



— *with amended claims (Art. 19(1))*

Method and hydraulic system for mining operation

Technical Field

[0001] The present invention relates to mining operations and in particular to a method and system for operating a cable reel on a shuttle car in a mining operation. More particularly, the present invention relates to a hydraulic circuit for operating the cable reel on a shuttle car.

Background of the Invention

[0002] In underground mining operations, mined material needs to be transported from the miner at the cutting face to a feeder breaker at the head of a conveyor belt, which conveys the material to the surface. Electric shuttle cars are used to transport the mined material from the miner at the cutting face to the feeder breaker. The shuttle cars are typically powered by electricity that is delivered via an electrical cable from a power distribution control box. The cable extends from the power distribution control box to a reel mounted on the shuttle car and is constantly wound on and off the reel as the shuttle car travels between the cutting face and the conveyor belt.

[0003] Typically, at intervals of about 100 metres, the mining operation is shut down and stepped forward by 100 metres, including the power distribution control box and the conveyor. During the stepping forward process, the shuttle car is parked at or near the cutting face and power to the shuttle car is disconnected by detaching the electrical cable at the distribution control box. The electrical cable must then be manually spooled and carried forward to the new site of the power distribution control box, following the stepping forward process, where it is reconnected to once again supply power to the shuttle car.

[0004] The manual spooling and carrying of the electrical cable during the stepping forward process is both labour and time intensive and risks injury to workers and damage to the electrical cable. During this operation it is common for the electrical cable to become tangled or to get caught. Three workers are typically required to spool the electrical cable and load it into the bucket of a front end loader, which then carries the spooled cable forward to the new power distribution control box, where it has to be unloaded and reconnected. Following reconnection, the shuttle car is then able to operate the cable reel to wind the loose electrical cable back onto the cable reel.

Object of the Invention

[0005] It is an object of the present invention to substantially overcome or at least ameliorate one or more of the above disadvantages, or to provide a useful alternative.

Summary of the Invention

[0006] In a first aspect, the present disclosure provides a method of advancing an underground mining operation to an advanced location, the mining operation including an electric shuttle car powered by an electric cable from a power distribution control box, the shuttle car having a cable reel with a hydraulic motor for spooling and unspooling the electrical cable, the method comprising:

- locating the electric shuttle car in the advanced location;
- disconnecting the electrical cable from the power distribution control box;
- moving the distribution control box to the advanced location;
- connecting a hydraulic system of an ancillary vehicle to a hydraulic circuit that is connected to the hydraulic motor of the cable reel;
- operating the hydraulic system of the ancillary vehicle to power the motor of the cable reel and thereby spool the electrical cable onto the cable reel;
- reconnecting the electrical cable to the power distribution control box; and
- disconnecting the ancillary vehicle from the shuttle car.

[0007] In a preferred embodiment, the hydraulic circuit associated with the shuttle car controls the hydraulic pressure and flow rate applied to the cable reel motor.

[0008] Preferably, the hydraulic circuit associated with the shuttle car is adapted to automatically isolate a hydraulic supply of the shuttle car in response to the hydraulic supply lines of the ancillary vehicle being connected to the hydraulic circuit associated with the shuttle car.

[0009] The hydraulic circuit preferably comprises:

- a supply line connecting a first hydraulic system of the first vehicle to the hydraulic motor to operate the hydraulic motor;
- a return line connecting the hydraulic motor to the first hydraulic system of the first vehicle;
- an auxiliary supply inlet connected to the supply line and adapted to receive hydraulic fluid under pressure from a second hydraulic system;
- an auxiliary return outlet connected to the return line and adapted to return

hydraulic fluid from the hydraulic motor to the second hydraulic system; and

a valving system adapted to allow the second hydraulic system to control operation of the hydraulic motor when the second hydraulic system is connected to the auxiliary supply inlet and auxiliary return outlet of the hydraulic circuit.

[0010] Further preferably, the valving system comprises:

a resiliently biased first switching valve adapted to switch between a resiliently biased first state, in which the return line is in fluid communication with the first hydraulic system, and a second state, in which the return line is in fluid communication with the auxiliary return outlet.

[0011] In a second aspect, the present disclosure provides a hydraulic circuit for connecting a hydraulic motor on a first vehicle to a second hydraulic system, the hydraulic circuit comprising:

a supply line connecting a first hydraulic system of the first vehicle to the hydraulic motor to operate the hydraulic motor;

a return line connecting the hydraulic motor to the first hydraulic system of the first vehicle;

an auxiliary supply inlet connected to the supply line and adapted to receive hydraulic fluid under pressure from a second hydraulic system;

an auxiliary return outlet connected to the return line and adapted to return hydraulic fluid from the hydraulic motor to the second hydraulic system;

a valving system adapted to allow the second hydraulic system to control operation of the hydraulic motor when the second hydraulic system is connected to the auxiliary supply inlet and auxiliary return outlet of the hydraulic circuit.

[0012] In a preferred embodiment of the second aspect, the valving system comprises a resiliently biased first switching valve adapted to switch between a resiliently biased first state, in which the return line is in fluid communication with the first hydraulic system, and a second state, in which the return line is in fluid communication with the auxiliary return outlet.

[0013] The hydraulic circuit preferably further comprises:

a case drain line connecting the hydraulic motor to the first hydraulic system; and

an auxiliary drain outlet connected to the case drain line and adapted to drain hydraulic fluid from the hydraulic motor to the second hydraulic system;

wherein the valving system further comprises a resiliently biased second switching

valve adapted to switch between a resiliently biased first state, in which the case drain line is in fluid communication with the first hydraulic system, and a second state, in which the case drain line is in fluid communication with the auxiliary drain outlet.

[0014] Preferably, the supply line includes a pressure reducing valve and a flow control valve.

[0015] In a preferred embodiment of the second aspect, the first vehicle is a shuttle car and the hydraulic motor is a cable reel motor.

[0016] In a preferred embodiment of the second aspect, the second hydraulic system is provided by a second vehicle.

[0017] In a preferred embodiment of the second aspect, the second vehicle is an LHD loader.

[0018] In a third aspect, the present disclosure provides a system for operating a hydraulic motor on a first vehicle using a second vehicle, the system comprising:

- a first vehicle having a first hydraulic system and a hydraulic motor operable by the first hydraulic system;

- a second vehicle having a second hydraulic system;

- hydraulic supply lines adapted to connect the second hydraulic system to an external hydraulic circuit; and

- a hydraulic circuit as claimed in the second aspect above, the hydraulic circuit being associated with the first vehicle and adapted for connection to the second hydraulic system by the hydraulic supply lines.

[0019] In a preferred embodiment of the third aspect, the hydraulic circuit is permanently installed on the first vehicle.

[0020] In a preferred embodiment of the third aspect, the first vehicle is a shuttle car and the hydraulic motor is a cable reel motor.

[0021] In a preferred embodiment of the third aspect, the second vehicle is an LHD loader.

Brief Description of the Drawings

[0022] A preferred embodiment of the invention will now be described by way of specific example with reference to the accompanying drawings, in which:

[0023] Fig. 1 is a schematic depiction of a mining operation;

[0024] Fig. 2 depicts a hydraulic flow control circuit;

[0025] Fig. 3 is a hydraulic system of a shuttle car with the hydraulic circuit of Fig. 2;

[0026] Fig. 4 is a schematic depiction of a hydraulic circuit between a shuttle car and a loader;

[0027] Fig. 5 is a schematic depiction of a hydraulic circuit between a shuttle car and a loader; and

[0028] Fig. 6 is an alternative hydraulic circuit for use with a shuttle car; and

[0029] Fig. 7 is an alternative hydraulic circuit for use with a shuttle car.

Detailed Description of the Preferred Embodiments

[0030] Fig. 1 depicts an underground mining operation 10 involving a miner 12, a feeder breaker 14, a conveyor belt 16 and a shuttle car 18. The shuttle car 18 is used to transport material from the cutting face 20, where the miner 12 operates, to the feeder breaker 14 at the head of the conveyor belt 16. The shuttle car 18 runs on electrical power supplied from a power distribution control box 22 via an electrical cable 24. The electrical cable 24 runs from the power distribution control box 22 to the feeder breaker 14 and from there extends to a cable reel 26 on the shuttle car 18.

[0031] As the shuttle car 18 travels towards the feeder breaker 14, slack in the electrical cable 24 is spooled onto the cable reel 26. As the shuttle car 18 travels away from the feeder breaker 14, the electrical cable 24 is unspooled from the cable reel 26. Each time the miner 12 progresses an interval of 100m, the mining operation 10 is shut down and stepped forward 100m. During this stepping forward process, the electrical cable 24 is disconnected from the power distribution control box 22, which leaves the shuttle car 18 without a power source.

