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(54) Title: BRAKE ARRANGEMENT, ELEVATOR AND METHOD OF OPERATING AN ELEVATOR

(57) Abstract: The brake arrangement for an elevator (1) comprises a brake device (4) with a brake element (5) and a biasing spring (6), and brake release means (7) with a cylinder (8) and a piston (9) configured to move the brake element (5) to a release position when hydraulic pressure overcoming a biasing force of the biasing spring (6) is applied to the piston (9), the arrangement further comprising pressurizing means (11) with a hydraulic cylinder (12) and a piston (13), the hydraulic cylinder (12) being in fluid communication with the cylinder (8) of the brake release means (7), a fluid reservoir (22) in fluid communication with the cylinder (8) and the pressurizing means (11), and a safety valve (16, 17) arranged between the cylinder (8) and the fluid reservoir (22) such that in an open state of the safety valve (16, 17) flow from the cylinder (8) into the fluid reservoir (22) is allowed, and in a closed state of the safety valve (16, 17) flow from the cylinder (8) through the safety valve (16, 17) into the fluid reservoir (22) is prevented.

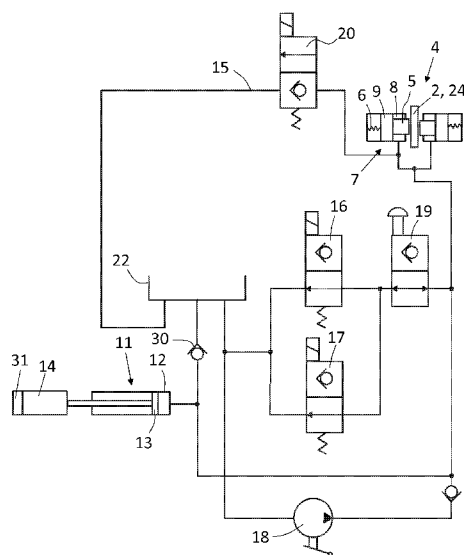


FIG. 3

BRAKE ARRANGEMENT, ELEVATOR AND METHOD OF OPERATING AN ELEVATOR

Technical field of the invention

- 5 The present invention relates to a brake arrangement for an elevator, as defined in claim 1. The invention also concerns an elevator and a method of operating an elevator.

Background of the invention

10 A traditional elevator may have electromechanical brakes as safety devices to stop and hold an elevator car standstill in an elevator shaft. An elevator hoisting machinery may be equipped with two or more brakes. Each brake may comprise an electromagnet and a compression spring. When the electromagnet is energized, it generates attractive force against the thrust force of the compression spring to keep the brake open, i.e. to keep brake
15 pads apart from a traction sheave of the hoisting machinery. The brake is activated by de-energizing the electromagnet such that the force created by the compression spring will press the brake pads against the traction sheave. Braking of an elevator car is then effected through hoisting ropes running via the traction sheave.

20 In some recent elevator systems, the lifting height and thus the travel length of the elevator car has been increased. This is the case for example in so called high-rise and ultra-high-rise elevators. In those elevator systems longer hoisting ropes may cause bouncing effect of the car, impairing stopping accuracy at a landing. To solve this problem elevator car may be provided with
25 car brakes, which engage against guide rails to brake the movement of the car. Those car brakes may also have electromagnets, compression springs and brake pads; therefore they may operate in this regard in the same way as the above-mentioned hoisting machinery brakes.

30 The operating principle of these electromechanical brakes requires that the electromagnet is energized throughout the elevator ride. This causes continuous power losses in the electromagnet, which is against a general need to reduce energy consumption of elevators.

Electromechanical brakes may also be large and difficult to be installed in small spaces in connection with the hoisting machinery or the elevator car. Consequently, there is a need for improvements in elevator brakes.

Summary of the invention

5 An object of the invention is to provide an improved brake arrangement for an elevator. Another object of the invention is to provide an improved elevator. A further object of the invention is to provide a method of operating an elevator.

The brake arrangement according to the invention comprises at least one
10 brake device, the brake device comprising at least one moveable brake
element, said at least one brake element having a braking position, in which
braking position the brake element is configured to be engaged with a
counterpart for stopping an elevator and/or for preventing moving of the
elevator, and a release position, in which release position the brake element
allows moving of the elevator, at least one biasing spring that is configured to
15 bias the brake element towards the braking position, and brake release means,
the brake release means comprising at least one cylinder and a piston
moveable within the cylinder, the brake release means being configured to
move said at least one brake element to the release position when hydraulic
pressure overcoming a biasing force caused by said at least one biasing spring
20 is applied to the piston. The brake arrangement further comprises pressurizing
means comprising a hydraulic cylinder and a piston that are configured to be
moveable relative to each other to pressurize hydraulic fluid in the hydraulic
cylinder, the hydraulic cylinder being arranged in fluid communication with said
at least one cylinder of the brake release means to allow supplying pressurized
25 hydraulic fluid into said at least one cylinder, a fluid reservoir arranged in fluid
communication with said at least one cylinder of the brake release means and
with the pressurizing means for supplying hydraulic fluid to the pressurizing
means and for receiving hydraulic fluid from said at least one cylinder of the
brake release means, and at least one safety valve having a closed state and
30 an open state, said at least one safety valve being arranged between said at
least one cylinder of the brake release means and the fluid reservoir such that
in the open state of the safety valve flow from said at least one cylinder into
the fluid reservoir is allowed, and in the closed state of the safety valve flow
from said at least one cylinder through the safety valve into the fluid reservoir
35 is prevented.

In the brake arrangement according to the invention, the brake is released by hydraulic pressure. The brake can be kept in the release position by means of the safety valve. There is thus no need to constantly supply hydraulic fluid to the brake release means, but the brake can be kept in the release position with a minimal energy consumption. Due to the safety valve and the mechanical biasing towards the braking position, the brake arrangement provides quick and fail-safe operation of the brake. The pressurizing means comprising a hydraulic cylinder and the piston allow precise operation of the brake device. The hydraulic cylinder and the piston also allow a low noise level, which is beneficial in particular when the brake device is used in an elevator car. The hydraulic cylinder and the piston also provide various possibilities for wear monitoring of the brake arrangement and for fault diagnosis.

According to an embodiment of the invention, the arrangement comprises at least two safety valves arranged in parallel such that flow from said at least one cylinder of the brake release means into the fluid reservoir is allowed when at least one of the safety valves is in the open state. The use of at least two safety valves provides redundancy and increases the safety. However, in particular if the elevator is provided with two or more independent brake arrangements, it is not necessary to provide the arrangement with two safety valves.

According to an embodiment of the invention, each of said at least one safety valves is a normally open valve comprising an electrical actuator for switching the valve to the closed state. The normally open electrically actuated valves provide increased safety, as the brake is switched to a braking state automatically when power supply to the safety valves is cut.

According to an embodiment of the invention, the pressurizing means comprise a linear actuator for driving the piston or the hydraulic cylinder. A linear actuator allows precise control of the mutual positions of the hydraulic cylinder and the piston, which enables controlling of the braking force.

According to an embodiment of the invention, the linear actuator is provided with a brake. The brake allows to maintain the pressure in the hydraulic cylinder with little or no energy consumption.

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According to an embodiment of the invention, the hydraulic cylinder is integrated with the linear actuator. A hydraulic cylinder integrated with the linear actuator provides a modular construction that is easy to mount to the elevator.

- 5 According to an embodiment of the invention, the hydraulic cylinder is configured to be moved relative to the piston by the linear actuator.

