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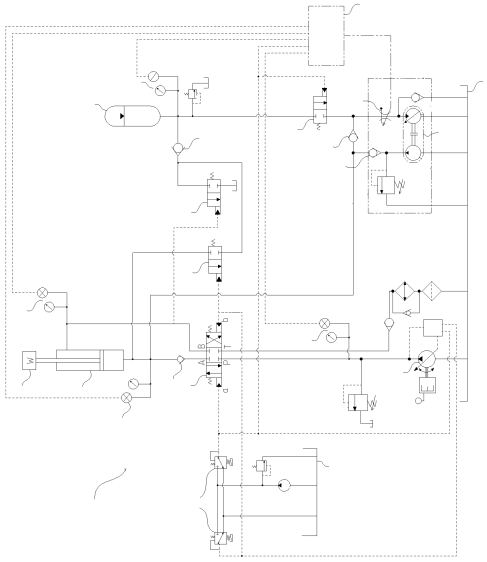
(54) Title: A HYDRAULIC HYBRID SYSTEM FOR ENERGY RECOVERY FROM BOOM OF AN OFFHIGHWAY MACHINES

(57) Abstract: A hydraulic system for recovering energy during vertical lifting/lowering of one or more component of an off-highway machine is disclosed. The disclosed hydraulic system includes at least one pump, one or more hydraulic cylinder, a plurality of direction control valves and a plurality of pressure transmitter/gauge. The hydraulic cylinder is operable to lift a lifting structural member by a high-pressure fluid wherein the fluid is either supplied by the pump from a tank or/and from an accumulator. The accumulator is configured to store the high-pressure fluid returning from the hydraulic cylinder during lowering of the lifting structural member. The direction control valves are configured to check: the flow of the high-pressure fluid from the hydraulic cylinder to the accumulator during lowering of the lifting structural member, the flow of the high-pressure fluid from the accumulator to the hydraulic cylinder during lifting of the lifting structural member; and the flow of the high-pressure fluid from the hydraulic cylinder to the tank during lowering of the lifting structural member once the accumulator capacity is full. The pressure transmitter/gauge may further be configured to measures the pressure at outlet/inlet of the pumps, hydraulic cylinder and the accumulator to enable control operation of the valves.



FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003
Complete Specification
(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

A Hydraulic Hybrid System for Energy Recovery from Boom of an Off-Highway Machines

2. APPLICANT(S)

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification particularly describes the invention and the manner in which it is to be performed.

DESCRIPTION

Technical field

[001] This disclosure relates generally to off-highway hydraulic machines, and more particularly to energy recovery from moveable parts of an off-highway hydraulic machine.

BACKGROUND

[002] Off-highway machines like construction equipment, material handling and agricultural equipment lift heavy objects, along with a lifting structural member and associated parts such as, but not limited to, boom and parts fitted on boom like Arm, Arm cylinder, bucket, bucket cylinders and mechanisms of excavator etc., to execute the tasks. Typically, the off-highway machines use one or more hydraulic cylinders or actuators for performing a lifting work. The hydraulic cylinders or actuators receive a fluid supply by a pump to lift or lower the lifting structural member. The lifting structural member acquire significant amount of potential energy on achieving an elevated position. Once the lifting task is performed by the hydraulic cylinder, the lifted or extended lifting structural member is lowered by retracting the hydraulic cylinder. On retracting, a high-pressure fluid returning from the hydraulic cylinder is throttled over a direction control valve to get controlled lowering speed of the lifted structural member to prevent accident and void formation in an upper side chamber of the cylinder. Sometime one or more orifices may be fitted in the return line to increase hydraulic resistance and control lowering. While lowering, the potential energy gets converted into heat, which is a wastage and may increases wear and tear.

[003] The energy loss may be more in machines where lifting and lowering is frequent like excavators, wheel loaders, forklift trucks, telescopic material handlers, Cranes etc. There is need of an energy recovery system, which can convert potential energy of lifted object and associated parts in a useful form and thereby reduce energy consumption.

