

Apparatus for Controlling a Hydraulic Machine

Abstract

Apparatus for controlling a hydraulic machine, for example a turbine, pump or pump turbine, using variable-speed driven fixed displacement pumps, comprising a device for carrying out an emergency shut-off that is characterized by low energy consumption and high efficiency while guaranteeing all the operation- and safety-relevant requirements of a hydraulic machine.

FIG. 1

1 Apparatus for Controlling a Hydraulic Machine

2 The invention relates to an apparatus for controlling a hydraulic machine, and in
3 particular to an apparatus for controlling a turbine, a pump or a pump turbine.

4 Conventional apparatuses for controlling a hydraulic machine are known from
5 the general prior art. For example, DE 27 13 867 A1 describes one such
6 apparatus (see FIG. 3), which comprises a pressure oil source, a hydraulic servo
7 motor (hydraulic cylinder) and control valves for metering the energy to adjust
8 the hydraulic cylinder. As a rule, the pressure oil source is an reservoir for the
9 hydraulic medium under overpressure. The reservoir must be filled, and brought
10 to and kept at the required working pressure, with the aid of pumps.

11 An apparatus for opening and closing the guide vanes of a hydraulic machine is
12 also known from DE 10 2013 212 937 A1, in which variable-speed hydraulic
13 fixed displacement pumps are used. In this document, only the fundamental
14 mode of operation of such an apparatus is disclosed.

15 The object of the present invention is to provide an apparatus for controlling a
16 hydraulic machine in which variable speed hydraulic fixed displacement pumps
17 are used, and which ensures the requirements of a hydraulic machine are met,
18 for example with regard to actuating times, emergency closing properties -- even
19 in the event of pump failure, suitability for large hydraulic cylinder volumes, etc.
20 Compared to conventional apparatus, the solution according to the invention is
21 characterized by high energy efficiency, good environmental compatibility, ease
22 of maintenance and low acquisition and operating costs.

23

24

25 The solution according to the invention is explained below with reference to the
26 drawings. The drawings illustrate the following, specifically:

1 FIG. 1 Schematic structure of an apparatus according to the
2 invention

3 FIG. 1 shows a schematic representation of an apparatus for controlling a
4 hydraulic machine according to the invention. The apparatus comprises a
5 collecting and equalizing tank marked 1, a pump assembly marked 2, a variable
6 speed pump drive marked 3, a reservoir marked 5, a hydraulic cylinder marked
7 6, an emergency shut-off slide marked 71, an emergency shut-off solenoid valve
8 marked 72, two unlockable check valves marked 81 and 82, two pilot valves
9 marked 91 and 92, three throttles marked 10, 11 and 12, a check valve marked
10 14, an optional solenoid valve marked 20, two optional pressure relief valves
11 marked 30 and 31, and two optional ports marked 40 and 50. The arrow below
12 the hydraulic cylinder 6 indicates its closing direction.

13 The hydraulic cylinder 6 may, for example, be the guide wheel hydraulic cylinder
14 or the hydraulic cylinder for adjusting the runner blades of a hydraulic machine.
15 Such hydraulic cylinders often require large volumes of hydraulic fluid for
16 operation. The hydraulic cylinder 6 may be designed as a synchronous cylinder,
17 as indicated in FIG. 1 by the dashed second rod. However, the hydraulic cylinder
18 6 may also be designed as a differential cylinder with different volumes for the
19 closing and opening sides.

