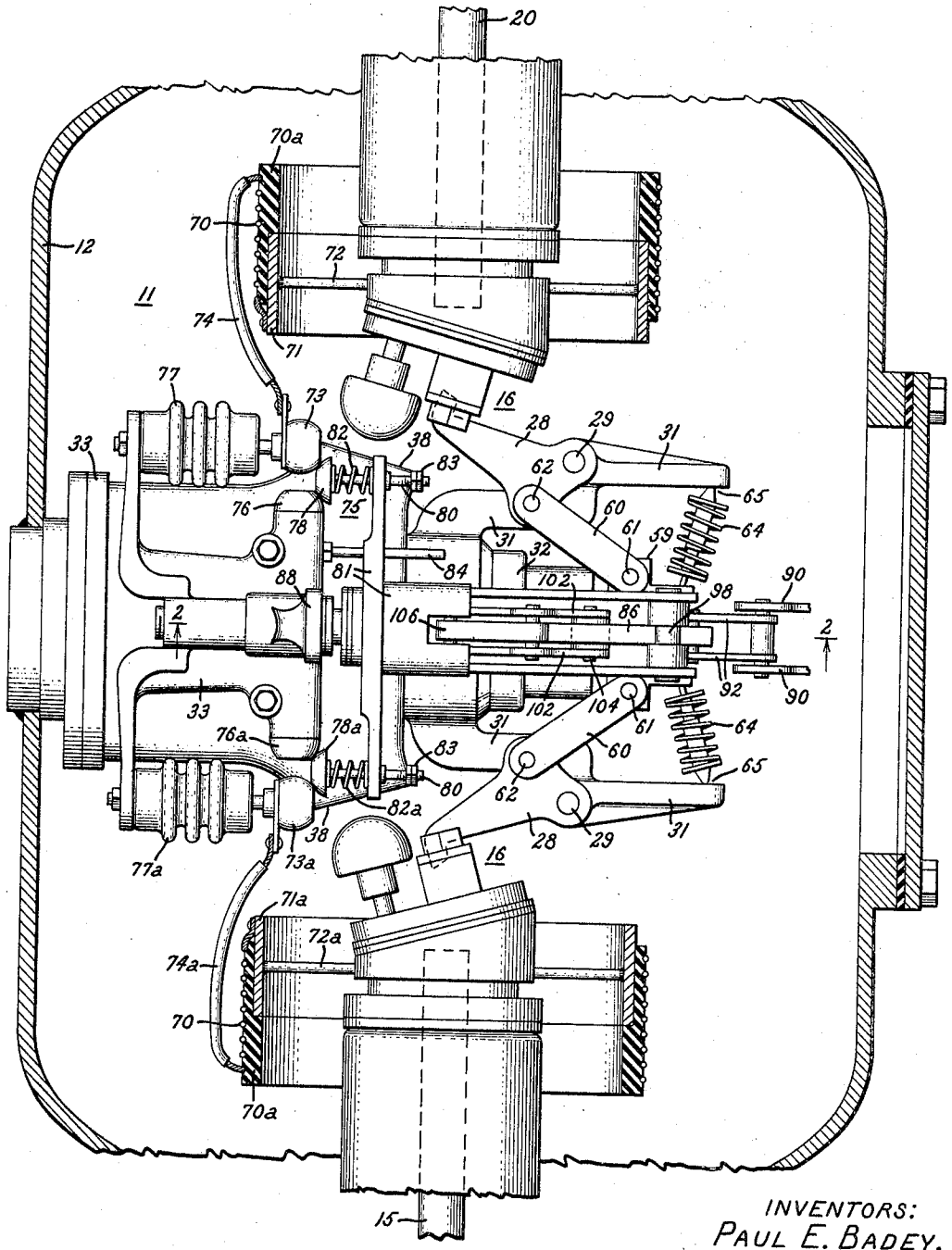
Dec. 2, 1969 P. E. BADEY ET AL 3,482,069

VOLTAGE CONTROLLING SHUNTING RESISTOR WITH OPERATING CAM CONTOUR MODIFYING MEANS

Filed Dec. 12, 1966

3 Sheets-Sheet 1

Fig. 1.