SUMMARY OF THE INVENTION

[004] A hydraulic system for recovering energy during vertical lifting/lowering of one or more component of an off-highway machine is disclosed. The disclosed hydraulic system includes at least one pump, one or more hydraulic cylinder, a plurality of direction control valves and a plurality of pressure transmitter/gauge. The hydraulic cylinder is operable to lift a lifting structural member by a high-pressure fluid wherein the fluid is either supplied by the pump from a tank or/and from an accumulator. The accumulator is configured to store the high-

pressure fluid returning from the hydraulic cylinder during lowering of the lifting structural member. The direction control valves are configured to check: the flow of the high-pressure fluid from the hydraulic cylinder to the accumulator during lowering of the lifting structural member, the flow of the high-pressure fluid from the accumulator to the hydraulic cylinder during lifting of the lifting structural member; and the flow of the high-pressure fluid from the hydraulic cylinder to the tank during lowering of the lifting structural member once the accumulator capacity is full. The pressure transmitter/gauge may further be configured to measures the pressure at outlet/inlet of the pumps, hydraulic cylinder and the accumulator to enable control operation of the valves.

BRIEF DESCRIPTION OF THE DRAWINGS

[005] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[006] Figure 1, illustrates an exemplary hydraulic system circuit diagram for recovering energy from one or more component of an off-highway machine according to an embodiment of the invention;

[007] Figure 2, illustrates another exemplary hydraulic system circuit diagram for recovering energy from one or more component of an off-highway machine according to an embodiment of the invention;

[008] Figure 3, illustrates yet another exemplary hydraulic system circuit diagram for recovering energy from one or more component of yet another off-highway machine according to an embodiment of the invention; and

[009] Figure 4, illustrates yet another exemplary hydraulic system circuit diagram for recovering energy from one or more component of an off-highway machine according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[010] Exemplary **e**mbodiments are described with reference to accompanying figures/diagrams, wherever convenient the same numbers are used throughout the drawings to refer to same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations and other implementations are possible without departing

from spirit and scope of disclosed embodiments. It is intended that the following detailed description be considered as exemplary only with the true scope and spirit being indicated in claims.

[011] Figure 1 illustrates an exemplary hydraulic system 100 circuit diagram for recovering energy from one or more component of an off-highway machine according to an embodiment of the invention. The illustrated circuit diagram is for an exemplary lifting/lowering mechanism of a hydro-mechanical machine such as, but not limited to, an excavator. The hydraulic system 100 includes a pump 102 and a hydraulic cylinder 104. According to an exemplary embodiment, the pump 102 is a variable displacement pump and the hydraulic cylinder 104 is a double acting hydraulic cylinder. The hydraulic cylinder 104 may be attached to a lifting structural member 106 such as, but not limited to, a bucket. A fluid may be supplied from a tank 108 by the pump 102 to operate the hydraulic cylinder 104 through a pilot operated first direction control valve 110 using a first controller 112. The first controller 112 may supply a signal to a first side of the first direction control valve 110 and the high-pressure fluid from the pump 102 may be supplied to the hydraulic cylinder 104 to lift the lifting structural member 106.

[012] According to embodiments of the invention, a pilot operated second direction control valve 114 may be employed during lowering the lifting structural member 106 and directs the fluid returning from the hydraulic cylinder 104 to pass to an accumulator 118 through a first check valve 120. The hydraulic system 100 may include a second check valve 122, which may prevent return of the high-pressure fluid from the hydraulic cylinder 104 to the tank 108 through the first direction control valve 110, while lowering.

[013] A pilot operated third direction control valve 124 may be provided to return the fluid to the tank 108, if the accumulator 118 is filled to its capacity. According to an embodiment, the third direction control valve 124 may work by sensing a rod end pressure of the hydraulic cylinder 104.

