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(54) FLUID PRESSURE DRIVE UNIT

(57) A fluid pressure drive unit is to supply a working fluid to and drive a fluid pressure actuator. The fluid pressure drive unit includes a fluid pressure pump for suctioning and discharging the working fluid, an electric motor for driving and rotating the fluid pressure pump, a power transmission mechanism for transmitting a power between a rotation shaft of the fluid pressure pump and a rotation shaft of the electric motor, and a circulation mechanism to be driven by the power transmitted by the power transmission mechanism, the circulation mechanism for guiding a lubricating fluid in the power transmission mechanism and cooling the electric motor.

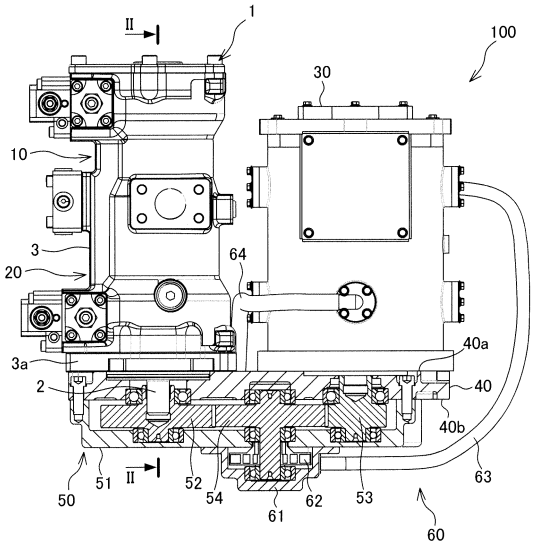

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a fluid pressure drive unit for adapted to supply a working fluid to and driving a fluid pressure actuator.

BACKGROUND ART

[0002] Conventionally, in a construction machine such as a power shovel, a hybrid structure in which a power generator is rotated by an extra output of an engine and emission energy of an actuator, electric power generated by the power generator is stored, and actuation of the actuator is assisted by using the stored electric power is used. In such a hybrid structure, a fluid pressure drive unit including an electric motor to be rotated with the stored electric power, and an assist pump to be driven and rotated by the electric motor, the assist pump for discharging a working fluid and assisting the actuation of the actuator by a main pump is used.

[0003] JP2011-127569A discloses an assist regeneration device including a motor generator to be actuated and rotated with electric energy, a regeneration motor for driving and rotating the motor generator with energy of a working fluid, and an assist pump to be driven and rotated by the motor generator, the assist pump for discharging the working fluid.

SUMMARY OF INVENTION

[0004] However, in the assist regeneration device of JP2011-127569A, when being driven and rotated or when generating the regenerative electric power, the motor generator generates heat. Therefore, there is a need for a cooling system of circulating a refrigerant by using a pump and cooling the motor generator from an exterior.

[0005] The present invention is achieved in consideration with the above problem, and an object thereof is to simplify a cooling mechanism of an electric motor in a hydraulic pressure drive unit.

[0006] According to one aspect of the present invention, a fluid pressure drive unit adapted to supply a working fluid to and driving a fluid pressure actuator is provided. The fluid pressure drive unit includes a fluid pressure pump that is configured to suction and discharge the working fluid, an electric motor that is configured to drive and rotate the fluid pressure pump, a power transmission mechanism that is configured to transmit a power between a rotation shaft of the fluid pressure pump and a rotation shaft of the electric motor, and a circulation mechanism that is configured to be driven by the power transmitted by the power transmission mechanism, the circulation mechanism that is configured to guide a lubricating fluid in the power transmission mechanism and cool the electric motor.

[0007] The details as well as other features and advantages of the present invention are set forth in the remainder of the specification and are shown in the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

[Fig. 1] Fig. 1 is a front view showing a part of a fluid pressure drive unit according to an embodiment of the present invention in a sectional view.
[Fig. 2] Fig. 2 is a sectional view by line II-II of a fluid pressure pump motor in Fig. 1.
[Fig. 3] Fig. 3 is a sectional view of a plate, a power transmission mechanism, and a circulation mechanism in Fig. 1.

DESCRIPTION OF EMBODIMENTS

[0009] Hereinafter, referring the drawings, a hydraulic drive unit 100 serving as a fluid pressure drive unit according to an embodiment of the present invention will be described. In the hydraulic drive unit 100, working oil is used as a working fluid. It should be noted that instead of the working oil, other fluids such as working water may be used as the working fluid.

[0010] Firstly, referring to Figs. 1 to 3, a configuration of the hydraulic drive unit 100 will be described.

[0011] The hydraulic drive unit 100 is to supply the working oil to and drive a hydraulic actuator (not shown) serving as a fluid pressure actuator. The hydraulic drive unit 100 is applied to a hybrid construction machine such as a power shovel for driving the hydraulic actuator with the working oil discharged from a main hydraulic pump (not shown) which is driven by a prime mover.

[0012] As shown in Fig. 1, the hydraulic drive unit 100 is provided with a hydraulic pump motor 1 serving as a fluid pressure pump motor which includes a hydraulic pump 10 serving as a fluid pressure pump for suctioning and discharging the working oil, and a hydraulic motor 20 serving as a fluid pressure motor to be driven and rotated with the supplied working oil.

[0013] The hydraulic drive unit 100 is also provided with an electric motor 30 arranged in parallel to the hydraulic pump motor 1, a plate 40 having an identical surface to which the hydraulic pump motor 1 and the electric motor 30 are attached, a power transmission mechanism 50 for transmitting a power between a rotation shaft 2 of the hydraulic pump motor 1 and a rotation shaft (not shown) of the electric motor 30, and a circulation mechanism 60 for guiding lubricant oil serving as a lubricating fluid in the power transmission mechanism 50 and cooling the electric motor 30.

