

Filed Nov. 7, 1966

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2 Sheets-Sheet 1

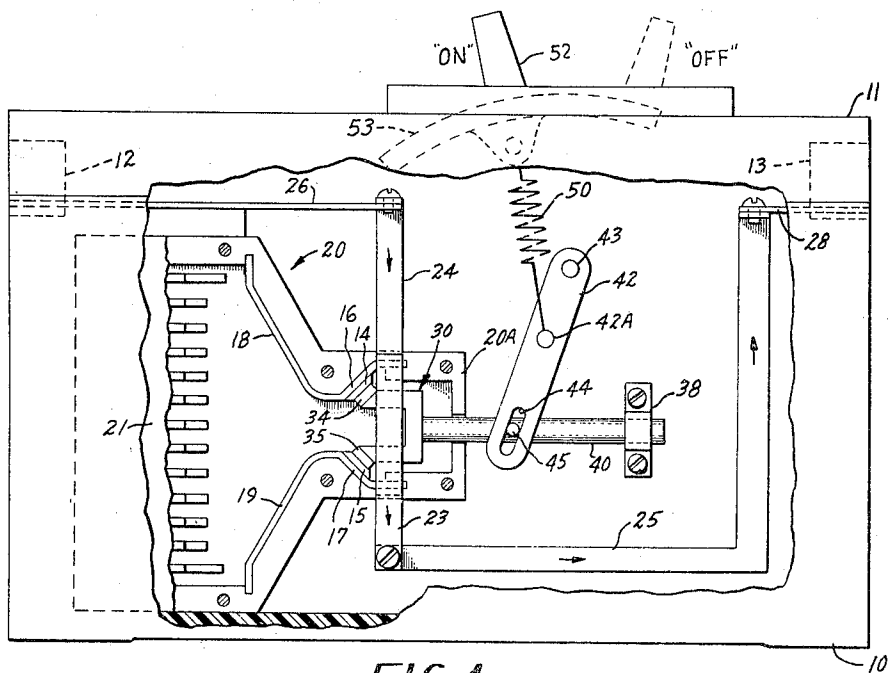


FIG. 1

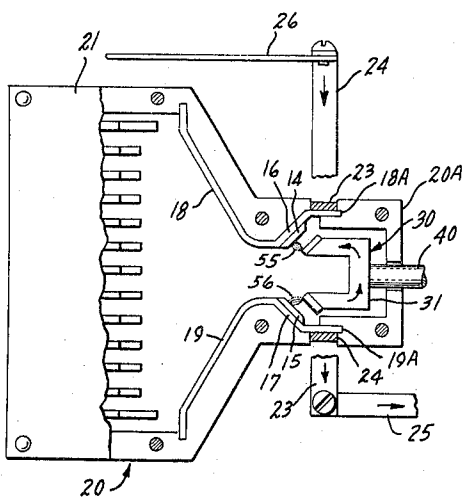


FIG. 2

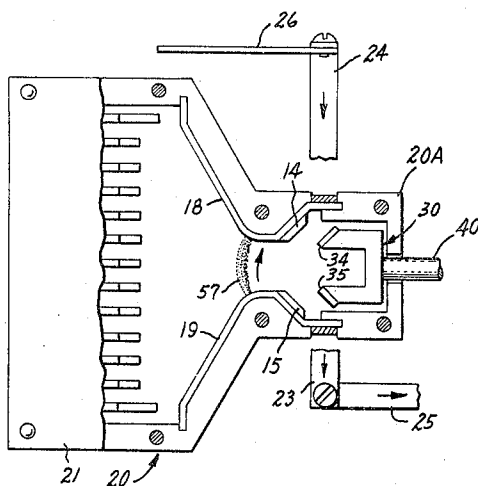


FIG.3

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ELECTRIC CIRCUIT BREAKER WITH SPECIAL
ARC EXTINGUISHING STRUCTURE

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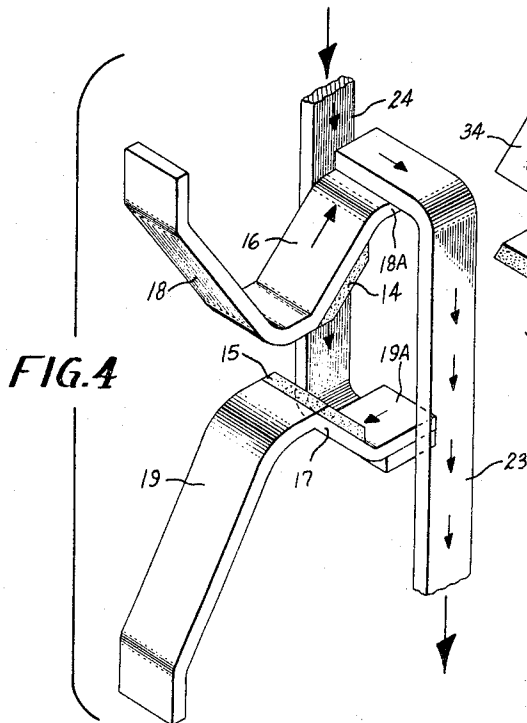


FIG. 4

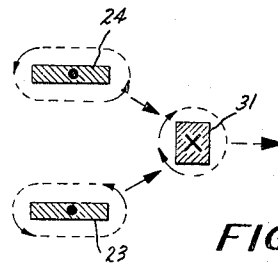
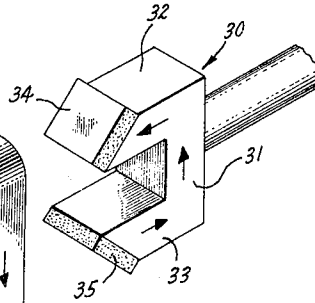


FIG. 5

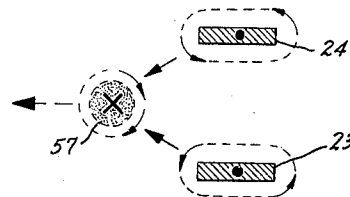


FIG. 6

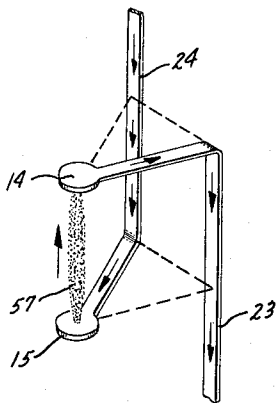


FIG. 8

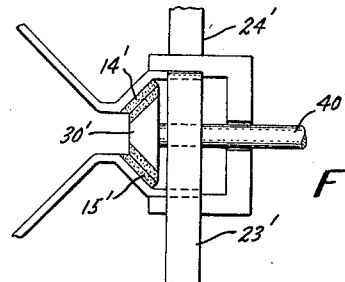


FIG. 7

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ELECTRIC CIRCUIT BREAKER WITH SPECIAL ARC EXTINGUISHING STRUCTURE

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Filed Nov. 7, 1966, Ser. No. 592,442

Int. Cl. H01h 33/18

U.S. Cl. 200—147

11 Claims

ABSTRACT OF THE DISCLOSURE

An electric circuit breaker having a pair of contacts between which an arc may be drawn along a predetermined path and a pair of elongated conductors each connected to one of the contacts, the conductors being positioned with respect to the contacts and the arc path so that the magnetic fields associated with current flowing in the conductors act on the arc to move it out along a pair of diverging arc runners away from the aforesaid electrical conductors.

In a special form, the arc is drawn by movement of a bridging contact member which is U-shaped, and the magnetic fields associated with the current in the aforesaid conductors also act on the bridging contact member to move it to open circuit position automatically.

My invention relates to electric circuit breakers, and more particularly to electric circuit breakers of the type including means for quickly creating an arc and elongating such arc at such high speed as to produce a "current-limiting" action.

