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(54) Drive mechanism and method for opening/closing of electric switchgear

(57) Electrical switchgear, e.g. circuit breaker, needs to perform switching operations in very short time in order to quickly react on fault conditions e.g. by opening the line the switchgear is connected to. The moveable contact of such switchgear is driven by a drive mechanism which must be able to provide enough energy in short time to accelerate the moveable masses of the switchgear and drive mechanism in such short times. The inventive drive mechanism provides an electric motor (12) as source of energy and an additional source of energy, which supports the electric motor (12) in driving the moveable contact (6) at least during part of the switching motion.

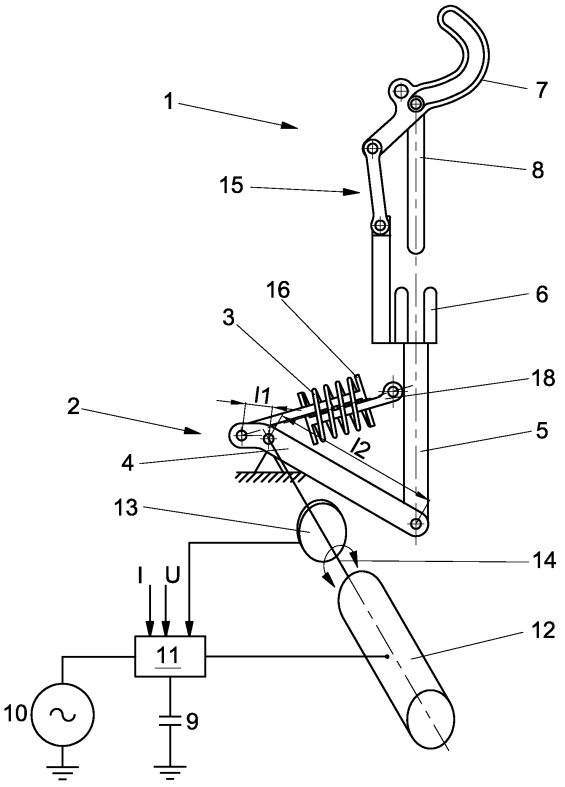


Fig. 1

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Description

[0001] The invention is pertaining to a drive mechanism and a method for opening and/or closing of electric switchgear comprising an electric motor for driving at least one moveable contact of the switchgear.

[0002] Conventional drive mechanisms for opening and closing of electric switchgear, e.g. high voltage (HV) switchgear like circuit breaker, disconnector, etc., are mechanical devices with mechanical components, like springs, shafts, rods, levers, etc., which act together to perform the opening or closing operation. The closing of the switchgear is often done by closing springs charged by electric motors. Part of the energy of closing springs is also used to charge the opening springs for the next opening operation. Such drive mechanisms exist in various solutions and are well known from prior art. Such mechanical drive mechanisms comprise a large number of single components which results in a complex design and which requires also a complicated presetting of the drive mechanism. Furthermore, such drives perform always the same motion once it is set and it is not possible to adjust its motion in consequence to particular exterior conditions, e.g. the type of failure causing the switchgear to open or close. A further disadvantage of such drive mechanisms is that it is not possible to implement a control of the switching movement, it is only possible to verify that the drive mechanism has reached the desired end position, e.g. by end position switches. A new generation of drive mechanism comprises an electric servo motor which directly or via a gearbox drives the moveable contact of the switchgear. Examples of such drives are given in EP 1 080 479 A1 and EP 1 092 227 A1. Such motors with the required torque and small size have become available during the last years and therefore, drive mechanisms with servo motors as power source for operating the switchgear, i.e. for opening and closing, have become an alternative to conventional spring-driven mechanical mechanisms. But such motors are still rather expensive. Moreover, if the motor or its power supply fails, a switching operation is not possible or an alternative power source, e.g. a conventional spring-driven mechanism, must be available to ensure that the switching operation can be performed. Switching operations, especially the opening of a switchgear like circuit breaker, needs to be performed in very short time periods, e.g. to ensure current interruption within 30-40ms. This means that the drive mechanisms must provide enough energy to perform the switching operation in such short time. Because of the high inertia of the mechanical system of the switchgear, i.e. the masses of driving rods and levers, moveable contacts, etc., considerable amount of energy must to be available or be provided in short time to allow quick enough acceleration of all masses of the drive mechanism and switchgear to be moved. Normally, this energy is stored in mechanical (e.g. spring) or electrical (e.g. electric motor) form. In case of a servomotor drive, the motor must provide a high torque, especially also at low speeds, in order to accelerate the mechanical parts of the switchgear in such short time periods.