According to an embodiment of the invention, the hydraulic cylinder is arranged within a non-circular pipe, and the outer surface the hydraulic cylinder is provided with guide means supporting the hydraulic cylinder against
10 an inner wall of the non-circular pipe to prevent rotation of the hydraulic cylinder. The non-circular pipe can have, for instance, a square profile. This arrangement allows using a linear actuator not having anti-rotation means.

According to an embodiment of the invention, the fluid reservoir is arranged to surround the hydraulic cylinder. This provides a compact and modular
15 structure of the hydraulic components needed for operating the brake device.

According to an embodiment of the invention, the arrangement comprises means for monitoring the relative mutual position of the piston and the hydraulic cylinder of the pressurizing means. By monitoring the mutual position
20 of the piston and the hydraulic cylinder, data allowing fault diagnosis and wear monitoring of the brake arrangement can be collected.

According to an embodiment of the invention, the arrangement comprises a rescue release valve having an open state and a closed state, the rescue release valve being arranged such that when the rescue release valve is switched to the closed state, flow from said at least one cylinder of the brake
25 release means to the fluid reservoir is prevented to allow pressurizing of said at least one cylinder and moving said at least one brake element of the brake device to the release position. The rescue release valve allows releasing of the brake when the safety valve is in the open state, for instance due to a power failure.

30 According to an embodiment of the invention, the arrangement comprises a rescue release pump that is arranged in fluid communication with said at least one cylinder of the brake release means to allow pressurizing said at least one cylinder independently of the operation of the pressurizing means. The rescue

release pump can be manually operable and/or battery-powered. By means of the rescue release pump, the brake can be released when the pressurizing means do not function, for instance due to a power failure. This allows moving the elevator car to the closest landing to rescue people from the elevator.

5 According to an embodiment of the invention, the arrangement comprises a bleeding line having a first end connected to said at least one cylinder of the brake release means and a second end connected to the fluid reservoir, the bleeding line comprising a bleeding valve having a closed state, in which flow
10 from said at least one cylinder to the fluid reservoir is prevented, and an open state, in which flow from said at least one cylinder to the fluid reservoir is allowed. The bleeding line and the bleeding valve allow easy bleeding of the hydraulic system of the brake arrangement.

According to an embodiment of the invention, the bleeding valve is integrated with the brake device. This provides a modular structure for the bleeding
15 arrangement.

According to an embodiment of the invention, said at least one brake element is configured to exert a friction force on the counterpart. The counterpart for the brake element can be, for instance, a guide rail of the elevator or a brake disc of the hoisting machinery of the elevator. The brake arrangement can thus
20 be used as a friction brake of the elevator car or the hoisting machinery. However, the brake device does not need to be a friction brake, but it could be, for instance, part of a safety arrangement of a low pit / low headroom elevator preventing the elevator car from moving beyond predetermined limits in an elevator shaft.

25 According to an embodiment of the invention, the arrangement comprises means for monitoring the pressure of the hydraulic fluid. By monitoring the pressure of the hydraulic fluid, the wear of the brake arrangement can be monitored and/or faults can be diagnosed. The pressure data can be used together with the position data of the piston / hydraulic cylinder of the
30 pressurizing means for wear monitoring and/or fault diagnosis.

The elevator according to the invention comprises a brake arrangement defined above.

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According to an embodiment of the invention, the elevator comprises a safety arrangement that is configured to monitor one or more predetermined trigger events, and in case a trigger event is detected, to cut power supply to said at least one safety valve to switch said at least one safety valve to the open state.

- 5 According to an embodiment of the invention, the brake device, pressurizing means, fluid reservoir and said at least one safety valve are attached to an elevator car.

The method of operating an elevator defined above comprises the step of monitoring the pressure in a hydraulic circuit comprising the pressurizing means and the brake release means. Pressure monitoring of the hydraulic circuit allows for instance fault diagnostics, wear monitoring and improved control of the brake device.

10

According to an embodiment of the invention, the method comprises the step of monitoring the relative mutual position of the piston and the hydraulic cylinder of the pressurizing means. The position monitoring allows for instance fault diagnostics, wear monitoring and improved control of the brake device, in particular when used in combination with the pressure monitoring.

15

According to an embodiment of the invention, the method comprises the step of determining wear of the brake element based on the pressure data collected by monitoring the pressure in the hydraulic circuit and the position data collected by monitoring the relative mutual position of the piston and the hydraulic cylinder.

20

According to an embodiment of the invention, the method comprises the step of comparing the pressure at a predetermined mutual position of the piston and the hydraulic cylinder to a reference value, and in case the pressure exceeds a first predetermined reference value and/or is below a second predetermined reference value, triggering an alarm. A too high pressure may be an indication of a leak in the system. A too low pressure may indicate that one or more of the brake elements or the pistons of the brake release means is jammed.

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A method for rescue release of a brake device of a brake arrangement comprising a rescue release valve and a rescue release pump comprises the steps of switching the rescue release valve to the closed state and operating

the rescue release pump until the force exerted on the piston of the brake release means by the pressure in the cylinder of the brake release means exceeds the biasing force of the biasing spring.

5 A method for bleeding a brake arrangement comprising a bleeding valve comprises the steps of operating an actuator of the pressurizing means to move the piston and the hydraulic cylinder into a relative mutual position, in which the hydraulic cylinder is filled to its maximum volume, opening the bleeding valve, closing the safety valves, and operating the actuator to move
10 the piston and the hydraulic cylinder into a relative mutual position, in which the amount of hydraulic fluid in the hydraulic cylinder is minimized.

Brief description of the drawings

Embodiments of the invention are described below in more detail with reference to the accompanying drawings, in which

Fig. 1 shows schematically parts of an elevator,

15 Fig. 2 shows as a block diagram a brake arrangement according to an embodiment of the invention,

Fig. 3 shows schematically a brake arrangement according to an embodiment of the invention,

Fig. 4 shows schematically a hoisting machinery of an elevator,

20 Fig. 5 shows a hydraulic unit for a brake arrangement,

Fig. 6 shows a hydraulic unit with anti-rotation means, and

Fig. 7 shows another cross-sectional view of the hydraulic unit of figure 6.

Detailed description of embodiments of the invention

25 The present invention concerns a brake arrangement for an elevator 1, an elevator comprising such a brake arrangement, and a method of operating an elevator 1. Figure 1 shows schematically part of an elevator 1 according to an embodiment of the invention. The elevator comprises an elevator car 3 that is arranged into an elevator shaft. The elevator car 3 can move in the elevator shaft in the vertical direction. The elevator 1 further comprises a counterweight

(not shown). The elevator car 3 is connected to the counterweight via a hoisting member. The hoisting member can be, for example, a steel wire, a belt, such as a toothed belt or a flat belt, a carbon fiber rope or a coated rope. The elevator can comprise several hoisting members. The elevator car 3 and the counterweight are connected to each other in such a way that they move to opposite directions in respect of each other. The elevator 1 is further provided with a hoisting machinery. The hoisting machinery can comprise an electric motor. The motor drives a sheave, which can be connected to the motor either directly or via a gear. As the sheave rotates, the hoisting member moves and the elevator car 3 and the counterweight are moved. The motor can be arranged in a machine room located above the elevator shaft. Alternatively, the elevator can be a machine-room-less elevator and the motor can be arranged in the elevator shaft.