[0032] As the shuttle car 18 has no power supply, a hydraulic circuit 100, such as depicted in Fig. 7, is used to connect the hydraulic system of an ancillary vehicle, such as an LHD loader, to the motor of the cable reel 26. The motor of the cable reel 26 is then driven to fully spool the electrical cable 24 onto the cable reel 26.

[0033] The whole mining operation 10, including the power distribution control box 22, the feeder loader 14 and the conveyor belt 16, are all moved forward by 100 metres and reinstalled. Then, the electrical cable 26 is reconnected to the power distribution control box 22, supplying power to the shuttle car 18 again and allowing the mining operation 10 to continue. The mining operation 10 depicted in Fig. 1 shows the sites of the former power

distribution control box 22' and the former feeder breaker 14' prior to the last stepping forward process.

[0034] This improved stepping forward process for the mining operation 10 requires much less manual labour and therefore, has the significant advantages of saving on labour costs and of reducing the occupational health and safety risks and equipment damage risks associated with manual spooling of the electrical cable.

[0035] Turning to Fig. 7, a hydraulic circuit 100 is connected via a first check valve 202 to a first hydraulic system 200 of a first vehicle, such as the shuttle car 18 depicted in Fig. 1. The hydraulic circuit 100 is also connected to the inlet and outlet of a hydraulic motor 210 of the first vehicle, which in this embodiment is the motor of the cable reel 26 depicted in Fig. 1. The first hydraulic system 200 includes a pump 204, a pressure filter 206, and a fluid reservoir 208. In a typical arrangement, the hydraulic circuit 100 is retro-fitted onto or into the shuttle car 18. Alternatively, the shuttle car 18 may be produced with the hydraulic circuit 100 inbuilt. A valving system is provided in the hydraulic circuit 100, which is adapted to allow a second hydraulic system to control operation of the hydraulic motor 210 when the second hydraulic system is connected to the hydraulic circuit 100.

[0036] The hydraulic circuit 100 includes a supply line 102 and a return line 104. The supply line 102 connects the first hydraulic system 200 of the first vehicle, via a first flow control valve 106 and a pressure regulating valve 108, to an inlet of the motor 210. The return line 104 connects an outlet of the motor 210, via a resiliently biased first switching valve 120, to the fluid reservoir 208 of the first vehicle. The pressure regulating valve 108 is also connected to the return line 104 via a second flow control valve 110. The first switching valve 120 is also connected to an auxiliary return outlet 122 and is adapted to switch between a first state, in which the return line 104 is in fluid communication with the fluid reservoir 208 of the first vehicle, and a second state, in which the return line 104 is in fluid communication with the auxiliary return outlet 122.

[0037] The hydraulic circuit 100 further includes a case drain line 112 connecting a drain port of the hydraulic motor 210, via a resiliently biased second switching valve 124, to a drain system 212 of the first vehicle. The second switching valve 124 is also connected to an auxiliary drain outlet 126 and is adapted to switch between a first state, in which the case drain line 112 is in fluid communication with the drain system 212 of the first vehicle, and a second state, in which the case drain line 112 is in fluid communication with the auxiliary drain outlet 126.

[0038] The hydraulic circuit 100 further includes an auxiliary supply inlet 130 connected via a second check valve 114 to the supply line 102 upstream of the first flow control valve 106. The auxiliary supply inlet 130 is also connected to pressure switches of the first and second switching valves 120, 124, such that hydraulic pressure over a predetermined level received via the auxiliary supply inlet 130 causes each of the first and second switching valves 120, 124 to switch from the first state to the second state. In particular embodiments, the first and second switching valves 120, 124 are pressure-sense, spring-return valves.

[0039] The hydraulic circuit 100 further includes an auxiliary port 132 connected to the supply line 102 downstream of the pressure regulating valve 108 to allow for load sense equipment to be connected or to allow for override of the hydraulic circuit 100. A pressure gauge 134 is also provided in the supply line 102 to monitor hydraulic pressure at the inlet to the pump 210.

[0040] In operation, when the first vehicle is without power and unable to power the first hydraulic system 200, such as when the shuttle car 18 is disconnected from the power distribution control box 22 in the method depicted in Fig. 1, a second vehicle with a powered second hydraulic system, such as the ancillary vehicle described in the method depicted in Fig. 1, can be used to power the hydraulic circuit 100 on the first vehicle.

[0041] Hoses are used to connect the second hydraulic system of the second vehicle to the hydraulic circuit 100 of the first vehicle. Specifically, the hydraulic pressure line from the second vehicle is connected to the auxiliary supply inlet 130, the fluid return system of the second vehicle is connected to the auxiliary return outlet 122, and the fluid drain system of the second vehicle is connected to the auxiliary drain outlet 126.

[0042] This applies hydraulic pressure to the hydraulic circuit 100 of the first vehicle via the auxiliary supply inlet 130. This hydraulic pressure forces each of the first and second switching valves 120, 124 to switch from the first state to the second state. This sets up a complete hydraulic circuit between the second hydraulic system of the second vehicle and the hydraulic motor 210 of the first vehicle.

[0043] Hydraulic pressure flows from the auxiliary supply inlet 130, through the second check valve 114, the first flow control valve 106, and the pressure regulating valve 108, to the pump 210. The first check valve 202 prevents hydraulic fluid from the auxiliary supply inlet 130 from entering the first hydraulic system. After powering the pump 210, the hydraulic fluid returns from the pump 210, through the first switching valve 120 and the auxiliary return outlet 122, to the second hydraulic system of the second vehicle.

Separately, the case drain line 112 delivers drained fluid from the motor 210, through the second switching valve 124 and the auxiliary drain outlet 126, to the second hydraulic system of the second vehicle.

[0044] If the hydraulic circuit 100 needs to be overridden, then a hydraulic pressure line can be connected to the auxiliary port 132 which will supply hydraulic pressure directly to the motor 210.

[0045] The hydraulic circuit 100 allows an ancillary vehicle, such as an LHD loader, to be quickly and easily connected to the shuttle car 18 to power the motor 210 of the cable reel 26. This allows the motor 210 of the cable reel 26 to be powered even when the shuttle car 18 has been disconnected from the power distribution control box 22. The hydraulic circuit 100, via the first and second switching valves 120, 124 automatically isolates the first hydraulic system 200 of the first vehicle when hydraulic pressure from the second hydraulic system is connected to the hydraulic circuit 100, thereby preventing hydraulic fluid from the second hydraulic system from entering the first hydraulic system 200 and maintaining a closed and isolated hydraulic circuit.

[0046] Once the operation of the motor 210 is completed, such as when the cable 24 is spooled on the cable reel 26, the second hydraulic system is disconnected from the hydraulic circuit 100 and due to the reduction of pressure from the auxiliary supply inlet 130, the resiliently biased first and second switching valves 120, 124 are each automatically biased to return to the first state, resulting in the motor 210 being operable by the first hydraulic system 200 once again.

[0047] Other embodiments of alternative hydraulic circuits are described with reference to Figs. 2 to 6 below.

[0048] As best depicted in Fig. 2, the hydraulic circuit 30 has a pair of corresponding flow lines, being a first and second flow lines 40, 41. The first flow line 40 extends from a first end 42 through a pressure reducing valve 44, then through a flow control valve 46 to a second end 48. The second flow line 41 extends from a first end 43 through a pressure reducing valve 45, then through a flow control valve 47 to a second end 49. The pressure reducing valve 44 of the first flow line 40 vents or drains via a first drain line 50 through a first one-way check valve 52 to the second flow line 41 at a point between the first end 43 and the pressure reducing valve 45. The pressure reducing valve 45 of the second flow line 41 vents or drains via a second drain line 51 through a second one-way check valve 53 to the first flow line 40 at a point between the first end 42 and the pressure reducing valve 44.

[0049] The first ends 42, 43 are adapted to be fluidly connected to a remote supply of hydraulic power, such as from an ancillary vehicle 32, and the second ends 48, 49 are adapted to be connected in fluid isolation to the motor 34 of the cable reel 26. The hydraulic circuit 30 may be physically provided on the shuttle car 18, on the ancillary vehicle 32 or as a detachable unit. This hydraulic circuit 30 is then able to power the motor 34 of the cable reel 26 using the hydraulic circuit of the ancillary vehicle 32, despite the shuttle car 18 itself having no power supply.

[0050] The hydraulic circuit 30 can be implemented to drive the cable reel motor 34 in a number of ways, which will be described in turn below.

[0051] As depicted in Fig. 3, the shuttle car 18 is fitted with a detachable hydraulic circuit 30. The shuttle car 18 has hydraulic supply lines, being a pressure line 60 and a return line 62, which are connected to and drive the cable reel motor 34. The cable reel motor 34 also has a case drain 64. The hydraulic supply lines 60, 62 and the case drain 64 each include an isolation valve 61, 63, 65 that can be either built-in or retro-fitted to the shuttle car 18. These isolation valves 61, 63, 65 are operable to isolate the hydraulic supply lines 60, 62 and the case drain 64 from the cable reel motor 34. In this embodiment, a first isolation valve 61 is provided in the pressure line 60, a second isolation valve 63 is provided in the return line 62 and a third isolation valve 65 is provided in the case drain 64.