20 The pump assembly 2 comprises two pumps with a reversible pumping direction.
21 In FIG. 1, the two pumps are arranged on a shaft that is driven by the pump
22 drive 3. However, other structural configurations are also possible; for example,
23 the pumps may be driven by the pump drive 3 by means of a gear. It is also
24 conceivable that the pump drive 3 would respectively comprise a motor and a
25 frequency converter for each of the two pumps. The further description refers to
26 the embodiment shown in FIG. 1. In the position of the emergency shut-off slide
27 71 shown in FIG. 1, one port of each pump is respectively connected to a control
28 line of the hydraulic cylinder, so that in one direction of rotation of the shaft,
29 one pump pumps hydraulic fluid toward the hydraulic cylinder 6 and the other

1 pump receives hydraulic fluid from the hydraulic cylinder 6. In the other
2 direction of rotation of the shaft, the reverse is the case. In FIG. 1, the right-
3 hand port of the lower pump is connected (via the unlockable check valve 82) to
4 the opening side of the hydraulic cylinder 6 and the left-hand port of the upper
5 pump is connected (via the unlockable check valve 81) to the closing side of
6 hydraulic cylinder 6. The other ports of the pumps are respectively directly
7 connected to the collecting and equalizing tank 1. In other words, in one
8 direction of rotation of the shaft the lower pump pumps hydraulic fluid from the
9 collecting and equalizing tank 1 into the opening side of the hydraulic cylinder 6,
10 and at the same time the upper pump pumps hydraulic fluid from the closing
11 side of the hydraulic cylinder 6 into the collecting and equalizing tank 1. In the
12 other direction of rotation of the shaft, the volume flows are reversed. If the
13 delivery volumes of the two pumps are the same, this means that ultimately no
14 hydraulic fluid flows into or is withdrawn from the collecting and equalizing tank
15 1 (see below regarding the synchronous cylinder). In the other case, only the
16 differential delivery of the pumps is transferred to or removed from the
17 collecting and equalizing tank 1 (see below regarding the differential cylinder). It
18 is assumed here that the respective check valves 81 and 82 are unlocked (see
19 below in the description of the operating conditions).

20 If the pumps used have marked pressure and suction ports, the pressure ports
21 should preferably always be connected to the hydraulic cylinder 6 and the
22 suction ports to the collecting and equalizing tank 1.

23 The shaft of the pump assembly 2 is driven by the variable speed pump drive 3,
24 which may be operated in both directions of rotation. The pump drive 3 usually
25 comprises an electric servo motor that is electrically fed by a frequency
26 converter.

27 The unlockable check valves 81 and 82, which are arranged in the connecting
28 lines of the hydraulic cylinder 6 with the pump assembly 2 in such a way that
29 they prevent movement of the piston of the hydraulic cylinder in the non-

1 unlocked state, are respectively connected to one of the pilot valves 91, 92.
2 These are respectively connected (via the valves 20 and 72) to the reservoir 5.
3 Opening a pilot valve 91, 92 thus causes unlocking of the associated check valve
4 81, 82. Opening the pilot valves 91, 92 is accomplished by the (electric)
5 controller of the hydraulic machine energizing them. Each of the pilot valves 91,
6 92 may be energized separately.

7 In the "emergency shut-off" or "quick-closing" operating mode, i.e. when the
8 emergency shut-off slide 71 is in a position other than that shown in FIG. 1, the
9 reservoir 5 is connected to the closing side of the hydraulic cylinder 6. In these
10 two operating conditions, the collecting and equalizing tank 1 is also connected
11 to the opening side of the hydraulic cylinder 6. The state of the emergency shut-
12 off slide 71 is controlled via the emergency shut-off solenoid valve 72, which is
13 located in a hydraulic line between the emergency shut-off slide 71 and the
14 reservoir 5. The emergency shut-off solenoid valve 72 is also located in the lines
15 between the pilot valves 91, 92 and the reservoir 5. The (spring-loaded)
16 emergency shut-off solenoid valve 72 is always permanently energized during
17 operation, and as a result, the emergency shut-off slide 71 is in the position
18 shown in FIG. 1, the reservoir 5 supplies the pilot valves 91, 92 with oil pressure
19 (i.e. the check valves 81, 82 may be unlocked in this state by the pilot valves 91,
20 92).