The term "current-limiting circuit breaker" is used to refer to an electric circuit breaker having the ability to interrupt an electric current while the current is in a rising condition, and to do so in such a manner that the current is prevented from reaching a value equal of the value that it would have attained if the circuit breaker had remained in the circuit but had remained in closed condition, such current value being known as the "prospective" current value. In other words, during a current-limiting circuit breaker interruption, the maximum actual or "peak let-through" current value is less than the maximum "prospective" current value. In addition, in a current-limiting circuit breaker, an arc voltage is produced which is substantially greater than the voltage of the system, thereby "over-riding" the voltage tending to maintain the arc and quickly driving the current to zero.

An important requirement of a current-limiting circuit breaker is that the arc be created a very short time after the occurrence of the short-circuit condition. This requires that the movable contact commence movement in a very short time, and that it be accelerated at a very high rate. Not only must the arc be created in an exceedingly short time after the interrupting signal is received, but in addition this arc *creation* must immediately be followed by substantial arc *elongation* to produce substantial arc voltage to over-ride the driving voltage of the circuit. This means that the movable contact must not only commence its movement in extremely short time after the short-circuit condition occurs, but in addition it must be accelerated at an extremely high rate away from its normally closed position to elongate the initially developed arc.

In prior art circuit breakers, operating means such as magnetic solenoids have been used to provide opening movement of movable contacts, and magnetic means have also been provided in the form of blow-out coils to "motor" arcs and to elongate them after their initial creation.

The necessity for such blow-out coils and their iron

core field pieces, and for such solenoids, add substantially to the size and cost of circuit breakers.

It is an object of the present invention to provide a current-limiting circuit breaker having means for creating an arc an exceedingly short time after occurrence of a short-circuit condition, and including a means for assisting elongation of the arc and for acting on the arc to move it along a pair of diverging arc runners.

It is another object of the invention to provide an electric circuit breaker of the current-limiting type including means acting directly on the movable contact for causing movement of the movable contact in opening direction upon the occurrence of predetermined current conditions.

It is a still further object of the invention to provide a *single* means for performing both of the aforementioned functions, that is, acting on the arc to produce rapid elongation while in a still relatively short initial condition, and for acting directly on the movable contact to move it in opening direction.

In accordance with the invention, an electric circuit breaker is provided of the type including a pair of spaced stationary contacts which are interconnected and bridged by a relatively movable contact. The relatively movable contact member comprises a generally U-shaped rigid member having contact surfaces at the end portions of the legs of the U. In addition, incoming and outgoing leads are brought to the spaced stationary contacts along paths which extend substantially parallel to the bight portion of the U of the movable contact member, and which are positioned substantially within the space between the aforesaid bight portion of the movable contact member and a line drawn between the aforesaid spaced stationary contacts. In accordance with the configuration thus provided by the invention, the current paths through the aforesaid lead-in conductors extend substantially parallel to each other and in the same direction. The current flowing between the stationary contacts via the bight portion of the U-shaped contact member flows in a direction opposite to the said direction. As a result of this configuration, the interaction of the magnetic fields between the lead-in conductors and the current in the bridging contact is such as to tend to force the movable bridging contact in the opening direction.

In addition, subsequently, when the two short arcs extending between the stationary contacts and the corresponding relatively movable contacts join together to form a single arc extending directly between the spaced stationary contacts, the magnetic field associated with each of the aforesaid lead-in conductors acts with respect to the magnetic field associated with the arc current in such a way as to move the arc in the desired direction away from its initial path and to rapidly elongate the arc so as to increase the arc voltage.

The invention will be more fully understood from the following detailed description, and its scope will be pointed out in the appended claims.

