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CIRCUIT INTERRUPTER

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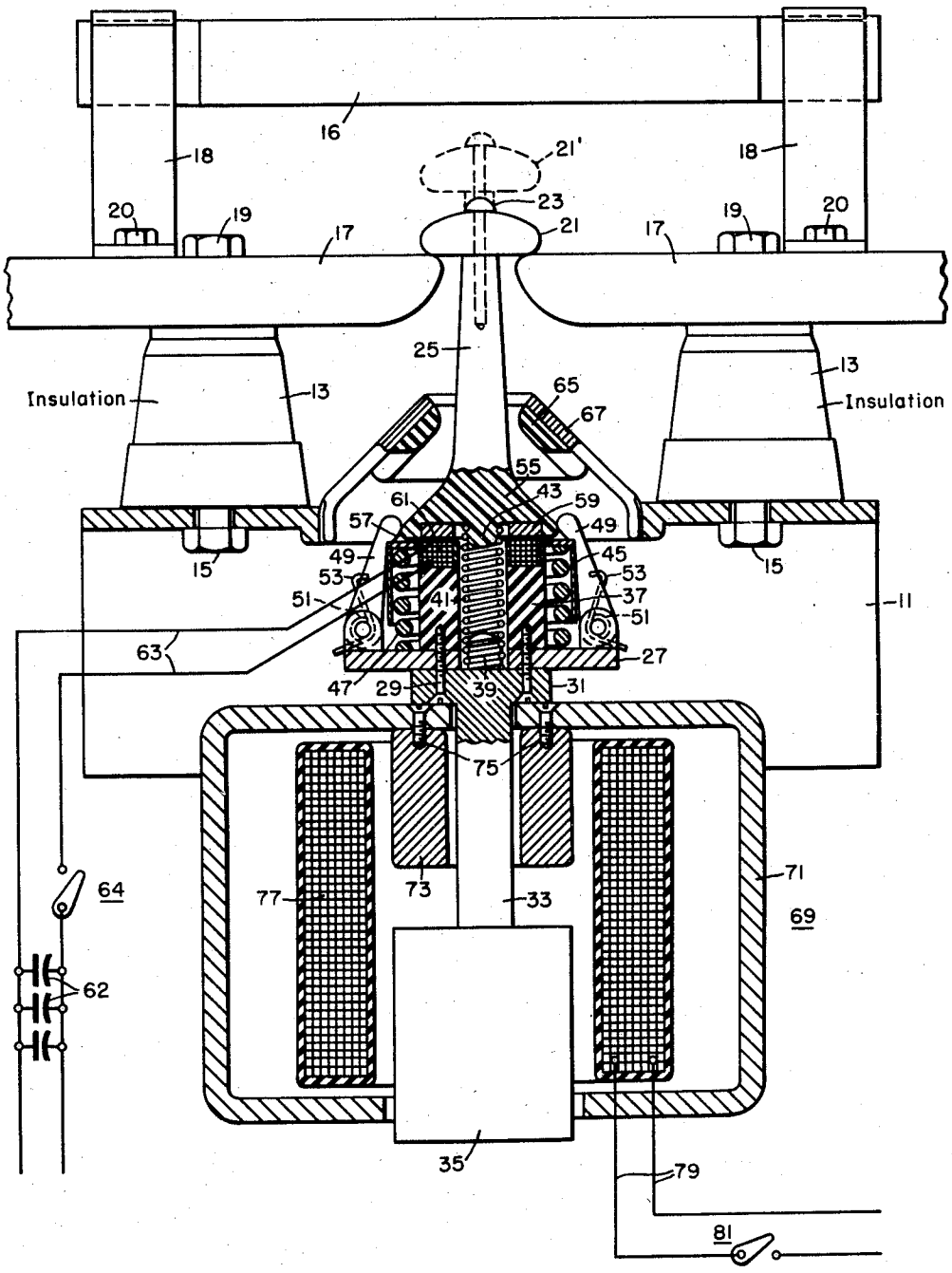

WITNESSES

Robert C. Baird

Wm. La Groove

INVENTORS

Fritz Kesselring &

Samuel Hammerli.

BY

Paul A. Harbers

ATTORNEY

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CIRCUIT INTERRUPTER

Fritz Kesselring, Kusnacht, Zurich, and Samuel Hämmerli, Oberengstringen, Switzerland, assignors to Siemens-Schuckertwerke Aktiengesellschaft, Erlangen, Germany, a corporation of Germany

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This invention relates to circuit breakers and more particularly to high-speed operating means therefor.

