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(54) Title: OPERATOR COMMANDED HYDRAULIC PUMP FLOW

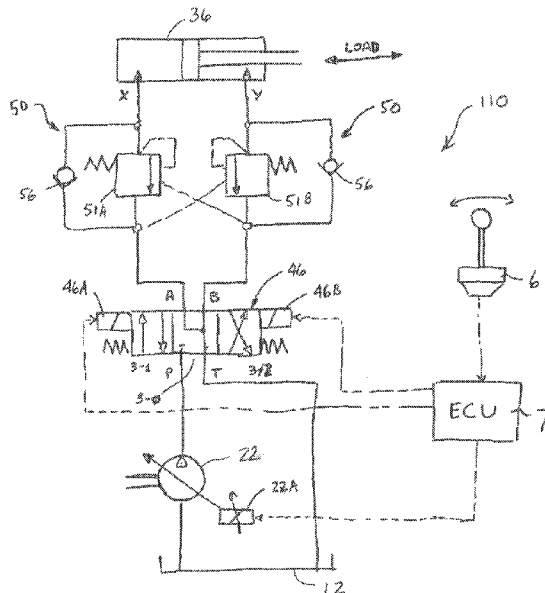


FIG. 2

(57) Abstract: A hydraulic actuator system is provided in which operator commanded flow is provided by a variable displacement hydraulic pump with electric control. The system includes an operator interface (5,6) which generates an output signal that is proportional to an input to the operator interface. The generated signal is used to control the variable displacement pump (22) to provide an operator commanded flow from the pump. The system includes a counterbalance valve (50) adapted to prevent over-running load conditions on the hydraulic actuator.

WO 2013/165951 A1

OPERATOR COMMANDED HYDRAULIC PUMP FLOW

CROSS-REFERENCE TO RELATED CASES

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/640,272; filed April 30, 2012, the disclosure of which is expressly incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a variable displacement hydraulic pump with electric control to generate the operator commanded flow. The invention has various applications including refuse vehicles used in residential curbside waste collection.

BACKGROUND

[0003] Modern refuse collection vehicles typically include an integral refuse collection bin and a compaction mechanism for compacting materials in or adjacent to the collection bin. Such vehicles may introduce refuse into the collection bin from the front, rear or side of the vehicle. Some such vehicles include mechanized handling devices which include a holding or grasping assembly for holding a refuse container. These handling devices typically include a container access assembly which is adapted to move the holding assembly into position to grab a container, and to cooperate with the holding assembly to lift and dump the contents of the container in the collection bin of the vehicle. The container access assembly may then be used to return the container to its original position. These holding assemblies and container access assemblies take many forms but are primarily in the form of an arm component that has a reaching, grabbing, lifting and/or rotating capabilities.

SUMMARY

[0004] At least one embodiment of the invention provides a hydraulic actuator system comprising: an operator interface adapted to generate an output signal that is proportional to an input to the operator interface; an electronic control unit which is adapted to control a variable displacement pump to provide an operator commanded flow from the pump which is selectively directed through a directional valve to control the flow direction to a hydraulic actuator, the system including a counterbalance valve adapted to prevent over-running load conditions on the hydraulic actuator.

[0005] At least one embodiment of the invention provides a system comprising: an operator interface adapted to generate an output signal that is proportional to an input to the operator interface, the operator interface connected to an electronic control unit which reads the output signal from the operator interface; a hydraulic pump having an input fluidly connected to a hydraulic fluid reservoir, the electronic control unit electrically connected to the pump through a pump solenoid valve such that an output flow of the pump is a function of the output signal from the operator interface; a directional control valve adapted to selectively allow hydraulic fluid to flow to a first port of a hydraulic actuator or to a second port of the hydraulic actuator or to prevent flow to the first and second ports of the hydraulic actuator, as directed by the electronic control unit; a counterbalance valve positioned between the directional control valve and one of the ports of the hydraulic actuator, the counterbalance valve adapted to prevent a load overrunning condition on the hydraulic actuator.

[0006] At least one embodiment of the invention provides a A system for a refuse vehicle having a refuse receptacle retrieval arm comprising: at least three variable displacement hydraulic pumps; a hydraulic fluid reservoir fluidly connected to the at least three hydraulic pumps; an electronic control unit which is adapted to control the at least three variable displacement pumps to provide an operator commanded flow from the pumps; a first pump of the at least three hydraulic pumps adapted to selectively supply hydraulic fluid to a first hydraulic actuator of the refuse receptacle retrieval arm through a first directional control valve; a second pump of the at least three hydraulic pumps adapted to supply hydraulic fluid to a second hydraulic actuator of the refuse receptacle retrieval arm through a second directional control valve; a third pump of the at least three hydraulic pumps adapted to supply hydraulic fluid to a third hydraulic actuator of the refuse receptacle retrieval arm through a third directional control valve; a counterbalance valve positioned between at least one of the directional control valves and an associated one of the hydraulic actuators.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of this invention will now be described in further detail with reference to the accompanying drawings, in which:

[0008] FIG. 1 is a system diagram of a first embodiment of the present invention in a refuse vehicle application;