In the drawings:

FIGURE 1 is a side elevation view of an electric circuit breaker, shown partly in semi-schematic form, embodying the invention;

FIGURE 2 is a side elevation view of a portion of the circuit breaker of FIGURE 1, portions of the lead-in conductors being broken away to better show the interior of the arc chamber, the movable contact being shown in a partly-open position;

FIGURE 3 is a view similar to FIGURE 2, showing the movable contact member in fully open position;

FIGURE 4 is a perspective view of the stationary contacts with their associated arc runner portions, and the lead-in conductors and movable contact member, showing their configuration and general arrangement in accordance with the invention;

FIGURE 5 is a schematic view showing the interrelation of the currents in the lead conductors and the movable contact member and their associated magnetic fields as they exist when the parts are in the position shown in FIGURES 1 and 2;

FIGURE 6 is a schematic view showing the interrelation of the currents in the lead conductors and in the arc, and their associated magnetic fields as they exist when the parts are in the position shown in FIGURE 3;

FIGURE 7 is a fragmentary side elevation view of another embodiment of the invention, and

FIGURE 8 is a diagrammatic illustration showing portions of the current path through the circuit breaker of the invention during the interruption process.

In FIGURE 1, the invention is shown as incorporated in an electric circuit breaker including a generally box-like insulating casing comprising a base portion 10 and a cover portion 11. A line terminal 12 is supported on the insulating base at one end thereof, and a load terminal 13 is supported on the insulating base at the opposite end thereof. A pair of spaced generally planar stationary contacts 14 and 15 are supported within the base 10 on angular portions 16, 17 respectively of elongated arc runner members 18 and 19 respectively. The arc runner members 18 and 19, in turn, are supported in an arc extinguishing chamber enclosure 20 having a cover 21. The inner side walls of the enclosure 20, particularly in the area of the stationary contacts 14 and 15, are preferably composed of an acetal resin material, such, for example as polyoxymethylene. A material of the type described, for example, is that sold under the trade name of "Celcon" by the Celanese Plastic Company, Newark, N.J. The enclosure 20 has a generally cup-shaped portion 20A at the side thereof opposite the arc runners 18 and 19. The stationary contacts 14 and 15 are connected to the load and line terminals 13, 12 respectively by means including elongated lead conductors 23, 24. The lead conductors, in turn are connected to terminal conductor straps 25-26 respectively. The conductor 26 connects the lead conductor 24 to the line terminal 12, while the conductors 25 and 28 connects the lead conductor 23 to the terminal 13.

The stationary contacts 14 and 15 are interconnected, when the circuit breaker is in the closed condition by a generally U-shaped movable contact member 30 comprising a generally U-shaped body portion including a bight portion 31 and parallel leg portions 32, 33, each of the leg portions 32, 33 carrying a movable contact 34, 35 at the end thereof, set at an angle thereto. The movable contact member 30 moves between open and closed circuit positions within the cup-shaped portion 20A of the enclosure 20.

The current path through the circuit breaker in the closed condition as shown in FIGURE 1 is therefore as follows: from the line terminal 12 through the conductor 26 to the lead conductor 24, to the arm runner extension 19A to the stationary contact 15, to the movable contact 35, to the U-shaped movable contact member 30, to the movable contact 35, to the U-shaped movable contact member 30, to the movable contact 34, to the stationary contact 14, to the arc runner extension 18A, to the lead conductor 23, to the conductor 25, and thence through the conductor 28 to the load terminal 13.

In accordance with the form of the invention illustrated in FIGURE 1, the movable contact member 30 is also made manually movable. For this purpose, a simplified operating mechanism has been illustrated comprising an operating link 42 pivotally supported on the pivot pin 43 in the insulating base 10. The operating link 42 has an elongated slot 44 therein which serves to transmit motion to the operating rod 40 by means of the pin 45 which extends into the slot 44. The rod 40 is guided for straight-line movement by the opening in the housing 20A and by a bearing member 38.

The operating link 42 is adapted to be operated between positions corresponding to open and closed conditions of the movable contact by means of an over-center tension type spring 50 having one end thereof connected to the pin 45 and the other end thereof connected to a manually operable handle member 52 which is supported for arcuate movement in track 53 in the casing, or by other suitable means.