21 The emergency shut-off slide 71 is designed so that, in the position shown in
22 FIG. 1, it connects the corresponding ports of the pumps of the pump assembly
23 2 to the ports of the hydraulic cylinder 6, while the collecting and equalizing tank
24 1 and the reservoir 5 are decoupled from the hydraulic cylinder, and in its other
25 position, the pumps of the pump assembly 2 are decoupled from the hydraulic
26 cylinder 6 and connect the collecting and equalizing tank 1 to the opening side
27 and connect the reservoir 6 to the closing side of the hydraulic cylinder 6. FIG. 1
28 shows that the emergency shut-off slide is pressurized on both sides with the
29 pressure of the reservoir 5. In this case, the effective area on which this
30 pressure acts must be selected so as to be of different magnitudes on the

1 respective sides. The area on the right side is larger, which means that if the
2 emergency shut-off solenoid valve 72 is energized, the emergency shut-off slide
3 71 is in the position shown in FIG. 1. If the emergency shut-off solenoid valve
4 72 is de-energized, the reservoir 5 is separated from the right-hand side of the
5 emergency shut-off slide 71 and the emergency shut-off slide 71 is pushed to
6 the other position by the forces acting on the left-hand side.

7 The throttle 10, also called the "basic throttle", is located in the line connected
8 to the opening side of the hydraulic cylinder 6 before the emergency shut-off
9 slide 71, i.e. in the immediate vicinity of the hydraulic cylinder 6. The throttle 11
10 is located in the line connecting the reservoir 5 to the remaining part of the
11 apparatus. The throttle 12 is located in the line between the emergency shut-off
12 slide 71 and the collecting and equalizing tank 1. One of the two throttles 11 or
13 12 should be regarded as optional (see discussion of emergency shut-off
14 function).

15 A line is also provided that connects one of the lines that runs from the pump
16 assembly 2 to the hydraulic cylinder 6 with the reservoir 5. In this line, the check
17 valve 14 is arranged so that no hydraulic fluid is able to pass from the reservoir
18 5. FIG. 1 shows only one of a plurality of possible alternatives, i.e. the case in
19 which the line with the check valve 14 connects the corresponding port of the
20 upper pump with the reservoir 5. The line with the check valve 14 may also be
21 connected to the corresponding port of the lower pump. For that purpose, the
22 line with the check valve 14 may open into any point of the lines from the pump
23 assembly 2 to the hydraulic cylinder 6.

24 Optionally, the apparatus may also comprise other emergency shut-off control
25 valves (for example an overspeed valve, etc.). These valves may be connected
26 via the port 50 that is located in the same hydraulic line as the emergency shut-
27 off solenoid valve 72.

1 Optionally, additional consumers may be connected to the reservoir 5 via the
2 port 40. The port 40 is located in the hydraulic line that connects the reservoir 5
3 with the remainder of the apparatus.

4 In the following, the modes of operation of the apparatus according to the
5 invention in the individual operating states of the hydraulic machine are
6 described in greater detail, and the advantages of the apparatus are explained.
7 The initial state is assumed to be that the reservoir 5 is charged with a defined
8 pressure and the hydraulic cylinder 6 is in any intermediate position.

9 Control operation of the hydraulic machine:

10 The emergency shut-off slide 71 is in the position shown in FIG. 1 because the
11 emergency shut-off solenoid valve 72 is energized.

12 The pilot solenoid valves 91, 92 controlled by the controller of the hydraulic
13 machine are in the de-energized state for as long as the position of the hydraulic
14 cylinder 6 is to be maintained. As a result, the unlockable check valves 81, 82 in
15 the control lines to the opening and closing sides of the hydraulic cylinder 6 are
16 likewise closed and the cylinder 6 is held in its position. In this state, the variable
17 speed drive 3 is switched off, so that no lost energy (heat) is introduced into the
18 system. As a result, oil cooling may in principle be dispensed with, which affords
19 the advantage of significantly better energy efficiency.

