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(54) **ELECTRIC SWITCHING DEVICE**

ELEKTRISCHE SCHALTVORRICHTUNG

DISPOSITIF DE COMMUTATION ELECTRIQUE

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Description

[0001] The present invention relates to an electric switching device, a so-called high-speed circuit closer, to achieve a fast mechanical electric short circuit of at least one phase in a multi-phase network. The switching device is preferably intended to be used as arc eliminator in cubicle-enclosed switchgear for low and medium voltage, that is, in the voltage range of up to about 45 kV. However, other fields of use are also possible. Such a much according Ar the preamble of claim 1 is described for example in US-A-3089006.

BACKGROUND ART

[0002] In short-circuit arcs, very large amounts of energy are released in the form of heat and radiation. In indoor switchgear, with its limited space, these amounts of energy give rise to increases in pressure which may blast the enclosures if the heated gases are not given a possibility of flowing out through relief openings. Further, the high arc temperatures cause conductor and switching material to melt and even evaporate. Burnable organic material may also be ignited when subjected to the high temperature and intense radiation of the arc. By decomposition of air (NOx) and evaporation of metals, the arc gives rise to poisonous gases. A minimization of the arc duration is therefore desirable. Material damage as a result of the heat and the pressure increase which are built up during the duration of the arc may thereby be reduced, as well as personal injury and the risk of poisoning.

[0003] In case of a duration of the arc of about 30 ms, a switchgear unit may be completely blown out. The pressure wave caused by the arc usually reaches its maximum even after 10-25 ms. However, the circuit breakers which are usually used in switchgear of the above-mentioned kind are not sufficiently fast to limit this pressure wave. It is therefore common that such switchgear units are provided with means for pressure relief in the form of evacuation channels, automatically openable doors, etc. This means that such switchgear will be bulky and costly. To reduce the damage, there is thus a need to limit the arc duration to less than 10 ms.

[0004] Usually a switching device of the type referred to here is arranged with one fixed and one movable contact part. To bring about a short closing time, the mass of the movable part must be small and the distance over which the movable part is to travel has to be small.

[0005] From, for example, DE-A-2623816, it is previously known to use, in gas-insulated, metal-enclosed switchgear, a fast grounding switch to extinguish a short-circuit arc between a high-voltage conductor and the grounded enclosure, to thus eliminate the risk of a dangerous overpressure building up. The grounding switch described in the publication is of single-phase design and is operated by a built-in explosive charge, the ignition of which is initiated by a sensor actuated by the arc. One disadvantage with such a grounding switch is that it must undergo a general overhaul or be replaced after one single operation. A further disadvantage are the handling and storage of explosives during such an overhaul.

[0006] From SE-B-420033, a high-speed circuit closer is previously known which, with a torsion-sprung contact device, brings three movable contact parts into contact with three fixed contact parts exposed in a container filled with insulating gas. The task of the known high-speed circuit closer is to prevent involuntary contact opening by the introduction of a damping means. One disadvantage with this high-speed circuit closer is that a relatively large number of parts are included in the actual movement. The force which is needed to accelerate the total mass of these parts is therefore considerable. Since the available force is limited, this means that the closing time is relatively long.

[0007] From SE B-455449 a switching device is previously known, the task of which is to conduct and rapidly break high operating currents. The known device has one fixed and one movable contact part, the contact surfaces of which are perpendicular to the direction of movement and utilize the rapid energy output which may be obtained by using a torsion spring. However, the device is only intended to break a current. A torsion-loaded rotating hammer is brought to accelerate and, through a shock, to transmit its energy to the movable contact part, which thus is to obtain a high initial speed. However, the known circuit breaker does not solve the problems which arise when designing a.circuit breaker, in which the speed of the movable contact part must be reduced and the surplus energy be damped.

SUMMARY OF THE INVENTION

[0008] The object of the present invention is to achieve a fast grounding switch, a so-called eliminator, the closing time of which is less than 10 ms. It shall prevent the occurrence of arcs at the moment of contact so as to avoid damage to the contact elements and effectively brake the movable contact system during a closing operation. The eliminator shall manage both a high voltage and a high current and shall be able to function several times. It shall have a simple and compact construction which makes possible an installation in conventional air-insulated switchgear without the above-mentioned disadvantages which are associated with prior art designs. This is achieved according to the invention by a switching device which exhibits the characteristic features described in the independent claims 1 and 6. Advantageous embodiments of the invention are described in the dependent claims.

[0009] In high-voltage switchgear, grounding switches of two kinds are used, namely, working grounding switches and high-speed grounding switches. The invention relates to a grounding switch of the latter kind. A high-speed grounding switch should manage to

ground the high-voltage parts also when these are energized during the closing operation. In such a switching case, the contacts are subjected to full short-circuit current. In order thus to limit the contact burn-off and other function-reducing effects which are caused by the arcs which are usually created during the closing operation, bouncing movements between the contacts must be limited or completely eliminated. The bouncing movements are primarily dependent on the speed at which the contact parts butt against each other. The amplitude of the bouncing movement thus increases with this speed. An important task of the high-speed circuit closer is therefore to achieve a low velocity of the contacts at the moment of closing and an ability to damp the kinetic energy of the contacts.

[0010] To achieve a fast closing, the distance between the contacts must be kept small while at the same time the movable mass associated with the closing operation is minimized. The grounding switch is therefore arranged with one fixed and one movable contact part, whereby the movable contact part is driven towards the fixed contact part by the force from a spring. At high voltages, the contacts are arranged enclosed in a container filled with insulating gas, whereby the insulating gas is utilized for further reducing the distance between the contact parts.

