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(54) **FLUID-PRESSURE PUMP**

(71) Applicant: **AISIN SEIKI KABUSHIKI KAISHA**, Aichi (JP)

(72) Inventor: **Masao Suzuki**, Owariasahi-shi (JP)

(73) Assignee: **AISIN SEIKI KABUSHIKI KAISHA**, Kariya-shi, Aichi (JP)

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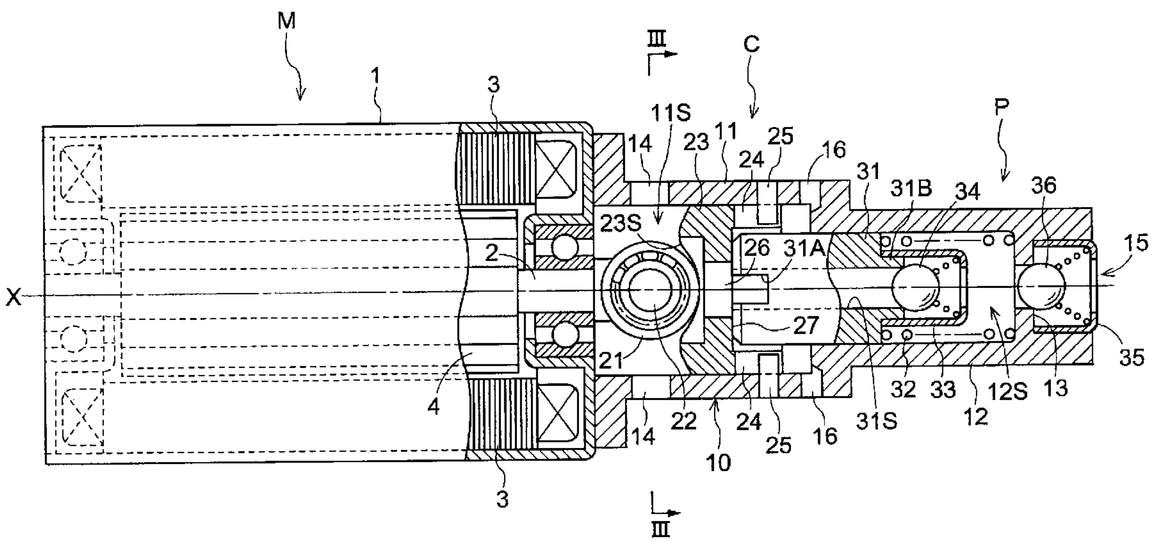
(57) **ABSTRACT**

A fluid-pressure pump operated by a drive force of an electric motor is configured compact. A cam mechanism and a pump portion are disposed coaxial with a rotational axis of an output shaft of an electric motor. A cam mechanism includes a rotational member rotating in unison with the output shaft and a cam member having a cam face to which the rotational member comes into contact. The pump portion includes a piston which reciprocates in unison with the cam member and a spring for operating the piston in a reverse direction. At the time of rotation of the output shaft, the cam mechanism operates the piston in the forward direction by a pressing force applied from the rotational member to the cam face, and the spring, with its urging force, operates the piston in the reverse direction.



