel 29, two outflow chambers 22a and 22b are arranged in the valve 14. From the inflow channel 29a a lead-through 44 is arranged to guide the medium 44 to the first outflow chamber 22a. From the outflow channel 29a a lead-through 45 is arranged to guide the medium to the second outflow chamber 22b. The lead-throughs operate as flow guides for the valve.

The cylindrical control member 19 is arranged to move in the outflow chambers 22a and 22b. The length of the control member 19 is selected in such a manner that it extends from the first outflow chamber 22a to the second outflow chamber 22b, wherein a part of its length is in contact with the surface of the magnet 16. The control member is installed in such a manner that it surrounds the flow channel 29. The coil 20 wound on the surface of the control member 19 is thus located inside the second outflow chamber 22a, surrounded by the medium contained therein.

Flow channels 47 are arranged on the inner surface of the control member 19, said flow channels guiding the medium from the inflow channel 29a and/or outflow channel 29b to the outflow chambers 22a and 22b. The flow channels 47 can be grooves, or holes penetrating the control member. The flow of the medium is guided by moving the control member 19 in accordance with the arrow marked in the Figure. In the situation shown in the Figure, the control member 19 is in such a position that there is no flow of the medium via the flow guides 44 and 45 to the outflow chambers 22a and 22b. When the control member 19 is moved in either direction, the medium is capable of flowing via the lead-through 44 and a flow channel 47 from the inflow channel 29a to the first outflow chamber 22a. The flow of the medium via the lead-through 45 and the flow channel 47 from the outflow channel 29b to the second outflow chamber 22 is controlled in a corresponding manner. It is also possible to move the control member in such a position that the medium is at the same time capable of flowing via both flow guides 44

and 45 to the outflow chambers 22a and 22b. The outflow chambers 22a and 22b are connected to the outflow channels 26a and 26b guiding the medium to the actuator. The valve is also provided with springs 31 enhancing the movement of the control member.

Fig. 5 shows a multinip calender 50 whose vibrations are dampened by means of one or several actuators using a valve according to the invention. The multinip calender comprises a frame 51 supported to the foundations 52 of the calender. The rolls 53 of the calender, the number of which can vary, are arranged on top of each other so that successive rolls are in nip contact with each other. The web W is brought to the calender and guided from bottom to top through the calender by means of guide rolls 54 so that the web travels through each nip.

The figure shows schematically three actuators 55, 56 and 57. The actuators can be any actuators to which pressurized medium is guided by means of a valve. The actuator 55 is arranged to dampen the vibrations occurring in the foundations 52 of the calender, and the actuator 56 is arranged to dampen vibrations occurring in the frame 52 of the calender. The actuator 57 is arranged in connection with a relieving arm 58 provided in one of the calender rolls to dampen the vibrations occurring therein.

Fig. 6 shows an embodiment of the invention. The control valve 14 shown in the figure comprises a valve frame 15. To supply pressurized medium to the valve 14, the frame 15 is provided with a lead-through for the flow channel 29. It extends continuously through the entire valve, and it is divided into an inflow channel 29a and an outflow channel, i.e. a tank channel 29b by means of a blocking plug 46.

There are two magnets arranged inside the frame, a first magnet 16a and a second magnet 16b. The coils 17a and 17b of the magnets have been wound around the magnets. The first magnet 16a partly surrounds the inflow channel 29a and the second magnet 16b partly surrounds the tank channel 29b. Electric current is supplied to the first

magnet 16a via a first conductor 18a, and electric current is supplied to the second magnet via a second conductor 18b.

A control member 60 surrounding the flow channel 29 is at least partly in contact with both magnets 16a and 16b. The inner surface of the first end 60a of the control member 60 is in contact with the surface of the first magnet 16a, and the inner surface of the second end 60b of the control member is in contact with the surface of the second magnet 16b. A first coil 20a is arranged around the first end 60a of the control member 60, and within a distance from the same, a second coil 20b is arranged around the second end 60b of the control member 19. To conduct the electric current required by the first coil 20a, conductors 21a' and 21a'' are connected thereto. To the second coil 20b electric current is conducted via conductors 21b' and 21b''. The volume flow of the medium supplied by the valve 14 to the actuator is controlled by controlling the quantity and direction of the control current supplied by the control member 60 to the first coil 20a and/or to the second coil 20b.

Apart from the flow channel 29, an outflow chamber 22 surrounding the flow channel 29 is arranged. From the inflow channel 29a a lead-through 44 is arranged to guide the medium to the outflow chamber 22. From the outflow channel 29b a lead-through 61 is arranged to guide the medium from the outflow chamber 22 to the tank channel 29b. The lead-throughs 44 and 61 operate as flow guides for the valve.

The cylindrical control member 60 is arranged to move in the outflow chamber 22. The length of the control member 60 is selected in such a manner that it extends over the length of the outflow chamber 22. The first coil 20a and the second coil 20b wound on the surface of the control member 60 are at least partly inside the outflow chamber 22, surrounded by the medium contained therein.

On the surface of the control member 60 at the flow channel 29 side, a flow channel 47 is arranged, said flow channel guiding the medium from the inflow channel 29a to the outflow chamber 22. The flow chan-

nel 47 can be a groove formed on the surface of the control member 60, or a hole penetrating the control member 60. The flow of the medium is also guided from the outflow chamber 22 to the outflow channel 29b via a lead-through arranged in the outflow channel and via the flow channel 47.

