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(54) CONTROL ROD DRIVE OF NUCLEAR REACTOR

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This invention relates to nuclear reactors and, more particularly, to a drive of a control rod of a nuclear reactor.

The invention allows power control, excess reactivity compensation, and emergency shut-down of a reactor.

According to the present invention there is provided a drive of a control rod of a nuclear reactor, comprising a driving bar; gripping means releasably engageable with the control rod and carried by the driving bar; a drive mechanism housed in an hermetically sealed housing for driving the driving bar; a guide tube mounted on the housing for guiding reciprocal movement of the control rod and cooperating with the drive mechanism and a tube in which the control rod is arranged; a control mechanism for controlling the gripping means coupled kinematically to the drive mechanism for the driving bar, the control mechanism including a rotary tube connected to a pin and being so arranged that the gripping means is engageable with and releasable from the control rod in response to rotation of the tube and pin; the driving mechanism including disengaging means, and said disengaging means comprising a driving element coupled through a self-braking reduction gear and torque transmitting means to an electromotor located outside the hermetically sealed housing, and a driven element releasably coupled to the driving element and rigidly coupled to a gear of a kinematic pair for converting rotary motion of the gear into linear motion of a toothed member connected to the driving bar; the torque transmitting means being rigidly coupled to an output shaft of the electromotor, to the control mechanism and to the drive mechanism and arranged for the electromotor to drive selectively either the control mechanism or the drive mechanism; and signalling means connected electromagnetically to the transmitting means and arranged to provide a signal in response to engagement of the drive with the control rod, the signalling means including a sensing rod spring-loaded in the direction towards the control rod and having one end adapted to contact the control rod, and an armature of ferromagnetic material carried by the sensing rod.

The drive of the present invention may be simpler in design, compared with conventional drives, due to the presence of the means for transmitting the torque of the electromotor, which makes it possible to control the drive mechanism and the control mechanism for the gripping means with a single electro-motor arranged outside the hermetically sealed drive housing.

The simplicity of the drive is also due to the fact that the guide tube can be directly driven by the drive mechanism, which makes it possible to dispense with a separate mechanism for the purpose.

The control rod drive makes it possible to reduce the dimensions of both the drive and the reactor as a whole.

The drive also makes it possible to speed up the preparation of the reactor for operation following a fuel recharging, as well as the preparation for fuel recharging, which cuts down the idle time and improves the reactor efficiency. The speed-up is due to the fact that the engagement of the drive with the control rod is checked in the lower position of the control rod.

The invention also raises the reliability of the rod drive because the means for transmitting the torque of the electromotor can protect the drive components against excessive overloads during operation and disconnect the electromotor if the torque is in excess of a predetermined value.

The invention can ensure reliable locking of the bar with the guide tube in the recharging position, through interlocking of the driving and driven elements of the disengaging means during release of the gripping means as the drive is being disengaged from the control rod.

The invention makes it possible to repair the drive of a control rod without withdrawing it from the reactor, due to the fact that the electromotor and exciting windings of the torque transmitting means are preferably located outside the hermetically sealed housing of the drive.

A better understanding of the present invention will be had from the following detailed description, given by way of example with reference to the accompanying drawings, wherein:

Figs. 1 and 1'are elevation views of a control rod drive of a nuclear reactor engaged with the control rod, in accordance with the invention;

Fig. 2 is an elevation view of the means for transmitting the torque of the electromotor, in accordance with the invention;

Fig. 3 is an elevation view of the lower portion of the bar engaged with the control rod, in accordance with the invention;

Fig. 4 is a view of Fig. 1' taken in the direction of the arrow A;

Figs. 5 and 5' are elevation views of the lower portion of the control rod drive of a nuclear reactor, disengaged from the control rod, in accordance with the invention;

Fig. 6 is an elevation view of the lower portion of the control rod drive of a nuclear reactor in the recharging position, in accordance with the invention;

Fig. 7 is a circuit diagram of the exciting winding, in accordance with the invention.

Referring now to the attached drawings, the proposed control rod drive of a nuclear reactor comprises an electromotor 1 (Figs. 1 and 2) whose shaft 2 is rigidly coupled to a drive shaft 3 of a means 4 (Fig. 1) for transmitting the torque of the electromotor 1 (Figs. 1 and 2). The drive shaft 3 is composed of two portions of a ferromagnetic material and a portion of a nonmagnetic material, interposed between the two portions of a ferromagnetic material. The shaft 3 is stepped and has two steps, 5 and 6 (Fig. 2). The step 5 has two rows of teeth 7 provided on its internal surface, separated by said nonmagnetic portion which will be now referred to as a nonmagnetic insert 8.

