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(54) **Device for recording the cylinder capacity of hydraulic motors having radial variable cylinder-capacity propulsors.**

(57) The invention relates to a device for recording the cylinder capacity of hydraulic motors having variable-capacity radial propulsors and in which the propulsors (4) have at least one oscillating portion coupled to an eccentric component (3) of the drive shaft (2), the device comprising at least one proximity sensor (12) mounted in a fixed position on the outer casing (1) of the motor and facing an oscillating means comprising a propulsor (4) or portion thereof, the sensor being adapted to generate an electric signal of varying intensity depending on the distance between it and the oscillating means, and the maximum amplitude of variation of the signal at each revolution of the motor corresponding to the maximum amplitude of oscillation of the oscillating means, which is related to the eccentrity of the eccentric component and to the cylinder capacity determined thereby.

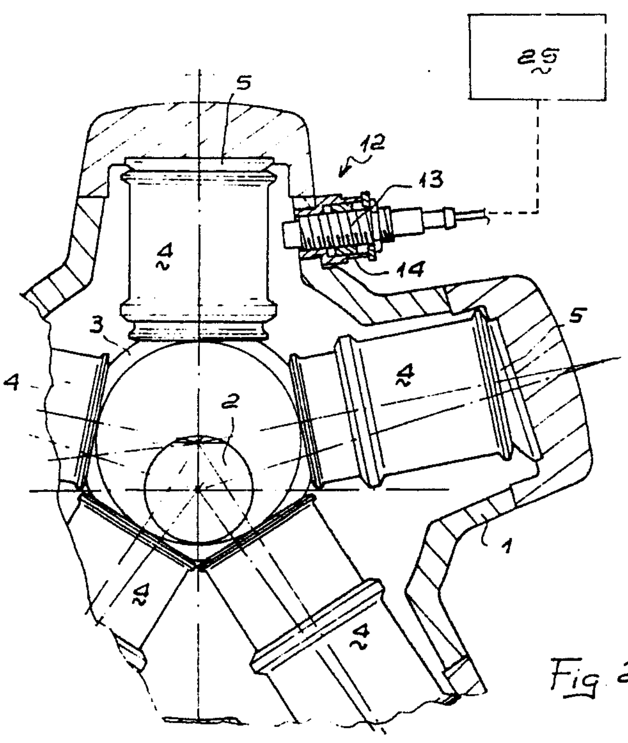

Fig 2

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Device for recording the cylinder capacity of hydraulic motors having radial variable cylinder-capacity propulsors.

The invention relates to a device for recording the cylinder capacity of hydraulic motors comprising radial variable cylinder-capacity propulsors.

There are numerous applications for hydraulic motors of the kind comprising radial propulsors and consisting of a shaft having an eccentric portion acted upon by a number of propulsors disposed substantiall radially around it and cyclically supplied with oil under pressure through a rotary distributor, which drives them in rotation at a speed depending on the flow rate of the oil supply.

Each propulsor substantially comprises a cylinder-piston group comprising a part bearing on or integral with the outer casing of the motor, and a part bearing directly against the eccentric component.

During rotation of the drive shaft, the part of the propulsor bearing against the eccentric, e.g. a connecting rod, or the entire propulsor if movable as a unit, becomes oriented with its axis along the line joining the centre of the eccentric component to a pivoting centre of the propulsor, which thus follows the motion of the eccentric and completes one oscillation at each revolution of the drive shaft.

In order to vary the performance of the motor in accordance with external requirements during use, it is necessary in some cases to vary the cylinder capacity during motion, by adjusting the eccentricity of the eccentric component of the drive shaft.

The usual method of varying the cylinder capacity is to provide one or more hydraulic actuators associated with the eccentric component and supplied and controlled from the exterior.

In that case it is necessary to indicate the actual value, at each moment of operation, of the selected cylinder capacity, which varies both as a result of the controls or actuators and also because of inevitable losses or withdrawal of hydraulic control fluid from the actuators; such variations have to be kept under control in order to keep the operating characteristics of the motor constant.

The indication of cylinder capacity should be obtainable without mechanical contact with moving parts, thus avoiding friction and wear, and also without substantial modifications in the motor structure in order to house bulky mechanical apparatus.

The problem therefore is to construct a device for recording the cylinder capacity of a motor having radial propulsors, the device operating without mechanical contact with the moving parts and recording a quantity associated with the actual cylinder capacity of the motor at each moment during motion thereof.

To this end. the invention provides a device for recording the cylinder capacity of hydraulic motors having variable-capacity radial propulsors and in which the propulsors have at least one oscillating portion coupled to an eccentric component of the drive shaft, the device comprising at least one proximity sensor mounted in a fixed position on the outer casing of the motor and facing an oscillating means comprising a propulsor or portion thereof, the sensor being adapted to generate an electic signal of varying intensity depending on the distance between it and the oscillating means, and the maximum amplitude of variation of the signal at each revolution of the motor corresponding to the maximum amplitude of oscillation of the oscillating means, which is related to the eccentricity of the eccentric component and to the cylinder capacity determined thereby.

In the device for recording the cylinder capacity in hydraulic motors comprising variable cylinder-capacity propulsors according to the invention, optionally at least one proximity sensor is disposed on the outer casing of the motor in the plane of oscillation of the oscillating means and with its end near the position of maximum amplitude of oscillation of the oscillating means; optionally also, one or more proximity sensors are disposed on the outer casing of the motor in the plane at right angles to the plane of oscillation of the oscillating means associated with the propulsors, the ends of the sensors being near the trajectory of the oscillating means.

In the latter case, the sensor or sensors are disposed so that their axis does not intersect the axis of the associated oscillating means when the latter is in the central position but at a short distance therefrom, or the sensor or sensors are disposed so that their axis intersects the axis of the associated oscillating means when it is in the central position.

