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

(11) EP 0 899 464 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.03.1999 Bulletin 1999/09

(51) Int. Cl.[6]: **F15B 15/28**

(21) Application number: **98116235.7**

(22) Date of filing: **27.08.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **01.09.1997 JP 251267/97**

(71) Applicant:
Mitsubishi Heavy Industries, Ltd.
Tokyo 100-8315 (JP)

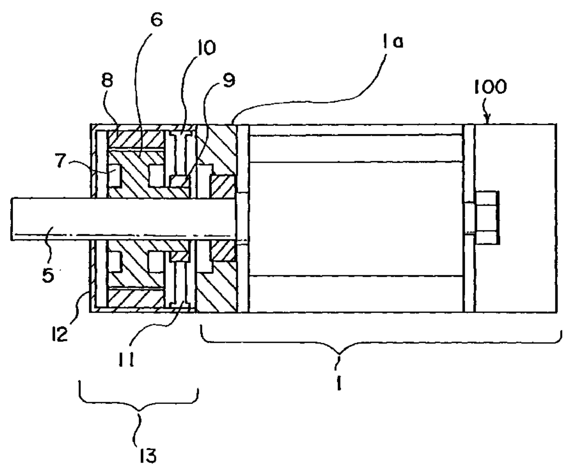
(72) Inventor:
Tawara, Satoshi,
c/o Takasago Res. & Devel. Center
2-chome, Takasago, Hyogo-ken, 676-8686 (JP)

(74) Representative:
Strehl Schübel-Hopf & Partner
Maximilianstrasse 54
80538 München (DE)

(54) **Hydraulic servomotor control assembly**

(57) A hydraulic servomotor control assembly is disclosed, for example a hydraulic servomotor control assembly which supplies the pressurized oil as operating fluid to a hydraulic motor 1, and which controls the volume of the pressurized fluid by means of a servo valve 2. In hydraulic servomotors of the prior art, the hydraulic motor and the tachogenerator or rotational speed sensor device for detecting the rotation, are two separate entities, so that the servomotor must be quite large, and it is difficult to find ways to make it any smaller. In contrast to such prior art, the hydraulic servomotor control assembly according to this invention is distinguished by the fact that a hydraulic motor 1 and a rotational speed detector device (13, 17, 20) are shaft coupled and integral with each other, so that the resulting assembly is both compact and stable.

Fig. 1



EP 0 899 464 A2

Description

Field of The Invention

[0001] This invention concerns a hydraulic servomotor control assembly such as a hydraulic servomotor control assembly which supplies the pressurized fluid for example oil, air, water, etc. as operating fluid to a hydraulic motor, and controls the volume of the pressurized fluid by means of a servo valve.

Background of The Invention

[0002] Figure 5 is a block diagram of an existing hydraulic servomotor control assembly for controlling the rotational speed of a load through the use of a hydraulic motor. In Figure 5, 34 is a hydraulic motor driven by fluid supplied from fluid source 32 via servo valve 33, and 36 is the load driven by the hydraulic motor 34.

[0003] In other words, the hydraulic motor 34 is connected to fluid source 32 via the servo valve 33. The rotational speed of hydraulic motor 34 is controlled by means of an input signal which is input to servo valve 33.

[0004] The rotation of the output shaft of the hydraulic motor 34 is transmitted through gears 37, which are affixed to the output shaft, to tachogenerator 35, whose purpose is to detect the rotational speed. The tachogenerator 35 outputs a voltage which is proportional to the rotational speed of hydraulic motor 34. 31 is a control device which calculates and outputs a signal to control the servo valve 33 based on the voltage signals output by the tachogenerator 35 and on the rotational speed 30 which has been prescribed.

[0005] Through this series of operations, the rotational speed of load 36, which is connected to the hydraulic motor 34, can be controlled. Hydraulic motor 34 can thus function as a servomotor.