The elevator car 3 is guided in the elevator shaft by guide rails 2. A pair of guide rails 2 is arranged on opposite sides of the elevator shaft. The guide rail 2 can be, for instance, a T-shaped profile. The arms of the profile are attached to the walls of the elevator shaft, for instance via guide rail brackets. The stem, or nose, of the profile forms two guide surfaces for guiding the elevator car 3. The elevator car 3 can be provided with rollers or other elements that roll or slide against the guide surfaces of the guide rail 2.

The elevator is provided with one or more brake arrangements for stopping the elevator and/or for preventing the elevator from moving. The brake arrangements can be configured to brake the hoisting machinery, the elevator car 3 or the counterweight. Different brake arrangements can provide redundancy and/or they can have different functions. Even a single brake arrangement can have different functions. For instance, a brake arrangement can function during the normal operation of the elevator for stopping the elevator or keeping the elevator car 3 in a correct position at a landing, but also as an emergency brake for stopping the elevator in an overspeed situation.

Figure 3 shows schematically a hydraulic system and other components of a brake arrangement according to an embodiment of the invention. The brake arrangement comprises at least one brake device 4. The brake arrangement can comprise two or more brake devices 4 connected into a common hydraulic circuit. The brake device 4 comprises at least one moveable brake element 5. The brake element 5 has a braking position, in which braking position the brake

element 5 is configured to be engaged with a counterpart 2, 24 for stopping the elevator 1 and/or for preventing moving of the elevator 1, and a release position, in which release position the brake element 5 allows moving of the elevator 1. The brake device 4 thus has a braking state and a release state.

5 As discussed above, the elevator 1 can comprise several brake arrangements, and it is thus possible that the elevator 1 cannot move even if the brake element 5 of one of the brake arrangements is in the release position.

10 In the embodiment of figure 3, the brake device 4 comprises two brake elements 5. The brake elements 5 are arranged on opposite sides of the counterpart 2, 24. However, the brake device 4 could also be implemented with a single brake element 5.

15 The brake device 4 further comprises at least one biasing spring 6 that is configured to bias the brake element 5 towards the braking position. The biasing spring 6 can be a mechanical spring, such as a coil spring. In the embodiment of figure 3, the brake device 4 comprises two brake elements 5, and each brake element 5 is biased by means of a biasing spring 6 towards the braking position. The brake device 4 could comprise two or more biasing springs 6 for each brake element 5. The brake elements 5 and the biasing springs 6 can be arranged in a brake caliper.

20 The brake device 4 further comprises brake release means 7. The brake release means 7 comprise at least one cylinder 8 and a piston 9 moveable within the cylinder 8. The brake release means 7 are configured to move the brake element 5 to the release position when hydraulic pressure overcoming a biasing force caused by the biasing spring 6 is applied to the piston 9. The
25 brake release means 7 can be integrated in the brake caliper. If the brake device 4 comprises two brake elements 5, the brake release means 7 can comprise two cylinders 8. However, the number of the brake elements 5 and the cylinders 8 does not need to be the same.

30 The brake arrangement comprises pressurizing means 11 comprising a hydraulic cylinder 12 and a piston 13 that are configured to be moveable relative to each other to pressurize hydraulic fluid in the hydraulic cylinder 12. The hydraulic cylinder 12 can be stationary and the piston 13 can be moveable. Alternatively, the piston 13 can be stationary and the hydraulic cylinder 12 can

be moveable. As the piston 13 and the hydraulic cylinder move relative to each other, the fluid volume of the hydraulic cylinder 12 changes.

The hydraulic cylinder 12 is arranged in fluid communication with the cylinder 8 of the brake release means 7 to allow supplying pressurized hydraulic fluid into the cylinder 8. The brake arrangement further comprises a fluid reservoir 22 arranged in fluid communication with the cylinder 8 of the brake release means 7 and with the pressurizing means 11 for supplying hydraulic fluid to the pressurizing means 11 and for receiving hydraulic fluid from the cylinder 8 of the brake release means 7. The brake arrangement also comprises a safety valve 16, 17. The safety valve 16, 17 has a closed state and an open state, and it is arranged between the cylinder 8 of the brake release means 7 and the fluid reservoir 22 such that in the open state of the safety valve 16, 17 flow from the cylinder 8 into the fluid reservoir 22 is allowed, and in the closed state of the safety valve 16, 17 flow from the cylinder 8 through the safety valve 16, 17 into the fluid reservoir 22 is prevented.

In the embodiment of figure 3, the arrangement comprises two safety valves 16, 17 arranged in parallel such that flow from the cylinder 8 of the brake release means 7 into the fluid reservoir 22 is allowed when at least one of the safety valves 16, 17 is in the open state. Two safety valves 16, 17 provide redundancy, but the brake arrangement could also be implemented with a single safety valve.

When at least one of the safety valves 16, 17 is open, the hydraulic fluid can flow from the cylinders 8 of the brake release means 7 into the fluid reservoir 22. If the pressurizing means 11 are operated, even hydraulic fluid from the hydraulic cylinder 12 of the pressurizing means 11 can flow into the fluid reservoir 22. There is thus no pressure in the hydraulic system of the brake arrangement, and the biasing springs 6 can push the brake elements 5 to the braking positions, or keep the brake elements 5 in the braking positions.

When the safety valves 16, 17 are closed, hydraulic fluid cannot flow from the cylinders 8 of the brake release means 7 into the fluid reservoir 22. When the pressurizing means 11 are actuated, the hydraulic fluid in the hydraulic cylinder 12 of the pressurizing means 11 is pressurized. When the force exerted on the pistons 9 of the brake release means 7 exceeds the biasing force of the biasing springs 6, the hydraulic fluid flows into the cylinders 8 of the brake release

means 7 and pushes the brake elements 5 to the release positions. The fluid line between the pressurizing means 11 and the fluid reservoir 22 is provided with a non-return valve 30, which allows flow from the fluid reservoir 22 to the pressurizing means 11, but prevents flow from the pressurizing means 11 into the fluid reservoir 22.

In the embodiment of figure 3, the safety valves 16, 17 are normally open valves. The safety valves 16, 17 are thus biased to an open position, for instance by means of a spring. Each of the valves 16, 17 is provided with an electrical actuator for switching the valve 16, 17 to the closed state. If the electrical actuator fails or there is a power failure, the valve 16, 17 is automatically switched to the open state. This releases pressure from the cylinders 8 of the brake release means 7 and switches the brake device 4 to a braking state. The brake arrangement thus functions in a safe manner in case of power failures and other fault situations.

The brake arrangement can be provided with a linear actuator 14 for operating the pressurizing means 11. The linear actuator can be an electrical linear motor. The linear actuator 14 can be coupled to either the piston 13 or the hydraulic cylinder 12 of the pressurizing means 11 for causing mutual linear movement of the piston 13 and the hydraulic cylinder 12. The linear actuator 14 can be provided with a brake 31. The brake 31 can be, for instance, electrically actuated. When the brake 31 is in a locked state, moving of the linear actuator 14 is prevented. Consequently, also the mutual movement of the piston 13 and the hydraulic cylinder 12 of the pressurizing means 11 is prevented. Pressure in the hydraulic system of the brake arrangement can thus be maintained even if the linear actuator 14 is not energized. This allows maintaining the brake device 4 in the release state with minimal energy consumption.