[0009] FIG. 2 is a system diagram of a variable displacement hydraulic pump with electric control to generate the operator commanded flow as an embodiment of the present invention corresponding to the reach function shown in FIG. 1;

[0010] FIG. 3 is a system diagram of a variable displacement hydraulic pump with electric control to generate the operator commanded flow as another embodiment of the present invention that utilizes a single counterbalance valve corresponding to the lift function shown in FIG. 1;

[0011] FIG. 4 is a hydraulic circuit diagram of another embodiment of the present invention in a refuse vehicle application having additional functions over those shown in the embodiment of FIG. 1;

[0012] FIG. 5 is a schematic hydraulic circuit diagram similar to FIG. 1 but including the circuit corresponding to the packing and tailgate portions of the refuse vehicle; and

[0013] FIG. 6 is a schematic hydraulic circuit diagram of the circuit of FIG. 4 but including the circuit corresponding to the packing and tailgate portions of the refuse vehicle.

DETAILED DESCRIPTION

[0014] A hydraulic circuit 10 for a refuse vehicle having a refuse receptacle retrieval arm is shown in FIG. 1, the circuit comprising at least three hydraulic pumps 20, 22, 24. The hydraulic pumps 20, 22, 24 may different sizes that are optimized to the needs of the functions supplied by the pumps. The first pump 20 is adapted to selectively supply hydraulic fluid to a first function 30 of the refuse receptacle retrieval arm through a first directional control valve 40. The first function 30 is shown as a rotation function in the form of a bidirectional hydraulic motor 30. The second pump 22 is adapted to supply hydraulic fluid to a second function 32 of the refuse receptacle retrieval arm through a second directional control valve 42. The second function 32 is shown as the grab

function in the form of a hydraulic cylinder 32. The third pump 24 is adapted to supply hydraulic fluid to a third function 34 of the refuse receptacle retrieval arm through a third directional control valve 44. The third function 34 is shown as the lift function in the form of a hydraulic cylinder 34. As shown, the second pump 22 is also adapted to supply hydraulic fluid to a fourth function 36 of the refuse receptacle retrieval arm through a fourth directional control valve 46. The fourth function 36 is shown as the reach function in the form of an elongated hydraulic cylinder 36. The second function 32 and the fourth function 36 are typically functions that do not operate at the same time but rather sequentially during operation of the arm such that the pump 22 is supplying fluid to only one function. The directional control valves 40, 42, 44, 46 are shown as simple four way, three position spool type solenoid valve. The use of multiple optimal sized pumps facilitates the use of simple directional control valves whereas the use of a single pump or even a tandem pump requires more complex and expensive valves.

[0015] The valves 40, 42, 44, 46 may be positioned in arm manifold 48. The rotation and grab functions 30, 32 may include swivel manifold 16. The circuit 10 as shown includes appropriate pressure relief and check valves in parallel (counterbalance valve) as shown at 50. The circuit also includes a filter and check valves in parallel as shown at 52 at the return to the hydraulic fluid reservoir 12. Shut off valves 54 are positioned between the hydraulic fluid reservoir 12 and the pumps 20, 22, and 24.

[0016] The system 10 may be controlled by an operator through one or more interfaces 5, 6. Operator interfaces 5, 6 are of the electric type, for example, a joystick or a similar human interface. These interfaces 5, 6 are proportional; this means each generates an output signal that is proportional to the lever position. The interfaces 5, 6

are connected to an electronic control unit or ECU 7 which reads the interface input. The ECU 7 has electric outputs connected to the pump solenoids 20A, 22A, 24A and the valve solenoids 40A, 40B, 42A, 42B, 44A, 44B, 46A, 46B. (the connections from the ECU 7 to valve solenoids 40A, 40B, 42A, 42B are not shown in FIG. 1 for clarity purposes). The displacement of the pumps 20, 22, 24 is controlled by the ECU 7 so that the pump outlet flow is a function of the electric signal outputted by the operator's interface 5, 6. Furthermore, the direction of the pump flow is diverted towards valve ports A or B by energizing the solenoids 40A, 40B, 42A, 42B, 44A, 44B, 46A, 46B depending on which direction the human interface 5, 6 is moved. E.g., if the device 5, 6 is a proportional joystick, the pump flow is a function of the joystick stroke imposed by the operator and the ECU 7 energizes the solenoids 40A, 40B, 42A, 42B, 44A, 44B, 46A, 46B depending if the joystick lever 5, 6 is shifted up or down (or left or right). In a refuse vehicle application, the operator interfaces 5, 6 may be replaced by a predetermined input that is configured to move the actuators 30, 32, 34, 36 through a predetermined cycle. In this instance the operator commanded flow is the flow required to complete the predetermined cycle. However the application of the concept of proportional movement of the load being achieved with the pump and not the valve is not limited to a refuse application. For example, an isolation of the cylinder 36 is shown in Fig. 2 as a separate system.

