



(12) **EUROPEAN PATENT APPLICATION**  
published in accordance with Art. 153(4) EPC

(43) Date of publication:  
**30.08.2017 Bulletin 2017/35**

(51) Int Cl.:  
**F15B 11/00 (2006.01) A61G 13/10 (2006.01)**

(21) Application number: **14904596.5**

(86) International application number:  
**PCT/CN2014/089339**

(22) Date of filing: **23.10.2014**

(87) International publication number:  
**WO 2016/061797 (28.04.2016 Gazette 2016/17)**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**

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(54) **HYDRAULIC DRIVE SYSTEM FOR OPERATING TABLE**

(57) A hydraulic drive system for an operating table, the system comprising an oil supplying device for providing hydraulic oil, an oil returning device and an oil returning circuit assembly; the oil returning circuit assembly comprises two oil cylinders (261, 262), two reversing valve assemblies and two two-way hydraulic locks; a rod-less cavity (2611, 2621) of each oil cylinder is connected to a working interface of the reversing valve assembly via a first oil path (31), and a rod cavity (2612, 2622) of each oil cylinder is connected to another working interface of the reversing valve assembly via a second oil

path (32); an oil returning opening of each reversing valve assembly is connected to the oil returning device via an oil returning path (30); the oil returning path (30) is provided with an on-off control valve thereon; and the first oil path (31) and the second oil path (32) are subjected to two-w control via the two-way hydraulic lock. The system enables piston rods of the two oil cylinders (261, 262) to move independently and to move synchronously, thus simplifying a system structure, providing reliability and reducing cost.

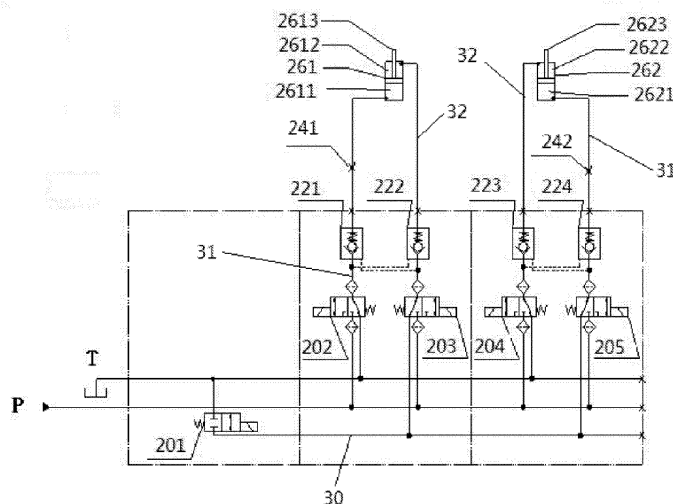


Figure 1

## Description

### TECHNICAL FIELD

**[0001]** This disclosure relates to a hydraulic drive system for an operation table.

### BACKGROUND

**[0002]** In an electro-hydraulic operation table, two leg supports are often configured to be driven by hydraulic control, so that left and right leg supports can be moved independently or those both leg supports can be moved synchronously. Additionally, it is demanded that there is low noise, stable and reliable control, highly precise synchronous motion and good synchronization performance during the movement of the leg supports. Here, operation tables include both operating tables and operating beds.

**[0003]** Below some methods are described for driving the two leg supports of the electro-hydraulic operation table in a hydraulic control way.

a) Hydraulic cylinders respectively corresponding to the left and right leg supports are connected in series using three four-way or five-way electromagnetic directional valves to coordinate with three bi-directional hydraulic locks and two hydraulically operated check valves, so that the left and right leg supports can be moved independently or these two can be moved synchronously.

B) Hydraulic cylinders respectively corresponding to the left and right leg supports are connected in series using three sets of two-position two-way electromagnetic switch valves (each set may include two two-position two-way electromagnetic switch valves) to coordinate with two two-position two-way electromagnetic switch valves, so that the left and right leg supports can be moved independently or these two can be moved synchronously.

c) Two sets of two-position three-way electromagnetic directional valves (each set may include two two-position three-way electromagnetic directional valves) and two bi-directional hydraulic locks are used in coordination to create a servo control system together with an angle transducer and a control unit of each leg support. When it is demanded to move the two leg supports synchronously, angular deviations between the two leg supports need to be quickly provided to the control unit as feedback, and the control unit can then eliminate the asynchronous deviations between the movement of the two leg supports in real time by swiftly switching on or off the electromagnetic valves, so as to realize the synchronized movement. Also, the left and right leg supports can be moved independently using such configuration.

## SUMMARY OF THIS DISCLOSURE

**[0004]** This disclosure provides a novel hydraulic drive system for an operation table.

**[0005]** This disclosure can provide a hydraulic drive system for an operation table, where the system is provided with an independent movement state and a synchronous movement state. The hydraulic drive system may include an oil supply device for supplying hydraulic oil, an oil return device and a hydraulic cylinder circuit component. The hydraulic cylinder circuit component may include two hydraulic cylinders, where each hydraulic cylinder may include a first chamber without a piston rod and a second chamber with a piston rod located therewithin. The hydraulic cylinder circuit component may also include two directional valve components and two bi-directional hydraulic locks, where said hydraulic cylinders, said directional valve components and said bi-directional hydraulic locks correspond to one other. The first chamber of each hydraulic cylinder may be connected with a working port of its corresponding directional valve component through a first flow pass, and the second chamber of each hydraulic cylinder may be connected with another working port of its corresponding directional valve component through a second flow pass. An oil inlet port of each directional valve component may be connected with the oil supply device, an oil return port of each directional valve component may be directly connected with the oil return device, and another oil return port of each directional valve component may be connected with the oil return device through a return line that may be arranged with an on-off control valve. The first flow pass and the second flow pass that correspond to each hydraulic cylinder may be capable of being bi-directionally switched on and off using the bi-directional hydraulic lock respectively corresponding to each hydraulic cylinder. The second chamber of one hydraulic cylinder may be connected in series with the first chamber of the other hydraulic cylinder. In the independent movement state, the return line may be switched on by the on-off control valve; in the synchronous movement state, the return line may be shut off by the on-off control valve.

**[0006]** The respective oil inlet port of the two directional valve components can be connected with the oil supply device. For the two oil return ports of each directional valve component, one oil return port may be directly connected with the oil return device, and the other oil return port may be connected with the oil return device through the return line that is provided with the on-off control valve.

**[0007]** The piston rods of the two hydraulic cylinders can be controlled to move independently and synchronously through coordination control of the directional valve components, the bi-directional hydraulic locks and the on-off control valve.