[014] According to an embodiment of the invention, the accumulator 118 is configured to store the high-pressure fluid received from the hydraulic cylinder 104. The stored high-pressure fluid from the accumulator 118 may be supplied to an input or piston side of the hydraulic cylinder 104 during the lifting command or to any other connected hydraulic cylinders or mechanisms, through a pilot operated fourth direction control valve 126. According to an exemplary embodiment, the fourth direction control valve 126 may be a two-position-two-way

direction control valve. The accumulator 118 supplies fluid either directly by opening of a third check valve 128 in free flow direction or through a secondary pump system 130 which increases the pressure of fluid supplied by the accumulator 118 and then supplies the fluid to the hydraulic cylinders 104 or to an outlet of the pump 102. The fluid from the accumulator 118 may be supplied to the secondary pump system 130 through a control valve 132.

[015] According to an embodiment, whenever the first direction control valve 110 is commanded by the first controller 112 to extend the cylinder 104 to lift an object, the fluid from the accumulator 118 is supplied to the piston side of the hydraulic cylinder 104 by opening of the pilot operated fourth direction control valve 126 and the third check valve 128 in the free flow direction.

[016] According to an embodiment of the invention, the tank 108 may provide a suction fluid to the secondary pump system 130. A first pressure transmitter/gauge 134 may be provided in the accumulator line to measure the pressure of fluid in the accumulator 118 and a fourth check valve 136 may be provided at the outlet of the secondary pump system 130, to prevent back or return of fluid from the outlet to a suction side of the secondary pump system 130. A second pressure transmitter/ gauge 138 may be provided to measure the piston side pressure of the hydraulic cylinder 104, a third pressure transmitter/ gauge 140 may be provided to measures the rod end pressure of the hydraulic cylinder 104 and a fourth pressure transmitter/gauge 142 may be provided to measures the pressure at outlet of the pump 102. The second 138, third 140 and fourth 142 pressure transmitter/gauges may be fitted to measure the pressures in the respective lines and transmit if required to a second controller 144 which in turn depending upon feedbacks and the first controller 112, decides command to control different hydraulic valves of hydraulic system 100, which may be manual/pilot operated or electronically controlled. The disclosed arrangement reduces the flow demand from the main pump 102 and thus fuel consumption or power consumption of hydro-mechanical machines reduces.

[017] According to yet another embodiment, the pilot operated direction control valve 114 works during lowering by sensing the pilot pressure and directs the fluid returning from the hydraulic cylinder 104 to pass to the accumulator 118 through a pilot operated direction control valve 146 and the check valve 120 as illustrated in figure 2. The pilot operated direction control valve 146 senses the piston side load pressure at its one end as measured by the second pressure transmitter/gauge 138 and the accumulator pressure at other end as measured by first pressure

transmitter/gauge 134 and dumps fluid returning from the cylinder 104 to the tank 108, if accumulator 118 is already sufficiently filled.

[018] According to yet another embodiment, the disclosed system may not require any secondary pump system as illustrated in figure 3. According to this embodiment, the accumulator 118 may supply back the stored fluid to the piston side of the hydraulic cylinder 104 during lifting command of boom or to other connected hydraulic cylinders or mechanisms, by opening of a pilot operated fifth check valve 148 which opens by the pilot pressure supply by the first controller 112 during lifting command and allows pressurized oil from the accumulator 118 to pass directly to the lifting cylinder 104 or to any other connected actuators (not shown).

[019] Figure 4 illustrates another exemplary hydraulic system 200 circuit diagram for recovering energy from one or more component of an off-highway machine according to an embodiment of the invention. The hydraulic system 200 includes a pump 202 and a hydraulic cylinder 204. The hydraulic cylinder 204 may be attached to a lifting structural member 206. A fluid may be supplied from a tank 208 by the pump 202 to operate the hydraulic cylinder 204 through a pilot operated first direction control valve 210 using a first controller 212. The first controller 212 may supply a signal to a first side of the first direction control valve 210 and the high-pressure fluid from the pump 202 may be supplied to the hydraulic cylinder 204 to lift the lifting structural member 206.

[020] According to embodiments of the invention, a pilot operated second direction control valve 214 may be employed during lowering the lifting structural member 206 and directs the fluid returning from the hydraulic cylinder 204 to pass to an accumulator 218 through a first check valve 220.