It will be observed that when the manually operable handle member 52 is in the "on" position as shown in solid lines in FIGURE 1, the tension spring 50 biases the operating link 42 clockwise about its pivot 43, acting on the pin 42A carried by the link 42 to urge the movable contact member 30 carried by the rod 40 to the left and toward its closed position. When the manually operable member 52 is moved to the "off" position as shown in dotted lines in FIGURE 1, the line of action of the tension spring 50 passes across the pivot pin 43 of the link 42, and then biases the link 42 in counterclockwise direction, moving the rod 40 and the movable contact member to the right as viewed. This movement is guided by the sliding of the rod 40 in the bearing 38, as well as by the sliding of the rod 40 through the restricted opening 20A in a portion of the enclosure 20 of the arc extinguishing housing.

Referring to FIGURE 2, it will be observed that when the movable contact member 30 is in the closed circuit condition and conducting current, the direction of current flow in the bight portion 31 of the movable contact member 30 is in the opposite direction from the direction of current flow in each of the lead conductors 23 and 24. The relation of the currents in these conductors is therefore as illustrated diagrammatically in FIGURE 5. As shown here, the effect of magnetic fields associated with the current in each of the branches 23 and 24 is such as to repel the bight portion 31 of the movable contact 30. On the occurrence of a short-circuit condition, this force becomes great enough to overcome the bias of the spring 50 holding the contacts in closed condition. Thereupon, the movable contact member is thrown in the opening direction at extremely high speed, giving a current-limiting action. It will be observed that this contact-opening action will take place even though the operating handle is in the "no" position. Thus the lower end of the spring 50 will be moved to the right as viewed, causing clockwise movement of the handle.

A second important function of the conductors 23 and 24 has is that they assist the change, illustrated in FIGURES 2 and 3, from two short arcs 55, 56 to a single long arc 57. This is accomplished by the repelling action between the magnetic fields associated with the current in the conductors 23, 24, which at any given time is in a first direction, against the magnetic fields associated with the arcs 55, 56, which current is flowing in a generally opposite direction. Thus the arcs 55, 56 are urged to the left as viewed, by the magnetic field action. This, together with the action of the gases generated in the closed chamber in which the movable contacts are located, and the ion-ejecting action of each arc, causes the two short arcs to be transformed into a single longer arc in a very short time. Analysis of oscillograms of actual interruptions indicates that the time between the creation of the two short arcs and their transformation to a single longer arc is only about .000350 second in interrupting short-circuit current in a circuit having 100,000 amperes short-circuit current available.

Referring to FIGURE 3, the parts are shown in the position they occupy when the movable contact has moved to the full open position. At this time the two initially created arcs 55 and 56 have joined together to form a single arc 57 extending directly between the arc runners 18 and 19. At this time it will be observed that the direction of current flow in the lead conductors 23 and 24 is opposite in sense to the direction of current flow through the arc 57. This condition is illustrated diagrammatically

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in FIGURE 6. The action of the magnetic fields associated with the currents in the conductors 23 and 24 at this time is then such as to repel the arc 57, which it does, moving the arc 57 out along the arc runners 18 and 19 and causing a very rapid current-limiting interruption.

Accordingly, because of the configuration provided for the lead conductors 23 and 24, the magnetic fields associated with the current in these conductors perform the following functions: (1) act to cause mechanical opening of the contacts at high speed and movement of the movable contact in opening direction, (2) act in a manner to elongate the initial two short arcs in a direction to cause them to impinge upon each other and form a single elongated arc and (3) act to move the single elongated arc out along the arc runners in a direction opposite the contact-opening direction.