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3 Sheets-Sheet 2

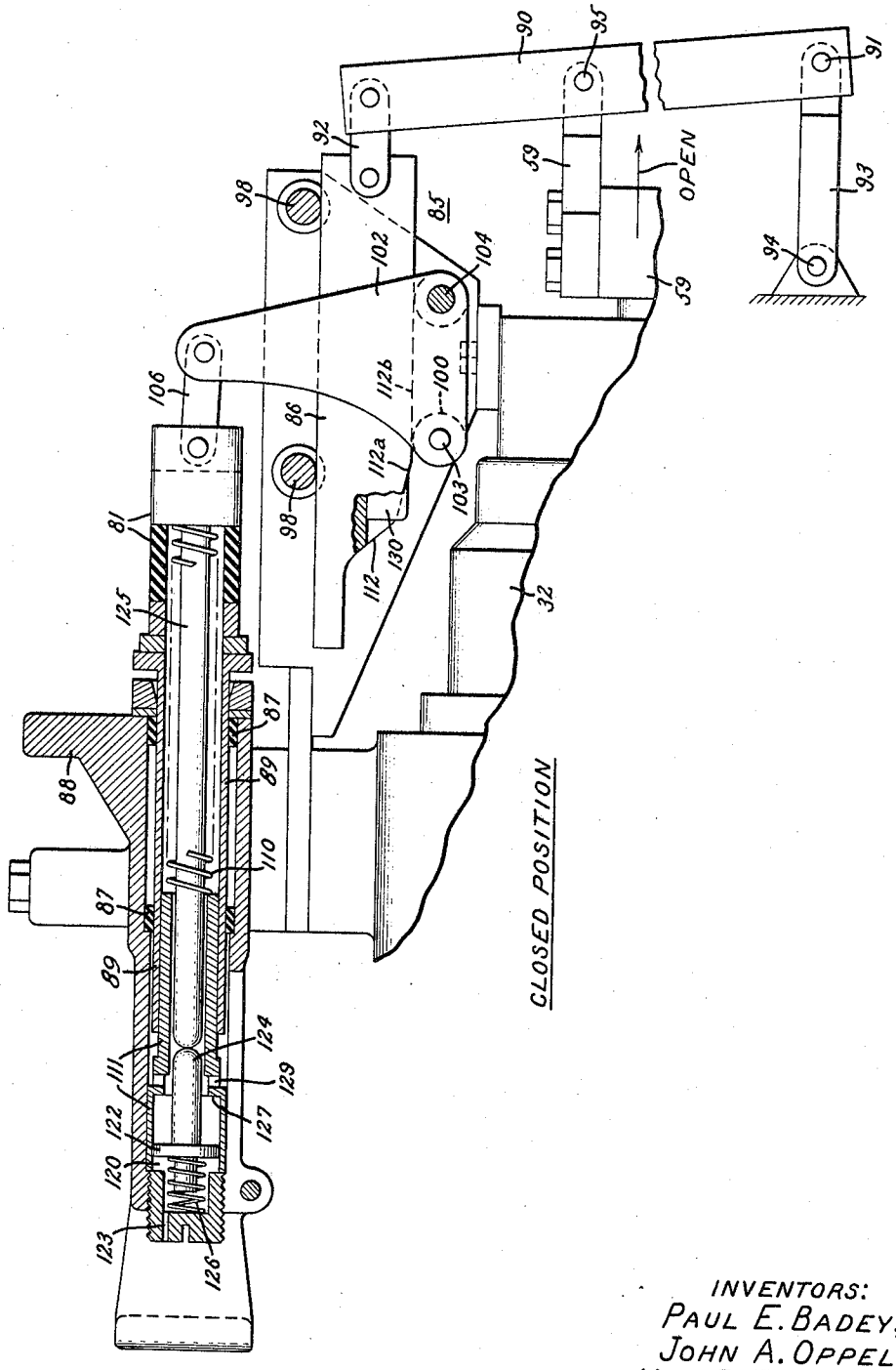


FIG. 2.