[0011] The force of a spring increases with the cross-section area whereas the amplitude increases with the length. In a short spring, a compromise therefore arises between spring force and amplitude. When designing a circuit closer, it is therefore desired that the force be maximized, which makes the amplitude small. The movement of the movable contact part may, however, be made longer by utilizing the spring force only during the first part of the movement, whereupon the spring is released. The potential energy stored in the spring is then transformed during an acceleration phase into kinetic energy in the movable contact part, which continues the closing movement with a constant speed. The movement thus arranged, with an acceleration phase and a movement phase with constant speed, also results in a lower speed being obtained between the contacts when they butt against each other than during a movement with an acceleration phase only.

[0012] The movable contact part is advantageously arranged as a contact arm attached at one end to a freely journalled torsion-spring rod. The moment of inertia then becomes small and the contact arm may be rapidly brought to accelerate by the force from the torsion-spring rod. At the other end of the torsion-spring rod, an operating arm is arranged, which is able to rotate freely between two supports. The circuit closer is activated by rotating the contact arm in the opening direction until its operating arm reaches the support in this direction. After this, the rotation is continued whereupon the torsion spring is tensioned to an open position where the contact arm is hooked by a latch. When releasing the latch, the potential energy stored by the torsion spring is changed into kinetic energy of the movable contact part during an acceleration phase. When the operating arm leaves the support, the energy has been completely transformed into kinetic energy of the movable contact part and the contact arm continues in a movement phase where it freely rotates towards the closing position at constant speed. When the operating arm reaches the second support, the contact arm continues its movement during a deceleration phase, during which the torsion-spring rod is tensioned in the opposite direction such that the movement of the contact arm stops. During the movement phase, the contact arm reaches the fixed contact part, whereby the kinetic energy of the contact arm is also consumed by friction between the contact arm and the fixed contact part.

[0013] When two contacts approach each other, an arc arises at the movement of contact. This is dependent on the current but also on the bouncing movement which arises between the contacts during the impact. The energy which is to be braked is dependent on the speed squared, which shows that a reduction of the speed also reduces the occurrence of bouncing movements. In case of a sliding contact, where the contact parts are moving in parallel with the contact surface, bouncing effects also occur in that a transverse force is imparted to the contact parts, upon impact, which sets the contact parts in oscillation. The oscillation causes the contact parts to alternately be in contact with each other and alternately be at a distance from each other. During the short time during which the contact parts are separated from each other, an arc arises which causes damage to the contact surfaces. However, in case of a sliding contact, the contact surfaces may be arranged with a number of part surfaces or so-called fingers, which may be brought to oscillate out of phase with each other. Yet the time of oscillation of such a finger of a conducting material as, for example, copper, is too long to completely eliminate the occurrence of arcs. The result is that burns arise in contact surfaces, whereby the contact surfaces are destroyed or even welded together by the arc.

[0014] According to the invention, the harmful arcs are eliminated with a sliding contact which comprises a plurality of contact fingers of a material with good conducting properties, as well as a plurality of spring fingers of a conducting material with a high modulus of elasticity (Young's modulus) and a high yield point. The spring fingers are placed inside the contact fingers and are adapted, upon oscillation, to exhibit a high mechanical resonance frequency. A knife-shape contact part which is caused to slide against such a finger contact hits both the contact fingers, which are thrown sideways by the transverse force, and the spring fingers, which are also thrown sideways. Both types of fingers are set into oscillation such that a bouncing movement can be discerned. However, for the same deflection the spring fingers may be dimensioned to obtain a resonance frequency which is about 20 times higher than the contact

fingers. On its way across the fingers, the movable contact part knocks against a plurality of fingers, which are all brought into oscillation. The spring fingers are struck at different times, which means that the phase difference between the oscillation of the different fingers will be random. Since the oscillation frequency is high, some finger will always be in contact with the movable contact part. This means that arcs do not arise and when the movable contact part has assumed the closed position, also the vibration of the contact fingers has decreased, enabling the grounding switch to carry the current.

[0015] According to the invention, the fixed contact part of the high-speed circuit closer is fork-shaped and comprises a plurality of contact fingers arranged on both sides of a groove. To ensure that the high-speed circuit closer is able to conduct full short-circuit current, the material in the contact fingers must have good conducting properties and may, for example, consist of copper. In addition, to prevent the occurrence of arcs, the high-speed circuit closer is provided with a plurality of spring fingers arranged inside the contact fingers. The material in the spring fingers must be conducting and have a high modulus of elasticity and a high yield point, for example steel with a high carbon content. The movable contact part is knife-shaped and when it is forced into the groove, arcs are prevented from arising on both sides of the knife as described above.

[0016] When a current is conducted in the same direction in two parallel conductors, an attractive force arises between them. This also occurs in the fork-shaped contact part. When the knife contact is pressed into the groove, the current is conducted through the parallel fingers to the yoke of the fork. An attractive force then arises between the fingers, which is dependent on the current intensity, the fingers thus being caused to squeeze the knife contact. The clamping force thus contributes to further eliminate the occurrence of arcs. However, when the knife contact forces its way into the groove, it is first subjected to a frictional force caused by the mechanical stiffness of the fingers, but also to a frictional force which is caused by the current-dependent clamping force. The greater frictional force results in the knife being braked to different degrees in the groove at different current intensities. For high currents, it may thus occur that a safe closed position is not obtained.

