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(54) **VARIABLE-DISPLACEMENT HYDRAULIC MOTOR HAVING AN APPARATUS FOR CONTROLLING THE VARIATION IN POSITION OF AN ECCENTRIC CAM OF THE MOTOR AND METHOD FOR CONTROLLING THE VARIATION IN POSITION OF THE ECCENTRIC CAM OF THE VARIABLE-DISPLACEMENT HYDRAULIC MOTOR**

HYDRAULISCHER VERSTELLMOTOR MIT EINER VORRICHTUNG ZUR STEUERUNG DER POSITIONSÄNDERUNG EINES EXZENTRISCHEN NOCKENS DES MOTORS UND VERFAHREN ZUR STEUERUNG DER POSITIONSÄNDERUNG DES EXZENTRISCHEN NOCKENS DES HYDRAULISCHEN VERSTELLMOTORS

MOTEUR HYDRAULIQUE À CYLINDRÉE VARIABLE COMPORTANT UN DISPOSITIF POUR COMMANDER LA VARIATION DE POSITION D'UNE CAME EXCENTRIQUE DU MOTEUR ET PROCÉDÉ POUR COMMANDER LA VARIATION DE POSITION DE LA CAME EXCENTRIQUE DU MOTEUR HYDRAULIQUE À CYLINDRÉE VARIABLE

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Description

[0001] The present invention relates to a variable-displacement hydraulic motor comprising an apparatus for controlling the position of an eccentric cam and to a method for controlling the position of said eccentric cam in said variable-displacement hydraulic motor.

[0002] In the prior art radial and/or axial hydraulic motors are known where the associated propulsion members consist of oscillating telescopic cylinders which rest on one side against a spherical eccentric cam of the rotating shaft and on the other side against spherical caps fastened to the motor casing.

[0003] Said motors may be of the fixed or variable displacement type.

[0004] As shown in Figs. 1a, 1b, in variable-displacement motors the spherical part 306 of the driving shaft (not shown), in addition to rotating, may also be displaced with respect to the said shaft, thus changing its eccentricity and therefore the operational motor displacement of the motor. In this way the value of the motor displacement may be varied, during operation of the motor, in order to adapt the latter to the external load conditions, optimizing the performance thereof.

[0005] For this purpose, the motor is equipped with sensors which measure the speed of rotation of the shaft and the motor displacement, then sending respective signals to circuits for controlling the eccentric cam of the machine in which the motor is mounted.

[0006] Given the position of the point E with respect to the centre O of rotation of the driving shaft, the distance between the two points and therefore the degree of operational eccentricity of the shaft for the instantaneous motor displacement of the motor is known, and a control unit may intervene in order to vary the existing value of the eccentricity E.

[0007] This control of the variation in position, with locking of the eccentric cam in the desired position, is however difficult since, in order to determine the displacement to be imparted to the eccentric cam, the control circuit must compensate for the forces applied by the propulsion members on the said eccentric cam, said forces, precisely because of the rotation of the cam, continuously varying in terms of intensity, direction and modulus.

[0008] Also known are devices for controlling the position of the eccentric cam substantially comprising either mechanical or electronic technology.

[0009] Both technologies are able to operate a proportional-control electrovalve depending on a signal supplied by the user; according to the prior art, the proportional valve operates in a constantly open condition, being operated by the control system so as to have a smaller opening for slow changes in motor displacement, or changes in motor displacement where the set displacement value is close to the existing value, and a larger opening for rapid changes in motor displacement, or changes in motor displacement where the set displacement

value is far from the existing value; opening the valve slightly however means creating constrictions which reduce the pressure at its output, to the point of halving it or even reducing it to zero when the valve is nearly closed; in these cases the pressure output is no longer sufficient to counteract the forces exerted by the propulsion members on the eccentric cam and control the changes in motor displacement which, on the contrary, tends to vary in an uncontrolled manner.

[0010] Both electronic technology and mechanical technology also have the drawback that the position of the eccentric cam must be constantly corrected so as to adapt it both to the needs of the specific use and to the continuous movements of the eccentric cam due to the thrusting movement of the said propulsion members.

[0011] As shown in Fig. 1c, this always open valve operating condition results in the control and command feedback circuits continuously trying to achieve the desired value for positioning of the eccentric cam, without in reality the said value being ever achieved because of the constant oscillations of the said eccentric cam.

[0012] Examples of these proportional valve control devices are for example described in US 5,628,188, US 2009/133761 and US 4,983,099. US 4,983,099, in particular, discloses a variable-displacement hydraulic motor comprising a shaft, a wobbler and an apparatus for controlling the position of the wobbler, that in turn comprises a double-acting cylinder acting on the wobbler for changing the motor displacement of the motor, a servovalve having two outputs respectively connected to an associated chamber of the double-acting cylinder by means of hydraulic control lines arranged between the servovalve and the double-acting cylinder, wherein the servovalve is an example of proportionally controlled valve.

[0013] Although performing their function, these known devices therefore have drawbacks which limit the efficiency thereof, both in terms of speed of change in the motor displacement and in terms of the precision of obtaining the desired motor displacement value. In particular, both the electronic devices and the mechanical devices never manage to be simultaneously fast and precise as instead would be required.

[0014] In both cases it also happens that the feedback loop must be kept constantly closed and therefore the hydraulic circuits must be kept under pressure, resulting in continuous leakages of fluid in the rotary seals which are not leak-tight and under pressure allow oil to seep out.

[0015] The technical problem which is posed, therefore, is that of providing an apparatus and a method for controlling the position of an eccentric cam connected to the shaft of a variable-displacement hydraulic motor, which provide a solution to the problems of the prior art, resulting in particular in variations of the eccentricity (and therefore motor displacement) which are fast and precise and also able to reduce substantially fluid leakages.

[0016] In connection with this problem it is also required that this apparatus should have small dimensions,

be easy and inexpensive to produce and assemble and be able to be easily installed on any motor also already operating using normal standardized connection means.

[0017] These results are obtained according to the present invention by a variable-displacement hydraulic motor comprising an apparatus for controlling the position of an eccentric cam of the shaft of said variable-displacement hydraulic motor as defined in Claim 1. The invention relates furthermore to a method for controlling the position of an eccentric cam of the shaft of a variable-displacement hydraulic motor as defined in Claim 10.

[0018] Further details may be obtained from the following description of a non-limiting example of embodiment of the subject of the present invention, provided with reference to the accompanying drawings, in which:

Figures 1a,1b: show a schematic cross-section of a variable-displacement radial hydraulic motor with control of the eccentric cam according to the prior art; Figure 1c: shows the diagram of displacement of the eccentric cam controlled by a proportional valve according to the prior art;

Figure 2: shows a block diagram of the feedback control loop of the valve for operating the eccentric cam;

Figure 3: shows a diagram of an example of embodiment of a circuit for controlling the position of the eccentric cam according to the present invention; Figure 4a: shows a diagram illustrating the curve for variation in the position of the eccentric cam and therefore of the motor displacement over time, obtained with the control apparatus according to the invention; and

Figures 4b-4c: show the diagram of the pulses for opening/closing the control valve according to the present invention and the corresponding conditions for opening and closing the stop valve.

[0019] As shown in Figs. 1a,1b a variable-displacement hydraulic motor 300 is composed of a casing 301 which houses the propulsion members 310 consisting of a cylinder 311 and a piston 312. In greater detail, each of the pistons 312 is placed in communication with a rotating distributor (not shown) housed inside a cover fastened to the casing 301 and designed to supply or discharge cyclically the pistons 312 in synchronism with rotation of the driving shaft.

[0020] In the pistons 312, resting against the caps 302 of the cover, the cylinders 311 are telescopically movable in a radial direction and rest against the outer surface of a spherical body 306, eccentrically movable in the radial direction relative to the axis of the driving shaft upon operation of associated means 308, said variation of eccentricity also determining the variation of motor displacement of the motor.

