(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 561 298 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.10.2019 Bulletin 2019/44

(21) Application number: **18425030.6**

(22) Date of filing: **24.04.2018**

(51) Int Cl.:
F04B 1/22 *(2006.01)* ***F04B 1/30*** *(2006.01)*
F04B 49/22 *(2006.01)* ***F04B 1/20*** *(2006.01)*
F04B 7/00 *(2006.01)* ***F04B 49/06*** *(2006.01)*
F03C 1/06 *(2006.01)* ***F03C 1/40*** *(2006.01)*

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

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(54) PISTON HYDRAULIC DEVICE

(57) A piston hydraulic device is disclosed. The device comprises a cylinder block having a plurality of cylinder assemblies. The cylinder block being rotatable about a first rotation axis wherein each cylinder assembly comprises a cylinder and a piston. A first conduit provides passage of a fluid at a first pressure. A second conduit provides passage of a fluid at a second pressure wherein the first pressure is different from the second pressure. The piston hydraulic device further comprises a plurality of directional control valves fluidly connected to the first and second conduits and the respective cylinders wherein each directional control valve connects the respective cylinder to the first conduit in a first position and to the second conduit in a second position. A controller is operatively associated with the directional control valves for switching between the first and the second positions.

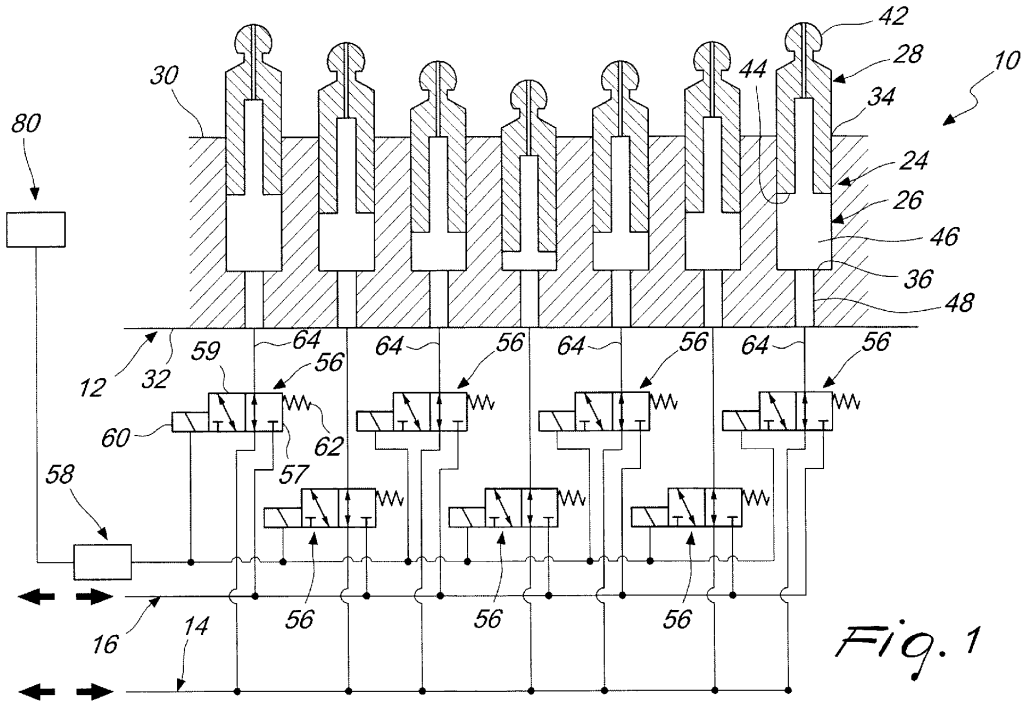

Fig. 1

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Description

Technical Field

[0001] This disclosure relates to the field of piston hydraulic devices such as pumps or motors, particularly to variable displacement piston hydraulic devices, and more particularly to the control of the fluid displacement and of management of early/late connection with the high/low pressure line in the piston hydraulic devices.

Background

[0002] Piston hydraulic devices may be axial piston machines or radial piston. The piston hydraulic devices may be operated as pumps or motors.

[0003] Variable axial piston hydraulic devices may be swash plate type devices or bent axis type devices. Swash plate type axial piston devices have a tiltable swash plate that controls the stroke of the piston within a rotating cylinder block. With bent axis type axial piston devices, the pistons are at an angle to the drive/ driven shaft.

[0004] In both the "swash plate" and the "bent axis" types, the devices comprise a cylinder block carrying the pistons. The cylinder block rotates about a first axis. The devices also comprise a transmission shaft that rotates around a second axis of rotation, also called the transmission axis. Through this shaft mechanical work that is carried out for the compression of fluid (in the case of the pumps) or mechanical work (in the case of the motors) is determined by the pressure of the operating fluid.

[0005] In the swash plate type device, the first and second axes coincide. The swash plate has a variable inclination to vary the stroke of the pistons between the dead points and, accordingly, the displacement of the machine. For varying displacement in the swash plate type device, the inclination of the plate is varied to change the stroke of the pistons.