[0017] According to the invention, the effect of a greater frictional force of the above-mentioned kind is counteracted by arranging the current path to the circuit closer in three parallel busbars. Two of them are stationary whereas one of the busbars is secured to the movable contact part. The current is first conducted through one of the stationary bars, then in the opposite direction through the other stationary bar, and finally via a flexible coupling through the movable bar. The three bars are arranged such that the movable bar is positioned between two stationary bars when the movable contact part reaches the fixed contact part. When the circuit is closed, an attractive force arises between the first stationary bar and the movable bar, and a repulsive force arises between the second stationary bar and the movable bar. The forces transmit a torque to the movable contact, which thus overcomes the frictional force increased by the current and safely reaches the closed position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention will be explained in greater detail by description of an embodiment with reference to the accompanying drawing, wherein

- Figure 1 shows a three-dimensional picture of a switching device with one fixed and one movable contact part according to the invention,
- Figure 2 shows a time diagram of the rotating movement (A) of a contact arm comprised in the movable contact part in comparison with a corresponding movement (B) of a known switching device,
- Figure 3 shows, in plan view, an advantageous embodiment of the fixed contact part of a switching device according to the invention,
- Figure 4 shows the fixed contact part in Figure 2 in a side view,
- Figure 5 shows an advantageous embodiment of the switching device, which comprises a current-dependent drive means for ensuring that the contact arm reaches its correct closed position also at high currents, and
- Figure 6 shows a locking device of the switching device to rapidly release the stored energy of the movable contact part.
- Figure 7 shows a three-dimensional picture of the fixed contact part with a contact element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] A switching device according to the invention includes one movable part 1 and one fixed part 5, which form a sliding contact. According to Figure 1, the movable contact part 1 forms a freely journalled torsion-spring rod 2, at one end of which a radially extending

operating arm 3 is fixed, and at the other end of which a radially extending contact arm 4 is fixed. The contact arm 4 is adapted to strike the fixed contact part 5 with a rotary movement. The torsion-spring rod 2 is journalled in a stationary stand 6 as well as in a holder (not shown) fixed to the stand, which holder, for high-voltage applications, is filled with insulating gas, and in which the contact arm 4 and the sliding contact 5 are enclosed. The stand 6 comprises a first support 7 and a second support 8, between which the operating arm is freely rotatable. In the embodiments, the two supports are formed as screws threaded in the stand, which permits the free rotary movement of the operating arm to be adjusted.

[0020] In Figure 1, the movable contact part 1 is shown with the contact arm in an initial position 4 where the torsion-spring rod 2 is relaxed and the operating arm 3 makes contact with the first support 7. During the tensioning of the torsion-spring rod, the contact arm 4 may be rotated in a counterclockwise direction and be hooked in an open position 4'. During a closing operation, the contact arm is released, whereby the potential energy stored by the torsional force rotates the contact arm through the angle α in an acceleration phase to its initial position 4. The potential energy now transformed into kinetic energy of the movable contact part rotates the contact arm through the angle β-α at a constant angular velocity during a movement phase to the position 4", whereby the operating arm in the same movement rotates through the angle γ and is caused to make contact with the second support 8. The contact arm continues the rotating movement in a deceleration phase, whereby the torsion-spring rod, through the contact of the operating arm with the second support, is again tensioned in the opposite direction such that the movement of the contact arm stops in a position 4". During the movement phase, the contact arm reaches the fixed contact 5, whereby the sliding friction therein also consumes kinetic energy and contributes to cancel the rotary movement.

[0021] The spring force of a torsion-spring rod is determined, besides by the material, also by its length and cross-section area. The spring force increases with the cross-section area whereas the amplitude increases with the length of the rod. In case of a limited length of the rod, the properties of the rod cannot be optimized. A great spring force results in a slight rotary movement whereas a great rotary movement results in too small a spring force. By arranging the movement of the contact arm in an acceleration phase, a movement phase and a deceleration phase, in the manner described above, the spring force of a torsion rod can be utilized in a better way. With the aid of the operating arm which is capable of rotating freely between two supports, a great spring force with a small amplitude may be brought to advantageously carry out a rotary movement of 90° or more.

[0022] Figure 2 shows a diagram which reflects the rotary movement of the contact arm per time without the effect of the damping in the fixed contact part 5. According to curve A, which relates to the contact knife according to the invention, the movement is initiated by an acceleration phase during the time t_1. During this time, the contact knife rotates through the angle α, whereupon the stored spring force is completely relaxed. A kinetic energy has now been transmitted to the movable contact part, which energy, by the ability of the operating arm to rotate freely between the supports, results in the contact knife, while keeping a constant speed, during the time t_2-t_1 rotating through the angle β-α. The contact knife can thus, according to the invention, be brought to reach the closed position in the same time as a conventional contact arm B on a fixed torsion spring (acceleration phase only), but with an end speed which is lower. A lower speed entails a smaller need of braking force but, in particular, it means that the velocity of impact of the knife against the fixed contact part is reduced.

[0023] An advantageous embodiment of the fixed contact part 5 is shown in Figures 3 and 4. This is formed as a fork-shaped sliding contact with a groove 10, into which the contact arm 4 is intended to penetrate. The contact arm 4 is formed as a contact knife with bevelled edges 9 to more easily penetrate into the groove. The fork-shaped sliding contact exhibits a first branch 11 and a second branch 12, which are kept spaced apart by a spacing plate 18. The first branch 11 comprises an outer plate 13a of a material with good conductivity and an inner plate 16b, lying inside the outer plate, of a conducting material with a high modulus of elasticity as well as a high yield point. The outer plate 13a is slotted so as to exhibit a plurality of parallel contact fingers 14a, the finger-tips 15a of which are inwardly folded towards the groove so as to surround the inner plate. The inner plate 16a is wider than the outer plate and arranged so that the contact knife in its closing movement first reaches this inner plate. Also the inner plate 16a is slotted so as to exhibit a plurality of parallel spring fingers 17a, which are arranged with their finger-tips in a circular path coinciding with the movement of the contact knife. The second branch is inversely-symmetrical with the first branch and, in a corresponding way, comprises an outer plate 13b comprising a plurality of contact fingers 14b with inwardly folded finger-tips 15b and an inner plate 16b with a plurality of spring fingers 17b.