[0006] In hydraulic servomotors of the prior art, the hydraulic motor 34, on the one hand, and the tachogenerator 35 or mechanism for detecting the rotation, on the other hand, are two separate entities. Thus in order to make a servomotor arrangement, a mechanism 35 for detecting the speed of rotation (i.e., a tachogenerator) must be attached to the exterior of hydraulic motor 34 and a means to transmit the rotation from the motor to the speed detecting mechanism must be employed. If a hydraulic motor 34 with a cylinder 30 mm in diameter is used for output control, the device (tachogenerator) 35 for detecting the speed of rotation will be about the same size as motor 34. This makes the servomotor quite large, and it is difficult to find ways to make it any smaller.

[0007] Furthermore, prior art servomotors are subject to backlash and chattering due to the gears, belt and/or chain used to transmit the rotation from the motor to the speed detector. This causes them to be less rigid and may result in vibration.

Summary of The Invention

[0008] The object of the present invention is to provide a hydraulic servomotor control assembly, comprising a hydraulic motor and a rotation detector, which is smaller in size and yet has a greater capacity. In this servomotor, the means for transmitting the rotation would not produce backlash or chattering, so the control function would be enhanced.

[0009] In view of the problems inherent in prior art servomotors, the hydraulic servomotor control assembly according to this invention is distinguished by the following configuration. Attached to the output shaft of the hydraulic motor is a rotational speed detector device (i.e. a rotational detecting means) which comprises 1) a rotor which constitutes part of a means for detecting the speed at which the hydraulic motor is rotating, and 2) a rotational speed sensor for detecting the rotational speed of the rotor. The speed sensor may be placed either on the peripheral surface of the rotor or adjacent its external periphery. Thus the rotational speed detector device for directly detecting rotational speed is built into the hydraulic motor of the hydraulic servomotor control assembly, and is shaft coupled with the output shaft of the hydraulic motor.

[0010] Furthermore the rotor may be either the rotating coil element in a tachogenerator, the disk plate in an optical rotary encoder, or the magnetic ring in a magnetic rotary encoder. The rotational speed sensor for detecting the rotation according to this invention can be either the magnetic element in a tachogenerator, the photointerrupter in an optical rotary encoder, or the Hole IC in a magnetic rotary encoder.

[0011] With this invention, a rotational speed detector device for detecting rotational speed, which comprises a tachogenerator or an optical or mechanical encoder, is mounted directly on the output shaft of a hydraulic motor. Because the rotational speed detector device is integral to and within the hydraulic motor, the motor assembly is considerably smaller than prior art devices in which the hydraulic motor and the means for detecting rotation were separate units.

[0012] Making the device so much smaller has the effect of removing many spatial limitations in the assembly process. It also increases the freedom with which the hydraulic motor can be designed. This invention makes it possible to achieve a hydraulic servo device which is smaller than prior art devices and has greater output.

[0013] Because the rotor comprising the rotational speed detector device is mounted directly on the output shaft of the hydraulic motor, there is no backlash or chattering as occurred with prior art devices due to the means required to transmit rotation from the motor to the speed detector. Thus there is no loss of rigidity in control and no vibration, so the control function is enhanced.

Brief Description of The Drawings

[0014]

Figure 1 is a partial cross section view showing the configuration of a first preferred embodiment of a hydraulic motor according to this invention.

Figure 2 is a block diagram of a hydraulic servomotor control assembly in which the hydraulic motor of Figure 1 is employed.

Figure 3 is a drawing of a second preferred embodiment of this invention which is comparable to Figure 1. Figure 4 is a drawing of a third preferred embodiment of this invention which is comparable to Figure 1.

Figure 5 is a block diagram of a hydraulic servomotor control assembly employing a hydraulic motor of the prior art.

Detailed Description Of The Invention

[0015] The following section gives a detailed explanation of three preferred embodiments of this invention with reference to the appended drawings. To the extent that the dimensions, material, shape and relative positions of the constituent components are not specifically disclosed in these embodiments, the scope of the present invention is not limited by these factors. The embodiments serve merely as illustrative examples.