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3 Sheets-Sheet 3

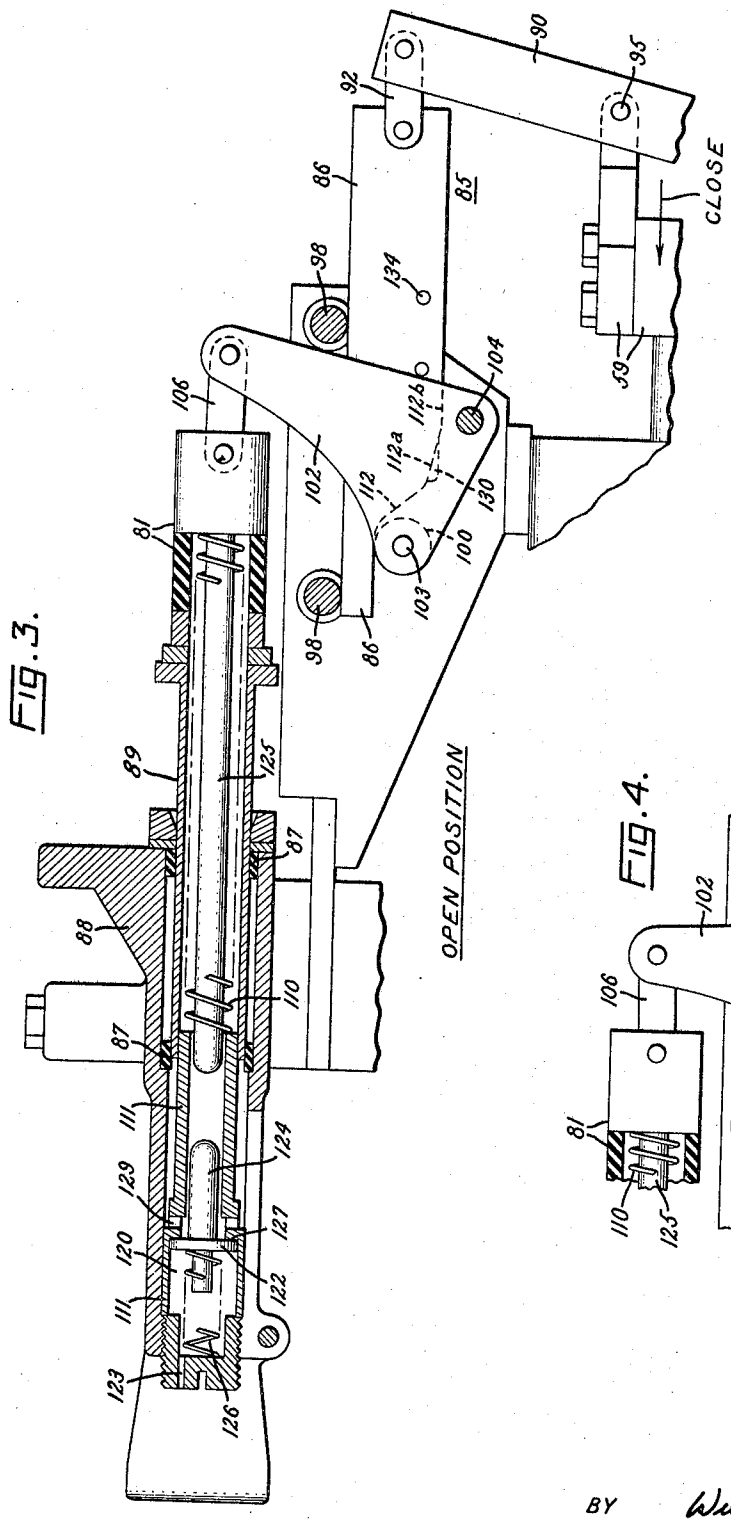


FIG. 3.

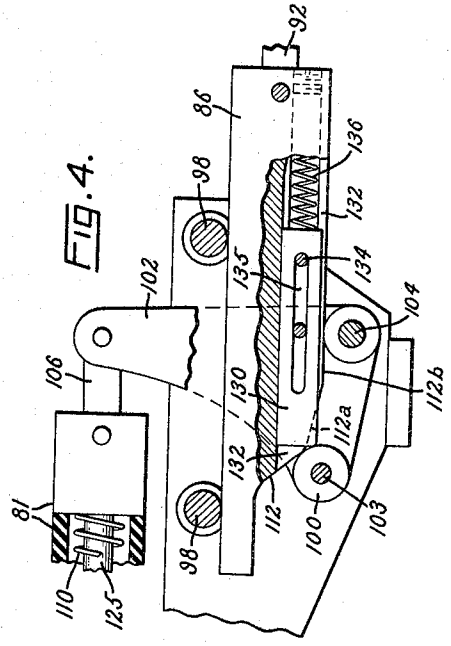


FIG. 4.

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United States Patent Office

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VOLTAGE CONTROLLING SHUNTING RESISTOR WITH OPERATING CAM CONTOUR MODIFYING MEANS

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U.S. Cl. 200—148 4 Claims

ABSTRACT OF THE DISCLOSURE

Discloses a high voltage circuit breaker in which a resistor is connected across the main contacts of the breaker just prior to their engaging during a closing operation. The resistor remains so connected until an intermediate point in a subsequent opening operation. The resistor is inserted and removed in this manner by means of a resistor switch controlled by a cam coupled to the movable main contact of the breaker. Means is provided for modifying the effective contour of the cam during breaker-opening as compared to its contour during closing. Such contour-modification is accomplished by extending a dwell portion of the cam during breaker-opening to delay initiation of resistor switch-opening.

This invention relates to an electric circuit breaker of the type that is provided with a voltage controlling resistor shunting its main contacts and resistor switch means for interrupting the current flowing through the resistor after the main contacts have been opened.

For controlling the voltage developed across the main contacts of a high voltage circuit breaker during a circuit interrupting operation, it has been customary to shunt these contacts with a resistor through which current is transferred when the main contacts are opened to interrupt the circuit. For interrupting the current through the resistor, there is customarily provided a resistor switch connected in series with the resistor and in shunt with the main contacts.