[0003] It is therefore an object of the invention to provide a drive mechanism of an actuation device of electric switchgear with low complexity and capable to perform switching operations in very short time periods. A further object of the invention is to provide a flexible drive mechanism which is adjustable to the requirements of different events causing switching operations.

[0004] These objects are reached by providing an additional source of energy, preferably a spring or a hydraulic or pneumatic cylinder, for supporting the electric motor in driving the moveable contact at least during part of the opening or closing motion. By using an additional source of energy for opening and/or closing the switchgear a smaller motor can be chosen and/or a faster acceleration of the masses to be moved can be reached. Moreover, such a drive mechanism is capable to keep the switchgear open and/or closed and to perform an emergency opening/closing (although with restricted speed) even in case of a fault of the motor or its power supply by means of the additional source of energy. Hence, the flexibility of the drive mechanism is increased and the reliability of the drive mechanism, which is a very important aspect for such devices, is improved significantly.

[0005] The additional source of energy is advantageously arranged to support the electric motor during the beginning of the opening and/or closing operation, i.e. during the phase of motion most energy is needed to accelerate the masses to be moved and the motor is burdened most.

[0006] An advantageous embodiment of the inventive drive mechanism comprises a drive lever connected to a shaft or actuator of the electric motor and an additional source of energy connected to a first end of the drive lever in a distance from the centre of rotation and a drive member The drive member is connected to the moveable contact of the actuating device and is connected to a second end of the drive lever in a distance from the centre of rotation. An alternative advantageous embodiment comprises a linear electric motor and an additional source of energy both connected to the drive member.

[0007] Further advantageous embodiments and advantages of the invention follow from the following description and claims.

[0008] The invention is described in the following by way of example with reference to schematic, non-limiting drawings Fig. 1 to 3 which show preferred embodiments of the invention, wherein

Fig. 1 shows a schematic view of an inventive drive mechanism and switchgear in open position,
Fig. 2 shows a schematic view of an inventive drive mechanism and switchgear in closed position and
Fig. 3 shows a schematic view of a further embodiment of the inventive drive mechanism and switchgear.

[0009] Fig. 1 schematically shows a HV switchgear 1, e.g. a circuit breaker, with two moveable contacts 6, 8 and an inventive drive mechanism 2. The first moveable contact 6 is connected to a drive member 5, here a drive rod, which is actuated by the drive mechanism 2. The driving motion is transferred from the first moveable contact 6 to the second moveable contact 8 by a motion transfer mechanism 15, e.g. comprising levers and a non-linear profile cam 7 which is connected to the second moveable contact 8. Such a switchgear is described in EP 1 211 706 A1 of the Applicant and forms part of the disclosure of the current application. But it is to be pointed out that the inventive drive mechanism can be applied to any switchgear 1 and especially also to switchgear 1 with only one moveable contact 6 as indicated in Fig. 2

[0010] The inventive drive mechanism 2 comprises an electric motor 12, e.g. a servo motor, which drives the drive mechanism 2 and which is supplied with electric energy by a capacitor or capacitor bank 9. A power supply 10, e.g. the electric supply grid the switchgear 1 is connected to or a suitable battery, is provided for recharging the capacitor bank 9 after each switching operation or when required. It is of course also possible that the power supply 10 feeds directly the electric motor 12. The operation of the electric motor 12 and consequently of the drive mechanism 2 is controlled by control unit 11, which may include a control member, like e.g. a microprocessor-based or computer-based unit, and a power unit, like e.g. a well known power electronics converter unit. A position sensor 13 may provide the current position of the motor 12 and consequently also of the drive mechanism 2 to the control unit 11. The motor shaft 14 (only schematically indicated in Fig. 1 and 2) is connected to and drives a drive lever 4. The motor shaft 14 defines the centre of rotation of the drive shaft 4 which is located between the two ends of the drive lever 4. One end of the drive lever 4 is connected to the drive rod 5, hence driving the drive rod 5, and the other end is connected to an additional source of energy for supporting the electric motor 12 in driving the drive mechanism 2, in the embodiment shown a spring 3, here a coil spring, thus forming two lever arms with lengths l_1 and l_2.