**[0008]** Each directional valve component may include two two-position three-way electromagnetic directional valves, where each two-position three-way electromag-

netic directional valve may include one oil inlet port, one oil return port and one working port.

**[0009]** Each two-position three-way electromagnetic directional valve may be integrally connected with the on-off control valve to form a control component.

**[0010]** Each directional valve component may include one two-position five-way electromagnetic directional valve, where the two-position five-way electromagnetic directional valve may include one oil inlet port, two working ports and two oil return ports.

**[0011]** Each bi-directional hydraulic lock may include two hydraulic operated check valves. The two hydraulic operated check valves of each bi-directional hydraulic lock may be respectively arranged in the first flow pass and the second flow pass, where the hydraulic operated check valve arranged in the second flow pass can be controlled by an oil pressure of the first flow pass, and the hydraulic operated check valve arranged in the first flow pass can be controlled by an oil pressure of the second flow pass.

**[0012]** Using the bi-directional hydraulic lock, the first flow pass and the second flow pass can be bi-directionally switched on along a first direction and a second direction, and can be unidirectionally shut off along the second direction. Here, the second direction is along a reverse direction relative to the first direction.

**[0013]** The on-off control valve may be a two-position two-way electromagnetic switch valve or a two-position three-way electromagnetic directional valve.

**[0014]** An effective action area of the first chamber of one hydraulic cylinder is equal to that of the second chamber of the other hydraulic cylinder.

**[0015]** Each hydraulic cylinder may correspond to one movable part of the operation table. In this case, multiple movable parts of the operation table can be controlled in combination through the logic control of the hydraulic drive system. For instance, the movable part can be a leg support, or some other parts which need both synchronous and independent control.

**[0016]** A throttling device that can be used for flow regulation can be respectively provided in both the first flow pass and the second flow pass. The throttling device can be, for example, a throttle bolt, a speed throttle valve or other devices which enable flow regulation, so as to regulate a movement speed of the piston rod or a movement speed of any action of the operation table.

**[0017]** A hydraulic drive system for an operation table, which may be provided with an independent movement state and a synchronous movement state, may include an oil supply device for supplying hydraulic oil, an oil return device and a hydraulic cylinder circuit component. The hydraulic cylinder circuit component may include two hydraulic cylinders, where each hydraulic cylinder may include a first chamber without a piston rod and a second chamber with a piston rod located therewithin. The hydraulic cylinder circuit component may also include two directional valve components and two bi-directional hydraulic locks, where said hydraulic cylinders, said direc-

tional valve components and said bi-directional hydraulic locks correspond to one other. Each directional valve component may include two two-position three-way electromagnetic directional valves, where each two-position three-way electromagnetic directional valve may include one oil inlet port, one oil return port and one working port. The oil inlet port of each two-position three-way electromagnetic directional valve may be connected with the oil supply device. For each directional valve component, the working port of one two-position three-way electromagnetic directional valve may be connected with the first chamber of its corresponding hydraulic cylinder through a first flow pass, and the working port of the other two-position three-way electromagnetic directional valve may be connected with the second chamber of its corresponding hydraulic cylinder through a second flow pass. The two hydraulic cylinders can be a left hydraulic cylinder and a right hydraulic cylinder. The oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the right hydraulic cylinder may be directly connected with the oil return device, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the right hydraulic cylinder may be connected with the oil return device through a return line. The oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the left hydraulic cylinder may be connected with the oil return device through the return line, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the left hydraulic cylinder may be directly connected with the oil return device. The return line can be arranged with an on-off control valve. The first flow pass and the second flow pass which correspond to each hydraulic cylinders can be bi-directionally switched on and off through the bi-directional hydraulic lock respectively corresponding to each hydraulic cylinder. The second chamber of the right hydraulic cylinder and the first chamber of the left hydraulic cylinder can be connected in series. In the independent movement state, the return line can be switched on through the on-off control valve; in the synchronous movement state, the return line can be shut off through the on-off control valve. An effective action area of the first chamber of the right hydraulic cylinder is equal to that of the second chamber of the left hydraulic cylinder.

**[0018]** In an alternative implementation, the oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the left hydraulic cylinder may be directly connected with the oil return device, the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the left hydraulic cylinder may be connected with the oil return device through the return line, the oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the right hydraulic cylinder may

be connected with the oil return device through the return line, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the right hydraulic cylinder may be directly connected with the oil return device. An effective action area of the first chamber of the left hydraulic cylinder is equal to that of the second chamber of the right hydraulic cylinder.

**[0019]** The advantageous effect of this disclosure can be as follows:

- 1) The piston rods of two hydraulic cylinders can be controlled to move independently or synchronously only using two directional valve components, two bi-directional hydraulic locks and one on-off control valve. Thus, the hydraulic drive system can become simplified in structure, enhanced in reliability and reduced in cost.
- 2) The respective two-position three-way electromagnetic directional valves and the on-off control valve can be secured together to provide an integrated module. The hydraulic drive system can thus be reduced in its dimension to become more compact, thereby facilitating both the installation and overall configuration of the whole system.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0020]**

Figure 1 is a structure diagram for a hydraulic drive system for an operation table according to a first embodiment;

Figure 2 is a structure diagram for a hydraulic drive system for an operation table according to a second embodiment;

Figures 3 and 4 are a right view and a front view illustrating when a two-position two-way electromagnetic switch valve and two-position three-way electromagnetic directional valves are assembled together in a first embodiment;

Figures 5 and 6 are a right view and a front view illustrating when a two-position two-way electromagnetic switch valve and two-position three-way electromagnetic directional valves are assembled together in a second embodiment.

#### DETAILED DESCRIPTION

**[0021]** As shown in Figures 1 and 2, a hydraulic drive system for an operation table may include an oil supply device, an oil return device and a hydraulic cylinder circuit component. The oil supply device can supply hydraulic oil, and the oil return device can receive the hydraulic oil flowing back from the hydraulic cylinder circuit component. The hydraulic cylinder circuit component may include two hydraulic cylinders 261, 262, two directional valve components and two bi-directional hydraulic locks,

where the hydraulic cylinders, the directional valve components and the bi-directional hydraulic locks correspond to one other. Here, one hydraulic cylinder, one directional valve component and one bi-directional hydraulic lock correspond to one other, and the other hydraulic cylinder, the other directional valve component and the other bi-directional hydraulic lock correspond to one other. Each hydraulic cylinder may include a first chamber 2611, 2621 without a piston rod and a second chamber 2612, 2622 with a piston rod 2613, 2623 located therewithin. Each directional valve component can include one or two oil inlet ports, two oil return ports and two working ports, where one of the two working ports may be connected with the first chamber 2611, 2621 through a first flow pass 31, and the other one of the two working ports may be connected with the second chamber 2612, 2622 through a second flow pass 32. The first flow pass 31 and the second flow pass 32 may be controlled to be switched on and off by the bi-directional hydraulic lock, so that the hydraulic oil can flow in two directions and be shut off in one of the two directions in the first flow pass and the second flow pass. The oil inlet port(s) of each directional valve component may be connected with the oil supply device, one of the oil return ports, of each directional valve component may be directly connected with the oil return device, and the other one of the oil return ports of each directional valve component may be connected with the oil return device through a return line 30. The return line 30 may be controlled to be switched on and off by an on-off control valve. When the return line 30 is switched on, the hydraulic oil can flow through the return line 30; when the return line 30 is shut off, the hydraulic oil cannot flow through the return line 30.