[0014] The hydraulic pump 10 and the hydraulic motor 20 forming the hydraulic pump motor 1 are respectively swash-plate-type variable piston pump motors. The hydraulic motor 20 is a piston pump motor of a larger scale than the hydraulic pump 10.

[0015] As shown in Fig. 2, the hydraulic pump motor 1 is provided with a casing 3 for accommodating the hydraulic pump 10 and the hydraulic motor 20, and the single rotation shaft 2 rotatably and axially supported on the casing 3 and commonly used for the hydraulic pump 10 and the hydraulic motor 20.

[0016] The casing 3 has a flange portion 3a fastened to the plate 40 by bolts. The casing 3 has a supply and emission passage 4 through which the working oil to be supplied to the hydraulic pump 10 flows and the working oil emitted from the hydraulic motor 20 flows, a discharge passage 5 through which the working oil discharged from the hydraulic pump 10 flows, and a return passage 6 through which the working oil returned from the hydraulic actuator, to be supplied to the hydraulic motor 20 flows.

[0017] The supply and emission passage 4 communicates with a tank (not shown) in which the working oil is stored. The discharge passage 5 and the return passage 6 communicate with the hydraulic actuator. The supply and emission passage 4 is provided to oppose the discharge passage 5 and the return passage 6.

[0018] The hydraulic pump 10 and the hydraulic motor 20 are arranged to oppose each other in the axial direction of the rotation shaft 2 across the supply and emission passage 4, the discharge passage 5, and the return passage 6.

[0019] The hydraulic pump 10 suctions the working oil of the supply and emission passage 4 and discharges to the discharge passage 5. The hydraulic pump 10 assists drive of the hydraulic actuator by the main hydraulic pump with the discharged working oil. The hydraulic pump 10 is provided with a cylinder block 11 coupled to the rotation shaft 2, a plurality of pistons 13 respectively accommodated in a plurality of cylinders 12 which is defined in the cylinder block 11, a swash plate 14 for letting the pistons 13 in sliding contact reciprocate, and a port plate 15 to be brought into sliding contact with an end surface of the cylinder block 11.

[0020] The cylinder block 11 is formed into a substantially columnar shape, and rotated integrally with the rotation shaft 2. The cylinder block 11 is driven and rotated by the rotation shaft 2. In the cylinder block 11, the plurality of cylinders 12 is formed in parallel with the rotation shaft 2.

[0021] The cylinders 12 are arranged on an identical circumference of the cylinder block 11 centering on the rotation shaft 2 in an annular manner at fixed intervals. The pistons 13 are inserted into the respective cylinders 12, and volume chambers 12a are defined between the cylinders and the pistons 13. The volume chambers 12a communicate with the port plate 15 through communication holes.

[0022] When the cylinder block 11 is rotated together with the rotation shaft 2, the pistons 13 are brought into sliding contact with the swash plate 14. Thereby, the pistons 13 reciprocate in the cylinders 12 in accordance with a tilting angle of the swash plate 14, and hence extend and contract the volume chambers 12a.

[0023] The swash plate 14 is provided in such a manner that the tilting angle is adjustable by a capacity switching actuator (not shown). The swash plate 14 is tiltable into a state shown in Fig. 2 from a state where the swash plate is perpendicular to the rotation shaft 2 with the tilting angle of zero. The tilting angle of the swash plate 14 is steplessly adjusted by the capacity switching actuator.

[0024] The port plate 15 is formed into a disc shape, and has a through hole into which the rotation shaft 2 is inserted in center thereof. The port plate 15 has a supply port 15a formed into an arc shape centering on the rotation shaft 2, the supply port providing communication between the supply and emission passage 4 and the volume chambers 12a, and a discharge port 15b similarly formed into an arc shape centering on the rotation shaft 2, the discharge port providing communication between the discharge passage 5 and the volume chambers 12a.

[0025] In the hydraulic pump 10, a region where the pistons 13 are brought into sliding contact with the swash plate 14 and the volume chambers 12a are extended is a suctioning region, and a region where the pistons 13 are brought into sliding contact with the swash plate 14 and the volume chambers 12a are contracted is a discharging region. The supply port 15a is formed in correspondence with the suctioning region, and the discharge port 15b is formed in correspondence with the discharging region. Thereby, in accordance with rotation of the cylinder block 11, the working oil is suctioned into the volume chambers 12a facing the supply port 15a, and the working oil is discharged from the volume chambers 12a facing the discharge port 15b.

[0026] The hydraulic motor 20 is driven and rotated with the working oil emitted from the hydraulic actuator. The hydraulic motor 20 is provided with a cylinder block 21 coupled to the rotation shaft 2, a plurality of pistons 23 respectively accommodated in a plurality of cylinders 22 which is defined in the cylinder block 21, a swash plate 24 for letting the pistons 23 in sliding contact reciprocate, and a port plate 25 to be brought into sliding contact with an end surface of the cylinder block 21. The cylinder block 21, the cylinders 22, the pistons 23, and the swash plate 24 of the hydraulic motor 20 only have different size from the configurations of the above hydraulic pump 10 but have the same configurations. Thus, description thereof is omitted.

[0027] The port plate 25 is formed into a disc shape, and has a through hole into which the rotation shaft 2 is inserted in center thereof. The port plate 25 has a supply port 25a formed into an arc shape centering on the rotation shaft 2, the supply port 25a providing communication between the return passage 6 and volume chambers 22a, and an emission port 25b similarly formed into an arc shape centering on the rotation shaft 2, the emission port 25b providing communication between the supply and emission passage 4 and the volume chambers 22a.