In order for the resistor consistently to carry out its intended function during the interrupting process, it is important that the resistor switch always be opened at the expiration of a definite predetermined time interval following operation of the main contacts. An arrangement for obtaining this coordination between the main contacts and the resistor switch contacts is shown and claimed in U.S. Patent 3,211,868—Barken and Oppel, assigned to the assignee of the present invention.

In certain circuit breaker applications, it is highly desirable that, during closing, the resistor shunting the main contacts be inserted into the power circuit at a precisely controlled instant prior to closing of the main contacts. This type of operation, which is referred to as "resistor preinsertion," materially reduces the magnitude of the voltage trainsients developed by circuit breaker closing. The circuit breaker disclosed in the aforementioned Barkan and Oppel patent inserts the resistor at about the same time as the main contacts are closed and is not capable of preinserting the resistor.

An object of the present invention is to provide a circuit breaker which can preinsert its shunting resistor during a closing operation and can open the circuit through the resistor during an opening operation at a precisely controlled time following separation of the main contacts of the circuit breaker.

Another object is to control the shunting resistor in the manner set forth in the preceding object by means of a simple and compact linkage interconnecting the main contacts and the resistor switch contacts.

Still another object is to provide a simple interconnecting linkage that comprises a cam movable in one direction to effect closing of the resistor switch and in a reverse direction to effect opening of the resistor switch.

Still another object is to provide an interconnecting linkage of a type that obviates the need for the hold-closed latch used for holding the resistor switch closed in the aforesaid Barkan and Oppel patent.

In carrying out our invention in one form, we interconnect a movable one of the main contacts and a movable one of the resistor switch contacts by means of a linkage comprising a cam coupled to the movable main contact. This cam is movebale between first and second positions in response to movement of the main contact through a closing stroke and is returnable in a reverse direction to said first position in response to movement of said main contact through an opening stroke. A follower coupled to the movable resistor switch contact and actuated by the cam imparts closing motion to the movable resistor switch contact in response to movement of the cam between said first and second positions. The speed of said closing motion is determined by the effective contour of said cam during said closing stroke. Spring means biases the movable resistor switch contact toward open position and operates in response to return movement of the cam from its second to its first position to impart opening motion to the movable resistor switch contact at a starting point determined by the effective contour of said cam during said opening stroke. Means is provided for modifying the effective contour of the cam during said opening stroke as compared to its effective contour during said closing stroke.

For a better understanding of the invention, reference may be had to the following description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a side-elevational view, partially in section, showing a circuit breaker embodying one form of our invention. The circuit breaker is depicted in the closed position.

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1.

FIG. 3 is a view similar to that of FIG. 2 except showing the parts of FIG. 2 in the circuit breaker-open position.

FIG. 4 is an enlarged sectional view of a portion of the apparatus of FIGS. 1–3 at an intermediate point during a circuit breaker closing operation.

Referring now to FIG. 1, the circuit breaker shown therein is of the general type disclosed and claimed in the aforesaid Barkan and Oppel Patent No. 3,211,868 and in Patent No. 2,783,338—Beatty, both assigned to the assignee of the present invention. This circuit breaker comprises an enclosed interrupting chamber **11** defined, in part, by a metallic casing **12** which is filled with pressurized arc-extinguishing gas.

A pair of elongated conductive studs **15** and **20** project into the casing **12** from diametrically-opposed points, and each of these studs carries a suitable stationary contact assembly **16** at its radially-inner end. Cooperating with each stationary contact assembly is a movable contact **28** pivotally mounted upon a stationary pivot **29**. These pivots **29** are supported upon stationary brackets **31** which are integral with one end of a stationary operating cylinder **32**. Suitable means (not shown) are provided for transferring current between the movable contacts **28** and the brackets **31**, so that the brackets **31** together with the cylinder **32** form a conductive path electrically interconnecting the two movable contacts **28**.

The cylinder **32**, at its left hand end, is suitably supported from a generally cylindrical housing **33**, which, in turn, is suitably secured at its left hand end to the metallic casing **12**.

When each pair of main contacts **16** and **28** are separated, an arc is drawn therebetween, and this arc is subjected to a gas blast action which helps to extinguish it. The gas blast is produced in a conventional manner and flows through nozzles **38** and the hollow housing **33** to the surrounding atmosphere. A normally-closed blast valve (not shown) within the housing **33** is used for controlling this gas blast. When the blast valve is opened, the gas-blast is initiated and continues until the blast valve is closed.

For operating the blast valve and the movable contacts **28**, a combined operating mechanism preferably of the fluid-actuated type shown in the aforementioned Beatty patent is provided within the cylinders **32** and **33**. The details of this operating mechanism form no part of the present invention and, hence, such details are not shown in the present application. An adequate understanding of the present invention may be had if it is understood that the operating mechanism acts during an opening operation to drive a crosshead shown at **59** in FIG. 1 to the right and also acts to open the blast valve. The crosshead **59** is coupled to the contacts **28** (by means soon to be described) and, hence, such movement to the right of crosshead **59** serves to drive the main contacts **28** open. At a predetermined instant after the main contacts **28** have been opened, the then-open blast valve is driven closed by the operating mechanism, as is described in detail in the Beatty patent. This prevents further loss of gas from the interrupting chamber **11**.