[0011] A source of energy for driving the drive mechanism 2 in the context of the present invention is a device which can actively generate a force or torque acting on the drive mechanism 2 in order to drive the drive mechanism 2. Such a source of energy can be a mechanical device, like a spring 3 or a single or double acting hydraulic or pneumatic cylinder 21 or a cylinder filled with compressed gas, or a electrical or electro-mechanical device, like an electric motor, an electromagnet or a linear motor. Gravitational forces are typically passive forces and are not a source of energy in the sense of this invention.

[0012] The spring 3 as additional source of energy in the example shown in Fig. 1 is arranged between two spring rods 16, 18 which can be moved relative to each other. One spring rod 18 is rotatably mounted on one of its ends and is connected to the spring 3 at its other end. The second spring rod 16 is at one of its ends rotatably connected to the drive lever 4 at distance l_1 from the centre of rotation and is connected to the spring 3 at its other end. Hence, the spring 3 is charged or released by the relative movement of the spring rods 16, 18 or the spring rods 16, 18 are moved relative to each other when the spring 3 is charged or released. Because of the resulting lever arm l_1 between the centre of rotation of the drive lever 4 and the connection of the second spring rod 16, a rotational motion of the motor shaft 14 causes a charging or releasing of the spring 3. On the other hand supports a releasing spring 3 the rotational motion of the motor shaft 14 as explained in detailed below. But of course every other arrangement of spring 3, drive lever 4 and connection between spring 3 and drive lever 4 which would tense/release the spring 3 when the drive lever 4 is moved, or vice versa, would also be possible. E.g. by arranging the spring 3 and/or the spring rods 16, 18 differently or by providing different springs 3, e.g. like a torsion spring arranged on the motor shaft 14.

[0013] For a cylinder filled with compressed gas as additional source of energy the cylinder could be rotatably mounted and its piston, which is driven by the expanding gas, could be connected to the drive lever 4 in a distance l_1 from the centre of rotation. Also other sources of energy could be connected to the drive rod 5 or drive lever 4 with its actuating part and would be mounted on another part.

[0014] A linear motor connected to the drive lever 4 in a distance l_1 from the centre of rotation or connected to the drive rod 5 instead of a rotational electric motor 12 could of course also be employed just as well. Such an embodiment of the invention is shown in Fig. 3 described hereinafter. The switchgear 1 has a moveable contact 6 connected to a drive member 5 driven by a drive mechanism 2. The actuator 20 of a linear electric motor 22 is connected to the drive member 5 and drives the moveable contact 6 of the switchgear 1. An additional source of energy, here a hydraulic or pneumatic cylinder 21, is also connected to the drive member 5 thus supporting the linear electric motor 22 in driving the moveable contact 6 of the switchgear. A position sensor 13 may provide the position of the linear motor 22 and consequently also of the drive mechanism 2 to the control unit 11. The arrangement of the single components of the drive mechanism 2 may of course be different from that shown in Fig. 3.

[0015] In the following the operation of the drive mechanism 2 is explained by way of example for a switching operation with reference to Figs. 1 and 2. For closing the open switchgear 1 of Fig. 1 the motor 12 is actuated by the control unit 11 which causes the drive lever 4 to turn (in this particular embodiment) counter-clockwise. Simultaneously, the drive member 5 and consequently also the first moveable contact 6 are moved toward the second contact 8. In case of a double acting drive mechanism, the second moveable contact 8 moves also towards the first moveable contact 6 according to the profile defined