[0021] According to the conventional technology the motor is associated with means for detecting the motor displacement of the motor comprising, for example, at

least one pair of sensors, each of which is arranged on the cap 302 of a respective propulsion member 310 with its longitudinal axis parallel to and axially offset with respect to the longitudinal axis of the propulsion unit 310 in the rest condition and a data processing unit for detecting and storing the signals emitted by the sensors and performing the calculations necessary for obtaining also the position of the point of eccentricity "E".

[0022] The hydraulic motor 300 is subject to an external torque 310a, transmitted via the driving shaft, to a flow 310b, which flows through the mouths which supply and discharge the said motor, and to a disturbing force, due to the thrust of the propulsion members 310 which, changing periodically intensity and direction during rotation of the driving shaft, tends to move the eccentric cam 306 radially, modifying the motor displacement in a manner which is too difficult to control.

[0023] In Fig. 2 the speed 310c of rotation of the driving shaft is also indicated.

[0024] The motor 300 reacts, generally, to variations in torque and flowrate by modifying its operating parameters 320 including the operating pressure 320b of the motor and the speed of rotation of the shaft 320c.

[0025] In particular, for a given value of the motor displacement, an increase in the torque 310a results in an increase in the pressure 320b (and vice versa), while an increase in the flowrate 310b results in an increase in the speed of the shaft 320c (and vice versa).

[0026] In a similar manner, for a given torque value 310a and flowrate value 310b, an increase in the motor displacement results in a decrease in the pressure 320b and the speed 320c (and vice versa). With reference to Fig. 2, the apparatus, according to the invention, for controlling the position of the eccentric cam 306 of a variable-displacement hydraulic motor 300 comprises essentially a control and command unit 200 and an actuating unit 100.

[0027] The control and command unit 200 comprises a feedback loop (identified below by the same reference number 200 as the command unit) which comprises:

- a processing unit or controller 260 with microprocessor 262 connected to the actuating unit 100 and provided with a memory unit 261;
- a measurement system 230 able to receive the existing values of the parameters 320, i.e.: 320a,320b,320c of the motor 300 and emit a corresponding signal 230, i.e. 230a,230b,230c;
- although all three signals 230a,230b,230c may be available, the control unit 200 processes preferably only one of said signals depending on the initial selection made by the user who may set operation of the motor to the motor displacement 320a/250a; the pressure 320b/250b; or the speed 320c/250c;
- an adder 240 designed to:

-- receive at its input one of said signals 230a,230b,230c corresponding to the respec-

tive existing value 320a,320b,320c and one of the respective and corresponding reference values 250a,250b,250c set by the user 250 and stored in the memory unit 261, and
 -- compare the existing signal with the respective reference value of the prechosen signal and send a corresponding difference signal 240a,b,c to the processing unit 260.

[0028] As shown in Fig. 3, the actuating unit 100 comprises in turn a direct-control electrovalve 110 which has an input 110c for pressurized fluid 500a and an input 110d for discharged fluid 500b.

[0029] The electrovalve 110 is controlled by the control system 200 via two coils 110e and 110f from which it receives the activation/deactivation signals which, in a predefined and constant period, comprise a time interval of logic value 1 for opening the valve and a time interval of logic value 0 for closing the valve (Fig. 4b).

[0030] The electrovalve 110 also has two outputs 110a,110b, the end terminals of which are respectively connected to an associated chamber 350a,350b of a double-acting cylinder 350 which, via the piston 308, acts on the movable eccentric cam 306, changing the eccentricity thereof and therefore the motor displacement of the motor.

[0031] The hydraulic circuit situated between the electrovalve 110 and the cylinder 350 comprises two branches 120a,120b each comprising: rotary seals 121a,121b of the driving shaft, a stop valve 122a,122b, the input of which is driven by the fluid supplied from the corresponding output 110a,110b of the distribution valve 110 and each connected to the opposite branch of the input circuit of the other one, a throttle element 123a,123b arranged between the stop valves and the corresponding chamber 350a,350b of the double-acting cylinder 350 for operating the eccentric cam 306 which is thus displaced by the supplying/discharging of the two said chambers 350a,350b.

[0032] The throttle elements 123a,123b are designed to determine the speed of variation of the eccentricity, as will become clearer below. Preferably, the two throttle elements are adjustable so as to vary opening/closing thereof. With this configuration, the operating principle of the apparatus for controlling the eccentric cam 306 for varying the motor displacement of a variable-displacement hydraulic motor is as follows:

considering that control of the motor displacement may be performed alternately at a constant pressure or at a constant speed, the system controls continuously the existing value of the parameter selected, namely of the motor displacement 320a, pressure 320b or the speed 320c, comparing it with the corresponding desired value 250a;250b,250c of the said parameter, and acts via the actuating unit 100 so as to achieve the objective, i.e. the desired value of the selected parameter, modifying the position of the eccentric cam 306, and therefore the motor displacement, via the means 350,308.

[0033] In detail:

- when the motor is switched on, the following are assumed and preferably displayed for the user 250:
 - the existing values of the parameter 320 to be controlled: motor displacement 320a or pressure 320b or speed 320c;
 - the desired values of the corresponding parameter 250 to be controlled: motor displacement 250a or pressure 250b or speed 250c;
 - the period of maximum duration of the pulses for opening/closing the valve is defined;
- the processing unit sends said feedback signals 320 to the adder 240 which compares the signals 320 with the set/stored reference values 250 and emits and sends a difference signal 240a,b,c to the processor 260;

a) if the two values, existing and desired, of the parameter to be controlled coincide and the signal 240a,b,c=0:

the controller 260 does not activate the coils 110e,110f which remain de-energized, both the output connections 110a,110b of the valve are connected to the fluid 500b being discharged, such that the stop valves 130a,130b remain closed, sealing the fluid inside the double-acting cylinder 350 so that the eccentric cam 306 cannot vary its eccentricity, remaining at a standstill in its present position; the motor displacement of the motor consequently remains unchanged.

b) if the two values do not coincide and the difference signal 240a,b,c is smaller than or greater than 0 the controller 260 activates either one of the two coils of the valve 110; in detail: b1) if 240a,b,c<0: the coil 110e is excited and the pressurized input 500a is connected to the output 110b, while the input 110d for the fluid being discharged is connected to the output 110a; in this way the pressurized fluid 500a flows towards the chamber 350b of the double-acting cylinder 350, which acts on the eccentric cam 306 displacing it into a position corresponding to a reduction in the motor displacement of the motor; the pressurized fluid 500a, acting along the output 110b, also releases the valve 122a, allowing the fluid to flow out from the double-acting cylinder through the chamber 350a;

b2) if 240a,b,c>0: the coil 110f is excited and the pressurized input 500a is connected to the output 110a, while the input 110d for the fluid being discharged is connected to the output 110b; consequently the pressurized fluid 500a flows towards the chamber 350a of the double-acting cylinder 350, displacing it into a position corresponding to an increase in the motor displacement.

ment of the motor; the pressurized fluid 500a, acting along the output 110a, also releases the valve 122b, allowing the fluid to flow out from the double-acting cylinder through the chamber 350b;

[0034] According to a preferred characteristic feature of the apparatus it is envisaged (Fig. 4) that the following modes for controlling the valve 110 are defined:

- if the existing value of the parameter to be controlled is equal to the desired Set Point value (240a,b,c=0), less an admissible margin of error, normally ranging between +0.5% and 1.5% of the target value required: the valve 110 is not excited, the stop valves remain shut and the motor displacement of the motor remains fixed at the existing value; the system is in the so-called "dead range";
- if the existing value of the parameter to be controlled is within a range of values differing between 20% and 35% from the desired value, the valve 110 is excited with a long duration pulse, if necessary long enough to be close to the duration of the period, the motor displacement of the motor therefore changes to the maximum speed in order to move closer to the desired value; the system in this case is "out of range"; (interval t2-t3 in Fig. 4b).
- if the existing value of the parameter to be controlled is, with respect to the desired value, in a zone which is between the "dead range" and the "out-of-range" zone, exciting the valve 110 with long pulses, the change in motor displacement would be too fast and there is the risk that there will be imprecise control; in this zone, the so-called "slowing down range", the valve 110 is therefore excited with pulses of decreasing 7 variable duration (interval t2-t3 in Fig. 4b) depending on the difference calculated between the existing value 320a,320b,320c and the desired value 250a,250b,250c of the parameter to be controlled. The duration of the excitation pulse of the valve is gradually decreased as the existing value moves closer to the desired value, namely as the parameter to be controlled moves towards the "dead range".