The flow of the medium is guided by moving the control member 60 in accordance with the arrow marked in the Figure. In the situation shown in Fig. 6, the control member 60 is in such a position that there is no flow of the medium via the flow guide 44 and the flow channel 47 to the outflow chamber 22. When the control member 60 is moved in the direction of the first magnet 16a, the medium is capable of flowing via the lead-through 44 and the flow channel 47 from the inflow channel 29a to the outflow chamber 22. The outflow chamber 22 is connected to the outflow channel 26a guiding the medium to the actuator. When the control member 60 is moved in the direction of the second magnet 16b, the medium is capable of flowing via the flow channel 47 the lead-through 61 to the tank channel 29b. The valve is also provided with at least one spring 31 enhancing the movement of the control member.

The position of the control member 60 can be adjusted either by supplying control current to both coils 20a and 20b simultaneously, or by supplying control current only to the first coil 20a or to the second coil 20b.

In all the above-presented examples the coil wound around the control member can be formed for example by winding litz wire or aluminium foil around the stem of the valve. Advantageously litz wire is used, which is a very strong coil material. When litz wire is use, it is possible to utilize higher control frequencies and still the losses are smaller. As a coil material it is also possible to use other conductor materials as a wire comprising one or several threads.

The invention is not intended to be limited to the embodiments presented as examples above, but the invention is intended to be applied widely within the scope of the inventive idea as defined in the ap-

pended claims. By means of the control valve it is possible to control various kinds of media. Liquids, gases and liquid-gas mixtures can be controlled. Thus, it is possible to use the control valve to guide the medium both to hydraulic and pneumatic actuators.

Claims

1. A control valve for supplying pressurized medium to an actuator (23) said actuator (23) being arranged to dampen the vibrations of a process device connected thereto, said control valve comprising:

- a frame (2, 15),
- at least one magnet (1, 16, 16a, 16b) for generating a magnetic field,
- at least one inflow channel (9, 29, 29a) and at least one outflow channel (10, 26, 26a, 26b) for the flow of the medium, and
- a control member (7, 19, 60) for controlling the flow of the medium,

characterized in that

- at least one coil (20, 20a, 20b) is arranged around the control member (19, 60) for moving the control member (19, 60) in the magnetic field.

2. The control valve according to claim 1, **characterized** in that at least one conductor (21a, 21a', 21a", 21b, 21b', 21b") is connected to the coil (20, 20a, 20b) for supplying electric current to the coil (20, 20a, 20b) and that the control member is arranged to move in the magnetic field generated by the magnet (16, 16a, 16b), said movement being produced by the electric current supplied to the coil (10, 20a, 20b).

3. The control valve according to claim 1, **characterized** in that the control valve comprises at least one outflow chamber (22) and at least one inflow chamber (28) and at least one flow guide (25) for guiding pressurized medium from the inflow chamber (28) to the outflow chamber (22).

4. The control valve according to claim 3, **characterized** in that the flow guide (25) is arranged in the wall (27) of the outflow chamber (22).

5. The control valve according to any of the preceding claims 1 to 4, **characterized** in that the control member (19) is cylindrical and that

the outflow chamber (22) is arranged concentrically in such a manner that the control member (19) surrounds the outflow chamber (22).

6. The control valve according to claim 3, **characterized** in that the inflow chamber (28) is connected to the inflow channel (29), and that the control member (19) is positioned in such a manner that the coil (20) arranged around the same is in the inflow chamber (28).

7. The control valve according to claim 1, **characterized** in that the control valve comprises at least one outflow chamber (22, 22a, 22b) and at least one flow guide (44) for guiding pressurized medium from the inflow channel (29) to the outflow chamber (22, 22a, 22b).

8. The control valve according to claim 7, **characterized** in that the flow guide (44) is arranged in the wall of the outflow chamber (29a).

9. The control valve according to claim 7, **characterized** in that the control member (19, 60) is cylindrical and that the inflow channel (29a), the outflow channel (29b) and the control member (19, 60) are arranged concentrically in such a manner that the control member (19, 60) surrounds the inflow channel (29a) and outflow channel (29b) functioning as extensions for each other.

10. The control valve according to claim 7, **characterized** in that the control valve comprises at least one flow guide (45) for conveying medium from the outflow channel (29b) to the outflow chamber (22).

11. The control valve according to claim 7, **characterized** in that at least one flow guide (45) is arranged in the wall of the outflow channel (29b).

12. The control valve according to any of the claims 7 to 11, **characterized** in that the control valve comprises at least two outflow chambers (22a, 22b) and that the length of the flow guide (19) is selected in such a manner that the flow guide extends inside each of them.

13. The control valve according to claim 7, **characterized** in that at least two coils (20a, 20b) are arranged around the control member (60) in such a manner that the first coil (20a) is arranged at the first end (60a) of the control member (60) and the second coil (20b) is arranged at the second end (60b) of the control member.

14. The control valve according to claim 7, **characterized** in that the control valve (14) comprises at least one flow guide (61) for conveying medium from the outflow chamber (22) to the outflow channel (29b).

15. The control valve according to any of the claims 7 to 14, **characterized** in that the control member (19, 60) is positioned in relation to at least one outflow chamber (22, 22a, 22b) so that the at least one coil (20, 20a, 20b) arranged in the control member (19, 60) is located in at least one outflow chamber (22, 22a, 22b).