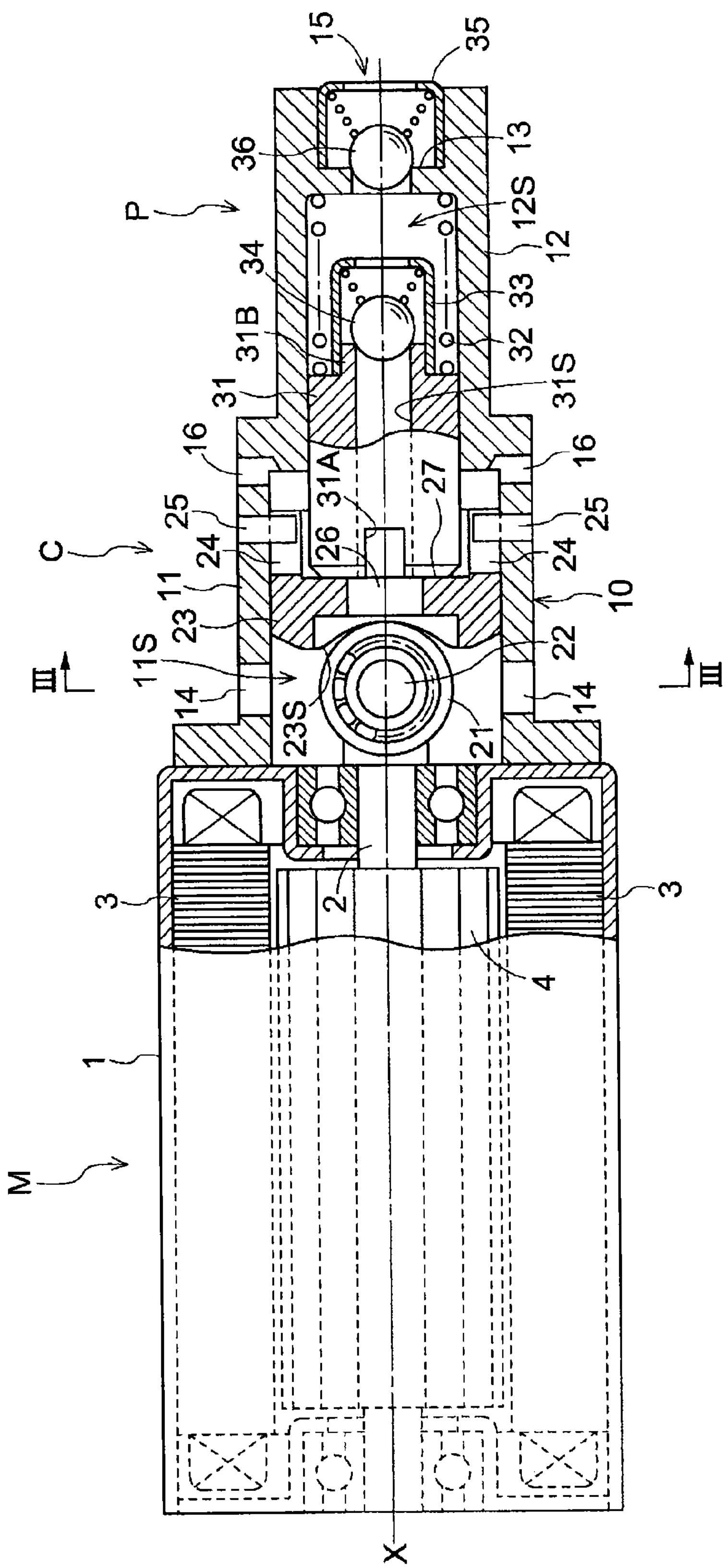

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Fig.1

Fig.2

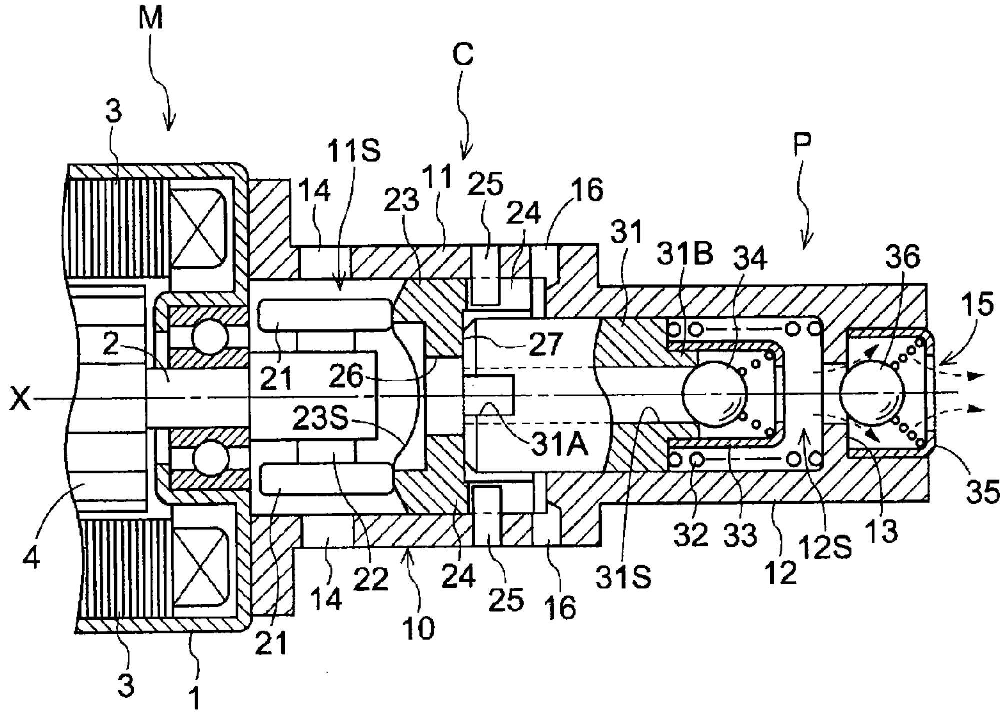
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Fig.3