The second step 6 also has two rows of teeth 9 provided on its outer surface. The drive shaft 3 (Figs. 1 and 2) is mounted with the aid of bearings 10 and 11 (Fig. 2) in a cylinder-shaped housing 12. The housing 12 is composed of alternating portions of a ferromagnetic material and a non-magnetic material; the latter portions are referred to as nonmagnetic inserts 13 and 14. A driven shaft 15 (Figs. 1 and 2) of the means 4 (Fig. 1) is arranged inside the drive shaft 3 (Figs. 1 and 2), coaxially with the latter. The driven shaft 15 is mounted in bearings 16 at the level of the step 5 (Fig. 2). The driven shaft 15 is of a ferromagnetic material and provided with two rows of teeth 17 (Fig. 2) on its outer surface. A second driven shaft 18 (Figs. 1 and 2) is mounted in bearings 19 (Fig. 2) inside the cylinder-shaped housing 12 and envelops the drive shaft 3 (Figs. 1 and 2) at the level of the latter's second step 6 (Fig. 2).

The driven shaft 18 (Figs. 1 and 2) is also composed of two portions of a ferromagnetic material and a portion of a nonmagnetic material interposed between the two portions of ferromagnetic material and has two rows of teeth 20 (Fig. 2) on its internal surface, which are separated by said nonmagnetic portion which will be referred to below as a nonmagnetic insert 21. The teeth 17 of the driven shaft 15 and the teeth 20 of the driven shaft 18 are arranged at a minimum distance from and opposite the teeth 7 and 9, respectively, of the drive shaft 3. The nonmagnetic insert 8 of the drive shaft 3 and the nonmagnetic insert 21 of the driven shaft 18 are respectively arranged opposite the nonmagnetic inserts 13 and 14 of the cylinder-shaped housing 12. On the outer surface of the cylinder-shaped housing 12, at the level of the nonmagnetic insert 13, there is mounted an exciting winding 22; at the level of the nonmagnetic insert 14 there is mounted an exciting winding 23; the exciting winding 22 comprises a control winding 24 which produces a magnetic flux penetrating through the drive shaft 3 (Figs. 1 and 2) and the driven shaft 15 and 18. The winding 22 also includes a signal winding 25 (Fig. 2) which produces a signal to stop the electromotor 1 (Figs. 1 and 2) if its torque is in excess of a predetermined value.

The winding 23 is similar to the winding 22 and also comprises a control winding 26 and a signal winding 27. The exciting windings 22 and 23 (Fig. 2) are arranged in a casing 28. The driven shaft 15 (Figs. 1 and 2) of the means 4 (Fig. 1) is rigidly coupled with the aid of a connection shaft 29 (Figs. 1 and 2) and through a self-braking reduction gear 30 (Fig. 1), a shaft 31 and a spur-gear drive 32 to a driving element 33 of a disengaging means 34.

The driving element 33 of the disengaging means 34 is similar to the step 5 (Fig. 2) of the drive shaft 3 (Figs. 1 and 2) and has two rows of teeth 35 (Fig. 1) on its internal surface, which are separated by a nonmagnetic insert 36. The driving element 33 is mounted in bearings 37 and 38 in a casing 39 of the disengaging means 34. The casing 39 is composed of two portion of a ferromagnetic material, wherebetween there is interposed a portion of a nonmagnetic material, which will be referred to as a nonmagnetic insert 40. A driven element 41 of the disengaging means 34 is mounted inside the driving element 33, coaxially with the latter, in bearings 42 and 43.

The driven element 41 is similar to the driven shaft 15 (Figs. 1 and 2) of a ferromagnetic material and has two rows of teeth 44 (Fig. 1).

The teeth 44 of the driven element 41 of the disengaging means 34 are arranged, according to the invention, opposite to and at a minimum distance from the teeth 35 of the driving element 33. The nonmagnetic insert 36 of the driving element 33 is arranged opposite the nonmagnetic insert 40 of the casing 39. In the casing 39, at the level of the nonmagnetic insert 40, there is arranged a control winding 45.

The driven element 41 of the disengaging means 34 is coupled through a cylindrical-conical gear 46 to a gear 47 of a reciprocating pair, whose toothed member, referred to as a rack 48, is coupled to a bar 49 (Figs. 1 and 1'). The upper portion of said toothed member is placed in a jacket 50 (Fig. 1).

Mounted on the same shaft with the gear 47 is a transducer 51 of the position of the bar 49 (Figs. 1 and 1'). Mounted on the jacket 50 (Fig. 1) are an inductive transducer 52 of the lower position of a control rod 53 (Fig. 1), an inductive transducer 54 (Fig. 1) of the upper position of said control rod 53 (Fig. 1), and an inductive transducer 55 (Fig. 1) of the recharging position. On the bar 49 (Figs. 1 and 1') there is rigidly mounted a bushing 56 (Fig. 1'), whereof one end abuts against a compressed spring 57, whereas its other end abuts against a shock absorbing spring 58.