[0024] When the contact arm penetrates between the contact fingers in the fixed fork-like contact, the contact fingers are subjected to transverse forces which tend to throw the fingers to the side. This causes the fingers to start vibrating and, for short moments, to leave the contact with the contact arm. During this moment, an arc arises between the finger and the contact arm, the high heat radiation of this arc causing damage to the contact surfaces and, in case of longer times, welding of the contact parts. To prevent such damage, the contact finger must again be brought into contact with the contact arm as quickly as possible. This can be achieved by dimensioning the fingers with a high mechanical resonance frequency. For materials with good conductivity, for ex-

ample copper, this is a difficult task, since such materials normally have a very low yield point. Cold-rolled steel with a high carbon content, for example spring steel, on the other hand, has a yield point which is about 20 times greater than that of copper. Fingers formed in such material may therefore exhibit a high mechanical resonance frequency, while at the same time the deflection to allow the knife to penetrate into the groove may be made sufficiently large. Other feasible materials are beryllium copper but this is expensive and, in addition, poisonous and thus has a negative influence on the environment. So-called sandwich designs with a combination of conducting and nonconducting materials are further examples of possible choices of materials.

[0025] Spring steel has inferior conductivity, so fingers of steel only would burn up when conducting a short-circuit current. By a combination of fingers with good conductivity and fingers with good resilient properties, a suitable solution may be obtained. The spring fingers are then arranged nearest the knife and are given a high resonance frequency which is only limited by the elastic deflection defined by the penetration of the knife into the groove. Outside the spring fingers, the contact fingers are arranged. The spring fingers are to be arranged as near the contact fingers as possible; however, so that they can freely swing during excitation of the knife. The contact fingers must be provided with inwardly folded finger-tips, allowing the fingers to be brought into contact with the knife. The mechanical resonance frequency of the contact finger thus becomes lower but the arc-preventing function has been taken over by the spring fingers. The two finger types must be placed close to each other to reduce the inductive resistance, which makes it possible to commutate the current between the fingers without an arc arising.

[0026] Between parallel conductors which are traversed by current in the same direction, an attractive force arises. This condition occurs at the contact fingers and the spring fingers in the two branches of the fork contact. Between the fingers, a current-dependent force arises which attracts the fingers in the first branch and the fingers in the second branch towards each other. The pinch effect which is exerted against the contact knife entails a frictional force which increases with the current. The contact knife then does not reach the closed position by the force from the torsion-spring rod. According to the invention, this is overcome with the aid of a current-dependent motor device.

[0027] Figure 5 shows such a motor device, comprising a first current busbar 20, a second current busbar 21 and a third current busbar 22. The first two busbars are thus fixedly secured whereas the third one is fixed to the contact arm 4. All the busbars are parallel to the torsion rod 2. The current is first introduced at the upper part of the first busbar 20, is conducted down therethrough and further to the lower part of the second busbar 21 and up therethrough. From the upper part of the second busbar, the current is conducted through a flexible conductor to the upper part of the third busbar 22 and further down through this and out through the contact knife to the fixed sliding contact. The busbars are arranged such that the third busbar, at the moment that the current is closed, is positioned between the first and the second busbars and that the first busbar is positioned right in front of the third busbar in the closed position. When a current traverses the busbars, an attractive force arises between the first and third busbars which strives to rotate the contact knife in a clockwise direction. Between the second and third busbars, a repulsive force instead arises during energization, but this repulsive also strives to rotate the contact knife in a clockwise direction. The greater degree of braking at high currents to which the contact knife is subjected because of increased frictional force between the contact fingers is compensated for by the motor power exerted by the three current busbars on one another.

[0028] Figure 6 shows a release latch according to the invention. In a cylindrical housing 25 of insulating material, a mushroom-shaped locking device 26 of a conducting material is arranged. The housing comprises a cover 27 and a bottom 28 with a central hole 29 for the foot 30 of the locking device and, surrounding the hole 29, a circular recess 31 containing a flat coil 32. The hat of the locking device is pressed against the bottom of the housing by a spring 33 clamped against the cover such that the foot of the locking device projects through the hole and hooks the operating arm 3. At a current pulse through the coil, a magnetic field arises which generates eddy currents in the hat of the locking device. Between the current through the coil and the eddy current in the hat, a great repulsive force arises which rapidly pulls the foot of the latching device away from the operating arm.

[0029] The invention is not limited to comprising switching devices with a rotating closing movement only. The division of a closing movement into an acceleration phase followed by a movement phase with a constant speed may be advantageously applied also to a switching device with a linear closing movement.

[0030] Nor is the fixed contact limited to comprising rotary movements only. The fixed contact may very well be designed with one branch only, or a combination of fingers on one side of the knife and a movement-damping device on the other side. The knife is then arranged to slide at an angle to the fingers in an arbitrary movement. Thus, the invention may also be applied to switching devices with circular sliding surfaces and translatory movements. In such applications, the contact and spring fingers may be arranged with bent fingers, which follow the contact surface.

[0031] Figure 7 shows an advantageous embodiment of the fixed contact part 5. The fixed contact part is here one-sided and exhibits a layer of spring fingers 17, behind which is arranged a layer of contact fingers 14 with folded-up finger-tips. The movable contact part 4 slides in over the fixed contact part in a direction designated v

in the figure. In its movement, the movable contact part strikes the fingers 14, 17, whereby these are thrown by the transverse forces, thus arising, away from the movable contact part in a direction downwards in the figure. In the same way as described above, the spring fingers prevent arcs from arising, whereby no burns arise and the contact fingers can carry the current in the closed position.

Claims

1. An electric switching device for fast closing of a high current comprising at least one movable contact element (4) operated by an operating member (2), **characterized in that** the operating member (2) comprises a spring means, by which a spring force affects the movable contact element (4) causing the movable contact element to accelerate during a first part only, the acceleration phase(t_1), of a closing operation and that the spring force thereafter ceases to affect the movable contact element (4) causing the movable contact element to move freely and at a substantially constant speed towards a closed position during a second part, the linear phase (t_2-t_1) of the closing operation.

2. A switching device according to claim 1, **characterized in that** the operating member (2) comprises a freely journalled torsion-spring rod, to one end of which the contact element (4) is fixed and to the other end of which an operating arm (3), freely rotatable between a first support (7) and a second support (8), is fixed, whereby the torsion-spring rod is adapted to store energy by clamping the contact element, with the operating arm making contact with the first support (7), in a movement opposite to the closing movement, such that, during a closing operation, the torsion-spring rod during the acceleration phase relaxes and imparts to the contact element (4) an acceleration, and that the operating arm (3) during the linear phase freely rotates between the supports.