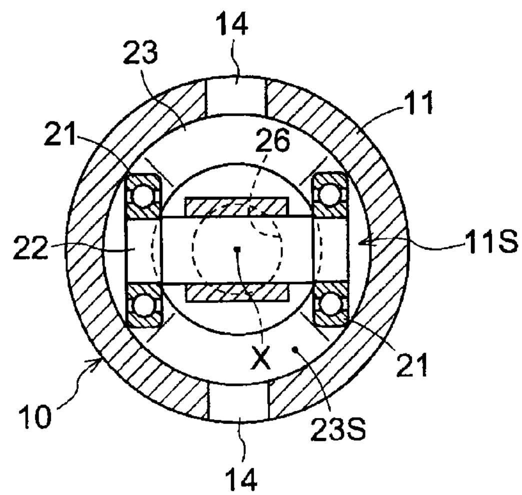
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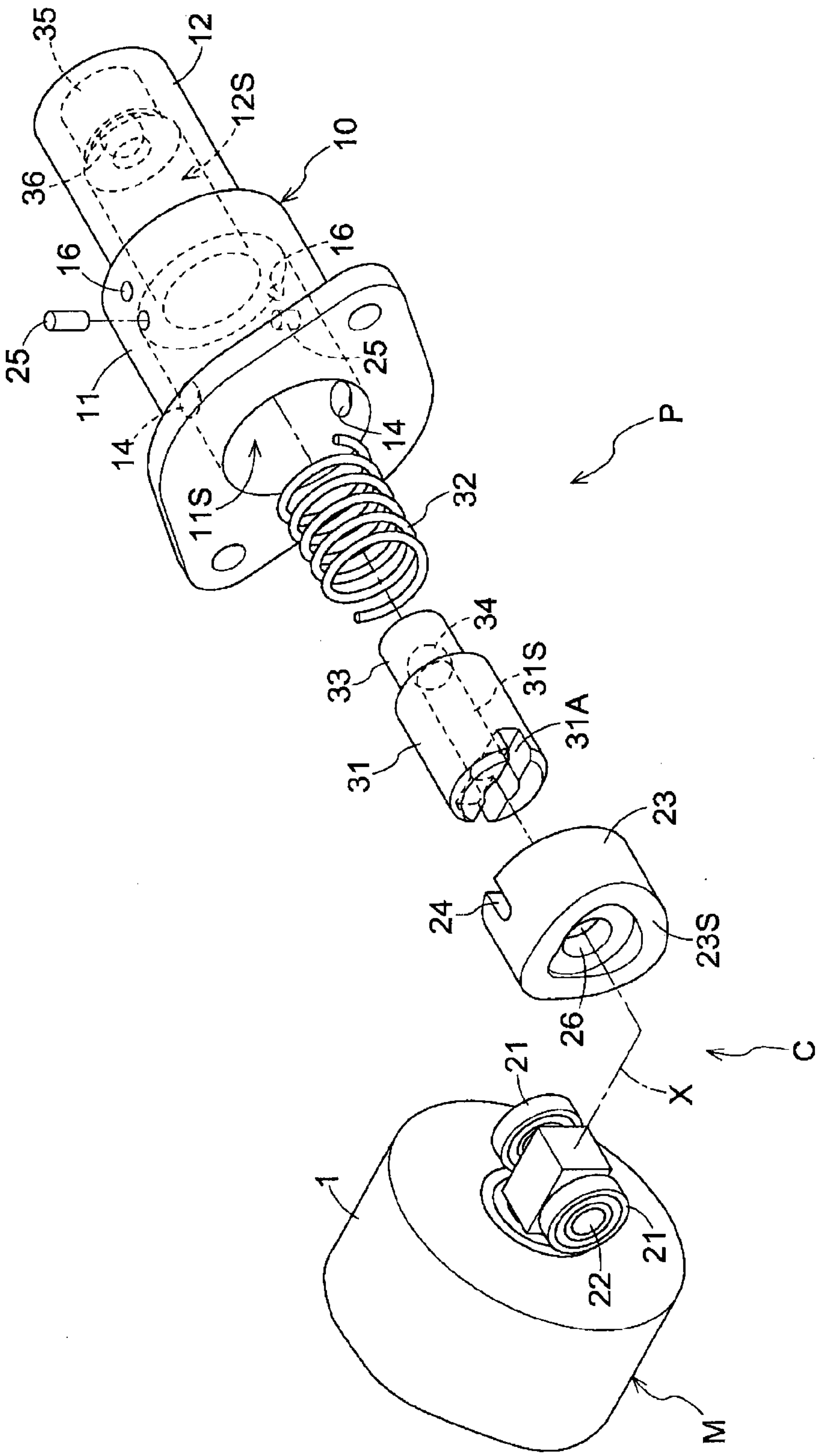
Fig.4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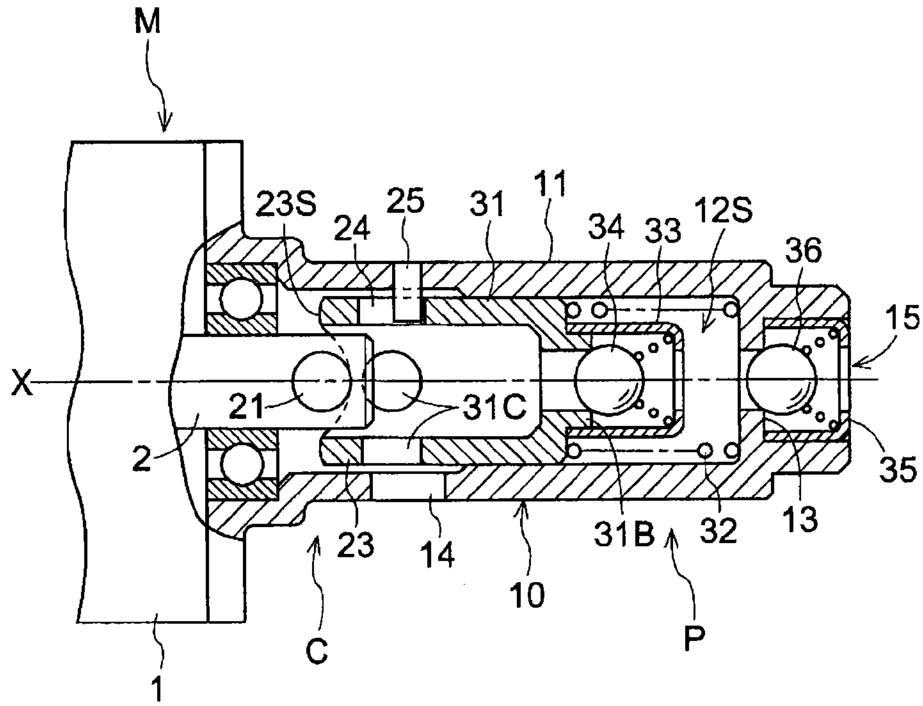
1
21
22
M