[021] According to an embodiment of the invention, the accumulator 218 supplies fluid either directly by opening of a third check valve 228 in free flow direction or through the secondary pump system 230 which increases the pressure of fluid supplied by the accumulator 218 and then supplies the fluid to the hydraulic cylinders 204 or to an outlet of the pump 202. The fluid from the accumulator 218 may be supplied to the secondary pump system 230 through a flow control valve 254.

[022] According to an embodiment of the invention, the accumulator 218 may supply back the stored high-pressure fluid by a three-position three-way pilot operated direction control

valve 252 to hydraulic cylinder 204 during lifting of boom as commanded by the first controller 212 and also partly to outlet of the pump 202 during lowering of boom as controlled by a flow controlled valve 254, which may be manual or electronic controlled depending upon application. Further, the flow control valve 254 may be pressure and temperature compensated to control flow independent of variation in temperature, viscosity or any other physical property of fluid.

We Claim:

1. A hydraulic system 100 for recovering energy during vertical lifting/lowering of one or more component of an off-highway machine comprising:

at least one pump 102;

one or more hydraulic cylinder 104, the hydraulic cylinder 104 is operable to lift a lifting structural member 106 by a high-pressure fluid, the fluid is either supplied by the pump 102 from a tank 108 or/and from an accumulator 118, wherein the accumulator 118 being configured to store the high-pressure fluid returning from the hydraulic cylinder 104 during lowering of the lifting structural member 106;

a plurality of direction control valves for:

configuring the flow of the high-pressure fluid from the hydraulic cylinder 104 to the accumulator 118 during lowering of the lifting structural member 106;

configuring the flow of the high-pressure fluid from the accumulator 118 to the hydraulic cylinder 104 during lifting of the lifting structural member 106; and

configuring the flow of the high-pressure fluid from the hydraulic cylinder 104 to the tank 108 during lowering of the lifting structural member 106 once the accumulator 118 capacity is full;

a plurality of pressure transmitter/gauge 134, 138, 140, 142 to measures the pressure at outlet/inlet of the pumps, hydraulic cylinder 104 and the accumulator 118

2. The hydraulic system 100 as claimed in claim 1, wherein the fluid returning from the hydraulic cylinder 104 to the accumulator 118 is through a first check valve 120.

3. The hydraulic system 100 as claimed in claim 1, wherein the lifting structural member 106 is a bucket.

4. The hydraulic system 100 as claimed in claim 1, wherein the pump 102 is a variable displacement pump and the hydraulic cylinder 104 is a double acting hydraulic cylinder.

5. The hydraulic system 100 as claimed in claim 1, wherein at least one of the direction control valve is a two-position-two-way direction control valve.

6. The hydraulic system 100 as claimed in claim 1, wherein the fluid from the accumulator 118 may be supplied through a second pump to the hydraulic cylinder 104 during lifting of the lifting structural member 106.

7. The hydraulic system 100 as claimed in claim 1, wherein the direction control valve is pilot operated.

8. The hydraulic system 100 as claimed in claim 1, wherein the direction control valve is pilot operated check valve.

9. The hydraulic system 100 as claimed in claim 1, wherein the hydraulic cylinder 104 is a single acting hydraulic cylinder.

Dated this 24th day of March 2020

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A HYDRAULIC HYBRID SYSTEM FOR ENERGY RECOVERY FROM BOOM OF AN OFF- HIGHWAY MACHINES

Abstract

A hydraulic system for recovering energy during vertical lifting/lowering of one or more component of an off-highway machine is disclosed. The disclosed hydraulic system includes at least one pump, one or more hydraulic cylinder, a plurality of direction control valves and a plurality of pressure transmitter/gauge. The hydraulic cylinder is operable to lift a lifting structural member by a high-pressure fluid wherein the fluid is either supplied by the pump from a tank or/and from an accumulator. The accumulator is configured to store the high-pressure fluid returning from the hydraulic cylinder during lowering of the lifting structural member. The direction control valves are configured to check: the flow of the high-pressure fluid from the hydraulic cylinder to the accumulator during lowering of the lifting structural member, the flow of the high-pressure fluid from the accumulator to the hydraulic cylinder during lifting of the lifting structural member; and the flow of the high-pressure fluid from the hydraulic cylinder to the tank during lowering of the lifting structural member once the accumulator capacity is full. The pressure transmitter/gauge may further be configured to measures the pressure at outlet/inlet of the pumps, hydraulic cylinder and the accumulator to enable control operation of the valves.