[0016] Figure 1 shows the configuration of a hydraulic servomotor assembly in which the motor and the tachogenerator have been integrated in a single package. This motor assembly is the first preferred embodiment of this invention. Figure 2 is a block diagram of a hydraulic servomotor control assembly employing the hydraulic servomotor of Figure 1.

[0017] In Figure 2, 1 is the hydraulic motor; 2 is the servo valve; 4 is a control device; and 41 is the load. The hydraulic motor 1 is connected to fluid source 3 by way of servo valve 2. The rotational speed of hydraulic motor 1 is controlled according to signals input to the servo valve 2.

[0018] The rotation of output shaft 5 of the hydraulic motor 1 is transmitted directly to tachogenerator 13 which is shaft coupled with the hydraulic motor 1. Tachogenerator 13 outputs a voltage which is proportional to the rotational speed of hydraulic motor 1. Based on the voltage signal output by tachogenerator 13 and the predetermined input signal for rotational speed 30, the control device 4 calculates and outputs a signal to control servo valve 2.

[0019] Through this series of operations, the rotational speed of load 41, which is connected, or shaft coupled to hydraulic motor 1, can be controlled, and hydraulic motor 1 can be employed as a servomotor.

[0020] Hydraulic motor assembly 100, shown in Figure 1, comprises hydraulic motor 1 and tachogenerator 13, which are integrated into a single machine through their common connection to output shaft 5, and shaft coupled to each other.

[0021] Rotating element 6 of tachogenerator 13 is affixed to the periphery of output shaft 5, which extends outward from the hydraulic motor 1. Rotating element 6 contains a coil 7 around which an insulated electrical wire is wrapped. The ends of the wire on the coil 7 are connected to commutator 9, which is separately insulated above the rotating element 6.

[0022] 12 is the cover, which is fixed to the housing of the hydraulic motor 1 by a bolt (not shown). A ring-shaped magnetic element 8 is fixed to the interior of the cover 12 so that it faces the exterior of the rotating element 6.

[0023] As illustrated in Figure 2, when a hydraulic motor assembly 100 configured as described above operates, hydraulic motor 1 is driven to rotate by the fluid supplied from fluid source 3 via servo valve 2. Output shaft 5 rotates, causing rotating element 6 of tachogenerator 13, which is attached to the shaft, to rotate as well.

[0024] The magnetic element 8 generates a fixed magnetic field whose field lines run along the diameter of output shaft 5. Thus, when the rotating element 6 rotates, both element 6 and coil 7 are rotating within this fixed magnetic field. This rotation generates electromotive force in both ends of the electrical wire on coil 7.

[0025] The voltage at either end of the electrical wire on coil 7 varies sinusoidally with the relative angle of coil 7 with respect to the fixed magnetic field. Commutator 9 is placed so that the ends of the wire on coil 7 and brushes 10 and 11 are connected during the period when this voltage has straight polarity; it rectifies the voltage. With the operation described above, a voltage proportional to the speed of rotation of the rotating shaft (i.e., output shaft 5) is output between brushes 10 and 11. This output signal is transmitted to control device 4 (shown in Figure 2) as the signal representing the detected rotational speed (i.e., r.p.m.) of hydraulic motor 1.

[0026] In a prior art device as described above, hydraulic motor 1 and the tachogenerator are housed separately. The rotation of motor 1 must be transmitted to the tachogenerator through gears, a belt and/or a chain, and space must be provided for the tachogenerator to be placed outside the motor. In contrast, in this embodiment of the present invention, tachogenerator 13 is mounted directly on output shaft 5 of hydraulic motor 1 and housing 1a. Hydraulic motor assembly 100, which comprises both motor 1 and tachogenerator 13, is much smaller than the aforedescribed prior art device. Spatial limitations in the assembly of motor 1 have been eliminated, thus increasing the freedom with which hydraulic motor assembly 100 may be designed.

[0027] This design allows a servomotor assembly to be produced which is smaller and has greater output than an electromagnetic servomotor assembly of the prior art.