Fig.5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12S
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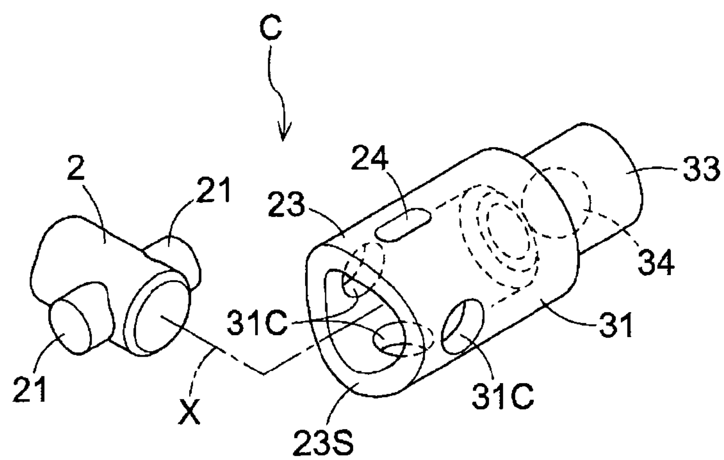
Fig.6


C
24
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21
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31C
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31C
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FLUID-PRESSURE PUMP

TECHNICAL FIELD

[0001] The present invention relates to a fluid-pressure pump, more particularly to a fluid-pressure pump operating a piston by a drive force of an electric motor.

BACKGROUND ART

[0002] As an example of the fluid-pressure pump configured as above, Patent Document 1 discloses a pump configured such that a rotary motion of a motor shaft of an electric motor is converted into a reciprocal motion by means of an eccentric bearing to operate a piston (in the form of a plunger in this document) for feeding an amount of oil.

[0003] Further, Patent Document 2 discloses a pump configured such that a swashplate is mounted on an output shaft of an electric motor, and the pump includes a plurality of pistons operated in association with rotation of the swashplate and a cylinder block forming a plurality of cylinders housing the plurality of pistons.

[0004] The pump disclosed in this Patent Document 2 is configured as an axial piston type that the swashplate is rotated in unison with the output shaft of the electric motor, thus moving the plurality of pistons in forward and reverse directions.

[0005] Moreover, Patent Document 3 discloses a pump configured such that a piston is mounted on a same axis shared by an output shaft (in the form of a rotational shaft in the document) of an electric motor and this piston is housed in a cylinder to be rotatable about the axis of the output shaft.

[0006] In this Patent Document 3, an engaging pin projecting from an inner circumferential face of the cylinder is engaged in a waveform cam groove defined in the outer circumference of the piston. With this configuration in operation, when the electric motor is activated, the piston is rotated with rotation of the output shaft, and the piston is moved back and forth by the function of the cam groove engaged with the engaging pin.

CITATION LIST

Patent Literature

[0007] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2006-121788

[0008] Patent Document 2: Japanese Unexamined Patent Application Publication No. 2011-69469

[0009] Patent Document 3: Japanese Unexamined Patent Application Publication No. 2009-52540

SUMMARY OF INVENTION

[0010] As a vehicle traveling by an engine, there is known one having a hydraulic pump driven by the engine and a hydraulic device operated by oil fed from this hydraulic pump. Such vehicle often includes, as the hydraulic device, a speed changer mechanism having a clutch which is engaged or disengaged by an oil pressure or a variable valve timing system for setting an intake timing by means of oil pressure.

[0011] In the case of an arrangement provided in a vehicle having the no-idling feature wherein the engine is stopped when the vehicle makes a stop, there is provided an electric type oil pump for feeding oil to the hydraulic device when the engine is stopped, as shown also in Patent Document 2. This oil pump is configured as a relatively small type since this pump needs only to be able to maintain an oil pressure to be fed to the hydraulic device.

[0012] In the case of the arrangement disclosed in e.g. Patent Document 1 that includes an eccentric bearing for converting a rotary motion of the output shaft of the electric motor into a reciprocal motion, the pump as a whole would tend to be large since this pump protrudes laterally from the space of the electric motor. Further, in the case of the axial piston type shown in e.g. Patent Document 2, due to the presence of a plurality of pistons, compactization is difficult because of its construction and also high manufacturing precision is needed.

[0013] In addressing to the problems as noted above, in the case of the pump shown in Patent Document 3, as the electric motor and the piston are mounted coaxially and no mechanism such as an eccentric bearing is needed for reciprocating the piston, compactization is possible. However, this pump requires an arrangement for providing relative rotation between the piston and the cylinder and a predetermined precision is required for the engagement of the engaging pin in the cam groove defined in the outer circumference of the piston. In this regard, there remains room for improvement.