In order to solve numerous switching problems, it is necessary to initially separate the contacts of a circuit breaker in a fraction of a millisecond, for instance, in no more than 0.3 millisecond after the occurrence of a disturbance such as an overcurrent, a short-circuit, etc. A longer time of, for instance, 0.3 to 1.5 milliseconds, may be used for reaching the full disconnecting position. To accomplish this, it appears to be advisable to divide the disconnecting operation into two parts. Heretofore, it has been proposed that two energy storing means such as electrical and mechanical devices be provided for operating such high-speed circuit breakers. The mechanical means were released in most cases by destruction of the mechanical means, such as, by an explosion.

The present invention relates to an opening device in which the masses to be moved are actuated by at least two energy storing means. The first means which is instantly operable and its energy translating device are designed and dimensioned in such a manner that the masses to be moved attain an acceleration of at least 5000 g. in not more than 0.3 millisecond after the disconnecting impulse is given, that is, after the occurrence of a disturbance such as an overcurrent. The second energy storing means is mainly used to bring the moving masses to their final position. Charged condensers which operate electrodynamic systems are preferably used as the first instantaneously operating energy storing means. They may use a stationary coil and a second coil inductively coupled to the first coil, which preferably has only a single turn. Such an arrangement will provide acceleration of at least 5000 g. in a simple manner. Systems using magnetic materials cannot be used since it can be easily shown that large forces of 100 kgr. or more are necessary and accelerations of 5000 g. cannot be produced thereby. In case devices are used, for instance, cylinders completely filled with oil or similar material wherein a heavy current arc is fired to generate gas pressure by decomposition of the material, the required high accelerations of a piston can be produced. However, such systems as well as those using explosive materials have the disadvantage that the materials are destroyed and have to be regenerated or replaced. Spring means should be preferably used as the second energy storing means, and, at high accelerations, that is, for short disconnecting periods, spring means with high natural frequency should be used.

An object of the invention is to provide a circuit breaker embodying high-speed operating means in which a repulsion type coil initiates opening movement of the movable contact means of the breaker.

Another object of the invention is to provide a circuit breaker embodying high-speed operating means in which a repulsion type coil initiates opening movement of the breaker contact means and stored energy means completes the opening movement.

Antoher object of the invention is to provide a circuit breaker embodying high-speed operating means wherein

energization of a repulsion type coil initiates opening movement of the breaker contact means and the opening movement of the contact means effects release of stored energy means to move said contact means to the open position.

Another object of the invention is to provide a circuit breaker in which the opening movement of the breaker contact means is initiated by energization of a repulsion coil, the contact means being moved to full open position by stored energy means and in which opening movement of the contact means effects release of the stored energy means.

The invention, both as to structure and operation, together with additional objects and advantages thereof, will be best understood from the following detailed description when read in conjunction with the accompanying drawing which shows an elevational view, partly in section, of a circuit breaker embodying the principles of the invention.

Referring to the drawing, the circuit breaker comprises a base or frame 11 on which are mounted spaced insulators 13. The insulators 13 are secured to the base 11 by bolts 15, and at their upper ends the insulators 13 support spaced stationary contacts 17 which are secured thereto by means of bolts 19. A high-power or current-limiting fuse 16 may be mounted in fuse support members 18 which are mounted by means of bolts 20 on the stationary contacts 17. A movable bridging contact 21 is secured by means of a screw 23 to the upper end of an insulating operating rod 25.

The operating mechanism for the contact operating rod comprises a plate 27 secured by means of screws 29 to a flange 31 on the upper end of an armature rod 33 to the lower end of which is secured a moving armature 35. The screws 29 also secure a hollow cylindrical member of insulating material 37 to the upper face of the plate 27. A projection 39 on the flange 31 extends into the bore of the insulating member 37 and is threaded to tightly receive one end of a coil spring 41, the other end of the spring being tightly threaded onto a projection 43 on the lower end of the contact rod 25. The spring 41 is connected under tension between contact rod 25 and the flange 31 to provide contact pressure between moving contact 21 and the contacts 17. Surrounding the insulating block 37 and compressed between a cup-shaped member 45 and the plate 27 is a powerful coil spring 47 which is latched under compression by latch members 49 pivotally supported on ears 51 projecting from the plate 27. The latch members 49 are biased by springs 53 into latching engagement with the cup-shaped member 45 in order to releasably restrain the spring 47 in operative condition, that is, under compression.