In the form of the invention shown in FIGURE 7, the movable contact member 30' substantially directly interconnects the stationary contacts 14' and 15'. The action of the current in the conductors 23', 24' on the movable contact, therefore, while the movable contact is in closed position, is such as to urge the movable contact in "closing" direction. In this form, it is contemplated that a separate device, such as a separate solenoid, will be used to cause opening of the contacts upon the occurrence of short-circuit conditions. A construction of the type referred to is shown, for example, in application Ser. No. 768,963 filed Oct. 10, 1968 by R. L. Hurtle and H. G. Willard and assigned to the same assignee as the present invention, said application being a continuation of application Ser. No. 457,557 filed May 21, 1965 by the same inventors Hurtle-Willard application. The action of the magnetic fields associated with the conductors 23, 24 is desirable here, however, since they help to assure that good contact pressure will be maintained until actual opening takes place. That is, they give a desirable "snap opening" action.

The general relationship of the conductors 23 and 24 and the contacts 14 and 15 will be better understood by reference to FIGURE 8. As shown here, the conductors 23 and 24 are arranged so that they extend parallel to each other and in such a way with relation to the contacts 14 and 15 form a triangular configuration in space. Moreover, one end of each of the conductors 23, 24 is adjacent and connected to one of the contacts 14, 15, and the conductor extends away from that contact toward the other contact.

While I have illustrated only a simplified operating mechanism and single-pole form, it will be readily understood that more sophisticated, higher contact pressure generating operating mechanisms may be used to move the movable contact member between open and closed circuit positions, and the use of such mechanisms and of multi-pole forms is within the contemplation of the present invention. It is also contemplated by the present invention that the U-shaped form of the movable contact member 30 may, if desired, be utilized together with and supplementing the action of a separate solenoid acting on the contact rod 40.

While the invention has been described in connection with only two specific embodiments, it will be readily apparent that numerous modifications thereof may readily be made. It is therefore intended by the appended claims to cover all such modifications and variations as come within the true spirit and scope of the invention.

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

1. An electric circuit breaker comprising:

- (a) a support;
- (b) a first stationary contact supported on said support;
- (c) a second stationary contact supported on said support in spaced relation to said first stationary contact;

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(d) movable contact bridging means supported on said support and movable between open and closed circuit positions, said movable contact means when in said closed circuit position electrically interconnecting said first and second stationary contacts and when in said second position being disconnected from said first and second stationary contacts;

(e) a pair of elongated rectilinear electrical conductors supported on said support in spaced relation parallel to each other and parallel to and closely spaced from a line representing the shortest distance between said spaced stationary contacts, said pair of conductors lying in a plane extending parallel to and spaced from said line between said contacts whereby said conductors and said line between said contacts form a triangular configuration in space;

(f) each of said conductors having one end thereof terminating adjacent and connected to a different one of said stationary contacts respectively and each of said conductors extending from said one stationary contact in the general direction of the other of said stationary contacts, whereby current passing through each of said conductors flows in the same general direction, and the current passing directly between said stationary contacts flows in the opposite direction whereby an arc extending directly between said stationary contacts is repelled by action of the magnetic fields associated with said conductors in a direction away from both of said electrical conductors.

2. An electric circuit breaker as set forth in claim 1 wherein said circuit breaker also comprises a pair of diverging arc runners each electrically connected to one of said stationary contacts, said arc runners extending in the direction in which said arc is urged by said magnetic fields of said elongated conductors.

3. An electric circuit breaker as set forth in claim 2, wherein said spaced stationary contacts are enclosed within an enclosure having a generally cup-shaped portion at the side thereof opposite said diverging arc runners.

4. An electric circuit breaker as set forth in claim 2, wherein said movable contact bridging means comprises a pair of movable contacts and rigid supporting means supporting said movable contacts in fixed relation with respect to each other, said supporting portion including a straight-line portion extending substantially parallel to said line connecting said spaced stationary contacts and parallel to said elongated conductors.