[0014] The object of the present invention is to configure a pump operated by a drive force of an electric motor compact.

[0015] According to a characterizing feature of the present invention, a fluid-pressure pump comprises:

- **[0016]** a piston mounted coaxially on a rotational axis of an output shaft of an electric motor to be reciprocatable along the rotational axis;
- **[0017]** a cam mechanism converting a rotational force of the output shaft into a pressing force along a direction of the rotational axis for operating the piston in a forward direction; and
- **[0018]** a spring operating the piston in a reverse direction opposite the forward direction;
- **[0019]** wherein the cam mechanism includes a rotational member rotatable in unison with the output shaft and a cam member having a cam face to which the rotational member comes into contact, the cam member being non-rotatable about the rotational axis and being reciprocatable along the rotational axis.

[0020] With the above-described configuration, at the time of driving of the electric motor, the rotational member is rotated in unison with the output shaft; and as this rotational member comes into contact with the cam face, the cam member is operated in the direction along the rotational axis thereby to operate the piston in the forward direction in association with this operation. Further, upon release of the pressing force applied by the cam member, the piston is operated in the reverse direction by an urging force of the spring. With this, at the time of driving of the electric motor, the piston is reciprocated, so that fluid is suctioned to the piston portion and then the suctioned oil is discharged.

[0021] According to the present invention, preferably;

- **[0022]** a plurality of said rotational members are disposed at a plurality of positions in a circumferential area about the rotational axis;
- **[0023]** the cam member includes the cam face to which the plurality of rotational members come into contact simultaneously; and
- **[0024]** when the plurality of rotational members are rotated, a direction of a resultant force combining com-

ponent forces applied from the plurality of rotational members to the cam member is set on the rotational axis.

[0025] With the above-described configuration, at the time of driving of the electric motor, the plurality of rotational members apply pressing forces simultaneously to a plurality of positions in the cam face. Also, as the direction of the resultant force combining these component forces applied from the plurality of rotational members to the cam member is set on the rotational axis, no force will be applied to the cam member or the piston in a direction deviating from the rotational axis. Consequently, there occurs no waste of energy and no uneven wear will be invited.

[0026] According to the present invention, preferably, a shape of the cam face when the cam member is developed in a circumferential direction is waveform.

[0027] With the above-described arrangement, at the time of driving of the electric motor, a pressing force is applied to the cam member along the cam face in association with rotation of the rotational members, so that the piston can be operated in a smooth manner.

[0028] According to the present invention, still preferably, the cam face includes a reverse-side cam face for operating the piston in the reverse direction and a forward-side cam face for applying a pressing force to the piston in the forward direction, the reverse-side cam face having a steeper slope than the forward-side cam face.

[0029] With the above-described setting of the reverse-side cam face being provided with a steeper slope than the forward-side cam face, the operation of feeding an amount of fluid by operating the piston in the forward direction is allowed to proceed in an appropriate manner, and it is also possible to return the piston at a speed higher than its operational speed in the forward direction. With this, there is realized also increase in the feeding amount of unit per unit rotation of the electric motor.

BRIEF DESCRIPTION OF DRAWINGS

[0030] FIG. **1** is a section view of a fluid-pressure pump,

[0031] FIG. **2** is a section showing a cam mechanism and a pump portion under a state for feeding oil,

[0032] FIG. **3** is a section taken along a line III-III in FIG. **1**,

[0033] FIG. **4** is an exploded perspective view of the fluid-pressure pump,

[0034] FIG. **5** is a section view showing a fluid-pressure pump according to a further embodiment (a), and

[0035] FIG. **6** is an exploded perspective view showing the fluid-pressure pump according to the further embodiment (a).

DESCRIPTION OF EMBODIMENTS

[0036] Next, embodiments of the present invention will be described with reference to the accompanying drawings.

[Basic Configuration]

[0037] As shown in FIGS. **1** through **4**, a fluid-pressure pump includes an electric motor M, a cam mechanism C and a pump portion P. This fluid-pressure pump is configured such that the cam mechanism C and the pump portion P are disposed coaxially on a rotational axis X of an output shaft **2** of the electric motor M.

[0038] With a vehicle which realizes speed changes by way of engagement/disengagement of a hydraulic clutch with oil fed from a hydraulic pump driven by an engine, the hydraulic clutch is switched from a transmitting state to a non-transmitting state in association with reduction in the oil pressure at the time of engine stop. On the other hand, when the engine is started, in association with resultant rise in the oil pressure, the hydraulic clutch is returned to the transmitting state, which may sometimes cause a shock at the time of start of traveling. This tendency appears conspicuously especially with a vehicle having the no-idling feature. As a solution to such inconvenience, the fluid-pressure pump according to the present invention is included in a vehicle having the no idling feature and is activated at the time of engine stop to maintain supply of oil to a hydraulic device.

[0039] Further, the vehicle may include a hydraulic device such as a variable valve timing system for setting an intake timing so that oil may be fed thereto from the fluid-pressure pump. The fluid-pressure pump according to the invention may also be configured to feed such fluid as water, gas, etc. instead of oil.