In the embodiment of figure 3, the brake arrangement comprises a rescue release valve 19. The rescue release valve 19 has an open state and a closed state, and it is arranged such that when the rescue release valve 19 is switched to the closed state, flow from the cylinders 8 of the brake release means 7 to the fluid reservoir 22 is prevented to allow pressurizing of the cylinders 8 and moving the brake elements 5 of the brake device 4 to the release position. In the embodiment of figure 3, the rescue release valve 19 is arranged between the brake device 4 and the safety valves 16, 17, but the rescue release valve

19 could also be arranged between the safety valves 16, 17 and the fluid reservoir 22. If one of the safety valves 16, 17 or both valves are open for example due to a power failure or a fault, the rescue release valve 19 can be used for allowing pressurizing of the cylinders 8 of the brake release means 7.

5 This allows releasing of the brake device 4 and driving the elevator car 3 to the closest landing for rescuing people from the elevator car 3. The rescue release valve 19 can be a manually operable valve. However, the rescue release valve 19 could also be an electrically actuated valve. For instance, it could be powered by a battery that can be used for supplying electrical power to the

10 elevator for a rescue drive of the elevator.

In the embodiment of figure 3, the brake arrangement comprises a rescue release pump 18 that is arranged in fluid communication with the cylinders 8 of the brake release means 7 to allow pressurizing the cylinders 8 independently of the operation of the pressurizing means 11. The rescue

15 release pump 18 can be manually operable and/or battery-powered. The rescue release pump 18 has a similar purpose as the rescue release valve 19, namely allowing pressurizing of the cylinders 8 of the brake release means 7 in case of a power failure or a fault of the pressurizing means 11. The rescue release pump 18 is not necessary in a system comprising the rescue release

20 valve 19, but the pressurizing means 11 could be connected to back-up power to allow operation also in case of a power failure.

A method for rescue release of the brake device 4 comprises the steps of switching the rescue release valve 19 to the closed state and operating the rescue release pump 18 until the force exerted on the piston 9 of the brake

25 release means 7 by the pressure in the cylinder 8 of the brake release means 7 exceeds the biasing force of the biasing spring 6.

In the embodiment of figure 3, the brake arrangement comprises a bleeding line 15. The purpose of the bleeding line 15 is to allow easy removal of air from the hydraulic system of the brake arrangement. The bleeding line 15 has a first

30 end connected to a cylinder 8 of the brake release means 7 and a second end connected to the fluid reservoir 22. The bleeding line 15 comprises a bleeding valve 20 having a closed state, in which flow from the cylinder 8 to the fluid reservoir 22 is prevented, and an open state, in which flow from the cylinder 8 to the fluid reservoir 22 is allowed. The bleeding valve 20 can be integrated to

35 the brake device 4.

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In the method of bleeding the brake arrangement, the actuator 14 of the pressurizing means 11 is operated to move the piston 13 and the hydraulic cylinder 12 into a mutual position, in which the hydraulic cylinder 12 is filled to its maximum volume. The bleeding valve 20 is then opened. The safety valves 5 16, 17 are closed. The safety valves 16, 17 can be closed either before or after operating the actuator 14 to fill the hydraulic cylinder 12. The actuator 14 is then operated to move the piston 13 and the hydraulic cylinder 12 into a mutual position, in which the amount of hydraulic fluid in the hydraulic cylinder 12 is minimized. Hydraulic fluid and air bubbles can thus flow via the bleeding valve 10 20 and bleeding line 15 into the fluid reservoir 22. The bleeding valve 20 is then closed.

After the bleeding steps described above, a pressure test can be conducted. The actuator 14 is operated to pressurize the hydraulic fluid in the hydraulic cylinder 12. The relative mutual position of the piston 13 and the hydraulic cylinder 12 of the pressurizing means 11 is monitored. Also the pressure in the hydraulic circuit comprising the pressurizing means 11 and the brake release means 7 is monitored. If the pressure does not reach a predetermined limit after a predetermined relative movement of the piston 13 and the hydraulic cylinder 12, it is an indication that there is still air in the system. In that case, 15 20 the bleeding steps described above can be repeated.

The bleeding process can be automated. The brake arrangement can thus be configured to carry out the bleeding automatically, for instance when a fitter initiates a bleeding sequence. Also the pressure test can automatically follow the bleeding steps.

25 In the embodiment of figure 1, the elevator 1 comprises a brake arrangement that is configured to cooperate with the guide rails 2 guiding the elevator car 3. The elevator 1 comprises two brake devices 4 arranged at an upper part of the elevator car 3 and two brake devices 4 arranged at a lower part of the elevator car 3. The elevator car 3 is provided with two sets of pressurizing means 11. 30 The pressurizing means 11 arranged on the roof of the elevator car 3 supply pressurized hydraulic fluid to the upper brake devices 4 and the pressurizing means 11 arranged below the elevator car 3 supply pressurized hydraulic fluid to the lower brake devices 4. The elevator car 3 is thus provided with two brake arrangements according to an embodiment of the invention. By connecting the 35 brake devices 4 on opposite sides of the elevator car 3 to the same

pressurizing means 11, it is ensured that simultaneous and uniform braking force is applied to both guide rails 2.

Figure 4 shows schematically a hoisting machinery 23 of an elevator 1. In the embodiment of figure 4, the hoisting machinery 23 is provided with two brake discs 24, and the brake devices 4 are configured to apply a braking force to the brake discs 24. However, the hoisting machinery 23 could be provided with a single brake disc 24. All the brake devices 4 of the hoisting machinery 23 can be connected to a single hydraulic cylinder 12 of pressurizing means 11.

In the embodiments of the figures, the brake element 5 is configured to exert a friction force on the guide rail 2 or the brake disc 24. However, the brake device 4 does not need to be a friction brake, but it could also be a safety device where the brake element 5 is configured to be engaged in the braking position with a counterpart to prevent the elevator car 3 from moving beyond a certain limit in the elevator shaft. For instance, the brake arrangement could be used as a safety arrangement in a low pit or low headroom elevator to prevent the elevator car 3 from moving too close to an end of the elevator shaft in a situation where there is a risk that a person is in the elevator shaft.

The hydraulic cylinder 12 of the pressurizing means 11 can be integrated with the linear actuator 14. In the embodiment of figure 5, the piston 13 of the pressurizing means 11 is attached directly to a shaft of a linear actuator 14. Also, the fluid reservoir 22 is integrated with the pressurizing means 11.

Several components and functions of the brake arrangement can be integrated into a hydraulic unit. The hydraulic unit could comprise, for instance, the pressurizing means 11, the fluid reservoir 22, the safety valves 16, 17, the rescue release valve 19 and the rescue release pump 18 or some of the above mentioned components.

In the embodiment of figures 6 and 7, the piston 13 of the pressurizing means 11 is stationary and the hydraulic cylinder 12 around the piston 13 is moveable by the linear actuator 14. A hollow steel bar 28 with a square profile is arranged around the hydraulic cylinder 12. The outer surface of the hydraulic cylinder 12 is provided with guide means 29 that are configured to cooperate with the inner walls of the hollow steel bar 28 to prevent rotation of the hydraulic cylinder 12. Instead of the hollow bar with a square profile, also some other non-circular

pipe could be used. The fluid reservoir 22 is arranged around the hydraulic cylinder 12 and the hollow steel bar 28.

Further components of the brake arrangement are shown in the block diagram of figure 2. The brake arrangement can comprise means 27 for monitoring the relative mutual position of the piston 13 and the hydraulic cylinder 12 of the pressurizing means 11. Said means 27 can comprise a position sensor that is configured to monitor the position of the piston 13 or the cylinder 12 directly. Alternatively, the position information could be received from the linear actuator driving the piston 13 or the cylinder 12.