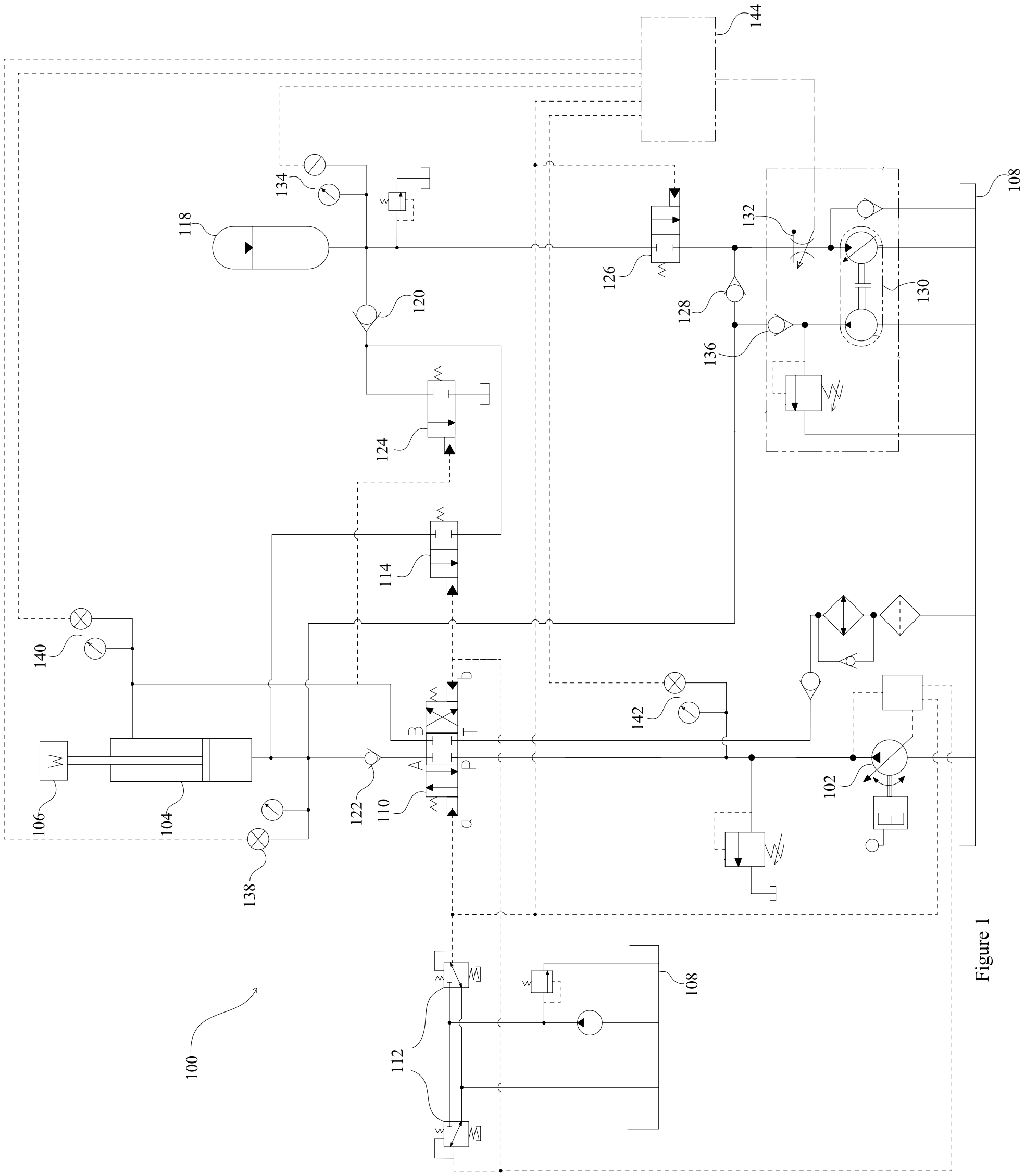

Figure 1