[0040] [Electric Motor]

[0041] The electric motor M includes an output shaft **2** mounted inside a motor case **1** to be rotatable about a rotational axis X, a field-system coil **3** provided along an inner circumference of the motor case **1**, and a rotor **4** having a permanent magnet and mounted on the output shaft **2**. This electric motor M is configured as a brushless DC motor, configured such that with supply of electric power from a special motor control circuit to the field-system coil **3**, rotation of the output shaft **2** is controlled.

[0042] A unit case **10** is connected to an end of the electric motor M. This unit case **10** includes a large-diameter portion **11** housing the cam mechanism C and a small-diameter portion **12** forming the pump portion P, the large-diameter portion **11** and the small-diameter portion **12** being formed integral with each other. At an end of the small-diameter portion **12**, there is formed a partition wall portion **13**. The large-diameter portion **11** of the unit case **10** integrally forms a flange to be connected to the electric motor M and forms also a cam mechanism housing space **11S** having a cylindrical inner face coaxial with the rotational axis X. The small-diameter portion **12** forms a pump space **12S** having a cylindrical inner face coaxial with the rotational axis X.

[0043] [Cam Mechanism]

[0044] The cam mechanism C includes rotational members **21** rotatable in unison with the output shaft **2** of the electric motor M and a cam member **23** having a cam face **23S** to which the rotational members **21** come into contact, with these mentioned components all being housed in the cam mechanism housing space **11S**.

[0045] The rotational members **21** are configured as ball bearings supported to opposed ends of a shaft member **22** under a posture perpendicular to the rotational axis X relative to the protruding end of the output shaft **2**. Incidentally, each ball bearing has an inner race thereof engaged and coupled to the shaft member **22** and an outer face rotatable relative to the shaft member **22**.

[0046] The cam face **23S** is formed like a ring having a predetermined width about the rotational axis X as seen in the direction along the rotational axis X. Further, the cam member **23** is configured such that a width portion of the ring-shaped cam face **23S** is caused to protrude smoothly along the entire circumference, thereby to cause the outer circumference of the rotational member **21** to come into point-contact with the cam face **23S**.

[0047] That is, since the outer circumference of the rotational member **21** is provided in the form of a smooth circumference, in case e.g. the surface of the cam face **23**S is formed smoothly flat in the width direction, the rotational member **21** and the cam face **23**S contact over a large area each other. Therefore, when the rotational member **21** is rotated about the rotational axis X, the rotational member **21** will be rotated about the shaft member **22**, but a slip will occur due to speed difference between the center side and the outer circumference side of the cam face **23**S relative to the rotational axis X, which is believed to lead to heat generation and/or frictional wear. In addressing to this problem, by causing a width portion of the cam face **23**S to protrude smoothly along the entire circumference, a point contact is formed between the cam face **23**S and the rotational member **21**, so that slippage is restrained effectively.

[0048] Incidentally, in the fluid-pressure pump of the present invention, such point contact between the cam face **23**S and the rotational member **21** can be formed also by providing the rotational member **21** in such a shape protruding to the outer circumference side at the thickness center thereof (e.g. a shape similar to a bead of an abacus).

[0049] The cam member **23** is provided in the form of a cylindrical body forming the cam face **23**S to which the pair of rotational members **21** come into contact, at an end portion of the cylindrical body. And, this cam member **23** is fitted in the cam mechanism housing space **11**S to be movable in the direction along the rotational axis X. In the outer circumference of the cam member **23**, there are formed a pair of guide recesses **24** in the direction along the rotational axis X, whereas a pair of guide pins **25** engageable with these guide recesses **24** are provided to extend through the large-diameter portion **11** of the unit case **10**.

[0050] The cam face **23**S has a waveform such as a sinuous waveform when developed in the circumferential direction, and the pair of rotational members **21** come into contact with this cam face **23**S simultaneously and with equal pressure. Further, in the cam member **23**, there is defined a through hole **26** coaxial with the rotational axis X; and in the cam member **23**, on the side opposite the cam face **23**S, there is formed an engaging portion **27** into which an end portion of the piston **31** engages.

[0051] With the above-described configuration, when the rotational members **21** are rotated about the rotational axis X, pressures are applied from these rotational members **21** to the cam face **23**S, which pressures cause the cam member **23** to move along the rotational axis X, thereby to operate the piston **31** of the pump portion P in the forward direction (the right direction in FIG. **1** illustration).

[0052] [Pump Portion]

[0053] The pump portion P includes the piston **31** mounted within the small-diameter portion **12** of the unit case **10** to be movable in the direction along the rotational axis X and a coil spring **32** configured to urge the piston **31** in the reverse direction (the left direction in FIG. **1** illustration) opposite the forward direction. Further, the pump portion P includes also a first ball valve **34** supported to a first holder **33** relative to the piston **31** and a second ball valve **36** supported to a second holder **35** relative to the partition wall portion **13** of the unit case **10**.

[0054] Referring more particularly to the piston **31**, its outer circumference face is placed in gapless contact with the inner circumferential face of the pump space **12**S. With this arrangement, of the unit case **10**, its small-diameter portion **12** into which the piston **31** engages functions as a "cylinder".

[0055] In the piston **31**, at its end portion opposing the cam member **23**, there is formed an external passage **31**A in the form of a groove and at its other end portion, there is formed a protruding portion **31**B. Further, from the end portion of the piston **31** opposing the cam member **23** to the protruding end of the protruding portion **31**B, there is formed an oil communication space **31**S in the form of a through hole coaxial with the rotational axis X.