3. A switching device according to claim 2, **characterized in that** the operating arm (3) during the linear phase reaches the second support (8), whereby the torsion-spring rod (2), by clamping the operating arm against the second support, is adapted to impart to the contact element (4) a deceleration, during which the closing movement stops and the kinetic energy is transformed into a spring force stored in the torsion rod and directed opposite to the closing operation.

4. A switching device according to any of the preceding claims, **characterized in that** a locking device trips the contact element (4), said locking device comprising a mushroom-shaped latch (26), the foot (30) of which extends through a flat circular coil (32), whereby a current pulse through the coil causes an eddy current in the hat of the latch such that a repulsive force arises between the hat of the latch and the coil, the foot of the latch thus tripping the closing operation.

5. A switching device according to claims 2-4, **characterized in that** the current path comprises at least two busbars parallel to the torsion-spring rod, at least one busbar (21) being stationary and one busbar (22) being fixed to the movable contact element (4), whereby the current path is adapted to impart to the current such a direction in the busbars that the mechanical force which, during a closing operation, arises between the busbar (22) fixed to the contact element (4) and each other stationary busbar transmits a torque, directed in the closing direction, to the contact element (4).

6. A switching device according to any of the preceding claims, **characterized in that** the movable contact element (4) is adapted to form a sliding contact with a fixed contact element (5) comprised in the switching device, said contact element comprising a plurality of contact fingers (14) designed of a first electrically conducting material with good electrical conductivity as well as a plurality of spring fingers (17) designed of a second conducting material with a high yield point and designed such that they have a considerably higher resonance frequency than the contact fingers (14), the spring fingers being adapted to rapidly resume a contact position after a deflection excited by the movable contact element (4).

7. A switching device according to claim 6, **characterized in that** the contact fingers (14) and the spring fingers (17) are so arranged that, during a closing operation, the movable contact element (4) is brought into contact with the spring fingers before the contact fingers.

8. A switching device according to claim 6 or 7, **characterized in that** the fixed contact element (5) arranged with contact fingers (14) and spring fingers (17) is inversely symmetrical in a plane parallel to the closing movement of the movable contact element and surrounds a groove (10), into which the movable contact element (4) penetrates.

9. A switching device according to any of the preceding claims, **characterized in that** the contact elements (4, 5) are arranged in a container filled with protective gas.

10. A method for manufacturing an electric switching

device for fast closing of a high current comprising at least one movable contact element (4) operated by an operating member (2), **characterized in that** the operating member (2) is brought to comprise a spring means, by which spring force the movable contact element (4) is brought to accelerate during a first part only, the acceleration phase(t_1), of a closing operation and that the spring force thereafter is brought to cease to affect the movable contact element (4) causing the movable contact element to move freely and at a substantially constant speed towards a closed position during a subsequent part, the linear phase (t_2-t_1), of the closing operation.

Patentansprüche

1. Elektrische Schaltvorrichtung zum Schnell-Schließen eines hohen Stroms, die mindestens ein bewegliches Kontaktelement (4) einschließt, das durch ein Federelement (2) betätigt wird, **dadurch gekennzeichnet, dass** die Schließbewegung des Kontaktelements eine Beschleunigungsphase (t_1), während der die Federkraft, die in dem Federelement (2) durch Klemmen gespeichert ist, in kinetische Energie des Kontaktelements überführt wird, und eine Bewegungsphase (t_2-t_1) abschließt, während der sich das Kontaktelement mit einer konstanten Geschwindigkeit in Richtung auf die geschlossene Stellung zu bewegt.

2. Schaltvorrichtung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** das Federelement (2) einen frei gelagerten Torsionsfeder-Stab einschließt, dessen eines Ende an einem Betätigangsarm (3) befestigt ist, der zwischen einer ersten Haltevorrichtung (7) und einer zweiten Haltevorrichtung (8) frei drehbar ist, und dass das Kontaktelement (4) an dem anderen Ende des Torsionsfeder-Stabs befestigt ist, wobei der Torsionsfeder-Stab daher durch Drehen des Kontaktelements in die Öffnungsrichtung mit dem Betätigungsarm in Richtung auf die erste Haltevorrichtung geklemmt ist, so dass sich der Torsionsfeder-Stab während der Beschleunigungsphase während eines Schließvorgangs entspannt und dass sich der Betätigungsarm (3) während der Bewegungsphase zwischen den Haltevorrichtungen frei dreht.

3. Schaltvorrichtung gemäß Anspruch 2, **dadurch gekennzeichnet, dass** der Betätigungsarm (3) während der Bewegungsphase der Schließbewegungsphase die zweite Haltevorrichtung (8) erreicht, wodurch die Schließbewegung des Kontaktelements (4) in eine Veriangsamungsphase überführt wird, während der der Torsionsfeder-Stab (2) in der entgegengesetzten Richtung geklemmt wird und die Bewegung des Kontaktelements (4) anhält.

4. Schaltvorrichtung gemäß einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Schließvorrichtung das Kontaktelement (4) auslöst, wobei die Schließvorrichtung einen pilzförmigen Riegel (26) einschließt, dessen Fuß (30) sich durch eine flache kreisförmige Spule (32) erstreckt, wodurch ein Strompuls durch die Spule einen Wirbelstrom in dem Hut des Riegels verursacht, so dass eine Rückstellkraft zwischen dem Hut des Riegels und der Spule auftritt, wobei der Fuß des Riegels dadurch die Schließbewegung auslöst.