[0052] The shuttle car 18 is also provided with hydraulic connection points 66, 67, 68, with a first connection point 66 being provided between the first isolation valve 61 and the cable reel motor 34, a second connection point 67 being provided between the second isolation valve 63 and the cable reel motor 34 and a third connection point 68 being provided between the third isolation valve 65 and the cable reel motor 34.

[0053] The second ends 48, 49 of the first and second flow lines 40, 41 of the hydraulic circuit 30 are adapted to be connected to the first and second connection points 66, 67 of the shuttle car 18, respectively, to provide direct fluid communication between the first and second flow lines 40, 41 of the hydraulic circuit 30 and the cable reel motor 34. The first ends 42, 43 of the first and second flow lines 40, 41 of the hydraulic circuit 30 are connection points that allow the hydraulic circuit 30 to be connected to a hydraulic circuit of an ancillary vehicle 32.

[0054] In order to operate the cable reel motor 34 using hydraulic power from an ancillary vehicle 32, the hydraulic circuit 30 is connected and operated as follows. The isolation valves 61, 63, 65 are actuated to isolate the cable reel motor 34 from the hydraulic supply lines 60, 62 and the case drain 64. The second ends 48, 49 of the first and second flow lines

40, 41 of the hydraulic circuit 30 are connected to the first and second connection points 66, 67, respectively, of the shuttle car 18. The connection points at the second ends 48, 49 of the first and second flow lines 40, 41 of the hydraulic circuit 30 are adapted to be connected to a pressure line and return line, respectively, on an ancillary vehicle 32. The third connection point 68 of the shuttle car 18 is adapted to be connected to a case drain of the ancillary vehicle 32.

[0055] In operation, hydraulic pressure from the ancillary vehicle 32 is applied via the first end 42 of the first flow line 40 of the hydraulic circuit 30. The pressure reducing valve 44 and flow control valve 46 of the first flow line 40 are used to control the flow rate and pressure to suit operation of the cable reel motor 34. The oil passing through the pressure reducing valve 44 and flow control valve 46 of the first flow line 40 enters the cable reel motor 34 via the first connection point 66 and drives rotation of the cable reel. The oil then exits the cable reel motor 34 via the second connection point 67 and passes into and along the second flow line 41 of the hydraulic circuit 30, before passing into the return line of the ancillary vehicle 32 via the connection point at the first end 43. Excess oil pressure in the first flow line 40 is vented via the first drain line 50 to the second flow line 41, which flows back along the second flow line towards the first end 43 and into the return line of the ancillary vehicle 32. Oil that drains through the cable reel motor 34 is drained to the case drain of the ancillary vehicle 32 via the third connection point 68 of the shuttle car 18.

[0056] In order to reverse the operation of the cable reel motor 34, the hydraulic circuit of the ancillary vehicle 32 is simply operated in the reverse direction, such that hydraulic pressure is now applied to the second flow line 41 of the hydraulic circuit 30 and the circuit flows in the reverse direction.

[0057] Alternatively, as depicted Fig. 4, the shuttle car 18 can have a permanently installed hydraulic circuit 30 connected to the cable reel motor 34 that can be detachably connected to a hydraulic circuit of the ancillary vehicle, depicted here as a loader 32.

[0058] The shuttle car 18 has a hydraulic cable reel motor 34, connected to hydraulic supply lines, being a pressure line 60 and a return line 62. The cable reel motor 34 also has a case drain 64. The hydraulic supply lines 60, 62 and the case drain 64 each include an isolation valve, in the form of a three-way diversion valve 70, 72, 74 that can be either built-in or retro-fitted to the shuttle car 18. A first three-way diversion valve 70 is provided in the pressure line 60, a second three-way diversion valve 72 is provided in the return line 62 and a third three-way diversion valve 74 is provided in the case drain 64. These three-way diversion valves 70, 72, 74 are operable to isolate the hydraulic supply lines 60, 62 and the

case drain 64 from the cable reel motor 34 and to open flow from the first and second flow lines 40, 41 of the hydraulic circuit 30 to the cable reel motor 34.

[0059] The loader 32 has a power take off hydraulic circuit 76 and a locking tongue hydraulic circuit 80 that drives movement of a locking tongue piston 81. The power take off hydraulic circuit 76. The locking tongue hydraulic circuit 80 has hydraulic supply lines being a pressure line 82 and a return line 86. The hydraulic supply lines 82, 86 each include an isolation valve in the form of a three-way diversion valve 84, 88 that can be either built-in or retro-fitted to the loader 32. A first three-way diversion valve 84 is provided in the pressure line 82 and a second three-way diversion valve 88 is provided in the return line 86. These three-way diversion valves 84, 86 are operable to isolate the locking tongue piston 81 from the hydraulic supply lines 82, 86 and to allow flow between the hydraulic supply lines 82, 86 and externally attached flow lines.

[0060] In the Fig. 4 embodiment, the hydraulic circuit 30, as shown in detail in Fig. 2, is provided on the shuttle car 18. The second end 48 of the first flow line 40 of the hydraulic circuit 30 is fluidly connected into the first three-way diversion valve 70 of the pressure line 60 of the cable reel motor 34. The second end 49 of the second flow line 41 of the hydraulic circuit 30 is fluidly connected into the second three-way diversion valve 72 of the return line 62 of the cable reel motor 34.

[0061] Prior to operation, the loader 32 is hydraulically connected to the hydraulic circuit 30 as follows using hydraulic hoses and quick connect couplers. The third three-way diversion valve 74 in the case drain 64 of the cable reel motor 34 is detachably connected to the case drain hydraulic coupler 78 of the power take off hydraulic circuit 76. The first end 42 of the first flow line 40 of the hydraulic circuit 30 is detachably connected into the first three-way diversion valve 84 of the pressure line 82 of the locking tongue hydraulic circuit 80. The first end 43 of the second flow line 41 of the hydraulic circuit 30 is detachably connected into the second three-way diversion valve 88 of the return line 86 of the locking tongue hydraulic circuit 80. Then the first, second and third three-way diversion valves 70, 72, 74 of the cable reel motor 34 are operated to isolate the hydraulic supply lines 60, 62 and the case drain 64 from the cable reel motor 34 and to open flow from the first and second flow lines 40, 41 of the hydraulic circuit 30 to the cable reel motor 34. The first and second three-way diversion valves 84, 88 of the locking tongue hydraulic circuit 80 are also operated to isolate the locking tongue piston 81 from the hydraulic supply lines 82, 86 and to allow flow between the hydraulic supply lines 82, 86 and the first and second flow lines 40, 41 of the hydraulic circuit 30.

[0062] The cable reel motor 34 is then operable by way of the locking tongue hydraulic circuit 80. Hydraulic pressure from the pressure line 82 of the locking tongue hydraulic circuit 80 is applied through first flow line 40 of the hydraulic circuit 30, as described above, to the cable reel motor 34. The oil then returns from the cable reel motor 34 through the second flow line of the hydraulic circuit 30, as described above, before passing into the return line 86 of the locking tongue hydraulic circuit 80. Oil that drains through the cable reel motor 34 is drained to the case drain 78 of the power take off hydraulic circuit 76.

[0063] As before, in order to reverse the operation of the cable reel motor 34, the locking tongue hydraulic circuit 80 is simply operated in the reverse direction, such that hydraulic pressure is now applied to the second flow line 41 of the hydraulic circuit 30 and the circuit flows in the reverse direction.

[0064] In a further alternative configuration, depicted Fig. 5, an ancillary vehicle, depicted here as a loader 32, can have a permanently installed hydraulic circuit 30 connected to a hydraulic circuit of the ancillary vehicle, such as the locking tongue hydraulic circuit 80 of circuit of the loader 32, as depicted in this embodiment.

[0065] The operation of the hydraulic circuits in the Fig. 5 embodiment is identical to those described above in respect of the Fig. 4 embodiment. However, in the Fig. 5 embodiment, the hydraulic circuit 30 is mounted on the loader 32 and detachable hoses are used to connect the hydraulic circuit 30 to the three-way diversion valves 70, 72, 74 of the cable reel motor 34.

[0066] In a different embodiment, depicted in Fig. 6, a mono-directional hydraulic circuit, such as the power take off hydraulic circuit of an ancillary vehicle 32, is used to power the cable reel motor 34 of the shuttle car 18.