[0056] The first ball bearing **34** mentioned above is mounted to be movable between a position for closing an aperture defined at the end portion of the protruding portion **31**B of the piston **31** and a position for opening up this aperture, and the first ball bearing **34** is urged to a closing direction by a spring. Also, the second ball bearing **36** mentioned also above is mounted to be movable between a position for closing an aperture defined in the partition wall portion **13** of the unit case **10** and a position for opening up this aperture, and the second ball bearing **36** is urged to a closing direction by a spring.

[0057] The large-diameter portion **11** of the unit case **10** defines suction ports **14** for feeding oil to the oil communication space **31**S of the piston **31**, and a discharge port **15** is defined at a portion to which oil from the second holder **35** mounted at the end portion of the unit case **10** is fed.

[0058] Further, the inner circumference diameter of the engaging portion **27** of the cam member **23** is set to be slightly larger than the outer circumference diameter of the piston **31**, and the piston **31** is fitted into this engaging portion **27**. And, a gap is formed between the inner circumference of the engaging portion **27** and the outer circumference of the piston **31** which are engaged with each other in the manner described above, and this gap is communicated via the external flow passage **31**A to the oil communication space **31**S. Moreover, in the large-diameter portion **11** of the unit case **10**, there is formed feeding/discharging openings **16** communicated to the engaging space where the piston **31** is fitted within the cam member **23** in the cam mechanism housing space **11**S.

[0059] [Mode of Operation]

[0060] This fluid-pressure pump is disposed inside a transmission at a position lower than the oil liquid level. Although this arrangement requires a conduit for guiding oil from the discharge port **15** to the hydraulic device, the arrangement nevertheless can omit any conduit for feeding oil to the suction ports **14**, so that an amount oil present inside the transmission can be fed directly to the suction ports **14**.

[0061] With the above-described configuration in operation, when the electric motor M is driven, the pair of rotational members **21** are rotated about the rotational axis X together with the output shaft **2**. In this, the pair of rotational members **31** come into contact with the cam face **23**S simultaneously and equally. Thus, in a situation when the rotational member **21** moves in the direction riding over a crest-like portion of the cam face **23**S, a pressing force is applied to the cam member **23** in association with the above rotation, whereby this cam member **23** and the piston **31** are slid together in the forward direction.

[0062] In particular, the two (plurality of) rotational members **21** are disposed at positions to come into contact with two (plurality of) positions in the circumferential area about the rotational axis X in the cam face **23**S, and the pair of rotational members **21** come into contact with the cam face **23**S of the cam member **23** simultaneously and with equal pressure. More specifically, the two rotational members **21** come into contact with the cam face **23**S at positions opposed to each other across the rotational axis X therebetween. With this, when the rotational members **21** are rotated about the rotational axis X, a resultant force combining the (component) forces applied from the two positions of the cam face **23**S contacting the rotational members **21** to the cam member **23** will act on the rotational axis. That is, no force will be applied to the cam member **23** or the piston **31** in a direction deviating from the rotational axis X, whereby the force will be applied linearly along the rotational axis X. Consequently, no loss of energy will occur and no uneven wear will occur either.

[0063] As described above, since ball bearings are employed as the rotational members **21**, during rotation thereof about the rotational axis X, this rotation will occur about the rotational axis of the shaft member **22**, with the outer races in the outer circumference thereof contacting the cam face **23**S of the cam member **23**. With this, resistance encountered when the rotational members **21** are rotated about the rotational axis X can be minimized.

[0064] Further, since the guide pin **25** comes into engagement with the corresponding guide recess **24** of the cam member **23**, when the rotational member **21** is rotated about the rotational axis X, the cam member **23** will not be rotated, but will move linearly along the rotational axis X.

[0065] When the piston **31** is operated in the forward direction, as shown in FIG. **2**, in association with a drop in the inside pressure of the pump space **12**S, the first ball valve **34** closes the aperture of the protruding portion **31**B whereas the second ball valve **36** opens up the aperture of the partition wall portion **13**. With this, the oil present in the oil space **12**S is fed from the discharge port **15** to the outside.

[0066] Next, in a situation when the rotational members **21** are moved in the direction descending the valley-like portions of the cam face **23**S, there will occur a drop in the pressing force applied to the cam member **23** in association with the rotation, whereby under the urging force of the coil spring **32**, the piston **31** and the cam member **23** are slide together in the reverse direction.

[0067] In this case of operation in the reverse direction too, the pair of rotational members **21** come into contact with the cam face **23**S of the cam member **23** simultaneously with equal pressure, so that equal pressures will be applied from the two positions of the cam face **23**S contacting the rotational members **21** to the pair of these rotational members **21**, thereby to operate the cam member **23** in the linear direction along the rotational axis X and the piston **31** too will be operated linearly in operative association therewith.

[0068] And, in this case of the operation of the piston **31** in the reverse direction, in association with resultant drop in the inside pressure of the pump space **12**S, the first ball valve **34** will open up the aperture of the protruding portion **31**B whereas the second ball valve **36** will close the aperture of the partition wall portion **13**. With this, an amount of oil will be suctioned through the suction ports **14** through an inlet opening **31**C of the piston **31** to the oil communication space **31**S to be supplied eventually to the pump space **12**S.