The means for coupling the crosshead **59** to the main contacts **28** comprises two sets of connecting links **60**, each pivotally connected at **61** and **62** to the crosshead **59** and movable contacts **28**, respectively.

In the position of FIG. 1, the movable contacts **28** are biased into closed position by means of overcenter compression springs **64** acting to the left on crosshead **59**. Each of these springs **64** has one end pivotally supported at **65** on a projecting portion of one of the stationary brackets **31**. At their inner ends, the springs **64** are pivotally supported on the crosshead **59**. These overcenter springs **64** tend to urge the contacts **28** closed while the crosshead **59** is to the left of a reference line connecting the pivots **65**. But when the crosshead is moved to the right beyond this reference line (as occurs during a contact-opening operation), the overcenter springs thereupon tend to urge the contacts in a contact-opening direction. This action coupled with that of the operating mechanism acts to hold the contacts **28** in a fully-open position until the operating mechanism is subsequently operated to close the contacts **28**.

Shunting the upper pair of main contacts **16, 28** is a resistor **70**, shown schematically as a resistor element wound about an insulating core **70***a* carried by a conductive tube **71**. The conductive tube **71** is supported from the conductive stud **20** by means of conductive webs **72** electrically interconnecting the tube **71** and the stationary contact assembly **16**. The lower terminal of the resistor **70** is connected to the tube **71**, whereas the upper terminal is locally insulated from the tube **71** and is connected by means of a conductor **74** to an electrode **73** of an auxiliary or resistor switch **75**.

The resistor switch **75** comprises, in addition to the electrode **73**, a second electrode **76** spaced from electrode **73** and coacting with electrode **73** to form an interrupting gap between the two electrodes. The electrode **73** is supported on the central housing **33** by an insulator **77** which is capable of electrically isolating the electrode **73** from housing **33** when the resistor switch is open. The electrode **76** is also supported on the housing **33** but is electrically connected to the housing. Electrically bridging the two stationary electrodes **73** and **76** is a movable electrode **78**, which in its closed position of FIG. 1, butts against the two stationary electrodes. Thus, it will be seen that the resistor **70** is connected in shunt with the upper contacts **16, 28** by means of a circuit which extends through the parts **72, 71, 70, 74, 73, 78, 76** and **33**. As will be apparent from FIG. 1, the lower main contacts **16, 28** are shunted by a similar circuit. Since the parts forming this lower shunting circuit are substantially identical to those forming the upper circuit, corresponding lower parts have been assigned corresponding reference numerals followed by the suffix "*a*."

Referring more particularly to the resistor switch **75**, it will be noted from FIG. 1 that each of the movable electrodes **78** and **78***a* has an elongated pin **80** integral therewith and projecting therefrom to the right. Each of these pins is freely received in an opening formed in a reciprocable cross-beam **81** of insulating material. A pair of compression springs **82** and **82***a*, each of which is disposed between the cross-beam **81** and one of the movable electrodes **78** or **78***a*, urge the movable electrodes into firm circuit-closing engagement with the stationary electrodes. While the switch **75** is in its normal closed position of FIG. 1, the cross-beam **81** is restrained from moving to the right as will soon appear more clearly. When, however, the cross-beam **81** is driven to the right during a switch-opening operation, it eventually impacts against suitable abutments **83** adjustably secured to the outer ends of the pins **80** and **80***a*, and, thus, drives the movable electrodes **78** and **78***a* to the right into an open position spaced from the stationary electrodes. To aid in guiding the cross beam **81** during such opening movement, a suitable guide pin **84** is shown secured to a stationary portion of the switch **75** and projecting through a guide opening formed in the cross-beam. Additional guidance is provided by a metal tube **89** fixed to the cross-beam **81** and slidably mounted in bearings **87** on a stationary part **88** of the circuit breaker, as may be seen in FIGS. 2 and 3.

Opening and closing of the resistor switch **75** are precisely coordinated with opening and closing, respectively, of the main contacts **16, 28** by a linkage **85** which is connected between movable main contact **28** and movable resistor switch contact **78**. More specifically, this linkage **85** is connected at one end to the crosshead **59** that actuates the movable main contacts **28** and at its other end to the cross beam **81** that actuates the movable resistor switch contacts **78, 78***a*.