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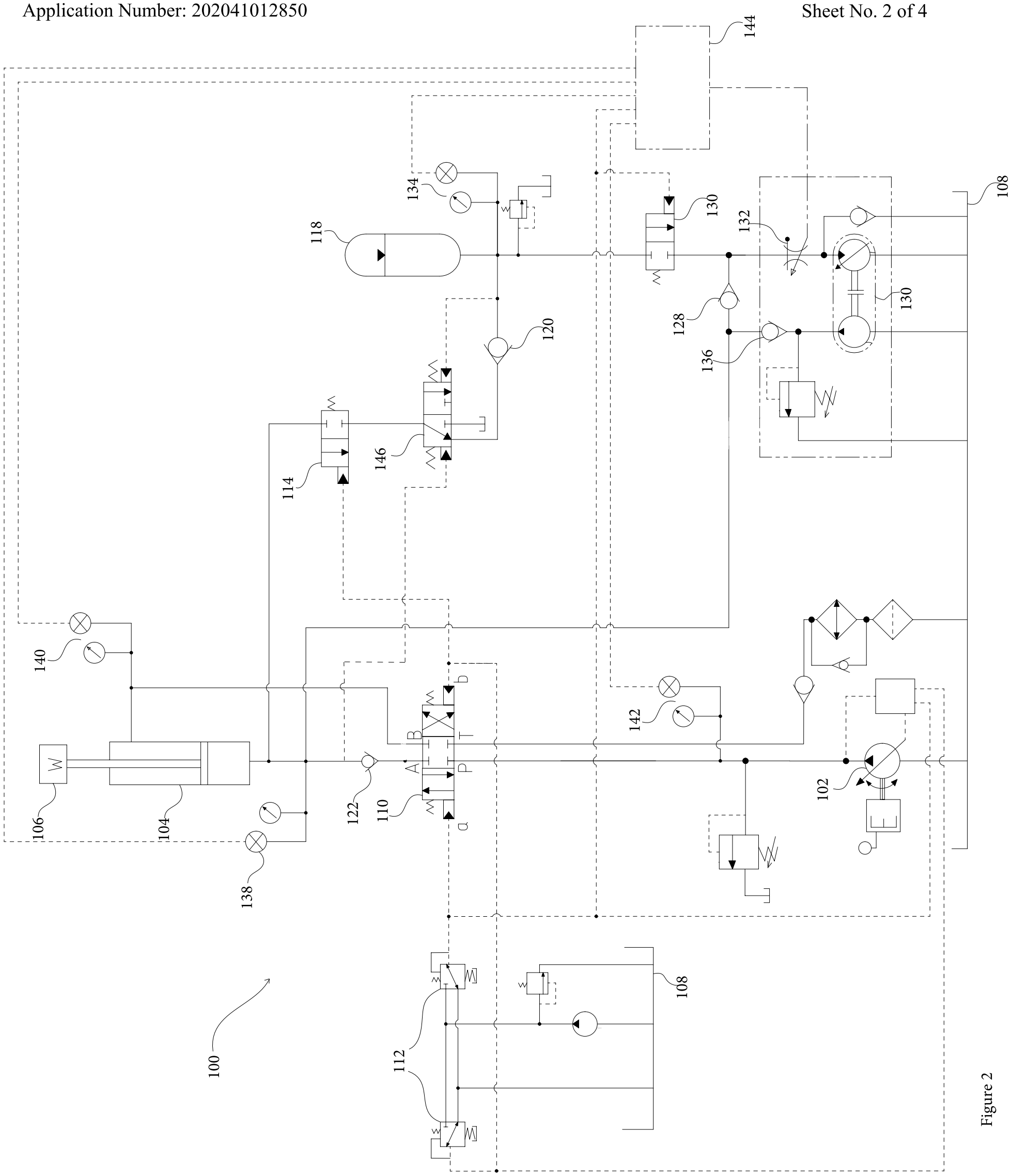