Mounted on the lower portion of the bar 49 (Figs. 1 and 3) are a stop 59 and a head 60 with profiled grips 61 mounted in turn, on axles 62 (Fig. 3). The lower portion of the bar 49 is also provided with an annular groove 63 (Fig. 1').

The connection shaft 29 (Fig. 1), the shaft 31, the spur-gear drive 32, the disengaging means 34, the cylindrical-conical gear 46, the gear 47 with the rack 48 of the reciprocating kinematic pair, the bar 49 (Figs. 1 and 1'), the jacket 50 (Fig. 1), the transducer 51, the inductive transducers 52, 54 and 55, the bushing 56 (Fig. 1'), the compressed spring 57, the shock absorbing spring 58, and the head 60 with the profiled grips 61 make up a mechanism for driving the bar 49 (Figs. 1 and 1').

The driven shaft 18 (Fig. 1) of the means 4 for transmitting the torque of the electromotor 1 is coupled through the self-braking reduction gear 30 to a rotary tube 64 arranged in the jacket 50 in bearings 65 and 66. On the internal surface of the rotary tube 64 there are mounted two feather keys 67 whose length corresponds to that of the working stroke of the control rod 53 (Fig. 1'). Inside the rotary tube 64 (Fig. 1) there is installed a bushing 68 provided with slots to receive the feather keys 67, said bushing 68 being rigidly coupled to a control pin 69 (Figs. 1 and 3) extending inside the rack 48 (Fig. 1) and bar 49 (Figs. 1 and 3). On the lower end of the control pin 69 there is rigidly mounted a tip 70 (Fig. 3) with cams 71 arranged at different levels and at an angle of 90° with respect to each other. The cams 71 are located at the levels of the respective arms of the profiled grips 61 (Fig. 1').

The self-braking reduction gear 30 (Fig. 1), the rotary tube 64, the feather keys 67, the bushing 68, the control pin 69 and the tip 70 with the cams 71 make up a mechanism for controlling the profiled grips 61 (Fig. 1').

The mechanism for driving the bar 49 (Figs. 1 and 1') and the mechanism for controlling the profiled grips 61 (Fig. 1') are kinematically interconnected by an interlocking means 72 (Figs. 1 and 5).

The interlocking means 72 comprises two half-clutches 73 and 74 of the claw type. The claw half-clutch 73 is rigidly mounted on the driven element 41 of the disengaging means 34, whereas the claw half-clutch 74 is movable in the axial direction, being mounted with the aid of a ball key 75 on the driving element 33 of the disengaging means 34. On the half-clutch 74 there are mounted a locking bushing 76 and a spring 77. The half-clutch 74 and the locking bushing 76 are axially movable with respect to each other. The extent of their relative movement is limited by pins 78. The half-clutch 74 is coupled by means of a ball lock 79 to a control bushing 80. The control bushing 80 is provided with helical grooves 81 on its outer surface, which receive guide pins 82 fixed in a casing 83 of the interlocking means 72. The control bushing 80 is coupled by means of end face teeth 84 to the rotary tube 64 of the mechanism for controlling the profiled grips 61 (Fig. 1').

Inside the control pin 69 (Fig. 1) of the mechanism for controlling the profiled grips 61 (Fig. 1') there is arranged a sensing rod 85 (Figs. 1 and 3) on whose upper end there are mounted an armature 86 (Fig. 1) of a ferromagnetic material, a stop 87 and a spring 88. One end of the spring 88 abuts against the stop 87 of the sensing rod 85, whereas its other end abuts against the bushing 68 of the mechansim for controlling the profiled grips 61 (Fig. 1').

The control rod 85 (Fig. 1), the armature 86 and the spring 88 make up a signalling means to signal the engagement of the drive with the control rod 53 (Fig. 1'). The bar 49 is arranged inside a casing 89 connected to the reduction gear 46 (Fig. 1). On the casing 89 (Fig. 1') there is mounted a guide tube 90 provided with grooves 91 which receive axles 92. Double-arm levers 93 (Figs. 1' and 4) with rollers 94 and 95 are mounted on the axles 92. On the internal surface of the guide tube 90 (Fig. 1') there is provided a stop 96. On the guide tube 90 there are also mounted limiting pins 97. The casing 89 is provided with a groove 98 to receive the rollers 94 of the levers 93. The signalling means, the mechanism for driving the bar 49 (Figs. 1 and 1') and the mechanism for controlling the profiled grips 61 (Fig. 1') are arranged inside a hermetically sealed housing 99 (Figs. 1) mounted on the reactor lid (not shown).