[0028] In the hydraulic motor 20, a region where the pistons 23 are brought into sliding contact with the swash plate 24 and the volume chambers 22a are extended is

a suctioning region, and a region where the pistons 23 are brought into sliding contact with the swash plate 24 and the volume chambers 22a are contacted is an emitting region. The supply port 25a is formed in correspondence with the suctioning region, and the emission port 25b is formed in correspondence with the emitting region. Thereby, in accordance with rotation of the cylinder block 21, the working oil is suctioned into the volume chambers 22a facing the supply port 25a, and the working oil is emitted from the volume chambers 22a facing the emission port 25b.

[0029] The electric motor 30 drives and rotates the hydraulic pump 10, and is capable of generating regenerative electric power by the rotation of the hydraulic motor 20. The electric power generated in the electric motor 30 is stored in an electric power storage device (not shown). The electric motor 30 drives and rotates the hydraulic pump 10 by using the regenerative electric power regenerated by the rotation of the hydraulic motor 20 and stored in the electric power storage device.

[0030] As shown in Fig. 1, the plate 40 is a plate shape member having one surface 40a to which the hydraulic pump motor 1 and the electric motor 30 are attached, and the other surface 40b to which a casing 51 of the power transmission mechanism 50 is attached. Thereby, the power transmission mechanism 50 is provided to oppose the hydraulic pump motor 1 and the electric motor 30 across the plate 40. In the plate 40, a through hole (not shown) through which the rotation shaft 2 of the hydraulic pump motor 1 passes, a through hole (not shown) through which a rotation shaft of the electric motor 30 passes, and a reflux port 42 (refer to Fig. 3) through which the lubricant oil after cooling the electric motor 30 is refluxed are formed.

[0031] As described above, in the hydraulic drive unit 100, the hydraulic pump motor 1 and the electric motor 30 are arranged in a U shape through the plate 40 and the power transmission mechanism 50. Therefore, as the hydraulic pump motor 1 and the electric motor 30 are arranged in parallel, the entire length of the hydraulic drive unit 100 can be shortened. Thus, mountability of the hydraulic drive unit 100 to the hybrid construction machine can be improved.

[0032] It should be noted that instead of the U shape arrangement, the hydraulic pump motor 1 may be attached to the one surface 40a of the plate 40, and the electric motor 30 may be attached to the other surface 40b of the plate 40. The hydraulic pump motor 1 and the electric motor 30 may be arranged in series across the plate 40.

[0033] As shown in Fig. 3, the power transmission mechanism 50 is provided with the casing 51 fixed to the plate 40, a first gear 52 to be rotated integrally with the rotation shaft 2 of the hydraulic pump motor 1, a second gear 53 to be rotated integrally with the rotation shaft of the electric motor 30, and an idle gear 54 provided between the first gear 52 and the second gear 53, the idle gear 54 for transmitting the power.

[0034] The casing 51 accommodates the first gear 52, the second gear 53, and the idle gear 54. The casing 51 is fastened by bolts in a state where an opening end surface 51a is abutted with the other surface 40b of the plate 40. The lubricant oil is charged inside the casing 51. The casing 51 has a through hole 51b formed on an end surface on the opposite side of the opening end surface 51a, the through hole 51b into which a rotation shaft of the idle gear 54 is inserted.

[0035] The first gear 52 has a recessed portion 52a formed on a rotation shaft, the recessed portion into which the rotation shaft 2 of the hydraulic pump motor 1 is inserted and fitted. Thereby, the first gear 52 is rotated integrally with the rotation shaft 2 of the hydraulic pump motor 1. In the first gear 52, one end of the rotation shaft is rotatably and axially supported on the plate 40 by a first bearing 52b, and the other end of the rotation shaft is rotatably and axially supported on the casing 51 by a second bearing 52c.

[0036] Similarly, the second gear 53 has a recessed portion 53a formed on a rotation shaft, the recessed portion into which the rotation shaft of the electric motor 30 is inserted and fitted. Thereby, the second gear 53 is rotated integrally with the rotation shaft of the electric motor 30. In the second gear 53, one end of the rotation shaft is rotatably and axially supported on the plate 40 by a first bearing 53b, and the other end of the rotation shaft is rotatably and axially supported on the casing 51 by a second bearing 53c.

[0037] The idle gear 54 is respectively meshed with the first gear 52 and the second gear 53 and transmits the power between the gears. In the idle gear 54, one end of the rotation shaft is rotatably and axially supported on the plate 40 by a first bearing 54b, and a substantially center part of the rotation shaft is rotatably and axially supported on the casing 51 by a second bearing 54c. The other end of the rotation shaft of the idle gear 54 is inserted into the through hole 51b and extended in a casing 61 of the circulation mechanism 60.

[0038] In such a way, by providing the idle gear 54 between the first gear 52 and the second gear 53, even in a case where the hydraulic pump motor 1 and the electric motor 30 are relatively distant from each other, diameters of the first gear 52 and the second gear 53 are suppressed from being large. Therefore, the power transmission mechanism 50 can be downsized, and the entire hydraulic drive unit 100 can be downsized.

[0039] By adjusting a gear ratio between the first gear 52 and the second gear 53, a reduction ratio between the hydraulic pump motor 1 and the electric motor 30 can be set to be a proper value.