This linkage **85** comprises a cam **86** mounted for linear movement and coupled to the main contact crosshead **59** by a connecting lever **90**. The connecting lever **90** has one end mounted on a suitable pivot **91** (FIG. 2) and its opposite end pivotally connected to cam **86** through a link **92**. Link **92** is pivotally connected at its opposite ends to cam **86** and lever **90**. The pivot **91** on which connecting lever **90** is mounted is carried by a guide link **93** pivotally mounted on a stationary pivot **94**. The crosshead **59** is pivotally connected to the lever **90** through a pivot **95**.

During a circuit breaker-opening operation, the crosshead **59** is moved to the right from its position of FIG. 2 into its position of FIG. 3. Such movement forces lever **90** clockwise about pivot **91** to drive cam **86** to the right into its position of FIG. 3. During a circuit breaker-closing operation, the crosshead **59** returns from its position of FIG. 3 to its position of FIG. 2, acting through lever **90** to drive cam **86** leftward from its position of FIG. 3 to its position of FIG. 2. The cam is guided during such movement by a plurality of spaced guide rollers **98** and **99**, which force the cam to follow a linear path.

For controlling the resistor switch in accordance with this motion of cam **86**, a follower **100** mounted on a bell crank **102** is provided. This follower **100** is preferably a roller rotatably mounted on a supporting pin **103** fixed to bell crank **102**. Bell crank **102** is pivotally mounted on a stationary pivot **104** and has one arm pivotally connected through a link **106** to the cross beam **81** of the resistor switch **75**. Link **106** is pivotally con-

nected at its opposite ends to crank **102** and cross beam **81**, respectively.

The cross beam **81** of resistor switch **75** is biased toward open position by means of a resistor-switch opening spring **110** and the wipe springs **82** and **82***a*. Opening spring **110** is a compression spring bearing at its left hand end on a stationary cylinder **111** and at its right hand end on a hub portion of the cross beam **81**. This opening spring **110** and the wipe springs **82**, **82***a* bias crank **102** clockwise about its pivot **104**, thereby urging follower **100** upwardly against cam **86**. When cam **86** is moved to the left from its position of FIG. 3 toward its position of FIG. 2 during a circuit breaker closing operation, a steep ramp surface **112** on cam **86** first engages follower **100**, thereby pivoting the follower bell crank **102** counterclockwise about its pivot **104** to carry cross beam **81** to the left to produce resistor-switch closing. When the cam **86** has moved through only a portion of its total closing stroke, the cross beam **81** has moved sufficiently to the left to drive the movable resistor switch contact **78** into engagement with stationary contacts **73** and **76**. Shortly thereafter, a less steep portion **112***a* of the ramp **112** passes into engagement with follower **100** to continue driving the cross beam **81** to the left but at a much reduced speed. This additional leftward movement of cross beam **81** compresses wipe springs **82**, **82***a* on the resistor switch contacts. Leftward motion of cross beam **81** is terminated when a zero-slope, or dwell, portion **112***b* of cam **86** passes into engagement with follower **100**. Cam **86** continues moving a slight additional distance to the left but imparts no further leftward motion to cross beam **81** since the follower **100** is then on the dwell portion **112***b*. The ramp surfaces **112** and **112***a* constitute what is referred to hereinafter as a motion-producing portion of the cam. It will be noted that the dwell surface **112***b* extends substantially parallel to the linear path of motion followed by cam **86**, and the ramp surfaces **112** and **112***a* extend transversely of said linear path.

For decelerating cross beam **81** at the end of its resistor-switch closing stroke, a dashpot **120** is provided. This dashpot **120** comprises a dashpot piston **122** which is slidably mounted in a stationary dashpot cylinder **111**. When the dashpot piston **122** is driven to the left from its position of FIG. 3, its motion is opposed by fluid trapped in the cylinder space to the left of the piston. The rate at which the piston **122** can move to the left is determined by a metering orifice **123** through which the dashpot fluid is expelled as the dashpot piston moves to the left. The dashpot piston **122** comprises a projecting portion **124** which is adapted to engage a buffer rod **125** fixed to crossbeam **81**. A reset spring **126** biases dashpot piston **122** to the right toward its position of FIG. 3, where it engages a stop **127**. Large vent openings **129** at the right hand end of cylinder **111** permit free movement of the piston **122** to the right to allow for resetting thereof when the resistor switch opens.

When the circuit breaker is open, as shown in FIG. 3, there is a space present between buffer rod **125** and dashpot piston **124** which permits cross beam **81** to move a predetermined distance to the left before the dashpot **120** becomes effective. The dashpot becomes effective when the leftward moving buffer rod **125** strikes dashpot piston portion **124**. When this occurs continued movement of the buffer rod **125** to the left drives dashpot piston **122** to the left against the opposition of fluid in the cylinder space to the left of the dashpot piston, forcing the dashpot fluid at a controlled rate through metering orifice **123**. Motion of the resistor switch cross beam **81** is thus smoothly terminated at the end of its closing stroke. The parts of the circuit breaker are then in the fully-closed position depicted in FIG. 2.