The brake arrangement can comprise means 26 for monitoring the pressure of the hydraulic fluid. The pressure is at least in a static situation substantially the same in the hydraulic cylinder 12 and the cylinders 8 of the brake release means 7, and the pressure could be thus monitored by means of a pressure sensor arranged in one of the cylinders 8, 12 or in a fluid line between them.

The brake arrangement can comprise a drive unit 32 for supplying electrical power to the linear actuator 14.

The elevator 1 can comprise a safety arrangement 15 that is configured to monitor one or more predetermined trigger events, and in case a trigger event is detected, to cut power supply to the safety valves 16, 17 to switch the safety valves 16, 17 to the open state. The trigger events could comprise, for instance, overspeed of the elevator car 3 or a counterweight or opening of a landing door of the elevator 1.

For switching the brake device 4 to the release state, the safety valves 16, 17 are closed. A brake release command is sent to the drive unit 32 of the linear actuator 14. The drive unit 32 supplies electrical power to the linear actuator 14, which drives the pressurizing means 11. The pressurizing means 11 are driven until the mutual position of the piston 13 and the hydraulic cylinder 12 of the pressurizing means 11 corresponds to a predetermined target value. The brake 31 of the linear actuator 14 is then switched to the braking state. The pressure in the system is thus maintained with minimal energy consumption.

For switching the brake device 4 to the braking state, a braking command is sent to the brake 31 of the linear actuator and to the drive unit 32. The brake

31 of the linear actuator 14 is released. The motor of the linear actuator functions as a generator and resists the relative mutual movement of the piston 13 and the hydraulic cylinder 12 of the pressurizing means 11. When the brake device 4 is in the braking state, the safety valves 16, 17 are opened to equalize
5 the pressure between the fluid reservoir 22, the pressurizing means 11 and the brake device 4.

In the method according to the invention, the pressure in the hydraulic circuit comprising the pressurizing means 11 and the brake release means 7 is monitored. Pressure monitoring of the hydraulic circuit allows, for instance,
10 fault diagnostics, wear monitoring and improved control of the brake device 4. Also the relative mutual position of the piston 13 and the hydraulic cylinder 12 of the pressurizing means 11 can be monitored using the position sensor 27.

By comparing the measurement data of the position sensor 27 and the pressure sensor 26, wear and faults of the system can be diagnosed. For
15 instance, if the pressure is lower than expected based on the position data, that may imply fatigue of the biasing springs 6 of the brake device 4 or leak of hydraulic fluid. If the pressure is higher than expected based on the position data, that may imply a stuck piston 9 of the brake release means 7.

When the pressure and position monitoring are used for wear monitoring or
20 fault diagnosis, the safety valves 16, 17 need to be in the closed state.

According to an embodiment of the invention, the method comprises a computer-implemented step of determining wear of the brake elements 5 based on the pressure data collected by monitoring the pressure in the hydraulic circuit and the position data collected by monitoring the relative
25 mutual position of the piston 13 and the hydraulic cylinder 12.

According to an embodiment of the invention, the method comprises a computer-implemented step of comparing the pressure at a predetermined mutual position of the piston 13 and the hydraulic cylinder 12 to a reference value, and in case the pressure exceeds a first predetermined reference value
30 and/or is below a second predetermined reference value, triggering an alarm. Alternatively, the position at a predetermined pressure could be compared to a reference value, and in case the position value exceeds a first predetermined

reference value and/or is below a second predetermined reference value, an alarm is triggered.

The reference values can be determined based on measurement data collected after installation of the brake arrangement.

- 5 Comparison of position data and pressure data also allows determining whether the bleeding of the hydraulic system of the brake arrangement has been successful.

Claims:

1. A brake arrangement for an elevator (1), the brake arrangement comprising at least one brake device (4), the brake device (4) comprising
- 5 - at least one moveable brake element (5), said at least one brake element (5) having a braking position, in which braking position the brake element (5) is configured to be engaged with a counterpart (2, 24) for stopping an elevator (1) and/or for preventing moving of the elevator (1), and a release position, in which release position the brake element (5) allows moving of the elevator (1),
 - 10 - at least one biasing spring (6) that is configured to bias the brake element (5) towards the braking position, and
 - brake release means (7), the brake release means (7) comprising at least one cylinder (8) and a piston (9) moveable within the cylinder (8), the brake release means (7) being configured to move said at least one brake element (5) to the release position when hydraulic pressure overcoming a biasing force caused by said at least one biasing spring (6) is applied to the piston (9),
 - 15 the brake arrangement further comprising
 - 20 - pressurizing means (11) comprising a hydraulic cylinder (12) and a piston (13) that are configured to be moveable relative to each other to pressurize hydraulic fluid in the hydraulic cylinder (12), the hydraulic cylinder (12) being arranged in fluid communication with said at least one cylinder (8) of the brake release means (7) to allow supplying pressurized hydraulic fluid into said at least one cylinder (8),
 - 25 - a fluid reservoir (22) arranged in fluid communication with said at least one cylinder (8) of the brake release means (7) and with the pressurizing means (11) for supplying hydraulic fluid to the pressurizing means (11) and for receiving hydraulic fluid from said at least one cylinder (8) of the brake release means (7), and
 - 30 - at least one safety valve (16, 17) having a closed state and an open state, said at least one safety valve (16, 17) being arranged between said at least one cylinder (8) of the brake release means (7) and the fluid reservoir (22) such that in the open state of the safety valve (16, 17) flow from said at least one cylinder (8) into the fluid reservoir (22) is allowed, and in the closed state of the safety valve (16, 17) flow
 - 35

from said at least one cylinder (8) through the safety valve (16, 17) into the fluid reservoir (22) is prevented.

2. A brake arrangement according to claim 1, wherein the arrangement comprises at least two safety valves (16, 17) arranged in parallel such that flow from said at least one cylinder (8) of the brake release means (7) into the fluid reservoir (22) is allowed when at least one of the safety valves (16, 17) is in the open state.
3. A brake arrangement according to claim 1 or 2, wherein each of said at least one safety valves (16, 17) is a normally open valve comprising an electrical actuator for switching the valve (16, 17) to the closed state.
4. A brake arrangement according to any of the preceding claims, wherein the pressurizing means (11) comprise a linear actuator (14) for driving the piston (13) or the hydraulic cylinder (12).
5. A brake arrangement according to claim 4, wherein the linear actuator (14) is provided with a brake (31).
6. A brake arrangement according to claim 4 or 5, wherein the hydraulic cylinder (12) is integrated with the linear actuator (14).
7. A brake arrangement according to any of claims 4–6, wherein the hydraulic cylinder (12) is configured to be moved relative to the piston (13) by the linear actuator (14).
8. A brake arrangement according to claim 7, wherein the hydraulic cylinder (12) is arranged within a non-circular pipe (28), and the outer surface the hydraulic cylinder (12) is provided with guide means (29) supporting the hydraulic cylinder (12) against an inner wall of the non-circular pipe (28) to prevent rotation of the hydraulic cylinder (12).
9. A brake arrangement according to claim 8, wherein the non-circular pipe (28) has a square profile.
10. A brake arrangement according to any of the preceding claims, wherein the fluid reservoir (22) is arranged to surround the hydraulic cylinder (12).