**[0022]** Each directional valve component, each bi-directional hydraulic lock and the on-off control valve may be controlled and coordinated by a master control device, such that the hydraulic drive system for the operation table can have an independent movement state and a synchronous movement state, where these two states can be switched between each other.

**[0023]** In the independent movement state, the return line 30 is switched on by the on-off control valve, and it is enabled to control the two hydraulic cylinders independently in this situation. Taking one of the hydraulic cylinders as example, when it is desired to make the piston rod 2613 extend outwards, the hydraulic oil within the oil supply device can flow into the first chamber 2611 of the hydraulic cylinder 261 through the first flow pass 31, and the hydraulic oil within the second chamber 2612 may flow back to the oil return device through the second flow pass 32 and the return line 30. When it is desired to make the piston rod 2613 retract inwards, the hydraulic oil within the oil supply device can flow into the second chamber 2612 of the hydraulic cylinder 261 through the second flow pass 32, and the hydraulic oil within the first chamber 2611 may flow back into the oil return device through the first flow pass 31.

**[0024]** In the synchronous movement state, the return

line 30 can be shut off by the on-off control valve, and it is enabled to control the two hydraulic cylinders synchronously in this situation. When it is desired to make the two piston rods 2613, 2623 extend outwards synchronously, the hydraulic oil within the oil supply device may flow into the first chamber 2611 of one hydraulic cylinder 261 through one first flow pass 31, the hydraulic oil within the second chamber 2612 of this hydraulic cylinder 261 may flow into the first chamber 2621 of another hydraulic cylinder 262 through the second flow pass 32 and another first flow pass 31, and the hydraulic oil within the second chamber 2622 of the another hydraulic cylinder 262 can flow back into the oil return device. When it is desired to make the two piston rods retract inwards synchronously, the hydraulic oil within the oil supply device may flow into the second chamber 2622 of one hydraulic cylinder 262 through one second flow pass 32, the hydraulic oil within the first chamber 2621 of this hydraulic cylinder 262 may flow into the second chamber 2612 of another hydraulic cylinder 261 through the first flow pass 31 and another second flow pass 32, and the hydraulic oil within the first chamber 2611 of the another hydraulic cylinder 261 can flow back into the oil return device.

**[0025]** As shown in Figure 1, it illustrates a first embodiment of the hydraulic drive system for the operation table.

**[0026]** The hydraulic drive system for the operation table may include an oil supply device, an oil return device, two hydraulic cylinders 261, 262, two sets of two-position three-way electromagnetic directional valves and two bi-directional hydraulic locks. The oil supply device that includes an oil outlet port P can supply hydraulic oil. The oil return device that includes an oil port T can receive the hydraulic oil flowing from the hydraulic cylinders. The oil return device can be an oil tank, for example. The hydraulic cylinders 261, 262 may respectively include a first chamber 2611, 2621 without a piston rod 2613, 2623 and a second chamber 2612, 2622 with a piston rod 2613, 2623 located therewithin. One set of two-position three-way electromagnetic directional valves corresponding to the hydraulic cylinder 261 may include two two-position three-way electromagnetic directional valves 202, 203, and the other set of two-position three-way electromagnetic directional valves corresponding to the hydraulic cylinder 262 may include two two-position three-way electromagnetic directional valves 204, 205. Each two-position three-way electromagnetic directional valve may include one oil inlet port, one oil return port and one working port. For each set of two-position three-way electromagnetic directional valves that includes two working ports, one of the working ports can be connected with the first chamber 2611, 2621 of each hydraulic cylinder through a first flow passes 31, and the other one of the working ports can be connected with the second chamber 2612, 2622 of each hydraulic cylinder through a second flow passes 32. The two oil inlet ports of each set of two-position three-way electromagnetic directional valves can be both connected with the oil supply device. For

each set of two-position three-way electromagnetic directional valves that includes two oil return ports, one of the oil return ports may be directly connected with the oil return device, and the other one of the oil return ports may be connected with the oil return device through the return line 30. Here, a two-position two-way electromagnetic switch valve 201 may be arranged in the return line.

**[0027]** Each bi-directional hydraulic lock can include two hydraulically operated check valves 221, 222, which two can be respectively arranged in the first flow pass 31 and the second flow pass 32. The hydraulically operated check valve 222 of the second flow pass 32 may be controlled by oil pressure of the first flow pass 31, and the hydraulically operated check valve 221 of the first flow pass 31 may be controlled by oil pressure of the second flow pass 32.

**[0028]** The two hydraulic cylinders can respectively control a left leg support and a right leg support of the operation table. The hydraulic oil may be outputted from the oil outlet port P and flow to the respective oil inlet ports of the two-position three-way electromagnetic directional valves 202, 203, 204, 205. The oil inlet ports of the two-position three-way electromagnetic directional valves may be provided with a filter mesh so as to filter the hydraulic oil that may enter into a valve element. The hydraulic oil flowing from the hydraulic cylinder may flow through the two-position two-way electromagnetic switch valve 201 and the oil return ports of the two-position three-way electromagnetic directional valves 202, 204, and flow into the oil tank through the oil port T. The upward movement and downward movement of the left leg support and the right leg support can be respectively driven by an extending action and a retracting action of the piston rod of its corresponding hydraulic cylinder.