20 If a control process becomes necessary (for example, setpoint change or the
21 control deviation exceeding a certain value (dead band)), the pilot valves 91 and
22 92 are energized via the controller, which leads to the opening of the unlockable
23 check valves. The hydraulic cylinder may now be positioned directly over the
24 variable speed pump drive 3. If the hydraulic cylinder 6 is designed as a
25 synchronous cylinder, the pump assembly 2 takes in the same amount of oil on
26 the suction side as is introduced into the cylinder on the pressure side. In this
27 case, the two pumps in the pump assembly 2 have identical delivery volumes. If
28 the hydraulic cylinder 6 is designed as a differential cylinder, the delivery volume

1 ratio of the two pumps of the pump assembly 2 is adapted as accurately as
2 possible to the differential cylinder. The differential oil quantity arising during the
3 travel of the hydraulic cylinder 6 may be compensated via the corresponding
4 suction lines connected to the collecting and equalizing tank 1, or a small
5 oscillating volume at the reservoir 5. With respect to the configuration in FIG. 1,
6 the pump volume of the upper pump may be larger than required because the
7 excess quantity hydraulic fluid is pushed into the reservoir via the check valve 14
8 when the hydraulic cylinder 6 is closed. In the other direction of rotation of the
9 shaft, the excess quantity is provided by the collecting and equalizing tank 1 and
10 then received again. Clearly, in this way, the reservoir 5 is slightly charged with
11 every movement of the hydraulic cylinder 6 in the closing direction. An
12 overpressure valve (not shown in FIG. 1) or an optional additional consumer
13 (connection 40) may be used to prevent overcharging of the reservoir 5.

14 After reaching the desired position, the pilot valves 91, 92 are de-energized, and
15 as a result, the cylinder 6 may again be held in its position again without
16 applying energy. Notably, compared to conventional systems, the reservoir
17 volume is no longer used for control purposes, as this task is completely
18 performed by the pump assembly 2. Thus the reservoir volume, and
19 consequently the reservoir size, may be drastically reduced. This also leads to a
20 smaller collecting and equalizing tank 1, which reduces costs overall.

21 In order to protect the apparatus against impermissibly high pressure, pressure
22 relief valves 30, 31 may optionally be installed, one of which is respectively
23 connected to each of the lines between the unlockable check valves (81, 81) and
24 the emergency shut-off slide (71).

25 Emergency shut-off:

26 In order to ensure a safe shut-off of the hydraulic machine in the event of a
27 fault, an emergency shut-off function is implemented that allows the system to
28 be shut down without power supply (or in the event of a fault in the variable
29 speed drive 3). In the event of an emergency shut-off, the emergency shut-off

1 solenoid valve 72, which is permanently energized during operation, is de-
2 energized, whereupon the emergency shut-off slide 71 is pushed into the other
3 position in relation to FIG. 1. Thus, the "quasi-closed" hydraulic control circuit
4 becomes an open circuit. The reservoir 5 is connected to the closing side of the
5 hydraulic cylinder 6, the opening side now being discharged into the collecting
6 and equalizing tank 1. At the same time, the pressure to the pilot valves 91, 92
7 is relieved, so that the unlockable check valves 81, 82 close.

8 In this open circuit, the reservoir 5 delivers a defined volume within defined
9 pressure limits. A defined closing time may therefore be safely set with the aid
10 of the basic throttle 10 and an additional throttle 11 or 12 connected in series. If
11 two additional throttles 11 and 12 are used that are actually connected in series,
12 this results in greater flexibility and greater robustness against, for example, a
13 line break in the line between the emergency shut-off slide 71 and the reservoir
14 1 [sic], because the additional throttling effect is distributed over two throttles,
15 of which only one (12) fails due to the line break.