[0017] The system 110 of Fig. 2 comprises the cylinder 36, a pair of counterbalance valves 50, directional valve 46 actuated by ECU 7 through solenoids 46A, 46B and pump 22 controlled by ECU through solenoid 22A as proportionally controlled by interface 6. The suction of the pump 22 is connected to the hydraulic reservoir 12 which

contains the hydraulic fluid. The outlet of the pump 22 supplies flow to the one 4-way 3-position directional control valve 46 which has the following characteristics: the 4 ports of the valve are P (connected to the outlet of the pump 22), T (connected to the reservoir 12), A and B (connected to hydraulic actuator 36). The same valve 46 has three possible configurations (3-0, 3-1, and 3-2) and is electrically controlled with two on/off solenoids 46A and 46B: when no solenoid is energized, the valve spool is in neutral position (3-0) where the P port is blocked and the A, B and T port are mutually connected. If solenoid 46B is energized, the valve shifts in the position (3-1) where P port is connected to A and port B to T, if solenoid 46A is energized the valve shifts in the position (3-2), where P is connected to B and port A to T.

[0018] The ports A and B are each connected to a counterbalance valve 50 (shown designated as relief valves 51A and 51B with corresponding check valves 56). These valves have multiple functionalities: a) they hold the load when valve 46 is in neutral position, b) they provide relief protection in case of external loads when valve 46 is in neutral position, c) they avoid the phenomenon of uncontrolled run-away loads, when the actuator 36 is moving and the load has the same direction of the current actuator speed. This happens by sensing the pressure on the opposite line and creating a restriction on the return side if the pressure on the supply side drops below a threshold value, set by the counterbalance spring.

[0019] The actuator 36 has two ports (X and Y) which, depending on where the oil is supplied, determine the direction of movement. In Fig. 2 the actuator 36 is represented as linear type, however it can also be a rotary type actuator.

[0020] The operation of the counterbalance valves 50 in combination with the directional valve 46 with pump 22 is now discussed with respect to two distinct operating conditions.

[0021] If the load is resistive (this corresponds in Fig. 2 to energizing solenoid 46B), the pump flow is directed to port A, passes through the check valve 56 and moves the actuator 36 in the right direction (against the load). The pressure generated at port A by the load completely opens valve 51B and allows the return flow to go from port Y to the reservoir 12 (through port B) with no restrictions on the return line. The actuator 46 therefore moves at a speed which is proportional to the outlet flow of pump 22 and the pump pressure is determined by the load entity.

[0022] If the load is over-running (this corresponds in Fig. 2 to energizing solenoid 46A), the pump flow is directed to port B, passes through the check valve 56 and moves the actuator 36 towards the left (in the same direction of the load). Here, the load does not generate any pressure at port B, therefore valve 51A remains closed. This causes the pressure at port B (i.e. at pump outlet) to rise until this pressure is able to partially open valve 51A, which creates a restriction and avoids the cylinder 36 to move uncontrolled. Thanks to valve 51A the cylinder 36 will still move to a speed proportional to the speed of the pump 22. The pump pressure, instead, is determined by the settings of the counterbalance valve 51A in conjunction with the load magnitude.

[0023] In other words, the invention claims the use of a variable displacement pump 22 with electric control 7 to generate the operator commanded flow together with a simple on-off directional valve 46 to control the flow direction and one or two counterbalance valves 50 for preventing over-running load conditions. The solenoid

valve 46, when energized, opens completely offering theoretically no restriction to either the pump flow supply and the actuator return flow.

[0024] Fig. 3 shows a similar isolated system 110' to Fig. 2; in fact here the direction of the load is known to be in only one direction, therefore only one counterbalance is required. This system corresponds to the isolated lift actuator 34 and pump 24 in Fig. 1.

[0025] Returning to the application of the invention in a refuse vehicle application, various different arm configurations may include different functions and the present invention is not limited to a particular arm configuration. As shown in FIG. 4, the circuit 10' for the arm may include a fifth function 38. The second pump 22 is adapted to supply hydraulic fluid to the fifth function 38 of the refuse receptacle retrieval arm through a fifth directional control valve 48 shown in manifold 14'. The second function 32, fourth function 36, and fifth function 38 are typically functions that do not operate at the same time but rather sequentially during operation of the arm such that the pump 22 is supplying fluid to only one function. The fifth function 38 is shown as the boom function in the form of an elongated hydraulic cylinder 38. The rotation, grab and boom functions 30, 32, 38 may include swivel manifold 16'. The fifth function 38 includes appropriate pressure relief and check valves in parallel (counterbalance valve) as shown at 50 as well as check valves 56.

[0026] The hydraulic circuit may also be utilized to control other functions of the refuse vehicle. Referring now to FIG. 5, the hydraulic circuit 10'' is the same as circuit 10, except that the pumps 20, 22, 24 may supply hydraulic fluid to a packer function shown in the form of cylinders 60, 62 as well as tailgate functions shown as operation of

the top door cylinders 70, 72, the tailgate cylinders 74, 76, and the tailgate lock cylinders 78, 79. The supply of hydraulic fluid to the packer cylinders 60, 62 is provided by six way, three position, air piloted control valve 80, 82, respectively. The supply of hydraulic fluid to the tailgate cylinders 70 and 72, 74 and 76, 78 and 79 is provided by four way, three position, solenoid directional control valve 90, 92, 93, respectively. Pump 20 is connected to the packer functions and tailgate functions past check valve 56. Pump 22 and pump 24 may also provide hydraulic fluid to the packer functions and tailgate functions past check valves 56 and solenoid valve 58.