5. An electric circuit breaker as set forth in claim 1, wherein said movable contact bridging means comprises a rigid generally U-shaped conductive member having a pair of contact members supported at the outer ends of said U, the bight portion of said U extending parallel to said elongated conductors when said movable contact bridging means is in said closed circuit position.

6. An electric circuit breaker as set forth in claim 5, wherein said bight portion of said U-shaped contact member extends at the opposite side of said elongated electrical conductors from said line interconnecting said pair of spaced stationary contacts, whereby said bight portion of said movable contact means is initially repelled in contact opening direction by the action of the magnetic fields associated with said conductors and whereby said single elongated arc is acted on by the action of the magnetic field associated with the current in each of the elongated conductors following the time when the current takes a path directly between said spaced stationary contacts.

7. An electric circuit breaker comprising:

- (a) a support;
- (b) a first generally planar stationary contact supported on said support;
- (c) a second generally planar stationary contact supported on said support in spaced relation to and at an oblique angle to said first stationary contact

whereby said first and second stationary contacts converge toward each other in a first direction;

(d) a pair of conductive arc runners, each connected to one of said stationary contacts, said arc runners diverging in said direction away from said spaced stationary contacts;

(e) movable contact bridging means supported on said support and movable between open and closed circuit positions, said movable contact means when in said closed circuit position electrically interconnecting said first and second stationary contacts and when in said second position being disconnected from said first and second stationary contacts;

(f) a pair of elongated rectilinear electrical conductors supported on said support in spaced relation parallel to each other and parallel to and closely spaced from a line representing the shortest distance between said spaced stationary contacts, said pair of conductors lying in a plane extending parallel to and spaced from said line between said contacts whereby said conductors and said line between said contacts form a triangular configuration in space;

(g) each of said conductors having one end thereof terminating adjacent and connected to a different one of said stationary contacts respectively, and each of said conductors extending from said one stationary contact in the general direction of the other of said stationary contacts whereby current passing through each of said conductors flows in the same general direction and the current passing between said stationary contacts directly flows in the opposite direction, whereby an arc extending directly between said stationary contacts is repelled by action of the magnetic fields associated with said conductors in a direction away from both of said electrical conductors.

8. An electric circuit breaker as set forth in claim 7, wherein said movable contact means comprises a rigid generally U-shaped movable contact support member of conductive material having a pair of contact members supported on the end portions of said U respectively, said U-shaped member having its bight portion extending parallel to said elongated electrical conductors and at the opposite side of said conductors from said line directly interconnecting said spaced stationary contacts.

9. An electric circuit breaker as set forth in claim 7, wherein said spaced stationary contacts are contained in an enclosure having a generally cup-shaped portion at the

side of said stationary contacts opposite said arc runners, said movable contact bridging means moving between said open and closed circuit positions within said cup-shaped portion of said enclosure.

10. An electric circuit breaker as set forth in claim 1 wherein said movable contact bridging means includes a pair of movable contacts and rigid conductive supporting means supporting said contacts, said contact bridging means when in said closed circuit position providing a current path between said stationary contacts which is at the same side of said electrical conductors as said line between said stationary contacts.

11. An electric circuit breaker comprising:

- (a) a support;
- (b) a pair of contacts supported on said support;
- (c) means for drawing an arc between said contacts along a predetermined path;
- (d) a pair of elongated rectilinear electrical conductors supported on said support in spaced relation to each other and parallel to and closely spaced from said predetermined path, said pair of conductors lying in a plane extending parallel to and spaced from said path whereby said conductors and said path form a triangular configuration in space;
- (e) each of said conductors having one end thereof terminating adjacent and connected to a different one of said contacts respectively and each of said conductors extending from said one contact in the general direction of the other of said contacts, whereby current passing through each of said conductors flows in the same general direction, and the current passing between said contacts along said arc path flows in the opposite direction whereby said arc is repelled by action of the magnetic fields associated with said conductors in a direction away from both of said electrical conductors.

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ROBERT S. MACON, Primary Examiner

U.S. Cl. X.R.

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