[0069] Further, when the cam member **23** is slid in the cam mechanism housing space **11**S, in this cam mechanism housing space **11**S, there occurs a change in the pressure of the engaging space into which the piston **31** is engaged into the cam member **31**. With this fluid-pressure pump, in the case of such pressure change, the oil present in the engaging space will be fed and discharged via the external passage **31**A into the oil communication space **31**S to be fed and discharged eventually through the feeding/discharging openings **16** to the outside of the unit case **10**, thus realizing smooth operations of the cam member **23** and the piston **31**.

[0070] With this fluid-pressure pump, as a rotary motion of the output shaft **2** of the electric motor M is applied from the cam mechanism C to the piston **31**, the piston **31** is operated in the forward direction, thus discharging oil from the discharge port **15**. Next, when there occurs a drop in the pressing force applied from the cam mechanism C to the piston **31**, the urging force of the coil spring **32** operates the piston **31** in the reverse direction, thus suctioning an amount of oil through the suction ports **14**. The pump provides its pumping function with repetition of discharging and suction of the oil described above.

[0071] [Other Embodiments]

[0072] In addition to the above-described embodiment, the present invention may be embodied alternatively as follows.

[0073] (a) As shown in FIG. **5** and FIG. **6**, the rotational member **21** can comprise a rod member supported to extend through under a posture perpendicular to the rotational axis X. And, the pump portion P can comprise a tubular member, so that the cam member **23** and the piston **31** are formed integral with each other. In this configuration, in the tubular member, at the end portion thereof near the electric motor M, the cam face **23**S is formed, thus forming the cam member **23**. And, the piston **31** is formed at the portion continuous therefrom.

[0074] Further, the tubular member defines a guide recess **24** in the form of an elongate slot; and as a guide pin **25** is engaged therein. With these, an operation of the tubular member in the direction along the rotational axis X is made possible, with rotation of the tubular member about the rotational axis X being inhibited.

[0075] In the case of the configuration of this further embodiment (a) too, as the electric motor M is driven, the tubular member (the cam member **23** and the piston **31**) is continuously operated in the forward direction and the reverse direction along the rotational axis X, whereby operations of discharging the oil through the discharge port **15** and suctioning the oil through the suction ports **14** can be effected in alternation and repetition.

[0076] (b) The fluid-pressure pump according to the present invention can include only one rotational member **21** as the cam mechanism C or can include three or more of them. Namely, the rotational member **21** can provide its function even when only one such member **21** is provided and can also provide the function when three or more of them are provided. In particular, when three or more rotational members **21** are provided, by disposing these rotational members **21** in such a manner that the members **21** may come into contact with a plurality of positions dividing equally the circumferential area about the rotational axis X in the cam face **23**S, it becomes possible to cause the resultant force combining the component forces applied from the plurality of rotational members **21** to the cam member **23** to act on the rotational axis.

[0077] (c) In the cam face **23**S of the cam member **23**, a reverse-side cam face thereof for operating the piston **31** in the reverse direction is provided with a steeper slope than a forward-side cam face thereof for operating the piston **31** in the forward direction. With this particular slope arrangement of the forward-side cam face based on torque of the electric motor M for operating the piston **31** in the forward direction, it again is possible to return the piston at a higher speed than the operational speed in the forward direction.

[0078] (d) Instead of the first ball valve **34** and the second ball valve **36**, it is possible to employ a reed valve configured to control oil flow by pivotally moving a plate-like flexible member by oil pressures. The arrangement using this reed valve is simpler in its construction than the ball valves, thus achieving cost reduction.

INDUSTRIAL APPLICABILITY

[0079] The present invention is applicable to a fluid-pressure pump operating a piston by a driving force of an electric motor.

1. A fluid-pressure pump comprising:

a piston mounted coaxially on a rotational axis of an output shaft of an electric motor to be reciprocatable along the rotational axis;

a cam mechanism converting a rotational force of the output shaft into a pressing force along a direction of the rotational axis for operating the piston in a forward direction; and

a spring operating the piston in a reverse direction opposite the forward direction;

wherein the cam mechanism includes a rotational member rotatable in unison with the output shaft and a cam member having a cam face to which the rotational member comes into contact, the cam member being non-rotatable about the rotational axis and being reciprocatable along the rotational axis.

2. The fluid-pressure pump according to claim **1**, wherein:

a plurality of said rotational members are disposed at a plurality of positions in a circumferential area about the rotational axis;

the cam member includes the cam face to which the plurality of rotational members come into contact simultaneously; and

when the plurality of rotational members are rotated, a direction of a resultant force combining component forces applied from the plurality of rotational members to the cam member is set on the rotational axis.

3. The fluid-pressure pump according to claim **2**, wherein a shape of the cam face when the cam member is developed in a circumferential direction is waveform.

4. The fluid-pressure pump according to claim **2**, wherein the cam face includes a reverse-side cam face for operating the piston in the reverse direction and a forward-side cam face for applying a pressing force to the piston in the forward direction, the reverse -side cam face having a steeper slope than the forward-side cam face.

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