Figs. 5 and 5' show the lower portion of the drive of the control rod 53. The drive and control rod 53 are disengaged. The cams 71 are at an angle of 90° relative to each other, the profiled grips are driven apart, and the control rod 53 is released from the profiled grips 61. The sensing rod 85 extends beyond the lower end face of the tip 70. The armature 86 is on the upper end face of the bushing 68.

Fig. 6 shows the lower portion of the drive of the control rod 53 in the recharging position.

Fig. 7 is a circuit diagram of the exciting winding 22/23/ (Figs. 2 and 7). The control winding 24/26/ (Fig. 7) is connected to a d.c. source 100. The signal winding 25/27/ is directly connected to a control unit 101 placed in the control circuit (not shown) of the electromotor 1 (Figs. 1 and 2).

When the reactor is in operation, the drive of the control rod 53 (Figs. 1' and 3) is coupled to the latter and moves it in the reactor core at a certain speed intended to maintain a desired power of the reactor and compensate the fuel burn-up. To set the control rod 53 in motion, voltage is applied to the electromotor 1 (Figs. 1 and 2); at the same time voltage is applied from the d.c. source 100 (Fig. 7) to the control winding 24 (Figs. 2 and 7) of the means 4 (Figs. 1 and 2) for transmitting the torque of the electromotor 1 (Figs. 1 and 2). This voltage produces a magnetic flux which penetrates through the teeth 7 (Fig. 2) of the drive shaft 3 (Figs. 1 and 2) and the teeth 17 (Fig. 2) of the driven shaft 15 (Figs. 1 and 2). Thus the magnetic flux magnetically connects to the drive shaft 3 to the driven shaft 15. Hence, as supply voltage is applied to the electromotor 1, rotation of the shaft 2 of the electromotor 1 is transmitted to the drive shaft 3 and the driven shaft 15 of the means 4 for transmitting the torque of the electromotor 1. From the driven shaft 15, rotation is transmitted through the connection shaft 29, the self-braking reduction gear 30 (Fig. 1), the shaft 31 and the spur-gear drive 32 to the driving element 33 of the disengaging means 34. As voltage is applied to the electromotor 1, it is also applied to the control winding 45 of the disengaging means 34. This produces a magnetic flux which penetrates through the teeth 35 of the driving element 33 and the teeth 44 of the driven element 41 of the disengaging means 34. As a result, the driving element 33 and the driven element 41 are magnetically interconnected.

Thus from the driving element 33, rotation is transmitted to the driven element 41 of the disengaging means 34.

From the driven element 41 of the disengaging means 34, rotation is transmitted through the cylindrical-conical gear 46 to the gear 47 of the reciprocating kinematic pair which converts rotative motion of the gear 47 into reciprocating motion of the rack 48 of said kinematic pair. The rack 48 is rigidly connected to the bar 49 (Figs. 1, 1' and 3) and through the head 60 (Figs. 1' and 3) to the profiled grips 61 which hold the control rod 53. The rack 48 moves said control rod 53 within the confines of the reactor core. The position of the control rod 53 in the reactor core is determined by the transducer 51 (Fig. 1). When the control rod 53 (Fig. 1) reaches its extreme working positions, the electromotor 1 is disconnected by signals of the inductive transducer 52 (Fig. 1) of the lower position and the inductive transducer 53 of the upper position of said control rod 53, which transducers interact with the armature 86 of the signalling means to signal the engagement of the drive with the control rod 53 (Fig. 1').

In case an emergency signal is produced and it is necessary to shut down the reactor, the control winding 45 (Fig. 1) of the disengaging means 34 is de-energized, which breaks the magnetic connection between the driving element 33 and the driven element 41. The cylindrical-conical gear 46 and the rack 48—gear 47 pair are not self-braking, so the bar 49 (Figs. 1 and 1^1)with the control rod 53 (Fig. 1^1) is forced down by its own weight and the compressed spring 57; the control rod 53 is introduced into the reactor core at a preset speed. As this takes place, the gears of the cylindrical-conical reducer 46 (Fig. 1) and the driven element 41 of the disengaging means 34 are in rotation. Meanwhile, the driving element 33 is at rest, as it is coupled to the self-braking reduction gear 30. The impact of the bar 49 and the control rod 53 is taken by the shock absorbing spring 58. A rebound of the control rod 53 is countered by an overrunning clutch (not shown) interposed between the driving element 33 (Fig. 1) and the driven element 41 of the disengaging means 34. As the control winding 45 of the disengaging means 34 is re-energized, the driving element 33 and the driven element 41 are again magnetically coupled, so the operation proceeds as described above.