16 When the hydraulic cylinder 6 travels, a dynamic pressure is created by the basic
17 throttle 10 against which the pump assembly 2 acts and which must therefore
18 be kept within certain limits (required nominal pressures of the lines and
19 components, power of the pump drive 3, etc.). The individual throttles 10, 11,
20 12 accordingly require an individualized design. It must be a priority, in this
21 regard, that the greatest possible proportion of the total throttling effect, and
22 thus the closing time, must always be realized via the basic throttle 10. One of
23 the reasons for this is that the arrangement of the basic throttle 10 directly in
24 the opening side of the hydraulic cylinder 6 ensures a limitation of the closing
25 time even for example in the event of a line break on the opening control side
26 (i.e. a break in the line between the basic throttle 10 and the pump assembly 2).

27 Because the reservoir 5 is connected with the closing side of the cylinder 6 via
28 the line with the check valve 14, even in the fault state in which the pump drive
29 3 assumes a higher speed than the defined maximum speed in the closing

1 direction, the actuating time would be limited via the basic throttle 10. Only the
2 pressure in the reservoir 5 would slowly increase due to an increased pump flow
3 rate.

4 Reservoir charging function:

5 The filling level or system pressure of the reservoir 5 is monitored by means of
6 appropriate level and pressure sensors. The oil volume and pressure in the
7 reservoir 5 are kept at a defined maximum level during operation, irrespective of
8 the position of the hydraulic cylinder 6. This level will not change or will change
9 very little during operation if a synchronous cylinder is used (see above) or if no
10 other external consumers are connected to the reservoir 5 via the optional
11 connection point 40.

12 To enable the use of differential cylinders and external consumers, however, the
13 reservoir may be charged during operation by means of the variable speed drive
14 3 and the electrically controlled unlockable check valves 81 and 82,
15 independently of the position of the hydraulic cylinder 6.

16 For this purpose, the pilot solenoid valves 91 and 92 must be in the de-
17 energized state, which also causes the unlockable check valves 81 and 82 to be
18 closed. The pump assembly 2 is now controlled in such a way that it pumps
19 toward the closing side of the hydraulic cylinder 6. The position of the cylinder 6
20 does not change as a result, because the unlockable check valve 81 in the
21 opening side of the hydraulic cylinder 6 is closed and therefore no oil may
22 escape from the hydraulic cylinder 6. In the closing direction, however, the flow
23 may pass through the check valve 82, and as a result, the pressure is increased
24 and the reservoir 5 is charged via the line with the check valve 14. The
25 differential oil quantity required for this is drawn in by the pump assembly 2 via
26 a corresponding line from the collecting and equalizing tank 1. Charging works
27 analogously if the line with the check valve 14 is connected to the line from the
28 pump assembly 2 to the opening side of the hydraulic cylinder 6. For this,

1 however, the pump assembly 2 must be controlled in such a way that it pumps
2 toward the opening side of the hydraulic cylinder 6.

3 If a control process becomes necessary during charging, it takes priority over
4 the charging process. This is not a problem from a safety standpoint, because a
5 corresponding switching point for level and pressure monitoring ensures that
6 there is always sufficient volume or pressure in the reservoir for the possibility of
7 an emergency shut-off. Control movements may be carried out again
8 immediately as a result of energizing the pilot valves 91 and 92 and controlling
9 the variable speed drive 3.

10 The reservoir charging function is active during normal operation and when the
11 hydraulic machine is idle. In this way, it is ensured that there is always the
12 appropriate safety margin for a possible emergency shut-off, and that it is
13 available as quickly as possible at startup of the hydraulic machine.

14 Optional quick-close function:

15 Normally, with regard to the size, speed and output of the pumps, the pump
16 assembly 2 is designed in such a way that the opening and closing times of the
17 hydraulic cylinder 6 that the respective use case requires may be moved solely
18 via the pump drive 3.