[0006] In bent-axis type device, the first and the second axis are incident. The relative inclination of these axes is varied to vary the stroke of the pistons between the dead points and, accordingly, the displacement of the machine. For varying displacement in the bent-axis type device, the inclination of the cylinder block is varied.

[0007] In both the "swash plate" and the "bent axis" types, the device comprises a port plate having a first port and a second port for the connection of the chamber of each piston, alternately, to the high and low pressure line. The first and second ports are angularly spaced relative to the first rotation axis. The geometry of the first and second ports is fixed and defines the timing for the connection of the chamber of each piston to the high or the low pressure line relative to the dead points of piston travel.

[0008] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of the prior art system.

Brief Summary of the Invention

[0009] In a first aspect, the present disclosure describes a piston hydraulic device comprising a cylinder block having a plurality of cylinder assemblies, the cylinder block being rotatable about a first rotation axis wherein each cylinder assembly comprises a cylinder and a piston; a first conduit for the passage of a fluid at a first pressure; a second conduit for the passage of a fluid at a second pressure wherein the first pressure is different from the second pressure; characterized in that, the piston hydraulic device further comprises a plurality of directional control valves fluidly connected to the first and second conduits and the respective cylinders wherein each directional control valve connects the respective cylinder to the first conduit in a first position and to the second conduit in a second position; and a controller operatively associated with the directional control valves for switching between the first and the second positions.

[0010] In a second aspect, the present disclosure describes a method for controlling a piston hydraulic device. The method comprises the steps of providing a cylinder block having a plurality of cylinder assemblies, the cylinder block being rotatable about a first rotation axis wherein each cylinder assembly comprises a cylinder and a piston; supplying or receiving a fluid at a first pressure through a first conduit; supplying or receiving a fluid at a second pressure through a second conduit wherein the first pressure is different from the second pressure; and actuating independently a plurality of directional control valves between a first and a second positions, the plurality of directional control valves being fluidly connected to the first and second conduits and the respective cylinders wherein each directional control valve connects the respective cylinder to the first conduit in the first position and to the second conduit in the second position.

Brief Description of the Drawings

[0011] The foregoing and other features and advantages of the present disclosure will be more fully understood from the following description of various embodiments, when read together with the accompanying drawings, in which:

Fig. 1 is a schematic illustration of the piston hydraulic device according to the present disclosure;
Fig. 2 is a cross sectional view of a portion of a swash plate type axial piston hydraulic device according to the present disclosure; and
Fig. 3 is a cross sectional view of a portion of a bent axis type axial piston hydraulic device according to the present disclosure.

Detailed Description

[0012] This disclosure generally relates to a piston hydraulic device. The device is configured to have contin-

uous variation of fluid displacement and an efficient management of the timing for the connection of a cylinder assembly to the high or the low pressure line relative to the dead points of a piston stroke.

[0013] Fig. 1 schematically illustrates the piston hydraulic device **10** (hereinafter referred to as "device"). In an embodiment the device **10** is an axial piston hydraulic device. In an alternative embodiment, the device **10** may be a radial piston hydraulic device. The device **10** comprises a cylinder block **12,** a first conduit **14,** a second conduit **16,** a plurality of directional control valves **56** and a controller **58.**

[0014] The cylinder block **12** comprises a plurality of cylinder assemblies **24.** The cylinder block **12** is rotatable about a first rotation axis **A** (not shown). The cylinder block **12** is rotatably supported in the device **10.** Cylinder block **12** is rotatably supported in a housing (not shown) of the device **10.** The cylinder assemblies **24** are radially positioned in the cylinder block **12** relative to the first rotation axis **A.** The cylinder assemblies **24** are mutually angularly spaced. The cylinder block **12** has first block surface **30** and a second block surface **32.** First and second block faces **30, 32** are formed on opposite sides of the cylinder block **12.** First and second block faces **30, 32** are parallel.

[0015] Each cylinder assembly **24** comprises a cylinder **26** and a piston **28.** The cylinders **26** have respective openings **34** on the first block surface **30.** Pistons **28** extend and retract in the cylinders **26.** Pistons **28** extend from the openings **34.** Cylinders **26** have a base **36.** A cylinder conduit **48** extends from the base **36** to the second block face **32.** Cylinder conduit communicates with the cylinder **26.** Fluid enters and exits the cylinder **26** through the cylinder conduit **48.** Pistons **28** have a piston head **42** and a piston base **44.** Piston head **42** is positioned external to the cylinder **26.** Piston base **44** travels in the cylinder **26** during a stroke of the piston **28.** Piston base **44** may move towards the base **36** of the cylinder **26** at the end of the return stroke. Each piston **28** moves along the respective cylinder **26** in parallel to the first rotation axis A.

[0016] Piston **28** defines a chamber **46** in the cylinder **26.** The chamber **46** varies in volume as the piston **28** extends and retracts in the cylinder **26.** Change in the fluid in the chamber **46** acts on the piston base **44.** The chamber **46** varies in volume from a maximum volume which is reached when the piston **28** is at the top dead centre of an extraction stroke to a minimum volume which is reached when the piston **28** is at the bottom dead centre of a return stroke.