[0040] The circulation mechanism 60 is provided with the casing 61 whose interior communicates with an interior of the casing 51 of the power transmission mechanism 50, an impeller 62 serving as a rotation member to be rotated integrally with the idle gear 54 in the casing 61, a supply flow passage 63 for guiding the lubricating fluid stirred up by the impeller 62 to the electric motor 30,

and a reflux flow passage 64 for returning the lubricating fluid guided to the electric motor 30 into the power transmission mechanism 50.

[0041] The casing 61 is fixed in a state where an opening end surface 61a is abutted with the casing 51 of the power transmission mechanism 50. The lubricant oil charged in the interior of the casing 51 of the power transmission mechanism 50 flows into the interior of the casing 61. In the casing 61, a third bearing 54d for rotatably and axially supporting the other end of the rotation shaft of the idle gear 54 is provided.

[0042] The impeller 62 is a rotating part provided coaxially with the idle gear 54. The impeller 62 is attached to the rotation shaft of the idle gear 54. The impeller 62 is provided between the second bearing 54c and the third bearing 54d. It should be noted that the impeller 62 may be provided anywhere between the first bearing 54b and the third bearing 54d.

[0043] The impeller 62 is rotated when the power transmission mechanism 50 transmits the power between the hydraulic pump motor 1 and the electric motor 30, and stirs up the lubricant oil in the casing 51 of the power transmission mechanism 50 guided into the casing 61 toward an outer circumference. In accordance with an increase in the rotation number of the electric motor 30, the rotation number of the impeller 62 is increased. Therefore, in accordance with an increase in a heat generation amount of the electric motor 30, an amount of the lubricant oil stirred up by the impeller 62 is increased.

[0044] Since the impeller 62 is rotated integrally with the idle gear 54, rotational fluctuation of the idle gear 54 can be reduced by the flywheel effect. Therefore, noises due to the rotational fluctuation of the idle gear 54 can be reduced.

[0045] It should be noted that instead of providing the impeller 62 to be rotated integrally with the idle gear 54, the impeller may be provided to be rotated integrally with the first gear 52 or the second gear 53. A plurality of impellers 62 may be provided, for example, impellers 62 are respectively provided in the first gear 52 and the second gear 53. That is, the impeller 62 is to be rotated integrally with at least any one of the first gear 52, the second gear 53, and the idle gear 54.

[0046] Instead of the impeller 62, another mechanism such as a cylinder to be driven by the rotation of the idle gear 54, the cylinder for stirring up the lubricant oil may be provided. That is, as long as the mechanism is capable of converting rotation motion of the idle gear 54 and stirring up the lubricant oil, any mechanism may be provided.

[0047] As shown in Fig. 1, the supply flow passage 63 is a pipe pulled out to an exterior from the casing 61 and coupled to an exterior of the electric motor 30. The supply flow passage 63 is pulled out from a surface of the casing 61 facing the outer circumference of the impeller 62. The lubricant oil guided through the supply flow passage 63 is supplied to an oil jacket (not shown) formed inside the electric motor 30, and cools the electric motor 30.

[0048] The reflux flow passage 64 is a pipe pulled out to the exterior from the electric motor 30 and coupled to the reflux port 42 (refer to Fig. 3) formed in the plate 40. Through the reflux flow passage 64, the lubricant oil emitted from the oil jacket of the electric motor 30 is refluxed into the casing 51 of the power transmission mechanism 50. It should be noted that instead of the configuration in which the supply flow passage 63 and the reflux flow passage 64 are provided in the exterior of the electric motor 30, the supply flow passage 63 and the reflux flow passage 64 may be formed inside a casing of the electric motor 30.

[0049] Next, actions of the hydraulic drive unit 100 will be described.

[0050] In a case where the hydraulic drive unit 100 assists the drive of the hydraulic actuator by the main hydraulic pump, the electric motor 30 is rotated by using the electric power preliminarily stored in the electric power storage device. By the rotation of the electric motor 30, the rotation shaft 2 of the hydraulic pump motor 1 is driven and rotated via the power transmission mechanism 50.

[0051] Regarding the hydraulic pump 10, the tilting angle of the swash plate 14 is switched to have a predetermined value which is more than zero by the capacity switching actuator. In the hydraulic pump 10, in accordance with the rotation of the cylinder block 11, the pistons 13 reciprocate in the cylinders 12. By this reciprocation of the pistons 13, the working oil from the tank is suctioned into the volume chambers 12a through the supply port 15a of the port plate 15. The working oil discharged from the volume chambers 12a is guided to the discharge passage 5 through the discharge port 15b of the port plate 15.

[0052] Thereby, the working oil discharged from the hydraulic drive unit 100 is supplied for the drive of the hydraulic actuator, and assists the drive of the hydraulic actuator by the main hydraulic pump.

[0053] When the electric motor 30 drives and rotates the hydraulic pump motor 1, the rotation of the second gear 53 is transmitted to the idle gear 54, and the rotation of the idle gear 54 is transmitted to the first gear 52. By rotating the idle gear 54, the impeller 62 of the circulation mechanism 60 is rotated.

[0054] When the impeller 62 is rotated, the lubricant oil in the casing 51 of the power transmission mechanism 50 guided into the casing 61 of the circulation mechanism 60 through the through hole 51b is stirred up and supplied to the oil jacket of the electric motor 30 through the supply flow passage 63. Therefore, the electric motor 30 can be cooled by heat exchange between the lubricant oil and the electric motor 30. The lubricant oil after cooling the electric motor 30 is refluxed from the oil jacket of the electric motor 30 into the casing 51 of the power transmission mechanism 50 through the reflux flow passage 64.

