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Wilson

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[54] MAGNETIC CIRCUIT BREAKER

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[52] **U.S. Cl.** .....**200/147 R,** 200/144

[51] **Int. Cl.** **H01h 33/18**

[58] **Field of Search** .....200/144 B, 144 C, 147

[56] **References Cited**

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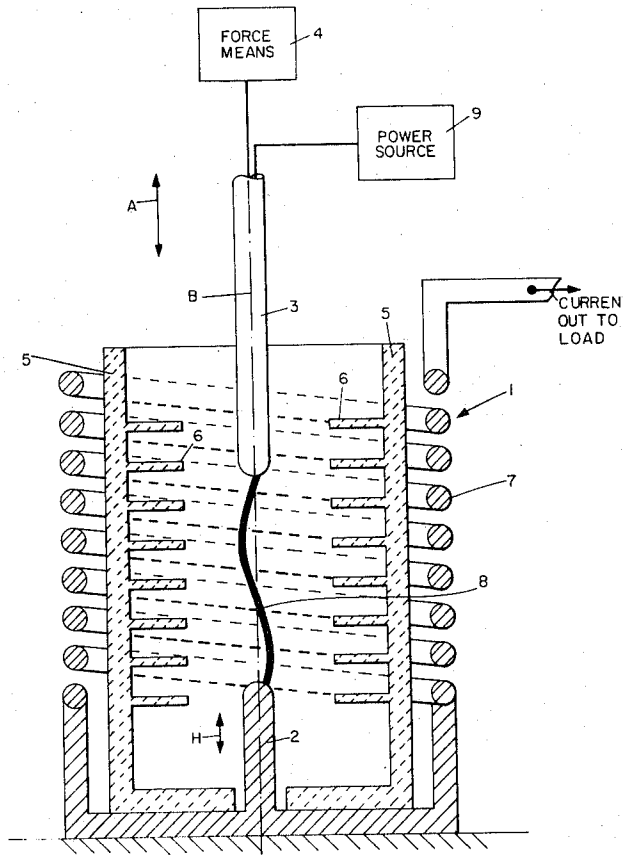
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[57] **ABSTRACT**

A circuit breaker adapted to interrupt substantial values of electric current. The breaker disclosed features a magnetic field in the region in which the break in current occurs and oriented in a direction both parallel to and radially perpendicular to the general direction of current flow at the instant the circuit is interrupted to create a kink instability in the arc thereby formed and to cause the arc to move into contact with surrounding baffles.