The lower end of the contact rod 25 is in the shape of a cone as at 55 with the edge 57 of the base of the cone extending under the upper ends of the latches 49 with enough overlap so that, upon upward or opening movement of the rod 25, the edge 57 moves the latch members 49 to unlatching position.

The opening movement of the contact rod is initiated from the first energy storing means by the electromagnetic repulsion between a solid metallic ring 59 of, for instance, copper or aluminum pressed in the lower end of the contact rod and a coil 61 secured to or embedded in the upper end of the insulating member 37. A connection 63 is provided for energizing the coil 61 in response to an overload current or a short-circuit current. The coil 61 may be energized by suitable energy storing means, for instance, by the discharge of a charged condenser 62, which is effected by closing a switch 64. When the coil 61 is energized, a substantial current will flow through the ring 59 in the opposite direction to the flow of current in the coil 61 thus producing an electrody-

namic repulsion force between the coil and the ring. This force is transmitted to the operating rod **25** to start the rod and the bridging contact **21** in opening direction.

The second energy storing means come into play when the contact rod starts in opening direction and the edge **57** of the cone **55** wipes by the rounded ends of the latches **49** moving the latches to unlatching position releasing the cup-shaped member **45**, whereupon the energy storing spring **47** expands and drives the contact rod **25** at high speed to the full open position. The contact rod **25** is stopped by engagement of the surface of the conical lower end thereof with a resilient or rubber bumper **65** on a conical member **67** suitably mounted in an opening in the base **11**. As the cup-shaped member **45** moves upwardly the rounded ends of the latches **49** ride on the surface thereof maintaining the latches in unlatched position.

Before the contact rod **25** can be moved to the closed position to close the breaker contacts, it is necessary to reengage the latches **49** with the cup-shaped member **45**. This is accomplished by means of an electromagnet indicated generally at **69** comprising a magnet yoke **71** rigidly mounted on the base **11**, a stationary core member **73** secured by means of screws **75** to the magnet yoke, the movable armature **35** and an energizing winding **77**. The winding **77** may be energized over a circuit **79** from a suitable source by closing a switch **81** which may be effected either manually or by automatic means. When the winding **77** is energized, the electromagnet **69** attracts the armature **35** upwardly and thrusts the plate **27** and the latches **49** upwardly to effect reengagement of the latches with the member **45**. At the same time the upward movement of the plate **27** compresses the spring **47**. Upon deenergization of the electromagnet **69**, which is effected by opening the switch **81**, the entire movable structure returns by its own weight to the closed contact position in which it is shown.

Tests and calculations show that a force of approximately 600 kgr. is exerted on the ring **59** of 3 cm. diameter and having a cross section (0.5×0.26) cm.^{2} by a coil **61** having twenty turns, when it is energized by an impulse current which attains a maximum current of 2000 amp. after 0.1 m. seconds. The total weight of the movable contact structure **21**, **25** and **59** is approximately 50.10^{-3} kgr. so that a maximal acceleration of 12,000 g. is obtained. A contact opening of 0.1 mm. is reached after 10^{-4} seconds at which time the contacts are safely disconnected.

Separation of the contacts **17–21** transfers the current to the current-limiting fuse **16** and the current is interrupted by melting of the fuse after the contacts are fully opened. The time available for moving the movable contact **21** to its fully open position **21'** is the melting time of the fuse which is approximately 0.5 to 2 milliseconds in response to heavy overloads. The characteristics of the spring **47** must, therefore, be such that it will move the movable contact to its full open position by the time the fuse melts.

While the operating device has been described in connection with a fuse arrangement, it can also be used for high-speed and synchronous circuit breakers. The operating device can also be used to advantage for modulation circuit breakers when an artificial zero current is obtained by means of a superimposed impulse current, and by using the superimposed impulse current for energizing the coil **61**. Thus, by superimposing on a positive D.C. current a negative D.C. current impulse of the same value an artificial zero current is obtained, and at the same time by using the superimposed current impulse to energize the coil **61**, the interruption will occur at zero current.