If the torque of the shaft 2 (Figs. 1 and 2) of the electromotor 1 exceeds a predetermined value due to an increased tractive resistance of the control rod 53 (Fig. 1^1). the driven shaft 15 (Figs. 1 and 2) of the means 4 stops, while the drive shaft 3 continues to rotate at the speed of the shaft 2 of the electromotor 1. As this takes place, the teeth 7 (Fig. 2) of the drive shaft 3 (Figs. 1 and 2) move relative to the teeth 17 (Fig. 2) of the driven shaft 15 (Figs. 1 and 2), which changes the clearance between said teeth. The change in the clearance brings about a changed resistance to the magnetic flux passing through the teeth 7 and 17. Thus the magnetic field, which is constant during normal operation, now becomes variable and induces variable voltage in the signal winding 25 (Fig. 2), applied to the control unit 101 (Fig. 7). The control unit 101, which is placed in the control circuit of the electromotor 1 (Figs. 1 and 2), disconnects the supply voltage from the electromotor 1, and the drive is brought to rest. The value of torque of the shaft 2, at which the electromotor is disconnected, is determined by the strength of the kinematic components of the drive.

When the reactor core is to be recharged, the drive is disengaged from the control rod 53 (Fig. 5^1). For this purpose, the rod 53 is lowered. The control winding 24 (Fig. 2) of the means 4 is de-energized, whereas voltage is applied to the control winding 26 (Fig. 2). This produces a magnetic flux which penetrates the teeth 9 (Fig. 2) of the drive shaft 3 (Figs. 1 and 2) and the teeth 20 (Fig. 2) of the driven shaft 18 (Figs. 1 and 2), so that the drive shaft 3 and the driven shaft 18 are magnetically coupled. Thus, as supply voltage is applied to the electromotor 1, rotation of the shaft 2 is transmitted to the drive shaft 3 and the driven shaft 18 of the means 4. From the driven shaft 18, rotation is transmitted through the self-braking reduction gear 30 (Fig. 1) to the rotary tube 64 (Fig. 5), and through the feather keys 67 to the bushing 68 and the control pin 69 (Fig. 5^1) with the tip 70 and the cams 71.

As the cams 71 are turned through an angle of about 90°, the profiled grips 61 are driven apart, releasing the control rod 53. As this takes place, the interlocking means 72 (Fig. 5) is brought into play because the rotating tube 64 rotates the control bushing 80 which also moves in the axial direction, as the pins 82 slide in its helical grooves 81. The control bushing 80 moves in the axial direction the locking bushing 76 which, in turn, acts through the spring 77 upon the movable claw-type half-clutch 74 and brings it into engagement with the stationary claw-type half-clutch 73, whereby the driving element 33 and the driven element 41 of the disengaging means 34 are rigidly coupled. If rotation of the tube 64 does not bring the half-clutches 73 and 74 into engagement, the spring 77 is compressed. As soon as the driving element 33 (Fig. 5) and the driven element 41 of the disengaging means 34 are displaced relative to each other so as to engage the cams of the half-clutches 73 and 74 and as the bar 49 (Fig. 5^1) is being lifted, the spring 77 brings the half-clutches 73 and 74 into engagement and rigidly couples the driving element 33 and the driven element 41. The bar 49 (Figs. 1 and 5^1) is locked in the self-braking reduction gear 30 (Fig. 1).

In order to check the disengagement of the drive from the control rod 53 (Fig. 5^1), the bar 49 is moved upwards until the inductive transducer 52 (Fig. 5) of the lower position of the control rod 53 (Fig. 5^1) is actuated. As the bar 49 is raised, the sensing rod 85 is lowered under the action of the spring 88 (Fig. 5), so that the armature 86 abuts against the bushing 68. In order to produce a signal to the effect that the transducer 52 (Figs. 1 and 5) has been actuated, the bar 49 must be raised higher, as compared to its position in engagement with the control rod 53 (Figs. 1^1 and 5^1), by the clearance value between the end faces of the armature 86 (Fig. 1) and the bushing 68. The travel of the bar 49 over this distance (the clearance between the armature 86 and the bushing 68) is registered by the transducer 52. This value is indicative of the presence of engagement.

In order to recharge the reactor core, the bar 49 (Fig. 6) is disengaged and raised to its upper working position. The groove 63 of the bar 49 is now opposite the roller 95, and the stop 59 reaches the stop 96 on the guide tube 90. As the bar 49 continues to move upwards, the stop 59 on the bar 49 acts upon the stop 96 of the guide tube 90 and moves said guide tube 90 upwards. The roller 95 of the lever 93 is received in the groove 63 of the bar 49, whereas the roller 94 leaves the groove 98 on the casing 89, so that the guide tube 90 is free to move upwards. Thus, the bar 49 and the guide tube 90 move up to assume the recharging position, in which the bar 49 is stopped as the electromotor 1 (Fig. 1) is disconnected by a signal of the recharging position transducer 55.