The proximity sensor is an inductive sensor adapted to supply an electrical signal at a voltage or current which varies in relation to the distance of the sensor from the oscillating means.

The sensor is inserted into a holder rigidly connected to the outer casing of the motor and the minimum distance of the sensor from the oscillating means is adjustable by screw means.

The screw means comprise a thread on the outer surface of the sensor coupled to a corresponding thread on the holder, means being present for locking the screwing rotation of the sensor on the holder and means being present for hydraulic sealing from the exterior.

The hydraulic sealing means comprise a piston connected in sealing-tight manner by synthetic resin to the threaded surface of the sensor and movable in sealing-tight manner, using gaskets, in an orifice in the holder coaxial with the screw-threading of the sensor.

Advantageously a number of sensors are disposed on the outer casing of the motor and each associated with a different oscillating means and adapted to record the maximum amplitude of oscillation at various times during each revolution of the motor.

In an advantageous embodiment of a motor according to the invention, the oscillating means comprise the entire propulsor, which is mounted so as to be freely guidable between the outer casing and the eccentric component; alternatively the oscillating component can be a portion of the propulsor, e.g. a link rod, bearing on the eccentric component of the drive shaft and pivoted to the remaining part of the propulsor.

The sensor or sensors are connected to an external electrical or electronic unit adapted to indicate the actual cylinder capacity of the motor corresponding to the amplitude of variations in the electric signal produced by the sensors.

Optionally, in addition to measuring the amplitude of variation of the voltage, the external electric or electronic unit records the frequency of variation of the signal produced by the sensors and indicates the speed of rotation of the motor corresponding to the frequency, in addition to indicating its cylinder capacity.

Optionally, when advantageous, discontinuities detectable by the sensor and adapted to increase the intensity and/or accuracy of the supplied signal are formed on the outer surface of the oscillating means facing a sensor.

Other details will be clear from the following description with reference to the accompanying drawings in which:

Fig. 1 is a diagram in section along the axis of the drive shaft of a motor comprising radial propulsors having variable cylinder capacity;

Fig. 2 is a view in cross-section of the drive shaft of a motor comprising radial propulsors and having a device for recording the cylinder capacity according to the invention;

Fig. 3 shows the motor in Fig. 2 with a propulsor in the maximum oscillation position;

Fig. 4 shows a detail of the structure and the mounting of the sensor element;

Fig. 5 diagrammatically shows the variation in time of the signal supplied by the sensor element in response to variations in cylinder capacity;

Fig. 6 shows a motor according to the invention having a number of sensors;

Fig. 7 shows a motor according to the invention having a sensor parallel to the drive shaft;

Fig. 8 is a partial view in cross-section of the drive shaft of the motor in Fig. 7 along plane VIII-VIII therein, and

Fig. 9 diagrammatically shows the variation in time of the signal supplied by an axially oriented, centrally positioned sensor element, in response to variations in the cylinder capacity.

As shown by way of example in Fig. 1, a hydraulic radial-piston motor has an external frame 1 in which a drive shaft 2 is rotatably mounted and comprises an eccentric member 3 abutting one end of a number of telescopic propulsors 4, the other ends of the propulsors abutting spherical caps 5 so that the propulsors are freely oriented relative to the angular position taken up by the eccentric member during rotation of the drive shaft.

The drive shaft 2 is made up of two half-shafts 2a, 2b rotatable in bearings 6 and having end drums 7 into which lateral sliding blocks 8 are inserted and project from member 3 and have pistons 9 inside them.

Any one of the chambers defined by pistons 9 inside slide blocks 8 can be supplied through an externally actuated valve 10, ducts 11 and the associated supply channels, thus moving the eccentric member 3 in the radial direction, i.e. varying the eccentricity of the member relative to shaft 2.

As Fig. 2 shows, in order to record the eccentricity of member 3 at each moment, a sensor means 12 is disposed alongside one of the propulsors 4 on casing 1 and comprises an inductive proximity transducer 13 inserted in a holder 14 and adapted to record the approach of a propulsor and supply a signal whose intensity depends on the distance between the propulsor surface and the end of the transducer.

As shown in detail in Fig. 4, holder 14 is screw-connected to the motor casing 1 transducer 13 is screwed inside it. The transducer has a sensitive end 15 facing the propulsor and also has a threaded portion 16 by means of which the transducer can be screwed to a varying amount into holder 14 in order to be placed at the optimum distance from the propulsor. Advantageously the distance "d" between the transducer end 15 and the wall of the propulsor under conditions of maximum inclination, is made as small as possible, e.g. about 1 mm.

The sensor is made sealing-tight to the pressure of hydraulic fluid in the motor casing by an 0-ring 17 for holder 14 and and a collar 18, which moves in an orifice 19 in the holder and seals it by an 0-ring 20. Collar 18 is connected to the threaded portion 16 via a layer of synthetic resin 21 adapted to secure the collar to the transducer and to seal the thread by keeping the collar connected to the transducer in every position in the holder.

The transducer is locked in the chosen position by a lock-nut 22 clamped against a ring 23 bearing the holder.

Transducer 13 accordingly has a cable 24 connected to an electronic device 25 for recording the characteristics of the produced signal and indicating the eccentricity corresponding thereto. The electronic device can be of known kind and is therefore not described in detail.

During rotation of the eccentric, as diagrammatically shown in Fig. 2, a propulsor makes one oscillation around the centre of curvature C of the spherical surface of the associated cap 5, moving from a position near transducer 13 and shown by a continuous line in Fig. 2, to a position remote therefrom and shown by a chain-dotted line in the drawing and denoted by reference 4'.

The size of the oscillation, i.e. the distance of the propulsor axis from the line joining the centre C to the axis of rotation of shaft 2, depends on the eccentricity "e" between the eccentric member 3 and the drive shaft 2, and is zero when the eccentricity is zero, i.e. in the case when the eccentric member 3 is coaxial with shaft 2, so that the propulsor axis extends through the axis of shaft 2 in each phase of rotation of the shaft.