9 Claims, 3 Drawing Figures



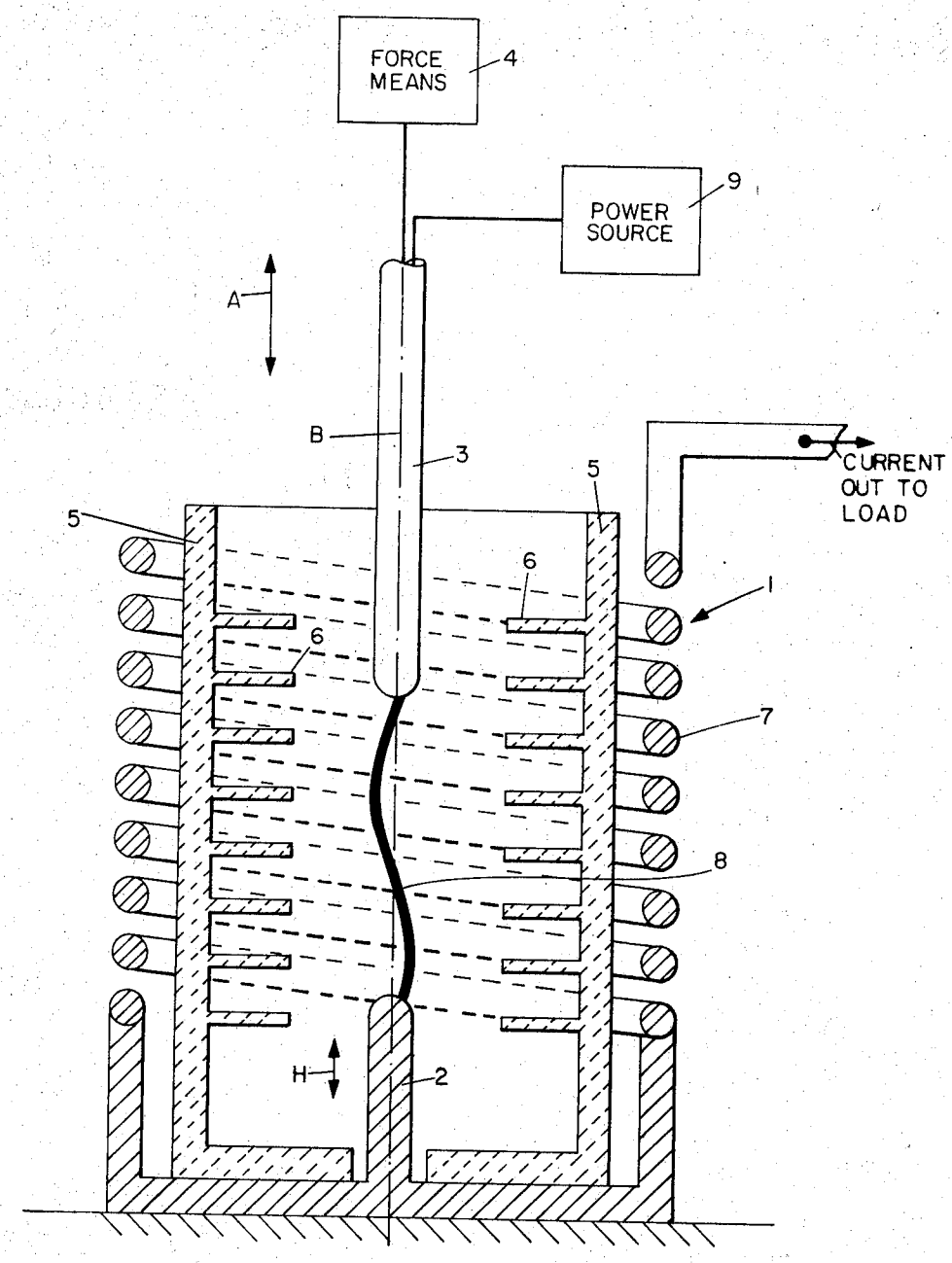


FIG. 1

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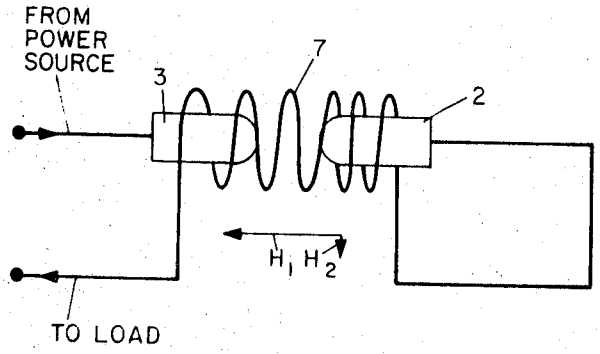