[0035] The invention also provides a method for controlling the position of an eccentric cam of the shaft of a variable-displacement hydraulic motor by means of an apparatus as described above, said method comprising the following steps:

- starting the motor and
- detecting the existing value 320 of at least one operating parameter 320a,320b,320c thereof;
- selecting a period of maximum duration of the pulses for opening/closing the valve;
- selecting one of said operating parameters to be controlled;
- comparing the existing value 320 of the chosen pa-

rameter with an associated set/stored reference value 250;

- emitting and sending a difference signal 240a,b,c for the difference between said values of the selected parameter to the control and command unit 200;
- sending, by the control and command unit 200, of the difference signal 240a,b,c, to the actuating unit 100;
- sending, to the electrovalve 110, by the actuating unit 100, of variable-duration excitation pulses for opening the electrovalve, having a duration determined on the basis of the difference signal 240a,b,c received;
- opening the electrovalve 110 so as to supply the hydraulic circuit for performing displacement of the eccentric cam 306;
- said electrovalve being of the direct-control type.

[0036] The method according to the invention envisages that the period of the command pulses of the electrovalve comprise time intervals of logic value 1 for opening the valve and time intervals of logic value 0 for closing the variable-duration valve. Preferably, said time intervals of logic value 1 have a longer duration if the existing value of the parameter to be controlled differs from the reference value set by an amount ranging between 25% and 30% of the said desired value, and shorter duration if said value is between 0.5% and 1.5% of the desired value.

[0037] According to preferred embodiments it is envisaged that the method comprises a step of adjusting the speed of variation of the eccentricity of the motor, by means of throttle elements 123a,123b arranged in the hydraulic circuit of the actuating unit; preferably opening/closing of said throttle elements is adjustable.

[0038] It is also envisaged that the method performs the control of at least one parameter 320 from among the motor displacement 320a, the pressure 320b or the speed 320c and that the command and control unit 200 comprises an adder 240 which receives at its input said existing values 320a,320b,320c of the at least one parameter and respective set/stored reference values 250a,250b,250c and emits a difference signal 240a,b,c, for said at least one selected parameter, which it sends to the input of a processing unit 260.

[0039] It is therefore clear how the apparatus and the method according to the invention, characterized by a direct-control distribution valve 110 which is always fully open when activated, but controlled by means of pulses of variable length in a predefined maximum time period, in combination with stop valves for stopping the flow of the fluid, ensure that in the cylinder actuating the eccentric cam there is always sufficient pressure to control the movements of the said eccentric and that the activation of the electrovalve with variable pulses allows the use of pulses of longer duration, when the existing value of the parameter to be controlled differs greatly from the desired value, and pulses of much shorter duration, when said

value is close to the desired value, locking the eccentric cam in position between one excitation period and the other of the valve, ensuring at the same time also that precision in variation of the motor displacement necessary for correct operation of the motor.

[0040] At the same time the maximum speed of motor displacement of the eccentric cam 306 and therefore of the system for varying the motor displacement may be adjusted by means of calibration of the throttle elements 123a, 123b.

[0041] In this way simultaneously both the required positioning speed and the necessary precision in the eccentricity position are obtained.

[0042] In addition to this, since the hydraulic circuit is under pressure only during the variation of eccentricity transients, a high reduction of the fluid leakages through the rotary seals of the driving shaft is obtained, with a consequent saving of energy.

[0043] Although described in connection with a number of embodiments and a number of preferred examples of implementation of the invention, it is understood that the scope of protection of the present patent is determined solely by the claims below.

Claims

1. Variable-displacement hydraulic motor (300) comprising a shaft, an eccentric cam (306) and an apparatus for controlling the position of the eccentric cam (306) which comprises:

- a means (350) for moving the eccentric cam (306), comprising a double-acting cylinder (350) acting via a piston (308) on the eccentric cam (306) for changing the eccentricity thereof and therefore the motor displacement of the motor;
- an actuating unit (100) for actuating the eccentric cam (306), comprising an electrovalve (110) having two outputs (110a, 110b) respectively connected to an associated chamber (350a, 350b) of the double-acting cylinder (350), and a hydraulic control circuit (120a, 120b) for controlling the means (350) for moving the eccentric cam (306), arranged between the outputs (110a, 110b) of the electrovalve (110) and the double-acting cylinder (350);

- a control and command unit (200), which is feedback-connected between points for detecting one or more existing operating parameters (320a, 320b, 320c) of the motor (300) and points for entering set values (250a, 250b, 250c) for the one or more operating parameters of the motor and which is designed to control operation of the actuating unit (100) for actuating the eccentric cam (306) wherein said electrovalve (110) is of the direct-control type that is always fully open when activated and is driven by pulses having

a predefined period with opening/closing time intervals of variable duration emitted by the control and command unit (200) depending on the difference between a detected existing value (320, 320b, 320c) and a desired stored (262) value (250a, 250b, 250c) of one of said parameters, and in that the hydraulic control circuit (120a, 120b) comprises stop valves (122a, 122b) for stopping the actuating fluid that remain shut when the electrovalve (110) is not excited for opening, locking the eccentric cam in position between one excitation and the other of the electrovalve.

2. Motor according to Claim 1, **characterized in that** the period of the command pulses of the electrovalve (110) comprises time intervals of logic value 1 for opening the electrovalve and time intervals of logic value 0 for closing the electrovalve, of variable duration.
3. Motor according to Claim 2, **characterized in that** said time intervals of logic value 1 have a longer duration, if the existing value of the parameter to be controlled differs by a value of between 25% and 30% from the desired value, and a shorter duration, if said value is between 0.5% and 1.5% of the desired value.
4. Motor according to any Claim 1-3, **characterized in that** the control and command unit (200) comprises:
 - a controller (260) with microprocessor (262) connected to the actuating unit (100) and a memory unit (261);
 - a measurement system (230) designed to receive the existing values of the one or more parameters (320a, 320b, 320c) of the motor (300) and to emit corresponding signals (230a, 230b, 230c);
 - an adder (240) designed to receive at its input said existing values (320a, 320b, 320c) and respective reference values (250a, 250b, 250c) set by the user (250) and stored in the memory unit (261) and to emit a difference signal (240a, b, c) for the said at least one parameter to be sent to the input of the processing unit (260).
5. Motor according to any Claim 1 to 4, **characterized in that** said at least one parameter (320) to be controlled is at least one of: the motor displacement (320a), the pressure (320b) or the speed (320c) of rotation of the motor shaft.
6. Motor according to any preceding Claim **characterized in that** said hydraulic control circuit situated between the outputs (110a, 110b) of the electrovalve (110) and the cylinder (350) for actuating the eccen-

tric cam (306) comprises two branches (120a,120b) each comprising: rotary seals (121a,121b) of the driving shaft, and one of said stop valves (122a,122b), the input of which is driven by the fluid supplied from the corresponding output (110a,110b) of the distribution electrovalve (110) and each connected to the opposite branch of the input circuit of the other one.