**[0029]** First, the left leg support and the right leg support can be independently controlled and driven as follows.

1. When the left leg support is desired to be moved upwards, the two-position three-way electromagnetic directional valve 202 is energized and its valve element position is left. In this case, the hydraulic oil may flow through the valve element, open the hydraulically operated check valves 221, 222, and flow, through a throttling orifice 241, into the first chamber 2611 of the hydraulic cylinder 261 corresponding to the left leg support. At this point, since the hydraulically operated check valve 222 is opened, the hydraulic oil that has entered into the first chamber 2611 of the hydraulic cylinder 261 can drive the piston rod 2613 to extend outwards, and the hydraulic oil within the second chamber 2612 of the hydraulic cylinder 261 may flow through the hydraulically operated check valve 222 and flow out of the two-position three-way electromagnetic directional valve 203 of which the valve element is left positioned. Simultaneously, the two-position two-way electromagnetic switch valve 201 is energized and its valve

element position is right, such that the hydraulic oil can flow through the two-position two-way electromagnetic switch valve and then flow into the oil tank through the port T to form a complete circuit.

2. When the left leg support is desired to be moved downwards, the two-position three-way electromagnetic directional valve 203 is energized and its valve element position is right. In this case, the hydraulic oil may flow through the valve element, open the hydraulically operated check valves 222, 221, and flow into the second chamber 2612 of the hydraulic cylinder 261 corresponding to the left leg support. At this point, since the hydraulically operated check valve 221 is opened, the hydraulic oil that has entered into the second chamber 2612 of the hydraulic cylinder 261 can drive the piston rod 2613 to retract inwards, and the hydraulic oil within the first chamber 2611 of the hydraulic cylinder 261 may successively pass through the throttling orifice 241 and the hydraulically operated check valve 221, flow out of the two-position three-way electromagnetic directional valve 202 of which the valve element is right positioned, and finally flow into the oil tank through the oil port T to form a complete circuit.

3. When the right leg support is desired to be moved upwards, the two-position three-way electromagnetic directional valve 205 is energized and its valve element position is right. In this case, the hydraulic oil may flow through the valve element, open the hydraulically operated check valves 224, 223, and flow, through a throttling orifice 242, into the first chamber 2621 of the hydraulic cylinder 262 corresponding to the right leg support. At this point, since the hydraulically operated check valve 223 is opened, the hydraulic oil that has entered into the first chamber 2621 of the hydraulic cylinder 262 can drive the piston rod 2623 to extend outwards, and the hydraulic oil within the second chamber 2622 of the hydraulic cylinder may pass through the hydraulically operated check valve 223, flow out of the two-position three-way electromagnetic directional valve 204 of which the valve element is right positioned, and flow into the oil tank through the oil port T to form a complete circuit.

4. When the right leg support is desired to be moved downwards, the two-position three-way electromagnetic directional valve 204 is energized and its valve element position is left. In this case, the hydraulic oil may flow through the valve element, open the hydraulically operated check valves 223, 224, and flow into the second chamber 2622 of the hydraulic cylinder 262 corresponding to the right leg support. At this point, since the hydraulically operated check valve 224 is opened, the hydraulic oil that has entered into the second chamber 2622 of the hydraulic cylinder 262 can drive the piston rod 2623 to retract inwards, and the hydraulic oil within the first chamber 2621 of the hydraulic cylinder 262 may successively

pass through the throttling orifice 242, the hydraulically operated check valve 221 and the two-position three-way electromagnetic directional valve 205 of which the valve element is left positioned, flow through the two-position two-way electromagnetic switch valve 201 that is energized to make its valve element be right positioned, and finally flow into the oil tank through the oil port T to form a complete circuit.

**[0030]** Second, the left leg support and the right leg support can be synchronously controlled and driven as follows.

**[0031]** An effective action area of the second chamber 2612 of the hydraulic cylinder 261 corresponding to the left leg support is equal to that of the first chamber 2621 of the hydraulic cylinder 262 corresponding to the right leg support.

1. When the two leg supports are desired to be moved upwards synchronously, the two-position three-way electromagnetic directional valve 202 is energized and its valve element position is left. The hydraulic oil may flow through the valve element, open the hydraulically operated check valves 221, 222, and flow, through the throttling orifice 241, into the first chamber 2611 of the hydraulic cylinder 261 corresponding to the left leg support. At this point, since the hydraulically operated check valve 222 is opened, the hydraulic oil that has entered into the first chamber 2611 of the hydraulic cylinder 261 can drive the piston rod 2613 to extend outwards. Simultaneously, the two-position two-way electromagnetic switch valve 201 is deenergized. In this case, after the hydraulic oil flowing out of the second chamber 2612 flows through the two-position three-way electromagnetic directional valve 203 of which the valve element is left positioned, it cannot flow to the oil port T because the valve element of the two-position two-way electromagnetic switch valve 201 is not right positioned. Instead, the hydraulic oil flowing out of the two-position three-way electromagnetic directional valve 203 may then flow through the two-position three-way electromagnetic directional valve 205 of which the valve element is left positioned, open the hydraulically operated check valves 224, 223, and enter, through the throttling orifice 242, into the first chamber 2621 of the hydraulic cylinder 262 corresponding to the right leg support. At this point, since the hydraulically operated check valve 223 is opened, the hydraulic oil that has entered into the first chamber 2621 of the hydraulic cylinder 262 can drive the piston rod 2623 to extend outwards, and the hydraulic oil within the second chamber 2622 of the hydraulic cylinder may flow through the hydraulically operated check valve 223, flow out of the two-position three-way electromagnetic directional valve 204 of which the valve element is right positioned,

and finally flow into the oil tank through the oil port T to form a complete circuit. The second chamber 2612 of the hydraulic cylinder 261 corresponding to the left leg support is connected in series with the first chamber 2621 of the hydraulic cylinder 262 corresponding to the right leg support, where the hydraulic cylinder corresponding to the right leg support is driven by the hydraulic cylinder corresponding to the left leg support to perform synchronous extending movement.

2. When the two leg supports are desired to be moved downwards synchronously, the two-position three-way electromagnetic directional valve 204 is energized and its valve element position is right. The hydraulic oil may flow through the valve element, open the hydraulically operated check valves 223, 224, and flow into the second chamber 2622 of the hydraulic cylinder 262 corresponding to the right leg support. At this point, since the hydraulically operated check valve 224 is opened, the hydraulic oil that has entered into the second chamber 2622 of the hydraulic cylinder 262 can drive the piston rod 2623 to retract inwards. Simultaneously, the two-position two-way electromagnetic switch valve 201 is deenergized. In this case, after the hydraulic oil flowing out of the first chamber 2621 flows through the throttling orifice 242, the hydraulically operated check valve 224 and the two-position three-way electromagnetic directional valve 205 of which the valve element is left positioned, it cannot flow to the port T because the valve element of the two-position two-way electromagnetic switch valve 201 is not right positioned. Instead, the hydraulic oil flowing out of the two-position three-way electromagnetic directional valve 205 can only flow through the two-position three-way electromagnetic directional valve 203 of which the valve element is left positioned, open the hydraulically operated check valves 222, 221, and enter into the second chamber 2612 of the hydraulic cylinder 261 corresponding to the left leg support. At this point, since the hydraulically operated check valve 221 is opened, the hydraulic oil that has entered into the second chamber 2612 of the hydraulic cylinder 261 can drive the piston rod 2613 to retract inwards synchronously, and the hydraulic oil within the first chamber 2611 of the hydraulic cylinder 261 may successively flow through the throttling orifice 241, the hydraulically operated check valve 221 and the two-position three-way electromagnetic directional valve 202 of which the valve element is right positioned, and finally flow into the oil tank through the oil port T to form a complete circuit. The first chamber 2621 of the hydraulic cylinder 262 corresponding to the right leg support is connected in series with the second chamber 2612 of the hydraulic cylinder 261 corresponding to the left leg support, where the hydraulic cylinder corresponding to the left leg support is driven by the hydraulic cylinder

corresponding to the right leg support to perform synchronous retracting movement.