Figure 2

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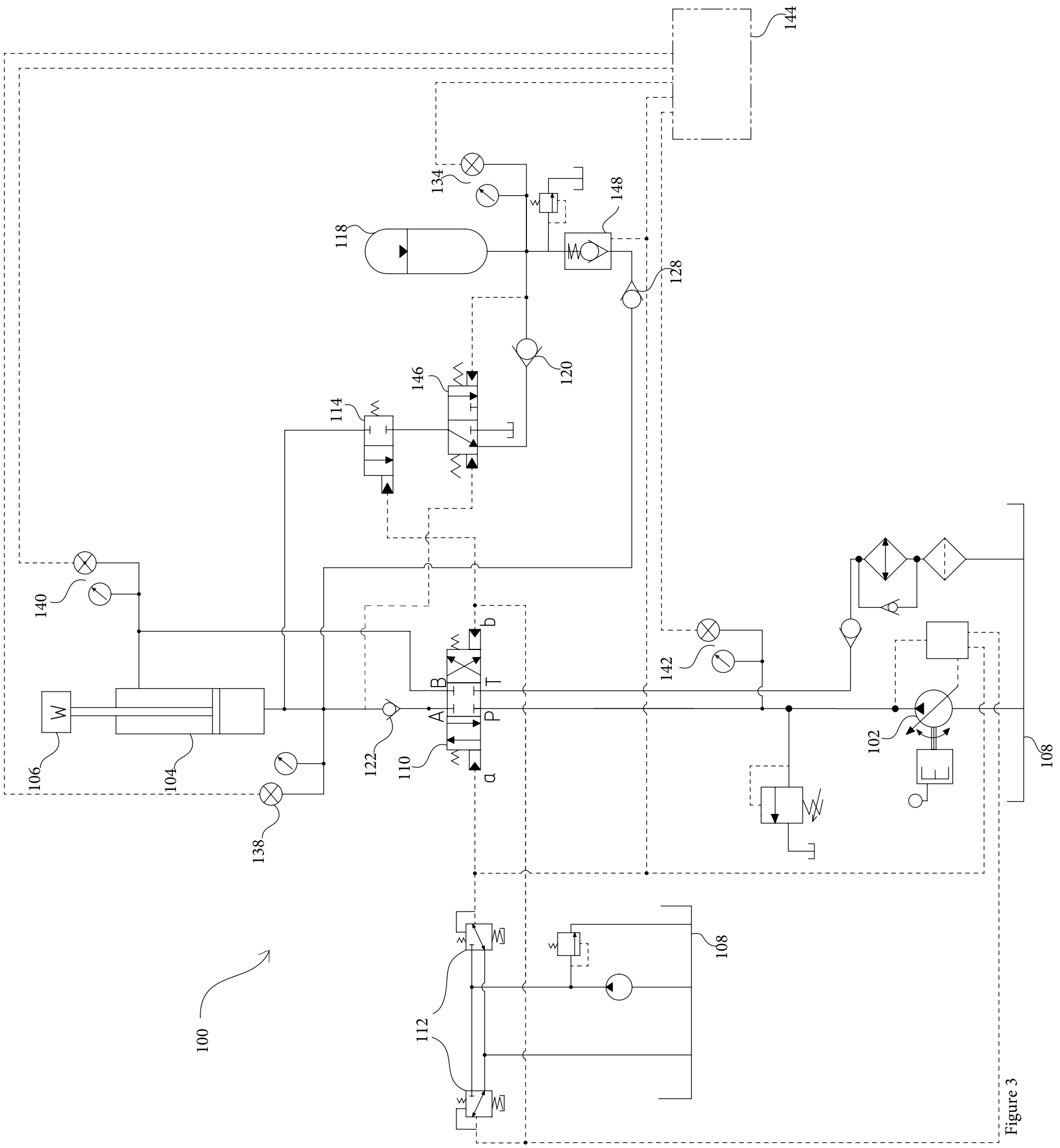