16. The control valve according to any of the claims 7 to 15, **characterized** in that at least one flow channel (47) is arranged on the inner surface of the control member (19, 60) for conveying the medium flowing via the flow guide (44, 45, 60) to the outflow chamber (22, 22a, 22b).

17. The control valve according to claim 6 or 15, **characterized** in that at least one coil (20, 20a, 20b) is at least partly surrounded by the medium.

18. The control valve according to any of the claims 2, 3, 7, 10 or 14, **characterized** in that the control member (19, 60) is arranged to move in relation to the flow guide (25, 44, 45, 61) for controlling the volume flow of the medium flowing through the flow guide (25, 44, 45, 61).

19. The control valve according to claim 1, **characterized** in that the magnet (16, 16a, 16b) is designed so that a magnetic gap (30) is formed and that the control member (19, 60) is installed in such a manner in relation to the magnetic gap (30), that the at least one coil

(20, 20a, 20b) of the control member is at least partly positioned in the magnetic gap (30).

20. The control valve according to claim 1, **characterized** in that the control valve comprises at least one spring (31).

21. The control valve according to claim 1, **characterized** in that the magnet (16, 16a, 16b) is provided with a coil (17, 17a, 17b) of the magnet and a conductor (18, 18a, 18b) is connected to the coil for supplying electric current to the coil (17, 17a, 17b) of the magnet.

22. The control valve according to claim 1, **characterized** in that the process device is one of the following: a papermaking device or finishing device for paper, processing device of mineral materials or a part of any of said devices.

23. The control valve according to claim 1, **characterized** in that the medium is one of the following: liquid, gas or a mixture of them.