We claim as our invention:

1. A circuit breaker having stationary and movable contact means, electromagnetic means operable when energized to apply a force to said movable contact means to start said movable contact means in opening direction, stored energy means operable to then move said movable contact means to full open position, restraining means normally restraining only said stored energy means in operative condition, said movable contact means after being started in opening direction by the force applied thereto by said electromagnetic means engaging and actuating said restraining means to non-restraining position and permitting said stored energy means to then move said movable contact means to open position.

2. A circuit breaker having stationary and movable contact means, electrodynamic means operable when energized to applying a repulsion force to said movable contact means to start said movable contact means in opening direction, stored energy means operable to then move said movable contact means to full open position, restraining means normally restraining only said stored energy means in operative condition, said movable contact means after being started in opening direction by the force applied thereto by said electromagnetic means engaging and actuating said restraining means to non-restraining position and permitting said stored energy means to then move said movable contact means to open position, and means operable to store energy in said stored energy means and to effect reengagement of said restraining means with said stored energy means.

3. A circuit breaker comprising stationary and movable contact means, means comprising a repulsion electromagnet operable when energized to apply a repulsion force to said movable contact means to start said movable contact means in opening direction, stored energy means operable to then move said movable contact means to full open position, restraining means normally releasably restraining only said stored energy means in operative condition, said movable contact means after being moved a predetermined distance by the force applied thereto by said repulsion electromagnet engaging and actuating said restraining means to release said stored energy means.

4. A circuit breaker having stationary and movable contact means, means comprising a repulsion electromagnet operable when energized to apply a force to said movable contact means to start said movable contact means in opening direction, stored energy means for energizing said repulsion electromagnet, a second stored energy means operable to then move said movable contact means to open position, restraining means releasably restraining only said second stored energy means in operative condition, said movable contact means being movable independently of said restraining means said movable contact means when moved a predetermined distance by said repulsion electromagnetic means engaging and actuating said restraining means to release said second stored energy means, and an electromagnet operable to store energy in said stored energy means and to effect engagement of said restraining means with said stored energy means.

5. A circuit breaker having stationary and movable contact means, electrodynamic means operable when energized to start said movable contact means in opening direction comprising an energizing coil, stored energy means for energizing said coil, conduiting means mounted on said movable contact means adjacent said coil, energization of said coil effecting an induced voltage in said conducting means which in turn effects a repulsion magnetic force on said movable contact means to start said movable contact means in opening direction, a second stored energy means for then moving said movable contact means to full open position, latch means releasably restraining said second stored energy means, and said movable contact means when moved a predetermined distance by said electromagnetic means actuating said latch means to release said second stored energy means.

6. A circuit breaker having stationary and movable

contact means, electromagnetic means for starting said movable contact means in opening direction comprising an energizing coil, a connection for energizing said coil, conducting means mounted on said movable contact means adjacent said coil, energization of said coil effecting an induced voltage in said conducting means which in turn applies a magnetic force to said movable contact means to start said movable contact means in opening direction, stored energy means for moving said movable contact means to full open position, latch means releasably retraining only said stored energy means, said movable contact means when moved by said electromagnetic means engaging and actuating said latch means to release said stored energy means, and means for storing energy in said stored energy means and for effecting relatching of said latch means.

7. A circuit breaker having stationary contact means, movable contact means biased closed, a closing electromagnet including a movable armature, support means mounted on and movable with said armature, means for moving said movable contact means in opening direction comprising a coil supported by said support means on said armature, a conducting member on said movable contact means adjacent said coil, energization of said coil inducing a current in said conducting member in the opposite direction to the current in said coil and producing a magnetic force on said conducting means to start said movable contact means in opening direction against its bias, stored energy means on said support means for then moving said movable contact means to full open position, latch means mounted on and movable with said support means releasably restraining said stored energy means in operative condition, movement of said movable contact means by said magnetic force causing said movable contact means to engage and actuate said latch means and release said stored energy means.

8. A circuit breaker having stationary contact means, movable contact means biased closed, a closing electromagnet including a movable armature, support means mounted on and movable with said armature, means for moving said movable contact means in opening direction comprising a coil supported by said support means on said armature, a conducting member on said movable contact means adjacent said coil, energization of said coil inducing a current in said conducting member in the opposite direction to the current in said coil and producing a magnetic force on said conducting member to start said movable contact means in opening direction against the bias, stored energy means for then moving said movable contact means to full open position, latch means mounted on and movable with said support means releasably restraining said stored energy means in operative condition, movement of said movable contact means by said magnetic force causing said movable contact means to engage and actuate said latch means and release said stored energy means, and said closing electromagnet when energized moving said support means together with said latch means to store energy in said stored energy means and to effect relatching of said latch means.