FIG. 2

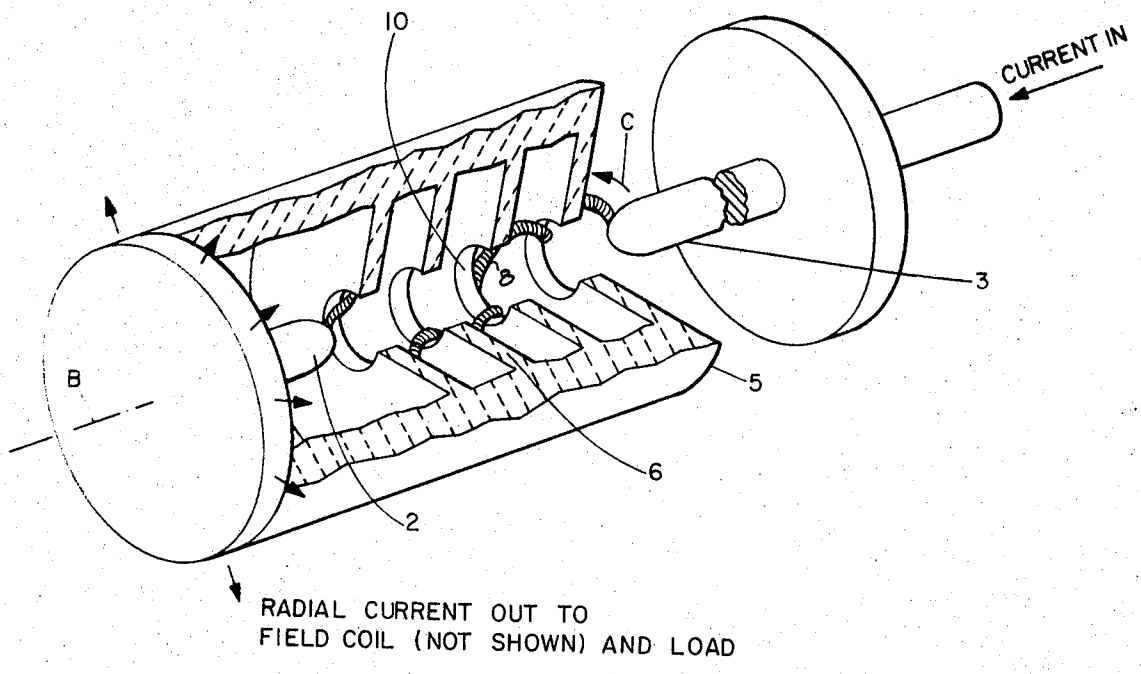


FIG. 3

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MAGNETIC CIRCUIT BREAKER

The present invention relates to circuit breakers and, in particular, to circuit breakers wherein a magnetic background field in the region occupied by the arc formed in the course of the current interruption aids in the extinguishment of said arc.

The general purpose of devices of the general type described herein is to interrupt currents in power circuits prior to or after a fault occurs on the power network. At present this is done in several ways, e.g., (a) air flowing by the arc formed between the open contacts, (b) contacts are opened under oil, (c) contacts are opened in a vacuum, and (d) contacts are opened and the magnetic field formed by passing the arc current through series coils, is utilized to blow it along a plane into electrically insulating baffle plates where it is cooled by thermal conduction. The particular type device used depends upon the voltage level of the circuit and the fault current of the system to be interrupted. The magnetic circuit breaker described under (d) above generally is used in the 4 kv, 20 mva range. This breaker is generally found in industrial plants using large motors above the 250 horsepower level. An object of the present invention is to provide a circuit breaker which also employs a background magnetic field to dissipate arc energy but which does so in a manner that is more efficient than has heretofore been possible in such apparatus.

Another object is to provide a circuit breaker particularly useful in electric circuits in which it is contemplated that high load and fault currents will be encountered, one which, because of its high energy dissipation efficiency allows, in a given circuit, smaller breaker elements while nevertheless affording greater arc cooling capability than has been heretofore possible.

Still another object is to provide a circuit breaker in which the arc dynamics are caused by a magnetic field consisting of a major component oriented parallel to the arc direction and, a minor component oriented transverse to the arc direction.

These and other objects are discussed in the following description and are particularly pointed out in the appended claims.

By the way of summary, the objects of the invention are achieved in a circuit breaker for use in an electrical circuit and adapted to interrupt substantial magnitudes of electric current in the circuit, which includes, a pair of contact members suitably positioned and actuated to move along an axis toward and away from one another, respectively to make and break electrical contact, and thereby respectively to allow current to flow in the circuit and to interrupt the flow. A non-magnetic baffle is disposed about the members and coaxial therewith and has a plurality of axially-spaced fins which extend radially inward toward the axis. Means is provided to furnish a high-intensity background magnetic field in the region of the contact members having a component in the axial direction and parallel to the flow of electric current in said members at the point of contact of said members and in the region therebetween at the instant the circuit is interrupted to twist the arc into a helix and to create a kink instability in the arc created upon interruption and having a radial component, the axial and radial components of field interacting with the arc current to cause the helical arc to move in a revolving path between the contacts as the distance therebetween widens, and to move radially outward to contact the fins and transfer arc energy thereto.