by the non-linear profile cam 7. The spring 3 is simultaneously tensed by the relative movement of the spring rods 16, 18 and stores the tensioning energy until it is released again. Hence, the electric motor 12 must provide the energy for moving the mechanical parts of the switchgear 1 (i.e. the moveable masses of the switchgear 1 and drive mechanism 2) and (at least for part of the movement) also for tensioning the spring 3. The drive mechanism 2 is advantageously mechanically locked after the final position is reached, e.g. by latching the driving mechanism 2 using suitable mechanical or electro-mechanical latching means, in order to avoid the accidental expansion of the spring 3 if the power supply of the motor 12 is switched off. In case of an external event, e.g. a fault in the electric grid which requires the opening of the switchgear 1, in this embodiment a circuit breaker, the drive mechanism 2 is unlocked (if locked before) and the control unit 11 actuates motor 12 to turn (in this particular embodiment) clockwise. The unlocking of the drive mechanism 2 causes the spring 3 to expand immediately and to release its stored energy thus supporting the motor 12 in driving the two moveable contacts 6, 8 or the single moveable contact 6 at least during the beginning of the switching motion, i.e. during the phase of motion when a high torque is required to accelerate the moveable masses of the mechanical parts of the drive mechanism 2 and switchgear 1 in short time.

[0016] For closing the open switchgear 1 of Fig. 3 the linear motor 22 would of course be actuated such to move the moveable contact 6 towards the second moveable or fixed contact. The hydraulic or pneumatic cylinder 21 would simultaneously be actuated in order to support the linear motor 22 in driving the drive mechanism 2. For opening of the switchgear 1 the linear motor 22 and the hydraulic or pneumatic cylinder 21 could be actuated the other way round.

[0017] The spring 3 or any other source of energy may be arranged such that it is in its neutral position, i.e. spring 3 totally released with no energy stored, in the final open or closed position of the switchgear 1, which means that spring 3 or any other source of energy would supply energy for the complete opening/closing motion of the switchgear 1.

[0018] But it is also possible that spring 3 or any other source of energy reaches its neutral position during the opening/closing motion. In this case spring 3 or any other source of energy could be released during the first part of the opening/closing motion and tensed during the second part of the opening/closing motion. Hence, spring 3 or any other source of energy would support the motor 12 in driving the drive mechanism 2 and switchgear 1 by supplying energy during the beginning of an opening motion, as well as during the beginning of a closing motion because motor 12 would always tense spring 3 at the end of the previous closing or opening motion. It would of course also be possible that a hydraulic or pneumatic cylinder 21 supports the driving movement of the motor 12, 22 only during part of the motion.

[0019] By adjusting the distances l_1 and l_2 which define the lever arms of the additional source of energy, in the embodiments of Fig. 1 and 2 a spring 3, and the drive member 5 it is possible to determine the quantity of the supporting effect of the additional source of energy. The torque generated by the additional source of energy is the bigger the greater the distance l_1 becomes.

[0020] The position sensor 13 provides the actual position of the drive mechanism 2 to the control unit 11 to allow position control or to detect malfunction of the drive mechanism 2. The electric motor 12, 22, and consequently also the drive mechanism 2, may be operated in feedback or feedforward mode. In feedback mode a closed position control loop may be implemented in the control unit 11 with the position sensor 13 providing the actual position of the drive mechanism 2 and an desired rule of motion defined by the control unit 11. The control unit 11 could control the movement such that the desired rule of motion is followed as accurately as possible. Because of the known geometry of the drive mechanism 2 it would of course also be possible to implement a speed control with the position sensor 13 to achieve a desired speed profile of the moveable contact 6 or the two moveable contacts 6, 8, e.g. to implement a control which ensures that the contacts 6, 8 of the switchgear are separated with a desired speed or following a desired speed profile. In feedforward mode the motor 12, 22 is driven by the control unit 11 according to a predefined rule of motion without position feedback, i.e. the motor 12, 22 is started and follows its predefined rule of motion without providing feedback information if the desired speed or motion profile is obeyed. A position sensor 13 may be used in this mode to ensure correct functioning of the drive mechanism 2, e.g. that a required end position is reached. The rule of motion may be adapted in both modes to an external event in order to ensure the best reaction on each possible external event. This allows adaptation of switching behaviour to different operating conditions, thus resulting in optimum synchronization of closing and opening operations related to the network fault conditions and in maximizing the electric life of the switchgear.