However, when the eccentricity "e" varies, at each revolution of the drive shaft 2 there is a different value for the nearest approach of the outer wall of propulsor 4 to transducer 13, and the signal generated by the transducer consequently indicates the amount of eccentricity.

As shown in Figs. 1 and 2, the amount of eccentricity of member 3 determines the maximum travel of the propulsor pistons and consequently the cylinder capacity of the motor, which is thus determined by the signal generated by the sensor.

As shown by the diagram in Fig. 5, transducer 13 supplies an electric signal at a voltage pulsating between a maximum voltage V_{max}constant in time and a minimum voltage V, the lowest value of which is equal to the value V_{min} corresponding to maximum eccentricity "e", whereas when the eccentricity decreases the voltage increases to near the value V_{max} for lower eccentricity. The drawings shows a variation in cylinder capacity which during the time T produces a change from a value near the maximum cylinder capacity, giving a signal of value V_1 equal to V_{min} to a lower cylinder capacity giving a signal of value V_2. In the case of commercial transducers, the difference between the minimum signal voltage and the maximum voltage V_{max} during one oscillation becomes undetectable at eccentricity values corresponding to about one third of the maximum cylinder capacity.

The signal supplied by the transducer remains constant and equal to V_{max} as long as the propulsor during its oscillations remains beyond a certain distance from the transducer, whereas the voltage decreases abruptly when the propulsor approaches within this distance, when the voltage decreases in proportion to the nearness of the propulsor to the transducer, thus showing the maximum approach of the transducer to the propulsor during oscillation thereof, i.e. the maximum amplitude of oscillation.

The information supplied by transducer 13 is a measure of the cylinder capacity at each revolution of the motor. If this information is insufficient, e.g. for motors rotating particularly slowly and where the variation of the cylinder capacity with time has to be accurately checked, two or more sensors 12 can be disposed on adjacent propulsors as illustrated in Fig. 5, each suppling a signal which is out of phase relative to the other sensor or sensors.

Consequently, even when a propulsor 4a is oscillating at a distance from the associated sensor 12a and therefore cannot yield useful information since its signal is in the phase when the value is substantially equal to V_{max}, another sensor 12b is provided for a propulsor 4b which is at its nearest approach to the sensor and can therefore, even during this period, supply the minimum voltage in the cycle, so that the eccentricity can be determined as requested. This feature enables the cylinder-capacity data to be revised by being recorded two or more times per revolution, depending on the number of sensors provided, whenever a propulsor approaches most closely to one of the sensors. This increases the accuracy of information provided in cases where the time in which the cylinder capacity varies in comparable with the time taken by a revolution of the motor.

As previously stated, the signal supplied by the sensor or sensors disposed on the motor is a periodic signal, the amplitude of which depends on the cylinder capacity of the motor. The frequency "f" of the signal depends on how often per unit time the propulsor is at the minimum distance from the sensor, an event which occurs once per revolution of the motor and is therefore a measure of the rotation speed thereof.

The electronic device associated with the sensor or sensors can thus measure not only the variation in the voltage supplied by the sensor, thus indicating the actual cylinder capacity at each moment, but also the frequency of oscillation of the signal, thus indicating the speed of rotation of the motor.

When the sensor is disposed as described, with its axis in the plane of oscillation of the propulsor, it is possible as stated to record variations in cylinder capacity between the maximum and about one-third thereof. If however it is necessary to record cylinder capacities near the minimum, i.e. corresponding to small eccentricity and to short oscillations of the propulsors, a sensor 12' can be disposed in the position shown in Figs. 7 and 8, i.e. with its axis "a" parallel to the motor axis "n" and out of axial alignment relative to the central position of the propulsor.

In this embodiment the sensor is influenced when approached by a generatrix of the outer surface of the propulsor, which is substantially cylindrical, and owing to its small distance from the central position the sensor can record very small oscillations, i.e. the minimum values for the eccentricity and cylinder capacity of the motor.

The sensor can also be disposed in the central position, i.e. in the plane containing the axis of the motor and the axis of the propulsor. In this case, as shown diagrammatically in Fig. 9, the signal will have a voltage V_{min} when the propulsor is in the central position and a maximum voltage of V_1 when the sensor is at the maximum distance from the propulsor.

This embodiment is particularly convenient when the propulsor or the oscillating part thereof cannot rotate around its axis during oscillation. In such cases the outer surface of the propulsor facing the sensor can be formed with a raised portion or the like which, when moving towards, or away from the sensor, produces appreciable variations in the signal emitted by the sensor and thus increases the sensitivity of the device. The aforementioned raised portion may also be advantageous in other embodiments of the sensor.

The sensor reading for small oscillations can be combined with the reading supplied by a sensor disposed as previously described with its axis in the plane of oscillation of the sensor, in order to measure larger oscillations and thus provide signals which, when combined by an external device, can be used to obtain the actual cylinder capacity throughout its range of variation.

In the case of sensors disposed at right angles to the plane of oscillation of the propulsor, the periodic variation of the signal occurs at twice the frequency of the signal supplied by a sensor disposed in the plane of oscillation, since the propulsor or oscillating component thereof travels near the central position twice during each oscillation. In order therefore to indicate the speed of rotation of the motor, the signal must be processed differently from the signal from the sensors in the plane of oscillation.

The sensor according to the invention has been described in detail by way of example in connection with a specific kind of hydraulic motor comprising telescopic propulsors which can be disposed between an eccentric member and a spherical cap. However, the invention is applicable to every kind of hydraulic motor in which a propulsor element is associated with a rotary eccentric element and therefore either it or at least a part thereof, e.g. a connecting rod, is subjected to lateral oscillations depending in amplitude on the eccentricity of the eccentric element.