**[0032]** Figure 2 is a second embodiment of the hydraulic drive system for the operation table. The differences between the first and the second embodiments lie in that: when the two leg supports are moved synchronously, an effective action area of the first chamber 2611 of the hydraulic cylinder 261 corresponding to the left leg support is equal to that of the second chamber 2622 of the hydraulic cylinder 262 corresponding to the right leg support, such that the hydraulic cylinder corresponding to the left leg support is driven by the hydraulic cylinder corresponding to the right leg support to perform synchronous extending movement, and the hydraulic cylinder corresponding to the right leg support is driven by the hydraulic cylinder corresponding to the left leg support to perform synchronous retracting movement.

**[0033]** Using the hydraulic drive system of this disclosure, each leg support can be moved independently or both leg supports can be moved synchronously for the operation table. When it is demanded to hold a current position (or any position status) of the operation table, it is only needed to deenergize the two-position, three-way electromagnetic directional valves in the hydraulic circuit where the hydraulic cylinder that is operated to drive said action of the leg support(s) is located. In this case, the hydraulically operated check valve can be shut off in the second direction, and the hydraulic oil within both the first chamber without the piston rod and the second chamber with the piston rod can be held within a sealed cavity without any discharge, thereby holding the current position of the leg support of the operation table reliably and stably.

**[0034]** As shown in Figures 3-6, a pipe and its pipe adapter 10 can be used to connect the hydraulic cylinder with the valves or connect the valves with the hydraulic pump, and the two-position, two-way electromagnetic switch valve 201 and the two-position three-way electromagnetic directional valves 202, 203, 204, 205 may be assembled to obtain a control valve block for the leg supports of the operation table, where a screw 14, 16 can be used to secure the control valve block.

**[0035]** In the hydraulic drive system for the operation table of this disclosure, two sets of two-position three-way electromagnetic directional valves (each set includes two two-position three-way electromagnetic directional valves) and two bi-directional hydraulic locks (each hydraulic lock includes two hydraulically operated check valves) can be used in coordination with a two-position two-way electromagnetic switch valve, and the hydraulic cylinders corresponding to the left and right leg supports can be connected in series, such that the left leg support and the right leg support can be moved independently and synchronously. The movement speed of the leg support of the operation table can be controlled by controlling an output flow of the oil supply device (such as, a hydraulic pump), or by controlling a size of the throttling

orifice of a throttling valve or a throttling bolt in the hydraulic circuit. A working pressure of the leg supports of the operation table can be adjusted by a hydraulic pump having an overflow valve.

**[0036]** For the hydraulic drive system of the operation table, each set of two-position three-way electromagnetic directional valves can be replaced by a two-position five-way electromagnetic directional valve, where five ports of the two-position five-way electromagnetic directional valve can be respectively connected with the first flow pass, the second flow pass, the oil supply device, the oil return device and the on-off control valve. The on-off control valve can be a switch valve, such as a two-position two-way electromagnetic switch valve, or a directional valve, such as a two-position three-way electromagnetic directional valve.

**[0037]** This disclosure is described above as detailed illustrations with reference to specific implementations, while this disclosure should not be limited to these illustrations. For those of ordinary skills in the art, various conclusions or equivalents may be made without departing from the concept of this disclosure, while such conclusions or equivalents should be deemed to be included within the scope of this disclosure.

#### Claims

1. A hydraulic drive system for an operation table that is provided with an independent movement state and a synchronous movement state; the system comprises an oil supply device for supplying hydraulic oil, an oil return device and a hydraulic cylinder circuit component; the hydraulic cylinder circuit component comprises two hydraulic cylinders, each hydraulic cylinder comprising a first chamber without a piston rod and a second chamber with a piston rod located therewithin; the hydraulic cylinder circuit component also comprises two directional valve components and two bi-directional hydraulic locks, wherein said hydraulic cylinders, said directional valve components and said bi-directional hydraulic locks correspond to one other; the first chamber of each hydraulic cylinder is connected with a working port of its corresponding directional valve component through a first flow pass, and the second chamber of each hydraulic cylinder is connected with another working port of its corresponding directional valve component through a second flow pass; an oil inlet port of each directional valve component is connected with the oil supply device, an oil return port of each directional valve component is directly connected with the oil return device, and another oil return port of each directional valve component is connected with the oil return device through a return line that is arranged with an on-off control valve; the first flow pass and the second flow pass that correspond to each hydraulic cylinder are capable of being bi-

directionally switched on and off using the bi-directional hydraulic lock corresponding to said hydraulic cylinder; the second chamber of one hydraulic cylinder is connected in series with the first chamber of the other hydraulic cylinder; in the independent movement state, the return line is switched on by the on-off control valve; in the synchronous movement state, the return line is shut off by the on-off control valve.