7. Motor according to Claim 6, **characterized in that** each branch of the hydraulic circuit (120a, 120b) comprises a throttle element (123a,123b) arranged between the stop valves and the corresponding chamber (350a,350b) of the double-acting actuating cylinder (350) and designed to determine the speed of variation of eccentricity of the motor.

8. Motor according to Claim 7, **characterized in that** the two throttle elements (123a,123b) are adjustable so as to vary opening/closing thereof.

9. Motor according to claim 1 wherein the apparatus for controlling the position of the eccentric cam (306) is configured so that if the existing value of the parameter to be controlled is equal to the desired value less an admissible margin of error, the electrovalve (110) is not excited, whereby the stop valves remain shut and the motor displacement of the motor remains fixed at the existing value.

10. Method for controlling the position of an eccentric cam (306) of the shaft of a variable-displacement hydraulic motor (300) according to any of the preceding Claims it comprising the following steps:

- starting the motor and
- detecting the existing value (320) of at least one operating parameter (320a,320b,320c) thereof;
- selecting a period of maximum duration of the pulses for opening/closing the electrovalve;
- selecting one of said operating parameters to be controlled;
- comparing the existing value (320) of the selected parameter with a corresponding set/stored reference value (250),
- emitting and sending a signal (240a,b,c) for the difference between said values of the selected parameter to the control and command unit (200);
- sending, by the control and command unit (200), of the difference signal (240a,b,c) to the actuating unit (100);
- sending to the electrovalve (110), by the actuating unit (100), of variable-duration excitation pulses for opening the electrovalve, having a duration determined on the basis of the difference signal (240a,b,c) received;

- opening the electrovalve (110) so as to supply the hydraulic control circuit for performing displacement of the eccentric cam (306); wherein said electrovalve is of the direct-control type that is always fully open when activated and wherein the stop valves (122a,122b) for stopping the actuating fluid remain shut when the electrovalve (110) is not excited for opening, locking the eccentric cam in position between one excitation and the other of the electrovalve.

11. Method according to Claim 10, **characterized in that** the period of the command pulses for the electrovalve (110) comprises time intervals of logic 1 for opening the valve and time intervals of logic 0 for closing the valve, which are of variable duration.

12. Method according to Claim 11, **characterized in that** said time intervals of logic value 1 have a longer duration if the existing value of the parameter to be controlled differs from the set reference value by an amount of between 25% and 30% of the said desired value and shorter length if said value is between 0.5% and 1.5% of the desired value.

13. Method according to Claim 10 or 11 or 12 **characterized in that** it comprises a step of adjusting the speed of variation of the eccentricity of the motor, by means of throttle elements (123a,123b) arranged in the hydraulic control circuit of the actuating unit.

14. Method according to Claim 13, **characterized in that** opening/closing of said throttle elements is adjustable.

15. Method according to any of Claims 10-14, **characterized in that** said at least one parameter (320) to be controlled is at least one of: the motor displacement (320a), the pressure (320b) or the speed (320c) of rotation of the motor shaft.

16. Method according to any of Claims 10-15, **characterized in that** the control and command unit (200) comprises an adder (240) which receives at its input said existing values (320a,320b,320c) of the at least one parameter and respective set/stored reference values (250a,250b,250c) and emits a difference signal (240a,b,c) for the said at least one selected parameter, which it sends to the input of a processing unit (260).

17. Method according to claim 10 wherein if the existing value of the parameter to be controlled is equal to the desired value less an admissible margin of error, the electrovalve (110) is not excited, whereby the stop valves remain shut and the motor displacement of the motor remains fixed at the existing value.

Patentansprüche

1. Hydraulischer Verstellmotor (300), der eine Welle, einen exzentrischen Nocken (306) und eine Vorrichtung zur Steuerung der Position des exzentrischen Nockens (306) umfasst, welche Folgendes umfasst:

- ein Mittel (350) zum Bewegen des exzentrischen Nockens (306), das einen doppelt wirkenden Zylinder (350) umfasst, der über einen Kolben (308) auf den exzentrischen Nocken (306) zum Ändern der Exzentrizität von diesem und daher der motorischen Verstellung des Motors einwirkt;
- eine Betätigungseinheit (100) zum Betätigen des exzentrischen Nockens (306), die ein Elektroventil (110), das zwei Auslässe (110a, 110b) aufweist, die jeweils mit einer zugehörigen Kammer (350a, 350b) des doppelt wirkenden Zylinders (350) verbunden sind, und eine hydraulische Steuerschaltung (120a, 120b) zum Steuern des Mittels (350) zum Bewegen des exzentrischen Nockens (306) umfasst, die zwischen den Auslässen (110a, 110b) des Elektroventils (110) und dem doppelt wirkenden Zylinder (350) angeordnet ist;
- eine Steuer- und Befehlseinheit (200), welche zwischen den Punkten zum Ermitteln eines oder mehrerer bestehender Betriebsparameter (320a, 320b, 320c) des Motors (300) und den Punkten zum Eingeben festgelegter Werte (250a, 250b, 250c) für den einen oder mehrere Betriebsparameter des Motors in einer Rückkopplung verbunden ist und welche dazu konzipiert ist, den Betrieb der Betätigungseinheit (100) zum Betätigen des exzentrischen Nockens (306) zu steuern, wobei das Elektroventil (110) von der direktgesteuerten Art ist, die bei Aktivierung stets vollends geöffnet ist und die durch Impulse angetrieben wird, die einen vordefinierten Zeitraum mit Zeitintervallen zum Öffnen/Schließen variabler Dauer aufweisen, die durch die Steuer- und Befehlseinheit (200) in Abhängigkeit von der Differenz zwischen einem ermittelten bestehenden Wert (320a, 320b, 320c) und einem gewünschten abgespeicherten (262) Wert (250a, 250b, 250c) von einem der Parameter ausgegeben wird, und in der die hydraulische Steuerschaltung (120a, 120b) Absperrventile (122a, 122b) zum Anhalten des Betätigungsfluids umfasst, die geschlossen bleiben, wenn das Elektroventil (110) nicht zum Öffnen angeregt wird, wobei der exzentrische Nocken in einer Position zwischen einer Anregung und der anderen des Elektroventils verriegelt wird.

2. Motor nach Anspruch 1, **dadurch gekennzeichnet**,

dass der Zeitraum der Befehlsimpulse des Elektroventils (110) Zeitintervalle vom logischen Wert 1 zum Öffnen des Elektroventils und Zeitintervalle vom logischen Wert 0 zum Schließen des Elektroventils variabler Dauer umfasst.

3. Motor nach Anspruch 2, **dadurch gekennzeichnet, dass** die Zeitintervalle vom logischen Wert 1 eine längere Dauer aufweisen, wenn sich der bestehende Wert des zu steuernden Parameters um einen Wert von zwischen 25 % und 30 % von dem gewünschten Wert unterscheidet, und eine kürzere Dauer, wenn der Wert zwischen 0,5 % und 1,5 % des gewünschten Werts liegt.

4. Motor nach einem der Ansprüche 1-3, **dadurch gekennzeichnet, dass** die Steuer- und Befehlseinheit (200) Folgendes umfasst:

- eine Steuerung (260) mit einem Mikroprozessor (262), der mit der Betätigungseinheit (100) und einer Speichereinheit (261) verbunden ist;
- ein Messsystem (230), das dafür konzipiert ist, die bestehenden Werte von dem einen oder mehreren Parametern (320a, 320b, 320c) des Motors (300) zu empfangen und entsprechende Signale (230a, 230b, 230c) auszugeben;
- einen Hinzufüger (240), der dafür konzipiert ist, die bestehenden Werte (320a, 320b, 320c) und jeweilige Referenzwerte (250a, 250b, 250c), die durch den Benutzer (250) festgelegt wurden und in der Speichereinheit (261) gespeichert sind, an seinem Einlass zu empfangen und ein Differenzsignal (240a,b,c) für den mindestens einen Parameter, der an den Einlass der Verarbeitungseinheit (260) zu senden ist, auszugeben.