[0067] As described in relation to the Fig. 3 embodiment, the shuttle car 18 is fitted with a detachable hydraulic circuit 90. The shuttle car 18 has hydraulic supply lines, being a pressure line 60 and a return line 62, which are connected to and drive the cable reel motor 34. The cable reel motor 34 also has a case drain 64. The hydraulic supply lines 60, 62 and the case drain 64 each include an isolation valve 61, 63, 65 that can be either built-in or retro-fitted to the shuttle car 18. These isolation valves 61, 63, 65 are operable to isolate the hydraulic supply lines 60, 62 and the case drain 64 from the cable reel motor 34. In this embodiment, a first isolation valve 61 is provided in the pressure line 60, a second isolation valve 63 is provided in the return line 62 and a third isolation valve 65 is provided in the case drain 64.

[0068] The shuttle car 18 is also provided with hydraulic connection points 66, 67, 68, with a first connection point 66 being provided between the first isolation valve 61 and the cable reel motor 34, a second connection point 67 being provided between the second isolation valve 63 and the cable reel motor 34 and a third connection point 68 being provided between the third isolation valve 65 and the cable reel motor 34.

[0069] However, in this embodiment, the hydraulic circuit 90 requires a different design to allow reversible operation of the cable reel motor 34, while connected to a non-reversible hydraulic circuit, such as a power take off hydraulic circuit.

[0070] The hydraulic circuit 90 has a pressure line 91 and a return line 92. The pressure line 91 extends from a first connection point 93 through a pressure reducing valve 95, then through a flow control valve 98 to a directional control valve 99. The return line 92 extends separately from the directional control valve 99 to a second connection point 94. The pressure reducing valve 95 of the pressure line 91 vents or drains via a first drain line 96 through a first one-way check valve 97 to the return line 92.

[0071] The directional control valve 99 is adapted to be separately connected to the first and second connection points 66, 67 of the shuttle car 18, to provide direct fluid communication between the directional control valve of the hydraulic circuit 90 and the cable reel motor 34. The connection points 93, 94 of the hydraulic circuit 90 allow connection of the hydraulic circuit 90 to a hydraulic circuit of an ancillary vehicle 32, such as a power take off hydraulic circuit.

[0072] In order to operate the cable reel motor 34 using hydraulic power from an ancillary vehicle 32, the hydraulic circuit 90 is connected and operated as follows. The isolation valves 61, 63, 65 are actuated to isolate the cable reel motor 34 from the hydraulic supply lines 60, 62 and the case drain 64. The directional control valve 99 of the hydraulic circuit 90 is connected to both the first and second connection points 66, 67, of the shuttle car 18. The connection points 93, 94 of the hydraulic circuit 90 are adapted to be connected to the pressure line and return line, respectively, of the power take off hydraulic circuit of an ancillary vehicle 32. The third connection point 68 of the shuttle car 18 is adapted to be connected to the case drain of the power take off hydraulic circuit of the ancillary vehicle 32.

[0073] For forward operation of the cable reel motor 34, the directional control valve 99 is opened in a first open configuration that allows direct flow across the directional control valve 99, linking the first flow line 91 with the first connection point 66 of the shuttle car 18. In forward operation, hydraulic pressure from the power take off hydraulic circuit of the ancillary vehicle 32 is applied via the first connection point 93 of the first flow line 91 of the

hydraulic circuit 90. The pressure reducing valve 95 and flow control valve 98 of the first flow line 91 are used to control the flow rate and pressure to suit operation of the cable reel motor 34. The oil passing through the pressure reducing valve 95 and flow control valve 98 of the first flow line 91 also passes through the directional control valve 99 and enters the cable reel motor 34 via the first connection point 93 and drives forward rotation of the cable reel. The oil then exits the cable reel motor 34 via the second connection point 67 and passes through the directional control valve 99 and then, into and along the second flow line 92 of the hydraulic circuit 90, before passing into the return line of the power take off hydraulic circuit of the ancillary vehicle 32 via the second connection point 94. Excess oil pressure in the first flow line 91 is vented via the drain line 96 to the second flow line 92, which flows back along the second flow line towards the second connection point 94 and into the return line of the power take off hydraulic circuit of the ancillary vehicle 32. Oil that drains through the cable reel motor 34 is drained to the case drain of the power take off of the ancillary vehicle 32 via the third connection point 68 of the shuttle car 18.

[0074] In order to reverse the operation of the cable reel motor 34, the directional control valve 99 is switched to a second open configuration that causes a crossover flow across the directional control valve 99, linking the first flow line 91 with the second connection point 67 of the shuttle car 18 and the first connection point 66 of the shuttle car 18 with the second flow line 92. In this configuration, the hydraulic circuit 90 flows in the same direction, however the oil in the cable reel motor 34 flows in the reverse direction, reversing the rotation of the cable reel 26.

[0075] Pressure gauges, filters, restrictors and other standard hydraulic circuit equipment can optionally be added to the hydraulic circuit of the present invention and are envisaged. Such modifications do not materially affect the basic operation of the circuit and fall within the ambit of the present invention.

[0076] These above described systems each allow bi-directional operation of the cable reel motor 34 of the shuttle car 18, despite the shuttle car 18 having no source of electrical power. These systems can be readily retro-fitted to existing machinery or built into new machinery during manufacture. Employing these systems saves time and labour cost, while also reducing the likelihood of injury to workers or damage to equipment.

[0077] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:

1. A method of advancing an underground mining operation to an advanced location, the mining operation including an electric shuttle car powered by an electric cable from a power distribution control box, the shuttle car having a cable reel with a hydraulic motor for spooling and unspooling the electrical cable, the method comprising:
 - locating the electric shuttle car in the advanced location;
 - disconnecting the electrical cable from the power distribution control box;
 - moving the distribution control box to the advanced location;
 - connecting a hydraulic system of an ancillary vehicle to a hydraulic circuit that is connected to the hydraulic motor of the cable reel;
 - operating the hydraulic system of the ancillary vehicle to power the motor of the cable reel and thereby spool the electrical cable onto the cable reel;
 - reconnecting the electrical cable to the power distribution control box; and
 - disconnecting the ancillary vehicle from the shuttle car.
2. The method of claim 1, wherein the hydraulic circuit associated with the shuttle car controls the hydraulic pressure and flow rate applied to the cable reel motor.
3. The method of claim 1 or 2, wherein the hydraulic circuit associated with the shuttle car is adapted to automatically isolate a hydraulic supply of the shuttle car in response to the hydraulic supply lines of the ancillary vehicle being connected to the hydraulic circuit associated with the shuttle car.
4. The method of any one of claims 1 to 3 wherein the hydraulic circuit comprises:
 - a supply line connecting a first hydraulic system of the first vehicle to the hydraulic motor to operate the hydraulic motor;
 - a return line connecting the hydraulic motor to the first hydraulic system of the first vehicle;
 - an auxiliary supply inlet connected to the supply line and adapted to receive hydraulic fluid under pressure from a second hydraulic system;
 - an auxiliary return outlet connected to the return line and adapted to return hydraulic fluid from the hydraulic motor to the second hydraulic system; and
 - a valving system adapted to allow the second hydraulic system to control operation of

the hydraulic motor when the second hydraulic system is connected to the auxiliary supply inlet and auxiliary return outlet of the hydraulic circuit.

5. The method of claim 4 wherein the valving system comprises:

a resiliently biased first switching valve adapted to switch between a resiliently biased first state, in which the return line is in fluid communication with the first hydraulic system, and a second state, in which the return line is in fluid communication with the auxiliary return outlet.

6. A hydraulic circuit for connecting a hydraulic motor on a first vehicle to a second hydraulic system, the hydraulic circuit comprising:

a supply line connecting a first hydraulic system of the first vehicle to the hydraulic motor to operate the hydraulic motor;

a return line connecting the hydraulic motor to the first hydraulic system of the first vehicle;

an auxiliary supply inlet connected to the supply line and adapted to receive hydraulic fluid under pressure from a second hydraulic system;

an auxiliary return outlet connected to the return line and adapted to return hydraulic fluid from the hydraulic motor to the second hydraulic system;

a valving system adapted to allow the second hydraulic system to control operation of the hydraulic motor when the second hydraulic system is connected to the auxiliary supply inlet and auxiliary return outlet of the hydraulic circuit.

7. The hydraulic circuit of claim 6 wherein the valving system comprises:

a resiliently biased first switching valve adapted to switch between a resiliently biased first state, in which the return line is in fluid communication with the first hydraulic system, and a second state, in which the return line is in fluid communication with the auxiliary return outlet.