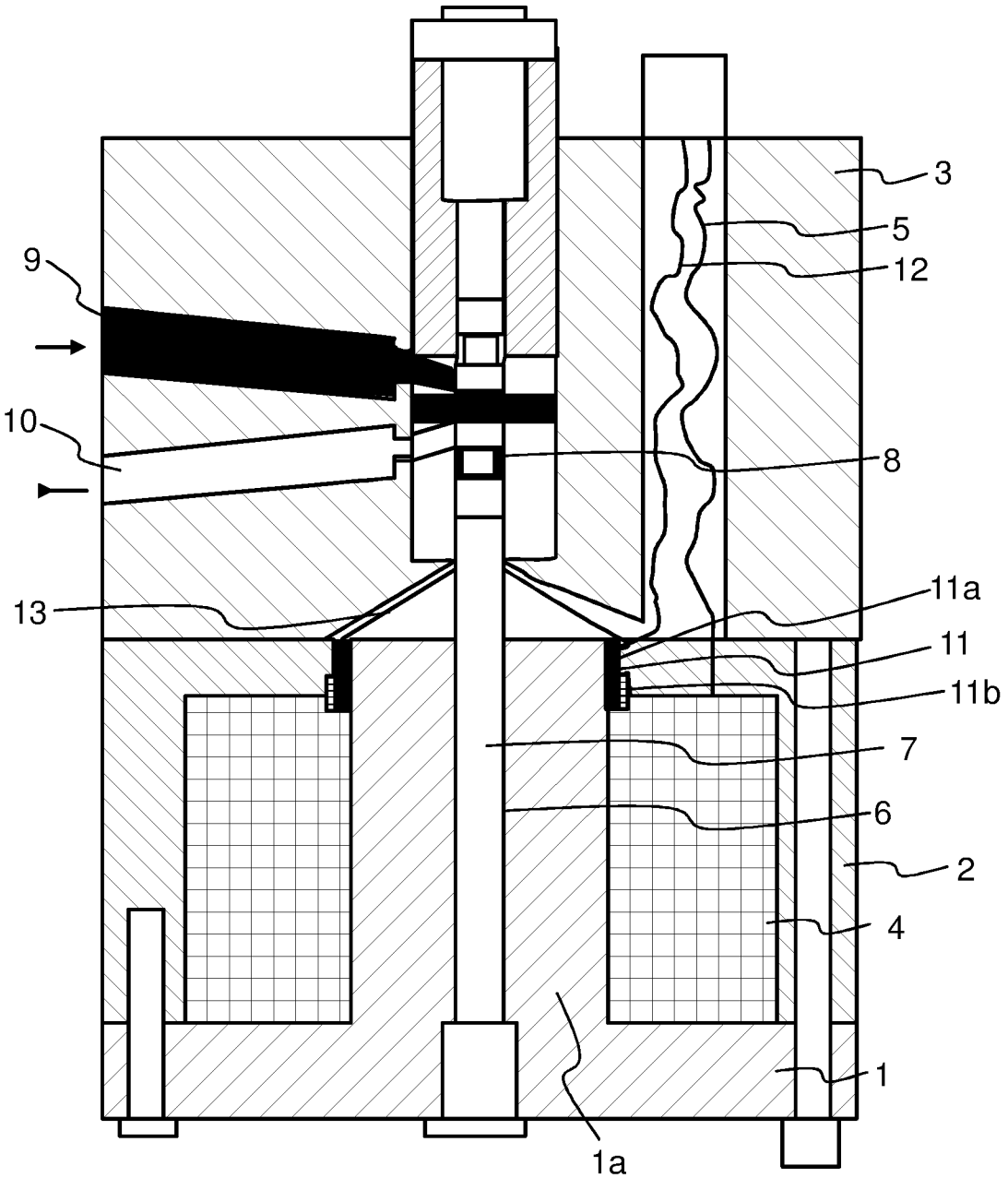


Fig. 1

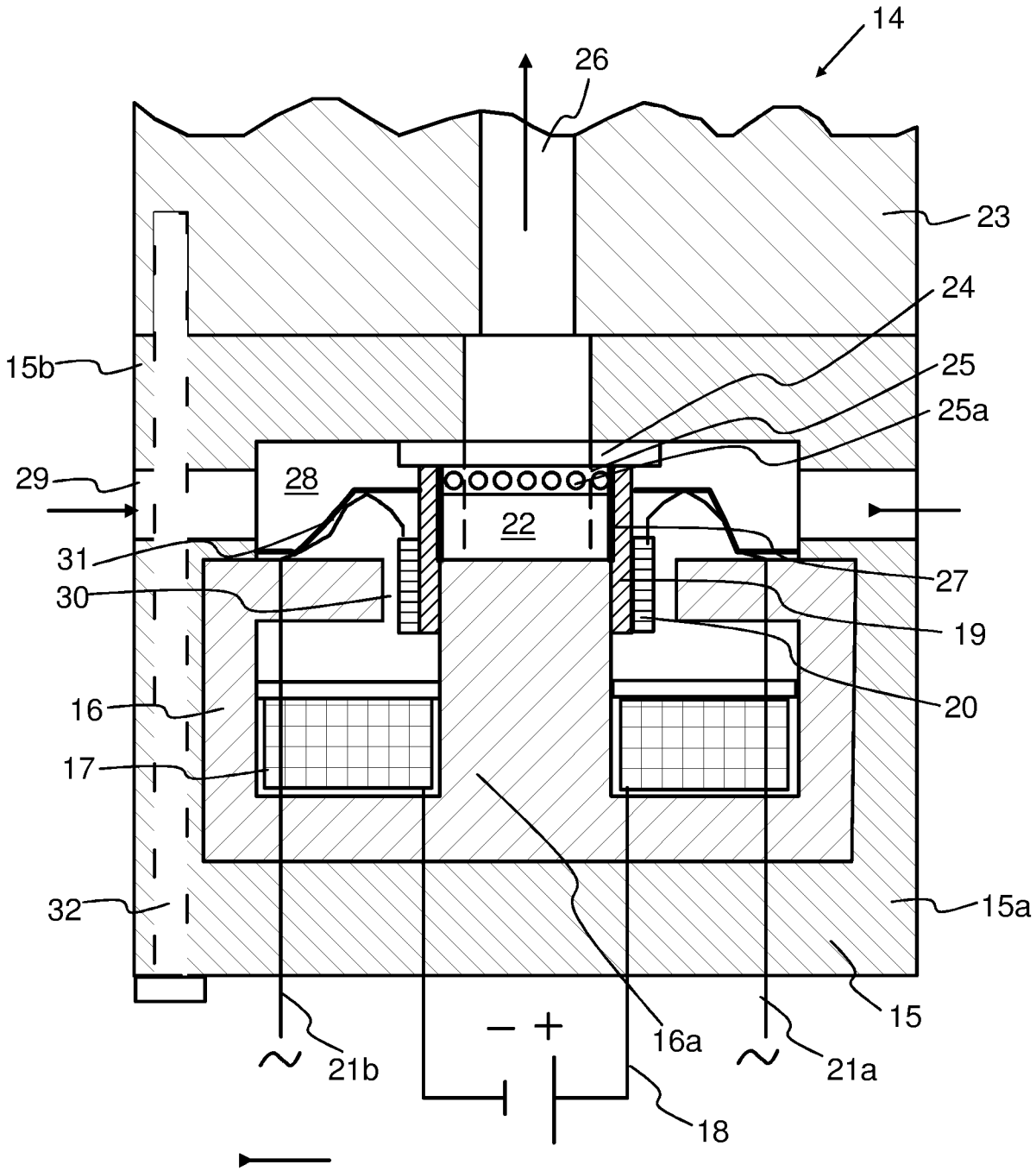

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25a
15b
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16a
21b
21a
18