The invention will now be discussed with references to the accompanying drawing, in which:

FIG. 1 is a side section view, in diagrammatic form, of a switch embodying the present invention;

FIG. 2 is a schematic representation showing a number of the elements of FIG. 1; and

FIG. 3 is an isometric view, partially cutaway, of some of the elements shown in FIG. 1.

Before going into details of the invention, a short discussion of the invention, generally, follows. The invention described herein utilizes a different geometry than that used in the prior art magnetic circuit breakers mentioned above. In such prior art magnetic circuit breakers, the magnetic field is formed perpendicular to the general direction of the current flow in the arc formed when the circuit is interrupted; the separate field is created by passing arc current through a series coil oriented to create the generally transverse field.

Interaction of this self-magnetic field and the current flowing in the arc forces the arc to move along a planar direction into baffle plates or fins. The arc then rests approximately statically in contact with the plates, until the heat is conducted away by thermal conduction and evaporation, thereby cooling and, finally, extinguishing the arc.

In the breaker of the present invention a magnetic background field is produced and is oriented parallel to the general direction of current flow in the arc. This is a basically unstable configuration and leads to a kink instability. If the arc moves in any direction away from the axis of symmetry of the device, the magnetic forces are such as to twist the arc in the azimuthal direction and simultaneously force it out in the radial direction. Thus, the arc is driven out radially to contact heat-sink type fins and is caused to twist at some angular velocity relative to the fins until the resultant arc is helical and following a serpentine position-varying path in contact with the fins. The fins are similar to those in the existing magnetic circuit breaker; however, these fins are located all around the periphery of the arc and the arc is forced to move across them at a high velocity. This has a definite advantage over the prior apparatus in that the heat transfer coefficient from the arc to the baffle plates is greatly enhanced by the forced convection of the arc. These are several advantages of this technique over the present magnetic circuit breaker: the increased heat transfer coefficient can result in a proportional reduction in the physical size of the breaker, the arc is not found to rest in the same position on the baffles and therefore is less likely to destroy the baffle material, and the increased heat transfer rate can result in a higher current interrupting capability for the circuit breaker at the same voltage level. Asymmetry in the magnetic field can be used to increase the unstable nature of the arc.

In the foregoing explanation the background magnetic field is one which is oriented axially, i.e., parallel to the direction of flow of the current in the arc at the moment of interruption.

It is possible, however, as hereinafter discussed, to use a magnetic field with a component in the radial or transverse direction to cause the arc to move at high

azimuthal velocities (i.e., to rotate) over the plates and therefore enhance heat transfer and arc extinction. Breakers developed to date have been for a-c type circuits, but the techniques discussed herein are useful in d-c circuit interruption as well, due to the inherent instability of the d-c arc in the axial magnetic field.

Turning now to FIG. 1, a circuit breaker is shown in diagrammatic form at 1 comprising a pair of contact members 2 and 3, the former of which is stationary in the illustrative example and the latter of which is movable along the axis designated B toward and away from the contact member 2 respectively to make and break electrical contact. A force means 4, which may be solenoid, spring, high pressure air unit, or the like, or a combination thereof, furnishes the force necessary to make and break electrical contact between the contacts and thereby respectively to allow current to flow in the circuit and then interrupt the flow. A cylindrical non-magnetic baffle or heat-sink, 5, disposed about the contact members 2 and 3 and coaxial therewith, has a plurality of axially spaced radial fins 6 which extend inward toward the cylinder axis B. A coil 7, wound about the cylinder 5, is adapted to provide a magnetic background field H, in the region of the contact members, oriented in the axial direction, and parallel to the flow of electric current in said contact members and in the region therebetween (i.e., the field H in FIG. 1 is oriented vertically and, therefore, generally parallel to the arc, labeled 8, which is created upon circuit interruption at the instant the circuit is interrupted) to create a kink instability in the arc 8 and to cause the arc 8 to twist into a helical shape, as shown in FIG. 1, a helix which twists or has an azimuthal component, as represented by the arrow shown at C in FIG. 3, and a path that moves radially outward to contact the fins and transfer energy thereto. The path of the arc is helical in the absence of fins and twists, as mentioned, but, as shown in FIG. 3, the fins deform the helical form of the arc to result in the serpentine track of the arc (or the ionized region represented by the arc between the contacts 2 and 3). Furthermore, the arc 8 has some angular or rotational movement, in an a-c system, as represented by the arrow C, so that the portion of the fins contacted continually changes, but in a d-c system the helix, once formed, does not rotate when just the axial component is present. The baffle 5 and fins 6 are made of heat dissipative material; in apparatus of this type such baffles are usually made of a non-conductive refractory material (e.g., zirconium oxide) which evaporates at its surface upon application of heat and thereby withdraws energy from the arc. By sweeping the arc along the fins in the manner described hereinafter in connection with FIG. 2, a new surface is continually presented to the arc which increases the life of the baffle used. The fins, however, can be conductive; in which case insulating spacers are provided. Also, as best shown in FIG. 3, the fins have aligned openings 10 along the B axis to receive the rod-shaped members 2 and 3, and the openings 10 are only slightly larger in cross dimensions than the cross dimensions of said members to enhance contact between the fins and the arc.