This is followed by de-energizing all the power-operated components of the drive, except the inductive transducer 55 of the recharging position, which produces a recharging signal.

Following the recharging, the drive of the control rod of the nuclear reactor is brought to its working state (in this case, the sequence of events is reversed).

The control rod drive of a nuclear reactor in accordance with this invention ensures reliable operation of the reactor throughout its expected life and properly holds the bar 49 (Fig. 1) with the guide tube 90 (Fig. 1[1]) in place during a recharging of the reactor core. It is quite easy to assembly or dismantle the drive.

The manufacture of the drive requires no special materials or equipment, and the manufacturing costs are relatively low.

WHAT WE CLAIM IS:—

1. A drive of a control rod of a nuclear reactor, comprising a driving bar; gripping means releasably engageable with the control rod and carried by the driving bar; a drive mechanism housed in an hermetically sealed housing for driving the driving bar; a guide tube mounted on the housing for guiding reciprocal movement of the control rod and cooperating with the drive mechansim and a tube in which the control rod is arranged; a control mechanism for controlling the gripping means coupled kinematically to the drive mechanism for the driving bar, the control mechanism including a rotary tube connected to a pin and being so arranged that the gripping means is engageable with and releasable from the control rod in response to rotation of the tube and pin; the driving mechanism including disengaging means, and soil disengaging means comprising a driving element coupled through a self-braking reduction gear and torque transmitting means to an electromotor located outside the hermetically sealed housing, and a driven element releasably coupled to the driving element and rigidly coupled to a gear of a kinematic pair for converting rotary motion of the gear into linear motion of a toothed member connected to the driving bar; the torque transmitting means being rigidly coupled to an output shaft of the electromotor, to the control mechanism and to the drive mechanism and arranged for the electromotor to drive selectively either the control mechanism or the drive mechanism; and signalling means connected electromagnetically to the transmitting means and arranged to provide a signal in response to engagement of the drive with the control rod, the signalling means including a sensing rod spring-loaded in the direction towards the control rod and having one end adapted to contact the control rod, and an armature of ferromagnetic material carried by the sensing rod.

2. A drive of a control rod of a nuclear reactor as claimed in claim 1, wherein the torque transmitting means comprises a cylinder-shaped casing of a ferromagnetic material with nonmagnetic inserts, in which casing there are coaxially arranged a drive shaft rigidly coupled to the shaft of the electromotor, and two driven shafts, one of which is kinematically coupled to the driving bar drive mechanism and arranged inside the drive shaft, and the other of which surrounds the lower portion of the drive shaft and is coupled to the control mechanism, the torque transmitting means further including exciting windings mounted on the outer surface of the cylinder-shaped casing adjacent the nonmagnetic inserts whose number is equal to that of the exciting windings.

3. A drive of a control rod of a nuclear reactor as claimed in claim 2, wherein the drive shaft of the torque transmitting means is of ferromagnetic material and is stepped in the axial direction, a first step having two rows of teeth provided on its inner surface and separated by a nonmagnetic insert, the second step having two rows of teeth provided on its outer surface, the driven shafts of the torque transmitting means being of a ferromagnetic material, said one driven shaft having two rows of teeth provided on its outer surface, said other driven shaft having two rows of teeth provided on its inner surface and separated by a nonmagnetic insert, the teeth of the respective driven shafts being arranged opposite to and at a minimum distance from the respective teeth of the drive shaft, and the nonmagnetic inserts of the drive shaft and said other driven shaft being opposite the nonmagnetic inserts of the casing.

4. A drive of a control rod of a nuclear reactor as claimed in claim 2 or 3, wherein

each exciting winding of the torque transmitting means has a control winding for producing a magnetic flux which penetrates through the drive shaft and one of the driven shafts, and a coaxial signal winding which produces a signal if the torque of the electromotor exceeds a predetermined value.

5. A drive of a control rod of a nuclear reactor as claimed in any one of claims 1 to 4, wherein the driving bar drive mechanism is coupled to the guide tube by locking means mounted on the guide tube, each of the locking means including a double-arm lever with rollers for cooperation with respective grooves provided in the driving bar and a stationary casing, cooperable stops being provided on the bar and the guide tube, and the locking means being arranged normally to lock the guide tube in a fixed position with respect to the casing and to release the guide tube for upward movement with the driving bar when the bar is raised above a predetermined position.

6. A drive of a control rod of a nuclear reactor as claimed in any one of claims 1 to 5, wherein the drive mechanism and the control mechanism are kinematically coupled by interlocking means for ensuring a predetermined clearance between the control rod and the drive in the course of recharging the nuclear reactor.