8. The hydraulic circuit of either claim 6 or 7 further comprising:
a case drain line connecting the hydraulic motor to the first hydraulic system; and
an auxiliary drain outlet connected to the case drain line and adapted to drain hydraulic fluid from the hydraulic motor to the second hydraulic system;
wherein the valving system further comprises a resiliently biased second switching valve adapted to switch between a resiliently biased first state, in which the case drain line is in fluid communication with the first hydraulic system, and a second state, in which the case drain line is in fluid communication with the auxiliary drain outlet.
9. The hydraulic circuit of any one of claims 6 to 8, wherein the supply line includes a pressure reducing valve and a flow control valve.
10. The hydraulic circuit of any one of claims 6 to 9, wherein the first vehicle is a shuttle car and the hydraulic motor is a cable reel motor.
11. The hydraulic circuit of any one of claims 6 to 10, wherein the second hydraulic system is provided by a second vehicle.
12. The hydraulic circuit of claim 11, wherein the second vehicle is an LHD loader.
13. A system for operating a hydraulic motor on a first vehicle using a second vehicle, the system comprising:
a first vehicle having a first hydraulic system and a hydraulic motor operable by the first hydraulic system;
a second vehicle having a second hydraulic system;
hydraulic supply lines adapted to connect the second hydraulic system to an external hydraulic circuit; and
a hydraulic circuit as claimed in any one of claims 6 to 12, the hydraulic circuit being associated with the first vehicle and adapted for connection to the second hydraulic system by the hydraulic supply lines.
14. The system of claim 13, wherein the hydraulic circuit is permanently installed on the first vehicle.

15. The system of claim 13 or 14, wherein the first vehicle is a shuttle car and the hydraulic motor is a cable reel motor.

16. The system of any one of claims 13 to 15, wherein the second vehicle is an LHD loader.

AMENDED CLAIMS

received by the International Bureau on 1 July 2016 (01.07.2016)

1. A method of advancing an underground mining operation to an advanced location, the mining operation including an electric shuttle car powered by an electric cable from a power distribution control box, the shuttle car having a cable reel with a hydraulic motor for spooling and unspooling the electrical cable, the method comprising:
 - locating the electric shuttle car in the advanced location;
 - disconnecting the electrical cable from the power distribution control box;
 - moving the distribution control box to the advanced location;
 - connecting a hydraulic system of an ancillary vehicle to a hydraulic circuit that is connected to the hydraulic motor of the cable reel;
 - operating the hydraulic system of the ancillary vehicle to power the motor of the cable reel and thereby spool the electrical cable onto the cable reel;
 - reconnecting the electrical cable to the power distribution control box; and
 - disconnecting the ancillary vehicle from the shuttle car.
2. The method of claim 1, wherein the hydraulic circuit associated with the shuttle car controls the hydraulic pressure and flow rate applied to the cable reel motor.
3. The method of claim 1 or 2, wherein the hydraulic circuit associated with the shuttle car is adapted to automatically isolate a hydraulic supply of the shuttle car in response to the hydraulic supply lines of the ancillary vehicle being connected to the hydraulic circuit associated with the shuttle car.
4. The method of any one of claims 1 to 3 wherein the hydraulic circuit comprises:
 - a supply line connecting a first hydraulic system of the first vehicle to the hydraulic motor to operate the hydraulic motor;
 - a return line connecting the hydraulic motor to the first hydraulic system of the first vehicle;
 - an auxiliary supply inlet connected to the supply line and adapted to receive hydraulic fluid under pressure from a second hydraulic system;
 - an auxiliary return outlet connected to the return line and adapted to return hydraulic fluid from the hydraulic motor to the second hydraulic system; and
 - a valving system adapted to allow the second hydraulic system to control operation of

the hydraulic motor when the second hydraulic system is connected to the auxiliary supply inlet and auxiliary return outlet of the hydraulic circuit.

5. The method of claim 4 wherein the valving system comprises:

a resiliently biased first switching valve adapted to switch between a resiliently biased first state, in which the return line is in fluid communication with the first hydraulic system, and a second state, in which the return line is in fluid communication with the auxiliary return outlet.