In each case, according to the invention, at least one proximity sensor is disposed in a position so as to measure the amount of oscillation of the propulsor means which is in contact with the eccentric and is therefore oscillating with an amplitude which varies in proportion to the eccentricity and thus provides the information for recording the cylinder capacity corresponding to the eccentricity.

Many variants can be introduced without thereby departing from the scope of the invention in its general features.

Claims

1. A device for recording the cylinder capacity of hydraulic motors having variable-capacity radial propulsors and in which the propulsors have at least one oscillating portion coupled to an eccentric component of the drive shaft, characterised in that it comprises at least one proximity sensor mounted in a fixed position on the outer casing of the motor and facing an oscillating means comprising a propulsor or portion thereof, the sensor being adapted to generate an electric signal of varying intensity depending on the distance between it and the oscillating means, and the maximum amplitude of variation of the signal at each revolution of the motor corresponding to the maximum amplitude of oscillation of the oscillating means, which is related to the eccentricity of the eccentric component and to the cylinder capacity determined thereby.

2. A device for recording the cylinder capacity in hydraulic motors comprising variable cylinder-capacity radial propulsors according to claim 1, characterised in that at least one proximity sensor is disposed on the outer casing of the motor in the plane of oscillation of the oscillating means and with its end near the position of maximum amplitude of oscillation of the oscillating means.

3. A device according to claim 1, characterised in that one or more proximity sensors are disposed on the outer casing of the motor in the plane at right angles to the plane of oscillation of the oscillating means associated with the propulsors, and ends of the sensors being near the trajectory of the oscillating means.

4. A device according to claim 3, characterised in that the sensor or sensors are disposed so that their axis does not intersect the axis of the associated oscillating means when the latter is in the central position but at a short distance therefrom.

5. A device according to claim 3, characterised in that the sensor or sensors are disposed so that their axis intersects the axis of the associated oscillating means when it is in the central position.

6. A device according to claim 1, characterised in that the proximity sensor is an inductive sensor adapted to supply an electrical signal at a voltage or current which varies in relation to the distance of the sensor from the oscillating means.

7. A device according to claim 1, characterised in that the sensor is inserted into a holder rigidly connected to the outer casing of the motor and the minimum distance of the sensor from the oscillating means is adjustable by screw means.

8. A device according to claim 7, characterised in that the screw means comprise a thread on the outer surface of the sensor coupled to a corresponding thread on the holder, means being present for locking the screwing rotation of the sensor on the holder and means being present for hydraulic sealing from the exterior.

9. A device according to claim 8, characterised in that the hydraulic sealing means comprise a piston connected in sealing-tight manner by synthetic resin to the threaded surface of the sensor and movable in sealing-tight manner, using gaskets, in an orifice in the holder coaxial with the screw-threading of the sensor.

10. A device according to claim 1, 2 or 3 characterised in that a number of sensors are disposed on the outer casing of the motor and each associated with a different oscillating means and adapted to record the maximum amplitude of oscillation at various times during each revolution of the motor.

11. A device according to claim 1, characterised in that the oscillating means comprise the entire propulsor, which is mounted so as to be freely guidable between the outer casing and the eccentric component.

12. A device according to claim 1, characterised in that the oscillating means is a portion of the propulsor bearing on the eccentric component of the drive shaft and pivoted to the remaining part of the propulsor.

13. A device for recording the cylinder capacity of hydraulic motors comprising variable cylinder-capacity radial propulsors according to one or more of the preceding claims, characterised in that the sensor or sensors are connected to an external electrical or electronic unit adapted to indicate the actual cylinder capacity of the motor corresponding to the amplitude of variations in the electric signal produced by the sensors.

14. A device according to claim 12, characterised in that the external electric or electronic unit records the frequency of variation of the signal produced by the sensors and indicates the speed of rotation of the motor corresponding to the frequency, in addition to indicating its cylinder capacity.

15. A device according to claim 1, characterised in that discontinuities detectable by the sensor and adapted to increase the intensity and or accuracy of the supplied signal are formed on the outer surface of the oscillating means facing a sensor.