[0027] Referring now to FIG. 6, the hydraulic circuit 10''' is the same as circuit 10'', but including the fifth function 36 as shown and described with respect to FIG. 4.

[0028] The circuits shown are adaptable for use with the controls disclosed by the applicant in PCT International Patent Application PCT/US12/27679 filed March 5, 2012 entitled Electro-hydraulic System for Controlling Multiple Functions and fully incorporated herein by reference.

[0029] Although the principles, embodiments and operation of the present invention have been described in detail herein, this is not to be construed as being limited to the particular illustrative forms disclosed. They will thus become apparent to those skilled in the art that various modifications of the embodiments herein can be made without departing from the spirit or scope of the invention.

CLAIMS

1. A hydraulic actuator system comprising:
 - an operator interface adapted to generate an output signal that is proportional to an input to the operator interface;
 - an electronic control unit which is adapted to control a variable displacement pump to provide an operator commanded flow from the pump which is selectively directed through a directional valve to control the flow direction to a hydraulic actuator, the system including a counterbalance valve adapted to prevent over-running load conditions on the hydraulic actuator.

2. The system of claim 1, wherein the counterbalance valve comprises two counterbalance valves, each positioned between the directional control valve and one of two ports on the hydraulic actuator, each counterbalance valve adapted to prevent a load overrunning condition on the hydraulic actuator.

3. The system of claim 1, wherein the directional control valve is a four way, three position directional control valve.

4. A system comprising:
 - an operator interface adapted to generate an output signal that is proportional to an input to the operator interface, the operator interface connected to an electronic control unit which reads the output signal from the operator interface;

a hydraulic pump having an input fluidly connected to a hydraulic fluid reservoir, the electronic control unit electrically connected to the pump through a pump solenoid valve such that an output flow of the pump is a function of the output signal from the operator interface;

a directional control valve adapted to selectively allow hydraulic fluid to flow to a first port of a hydraulic actuator or to a second port of the hydraulic actuator or to prevent flow to the first and second ports of the hydraulic actuator, as directed by the electronic control unit;

a counterbalance valve positioned between the directional control valve and one of the ports of the hydraulic actuator, the counterbalance valve adapted to prevent a load overrunning condition on the hydraulic actuator.

5. The system of claim 4, wherein the counterbalance valve comprises two counterbalance valves, each positioned between the directional control valve and one of the ports of the hydraulic actuator, each counterbalance valve adapted to prevent a load overrunning condition on the hydraulic actuator.

6. The system of claim 4, wherein the directional control valve is a four way, three position directional control valve.

7. The system of claim 4 wherein the pump is an electronically controlled variable displacement pump.

8. The system of claim 4, wherein the system is part of a refuse vehicle retrieval arm actuation and control system.

9. The system of claim 8, wherein the pump comprises at least three hydraulic pumps;

a first pump of the at least three hydraulic pumps adapted to selectively supply hydraulic fluid to a first function of the refuse receptacle retrieval arm through a first directional control valve;

a second pump of the at least three hydraulic pumps adapted to supply hydraulic fluid to a second function of the refuse receptacle retrieval arm through a second directional control valve;

a third pump of the at least three hydraulic pumps adapted to supply hydraulic fluid to a third function of the refuse receptacle retrieval arm through a third directional control valve.

10. The system of claim 9, wherein the second pump further adapted to supply hydraulic fluid to a fourth function of the refuse receptacle retrieval arm through a fourth directional control valve.

11. A system for a refuse vehicle having a refuse receptacle retrieval arm comprising:

at least three variable displacement hydraulic pumps;

a hydraulic fluid reservoir fluidly connected to the at least three hydraulic pumps;

an electronic control unit which is adapted to control the at least three variable displacement pumps to provide an operator commanded flow from the pumps;

a first pump of the at least three hydraulic pumps adapted to selectively supply hydraulic fluid to a first hydraulic actuator of the refuse receptacle retrieval arm through a first directional control valve;

a second pump of the at least three hydraulic pumps adapted to supply hydraulic fluid to a second hydraulic actuator of the refuse receptacle retrieval arm through a second directional control valve;

a third pump of the at least three hydraulic pumps adapted to supply hydraulic fluid to a third hydraulic actuator of the refuse receptacle retrieval arm through a third directional control valve;

a counterbalance valve positioned between at least one of the directional control valves and an associated one of the hydraulic actuators.

12. The system of claim 11, wherein the second pump further adapted to supply hydraulic fluid to a fourth hydraulic actuator of the refuse receptacle retrieval arm through a fourth directional control valve.

13. The system of claim 11 wherein the at least three hydraulic pumps are different sizes.

14. The system of claim 11 wherein the first hydraulic actuator provides a rotation function.

15. The system of claim 11 wherein the second hydraulic actuator provides a grab function.
16. The system of claim 11 wherein the third hydraulic actuator provides a lift function.
17. The system of claim 12 wherein the fourth hydraulic actuator provides a reach function.
18. The system of claim 12 wherein the second pump is adapted to supply hydraulic fluid to a fifth hydraulic actuator of the refuse receptacle retrieval arm.
19. The system of claim 18 wherein the fifth hydraulic actuator provides a boom function.
20. The system of claim 11 wherein at least one of the hydraulic pumps is adapted to provide hydraulic fluid to a plurality of packing cylinders of the refuse vehicle.
21. The system of claim 11 wherein at least one of the hydraulic pumps is adapted to provide hydraulic fluid to a plurality of tailgate cylinders of the refuse vehicle.
22. The system of claim 11 wherein the directional control valves are four way, three position spool type solenoid valves.