7. A drive of a control rod of a nuclear reactor as claimed in claim 6, wherein the interlocking means comprises two half-clutches of the claw type and a control bushing, one of the half-clutches being rigidly connected to the driven element of the disengaging means, the other half-clutch being mounted on the driving element of the disengaging means for axial movement, the control bushing having at least one helical recess on its outer surface, which recess receives a stationary guide pin fixed in a stationary casing of the interlocking means, the control bushing being connected by one of its ends to the movable half-clutch through a ball lock, the other end of the control bushing being coupled by means of teeth to the rotary tube of the control mechanism.

8. A drive of a control rod of a nuclear reactor as claimed in claim 6 or 7, wherein to ensure electromagnetic connection between the drive mechanism and the signalling device, the armature of the signalling device is directly mounted on the end of the sensing rod opposite said one end and cooperates with an inductive transducer arranged to sense when the control rod is engaged by the gripping means and in a lowermost position.

9. A drive of a control rod of a nuclear reactor, substantially as hereinbefore described with reference to the accompanying drawings.

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1576758 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

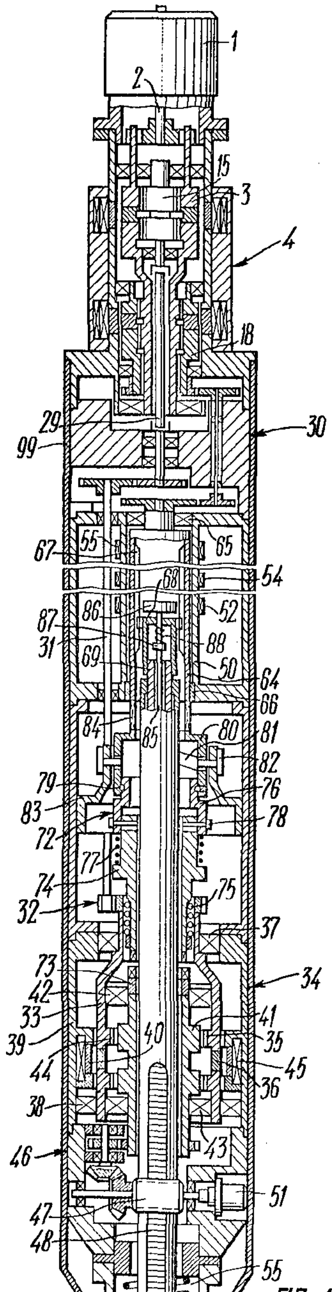

FIG. 1

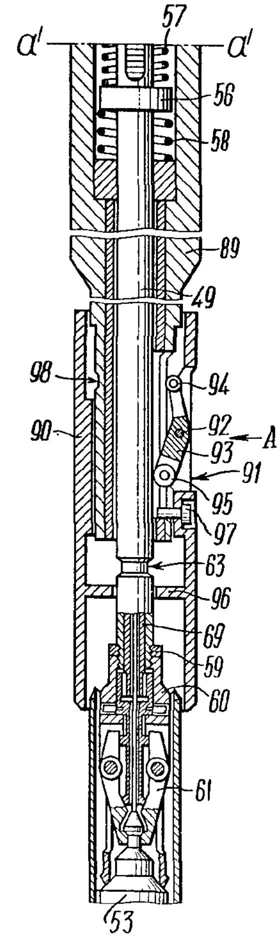

FIG. 1'