2. The hydraulic drive system for the operation table of claim 1, wherein each directional valve component comprises two two-position three-way electromagnetic directional valves; each two-position three-way electromagnetic directional valve comprises one oil inlet port, one oil return port and one working port.
3. The hydraulic drive system for the operation table of claim 2, wherein each two-position three-way electromagnetic directional valve is integrally connected with the on-off control valve.
4. The hydraulic drive system for the operation table of claim 1, wherein each directional valve component comprises one two-position five-way electromagnetic directional valve.
5. The hydraulic drive system for the operation table of claim 1, wherein each bi-directional hydraulic lock comprises two hydraulically operated check valves; said two hydraulically operated check valves are respectively arranged in the first flow pass and the second flow pass, wherein the hydraulically operated check valve in the first flow pass is controlled by an oil pressure of the second flow pass, and the hydraulically operated check valve in the second flow pass is controlled by an oil pressure of the first flow pass.
6. The hydraulic drive system for the operation table of claim 1, wherein the on-off control valve is a two-position two-way electromagnetic switch valve or a two-position three-way electromagnetic directional valve.
7. The hydraulic drive system for the operation table of claim 1, wherein an effective action area of the first chamber of one hydraulic cylinder is equal to that of the second chamber of the other hydraulic cylinder.
8. The hydraulic drive system for the operation table of claim 1, wherein the first flow pass and the second flow pass are respectively provided with a throttling device for flow regulation.
9. A hydraulic drive system for an operation table that is provided with an independent movement state and a synchronous movement state, comprising an oil supply device for supplying hydraulic oil, an oil return

device and a hydraulic cylinder circuit component; the hydraulic cylinder circuit component comprises two hydraulic cylinders, each hydraulic cylinder comprises a first chamber without a piston rod and a second chamber with a piston rod located therewithin; the hydraulic cylinder circuit component also comprises two directional valve components and two bi-directional hydraulic locks, wherein said hydraulic cylinders, said directional valve components and said bi-directional hydraulic locks correspond to one other; each directional valve component comprises two two-position three-way electromagnetic directional valves, each two-position three-way electromagnetic directional valve comprises one oil inlet port, one oil return port and one working port; the oil inlet port of each two-position three-way electromagnetic directional valve is connected with the oil supply device; for each directional valve component, the working port of one two-position three-way electromagnetic directional valve is connected with the first chamber of the corresponding hydraulic cylinder through a first flow pass, and the working port of the other two-position three-way electromagnetic directional valve is connected with the second chamber of the corresponding hydraulic cylinder through a second flow pass; the two hydraulic cylinders are a left hydraulic cylinder and a right hydraulic cylinder; the oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the left hydraulic cylinder is directly connected with the oil return device, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the left hydraulic cylinder is connected with the oil return device through a return line; the oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the right hydraulic cylinder is connected with the oil return device through the return line, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the right hydraulic cylinder is directly connected with the oil return device; the return line is arranged with an on-off control valve; the first flow pass and the second flow pass which correspond to each hydraulic cylinder are capable of being bi-directionally switched on and off using the bi-directional hydraulic lock corresponding to said each hydraulic cylinder; the second chamber of the left hydraulic cylinder and the first chamber of the right hydraulic cylinder are connected in series; in the independent movement state, the return line is switched on through the on-off control valve; in the synchronous movement state, the return line is shut off through the on-off control valve.

10. The hydraulic drive system for an operation table of claim 9, wherein an effective action area of the sec-

ond chamber of the left hydraulic cylinder is equal to that of the first chamber of the right hydraulic cylinder.

11. A hydraulic drive system for an operation table that is provided with an independent movement state and a synchronous movement state, comprising an oil supply device for supplying hydraulic oil, an oil return device and a hydraulic cylinder circuit component; the hydraulic cylinder circuit component comprises two hydraulic cylinders, each hydraulic cylinder comprises a first chamber without a piston rod and a second chamber with a piston rod located therewithin; the hydraulic cylinder circuit component also comprises two directional valve components and two bi-directional hydraulic locks, wherein said hydraulic cylinders, said directional valve components and said bi-directional hydraulic locks correspond to one other; each directional valve component comprises two two-position three-way electromagnetic directional valves, wherein each two-position three-way electromagnetic directional valve comprises one oil inlet port, one oil return port and one working port; the oil inlet port of each two-position three-way electromagnetic directional valve is connected with the oil supply device; for each directional valve component, the working port of one two-position three-way electromagnetic directional valve is connected with the first chamber of the corresponding hydraulic cylinder through a first flow pass, and the working port of the other two-position three-way electromagnetic directional valve is connected with the second chamber of the corresponding hydraulic cylinder through a second flow pass; the two hydraulic cylinders are a left hydraulic cylinder and a right hydraulic cylinder; the oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the right hydraulic cylinder is directly connected with the oil return device, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the right hydraulic cylinder is connected with the oil return device through a return line; the oil return port of the two-position three-way electromagnetic directional valve that is connected with the first chamber of the left hydraulic cylinder is connected with the oil return device through the return line, and the oil return port of the two-position three-way electromagnetic directional valve that is connected with the second chamber of the left hydraulic cylinder is directly connected with the oil return device; the return line is arranged with an on-off control valve; the first flow pass and the second flow pass which correspond to each hydraulic cylinder are capable of being bi-directionally switched on and off through the bi-directional hydraulic lock corresponding to said each hydraulic cylinder; the second chamber of the right hydraulic cylinder and the first chamber of the left hydraulic cylinder are connected in

series; in the independent movement state, the return line is switched on through the on-off control valve; in the synchronous movement state, the return line is shut off through the on-off control valve.

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12. The hydraulic drive system for an operation table of claim 11, wherein an effective action area of the second chamber of the right hydraulic cylinder is equal to that of the first chamber of the left hydraulic cylinder.

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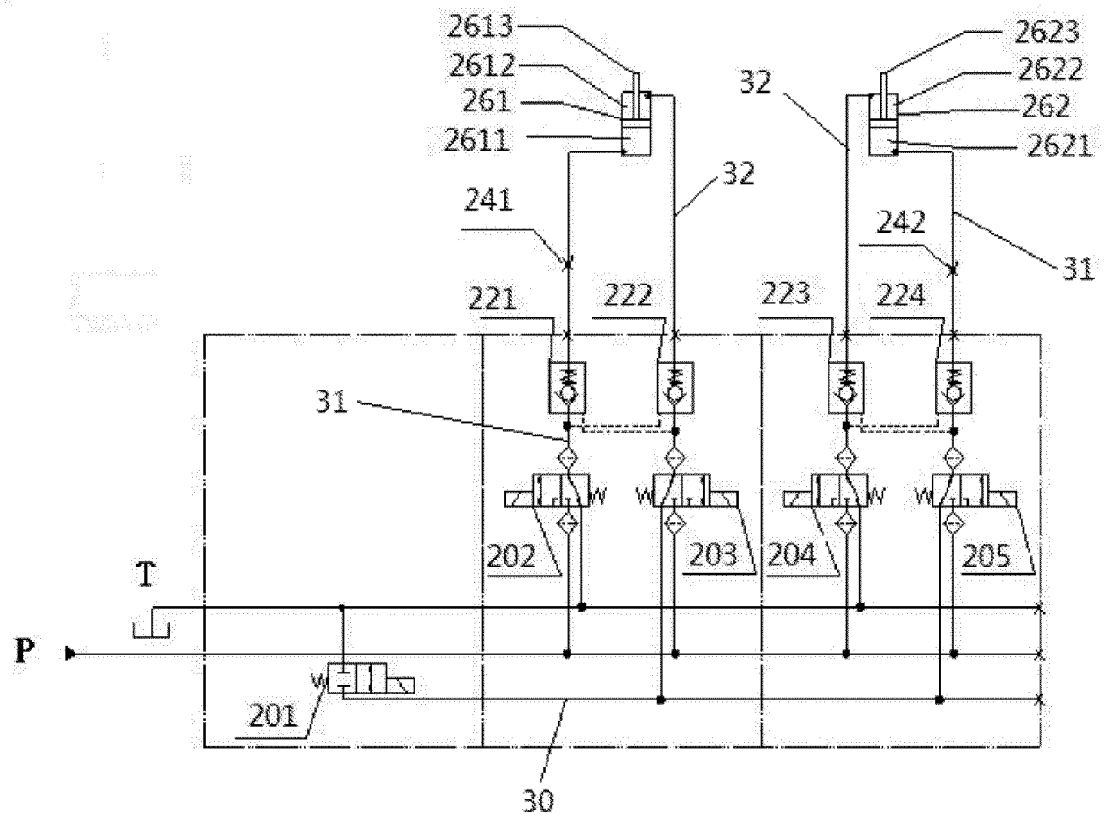