Fig. 2

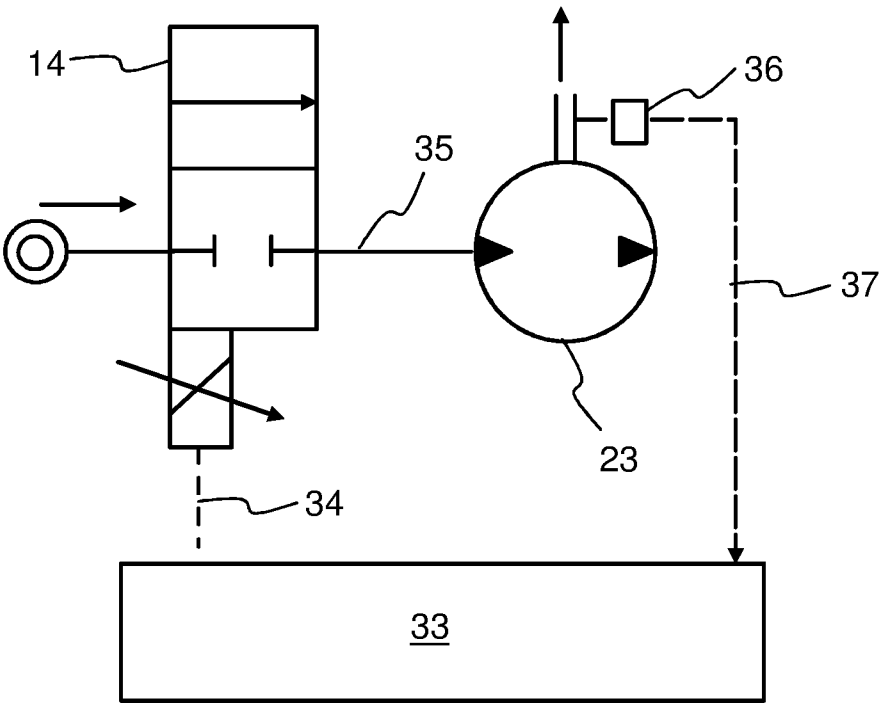


Fig. 3a

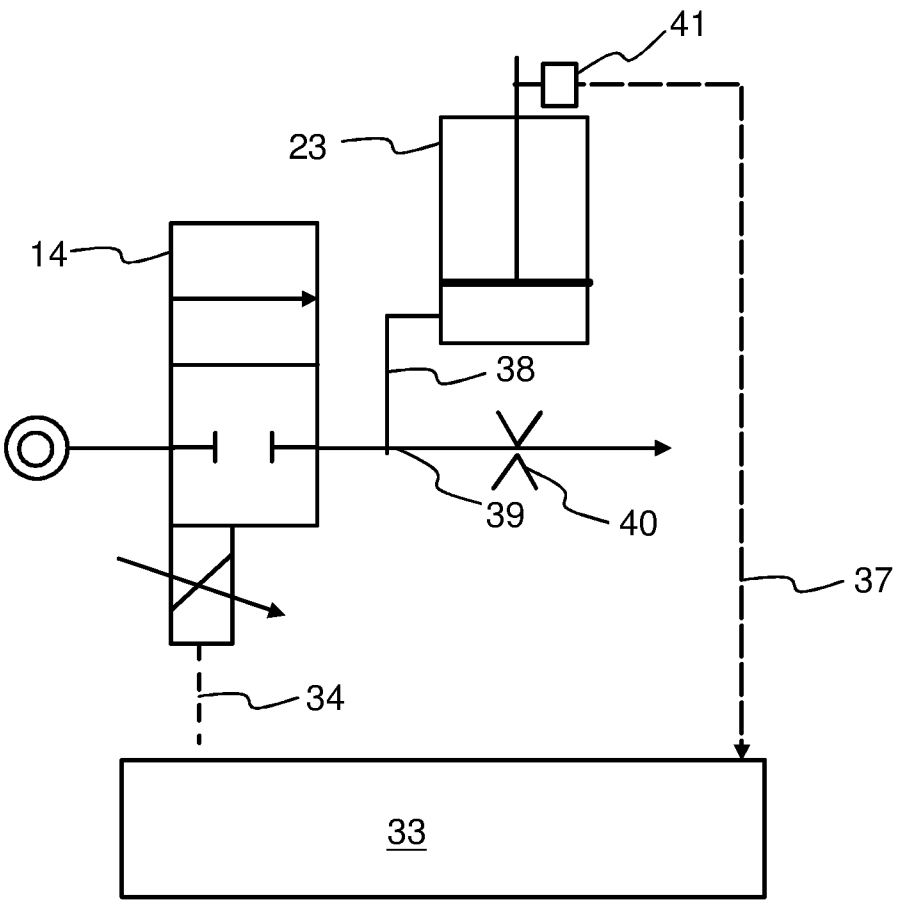


Fig. 3b

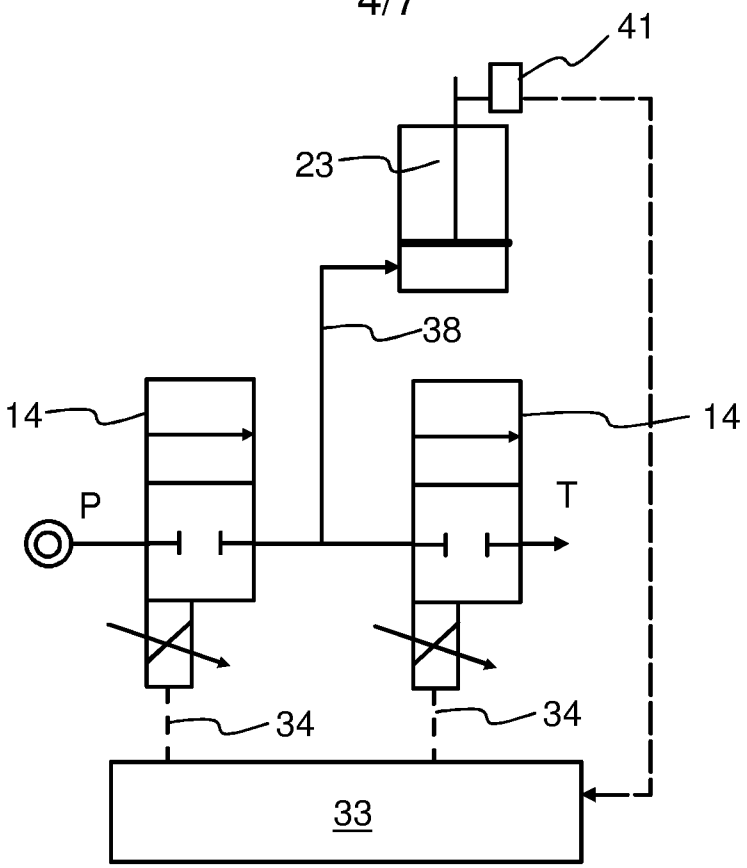


Fig. 3c

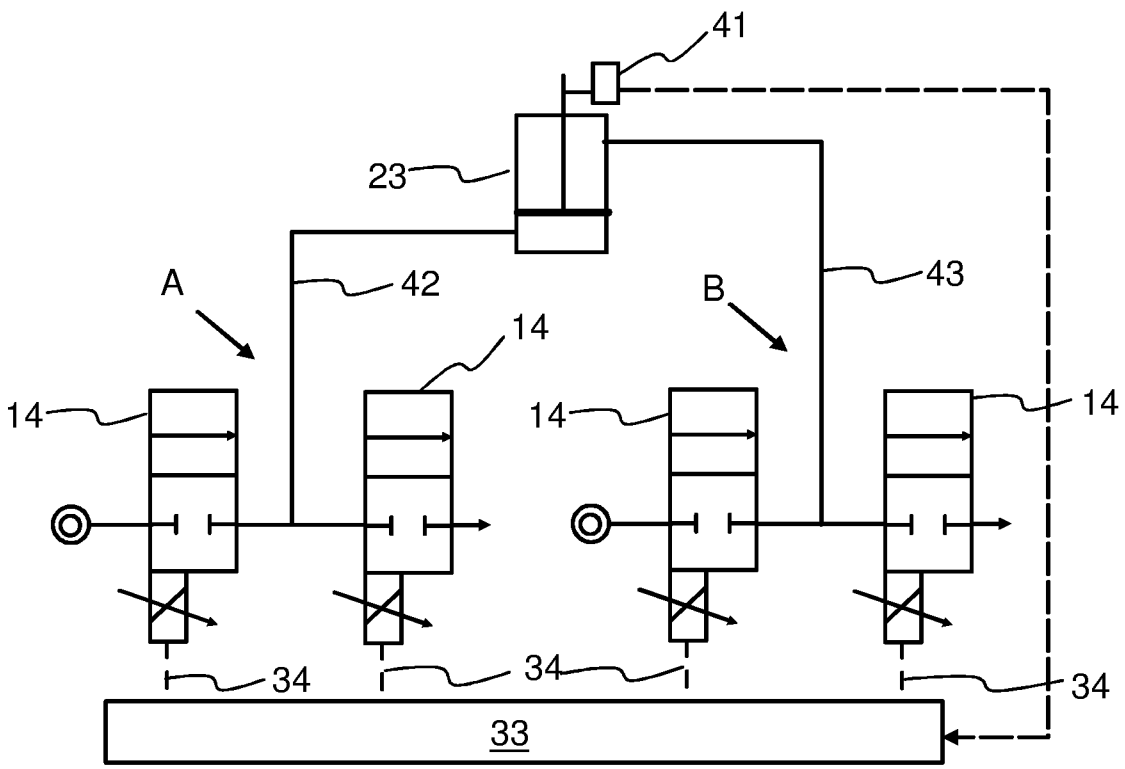


Fig. 3d

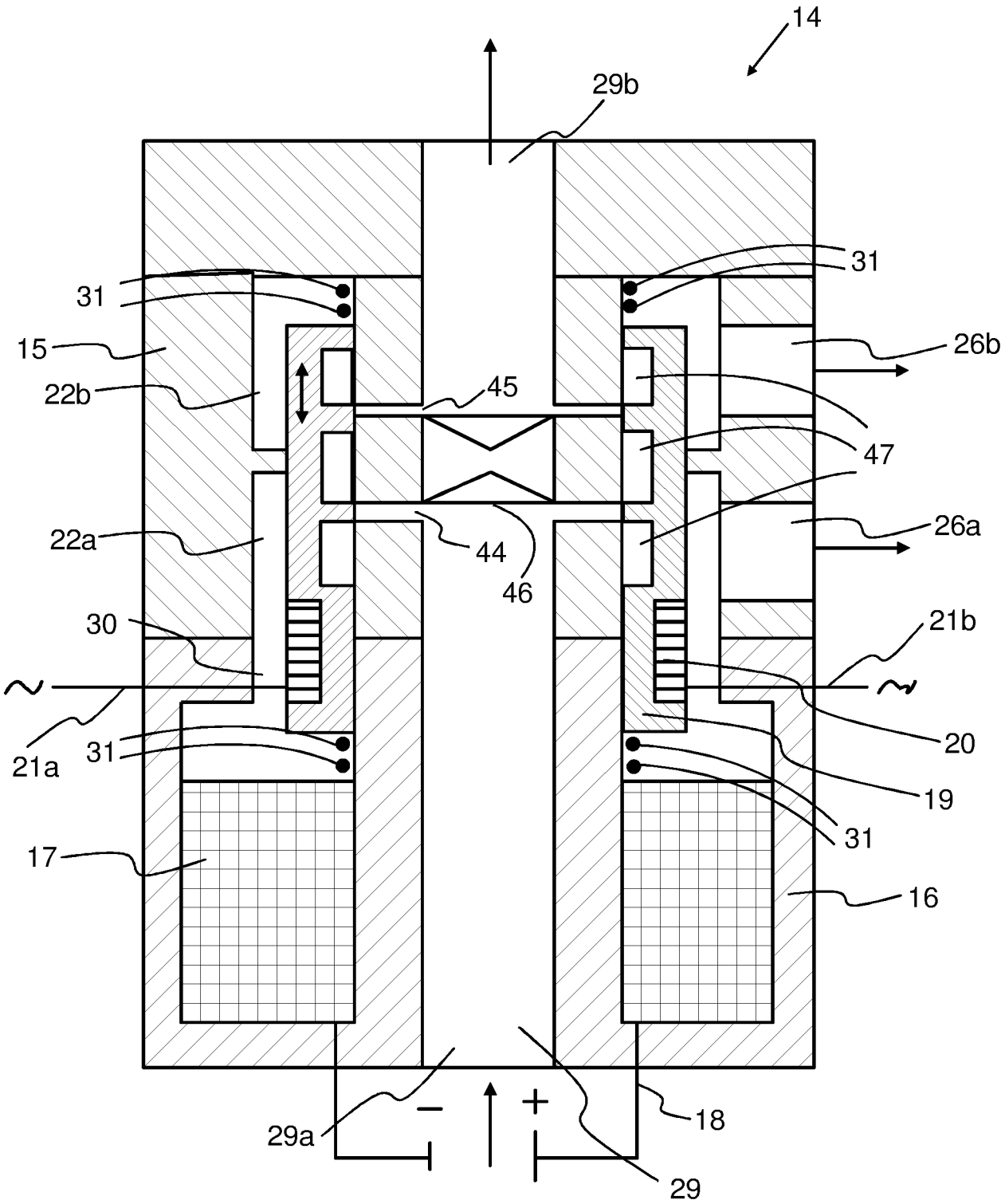

14
29b
31
31
15
26b
22b
45
47
22a
26a
44
46
30
21b
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21a
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19
31
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29a
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Fig. 4