[0028] Because the rotor (i.e., rotating element 6) of tachogenerator 13 is mounted directly on output shaft 5 of the hydraulic motor 1, the motor has no backlash or chattering caused by the means for transmitting the rotation, as occurred with prior art motors. Thus it is not subject to a loss of rigidity in the control assembly or vibration, and its control capabilities are enhanced.

[0029] Figure 3 shows the configuration of another hydraulic motor assembly, which is a second preferred embodiment of this invention. In this embodiment, hydraulic motor assembly 100 has an incremental-type optical encoder 17 which is integral with output shaft 5 of hydraulic motor 1. Encoder 17 consists primarily of encoder disk 14, photointerrupter 15 and cover 12.

[0030] In Figure 3, encoder disk 14 is mounted on the exterior surface of output shaft (rotary shaft) 5, which extends outward from hydraulic motor 1. Cover 12 of the optical rotary encoder 17 is attached to housing 1a of the motor 1 by means of a bolt (not shown).

[0031] Photointerrupter 15, which has a two-phase output, is mounted on the interior of the cover 12. Encoder disk 14 is attached to rotary shaft 5 of hydraulic motor 1 in such a way as to interrupt the optical path of photointerrupter 15. There are slits (not shown) at regular intervals on the edge of the encoder disk 14 which overlap the optical path of photointerrupter 15. As the output shaft 5 rotates, the optical path of photointerrupter 15 is blocked and cleared at regular intervals.

[0032] When such a rotary encoder 17 is mounted so as to be integral with output shaft 5 of hydraulic motor 1, a number of pulses proportional to the speed of rotation of motor 1 is output by interrupter 15 when hydraulic servo motor assembly 100 is operating. A second set of pulses, phase-shifted from the first set by a specified amount, is used to detect the direction of rotation. By counting the number of pulses per unit time, the speed of rotation of hydraulic motor 1 can be calculated.

[0033] In the second embodiment of this invention, optical rotary encoder 17 is mounted directly on output shaft 5 of hydraulic motor 1. Motor assembly 100, which consists of the hydraulic motor 1 and optical rotary encoder 17, is smaller than similar assemblies of the prior art. Spatial limitations in the assembly of motor 1 which existed in the prior art have been eliminated, thus increasing the freedom with which hydraulic motor assembly 100 may be designed.

[0034] This design allows a servomotor assembly to be produced which is smaller and has greater output than an electromagnetic servomotor of the prior art. The first embodiment discussed above measures only the speed of rotation of hydraulic motor 1. This embodiment cumulates the pulse output as well, so it can also detect the angle of rotation of motor 1. It can thus be used to control the position of the load.

[0035] Figure 4 shows the configuration of a hydraulic motor assembly which is a third preferred embodiment of this invention. In this embodiment hydraulic motor assembly 100, a ringshaped magnetic element 18 is attached to output shaft 5 of hydraulic motor 1. Magnetic element 18 is polarized so that it has a given number of poles along the direction of its perimeter. Placing Hole IC 19 adjacent the periphery of ring 18 creates magnetic rotary encoder 20. Hydraulic motor 1 and the rotary encoder 20 form an integral entity, in which encoder 20 serves to detect the speed of rotation of the motor 1.

[0036] In Figure 4, magnetic ring 18, which has been polarized so that it has a given number of poles along the direction of its perimeter, is mounted on the exterior surface of output shaft (rotary shaft) 5, which extends outward from hydraulic motor 1. Cover 12 of the rotary encoder 20 is attached to housing 1a of the motor 1 by means of a bolt (not shown). Hole IC 19 is attached to cover 12 so that it faces the outer edge of the magnetic ring 18 and can detect the passage of its poles during rotation.

[0037] When such a hydraulic servomotor assembly 100 operates, a number of pulses proportional to the speed of rotation of hydraulic motor 1 is output by the Hole IC 19. By counting the number of pulses per unit time, the speed of rotation of hydraulic motor 1 can be calculated.