Figure 1

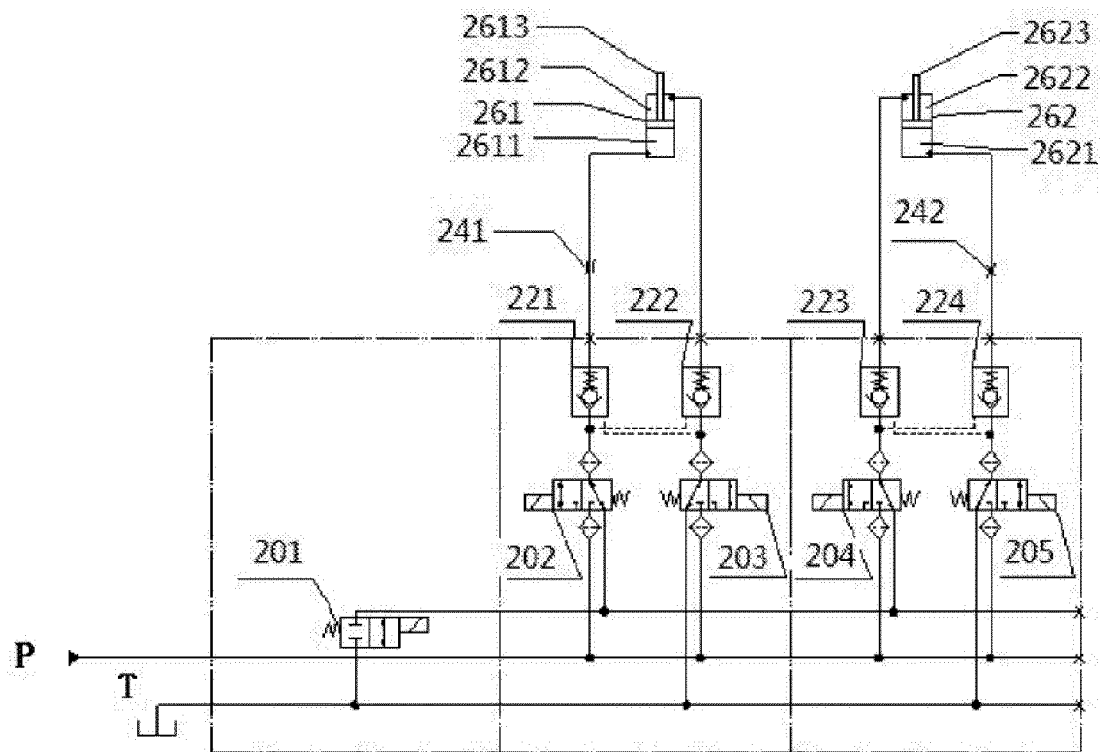


Figure 2

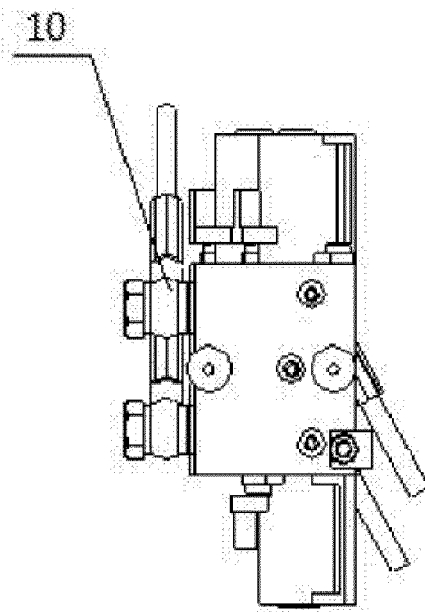


Figure 3

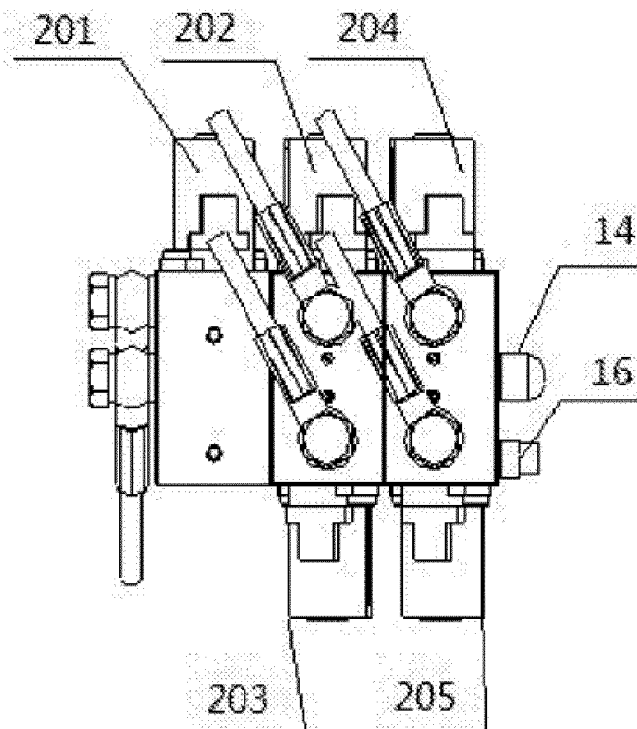


Figure 4

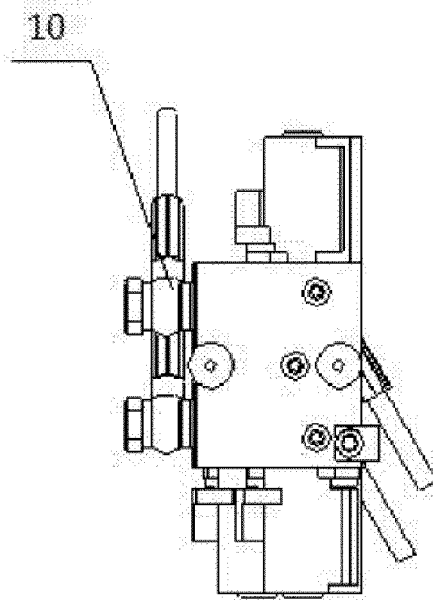


Figure 5

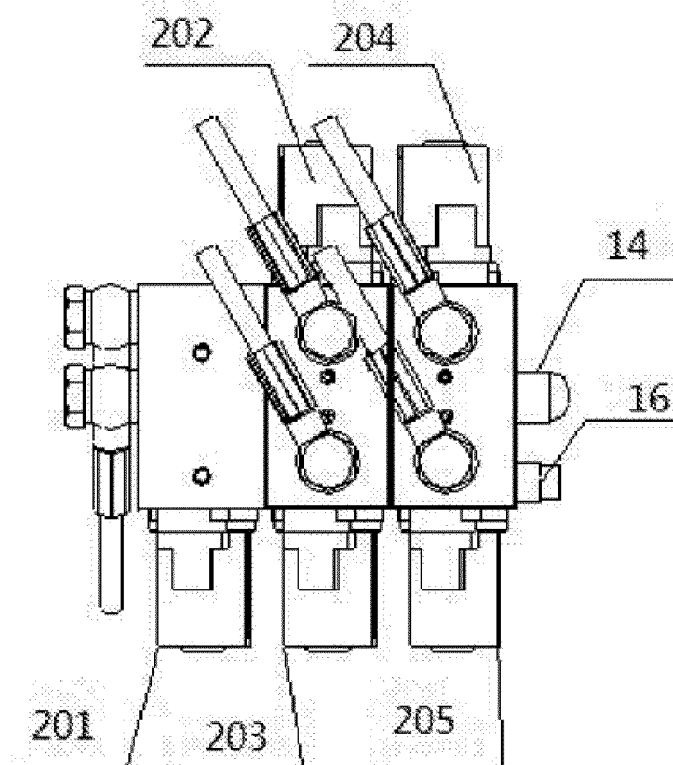


Figure 6

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/CN2014/089339

## A. CLASSIFICATION OF SUBJECT MATTER

F15B 11/00 (2006.01) i; A61G 13/10 (2006.01) i  
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)

F15B; A61G

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)

SIPOABS; CNABS; CN/US/EP/WOTXT: surgery table, operating table, hydraulic lock, check valve, one-way, non-return, cylinder

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                   | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | CN 203627352 U (CHINA HARZONE INDUSTRY CORP., LTD.) 04 June 2014 (04.06.2014) see description, paragraphs [0005]-[0022] and figure 1 | 1-12                  |
| A         | CN 1817322 A (ZHENG, Daxin) 16 August 2006 (16.08.2006) see the whole document                                                       | 1-12                  |
| A         | CN 102705275 A (SANY HEAVY IND CO., LTD.) 03 October 2012 (03.10.2012) see the whole document                                        | 1-12                  |
| A         | CN 203604293 U (ZOOMLION HEAVY IND SCIENCE & TECHNOLOGY) 21 May 2014 (21.05.2014) see the whole document                             | 1-12                  |
| A         | CN 203614480 U (CCCC XI AN ROAD CONSTRUCTION MACHINERY CO., LTD.) 28 May 2014 (28.05.2014) see the whole document                    | 1-12                  |
| A         | EP 1161929 A2 (SCHMITZ & SOEHNE GMBH & CO KG) 12 December 2001 (12.12.2001) see the whole document                                   | 1-12                  |

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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| * Special categories of cited documents:                                                                                                                                | "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                                              |
| "A" document defining the general state of the art which is not considered to be of particular relevance                                                                |                                                                                                                                                                                                                                                  |
| "E" earlier application or patent but published on or after the international filing date                                                                               | "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone                                                                     |
| "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "O" document referring to an oral disclosure, use, exhibition or other means                                                                                            |                                                                                                                                                                                                                                                  |