[0021] The control unit 11 may take into consideration also the phase relation between voltage U and current I of the line the switchgear is connected to, to determine the best moment to start an opening or closing operation and/or to determine a suitable rule of motion, as is well known from prior art.

Claims

1. Drive mechanism for opening and/or closing of electric switchgear (1) comprising an electric motor (12) for driving at least one moveable contact (6) of the switchgear (1), **characterised in that** an additional source of energy is provided for supporting the electric motor (12, 22) in driving the moveable contact

(6) at least during part of the opening or closing motion.

2. Drive mechanism according to claim 1, **characterised in that** the additional source of energy is a spring (3) or a hydraulic or pneumatic cylinder (21) or a gas filled cylinder.

3. Drive mechanism according to claim 1 or 2, **characterised in that** the additional source of energy is arranged to support the electric motor (12, 22) at least during the beginning of the opening and/or closing operation.

4. Drive mechanism according to one of claims 1 to 3, **characterised in that** the drive mechanism (2) comprises a drive lever (4) connected to a shaft or an actuator of the electric motor (12).

5. Drive mechanism according to claim 4, **characterised in that** the additional source of energy is connected to a first end of the drive lever (4) in a distance (l_1) from the centre of rotation.

6. Drive mechanism according to claim 4 or 5, **characterised in that** a drive member (5) which is connected to the moveable contact (6) of the electric switchgear (1) is connected to a second end of the drive lever (4) in a distance (l_2) from the centre of rotation.

7. Drive mechanism according to one of claims 4 to 6, **characterised in that** the additional source of energy (3) is arranged between the ends of a first and second spring rod (16, 18), whereat the other end of the first spring rod (16) is connected to the drive lever (4) in a distance (l_1) from the centre of rotation and the other end of the second spring rod (18) is rotatably mounted and the first and second spring rod (16, 18) are arranged to be moveable relative to each other.

8. Drive mechanism according to one of claims 1 to 3, **characterised in that** an actuator (20) of the electric motor (22) is connected to the drive member (5).

9. Drive mechanism according to claim 8, **characterised in that** the additional source of energy is connected to the drive member (5).

10. Electrical switchgear having at least one moveable contact which is driven by a drive mechanism according to one of claims 1 to 7.

11. Method for opening and/or closing of electric switchgear (1), whereat a electric motor (12, 22) drives a moveable contact (6) of the switchgear, **characterised in that** the motor (12, 22) is supported by an additional source of energy in driving the moveable contact (6) at least during part of the opening or closing motion.

12. Method according to claim 11, **characterised in that** the motor (12, 22) is supported by the additional source of energy during the beginning of the opening and/or closing operation.