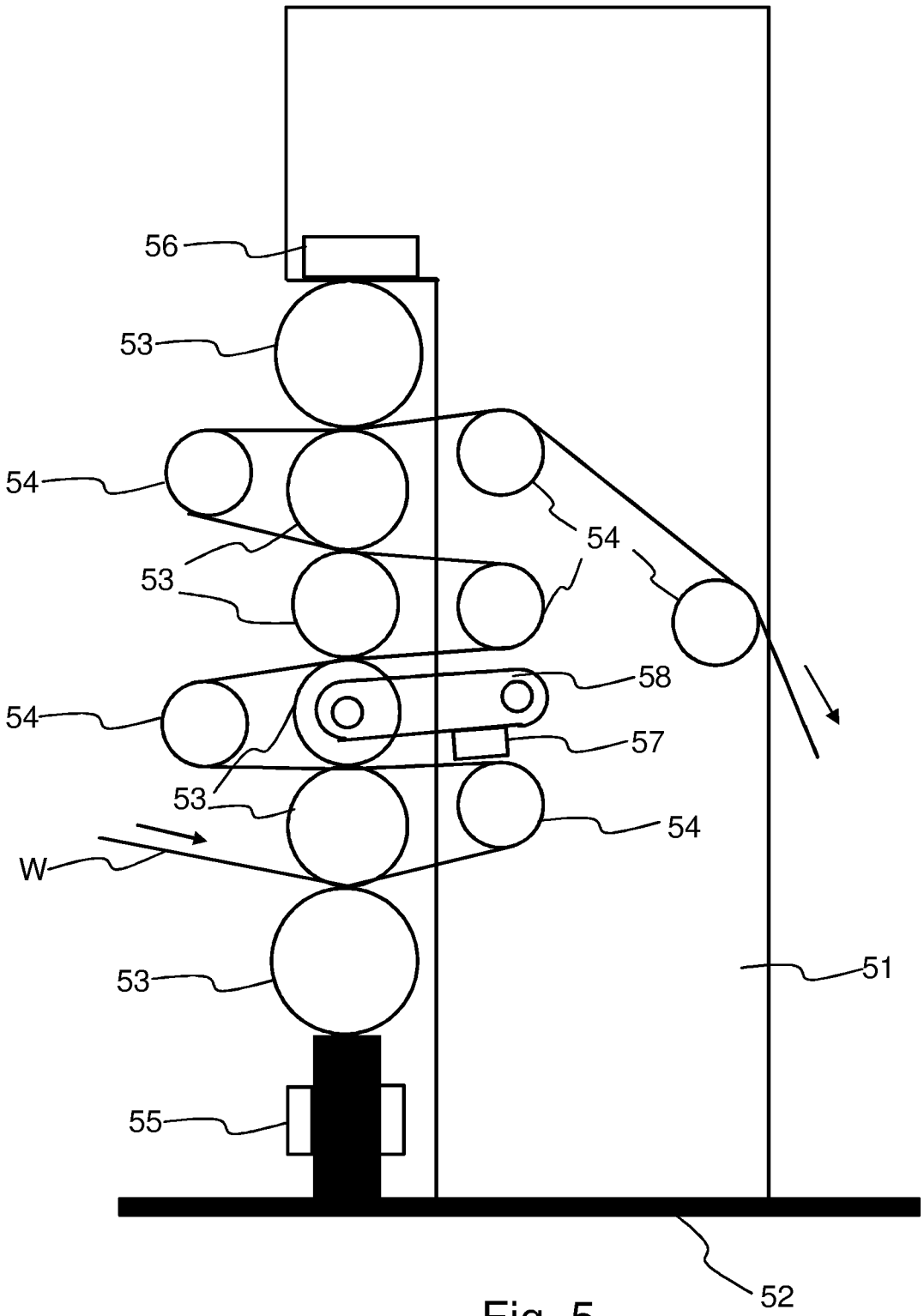


Fig. 5

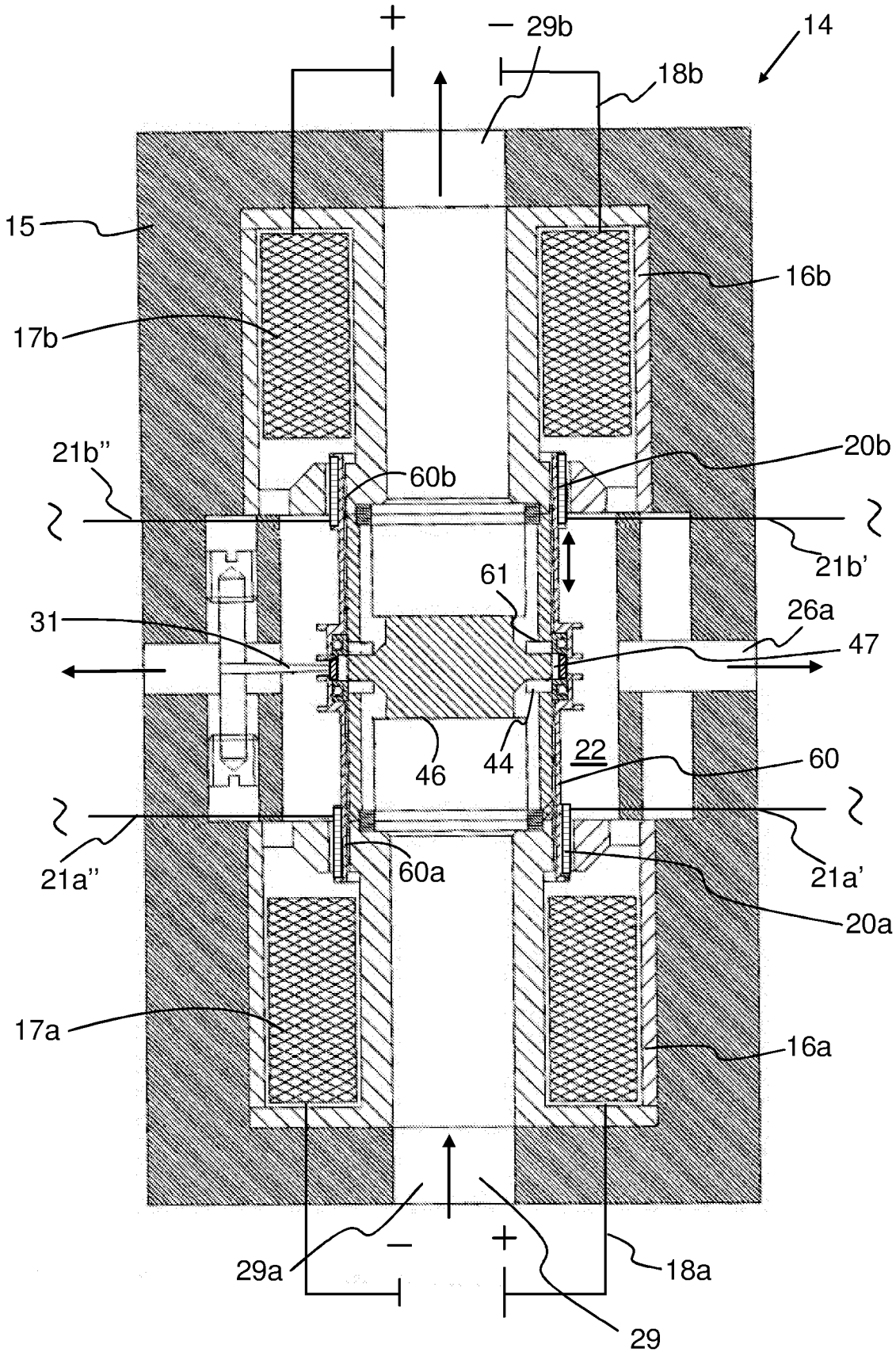

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– 29b
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21b”
20b
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21b’
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22
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21a”
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21a’
20a
17a
16a
29a
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Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2007/050172

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K31/06 F16F9/46 B65H23/195

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16F F16K B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 860 631 A (FEIGEL HANS-JORG [DE]) 19 January 1999 (1999-01-19) column 4, line 23 - column 6, line 26; figures 1-3	1,17,19, 20
X	US 5 004 079 A (IVERS DOUGLAS E [US] ET AL) 2 April 1991 (1991-04-02) column 10, line 32 - column 14, line 33; figures 1,4,5a-5d	1-8, 17-19
A	US 5 611 413 A (FEIGEL HANS-JOERG [DE]) 18 March 1997 (1997-03-18) column 6, line 51 - column 7, line 6; figures 4A,4B	1,3
A	US 4 907 680 A (WOLFE PAUL T [US] ET AL) 13 March 1990 (1990-03-13) abstract; figures 1-6	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 July 2007	02/08/2007

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2007/050172

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/FI2007/050172

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