5. Schaltvorrichtung gemäß einem der Ansprüche 2-4, **dadurch gekennzeichnet, dass** der Stromverlauf mindestens zwei parallel zu dem Torsionsfeder-Stab verlaufende Stromschienen einschließt, wobei mindestens eine Stromschiene (21) stationär ist und eine Stromschiene (22) an dem Kontaktelement (4) befestigt ist, wodurch der Stromverlauf derart angepaßt ist, so dass der Strom durch die Stromschienen in solche Richtungen fließt, dass die mechanische Kraft, die während eines Schließvorgangs zwischen der Stromschiene (22), die an dem Kontaktelement (4) befestigt ist, und jeder anderen Stromschiene entsteht, ein Drehmoment überträgt, das in der Schließrichtung in Richtung auf das Kontaktelement (4) gerichtet ist.

6. Schaltvorrichtung zum Schnell-Schließen eines hohen Stroms, die ein erstes Kontaktelement (4) und ein zweites Kontaktelement (5) einschließt, die einen gleitenden Kontakt bilden, wobei das zweite Kontaktelement mehrere Kontaktfinger (14) einschließt, **dadurch gekennzeichnet, dass** das zweite Kontaktelement mehrere Federfinger (17) einschließt, die eine hohe mechanische Resonanzfrequenz aufweisen wobei die Federfinger dazu angepaßt sind, eine Kontaktstellung nach einer quer zu der Schließrichtung angeregten Durchbiegung rasch wiederherzustellen.

7. Schaltvorrichtung gemäß Anspruch 6, **dadurch gekennzeichnet, dass** die Kontaktfinger (14) und die Federfinger (17) so angeordnet sind, dass während eines Schließvorgangs das erste Kontaktelement (4) vor den Kontaktfingern mit den Federfingern in Kontakt gebracht wird.

8. Schaltvorrichtung gemäß Anspruch 6 oder 7, **dadurch gekennzeichnet, dass** das zweite Kontaktelement (5), das mit Kontaktfingern (14) und Federfingern (17) angeordnet ist, invers symmetrisch in einer Ebene parallel zu der Schließbewegung ist und eine Nut (10) umgibt, in die das erste Kontaktelement (4) eindringt.

9. Schaltvorrichtung gemäß einem der Ansprüche 6-8, **dadurch gekennzeichnet, dass** ein

Schließvorgang durch eine Drehbewegung des ersten Kontaktelements (4) eintritt.

10. Schaltvorrichtung gemäß einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** die Kontaktelemente (4, 5) in einem mit Schutzgas gefüllten Behälter angeordnet sind.

Revendications

1. Dispositif de commutation électrique pour une fermeture rapide d'un courant élevé comportant au moins un élément (4) de contact mobile actionné par un élément (2) à ressort, **caractérisé en ce que** le mouvement de fermeture de l'élément de contact comporte une phase (T1) d'accélération, pendant laquelle la force de ressort, emmagasinée dans l'élément (2) à ressort par serrage, est transformée en énergie cinétique de l'élément de contact, et une phase (t2-t1) de mouvement pendant laquelle l'élément de contact se déplace en direction de la position fermée à une vitesse constante.

2. Dispositif de commutation suivant la revendication 1, **caractérisé en ce que** l'élément (2) à ressort comporte une tige élastique en torsion montée librement sur un tourillon, dont une extrémité est fixée à un bras (3) d'actionnement, monté librement rotatif entre un premier support (7) et un second support (8), et **en ce que** l'élément (4) de contact est fixé à l'autre extrémité de la tige élastique en torsion, la tige élastique en torsion étant ainsi serrée en tournant l'élément de contact dans la direction d'ouverture avec le bras d'actionnement en direction du premier support, de sorte que, pendant une opération de fermeture, la tige élastique en torsion pendant la phase décélération se relâche et que le bras (3) d'actionnement pendant la phase de mouvement tourne librement entre les supports.

3. Dispositif de commutation suivant la revendication 2, **caractérisé en ce que** le bras (3) d'actionnement pendant la phase de mouvement de la phase de mouvement de fermeture atteint le second support (8), le mouvement de fermeture de l'élément (4) de contact étant ainsi transformé en une phase de décélération, pendant laquelle la tige (2) élastique en torsion est serrée dans la direction opposée et le mouvement de l'élément (4) de contact s'arrête.

4. Dispositif de commutation suivant l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un dispositif de blocage déclenche l'élément (4) de contact, le dispositif de blocage comportant un loquet (26) en forme de champignon, dont le pied (30) s'étend dans une bobine (32) circulaire plate, une impulsion de courant passant dans la bobine entraînant un courant de Foucault dans le chapeau du loquet, de sorte qu'une force répulsive apparaît entre le chapeau du loquet et la bobine, le pied du loquet déclenchant ainsi le mouvement de fermeture.

5. Dispositif de commutation suivant l'une des revendications 2 à 4, **caractérisé en ce que** le trajet de courant comporte au moins deux omnibus parallèles à la tige élastique en torsion, au moins un omnibus (21) étant stationnaire et un omnibus (22) étant fixé à l'élément (4) de contact, le trajet de courant étant conçu de sorte que le courant passe par les omnibus dans des directions telles que la force mécanique qui, pendant une opération de fermeture, apparaît entre l'omnibus (22) fixé à l'élément (4) de contact et chaque autre omnibus transmet un couple, dirigé dans la direction de fermeture, à l'élément (4) de contact.

6. Dispositif de commutation pour une fermeture rapide d'un courant élevé comportant un premier élément (4) de contact et un second élément (5) de contact, qui forme un contact coulissant, le second élément de contact comportant une pluralité de doigts (14) de contact, **caractérisé en ce que** le second élément de contact comporte une pluralité de doigts (17) élastiques, qui présentent une fréquence de résonance mécanique élevée et qui sont conçus pour reprendre rapidement une position de contact après une déviation excitée transversalement de la direction de fermeture.

7. Dispositif de commutation suivant la revendication 6, **caractérisé en ce que** les doigts (14) de contact et les doigts (17) élastiques sont disposés de sorte que, pendant une opération de fermeture, le premier élément (4) de contact est mis en contact avec les doigts élastiques avant les doigts de contact.