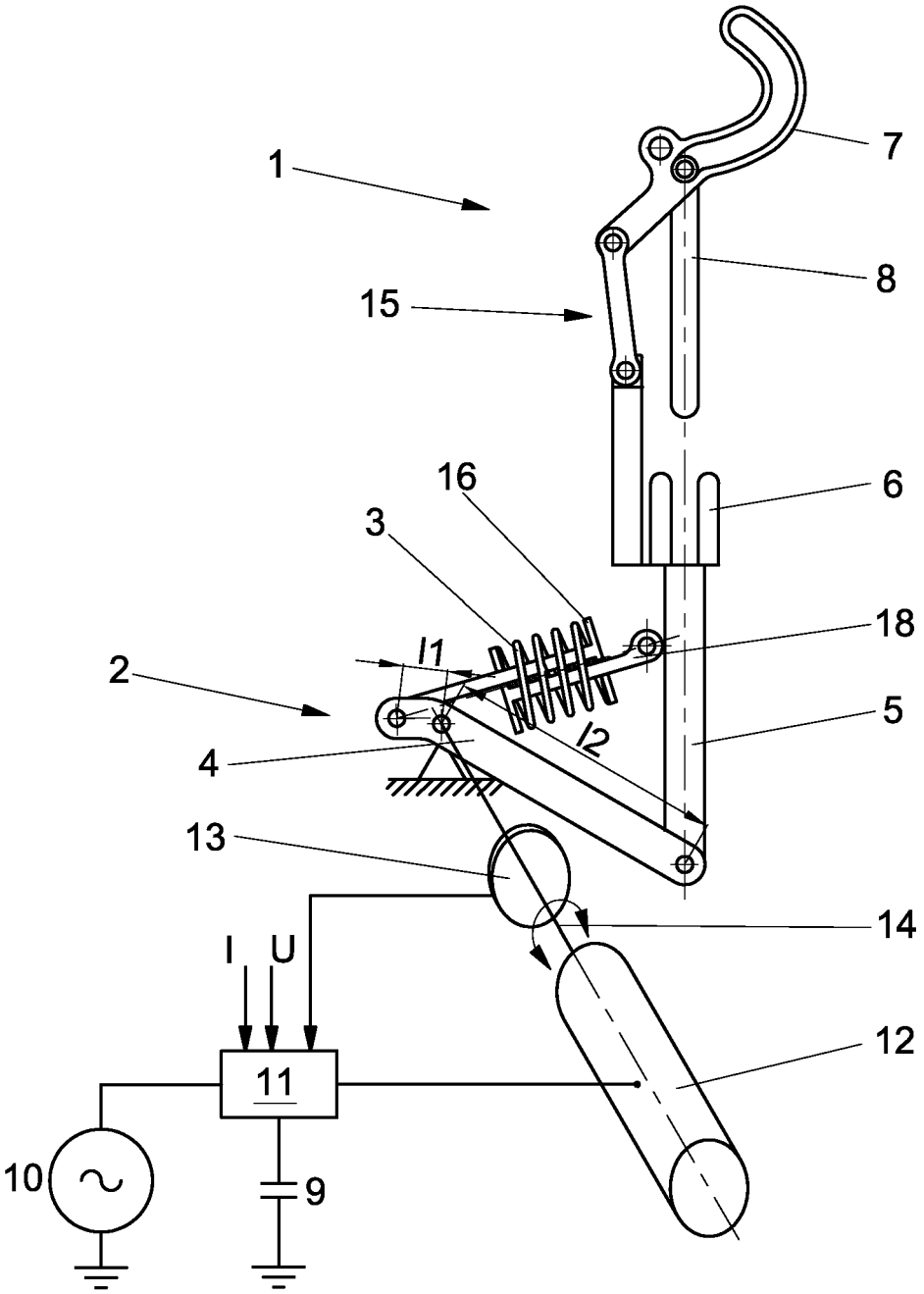


Fig. 1

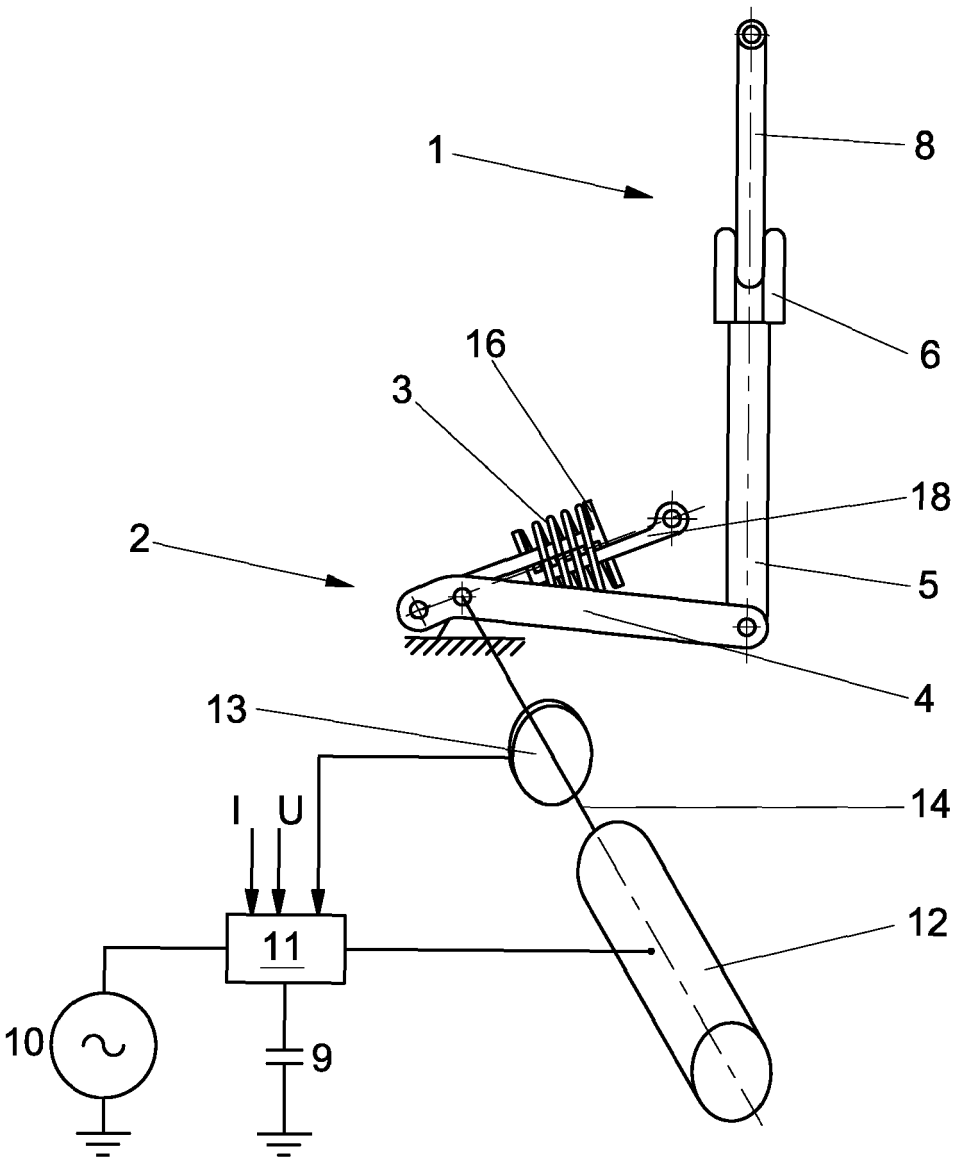


Fig. 2

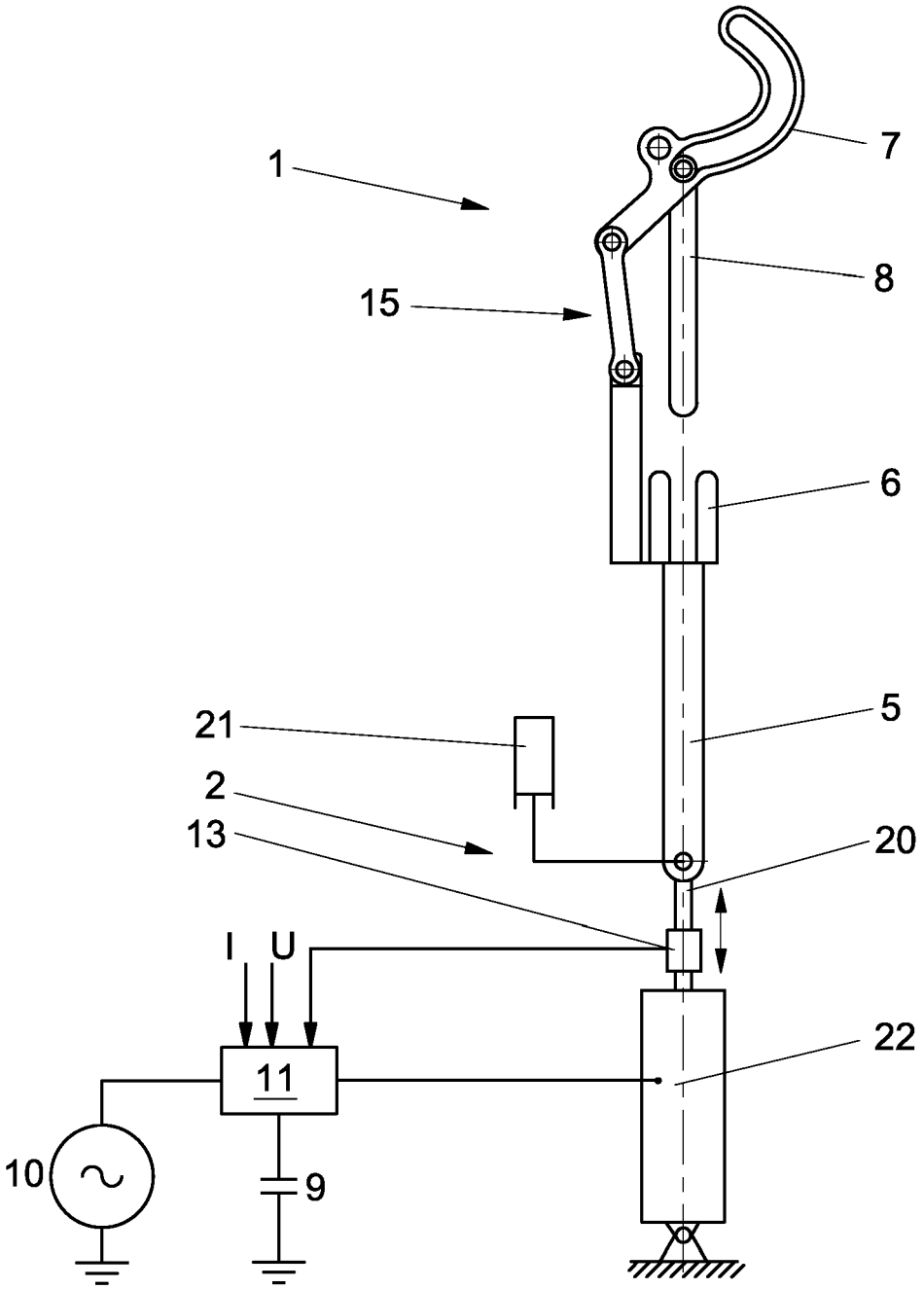


Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 05 10 6394

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
E	EP 1 583 119 A (AREVA T&D AG) 5 October 2005 (2005-10-05) * paragraphs [0032], [0033], [0069]; figures 1-4 *	1-4,8-12	H01H33/36 H01H33/40
E	WO 2005/076303 A (AREVA T & D SA; COURBON, ERIC; DUPRAZ, JEAN-PIERRE; POULLAIN, SERGE; P) 18 August 2005 (2005-08-18) * the whole document *	1-6,8-12	
X	US 2003/071522 A1 (BARANOWSKI JOHN FRANCIS ET AL) 17 April 2003 (2003-04-17) * paragraph [0138] - paragraph [0145] * * paragraph [0148] - paragraph [0150]; figures *	1,2,8-11	