[0055] As described above, when the electric motor 30 drives and rotates the hydraulic pump motor 1, the impeller 62 is rotated in accordance with transmission of the power by the power transmission mechanism 50, and

the lubricant oil is guided to the electric motor 30. Therefore, since there is no need for providing a cooling system of cooling the electric motor 30 from the exterior, a cooling mechanism of the electric motor 30 in the hydraulic drive unit 100 can be simplified.

[0056] Only when the power transmission mechanism 50 transmits the power, that is, when the electric motor 30 is rotated and generates heat, the lubricant oil can be supplied and cooling can be performed. Therefore, in comparison to a case where the cooling is always performed by using the cooling system of cooling the electric motor 30 from the exterior, cooling efficiency can be more enhanced.

[0057] Since the lubricant oil stirred up by the impeller 62 cools the electric motor 30 and is refluxed, the lubricant oil in the power transmission mechanism 50 is circulated. Therefore, the lubricant oil in the power transmission mechanism 50 flows and moves. Thus, the bearings for axially supporting the first gear 52, the second gear 53, and the idle gear 54 are prevented from being burnt out due to shortage of the lubricant oil.

[0058] At this time, the hydraulic motor 20 is retained in such a manner that a tilting angle of the swash plate 24 becomes zero by the capacity switching actuator. Therefore, since the pistons 23 do not reciprocate in the cylinders 22, a displacement volume by the pistons 23 becomes zero. Thus, since the hydraulic motor 20 does not supply and emit the working oil but only runs idle, a drive loss of the hydraulic motor 20 is suppressed.

[0059] Meanwhile, in a case where the regenerative electric power is generated with the working oil emitted from the hydraulic actuator, regarding the hydraulic motor 20, the tilting angle of the swash plate 24 is switched to be a predetermined value which is more than zero by the capacity switching actuator. In the hydraulic motor 20, in accordance with the rotation of the cylinder block 21, the pistons 23 reciprocate in the cylinders 22. By this reciprocation of the pistons 23, the pressurized working oil returned from the hydraulic actuator through the return passage 6 flows into the volume chambers 22a through the supply port 25a of the port plate 25. The pistons 23 reciprocate in the cylinders 22, and the cylinder block 21 is driven and rotated. The working oil flowing into the volume chambers 22a is emitted to the supply and emission passage 4 through the emission port 25b of the port plate 25, and refluxed to the tank.

[0060] The rotation shaft 2 is rotated integrally with the cylinder block 21. The rotation of the rotation shaft 2 is transmitted to the rotation shaft of the electric motor 30 via the power transmission mechanism 50. Thereby, the electric motor 30 can generate and store the regenerative electric power in the electric power storage device.

[0061] When the rotation of the rotation shaft 2 of the hydraulic pump motor 1 is transmitted to the electric motor 30, the rotation of the first gear 52 is transmitted to the idle gear 54, and the rotation of the idle gear 54 is transmitted to the second gear 53. By rotating the idle gear 54, the impeller 62 of the circulation mechanism 60 is rotated. Therefore, as well as a case where the electric motor 30 drives and rotates the hydraulic pump motor 1, the electric motor 30 can be cooled by the heat exchange between the lubricant oil and the electric motor 30.

[0062] At this time, the hydraulic pump 10 is retained in such a manner that the tilting angle of the swash plate 14 becomes zero by the capacity switching actuator. Therefore, since the pistons 13 do not reciprocate in the cylinders 12, a displacement volume by the pistons 13 becomes zero. Thus, since the hydraulic pump 10 does not supply and emit the working oil but only runs idle, a drive loss of the hydraulic pump 10 is suppressed.

[0063] It should be noted that in a case where the hydraulic drive unit 100 assists supply of the working oil to a plurality of hydraulic actuators by the main hydraulic pump, there is sometimes a case where drive of one hydraulic actuator is assisted and the working oil is refluxed from other hydraulic actuators.

[0064] According to the above embodiment, the following effects are obtained.

[0065] The circulation mechanism 60 for guiding the lubricant oil in the power transmission mechanism 50 by the rotation of the impeller 62 and cooling the electric motor 30 is provided. This impeller 62 is rotated integrally with the idle gear 54 for transmitting the power between the first gear 52 and the second gear 53. Therefore, when the electric motor 30 drives and rotates the hydraulic pump motor 1, the impeller 62 is rotated in accordance with the transmission of the power by the power transmission mechanism 50, and the lubricant oil is guided to the electric motor 30. Thus, since there is no need for providing the cooling system of cooling the electric motor 30 from the exterior, the cooling mechanism of the electric motor 30 in the hydraulic drive unit 100 can be simplified.

[0066] Embodiments of the present invention were described above, but the above embodiments are merely examples of applications of the present invention, and the technical scope of the present invention is not limited to the specific constitutions of the above embodiments.

[0067] For example, the hydraulic drive unit 100 is to assist the drive of the hydraulic actuator by the main hydraulic pump. However, instead of this, the hydraulic actuator may be driven by using only the hydraulic drive unit 100.

[0068] Both the hydraulic pump 10 and the hydraulic motor 20 are swash-plate-type piston pump motors. However, as long as the motors are variable motors in which a suction and discharge capacity is adjustable to be zero, the hydraulic pump and the hydraulic motor may be other types. The circulation mechanism 60 may supply the lubricant oil to the hydraulic pump motor 1.

[0069] This application claims priority based on Japanese Patent Application No. 2012-075565 filed with the Japan Patent Office on March 29, 2012, the entire contents of which are incorporated into this specification.