[0017] The first conduit **14** provides a passage of a fluid at a first pressure. The second conduit **16** provides a passage of a fluid at a second pressure. The first pressure is different from the second pressure. In an embodiment, the first pressure is higher than the second pressure. In a further embodiment, a high pressure fluid flows along the first conduit **14** and a low pressure fluid flows along the second conduit **16.** In an alternate embodiment the first pressure is lower than the second pressure. In a further embodiment, a low pressure fluid flows along the first conduit **14** and a high pressure fluid flows along the second conduit **16.**

[0018] The plurality of directional control valves **56** are fluidly connected to the first conduit **14.** Each directional control valve **56** is independently fluidly connected to the first conduit **14.** The first conduit **14** supplies/receives fluid at the first pressure to/from the plurality of directional control valves **56.**

[0019] The plurality of directional control valves **56** are fluidly connected to the second conduit **16.** Each directional control valve **56** is independently fluidly connected to the second conduit **16.** The second conduit **16** supplies/receives fluid at the second pressure to/from the plurality of directional control valves **56.**

[0020] Each directional control valve **56** is fluidly connected to the respective cylinder assembly **24.** In a preferred embodiment, each directional control valve **56** is fluidly connected to the respective cylinder **26.** In yet a preferred embodiment, each directional control valve **56** is fluidly connected to the respective cylinder **26** through the cylinder conduit **48.** Each cylinder assembly **24** is fluidly connected to the respective directional control valve **56.** In a preferred embodiment, each cylinder **26** is fluidly connected to the respective directional control valve **56.** In yet a preferred embodiment, each cylinder **26** is fluidly connected to the respective directional control valve **56** through the cylinder conduit **48.** The plurality of directional control valves **56** are each actuatable independently.

[0021] Fluid at a first pressure from the first conduit **14** is supplied to/sent out from the cylinder **26** through the respective directional control valve **56.** Fluid at a second pressure from the second conduit **16** is supplied to/sent out from the cylinder **26** through the respective directional control valve **56.** Each cylinder **26** receives/sends out either the fluid at the first pressure or the fluid at the second pressure from the respective directional control valve **56.**

[0022] The at least one directional valve **56** is actuatable between a first position **57** and a second position **59.** The at least one directional valve **56** is actuatable between a first position **57** and a second position **59** through mechanical means. The mechanical means is electronically controlled. In an embodiment, the mechanical means is an actuation member **60.** Actuation member **60** may be comprised in the at least one directional valve **56.**

[0023] In a further embodiment, the actuation member **60** may operate in conjunction with a return spring **62.** The activation of the actuation member **60** may actuate the at least one directional valve **56** from the first position **57** to the second position **59.** The deactivation of the actuation member **60** permits the return spring **62** to return the at least one direction valve **56** from the second position **59** to the first position **57.** In an embodiment, the directional control valve **56** is a three way two position

valve.

[0024] Each directional control valve **56** connects the respective cylinder **26** to the first conduit **14** in the first position **57.** The piston **28** extends or retracts corresponding to the first fluid pressure relative to the fluid pressure in chamber **46.** The piston **28** extends or retracts correspondingly in regards to the pressure differential between the chamber **46** and the first pressure in the first conduit **14.**

[0025] Each directional control valve **56** connects the respective cylinder **26** to the second conduit **16** in the second position **59.** The piston **28** extends or retracts corresponding to the second fluid pressure relative to the fluid pressure in chamber **46.** The piston **28** extends or retracts correspondingly in regards to the pressure differential between the chamber **46** and the second pressure in the second conduit **16.**

[0026] The controller **58** is operatively associated with the plurality of directional control valves **56** for switching between the first and the second positions **57, 59.** Controller **58** electronically sends signals to the actuation member **60** for actuation of the at least one directional control valve **56** between the first and the second positions **57, 59.** In embodiment, controller **58** electronically sends signals to the actuation member **60** for actuation of the at least one directional control valve **56** from the first position **57** to the second position **59.** Controller **58** comprises a programmable memory module. The memory module is programmable for the actuation of the at least one directional control valve **56.** The timing and operation of the actuation may be performed in accordance to the programmable memory.