5. Motor nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** der mindestens eine zu steuernde Parameter (320) mindestens einer der Folgenden ist: die motorische Verstellung (320a), der Druck (320b) oder die Geschwindigkeit (320c) der Drehung der Motorwelle.

6. Motor nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die hydraulische Steuerschaltung, die zwischen den Auslässen (110a, 110b) des Elektroventils (110) und dem Zylinder (350) zum Betätigen des exzentrischen Nockens (306) liegt, zwei Abzweigungen (120a, 120b) umfasst, die jeweils Folgendes umfassen: Drehdichtungen (121a, 121b) der Antriebswelle und eines der Absperrventile (122a, 122b), wobei deren Einlass durch das Fluid, das vom entsprechenden Auslass (110a, 110b) des Elektroventils (110) zur Verteilung bereitgestellt wird, angetrieben wird, und wobei jedes mit der gegenüberliegenden Abzweigung der

Einlassschaltung des anderen verbunden ist.

7. Motor nach Anspruch 6, **dadurch gekennzeichnet, dass** jede Abzweigung der hydraulischen Schaltung (120a, 120b) ein Drosselklappenelement (123a, 123b) umfasst, das zwischen den Absperrventilen und der entsprechenden Kammer (350a, 350b) des doppelt wirkenden Betätigungszyinders (350) angeordnet ist und dazu konzipiert ist, die Geschwindigkeit der Änderung der Exzentrizität des Motors zu bestimmen. 5
8. Motor nach Anspruch 7, **dadurch gekennzeichnet, dass** die zwei Drosselklappenelemente (123a, 123b) anpassbar sind, um das Öffnen/Schließen dieser zu variieren. 10
9. Motor nach Anspruch 1, wobei die Vorrichtung zur Steuerung der Position des exzentrischen Nockens (306) so konfiguriert ist, dass das Elektroventil (110) nicht angeregt wird, wenn der bestehende Wert des zu steuernden Parameters gleich dem gewünschten Wert, abzüglich einer zulässigen Fehlerspanne, ist, wodurch die Absperrventile geschlossen bleiben und die motorische Verstellung des Motors beim bestehenden Wert fixiert bleibt. 15
10. Verfahren zur Steuerung der Position eines exzentrischen Nockens (306) der Welle eines hydraulischen Verstellmotors (300) nach einem der vorhergehenden Ansprüche, die folgenden Schritte umfassend: 20
 - Starten des Motors und
 - Erfassen des bestehenden Werts (320) von mindestens einem Betriebsparameter (320a, 320b, 320c) von diesem;
 - Auswählen eines Zeitraums von maximaler Dauer der Impulse zum Öffnen/Schließen des Elektroventils;
 - Auswählen eines der zu steuernden Betriebsparameter;
 - Vergleichen des bestehenden Werts (320) des ausgewählten Parameters mit einem entsprechenden festgelegten/gespeicherten Referenzwert (250);
 - Ausgeben und Senden eines Signals (240a,b,c) für die Differenz zwischen den Werten des ausgewählten Parameters an die Steuer- und Befehlseinheit (200);
 - Senden des Differenzsignals (240a,b,c) durch die Steuer- und Befehlseinheit (200) an die Betätigungseinheit (100);
 - Senden von Anregungsimpulsen mit variabler Dauer zum Öffnen des Elektroventils durch die Betätigungseinheit (100) an das Elektroventil (110), wobei sie eine Dauer aufweisen, die auf Grundlage des empfangenen Differenzsignals 25

(240a,b,c) bestimmt wird;

- Öffnen des Elektroventils (110), um die hydraulische Steuerschaltung zum Durchführen einer Verstellung des exzentrischen Nockens (306) zu versorgen;

- wobei das Elektroventil von der direktgesteuerten Art ist, die bei Aktivierung stets vollständig geöffnet ist, und wobei die Absperrventile (122a, 122b) zum Anhalten des Betätigungsfluids geschlossen bleiben, wenn das Elektroventil (110) nicht zum Öffnen angeregt wird, wobei der exzentrische Nocken in einer Position zwischen einer Anregung und der anderen des Elektroventils verriegelt ist.

11. Verfahren nach Anspruch 10, **dadurch gekennzeichnet, dass** der Zeitraum der Befehlsimpulse für das Elektroventil (110) Zeitintervalle von Logik 1 zum Öffnen des Ventils und Zeitintervalle von Logik 0 zum Schließen des Ventils umfasst, welche von variabler Dauer sind.
12. Verfahren nach Anspruch 11, **dadurch gekennzeichnet, dass** die Zeitintervalle von Logikwert 1 eine längere Dauer aufweisen, wenn sich der bestehende Wert des zu steuernden Parameters vom festgelegten Referenzwert um eine Höhe von zwischen 25 % und 30 % des gewünschten Werts unterscheidet, und eine kürzere Länge, wenn der Wert zwischen 0,5 % und 1,5 % des gewünschten Werts liegt.
13. Verfahren nach Anspruch 10 oder 11 oder 12, **dadurch gekennzeichnet, dass** es einen Schritt zum Anpassen der Änderungsgeschwindigkeit der Exzentrizität des Motors mittels Drosselklappenelementen (123a, 123b) umfasst, die in der hydraulischen Steuerschaltung der Betätigungseinheit angeordnet sind.
14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** das Öffnen/Schließen der Drosselklappenelemente anpassbar ist.
15. Verfahren nach einem der Ansprüche 10-14, **dadurch gekennzeichnet, dass** der mindestens eine zu steuernde Parameter (320) mindestens eines der Folgenden ist: die motorische Verstellung (320a), der Druck (320b) oder die Geschwindigkeit (320c) der Drehung der Motorwelle.
16. Verfahren nach einem der Ansprüche 10-15, **dadurch gekennzeichnet, dass** die Steuer- und Befehlseinheit (200) einen Hinzufüger (240) umfasst, der an seinem Einlass die bestehenden Werte (320a, 320b, 320c) des mindestens einen Parameters und jeweilige festgelegte/gespeicherte Referenzwerte (250a, 250b, 250c) empfängt und ein Differenzsignal (240a,b,c) für den mindestens einen 30

ausgewählten Parameter ausgibt, welchen er an den Einlass einer Verarbeitungseinheit (260) sendet.

17. Verfahren nach Anspruch 10, wobei das Elektroventil (110) nicht angeregt wird, wenn der bestehende Wert des zu steuernden Parameters gleich dem gewünschten Wert, abzüglich einer zulässigen Fehlerspanne, ist, wodurch die Absperrventile geschlossen bleiben und die motorische Verstellung des Motors beim bestehenden Wert fixiert bleibt.