9. A circuit breaker comprising separable contacts, two stored energy means one of which is instantaneously operable, an energy translating device energized by an impulse from said instantaneously operable stored energy means, said translating device being operable when energized to apply a repulsion force to the movable masses of said circuit breaker to give the movable masses of said circuit breaker an initial acceleration, said instantaneously operable stored energy means and said energy translating device being so dimensioned that the movable masses are given an acceleration of at least 5000 g. after not more than 0.3 millisecond following said impulse and the other of said stored energy means after the initial acceleration then moving said movable masses to their final positions.

10. A circuit breaker comprising separable contacts, two stored energy means one of which is instantaneously operable, an energy translating device energized by an impulse from said instantaneously operable stored energy means for applying a force to the movable masses of said circuit breaker to start said movable masses in motion, and the other of said stored energy means after said movable masses have moved a predetermined distance then engaging and moving said movable masses to their final positions, said instantaneously operable stored energy means comprising a charged condenser, and said energy translating device comprising electrodynamic means.

11. A circuit breaker comprising separable contacts, two stored energy means one of which is instantaneously operable, an energy translating device energized by an impulse from said instantaneously operable stored energy means, said energy translating device when energized applying a repulsion force to the movable masses of said circuit breaker to start said movable masses in motion, and the other of said stored energy means then engaging and moving said movable masses to their final positions, said instantaneously operable stored energy means comprising a charged condenser, and said energy translating device comprising electrodynamic means, and said electrodynamic energy translating device having an insulating member connected between it and said separable contacts.

12. An operating device for an electric circuit breaker having a stationary contact and a movable contact biased closed, an insulating operating member for said movable contact, two stored energy means, one of which is instantaneously operable, an energy changing device energized by an impulse from said instantaneously operable stored energy means and when energized applying a force to the movable contact means of said circuit breaker to impart an initial acceleration to said movable contact in opening direction, said instantaneously operable stored energy means and said energy changing device being constructed and arranged in such a manner that the force applied to the movable contact gives said movable contact an acceleration of at least 5000 g. after not more than 0.3 millisecond following said impulse, and the other of said stored energy means being then operable to engage and move said movable contact to its final position.

13. An operating device for an electric circuit breaker having a stationary contact and a movable contact biased closed, two stored energy means, one of said stored energy means comprising a charged condenser and being instantaneously operable, an energy changing device comprising an electrodynamic system energized by an impulse from said charged condenser and operable when energized to apply a force to said movable contact to start said movable contact in motion, said electrodynamic system having a stationary part and a movable part with an air gap between them to provide contact pressure, and the other of said stored energy means being operable to then engage and move said movable contact to its final position.

14. An operating device comprising a movable member, electromagnetic means operable when energized to apply a force to said movable member to start said movable member in motion, stored energy means operable after said movable member has moved a predetermined distance to apply a force to said movable member to move said movable member to its terminal position, restraining means normally releasably restraining said stored energy means in operative condition, said movable member after being moved a predetermined distance by the force applied thereto by said electromagnetic means engaging and actuating said restraining means to a non-restraining position thereby permitting said stored energy means to move said movable member the remaining distance to its terminal position.

15. An operating device comprising an element freely movable from one position to another position, two stored energy means one of which is instantaneously operable, an energy translating device energized by an impulse from said instantaneously operable stored energy means and

operable when energized to apply a force to said movable element to start said movable element in motion from said one position in a direction toward the other of said positions, the other of said stored energy means then engaging and completing the movement of said movable element to said other position, said instantaneously operable stored energy means comprising a charged condenser, and said energy translating device comprising electrodynamic means.

16. An operating device comprising a movable element biased to one position and movable to a second position, means comprising a repulsion electromagnet operable when energized to apply a force to said movable element to start said movable element in motion toward said second position, stored energy means connected to energize said repulsion electromagnet, a second stored energy means operable after said movable element is started in motion to then move said movable element to said second position, restraining means releasably restraining said second stored energy means in operative condition, said

movable element being movable independently of said restraining means, said movable element when moved a predetermined distance by said repulsion electromagnet actuating said restraining means to cause release of said second stored energy means and permit said second stored energy means to complete the movement of said movable element to said second position.

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