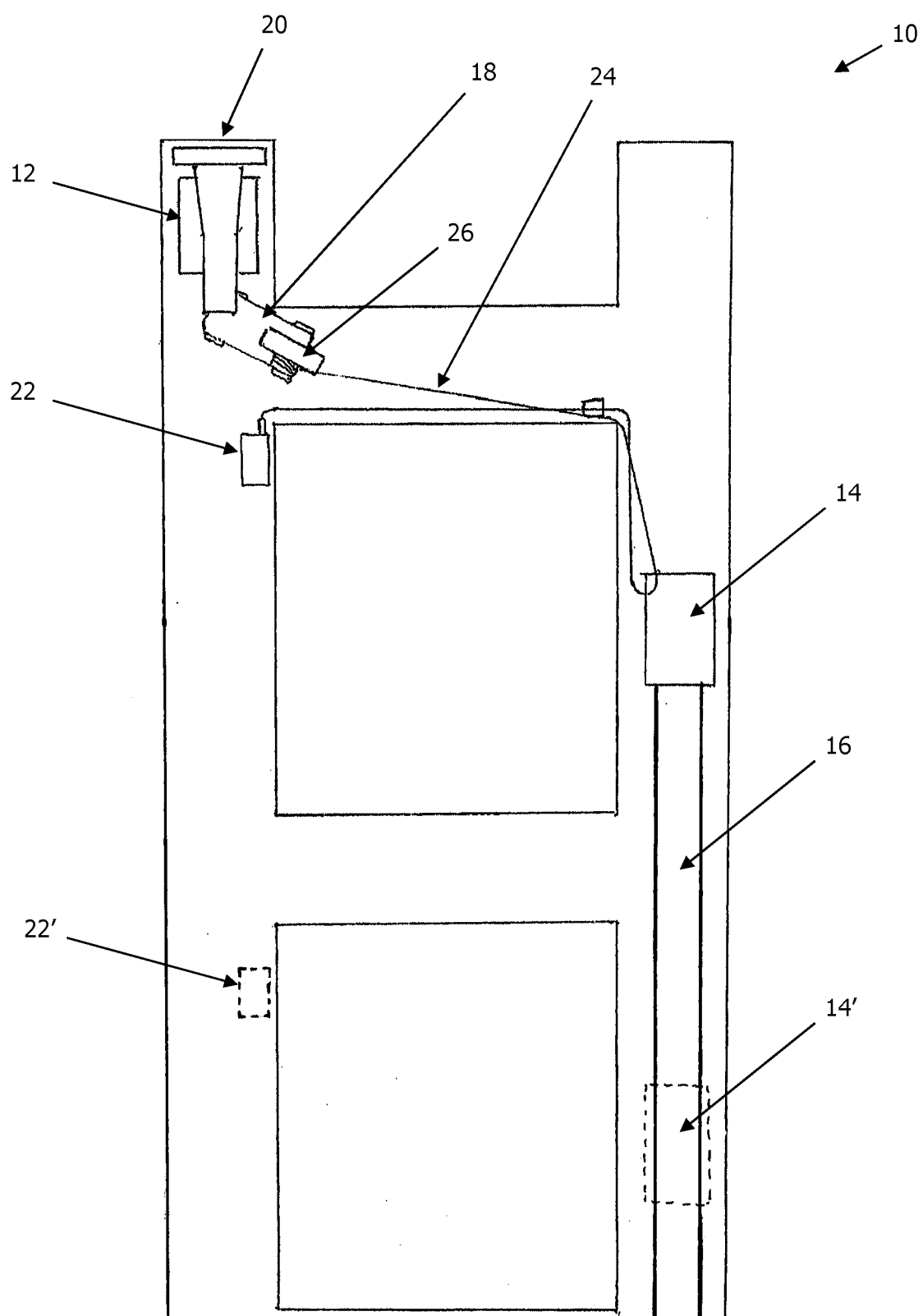


Fig. 1

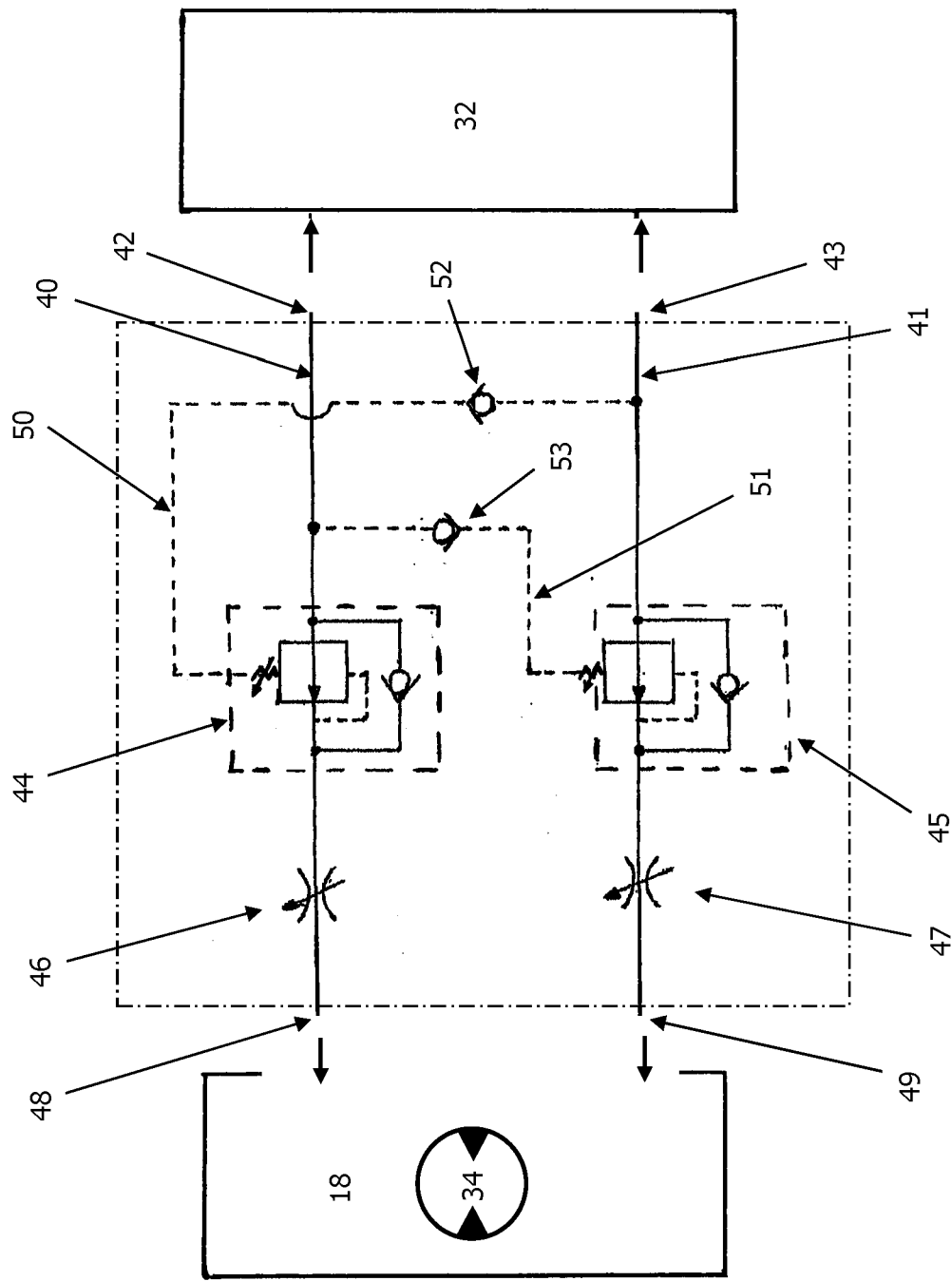


Fig. 2

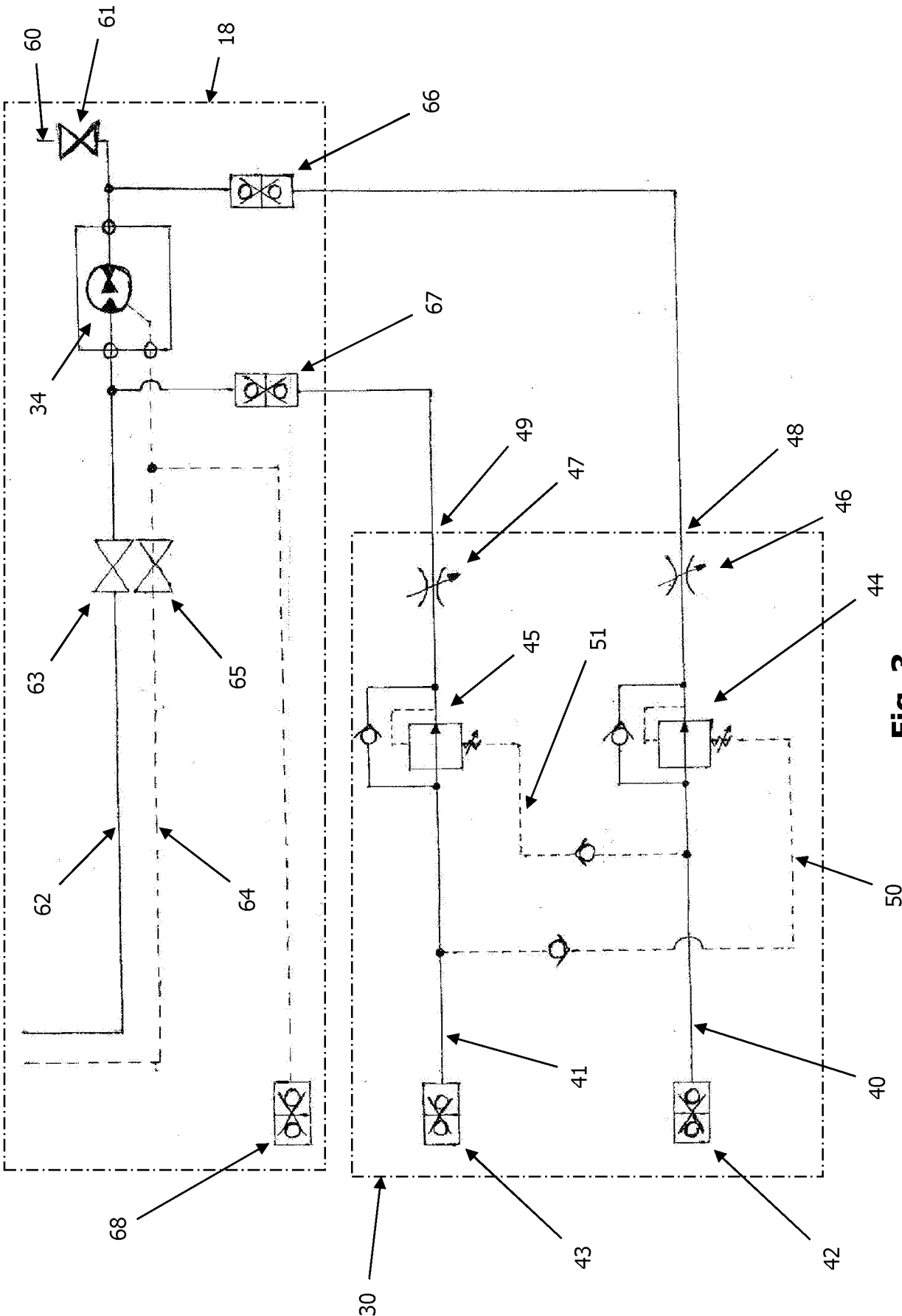


Fig. 3

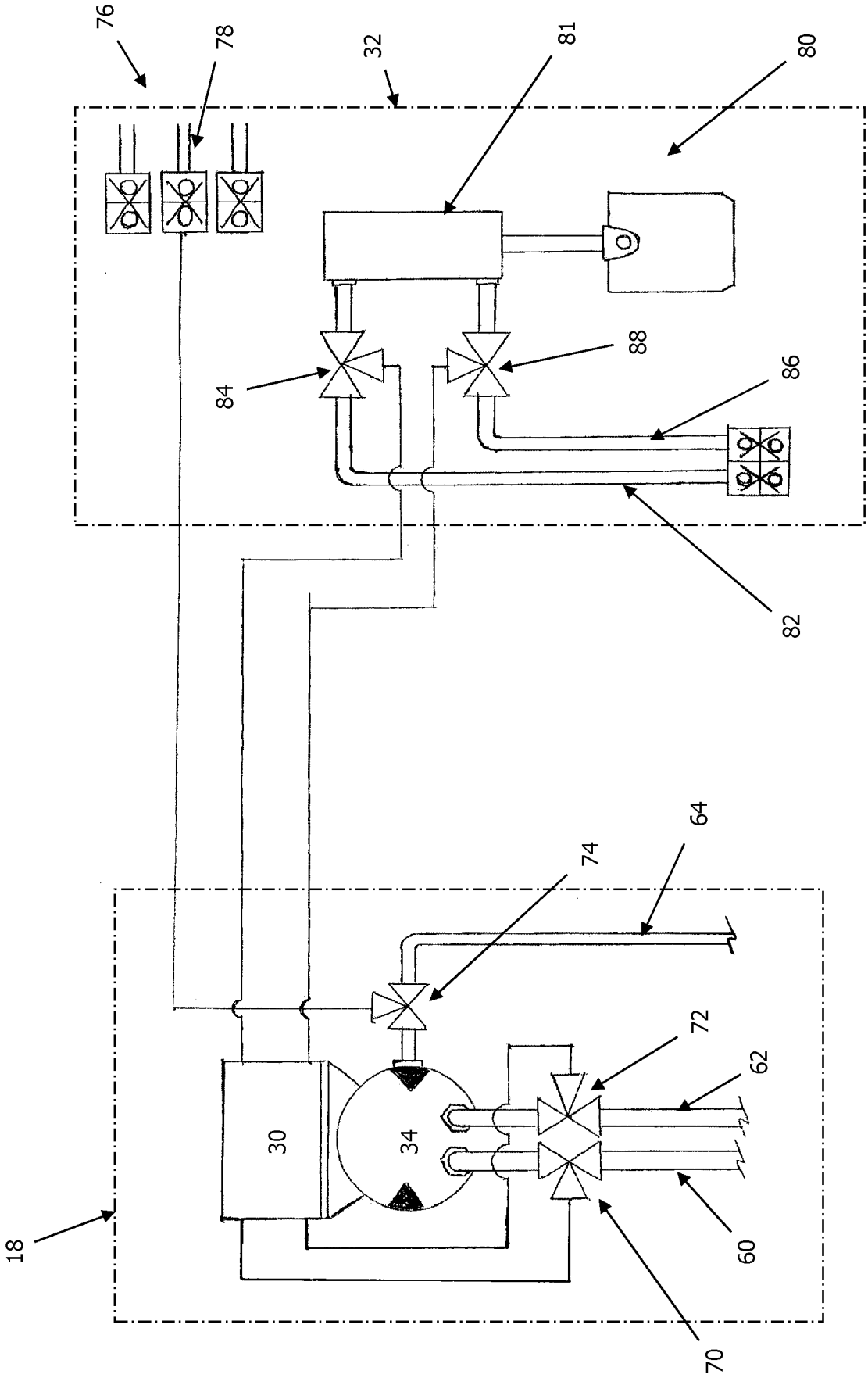


Fig. 4

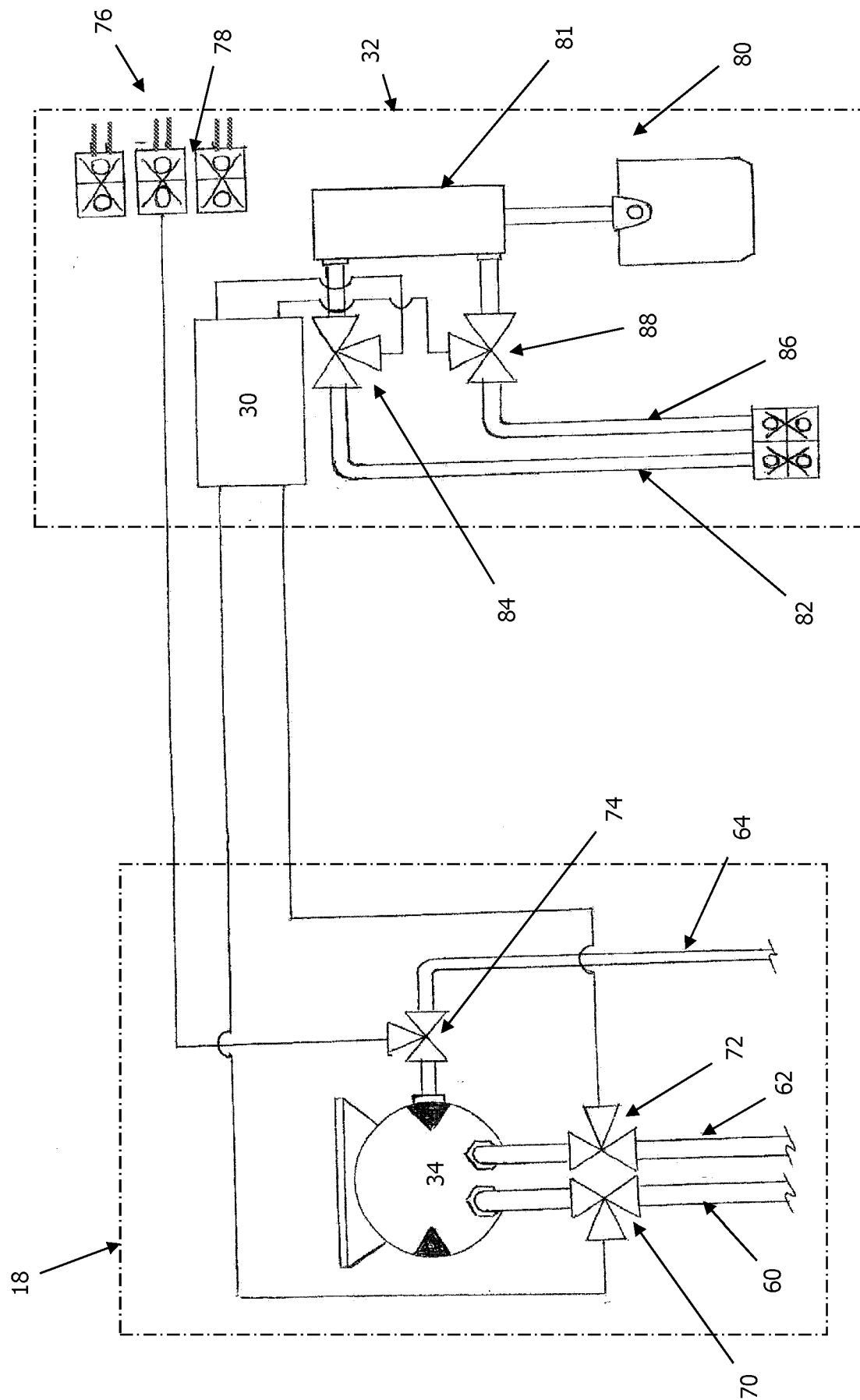


Fig. 5

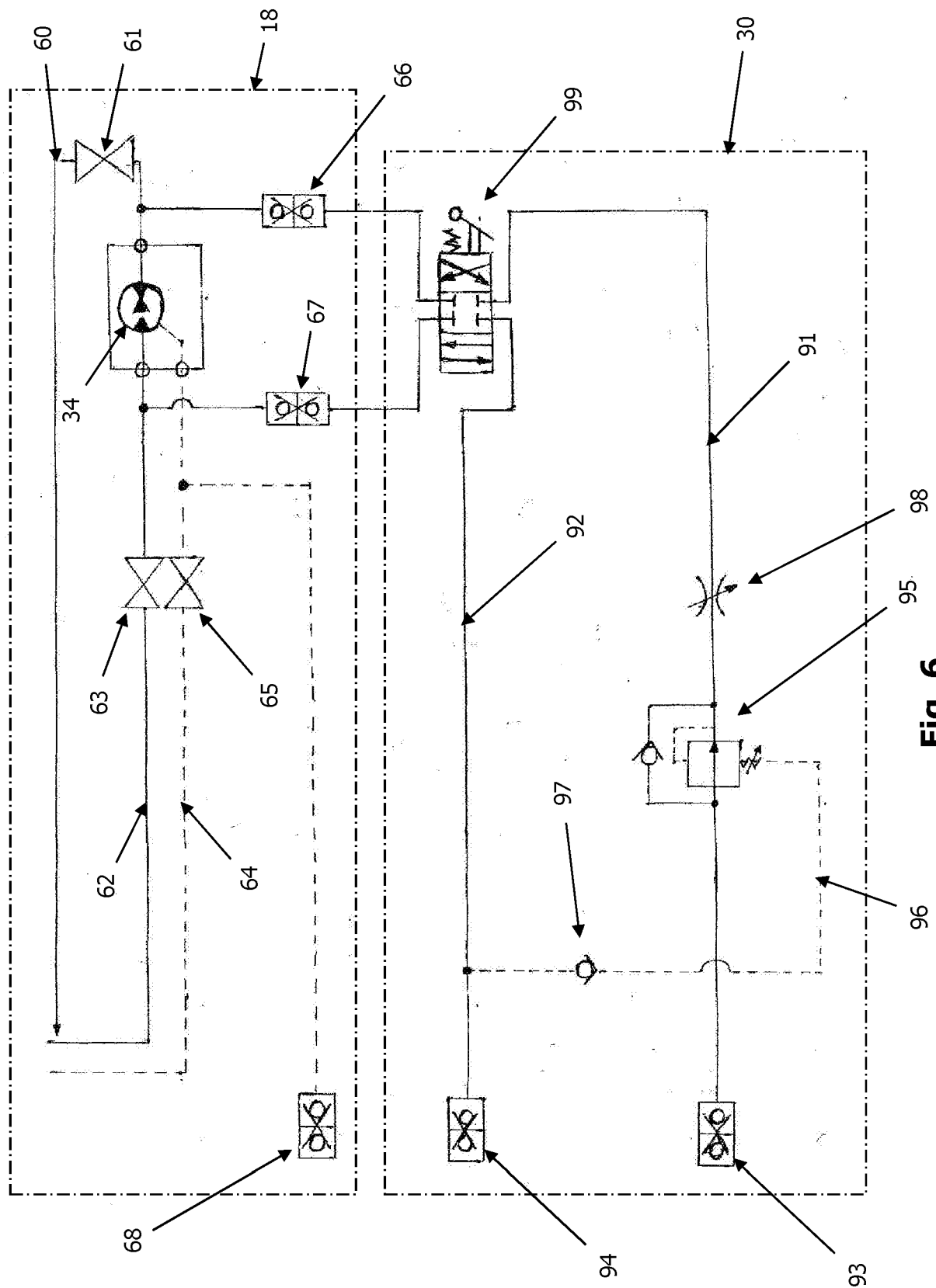


Fig. 6

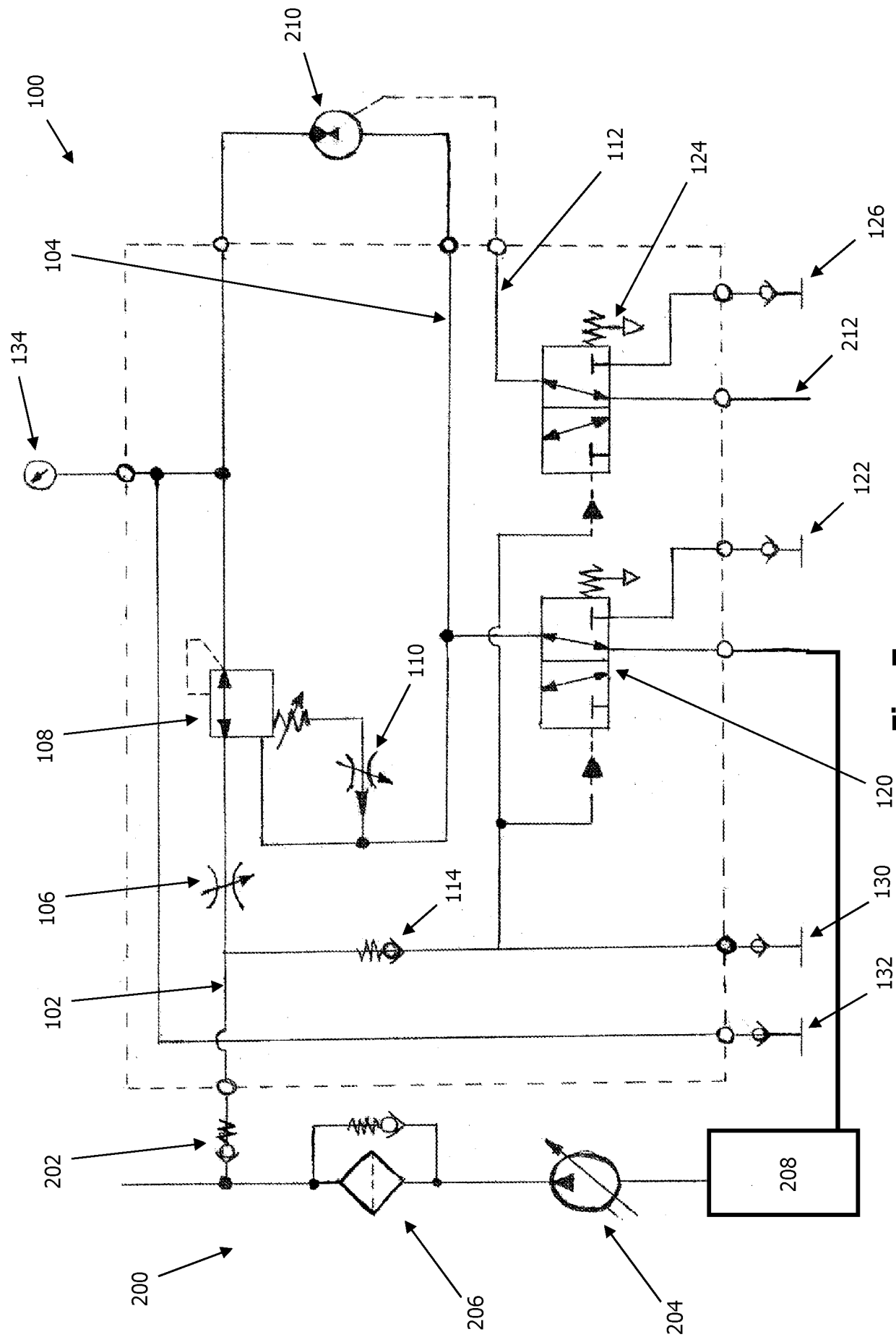


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2016/050146

A. CLASSIFICATION OF SUBJECT MATTER

E21F 13/02 (2006.01) E21C 41/16 (2006.01) B65H 75/42 (2006.01) H02G 11/02 (2006.01) B60K 17/10 (2006.01)
E02F 9/22 (2006.01)

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)

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)

EPODOC - CPC: E21F13/025, E21F13/02/low, H02G11/02, B65H75/42/low, B60K2025/005, B60K2025/06, B60K2025/065 and Keywords (reel, spool, electric) & like terms; **TXTE** - CPC as per **EPODOC** and Keywords (spool, sheave, reel, roll, pulley, drum, wind, hydraulic, fluid, hydrostatic, umbilical, trail, cable, conductor, auxiliary, supplement, supply, power, source) & like terms; **EPODOC/WPIAP** - IPC/CPC: E21F13/02, E21F13/08, E21F17/04/low, H02G11/02, B65H75/42/low, B60K2025/005, B60K2025/026, B60K2025/065, H02B1/52, E21C41/16/low, E02F13/low and Keywords (*As TXTE above* & shuttle, mine, car, wagon, vehicle, load, dump, underground, subterranean, mining) & like terms. IPC/CPC: B60K17/04, B60K17/10, B66F9/205, B66F9/22, E02F9/2264/low and Keywords (second, additional, separate, supplement, standby, auxiliary, cascaded, system, circuit, source, supply, switch, changeover, select, divert, shift, valve, cock, gate, spring, elastic, resilient, bias, flexible) & like terms.