Figure 3

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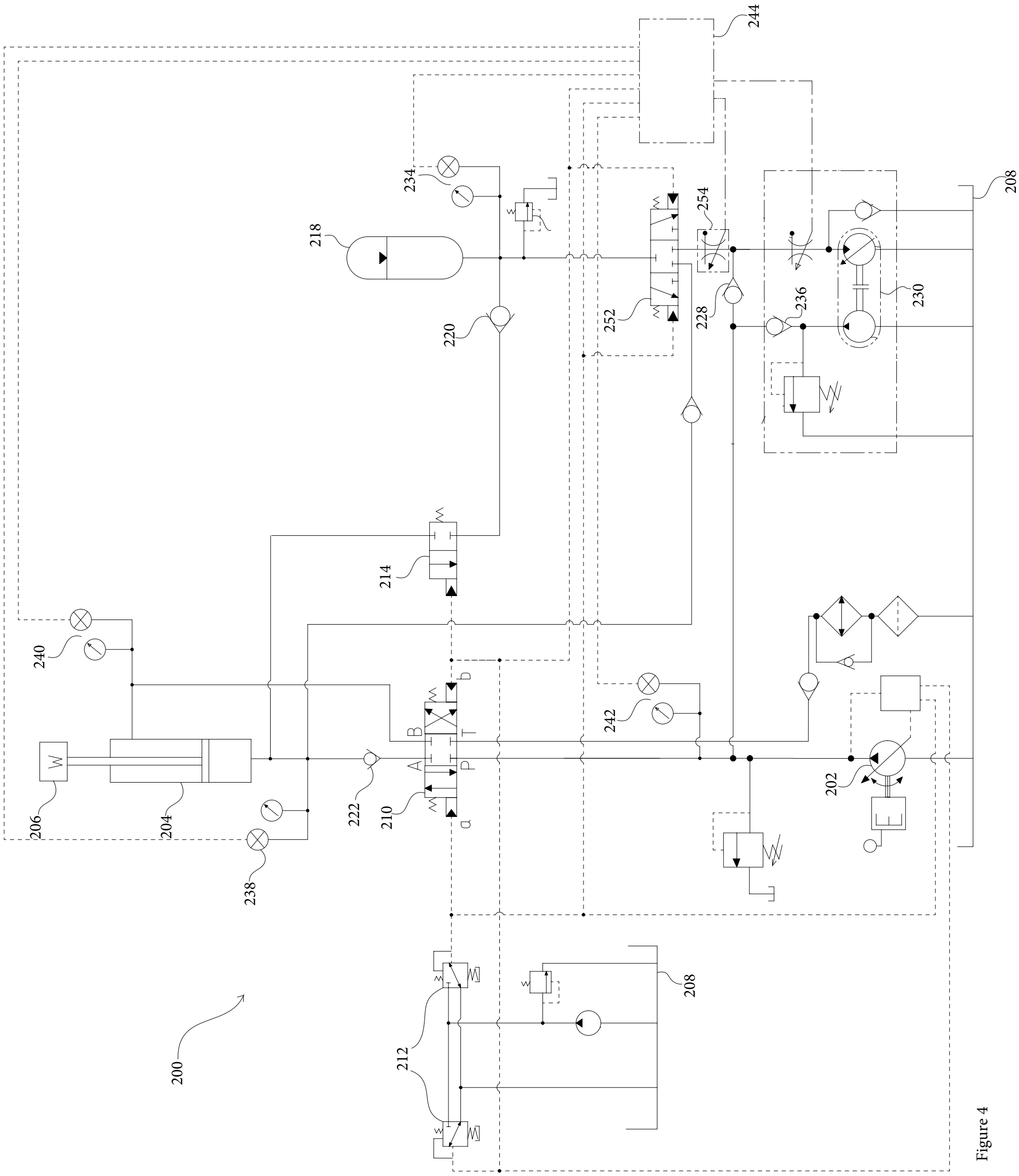

Figure 4

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