[0027] In an embodiment, a controller **58** is connected to the plurality of directional control valves **56.** In yet a further embodiment, a plurality of controllers **58** are connected to each directional control valve **56.**

[0028] The device **10** may further comprises a positioning sensor **80.** In an embodiment, the positioning sensor **80** senses the angular position of the cylinder block **12.** In alternative embodiment, the positioning sensor **80** senses the angular position of a shaft [not shown]. The positioning sensor **80** is connected to the controller **58.** The positioning sensor **80** provides information of the angular position to the controller **58.** The information in relation to the angular position may be used to compute the timing of the connection of the respective cylinders **26** to the first or second conduit **14, 16.**

[0029] The device **10** further comprises a plurality of connecting conduits **64.** The plurality of connecting conduits **64** are interposed between the plurality of directional control valves **56** and the respective cylinders **26.**

[0030] Fig. 2 illustrates the device **10** as a swash plate type axial piston hydraulic device. Device **10** comprises a housing **72.** A shaft **76** is coupled to the cylinder block **12.** In an embodiment, shaft **76** may be a drive shaft. In an alternative embodiment, shaft **76** may be a driven shaft. In a further embodiment, shaft **76** may be coupled to a drive shaft. In an alternative further embodiment, shaft **76** may be coupled to a driven shaft. The shaft **76** is rotatably supported by the housing **72** around the rotation axis **A.**

[0031] A swash plate **74** is coupled to the housing **72.** The shaft **76** is inserted passing through the swash plate **74.** The swash plate **74** has ring conformation. The plurality of directional control valves **56** are coupled to the housing **72.** The directional control valves 56 are separately connected to the first and the second conduits **14, 16.** The cylinder block **12** is rotatably supported in the housing **72.** Pistons **28** are movably positioned in the respective cylinders **26.** Pistons **28** are coupled to the swash plate **74.** The positioning sensor **80** is coupled to the housing **72.** The positioning sensor **80** is located to sense the angular position of the shaft **76.**

[0032] A plurality of annular grooves **78** are interposed between the connecting conduits **64** and cylinder conduits **48.** The annular grooves **78** are defined in the housing **72.** Each annular groove **78** is fluidly connected to a respective directional control valve **56.** Sealing gaskets (not shown) are interposed between the annular grooves **78,** the housing **72** and the cylinder block **12.**

[0033] Fig. 3 illustrates the device **10,** as a bent axis type axial piston hydraulic device. Device **10** comprises a housing **72.** A shaft **76** is coupled to the cylinder block **12.** In an embodiment, shaft **76** may be a drive shaft. In an alternative embodiment, shaft **76** may be a driven shaft. In a further embodiment, shaft **76** may be coupled to a drive shaft. In an alternative further embodiment, shaft **76** may be coupled to a driven shaft. The shaft **76** is rotatably supported by the housing **72** around the rotation axis **A.** The shaft **76** is rotatably supported by the housing **72** around a second rotation axis **B** inclined in respect of the first rotation axis **A.**

[0034] The plurality of directional control valves **56** are coupled to the housing **72.** The directional control valves 56 are separately connected to the first and the second conduits **14, 16.The** cylinder block **12** is rotatably supported in the housing **72.** Pistons **28** are movably positioned in the respective cylinders **26.** Pistons **28** are coupled to the shaft **76.** The positioning sensor **80** is coupled to the housing **72.** The positioning sensor **80** is located to sense the angular position of the shaft **76.**

[0035] A plurality of annular grooves **78** are interposed between the connecting conduits **64** and cylinder conduits **48.** The annular grooves **78** are defined in the housing **72.** Each annular groove **78** is fluidly connected to a respective directional control valve **56.** Sealing gaskets (not shown) are interposed between the annular grooves **78,** the housing **72** and the cylinder block **12.**

[0036] In operation, the device **10** controls the displacement through the plurality of directional control valves **56.** The switching between the first and second conduit **14, 16** by the directional control valves **56** controls the level of fluid displacement and the timing of the fluid connection of the cylinders **26** to the first or the second conduit **14, 16** during the rotation about the first rotation axis **A.** The actuation of the directional control valves **56**

are in turn controlled by the controller **58.**

[0037] Controller **58** controls the actuation of each directional control valve **56** for switching between the first and the second position **57, 59.** Controller **58** controls the time in the first or second position **57, 59** as a function of the rotation speed. This enables the management of an early or late connection of the cylinders **46** with either the first or second conduit **14, 16** with respect to the travel of the piston **28** between the top or bottom dead points.

[0038] Continuous control of displacement of the axial piston hydraulic device **10** is effected over a complete rotation of the cylinder block **12.** The fluid displacement of a cylinder assembly **24** is control through the actuation of the directional control valve **56** over a rotation of 360 degrees of the cylinder block **12** relative to said cylinder assembly **24.**

[0039] In an embodiment, the device **10** is configured to operate as a hydraulic motor. In an alternate embodiment, the device **10** is configured to operate as a pump.

[0040] A method for controlling of a piston hydraulic device **10** comprising the following steps:

providing a cylinder block **12** having a plurality of cylinder assemblies **24,** the cylinder block **12** being rotatable about a first rotation axis **A** wherein each cylinder assembly **24** comprises a cylinder **26** and a piston **28;** supplying/receiving a fluid at a first pressure through a first conduit **14;** receiving/supplying a fluid at a second pressure through a second conduit **16** wherein the first pressure is different from the second pressure; and actuating independently a plurality of directional control valves **56** between a first and a second positions **57, 59,** the plurality of directional control valves **56** being fluidly connected to the first and second conduits **14, 16** and the respective cylinders **26** wherein each directional control valve **56** connects the respective cylinder **26** to thefirst conduit **14** in the first position **57** and to the second conduit **16** in the second position **59.**