19 For example, if large hydraulic cylinder volumes are available and the opening
20 times may be considerably longer in contrast to the closing times, in order to
21 keep the dimensions of the pump assembly 2 and the pump drive 3 as small as
22 possible (space conditions, spare part costs, etc.), these may be designed in
23 such a way that the hydraulic cylinder 6 may only be moved with the minimum
24 opening time.

25 To then achieve a faster closing time (for example in the case of a hydropower
26 controller during load shedding), the quick-close solenoid valve 20 is optionally
27 provided, which is located in the same hydraulic line as the emergency shut-off

1 solenoid valve 72. By connecting this valve 20, the reservoir volume may now be
2 used for closing. The quick-close solenoid valve 20 is energized, and as a result,
3 the emergency shut-off slide 71 is pushed into the other position in relation to
4 FIG. 1. At the same time, the pressure supply to the pilot valves 91 and 92 is
5 hydraulically separated, so that in the control lines, the unlockable check valves
6 81 and 82 also close. The pump assembly 2 is thus completely decoupled from
7 the hydraulic cylinder 6.

8 In order to be able to synchronize the machine again, for example after load
9 shedding in a water turbine, the quick-close valve 20 is de-energized again when
10 a defined opening is reached. At the same time, the "fine control" is now
11 transferred back to the variable speed pump drive 3, and the machine may be
12 synchronized once again.

13 Because the reservoir 5 is emptied by a quick close, the reservoir 5 should be
14 refilled as quickly as possible in this situation. Because the controller is active
15 during and after completion of the synchronization process and after the turbine
16 has started up again at the corresponding cylinder position, and the pump
17 assembly 2 therefore cannot be used to charge the reservoir 5, the following
18 procedure may be followed in this case:

19 When the pump assembly 2 drives the hydraulic cylinder 6 onto the
20 corresponding opening, the pilot solenoid valves 91 and 92 are in the de-
21 energized state. This allows the medium to flow through the check valve 82 on
22 the opening side, while the check valve 81 on the closing side remains blocked.
23 As a result, the oil displaced from the hydraulic cylinder 6 during the drive-on
24 process is pushed back into the reservoir 5 via the line with the check valve 14.
25 The pump assembly 2 draws in the quantity of oil required for this purpose via
26 the corresponding line from the collecting and equalizing tank 1. When the
27 reservoir 5 has reached its nominal filling level, the corresponding check valves
28 81 and 82 are opened and the hydraulic cylinder 6 may be moved to its end
29 position without further filling of the reservoir 5.

- 1 Heating function:
- 2 When the oil temperature falls below a defined value, control is initiated via the
- 3 pump assembly 2, by opening the unlockable check valves 81 and 82. This
- 4 generates heat that is used to heat the system.

Claims

1. An apparatus for controlling a hydraulic machine, comprising a pump assembly (2), a variable-speed pump drive (3), a reservoir (5), a hydraulic cylinder (6), two unlockable check valves (81, 82) and two pilot valves (91, 92) for unlocking the check valves (81, 82), wherein the pump assembly (2) comprises two pumps with reversible pumping direction, which are connected to the variable-speed pump drive (3) in such a way that the pump drive (3) may drive the pumps in both pumping directions, **characterized in that** the apparatus further comprises a collecting and equalizing tank (1), an emergency shut-off solenoid valve (72), an emergency shut-off slide (71), a check valve (14), and at least 2 throttles (10, 11, 12), wherein the emergency shut-off slide (71) is so configured, and so connected to the pump assembly (2), hydraulic cylinder (6), collecting and equalizing tank (1) and reservoir (5) that in a first position of the emergency shut-off slide (71), a first port of the first pump may be connected with the opening side of the hydraulic cylinder (6) and a first port of the second pump may be connected with the closing side, and the reservoir (5) and collecting and equalizing tank (1) are decoupled from the hydraulic cylinder (6), and in a second position of the emergency shut-off slide (71) the collecting and equalizing tank (1) is connected with the opening side of the hydraulic cylinder (6) and the reservoir (5) is connected with the closing side and the pump assembly (2) is decoupled from the hydraulic cylinder (6), and wherein additionally, the remaining ports of the pumps are each connected to the collecting and equalizing tank (1), so that in drive direction of the pump drive (3), the first pump may pump hydraulic fluid from the collecting and equalizing tank (1) toward the hydraulic cylinder (6) and the second pump may pump hydraulic fluid from the hydraulic cylinder (6) into the collecting and equalizing tank (1), and wherein a respective unlockable check valve (81, 82) is located in one of the lines from the pumps to the hydraulic cylinder (6) and is oriented such that in any state the check valves (81, 82) may