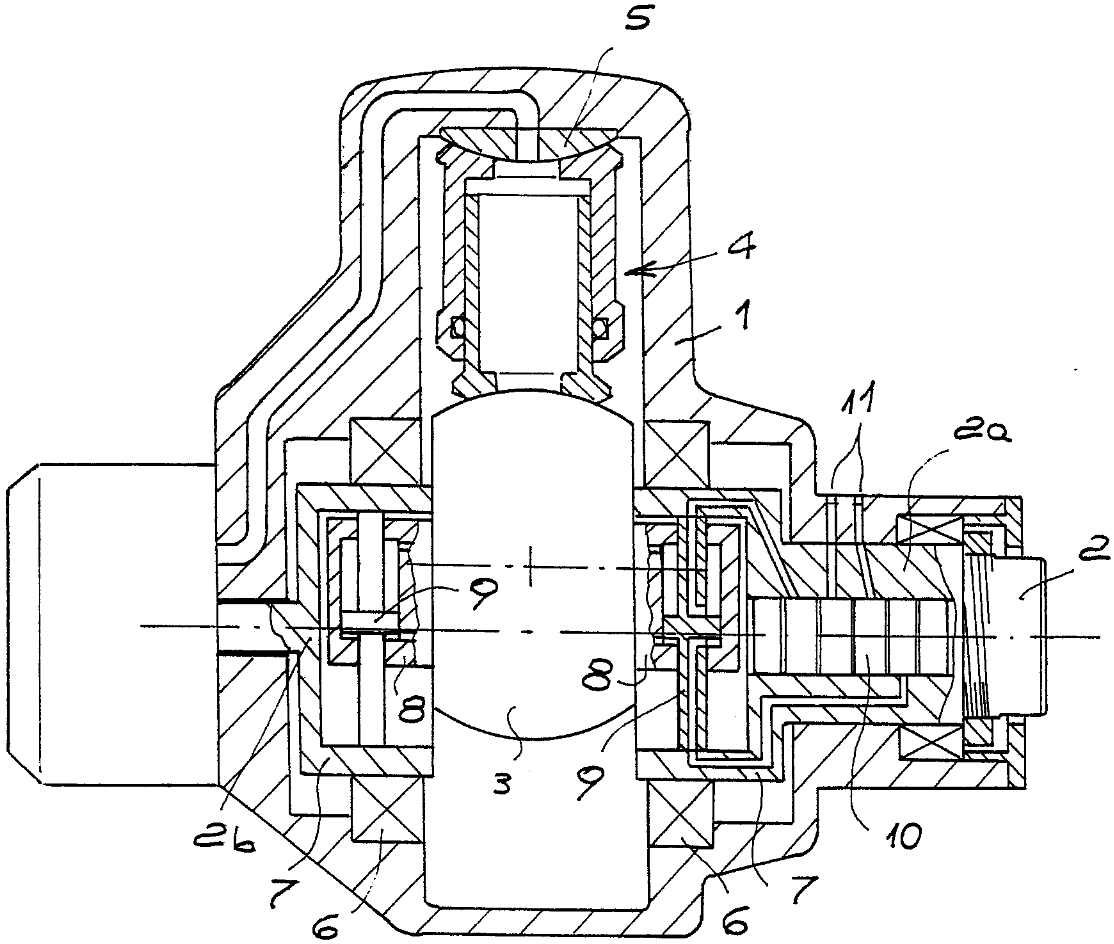

Fig. 1

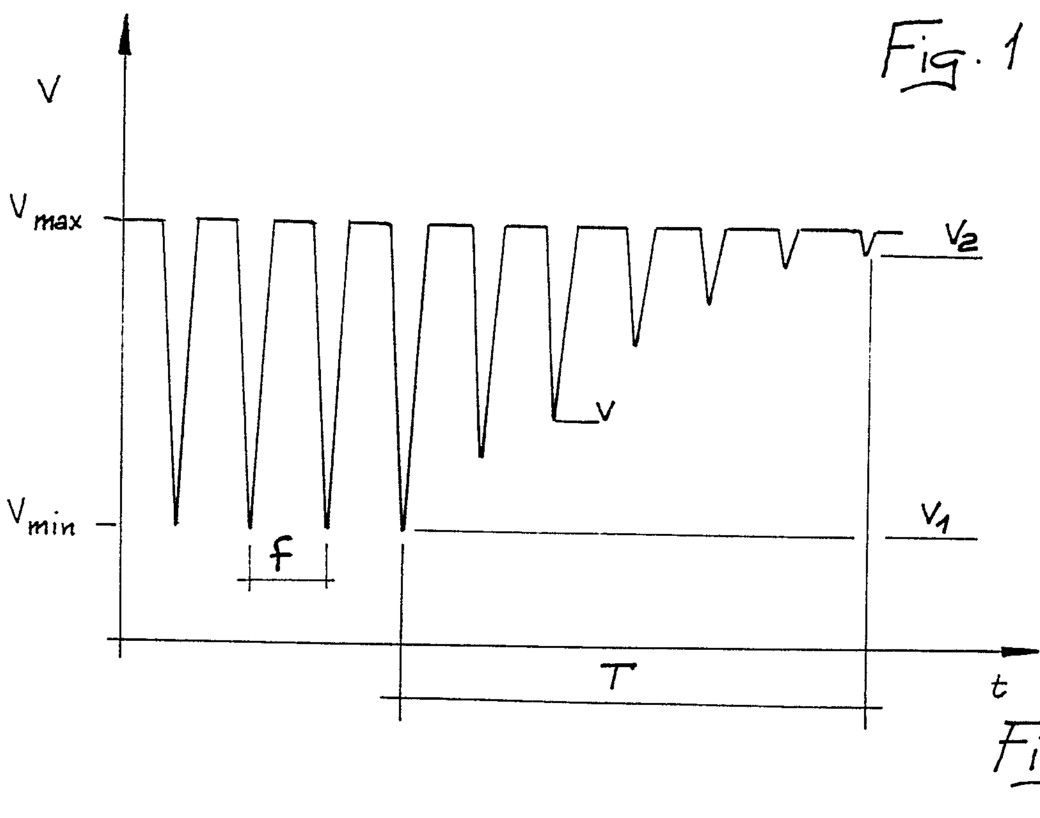

Fig. 5

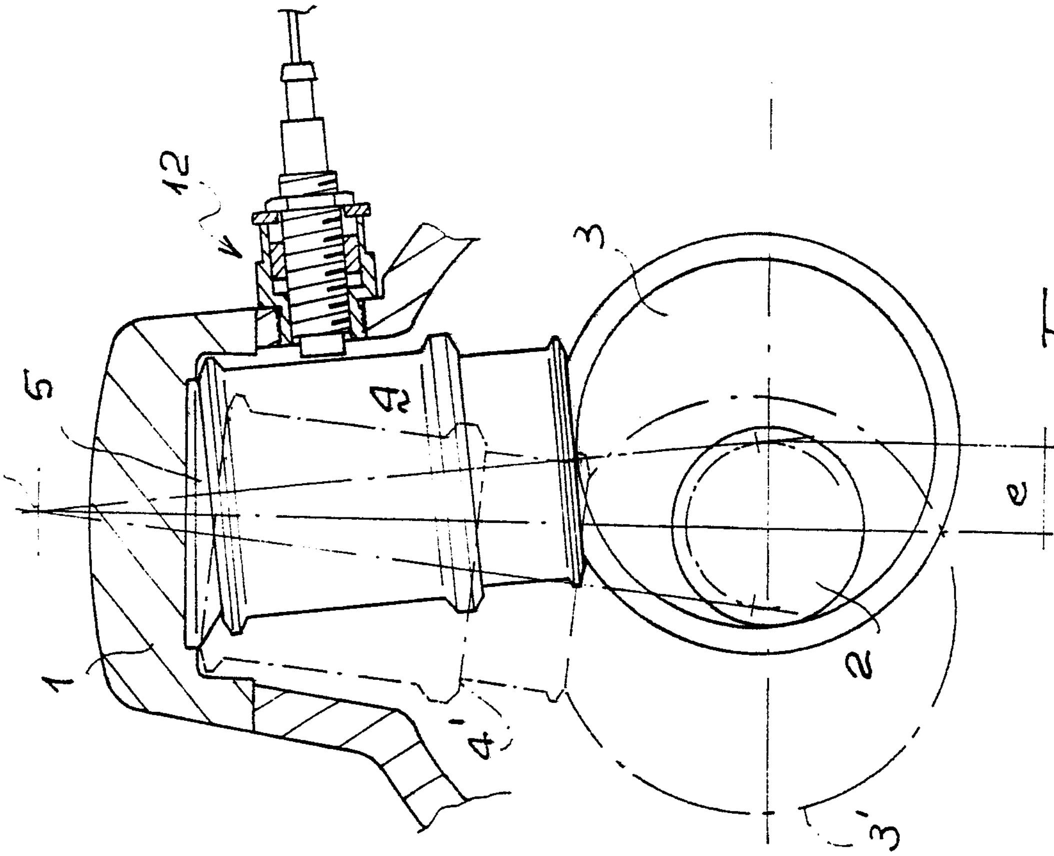