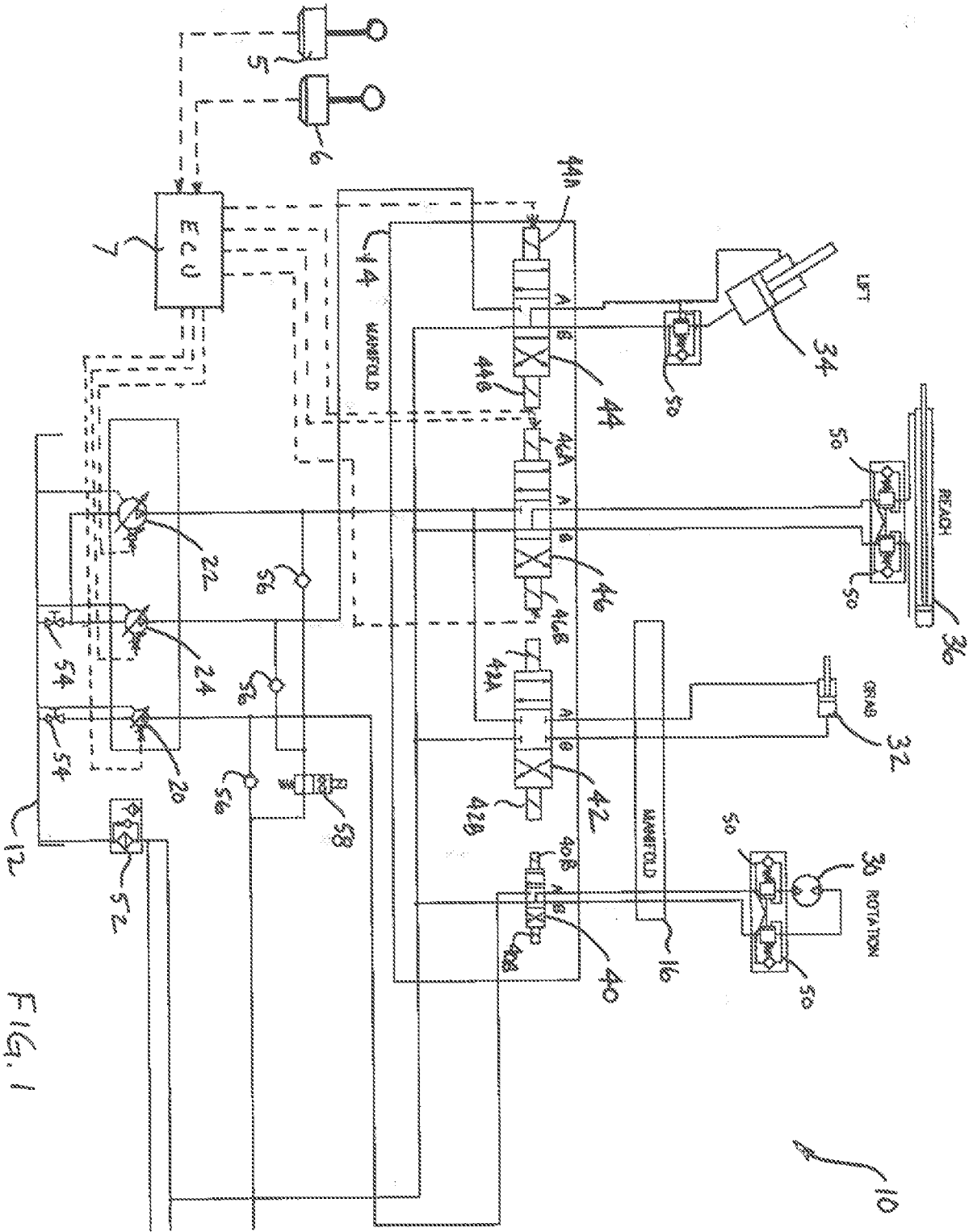


FIG. 1