Revendications

1. Moteur hydraulique à cylindrée variable (300) comprenant un arbre, une came excentrique (306) et un appareil pour commander la position de la came excentrique (306), qui comprend :
 - un moyen (350) pour mouvoir la came excentrique (306), comprenant un cylindre à double effet (350) agissant via un piston (308) sur la came excentrique (306) pour changer son excentricité et par conséquent la cylindrée moteur du moteur ;
 - une unité d'actionnement (100) pour actionner la came excentrique (306), comprenant une électrovanne (110) ayant deux sorties (110a, 110b) raccordées respectivement à une chambre (350a, 350b) associée du cylindre à double effet (350), et un circuit de commande hydraulique (120a, 120b) pour commander le moyen (350) pour mouvoir la came excentrique (306), agencé entre les sorties (110a, 110b) de l'électrovanne (110) et le cylindre à double effet (350) ;
 - une unité de commande et d'ordre (200), qui est connectée en rétroaction entre des points pour détecter un ou plusieurs paramètres de fonctionnement (320a, 320b, 320c) existants du moteur (300) et des points pour entrer des valeurs de consigne (250a, 250b, 250c) pour les un ou plusieurs paramètres de fonctionnement du moteur et qui est conçue pour commander un fonctionnement de l'unité d'actionnement (100) pour actionner la came excentrique (306), dans lequel ladite électrovanne (110) est du type à commande directe qui est toujours totalement ouverte lorsqu'elle est activée et est entraînée par des impulsions ayant une période prédéfinie avec des intervalles d'ouverture/de fermeture de durée variable émises par l'unité de contrôle et de commande (200) en fonction de la différence entre une valeur existante détectée (320, 320b, 320c) et une valeur (250a, 250b, 250c) stockée souhaitée (262) de l'un desdits paramètres, et le circuit de commande hydraulique (120a,

120b) comprend des vannes d'arrêt (122a, 122b) pour arrêter le fluide d'actionnement qui restent fermées lorsque l'électrovanne (110) n'est pas excitée pour l'ouverture, verrouillant la came excentrique en position entre une excitation et l'autre de l'électrovanne.

2. Moteur selon la revendication 1, **caractérisé en ce que** la période des impulsions d'ordre de l'électrovanne (110) comprend des intervalles de valeur logique 1 pour ouvrir l'électrovanne et des intervalles de valeur logique 0 pour fermer l'électrovanne, de durée variable.
3. Moteur selon la revendication 2, **caractérisé en ce que** lesdits intervalles de valeur logique 1 ont une durée plus longue, si la valeur existante du paramètre à commander diffère d'une valeur entre 25 % et 30 % de la valeur souhaitée, et une durée plus courte, si ladite valeur se trouve entre 0,5 % et 1,5 % de la valeur souhaitée.
4. Moteur selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'unité de commande et d'ordre (200) comprend :
 - un dispositif de commande (260) avec un microprocesseur (262) connecté à l'unité d'actionnement (100) et une unité de mémoire (261) ;
 - un système de mesure (230) conçu pour recevoir les valeurs existantes des un ou plusieurs paramètres (320a, 320b, 320c) du moteur (300) et pour émettre des signaux correspondants (230a, 230b, 230c) ;
 - un additionneur (240) conçu pour recevoir au niveau de son entrée lesdites valeurs existantes (320a, 320b, 320c) et des valeurs de référence (250a, 250b, 250c) respectives définies par l'utilisateur (250) et stockées dans l'unité de mémoire (261) et pour émettre un signal de différence (240a, b, c) pour ledit au moins un paramètre à envoyer à l'entrée de l'unité de traitement (260).
5. Moteur selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** ledit au moins un paramètre (320) à commander est au moins l'une parmi : la cylindrée moteur (320a), la pression (320b) ou la vitesse (320c) de rotation de l'arbre de moteur.
6. Moteur selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit circuit de commande hydraulique situé entre les sorties (110a, 110b) de l'électrovanne (110) et le cylindre (350) pour actionner la came excentrique (306) comprend deux dérivations (120a, 120b) comprenant chacune : des joints rotatifs (121a, 121b) de l'arbre d'entraînement, et l'une desdites vannes d'arrêt (122a, 122b),

- dont l'entrée est entraînée par le fluide fourni depuis la sortie correspondante (110a, 110b) de l'électrovanne de distribution (110) et chacune étant connectée à la dérivation opposée du circuit d'entrée de l'autre.
7. Moteur selon la revendication 6, **caractérisé en ce que** chaque dérivation du circuit hydraulique (120a, 120b) comprend un élément papillon (123a, 123b) agencé entre les vannes d'arrêt et la chambre (350a, 350b) correspondante du cylindre d'actionnement à double effet (350) et conçu pour déterminer la vitesse de variation d'excentricité du moteur.
8. Moteur selon la revendication 7, **caractérisé en ce que** les deux éléments papillon (123a, 123b) sont ajustables de façon à faire varier leur ouverture/fermeture.
9. Moteur selon la revendication 1, dans lequel l'appareil pour commander la position de la came excentrique (306) est configuré de telle sorte que, si la valeur existante du paramètre à commander est égale à la valeur souhaitée, inférieure à une marge d'erreur admissible, l'électrovanne (110) n'est pas excitée, moyennant quoi les vannes d'arrêt restent fermées et la cylindrée moteur du moteur reste fixe à la valeur existante.
10. Procédé pour commander la position d'une came excentrique (306) de l'arbre d'un moteur hydraulique à cylindrée variable (300) selon l'une quelconque des revendications précédentes, comprenant les étapes suivantes :
- le démarrage du moteur et
 - la détection de la valeur existante (320) d'au moins un paramètre de fonctionnement (320a, 320b, 320c) de celui-ci ;
 - la sélection d'une période de durée maximale des impulsions pour ouvrir/fermer l'électrovanne ;
 - la sélection de l'un desdits paramètres de fonctionnement à commander ;
 - la comparaison de la valeur existante (320) du paramètre sélectionné à une valeur de référence (250) définie/stockée correspondante,
 - l'émission et l'envoi d'un signal (240a, b, c) pour la différence entre lesdites valeurs du paramètre sélectionné à l'unité de commande et d'ordre (200) ;
 - l'envoi, par l'unité de commande et d'ordre (200), du signal de différence (240a, b, c) à l'unité d'actionnement (100) ;
 - l'envoi à l'électrovanne (110), par l'unité d'actionnement (100), d'impulsions d'excitation de durée variable pour ouvrir l'électrovanne, ayant une durée déterminée sur la base du signal de
- différence (240a, b, c) reçu ;
- l'ouverture de l'électrovanne (110) de façon à alimenter le circuit de commande hydraulique pour effectuer une cylindrée de la came excentrique (306) ;
 - dans lequel ladite électrovanne est du type à commande directe qui est toujours totalement ouverte lorsqu'elle est activée et dans lequel les vannes d'arrêt (122a, 122b) pour arrêter le fluide d'actionnement restent fermées lorsque l'électrovanne (110) n'est pas excitée pour l'ouverture, verrouillant la came excentrique en position entre une excitation et l'autre de l'électrovanne.
11. Procédé selon la revendication 10, **caractérisé en ce que** la période des impulsions d'ordre pour l'électrovanne (110) comprend des intervalles de logique 1 pour ouvrir la vanne et des intervalles de logique 0 pour fermer la vanne, qui sont de durée variable.
12. Procédé selon la revendication 11, **caractérisé en ce que** lesdits intervalles de valeur logique 1 ont une durée plus longue, si la valeur existante du paramètre à commander diffère de la valeur de référence de consigne d'une quantité entre 25 % et 30 % de ladite valeur souhaitée et une durée plus courte si ladite valeur se trouve entre 0,5 % et 1,5 % de la valeur souhaitée.
13. Procédé selon la revendication 10 ou 11 ou 12, **caractérisé en ce qu'il** comprend une étape d'ajustement de la vitesse de variation de l'excentricité du moteur, au moyen d'éléments papillon (123a, 123b) agencés dans le circuit de commande hydraulique de l'unité d'actionnement.
14. Procédé selon la revendication 13, **caractérisé en ce que** l'ouverture/la fermeture desdits éléments papillon est ajustable.
15. Procédé selon l'une quelconque des revendications 10 à 14, **caractérisé en ce que** ledit au moins un paramètre (320) à commander est au moins l'une parmi: la cylindrée moteur (320a), la pression (320b) ou la vitesse (320c) de rotation de l'arbre de moteur.
16. Procédé selon l'une quelconque des revendications 10 à 15, **caractérisé en ce que** l'unité de commande et d'ordre (200) comprend un additionneur (240) qui reçoit au niveau de son entrée lesdites valeurs existantes (320a, 320b, 320c) de l'au moins un paramètre et des valeurs de référence (250a, 250b, 250c) définies/stockées respectives et émet un signal de différence (240a, b, c) pour ledit au moins un paramètre sélectionné, qu'il envoie à l'entrée d'une unité de traitement (260).
17. Procédé selon la revendication 10, dans lequel, si la

valeur existante du paramètre à commander est égale à la valeur souhaitée, inférieure à une marge d'erreur admissible, l'électrovanne (110) n'est pas excitée, moyennant quoi les vannes d'arrêt restent fermées et la cylindrée moteur du moteur reste fixe à la valeur existante.