Fig. 3

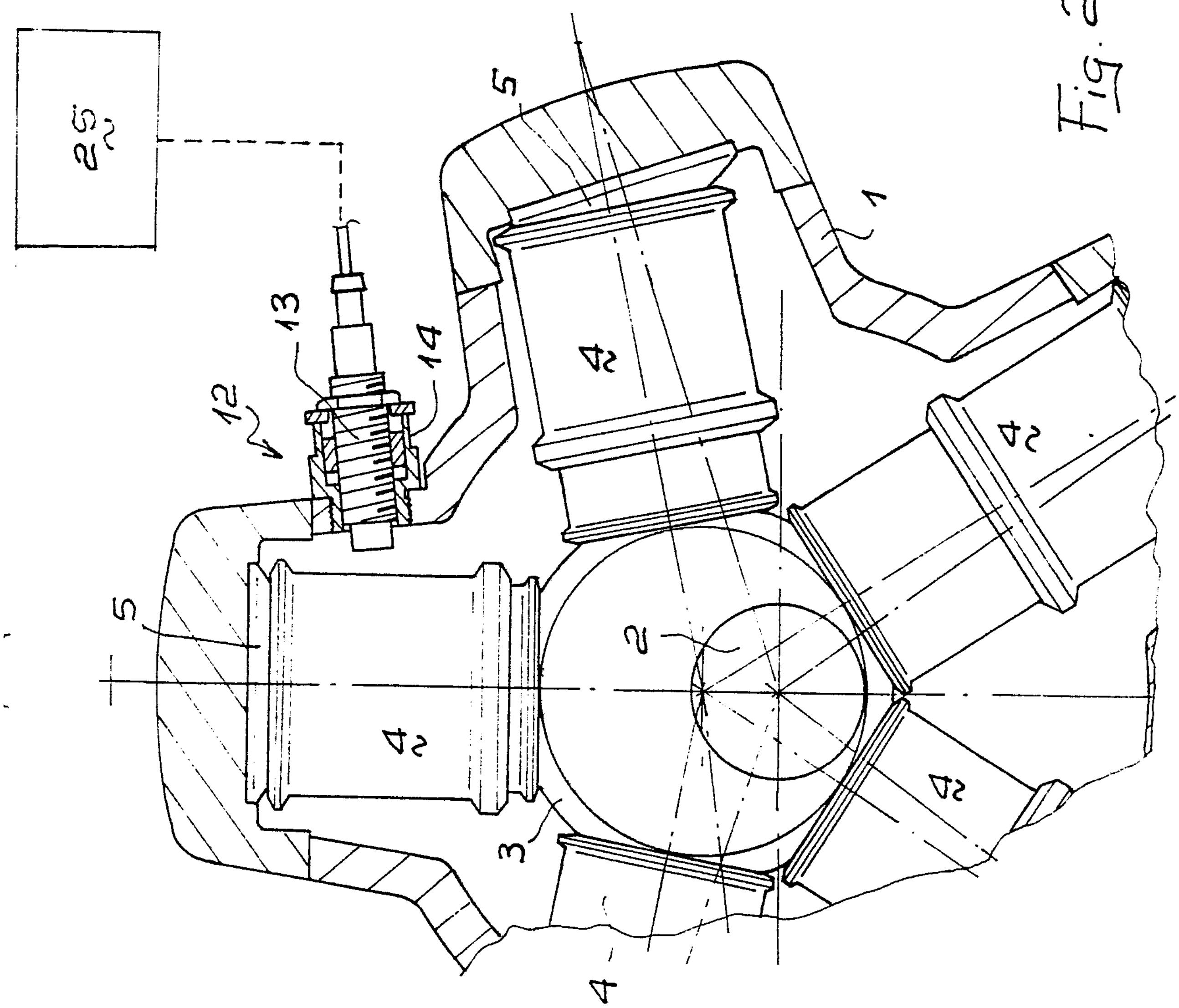

Fig. 2

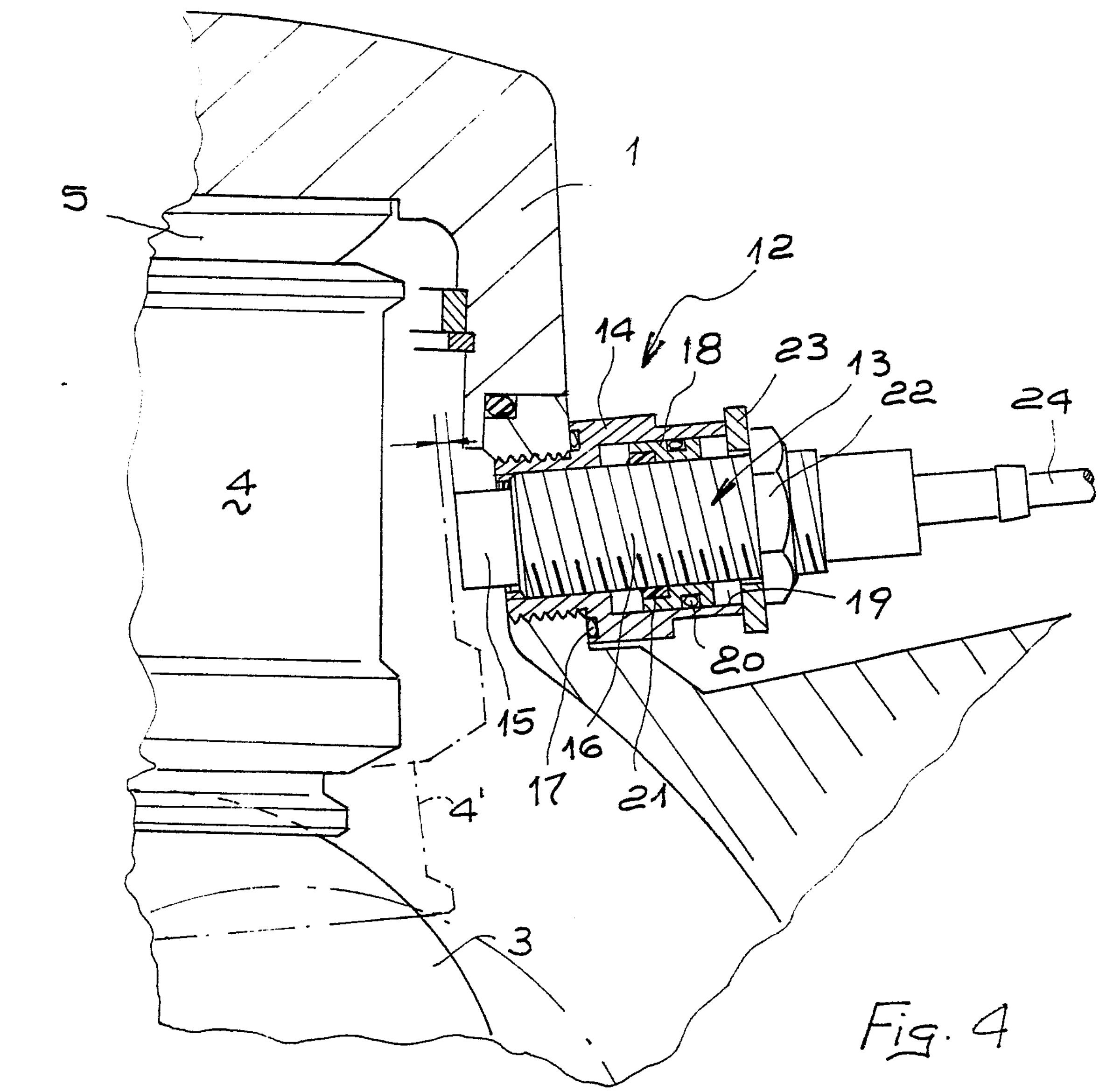
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