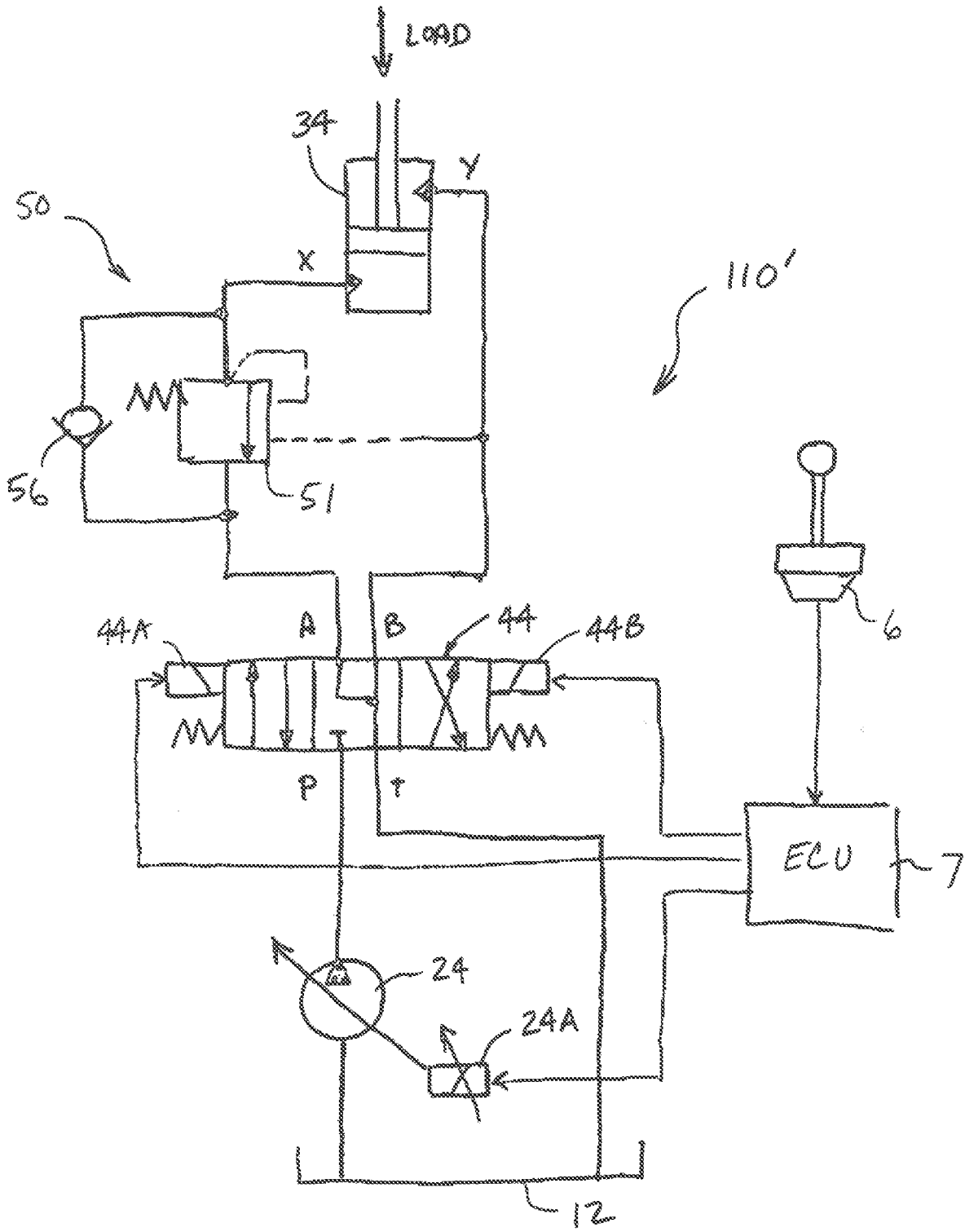
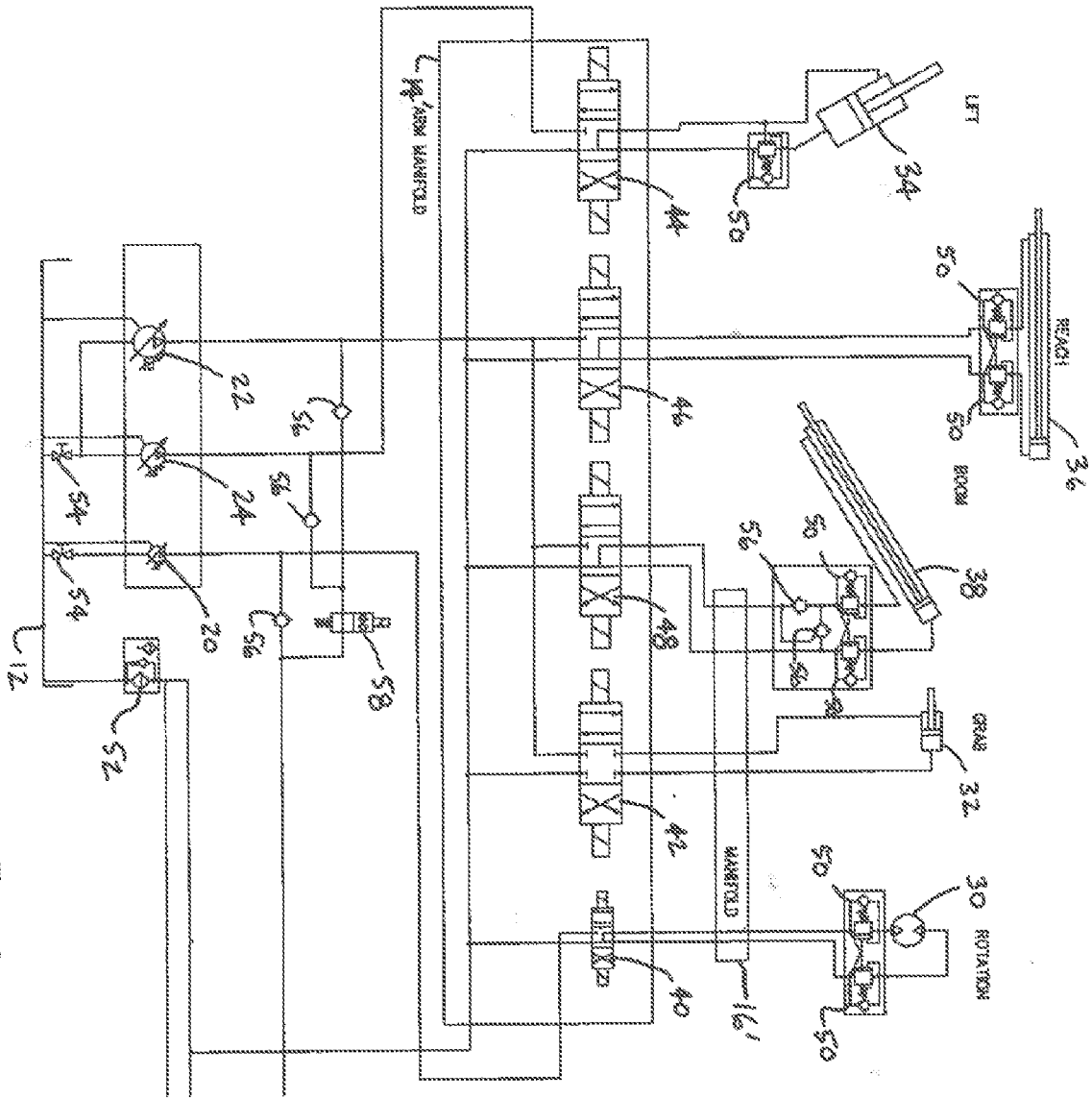