11. A brake arrangement according to any of the preceding claims, wherein the arrangement comprises means (27) for monitoring the relative mutual position of the piston (13) and the hydraulic cylinder (12) of the pressurizing means (11).
- 5 12. A brake arrangement according to any of the preceding claims, wherein the arrangement comprises a rescue release valve (19) having an open state and a closed state, the rescue release valve (19) being arranged such that when the rescue release valve (19) is switched to the closed state, flow from said at least one cylinder (8) of the brake release means
10 (7) to the fluid reservoir (22) is prevented to allow pressurizing of said at least one cylinder (8) and moving said at least one brake element (5) of the brake device (4) to the release position.
13. A brake arrangement according to any of the preceding claims, wherein
15 the arrangement comprises a rescue release pump (18) that is arranged in fluid communication with said at least one cylinder (8) of the brake release means (7) to allow pressurizing said at least one cylinder (8) independently of the operation of the pressurizing means (11).
14. A brake arrangement according to claim 13, wherein the rescue release pump (18) is manually operable and/or battery-powered.
- 20 15. A brake arrangement according to any of the preceding claims, wherein the arrangement comprises a bleeding line (15) having a first end connected to said at least one cylinder (8) of the brake release means (7) and a second end connected to the fluid reservoir (22), the bleeding line (15) comprising a bleeding valve (20) having a closed state, in which flow
25 from said at least one cylinder (8) to the fluid reservoir (22) is prevented, and an open state, in which flow from said at least one cylinder (8) to the fluid reservoir (22) is allowed.
16. A brake arrangement according to claim 15, wherein the bleeding valve (20) is integrated with the brake device (4).
- 30 17. A brake arrangement according to any of the preceding claims, wherein said at least one brake element (5) is configured to exert a friction force on the counterpart (2, 24).

18. A brake arrangement according to any of the preceding claims, wherein the counterpart for said at least one brake element (5) is a guide rail (2) of the elevator (1) or a brake disc (24) of the hoisting machinery (23) of the elevator (1).
- 5 19. A brake arrangement according to any of the preceding claims, wherein the arrangement comprises means (26) for monitoring the pressure of the hydraulic fluid.
20. An elevator (1) comprising a brake arrangement according to any of the preceding claims.
- 10 21. An elevator (1) according to claim 20, wherein the elevator (1) comprises a safety arrangement (15) that is configured to monitor one or more predetermined trigger events, and in case a trigger event is detected, to cut power supply to said at least one safety valve (16, 17) to switch said at least one safety valve (16, 17) to the open state.
- 15 22. An elevator (1) according to claim 20 or 21, wherein the brake device (4), pressurizing means (11), fluid reservoir (22) and said at least one safety valve (16, 17) are attached to an elevator car (3).
- 20 23. A method of operating an elevator (1) according to any of claims 20–22, the method comprising the step of monitoring the pressure in a hydraulic circuit comprising the pressurizing means (11) and the brake release means (7).
24. A method according to claim 23, the method comprising the step of monitoring the relative mutual position of the piston (13) and the hydraulic cylinder (12) of the pressurizing means (11).
- 25 25. A method according to claim 24, the method comprising the step of determining wear of the brake element (5) based on the pressure data collected by monitoring the pressure in the hydraulic circuit and the position data collected by monitoring the relative mutual position of the piston (13) and the hydraulic cylinder (12).
- 30 26. A method according to claim 24 or 25, the method comprising the step of comparing the pressure at a predetermined mutual position of the piston

(13) and the hydraulic cylinder (12) to a reference value, and in case the pressure exceeds a first predetermined reference value and/or is below a second predetermined reference value, triggering an alarm.

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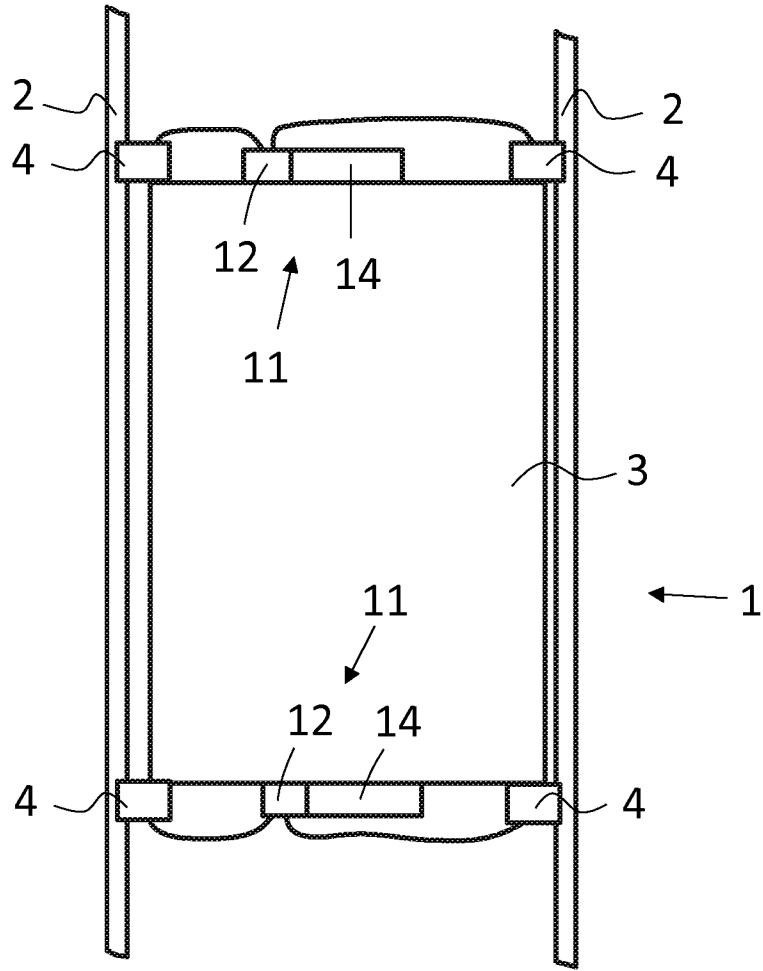