[0038] In this third embodiment of the invention, magnetic rotary encoder 20 is mounted directly on output shaft 5 of hydraulic motor 1. Motor assembly 100, which comprises hydraulic motor 1 and magnetic rotary encoder 20, is smaller than similar devices of the prior art. Spatial limitations in the assembly of motor 1 which existed in the prior art have been eliminated, thus increasing the freedom with which hydraulic motor assembly 100 may be designed.

[0039] This design allows a servomotor assembly to be produced which is smaller and has greater output than an electromagnetic servomotor of the prior art. In this embodiment, furthermore, the pulse generator requires few structural components, and its configuration is simpler than in the prior art.

[0040] In the second and third embodiments discussed above, an incrementaltype rotary encoder 17 (Figure 3) or a magnetic rotary encoder 20 may as an alternative be mounted on the supporting end (on the right in Figures 3 and 4) of hydraulic motor 1. Although lubricating oil is the optimal choice for an operating fluid for the hydraulic servomotor assembly, air or some other pressurized fluid could also be used.

[0041] The foregoing description and examples have been set forth merely to illustrate the invention and are not intended to be limiting. Since modifications of the described embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed broadly to include all variations falling within the scope of the appended claims and equivalents thereof.

Claims

1. A hydraulic servomotor control assembly for controlling operation of a hydraulic motor (1), said control assembly comprising a servo valve (2) for regulating supply of an operating fluid from a fluid supply source (3) to the motor (1), and a rotational speed detector device (13, 17, 20) for detecting the speed of the motor (1), wherein said servo valve is responsive to a speed detected by said speed detector device (13, 17, 20), and said speed detector is directly shaft (5) coupled with an output shaft of said hydraulic motor.

2. A hydraulic servomotor control assembly according to claim 1, wherein said rotational speed detector device (13, 17, 20) is integral with said hydraulic motor (1).

3. A hydraulic servomotor control assembly according to claim 1, wherein said rotational speed detector device (13, 17, 20) comprises a rotor (6, 7, 9; 14, 18) mounted on said output shaft (5) of said hydraulic motor (1), and a rotational speed sensor (8, 10, 11; 15; 19) for detecting the rotational speed of said output shaft (5) from rotation of said rotor (6, 7, 9; 14; 18).

4. A hydraulic servomotor control assembly according to claim 3, wherein said rotor is a rotating coil element (7) of a tachogenerator, and said rotational speed sensor is a magnetic element (8) of said tachogenerator.

5. A hydraulic servomotor control assembly according to claim 3, wherein said rotor is a disk plate (14) of an optical rotary encoder, and said rotational speed sensor is a photointerrupter (15) of said optical rotary encoder.

6. A hydraulic servomotor control assembly according to claim 3, wherein said rotor is a magnetic ring (18) of a magnetic rotary encoder, and said rotational speed sensor is a Hall IC (19) of said magnetic rotary encoder.