FIG. 3



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FIG. 4

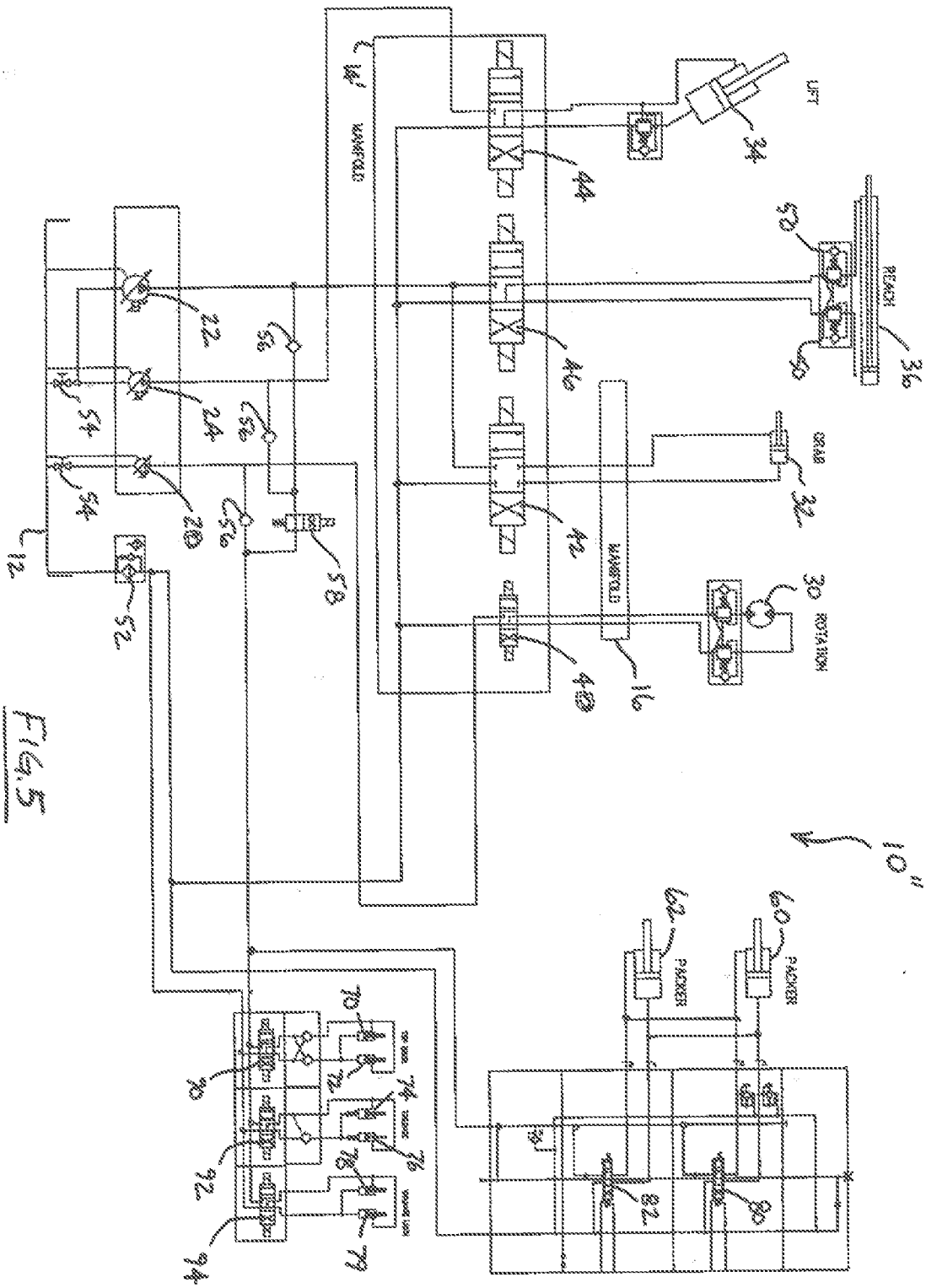


FIG. 5

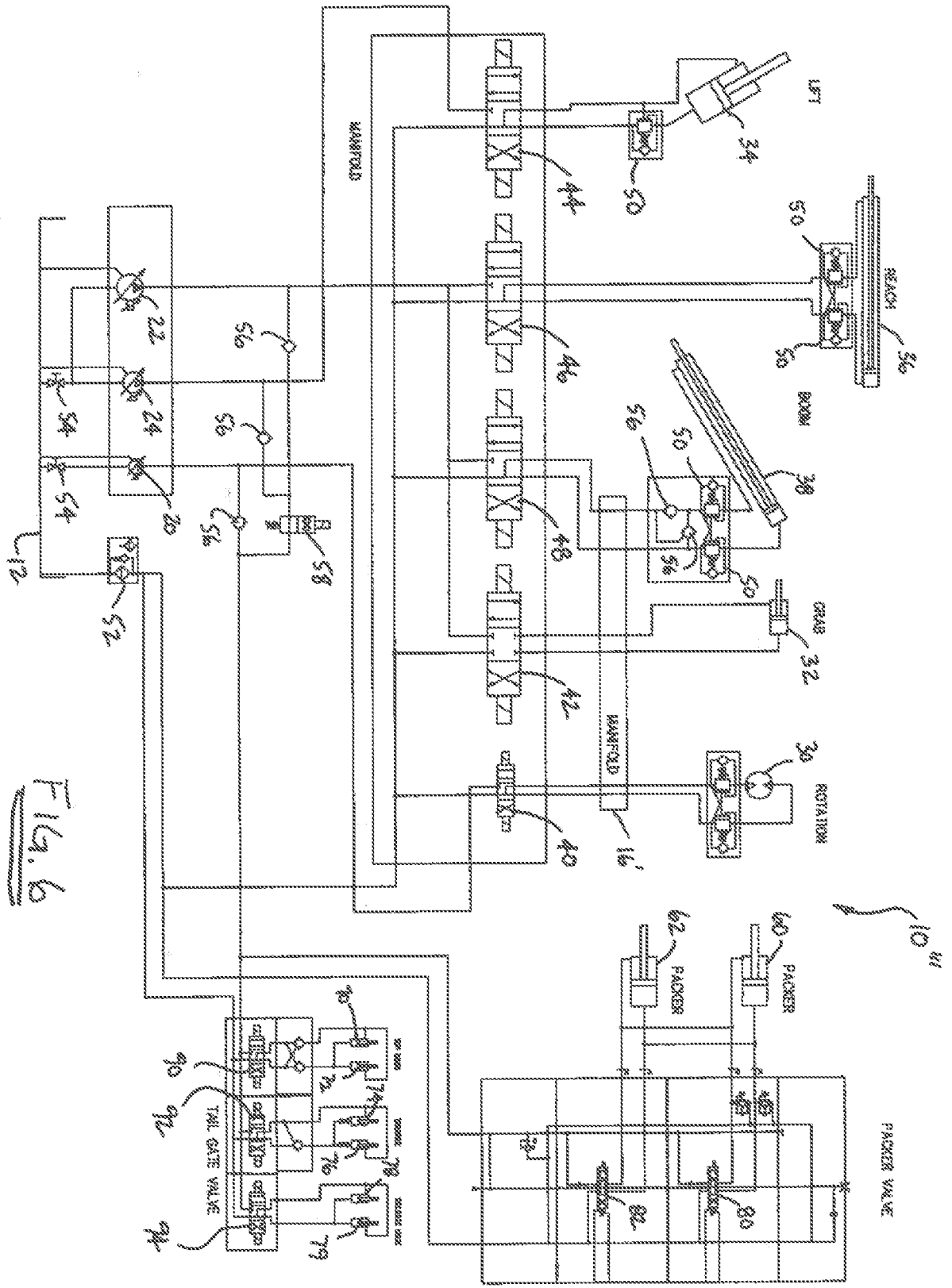


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/038766

A. CLASSIFICATION OF SUBJECT MATTER
INV. F15B11/044 B65F3/06
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
F15B B65F
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/009950 A1 (ARTEMIS INTELLIGENT POWER LTD [GB]; RAMPEN WILLIAM HUGH SALVIN [GB]; C) 24 January 2008 (2008-01-24) paragraph [0021] - paragraph [0035]; figure 1 -----	1-22
X	EP 1 930 604 A2 (BOSCH GMBH ROBERT [DE]) 11 June 2008 (2008-06-11) paragraph [0001] - paragraph [0004] paragraph [0018] - paragraph [0032]; figure 1 -----	1-22

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

"A" 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 2 July 2013	Date of mailing of the international search report 10/07/2013
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Bindreiff, Romain

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/038766

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