[0070] The embodiments of the present invention in which an exclusive property or privilege is claimed are defined as follows:

Claims

1. A fluid pressure drive unit adapted to supply a working fluid to and driving a fluid pressure actuator, comprising:

   a fluid pressure pump that is configured to suction and discharge the working fluid;
   an electric motor that is configured to drive and rotate the fluid pressure pump;
   a power transmission mechanism that is configured to transmit a power between a rotation shaft of the fluid pressure pump and a rotation shaft of the electric motor; and
   a circulation mechanism that is configured to be driven by the power transmitted by the power transmission mechanism, the circulation mechanism that is configured to guide a lubricating fluid in the power transmission mechanism and cool the electric motor.

2. The fluid pressure drive unit according to claim 1, wherein
   the power transmission mechanism includes a first gear that is configured to rotate integrally with the rotation shaft of the fluid pressure pump, a second gear that is configured to rotate integrally with the rotation shaft of the electric motor, and an idle gear provided between the first gear and the second gear, the idle gear that is configured to transmit the power, and
   the circulation mechanism has a rotation member that is configured to rotate integrally with at least any one of the first gear, the second gear, and the idle gear, the rotation member that is configured to stir up the lubricating fluid in the power transmission mechanism.

3. The fluid pressure drive unit according to claim 2, wherein
   the circulation mechanism includes:

   a supply flow passage through which the lubricating fluid stirred up by the rotation member is guided to the electric motor; and
   a reflux flow passage through which the lubricating fluid guided to the electric motor is returned into the power transmission mechanism.

4. The fluid pressure drive unit according to claim 2, wherein
   the rotation member is an impeller to be rotated integrally with the idle gear.

5. The fluid pressure drive unit according to claim 1, further comprising:

   a plate having an identical surface to which the fluid pressure pump and the electric motor are attached, the plate through which the rotation shaft of the fluid pressure pump and the rotation shaft of the electric motor pass, wherein
   the electric motor is arranged in parallel to the fluid pressure pump.

6. The fluid pressure drive unit according to claim 1, further comprising:

   a fluid pressure motor that is configured to be driven and rotated with the supplied working fluid, using a rotation shaft common to the rotation shaft of the fluid pressure pump, wherein
   the electric motor is capable of generating regenerative electric power by the rotation of the fluid pressure motor.

7. The fluid pressure drive unit according to claim 6, to be applied to a hybrid construction machine in which the fluid pressure actuator is driven with a working fluid discharged from a main fluid pressure pump which is driven by a motor, wherein
   the fluid pressure motor is configured to be driven and rotated with the working fluid emitted from the fluid pressure actuator,
   the electric motor that is configured to generate the regenerative electric power by the rotation of the fluid pressure motor, and is configured to drive and rotate the fluid pressure pump by using the regenerative electric power, and
   the fluid pressure pump that is configured to assist drive of the fluid pressure actuator by the main fluid pressure pump with the discharged working fluid.