[0041] The direction of rotation of the cylinder block **12** relative to the housing **72** is determined by relative pressures of the respective fluids flowing through the first and the second conduit **14, 16.** The cylinder block **12** may rotate in a first direction with a low pressure fluid flowing through the first conduit **14** and a high pressure fluid flowing through the second conduit **16.** The cylinder block **12** may rotate in a second direction with a high pressure fluid flowing through the first conduit **14** and a low pressure fluid flowing through the second conduit **16**

[0042] In a first operational configuration, the directional control valve **56** is actuated to the first position **57** for a rotation of 180 degrees of the respective cylinder assembly **24** about the rotational axis **A.** The directional control valve **56** is actuated to the second position **59** for the following rotation of 180 degrees of the respective cylinder assembly **24** about the rotational axis **A.** The first conduit **14** supplying/ receiving a high pressure fluid and the second conduit **16** supplying/ receiving a low pressure fluid or vice versa. The cylinder assembly **24** operates normally and contributes 100 percent to fluid displacement over a complete rotation of the cylinder block **12** relative to the cylinder assembly **24.** The cylinder assembly **24** operates normally and contributes 100 percent to fluid displacement over a complete rotation of the cylinder block **12**about the rotational axis **A.** The cylinder assembly **24** contributes to determining the fluid displacement for an amount equal to the difference between the maximum volume and the minimum volume of the corresponding chamber **46.**

[0043] In a second operational configuration, the directional control valve **56** is actuated to the first position **57** for a rotation of less than 180 degrees of the respective cylinder assembly **24** about the rotational axis **A.** The directional control valve **56** is actuated to the second position **59** for the rotation of an angle for completion of the rotation of the respective cylinder assembly **24** about the rotational axis **A.** The first conduit **14** supplying/ receiving a high pressure fluid and the second conduit **16** supplying/ receiving a low pressure fluid or vice versa. The cylinder assembly **24** operates normally and contributes partially to fluid displacement over a complete rotation of the cylinder block **12** relative to the cylinder assembly **24.** The cylinder assembly **24** operates normally and contributes partially to fluid displacement over a complete rotation of the cylinder block **12** about the rotational axis A. The cylinder assembly **24** contributes to determining the displacement only for a partial amount of the difference between the maximum volume and the minimum volume of the corresponding chamber **46.**

[0044] In a third operational configuration, the directional control valve **56** is actuated to either the first or the second position **57, 59** for a rotation of 360 degrees of the respective cylinder assembly **24** about the rotational axis **A.** The cylinder assembly **24** is non-operational and does not contribute to fluid displacement over a complete rotation of the cylinder block **12** relative to the cylinder assembly **24.** The cylinder assembly **24** is non-operational and does not contribute to fluid displacement over a complete rotation of the cylinder block **12** about the rotational axis **A.**

[0045] The skilled person would appreciate that foregoing embodiments may be modified or combined to obtain the piston hydraulic device **10** of the present disclosure.

Industrial Applicability

[0046] This disclosure describes a piston hydraulic device **10** that has individually variable pistons. The piston hydraulic device **10** provides for the continuous variation in fluid displacement. The continuous variation of displacement is enabled without modifying the geometric configuration piston hydraulic device **10.** The relative inclination of the various structures such as the swash plate or the housing, are not varied to obtain the same objectives.

[0047] The device **10** manages efficiently the timing for the connection of a cylinder **26** to the high or the low

pressure line (as determined by the fluid flowing in the first or second conduit **14, 16** relative to the dead points of piston **28** travel during the rotation about the rotational axis A.

[0048] Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein.

[0049] Where technical features mentioned in any claim are followed by reference signs, the reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, neither the reference signs nor their absence have any limiting effect on the technical features as described above or on the scope of any claim elements.

[0050] One skilled in the art will realise the disclosure may be embodied in other specific forms without departing from the disclosure or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting of the disclosure described herein. Scope of the invention is thus indicated by the appended claims, rather than the foregoing description, and all changes that come within the meaning and range of equivalence of the claims are therefore intended to be embraced therein.

Claims

1. A piston hydraulic device (10) comprising:

a cylinder block (12) having a plurality of cylinder assemblies (24), the cylinder block (12) being rotatable about a first rotation axis (A) wherein each cylinder assembly (24) comprises a cylinder (26) and a piston (28);
a first conduit (14) for the passage of a fluid at a first pressure;
a second conduit (16) for the passage of a fluid at a second pressure wherein the first pressure is different from the second pressure;

characterized in that, the piston hydraulic device (10) further comprises
a plurality of directional control valves (56) fluidly connected to the first and second conduits (16, 14) and the respective cylinders (26) wherein each directional control valve (56) connects the respective cylinder (26) to the first conduit (14) in a first position (57) and to the second conduit (16) in a second position (59); and
a controller (58) operatively associated with the directional control valves (56) for switching between the first and the second positions (57, 59).