FIG. 1

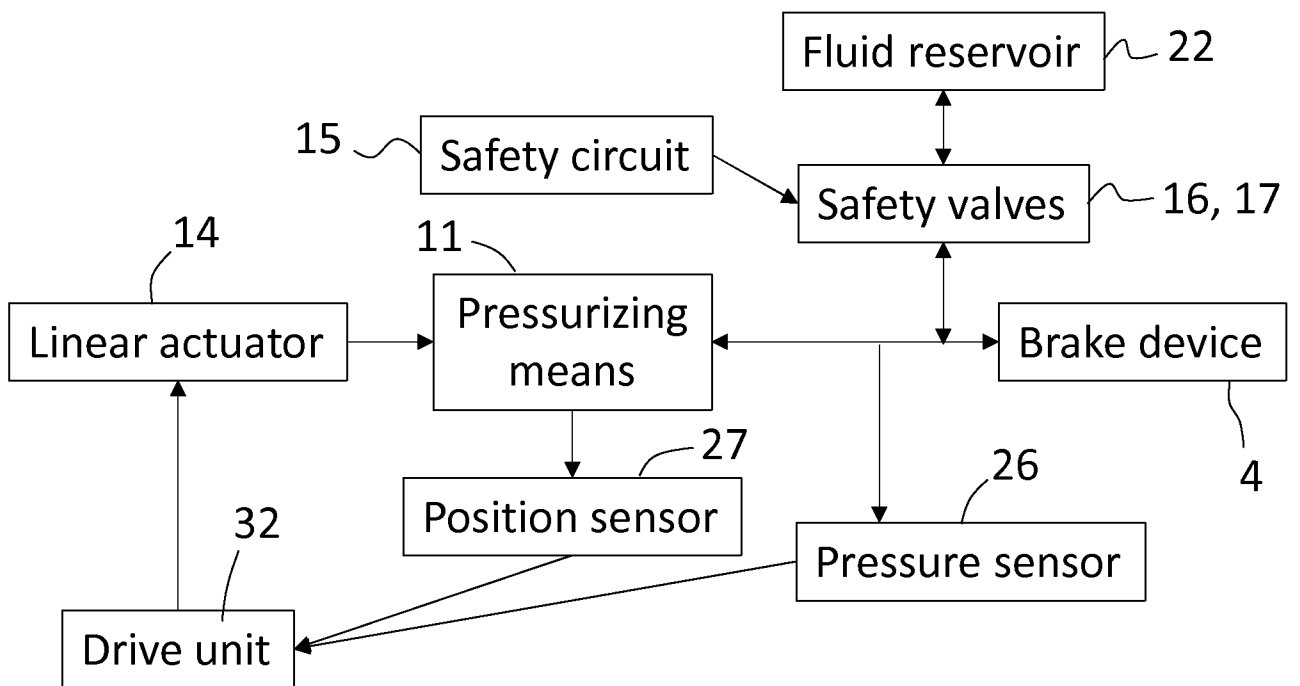


FIG. 2

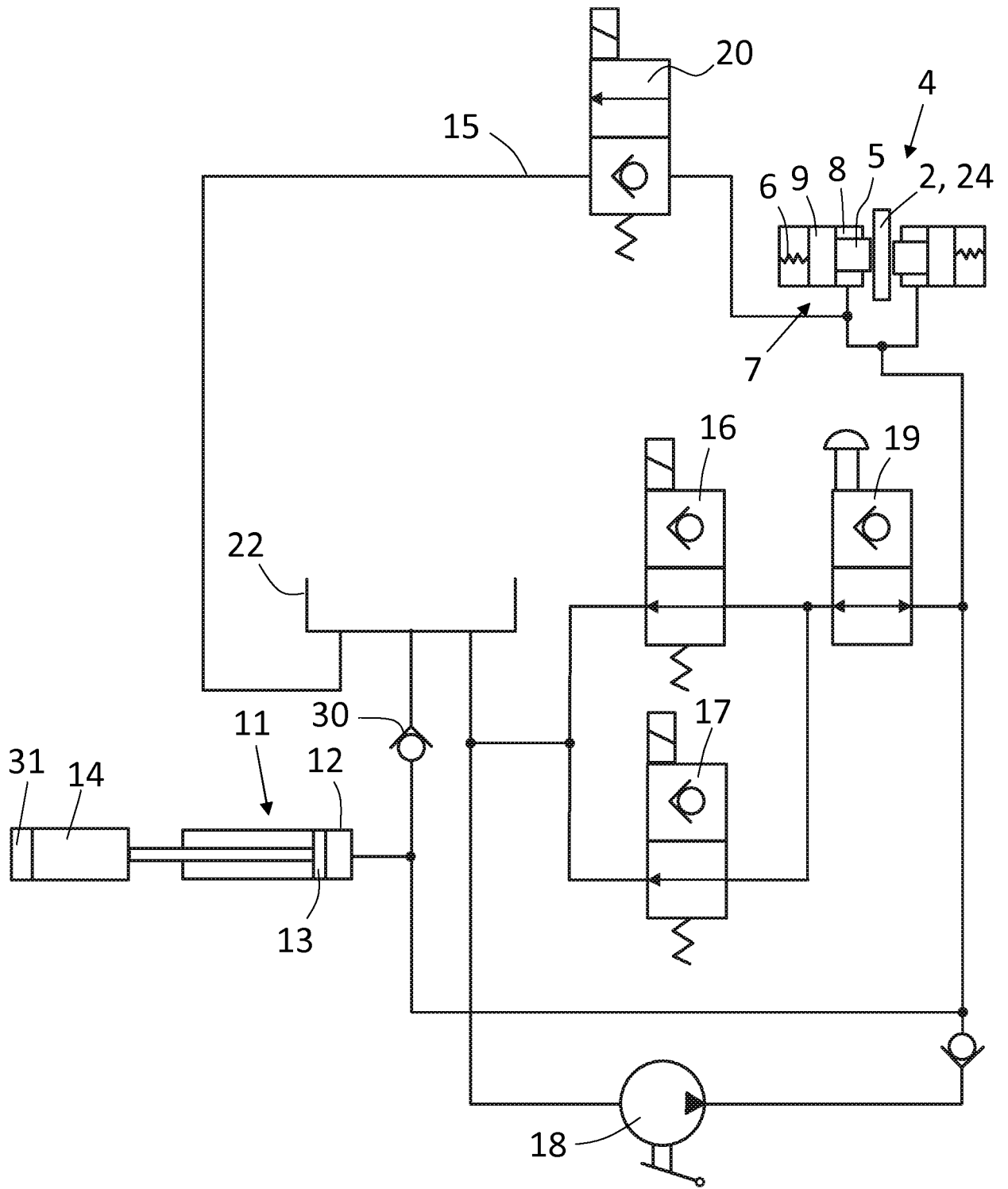


FIG. 3

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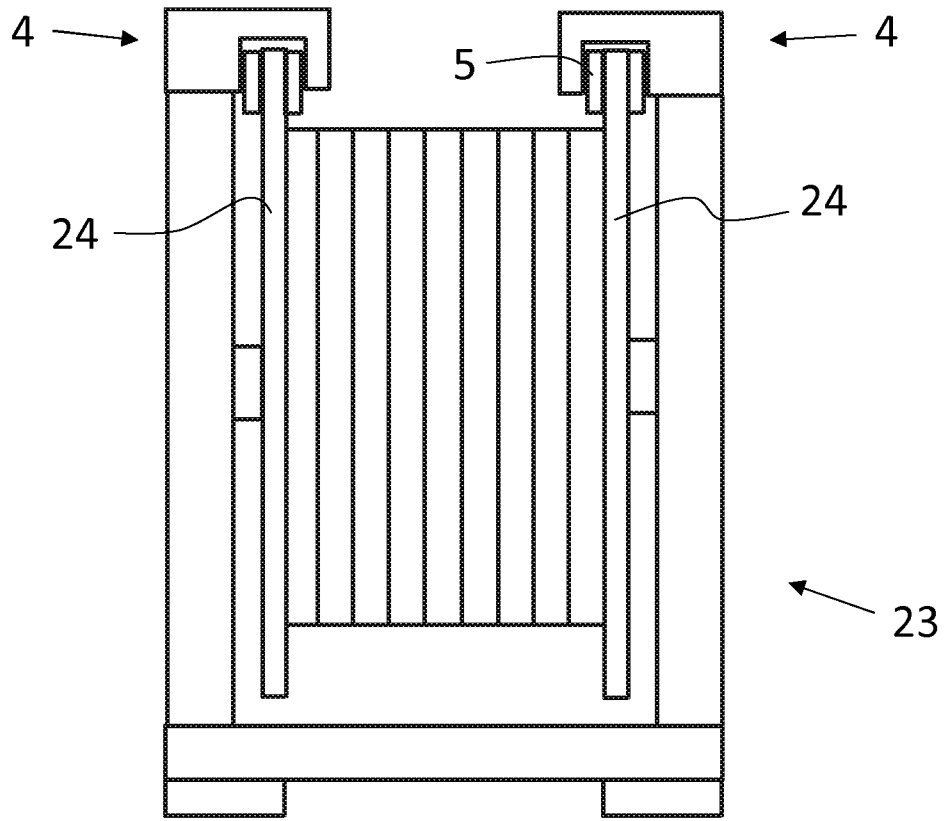