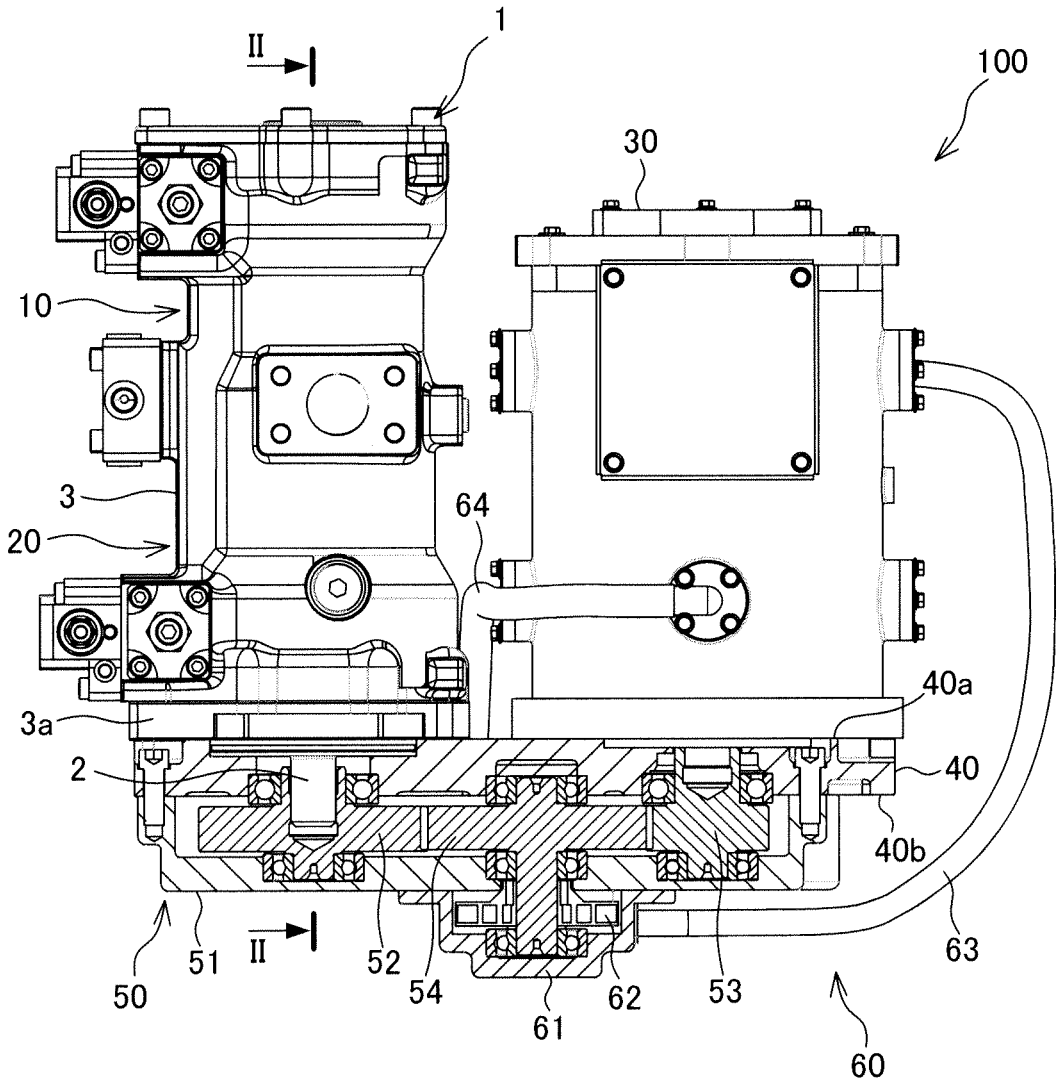
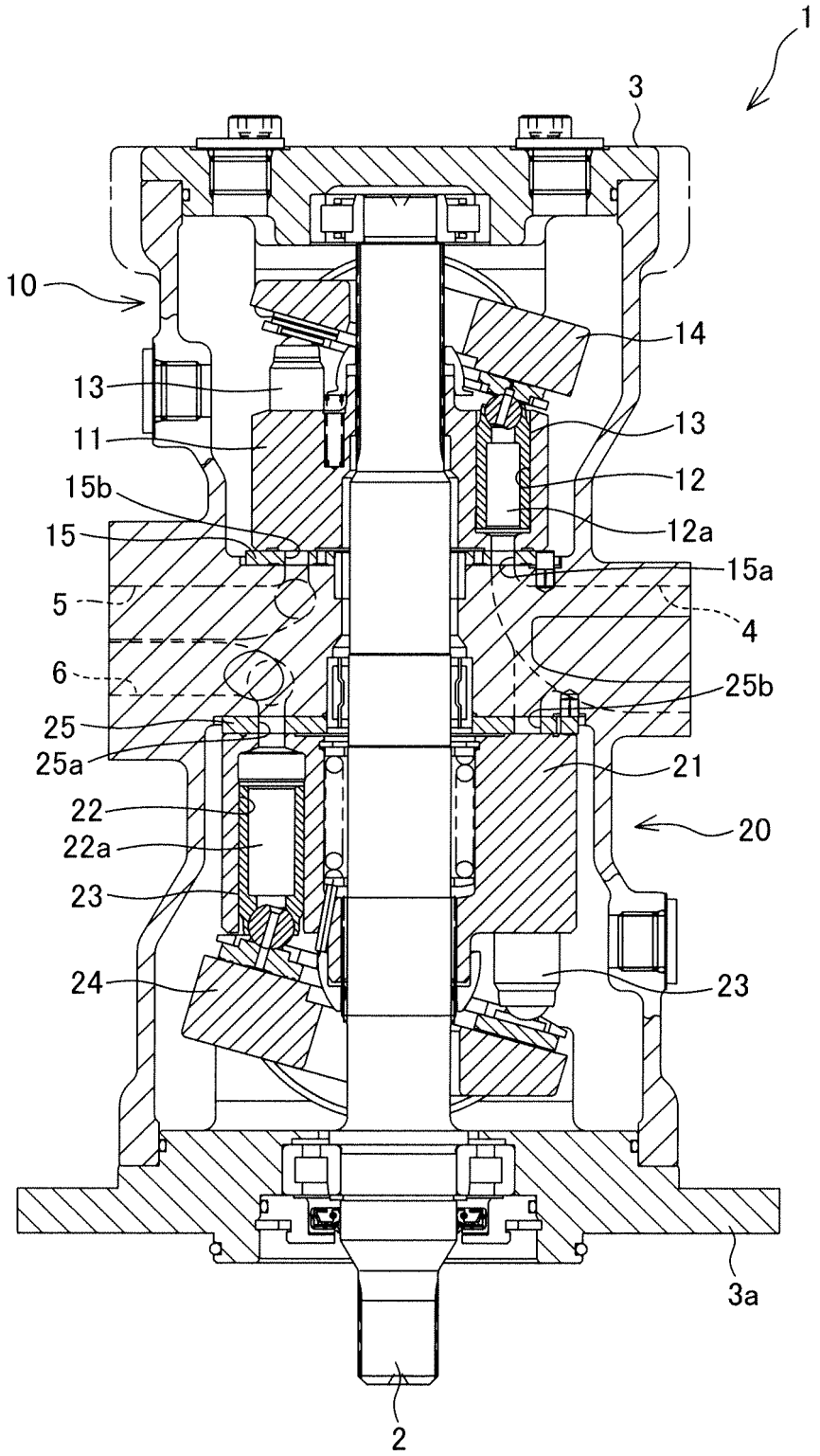