allow hydraulic fluid to pass towards the hydraulic cylinder (6), and the apparatus further comprises lines connecting the reservoir (5) respectively to the two check valves (81, 82) and the emergency shut-off slide (71), in order to be able to unlock the check valves (81, 82) and hold the emergency shut-off slide (71) in the first position, wherein these lines form, at least over a section, a single line, and in this section the emergency shut-off solenoid valve (72) is arranged in order to be permanently energized during the operation of the hydraulic system and to be continuous in this position, and wherein the pilot valves (91, 92) are each arranged in the separately extending sections of the lines between the reservoir (5) and the check valves (81, 82) and are designed to be electrically controllable, and wherein a throttle (10) is located in the line to the opening side of the hydraulic cylinder (6) in order to allow hydraulic fluid to flow through during each movement of the hydraulic cylinder (6), and the other throttle (11, 12) is located either in the line between the collecting and equalizing tank (1) and the emergency shut-off slide (71) in the line between the reservoir (5) and the emergency shut-off slide (71), wherein the check valve (14) is arranged in a line in such a way that connects one of the lines from the pump assembly (2) to the hydraulic cylinder (6) with the reservoir (5), so that no hydraulic fluid from the reservoir (5) can pass the check valve (14).

2. The apparatus according to Claim 1, **characterized in that** the apparatus comprises an additional throttle (11, 12) located either in the line between the collecting and equalizing tank (1) and the emergency shut-off slide (71) or in the line between the reservoir (5) and the emergency shut-off slide (71).
3. The apparatus according to any one of Claims 1 or 2, **characterized in that** the apparatus comprises two pressure relief valves (30, 31), one of which is respectively connected to one of the lines between the unlockable check valves (81, 82) and the emergency shut-off slide (71).

4. The apparatus according to any one of Claims 1 to 3, **characterized in that** the apparatus comprises an electrically controllable solenoid valve (20) arranged in the same line as the emergency shut-off solenoid valve (72) and is designed in such a way that, when electrically energized, it can push the emergency shut-off slide (71) into the second position and decouple the pilot valves (91, 92) from the reservoir (5).
5. The apparatus according to any one of Claims 1 to 4, **characterized in that** the apparatus comprises a connection point (50) for additional emergency shut-off valves that is arranged in the same line as the emergency shut-off solenoid valve (72).
6. The apparatus according to any one of Claims 1 to 5, **characterized in that** the apparatus comprises a connection point (40) for additional consumers of hydraulic fluid, which is arranged in the line from the reservoir (5) to the emergency shut-off slide (71).
7. The apparatus according to any one of Claims 1 to 6, **characterized in that** the hydraulic cylinder (6) is designed as a synchronous cylinder, and the pumps of the pump assembly (2) pump the same quantity of hydraulic fluid per revolution.
8. The apparatus according to any one of Claims 1 to 6, **characterized in that** the hydraulic cylinder (6) is designed as a differential cylinder, and the pumps of the pump assembly (2) pump different quantities of hydraulic fluid per revolution, wherein the delivery ratio is adapted to the volume ratio of the hydraulic cylinder (6) with respect to the closing and opening side.