FIG. 4

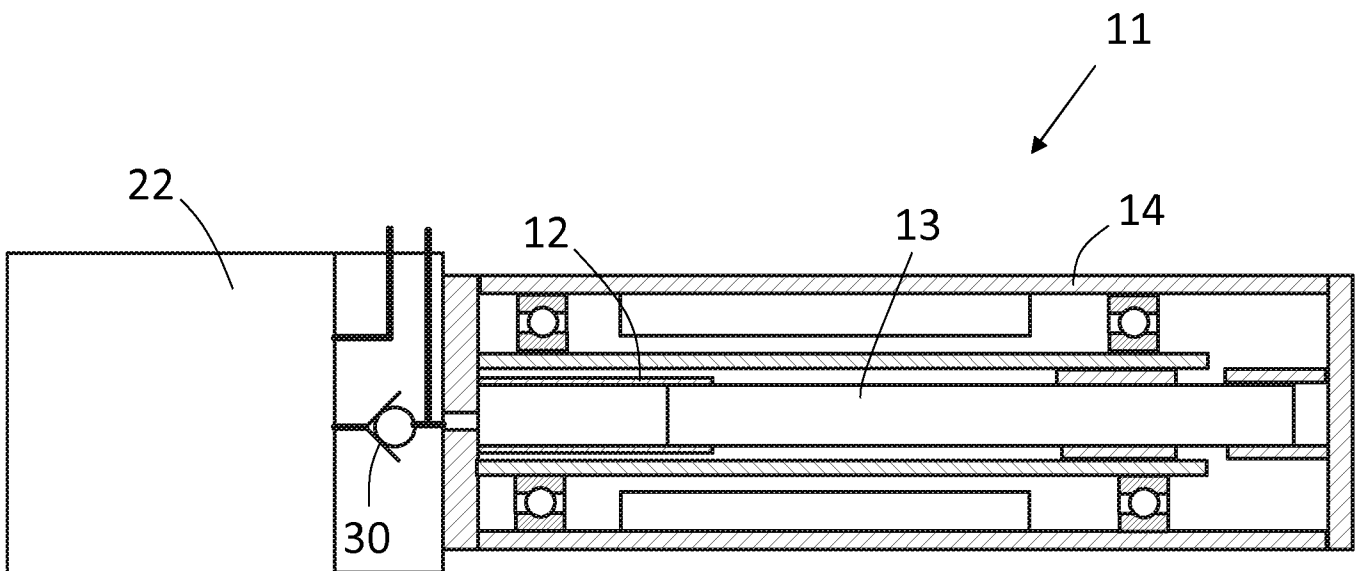


FIG. 5

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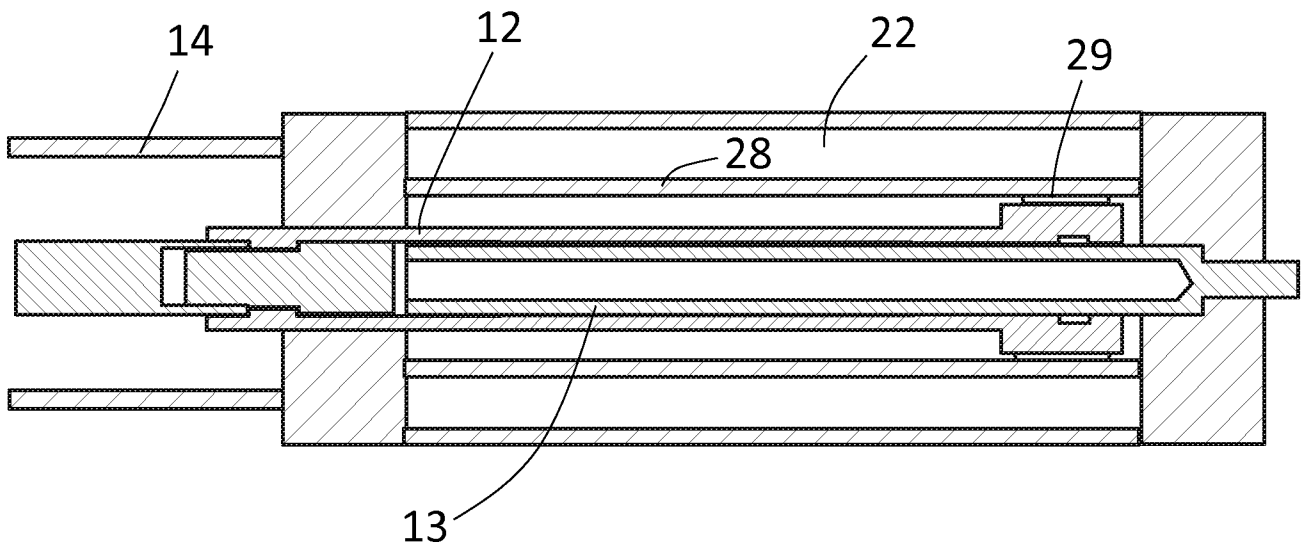


FIG. 6

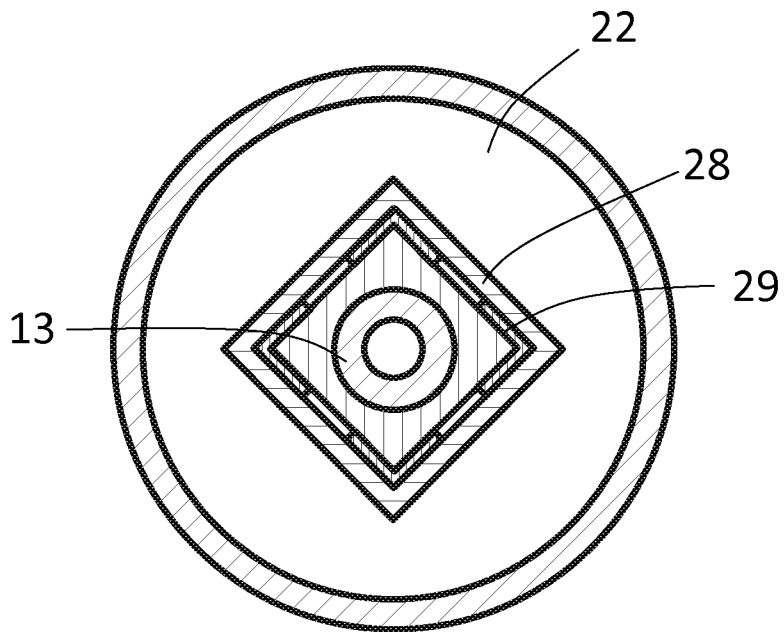


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2023/050336

A. CLASSIFICATION OF SUBJECT MATTER
INV. B66B5/18 B66D5/26
ADD.

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)
B66B B66F B66D

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2015/110509 A1 (INVENTIO AG [CH]) 30 July 2015 (2015-07-30) page 1, lines 4-9 page 5, line 9 - page 8, line 30 figures 1-4	1-26
Y	-----	
Y	US 6 193 026 B1 (SEVILLEJA JOSE [ES] ET AL) 27 February 2001 (2001-02-27) column 3, line 10 - column 4, line 15 figure 1	1-26
A	-----	
A	WO 2014/021896 A1 (OTIS ELEVATOR CO [US]; STRBUNCELJ ZLATKO [US]) 6 February 2014 (2014-02-06) paragraphs [0027] - [0038] figures 1-7	1-26

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Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

Date of mailing of the international search report

9 November 2023

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Authorized officer

Baytekin, Hüseyin

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2023/050336

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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Information on patent family members

International application No

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