Fig. 4

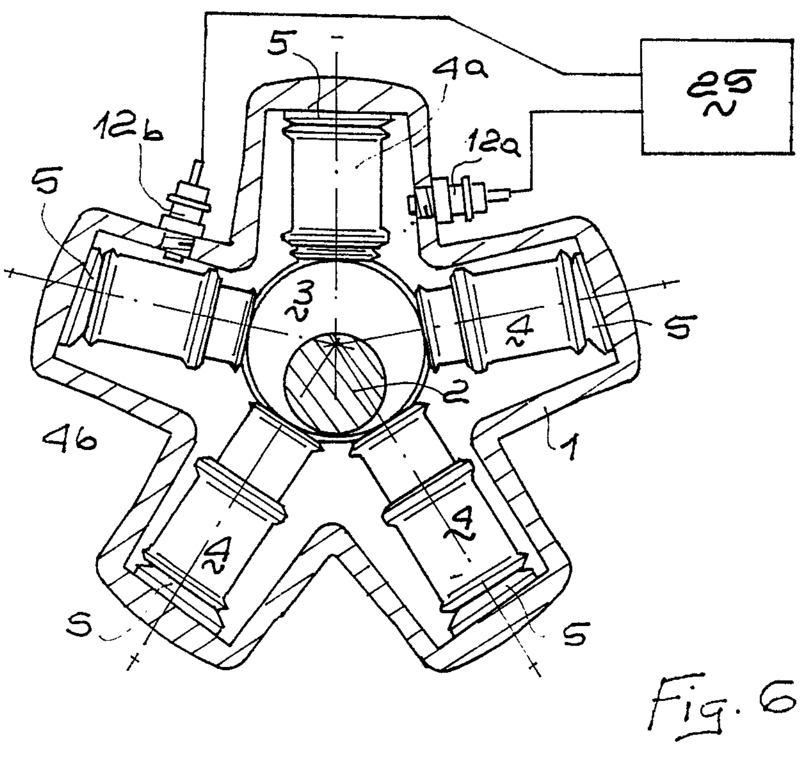
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Fig. 6