AUSPAT: Applicant/inventor names searches; ESPACENET: Applicant/inventor name searches, CPC: E21F13/025, E02F9/22/low.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"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	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 30 May 2016		Date of mailing of the international search report 30 May 2016	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au		Authorised officer Mark Smith AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832573	

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2016/050146
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 2007216811 A1 (WARATAH ENGINEERING PTY LTD) 02 April 2009 Whole document, esp. Page 1 lines 15 - page 2 line 2, page 3 line 32 - page 6 line 33; Figs 1 & 6	6, 9-16
Y	As above	7-8
A	As above	1-4
X	US 3770151 A (JAMISON) 06 November 1973 Abstract; Col. 3 line 27 - col. 6 line 41; Figs 1-6	6, 9
A	As above	14
Y	US 3334839 A (CARLSON) 08 August 1967 Col. 1 line 16 - col. 3 line 19; Fig. 1	7-8
A	As above	5, 9-10, 14-15
A	US 4528892 A (OKABE et al.) 16 July 1985 Abstract; Col. 3 - line 66 - col. 9 line 34; Fig. 1	4-9
A	US 2264007 A (RUSSELL) 25 November 1941 Page 2 line 23 - page 3 line 10; Figs 1, 5-6	1

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

Supplemental Box**Continuation of: Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-5 are directed to a method of advancing an underground mining operation. The feature of the steps (after advancing a mining shuttle) of disconnecting a trailing electrical cable supplying the mining shuttle from an underground power distribution control box, reeling the cable onto a mining shuttle using an ancillary hydraulic power source, moving the control box and reconnecting the electrical cable to the re-located control box is specific to this group of claims.