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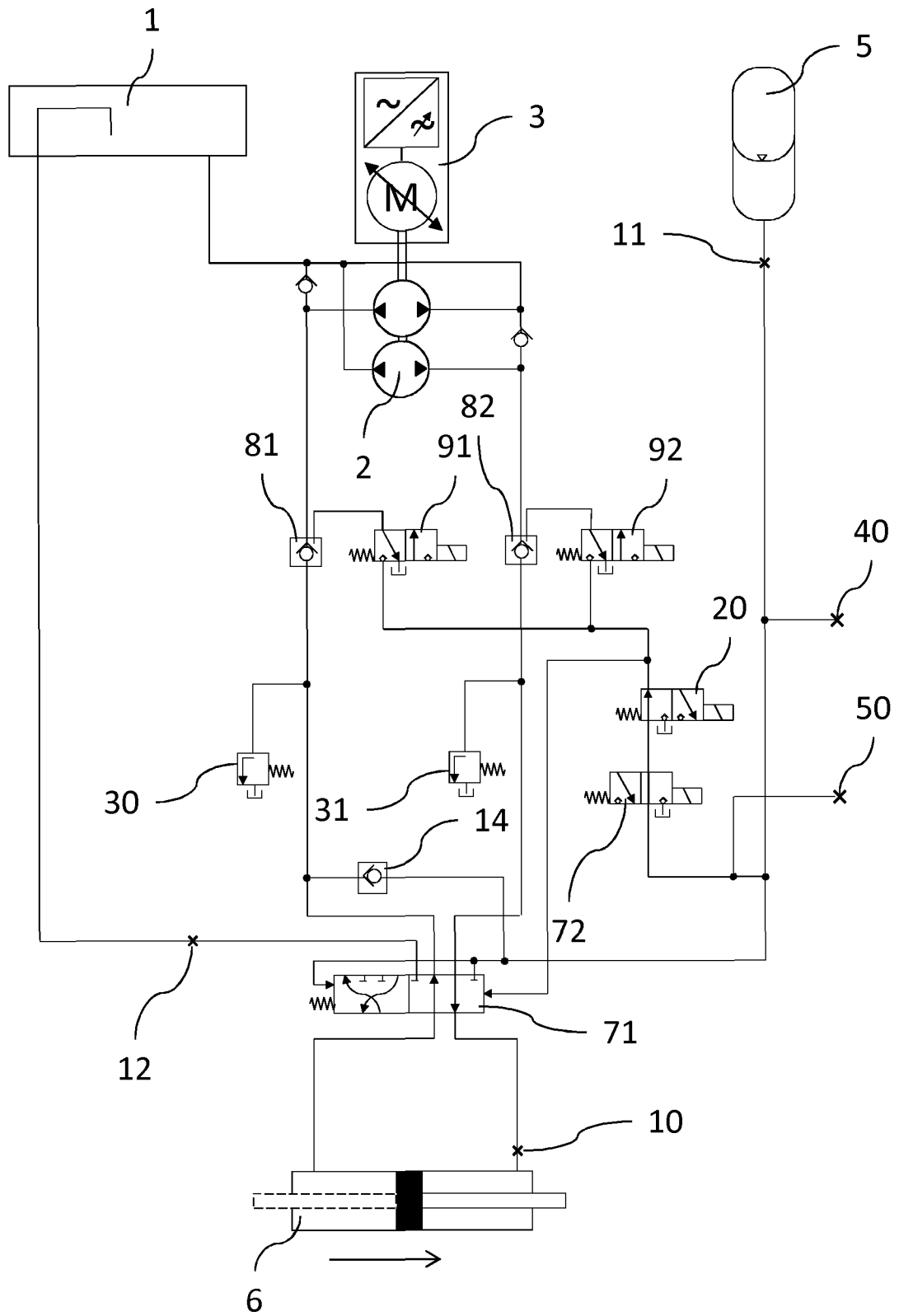


Figure 1