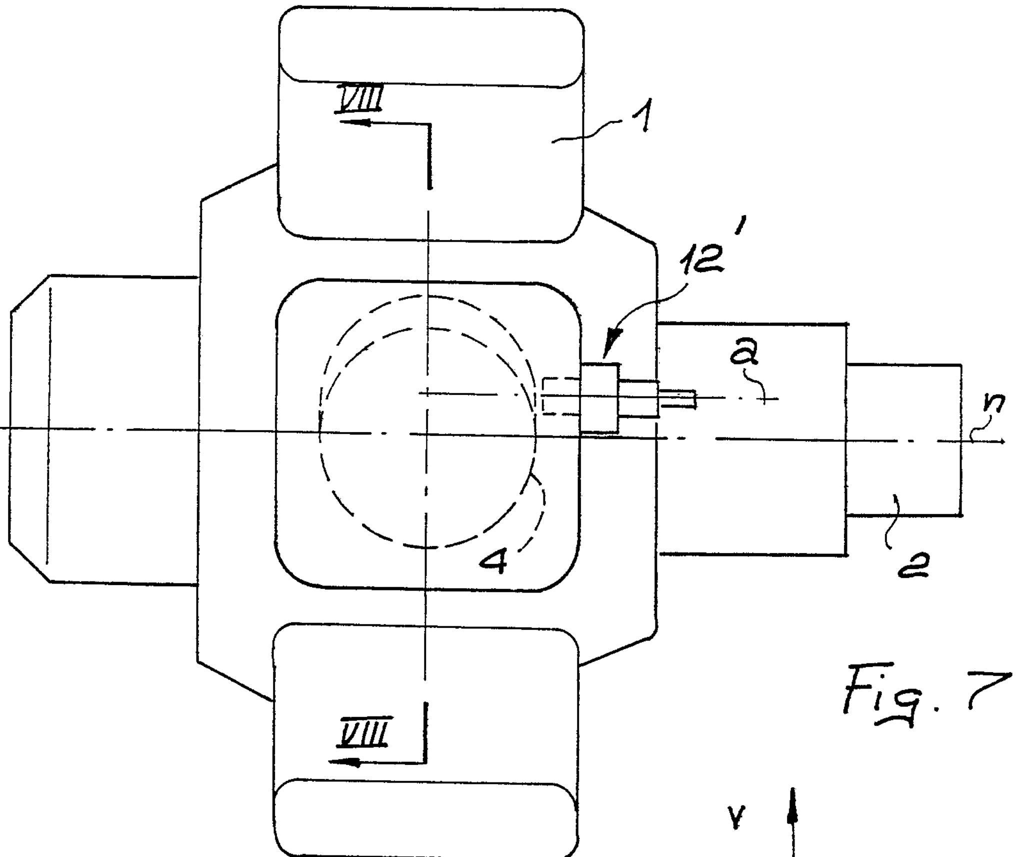

Fig. 7

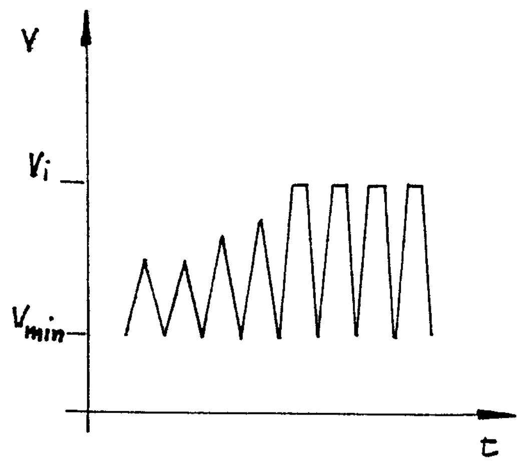

Fig. 9

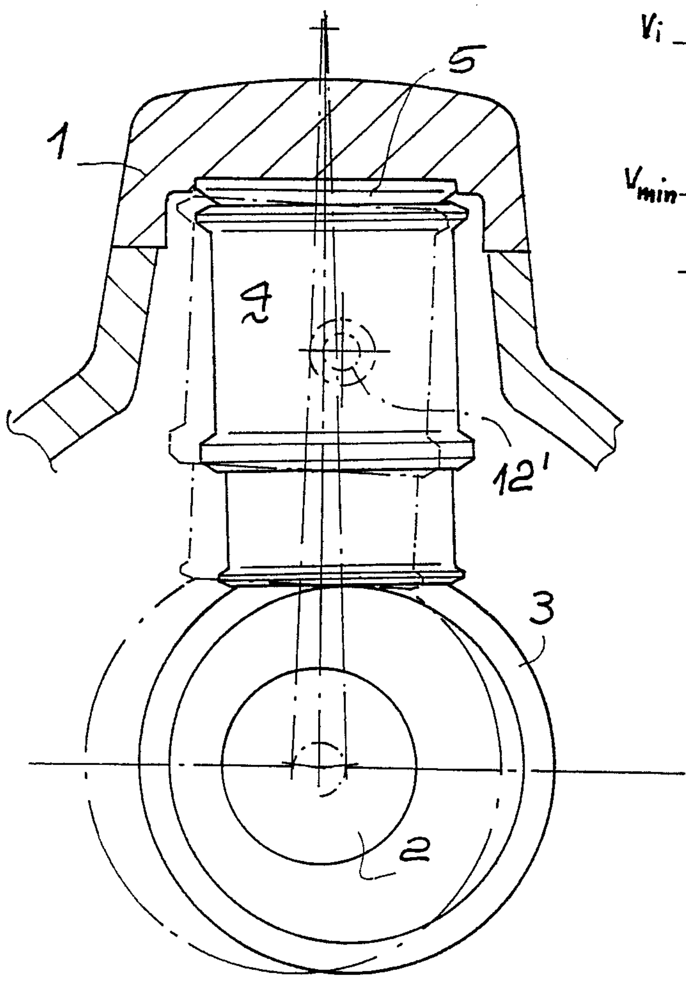

Fig. 8