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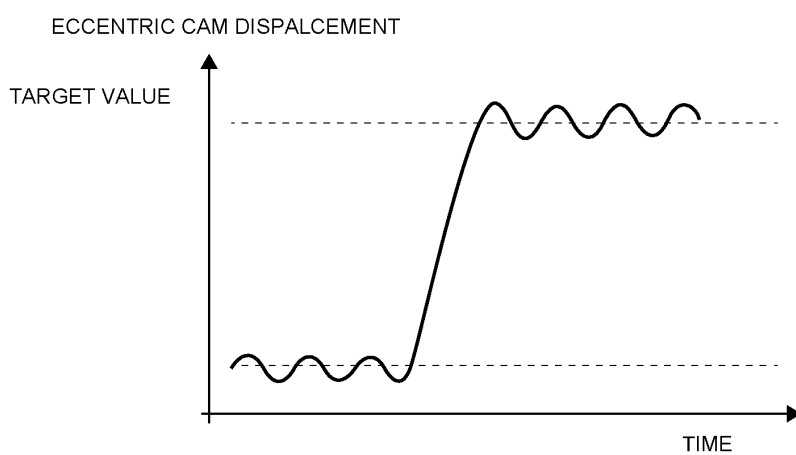
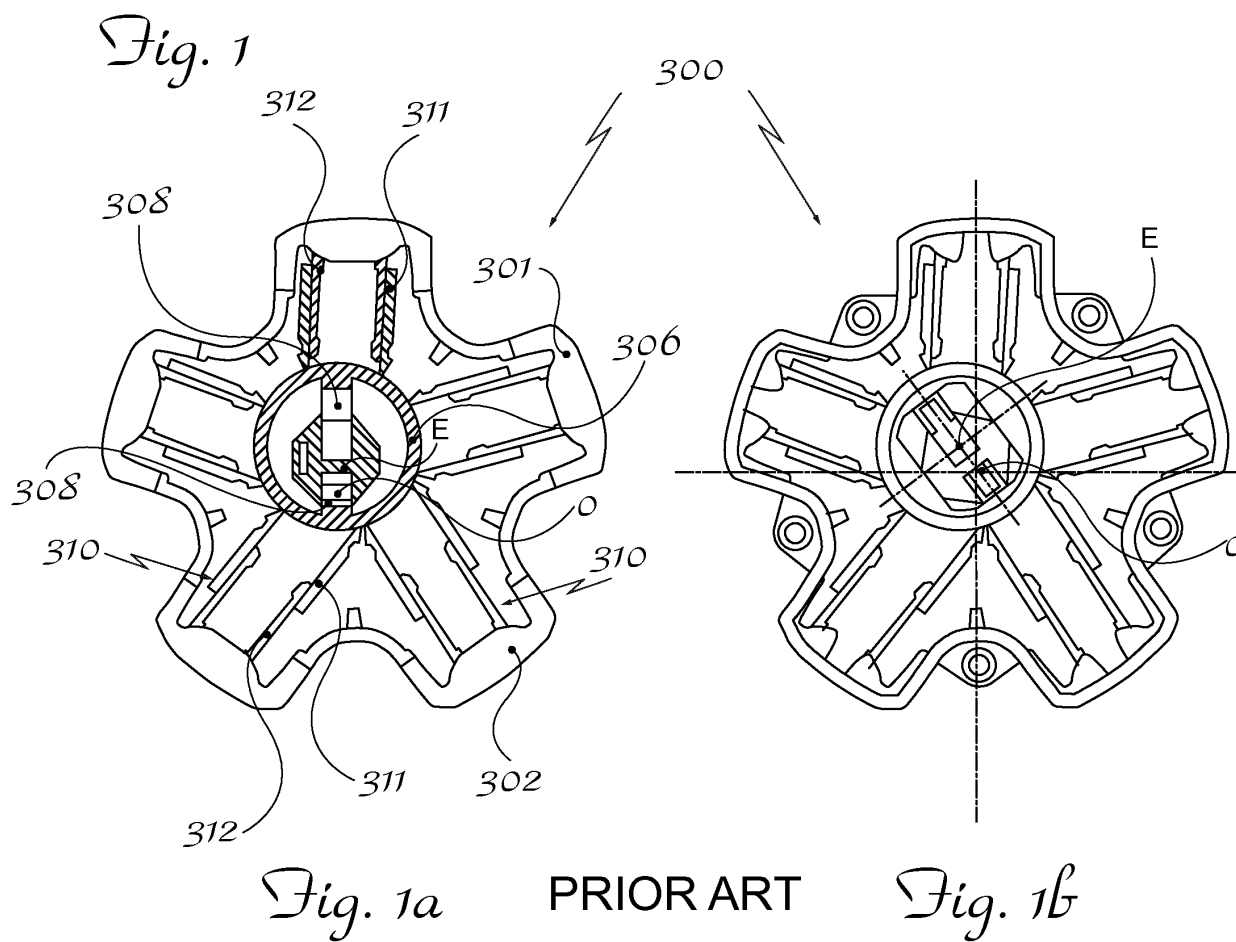
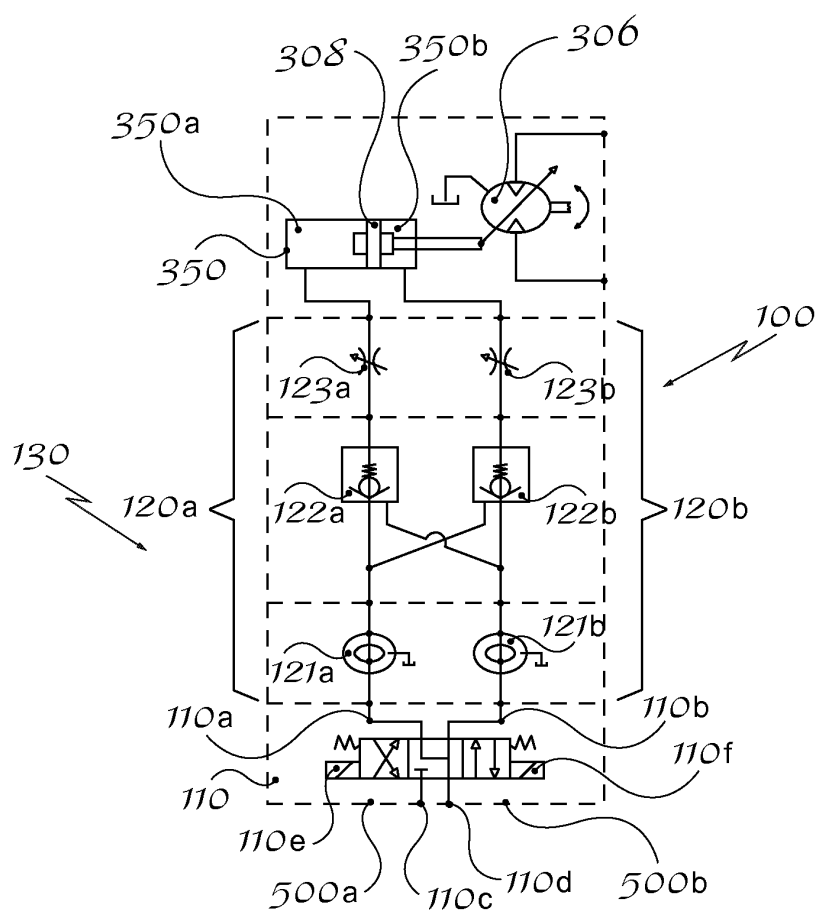
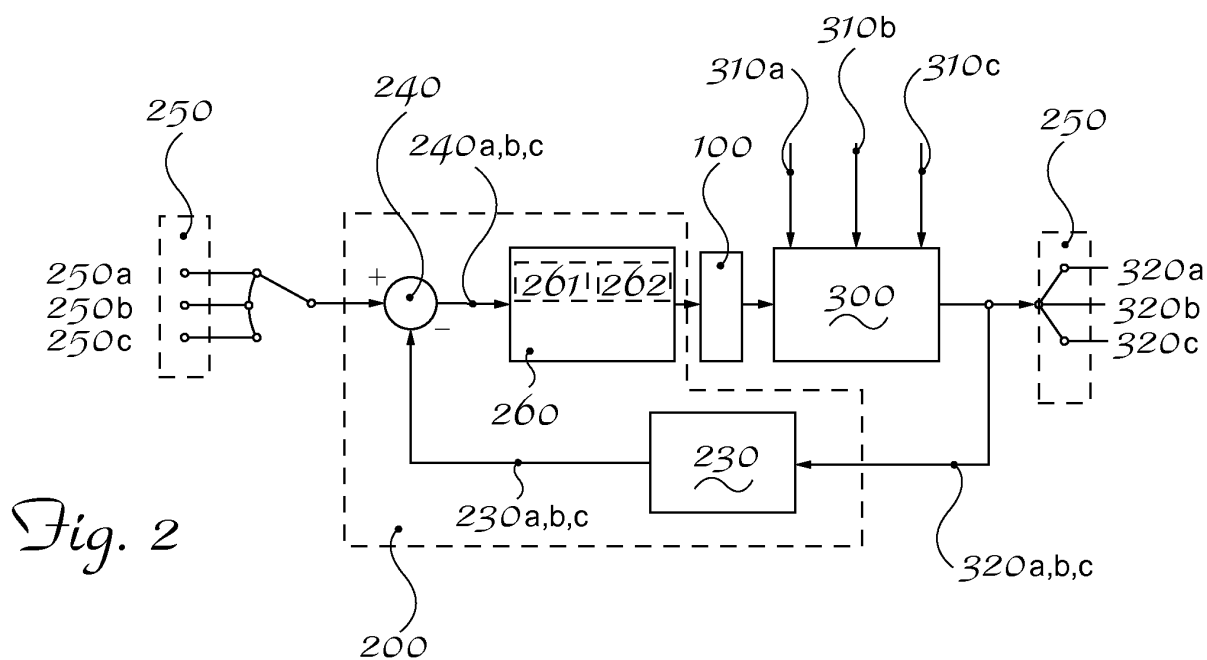