Fig. 1

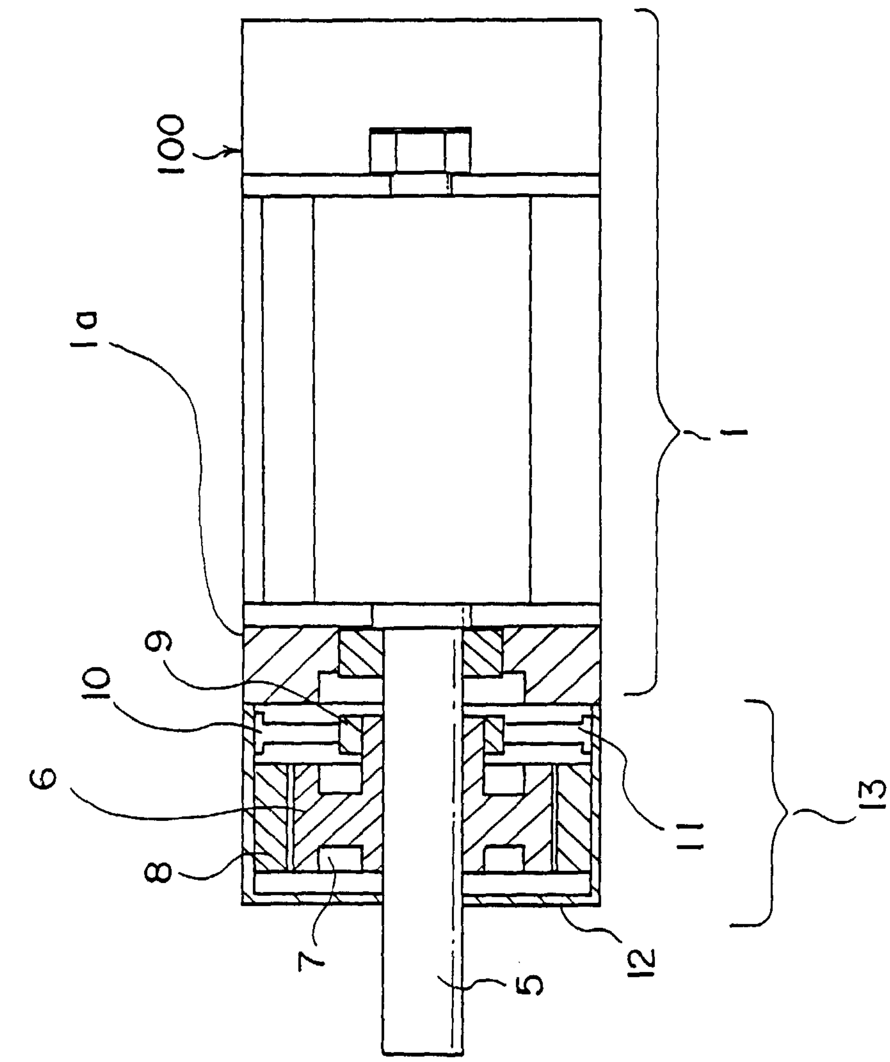


Fig. 2

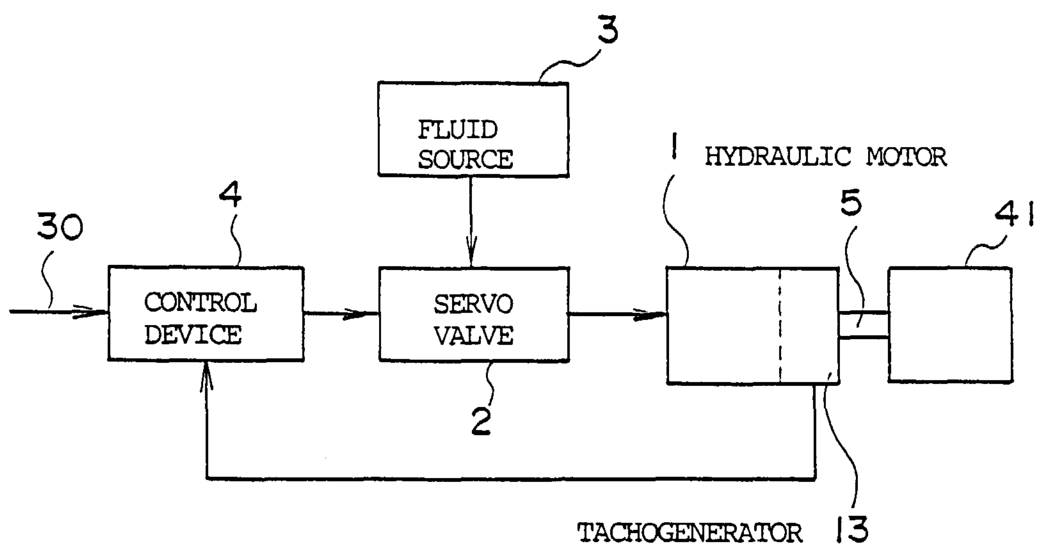

3
FLUID
SOURCE
1
HYDRAULIC MOTOR
4
30
5
41
CONTROL
DEVICE