This dashpotting action at the end of the closing stroke reduces closing shock that could cause harmful contact bounce and also reduces the tendency for cross-beam **81** to oscillate when its closing motion is terminated.

As pointed out hereinabove, in certain circuit breaker applications it is highly desirable that the resistor switch contacts engage well ahead of the instant at which the main contacts engage. Our cam-type linkage **85** readily lends itself to such resistor preinsertion inasmuch as the steep ramp portion **112** of the cam is shaped in such a manner that it quickly drives the resistor switch crossbeam **81** into a position that produces resistor-switch contact-engagement well ahead of the point at which the main contacts engage.

During a circuit breaker opening operation, the resistor switch must be opened at a precisely controlled instant, e.g., 22 milliseconds, after the main contacts part. For controlling this instant of resistor-switch contact-part, we utilize the same cam **86** that is used for closing; but we change the effective contour during a closing operation. More specifically, we provide the cam with a contour-modifying member in the form of a slider **130**, visible in FIGS. 2, 3 and 4, but best shown in FIG. 4. The illustrated slider **130** preferably is a bar member that is guided for linear motion in a guide slot **132** in the cam **86**. Suitable guide pins **134**, fixed to cam **86**, project through an elongated slot **135** in the slider to retain it in its guide slot **132** and to assist in its guidance. A reset spring **136** urges the slider toward the left, as shown in FIG. 4.

During a resistor-switch closing operation, such as described hereinabove, the ramp portions **112** and **112***a* of the cam freely engage the follower **100** without any significant interference from slider **130**. As the follower moves along the ramp portions **112** and **112***a*, it simply brushes aside the slider, forcing it to the right against its low force reset spring **136**, thus remaining in firm engagement with the ramp portions **112**, **112***a* despite the presence of the slider. When the follower **100** passes on to the dwell portion **112***b* of the cam, it exerts no further force on the slider, and the slider therefore becomes free to return to the left into its position of FIGS. 2 and 4. The surface of dwell portion **112***b* is located slightly below the lowermost surface of slider **130**, and thus the follower **100** is held out of engagement with the slider when on the dwell portion. This allows the slider to reset without any opposition from the follower **100** when the follower is on the dwell portion.

A circuit-breaker opening operation is performed by driving the crosshead **59** to the right from its position of FIG. 2 into its position of FIG. 3. Such motion of the crosshead **59** opens the main contacts **16**, **28** of the circuit breaker and also causes the cam **86** to move to the right from its position of FIG. 2 to that of FIG. 3. Cam **86** must move a predetermined distance to the right before the resistor switch is permitted to open; and, by this time, the main contacts **16**, **28**, have already parted. So long as the cam follower **100** is held in its position of FIG. 2, the resistor-switch opening spring **110** is prevented from driving the cross head **81** of the resistor switch through its opening travel. But when follower **100** is released, opening spring **110**, assisted by springs **82**, **82***a*, rapidly drives cross beam **81** and the connected resistor switch contacts **75**, **75***a* into their open positions. Cam **86** holds follower **100** in its position of FIG. 2 during initial movement of the cam to the right because during this time the follower rides on the dwell portion **112***b* of the cam and then upon the lower surface of slider **130**. But when the cam **86** has been moved sufficiently to the right to carry the lower surface of the slider **130** out of engagement with follower **100**; the follower is, in effect, released. The resistor switch opening spring **110** then becomes effective to pivot the follower crank **102** clockwise about pivot **104** driving the resistor switch cross beam **81** through an opening stroke. The cam **86** is moving at a relatively high speed when the follower is released. The follower, on the other hand, begins moving at a relatively low speed due to inertia, and thus the follower does not engage the ramp **112** during a switch-opening operation.

It will be noted that no significant opening travel of the resistor switch cross beam **81** was permitted until slider **130** passed beyond follower **100**. The lower surface of slider **130**, in effect, formed an extension of the dwell portion **112***b* which delayed initiation of resistor-switch opening motion while the cam **86** was being moved through additional travel.

The presence of slider **130** permits us to introduce the required delay in resistor-switch opening without compromising on the cam contour used for closing. Even though we use the same cam **86** for controlling both closing and opening speeds and use a cam contour which approaches the ideal shape for closing speed control, we are still able to introduce the required delay on opening. Had the cam contour during closing conformed to that present during opening, then an unsatisfactory closing contour would be present. In this respect, the cam contour during opening is the contour defined by ramp **112** and the surface of the fully-extended slider **130**, as viewed in FIG. 4. In effect, the steep slope of the ramp would extend all the way down to the dwell portion at the bottom surface of slider **130**. This cam shape, if used during closing, would cause the closing speed just prior to the end of the closing stroke to be so high that objectionable oscillations would occur at the end of a closing stroke. These oscillations could interfere with opening the resistor switch at the desired instant on those opening operations that immediately follow closing. The closing dashpot **120** helps to damp out these oscillations but not sufficiently to permit use of such a closing cam contour. In the illustrated linkage, the presence of the gradually sloping ramp portion **112***a* assures that the closing speed will be more gradually reduced at the end of the closing stroke. This enables the closing dashpot **120** to act with more effectiveness to damp out any oscillations tending to occur at that point. The buffer rod **125** engages the dashpot piston rod **124** only after the follower **100** has passed on to the gradually sloping ramp surface **112***a*.