Fig. 1c



ECCENTRIC CAM DISPLACEMENT

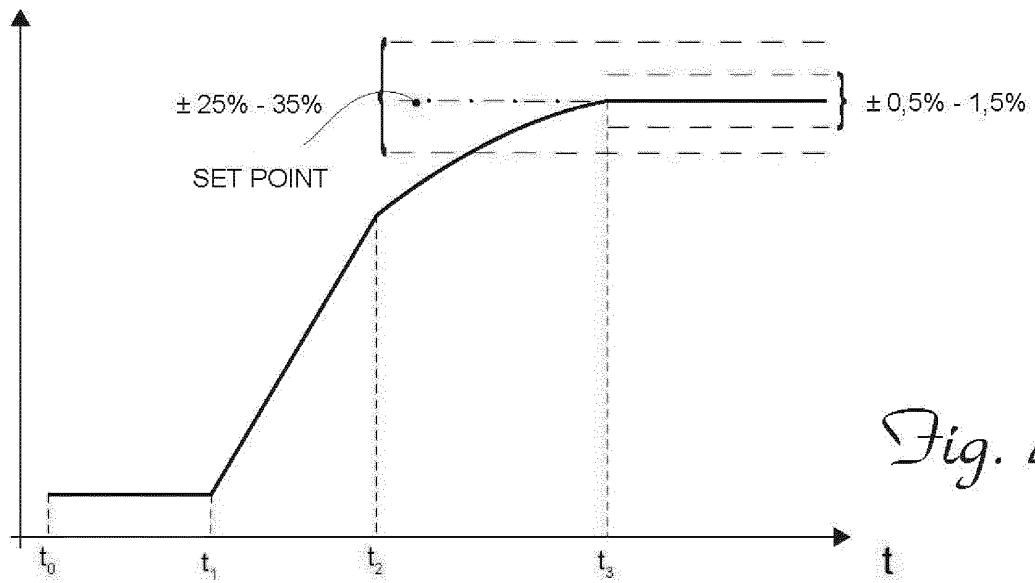


Fig. 4a

VALVE COMMANDE PULSE

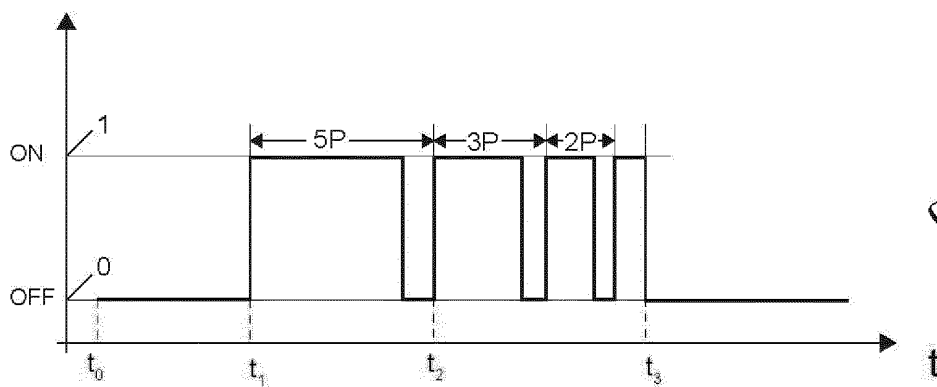


Fig. 4b

STOP VALVE

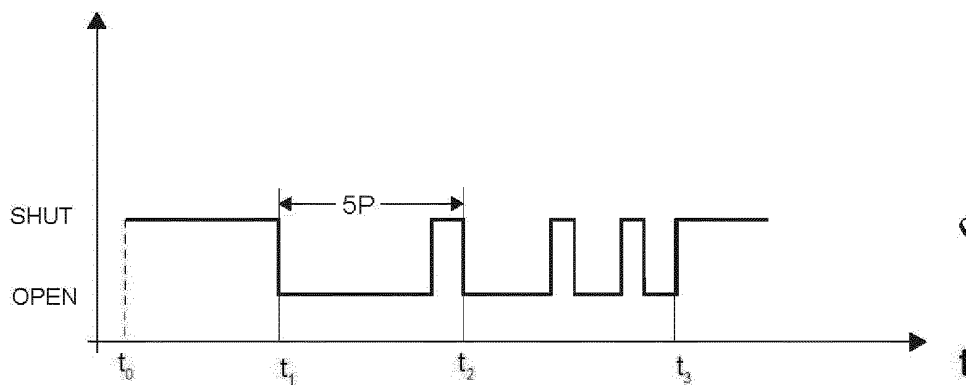


Fig. 4c

REFERENCES CITED IN THE DESCRIPTION

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