SERVO
VALVE
2
TACHOGENERATOR
13

Fig. 3

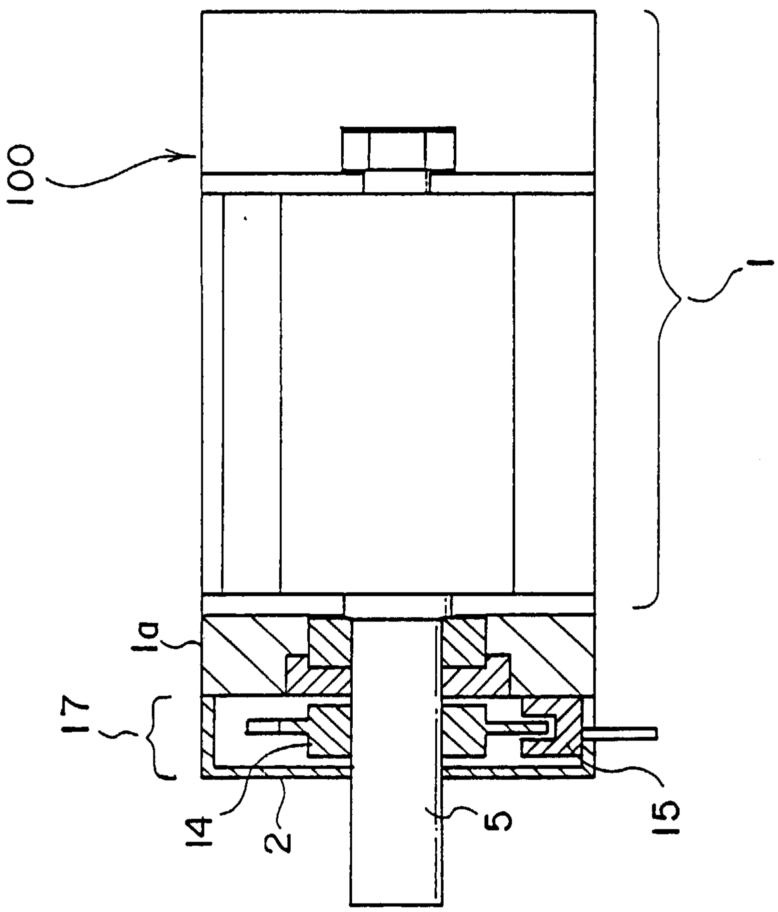


Fig. 4

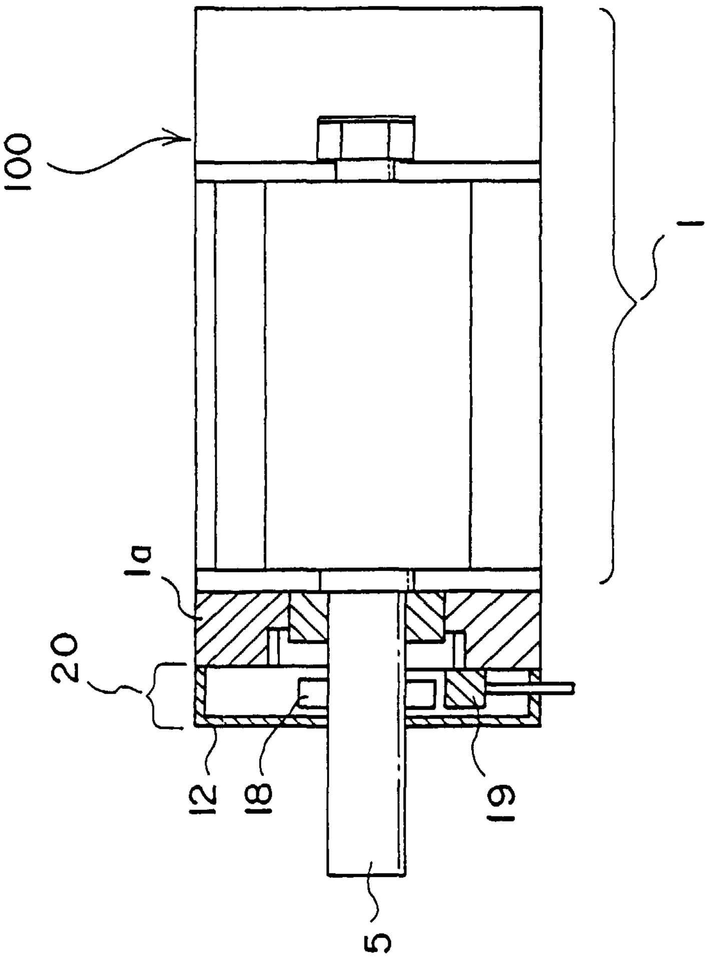
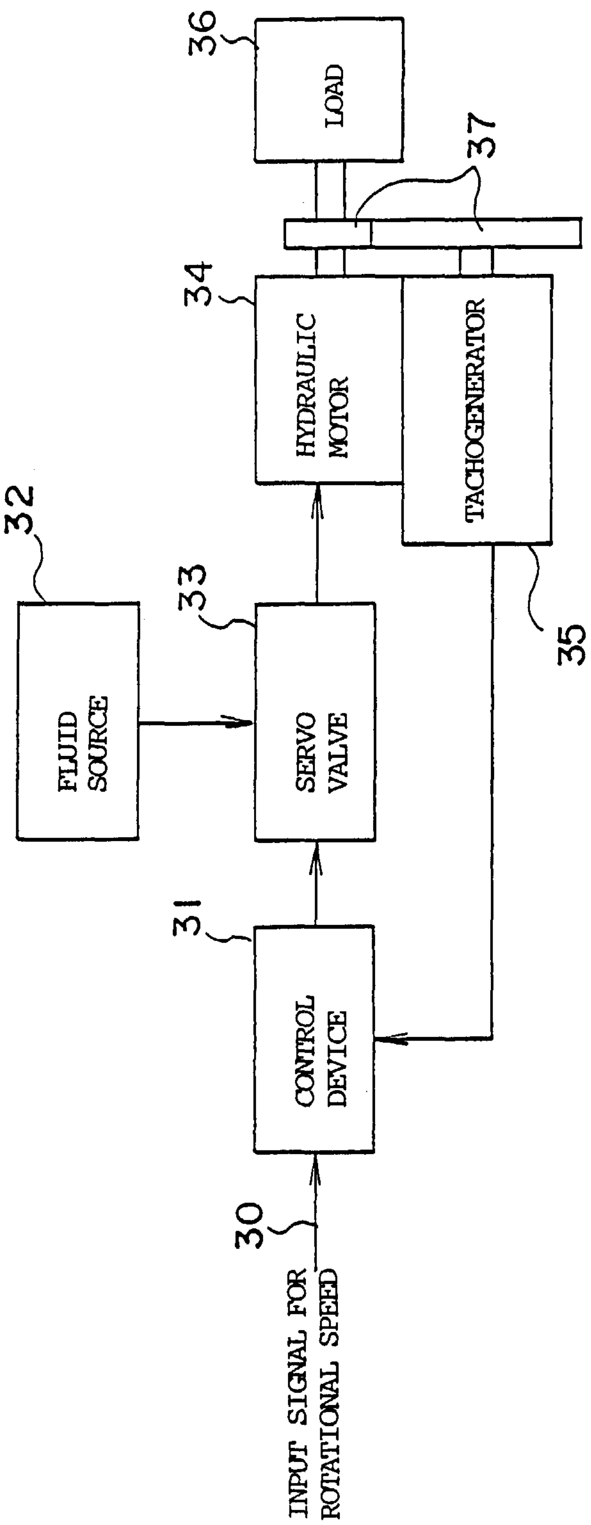


Fig. 5


36
LOAD
37
34
HYDRAULIC MOTOR
TACHOGENERATOR
32
FLUID SOURCE
33
SERVO VALVE
35
31
CONTROL DEVICE
30
INPUT SIGNAL FOR ROTATIONAL SPEED