- Claims 6-12 and 13-16 are directed to a hydraulic circuit and a system for connecting a hydraulic motor of a first vehicle to a second hydraulic system, wherein the vehicle has a first hydraulic system supplying the motor. The feature of the combination of an auxiliary supply inlet and a return outlet and associated valving system allowing the second hydraulic circuit to selectively control the hydraulic motor of the first hydraulic system is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is the step of connecting an ancillary or second hydraulic system to a first hydraulic circuit of a first vehicle (e.g. a mining shuttle), which first circuit is connected to a hydraulic motor for operating the motor.

However this feature does not make a contribution over the prior art because it is disclosed in:

D2: US 3770151 A (JAMISON) 6 November 1973

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

Given the technical differences that exist between the two inventions, search and examination for the substantially broader second invention required more than negligible additional effort over that for the first invention, and therefore an additional search fee was considered to be warranted.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2016/050146	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
AU 2007216811 A1	02 April 2009	AU 2007216811 A1	02 Apr 2009
		AU 2007216811 B2	27 Jun 2013
US 3770151 A	06 November 1973	US 3770151 A	06 Nov 1973
		AU 464450 B2	12 Aug 1975
		AU 4346772 A	20 Dec 1973
		CA 959422 A	17 Dec 1974
		US 3712489 A	23 Jan 1973
		ZA 7204039 A	27 Feb 1974
US 3334839 A	08 August 1967	US 3334839 A	08 Aug 1967
US 4528892 A	16 July 1985	US 4528892 A	16 Jul 1985
		EP 0087748 A1	07 Sep 1983
		EP 0087748 B1	18 Jun 1986
		JP S58146630 A	01 Sep 1983
		JP H0143097 B2	19 Sep 1989
US 2264007 A	25 November 1941	US 2264007 A	25 Nov 1941
End of Annex			