2. The piston hydraulic device (10) of claim 1 wherein a plurality of connecting conduits (64) are interposed between the plurality of directional control valves (56) and the respective cylinders (26).

3. The piston hydraulic device (10) of claim 1 or 2 wherein the plurality of directional control valves (56) are coupled to a housing (72).

4. The piston hydraulic device (10) of any one of preceding claims 1 to 3 wherein the device (10) is a bent axis hydraulic device.

5. The piston hydraulic device (10) of any one of preceding claims 1 to 4 wherein the device (10) is a swash plate type hydraulic device.

6. The piston hydraulic device (10) of any one of preceding claims further comprising a positioning sensor (80).

7. The piston hydraulic device (10) of claim 6 wherein the positioning sensor (80) senses the angular position of the cylinder block (12).

8. The piston hydraulic device (10) of claim 6 wherein the positioning sensor (80) senses the angular position of a shaft (76).

9. The piston hydraulic device (10) of claim 8 wherein the shaft is a drive shaft (76) or a driven shaft (76).

10. The piston hydraulic device (10) of any one of preceding claims wherein the device is axial piston hydraulic device.

11. A method for controlling a piston hydraulic device (10) comprising the steps of:

providing a cylinder block (12) having a plurality of cylinder assemblies (24), the cylinder block (12) being rotatable about a first rotation axis (A) wherein each cylinder assembly (24) comprises a cylinder (26) and a piston (28);
supplying or receiving a fluid at a first pressure through a first conduit (14);
supplying or receiving a fluid at a second pressure through a second conduit (16) wherein the first pressure is different from the second pressure; and
actuating independently a plurality of directional control valves (56) between a first and a second positions (57, 59), the plurality of directional control valves (56) being fluidly connected to the first and second conduits (16, 14) and the respective cylinders (26) wherein each directional control valve (56) connects the respective cylinder (26) to the first conduit (14) in the first po-

sition (57) and to the second conduit (16) in the second position (59).

12. The method of claim 11 comprising actuating at least one directional control valve (56) to the first position (57) for a rotation of 180 degrees of the respective cylinder assembly (24) about the rotational axis (A) and subsequently to the second position (59) for the following rotation of 180 degrees of the respective cylinder assembly (24) about the rotational axis (A).

13. The method of claim 11 comprising actuating at least one directional control valve (56) to the first position (57) for a rotation of less than 180 degrees of the respective cylinder assembly (24) about the rotational axis (A) and subsequently to the second position (59) for a rotation of an angle for the completion of rotation of the respective cylinder assembly (24) about the rotational axis (A).

14. The method of claim 11 comprising actuating at least one directional control valve (56) to either the first position (57) or the second position (59) during at least a complete rotation of the respective cylinder assembly (24) about the rotational axis (A).