| "P" document published prior to the international filing date but later than the priority date claimed                                                                  | "&" document member of the same patent family                                                                                                                                                                                                    |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Date of the actual completion of the international search<br>13 July 2015                                                                                                                                     | Date of mailing of the international search report<br>13 July 2015  |
| Name and mailing address of the ISA<br>State Intellectual Property Office of the P. R. China<br>No. 6, Xitucheng Road, Jimenqiao<br>Haidian District, Beijing 100088, China<br>Facsimile No. (86-10) 62019451 | Authorized officer<br>LIU, Jingyi<br>Telephone No. (86-10) 62085239 |

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/CN2014/089339

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|----|-------------------------------------------------------|-------------------------------------------------------------------------------------------------|-----------------------|
| 5  | C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                 |                       |
|    | Category*                                             | Citation of document, with indication, where appropriate, of the relevant passages              | Relevant to claim No. |
| 10 | A                                                     | US 2005198737 A1 (HILL ROM SERVICES INC.) 15 September 2005 (15.09.2015) see the whole document | 1-12                  |
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**INTERNATIONAL SEARCH REPORT**  
 Information on patent family members

 International application No.  
 PCT/CN2014/089339

| Patent Documents referred<br>in the Report | Publication Date  | Patent Family    | Publication Date  |
|--------------------------------------------|-------------------|------------------|-------------------|
| CN 203627352 U                             | 04 June 2014      | None             |                   |
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| CN 102705275 A                             | 03 October 2012   | CN 102705275 B   | 17 December 2014  |
| CN 203604293 U                             | 21 May 2014       | None             |                   |
| CN 203614480 U                             | 28 May 2014       | None             |                   |
| EP 1161929 A2                              | 12 December 2001  | EP 1161929 A3    | 07 April 2004     |
|                                            |                   | EP 1161929 B1    | 17 May 2006       |
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|                                            |                   | WO 02058615 A2   | 01 August 2002    |
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|                                            |                   | WO 02058615 A3   | 26 September 2002 |
|                                            |                   | US 2002144349 A1 | 10 October 2002   |
|                                            |                   | JP 2005500083 A  | 06 January 2005   |