8. Dispositif de commutation suivant la revendication 6 ou 7, **caractérisé en ce que** le second élément (5) de contact disposé avec des doigts (14) de contact et des doigts (17) élastiques est inversement symétrique dans un plan parallèle au mouvement de fermeture, et entoure une rainure (10), dans laquelle le premier élément (4) de contact pénètre.

9. Dispositif de commutation suivant l'une des revendications 6 à 8, **caractérisé en ce qu'**une opération de fermeture a lieu par un mouvement rotatif du premier élément (4) de contact.

10. Dispositif de commutation suivant l'une quelconque des revendications précédentes, **caractérisé en ce que** les éléments (4, 5) de contact sont disposés dans un conteneur emplit de gaz protecteur.

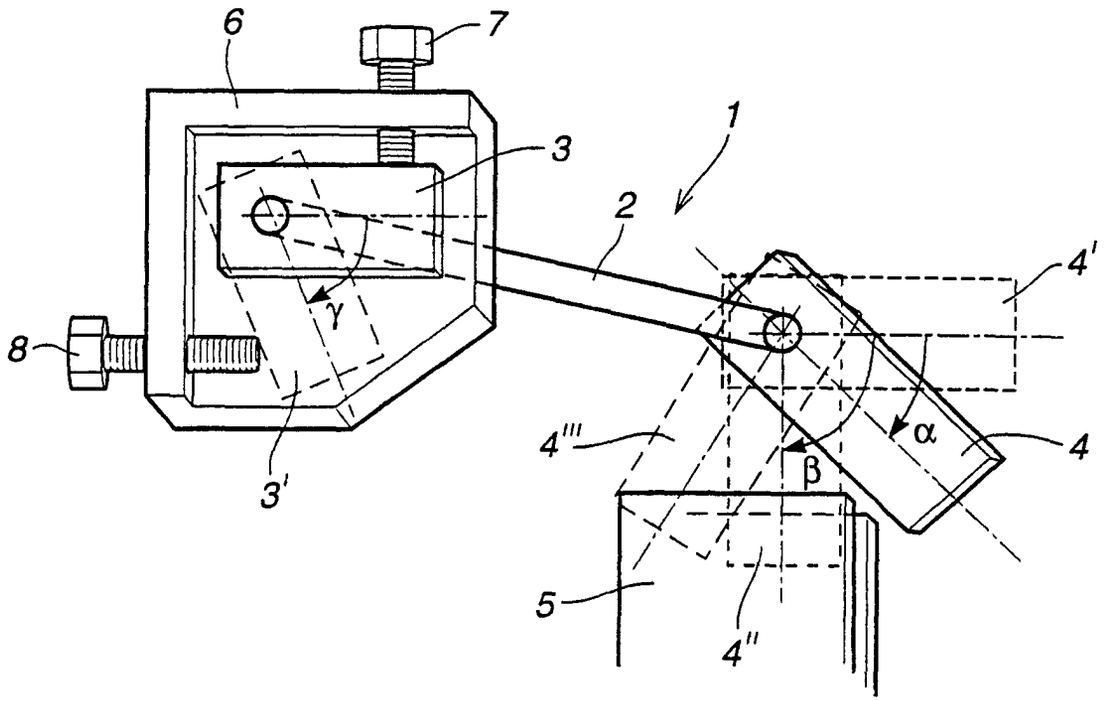


Fig. 1

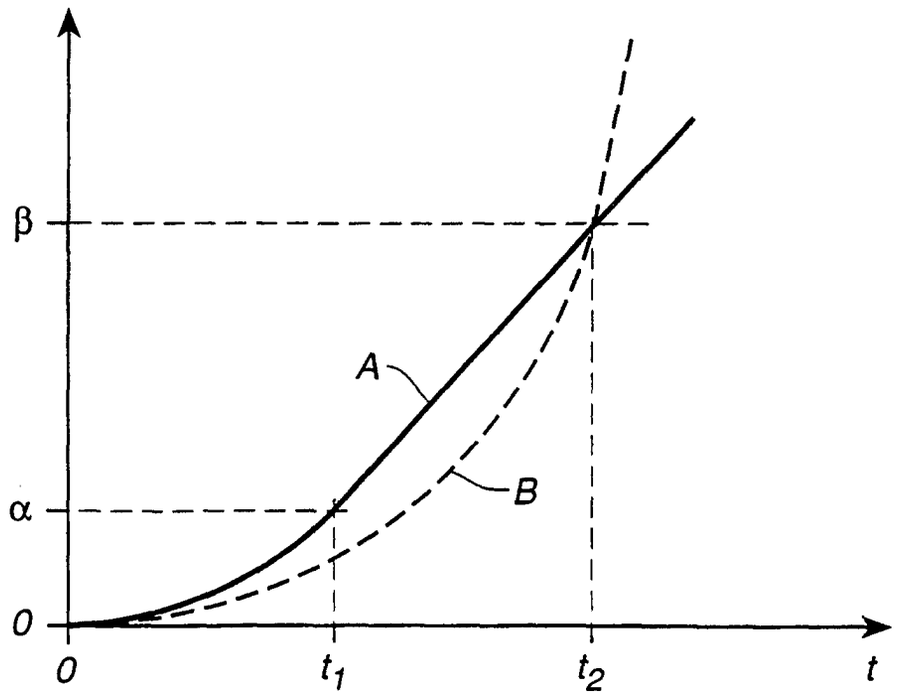


Fig. 2

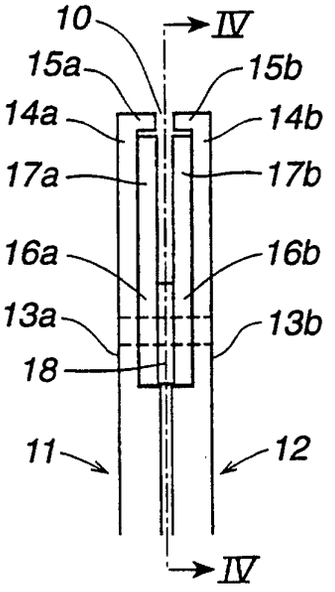


Fig. 3

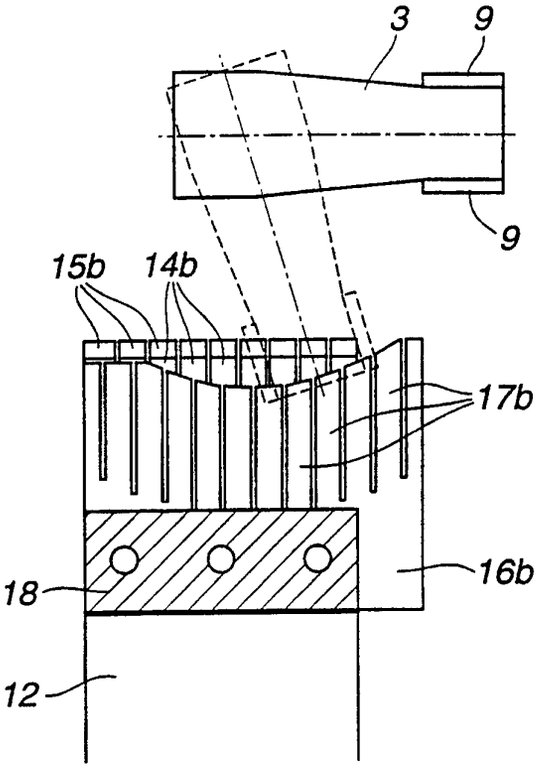


Fig. 4

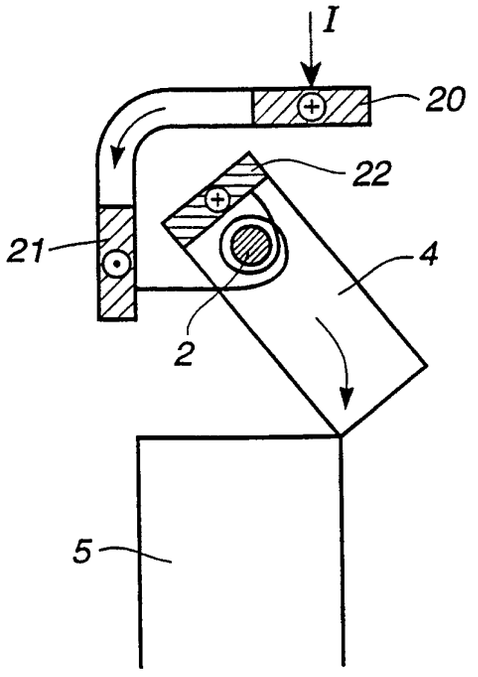


Fig. 5

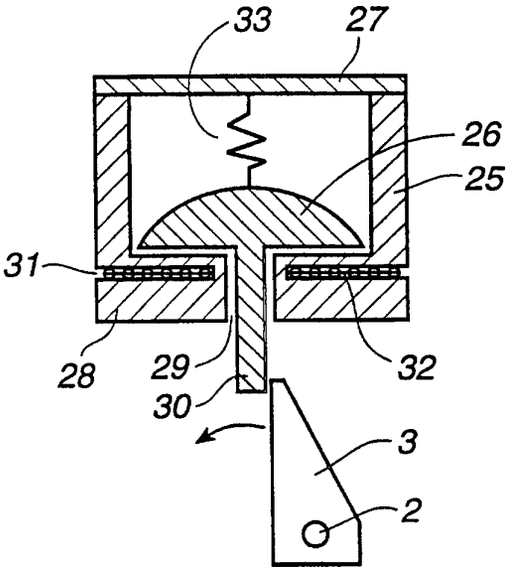


Fig. 6

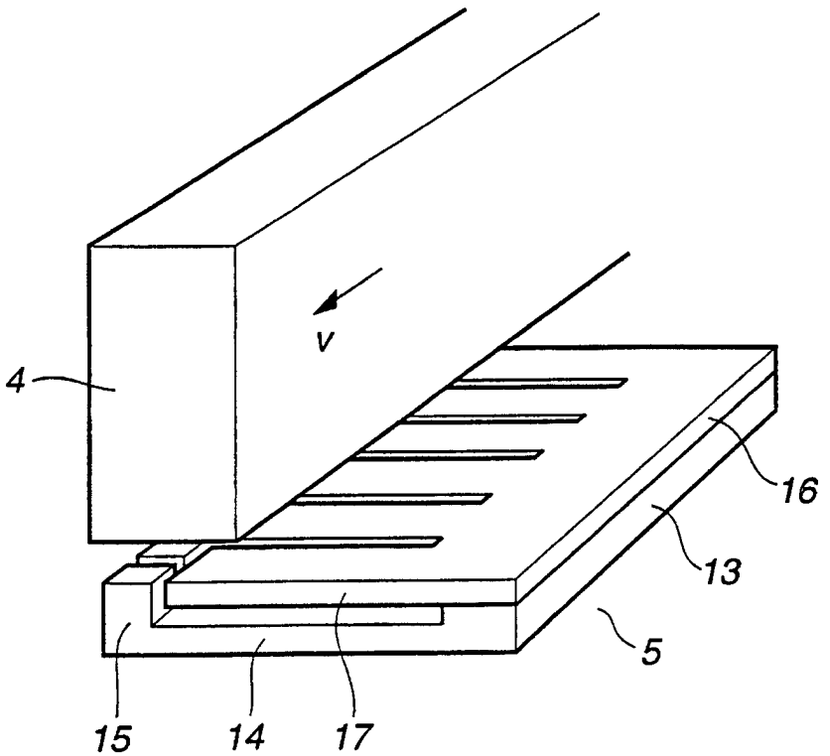


Fig. 7