In the resistor switch of the aforementioned Barkan and Oppel patent a hold-closed latch is used to hold the resistor switch cross beam **81** in its fully closed position when the circuit breaker is closed. By using the cam-type linkage **85** described hereinabove, we can eliminate this latch. In this respect, the dwell portion **112***b* of cam **86** acts to hold the resistor switch cross beam **81** in its closed position of FIG. 2 by blocking clockwise opening motion of the follower crank **102** when the cam **86** is so positioned. This holding action, combined with that performed by slider **103** during the early stages of an opening operation, obviates the need for a hold-closed latch.

It should be apparent that our resistor switch control linkage **85** is of a simple and compact design. This simplicity and compactness have enabled us to incorporate this linkage in a commercial circuit breaker of the design shown in the aforementioned Barkan and Oppel patent without substantially relocating or redesigning any of its major components. By incorporating this linkage into such a circuit breaker, we make the circuit breaker capable of resistor preinsertion, thus reducing the voltage transients produced by a closing operation. A factor that contributes to the simplicity and compactness of our linkage **85** is that the same cam **86** is used for both opening and closing control of the resistor switch, and this cam is of a simple reciprocating type.

While we have shown and described a particular embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects; and we, therefore, intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In an electric circuit breaker of the type comprising separable main contacts, a resistor shunting said main contacts, separable resistor switch contacts connected in series with said resistor and in shunt with said main contacts, and means for producing resistor preinsertion during circuit breaker closing comprising a linkage connected between a movable one of said main contacts and a movable one of said resistor switch contacts, said linkage comprising:

(a) a cam coupled to said movable main contact, said cam being movable between first and second positions in response to movement of said main contact through a closing stroke and returnable in a reverse direction to said first position in response to movement of said main contact through an opening stroke,

(b) means comprising a follower coupled to said movable resistor switch contact and actuated by said cam for imparting closing motion to said movable resistor switch contact in response to movement of said cam between said first and second positions, the speed of said closing motion being determined by the effective contour of said cam during said closing stroke,

(c) said cam having a motion-producing portion and a dwell portion sequentially engaged by said follower during a circuit breaker-closing operation,

(d) said follower engaging said motion-producing portion until said movable resistor switch contact substantially reaches the end of its closing travel and thereafter engaging said dwell portion, said dwell portion thereafter acting to hold said movable resistor switch contact closed while said circuit breaker is closed,

(e) spring means for biasing said movable resistor switch contact toward open position and operable in response to return movement of said cam from said second to said first position to impart opening movement to said resistor switch contact at a starting point determined by the effective contour of said cam during said opening stroke,

(f) and means for modifying the effective contour of said cam during said opening stroke as compared to its effective contour during said closing stroke comprising means for extending said dwell portion during a circuit breaker-opening operation across a part of said motion-producing portion, thereby delaying initiation of resistor switch-opening during circuit breaker-opening.

2. The circuit breaker of claim **1** in which:

(a) said dwell portion of said cam comprises a main dwell surface that is engaged by said follower during circuit breaker-closing,

(b) said means for extending said dwell portion comprises a contour-modifying member mounted on said cam for movement relative to said cam and having an auxiliary dwell surface which is substantially a continuation of said main dwell surface during circuit breaker-opening,

(c) means is provided for causing said follower to engage said auxiliary dwell surface after leaving said main dwell surface and before returning toward said switch-open position during a circuit breaker-opening operation, and

(d) means is provided for rendering said contour-modifying member ineffective to control movement of said follower during movement of said cam from said first to said second position incident to circuit breaker closing.

3. The circuit breaker of claim **2** in which:

(a) spring means is provided for biasing said contour-modifying member toward an effective position where its auxiliary dwell surface is substantially a continuation of said main dwell surface,

(b) said spring means is operable during switch-opening to hold said contour-modifying member in said effective position,

(c) said contour-modifying member is so mounted that during switch-closing said follower brushes aside said contour-modifying member against said spring means

and is thus essentially unaffected in its closing motion by said contour-modifying member.

4. The circuit breaker of claim 3 in which said cam is mounted for motion in a linear path between said first and second positions, said motion-producing surface is a ramp surface extending transversely of said linear path, and said main dwell surface extends substantially parallel to said linear path.

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