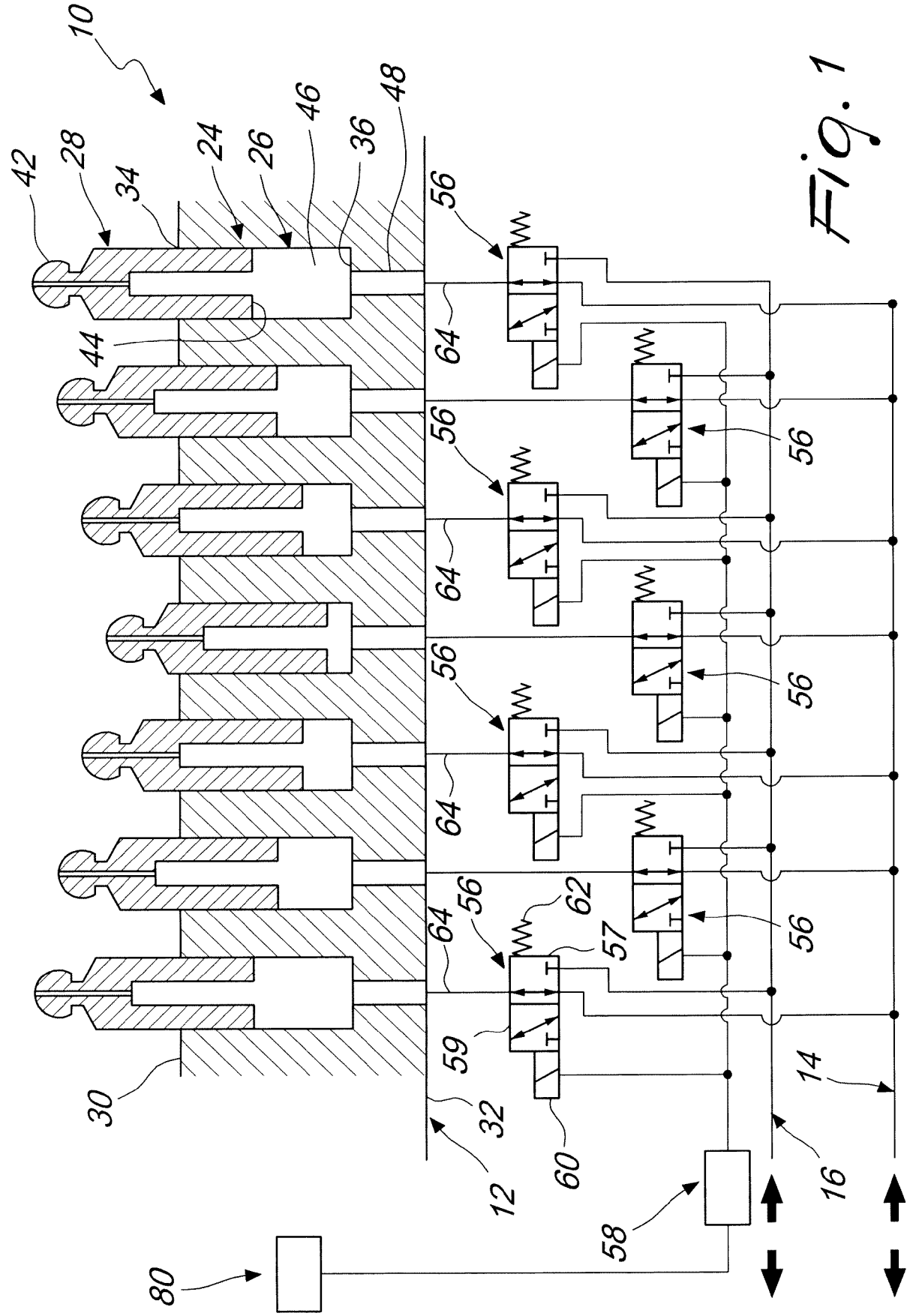

Fig. 1

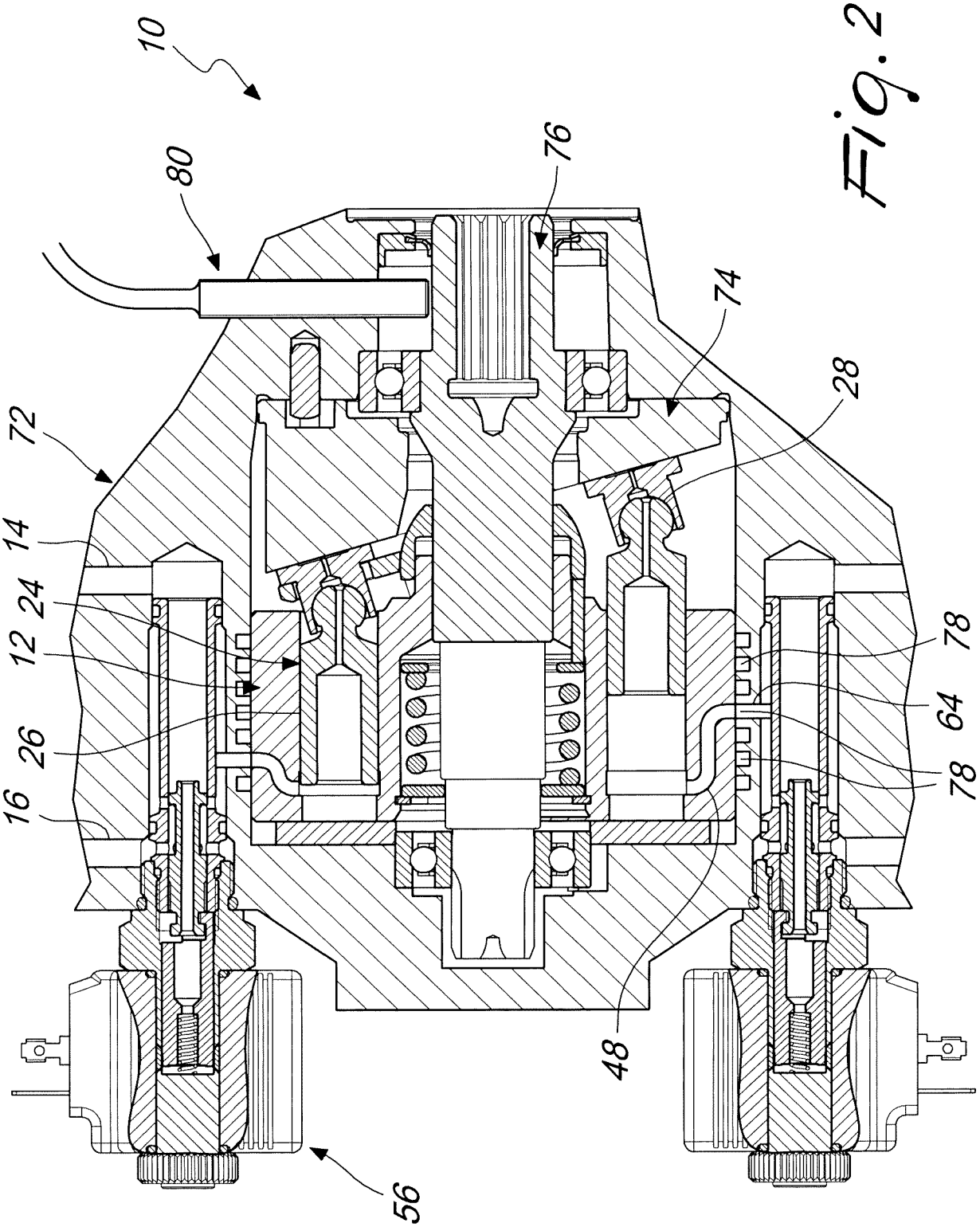

Fig. 2

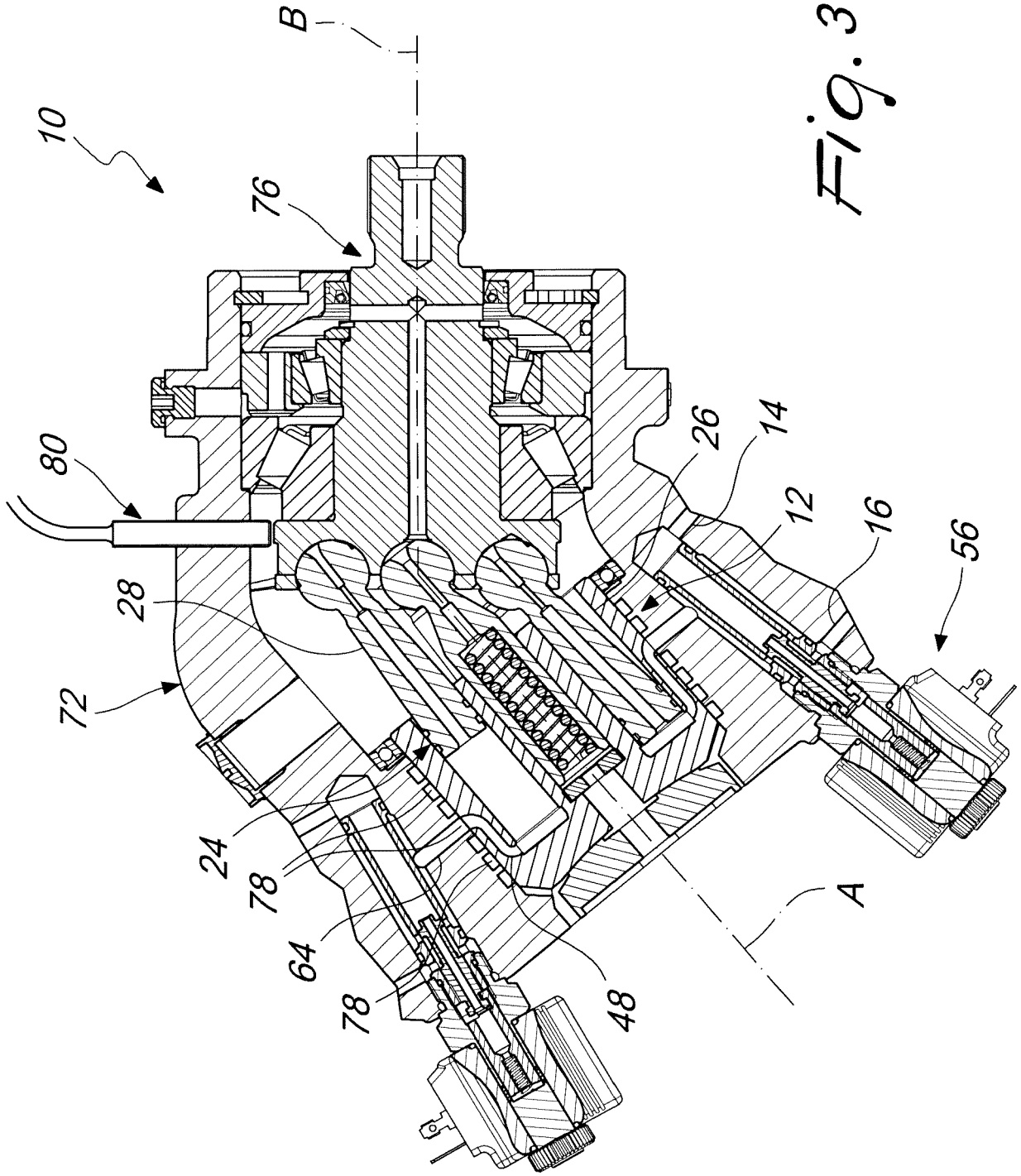

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 42 5030

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2015 206721 A1 (BOSCH GMBH ROBERT [DE]) 20 October 2016 (2016-10-20) * paragraphs [0027] - [0031], [0035] - paragraph [0036]; figure 4 *	1-6, 10-14 7-9	INV. F04B1/22 F04B1/30 F04B49/22 F04B1/20
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X	DE 100 20 453 A1 (KOMATSU MFG CO LTD [JP]) 21 December 2000 (2000-12-21) * column 5, line 53 - column 8, line 15; figures 1-4 *	1,2, 8-10,14	
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Place of search	Date of completion of the search	Examiner
Munich	19 September 2018	Ziegler, Hans-Jürgen

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