FIG. 1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3a
2

FIG.2

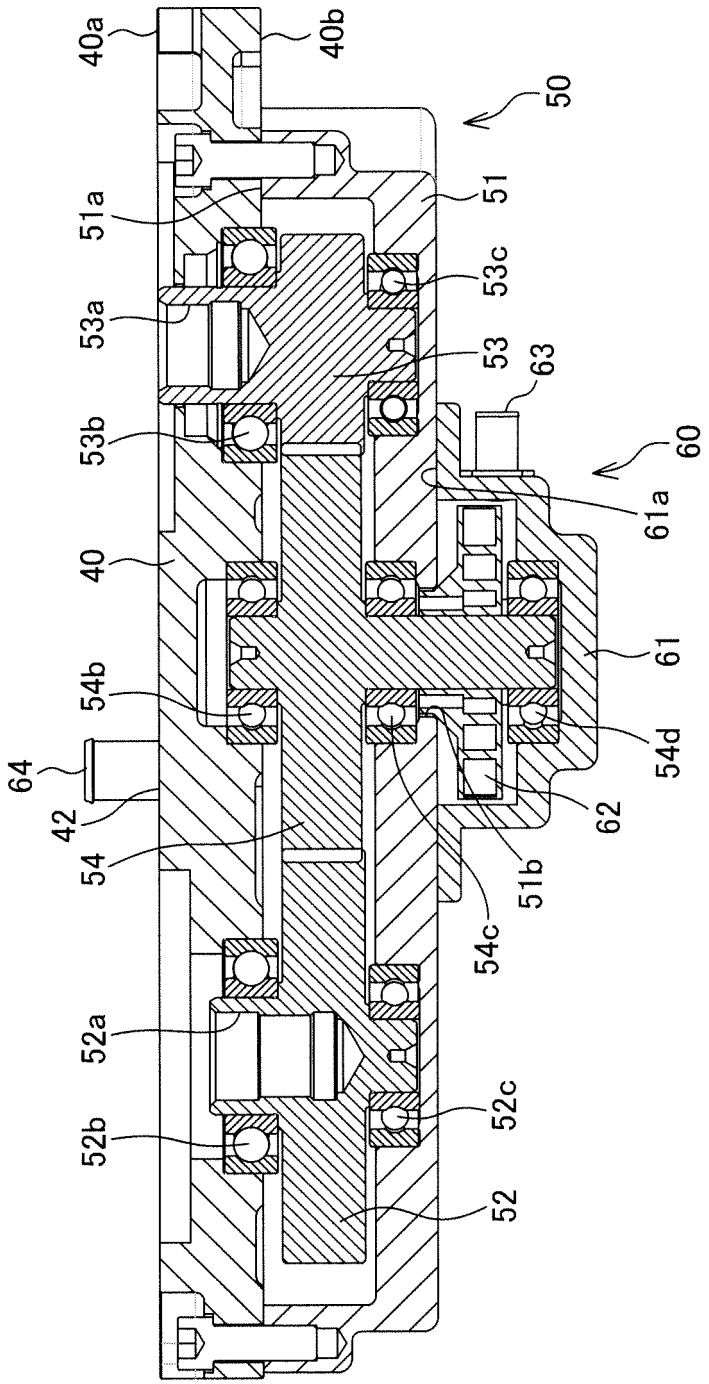
40a
40b
50
51
51a
53c
53a
53
63
53b
60
61a
40
61
54b
54d
64
42
62
54
51b
54c
52a
52c
52b
52

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/058254

A. CLASSIFICATION OF SUBJECT MATTER
F04B1/22(2006.01)i, *F03C1/253*(2006.01)i, *F04B9/02*(2006.01)i, *F04B17/05*(2006.01)i, *F04B53/00*(2006.01)i, *F04B53/08*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B1/22, F03C1/253, F04B9/02, F04B17/05, F04B53/00, F04B53/08, E02F9/02, F15B21/14, F16H9/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	WO 2009/110043 A1 (Kawasaki Precision Machinery Ltd.), 11 September 2009 (11.09.2009), paragraphs [0036] to [0043], [0056]; fig. 4 & JP 2009-209725 A & US 2011/0001370 A1 & EP 2261499 A1 & CN 101960139 A & KR 10-2010-0126656 A	1 2-5 6,7
Y	JP 2010-142086 A (Toshiba Machine Co., Ltd.), 24 June 2010 (24.06.2010), paragraphs [0008] to [0011]; fig. 4, 5 (Family: none)	2-5

☒ 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
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 June, 2013 (06.06.13)	18 June, 2013 (18.06.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/058254

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 87813/1992(Laid-open No. 51610/1994) (Shin Caterpillar Mitsubishi Ltd.), 15 July 1994 (15.07.1994), paragraphs [0013] to [0017]; fig. 1, 2 (Family: none)	2-4
A	WO 2012/023231 A1 (Kawasaki Heavy Industries, Ltd.), 23 February 2012 (23.02.2012), paragraph [0038]; fig. 3(d) & JP 2012-41978 A & CN 102753841 A & KR 10-2012-0051730 A	1-7
A	JP 11-303724 A (Yugen Kaisha Nagatomo Ryutai Kikai Kenkyusho), 02 November 1999 (02.11.1999), fig. 5 (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/058254

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:

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:

All configurations of the invention of claim 1 are disclosed in the document 1 (WO 2009/110043 A1 (Kawasaki Precision Machinery Ltd.), 11 September 2009 (11.09.2009), paragraphs [0036] to [0043], [0056]; fig. 4 & JP 2009-209725 A & US 2011/0001370 A1 & EP 2261499 A1 & CN 101960139 A & KR 10-2010-0126656 A).

Therefore, the invention of claim 1 cannot be considered to be novel in the light of the invention disclosed in the document 1, and does not have a special technical feature.

(Continued to extra sheet)

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.

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INTERNATIONAL SEARCH REPORT

International application No.
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Continuation of Box No.III of continuation of first sheet(2)

Consequently, the following three inventions (invention groups) are involved in claims.

Meanwhile, the invention of claim 1 having no special technical feature is classified into invention 1.

(Invention 1) the inventions of claims 1-4

(Invention 2) the invention of claim 5

(Invention 3) the inventions of claims 6 and 7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011127569 A **[0003] [0004]**
- JP 2012075565 A **[0069]**