X	DE 656 480 C (DIPL.-ING. SIEGMUND BAUER) 7 February 1938 (1938-02-07) * page 1, line 41 - line 44; figure *	1-3,11, 12	
A	DE 912 963 C (SACHSENWERK LICHT- UND KRAFT-AKTIENGESELLSCHAFT) 8 June 1954 (1954-06-08) * the whole document *	1-12	TECHNICAL FIELDS SEARCHED (IPC) H01H
A	US 2004/179318 A1 (HASHIMOTO HIROAKI ET AL) 16 September 2004 (2004-09-16) * the whole document *	1-12	
A	US 5 151 567 A (THURIES ET AL) 29 September 1992 (1992-09-29) * the whole document *	1-12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 December 2005	Ramírez Fueyo, M

CATEGORY OF CITED DOCUMENTS

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16-12-2005

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1583119 A	05-10-2005	FR 2868198 A1	30-09-2005
WO 2005076303 A	18-08-2005	FR 2865572 A1	29-07-2005
US 2003071522 A1	17-04-2003	NONE	
DE 656480 C	07-02-1938	NONE	
DE 912963 C	08-06-1954	NONE	
US 2004179318 A1	16-09-2004	CN 1530989 A	22-09-2004
		JP 2004273334 A	30-09-2004
US 5151567 A	29-09-1992	AT 124567 T	15-07-1995
		DE 69110805 D1	03-08-1995
		DE 69110805 T2	16-11-1995
		DK 475247 T3	02-10-1995
		EP 0475247 A1	18-03-1992
		ES 2073629 T3	16-08-1995
		FR 2666684 A1	13-03-1992

EPO FORM P0459

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1080479 A1 **[0002]**
- EP 1092227 A1 **[0002]**
- EP 1211706 A1 **[0009]**