1576758 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

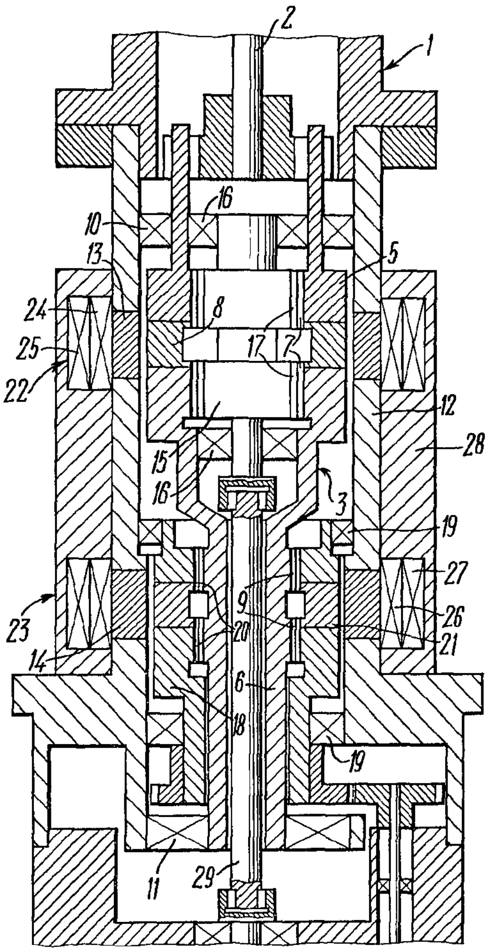

FIG. 2

1576758 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

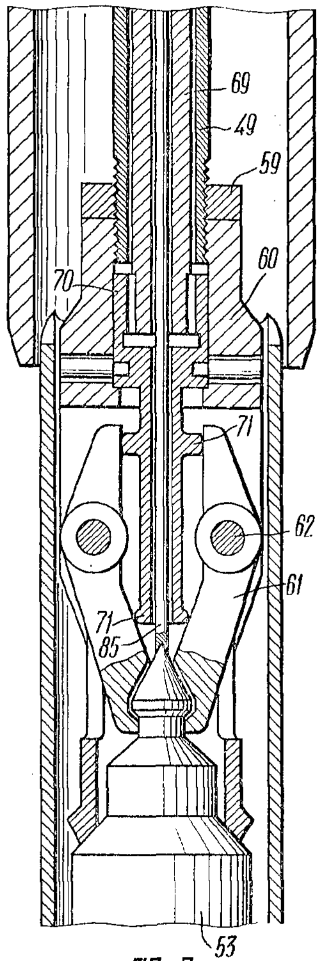

FIG. 3

1576758 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

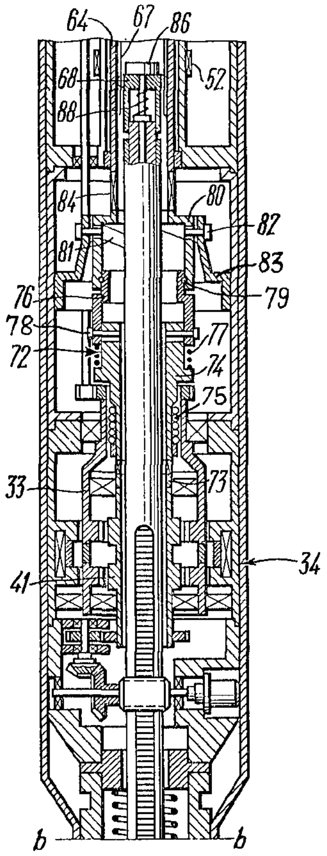

FIG. 5

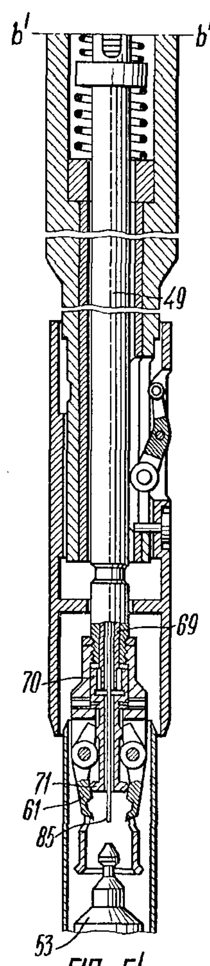

FIG. 5'

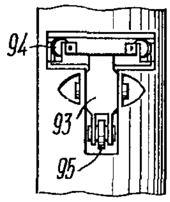

FIG. 4

1576758 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 5

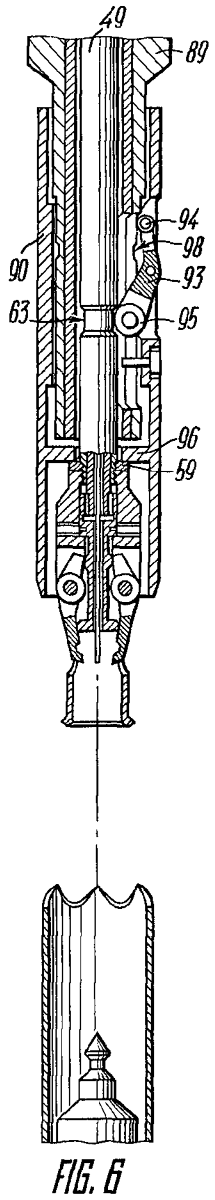

FIG. 6

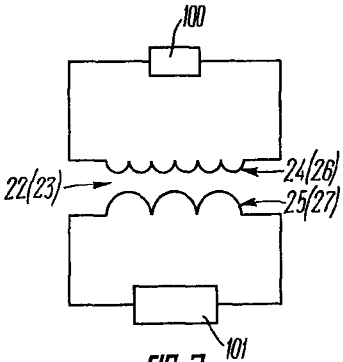

FIG. 7