In FIG. 1 the H field is shown axially oriented. In FIG. 2 the background magnetic field is shown having a major component H_1 oriented in the axial direction and a minor component H_2 (H_1 and H_2 represent relative vector magnitudes as well as direction) oriented in the transverse or radial direction. The component H_2 can be created by having non-uniform distribution of the coil 7 along the axial direction, as shown. The resultant asymmetry in the field of FIG. 2 has the effect of increasing the unstable nature of the arc 8, by giving it a high rotational velocity as before mentioned, and, therefore, hastens extinguishing thereof. Breakers of the type herein discussed can be expected to interrupt currents typically as high as the order of 5,000 amperes with recovery voltages up to 16,000 volts, the current being furnished by a power source 9. The coil 7, as best shown in the schematic of FIG. 2, is connected in series with the load so that current passes through the contact members (and the arc upon interruption) to the coil 7. Thus, the background field ceases when the arc is extinguished but exists at all other times; and there is a background magnetic field at all times in which there is electric current flow in the circuit and in proportion to the magnitude of such current flow. In addition, placing the non-magnetic contacts 2 and 3 within the central opening of a solenoidal coil 7, rather than in the fringe fields of electromagnets, as has heretofore been done, makes possible the creation of very high-intensity magnetic fields throughout the region occupied by the contact members and the arc 8. Typical rated voltages for breakers of the type herein discussed range from 4 –13.8 kv; load currents interrupted range up to 300 amperes and fault currents up to 5,000 amperes in 25–75 mva ratings. Magnetic background fields up to the order of 6,000 gauss are used and such fields occupy the whole of the region traversed by the arc.

The foregoing discussion has been made with reference to a single-phase, single-pole type breaker, but, of course, polyphase operation is almost always used for power loads of the type here contemplated. Polyphase breakers would merely be more of the type breaker discussed, mechanically, interconnected in a manner known to workers in this art. These and other modifications (e.g., relative location of the coil 7 and baffle 5) will occur to persons skilled in the art.

What is claimed is:

1. A circuit breaker for use in an electrical circuit to interrupt substantial magnitudes of electric current in the circuit, that comprises, a pair of contact members disposed to move along an axis toward and away from one another, respectively to make and break electrical contact, means for moving the members along the axis to make and break electrical contact therebetween and thereby respectively to allow current to flow in the circuit and to interrupt the flow, a non-magnetic cylindrical baffle disposed about the members and coaxial therewith and having a plurality of axially-spaced radial fins which extend inwardly toward the cylinder axis, a non-uniformly distributed electric coil wound about the cylindrical baffle and adapted upon energization to provide a magnetic field in the region of the contact members, the magnetic field having a component in the axial direction and parallel to the flow of electric current in said members and in the region therebetween at the instant the circuit is interrupted to create a kink instability in the arc created upon interruption and having a component in the radial-direction, the axial and radial components of the magnetic field interacting

with the arc current to cause the arc to twist into a helical shape between the contact members as the distance therebetween widens, to move radially outward to contact the fins and transfer arc energy thereto, and to revolve relative to the fins continuously changing the portion of the fins in contact with the arc.

2. A circuit breaker for use in an electrical circuit to interrupt substantial magnitudes of electric current in the circuit, that comprises, a pair of contact members adapted to move toward and away from one another respectively to make and break electrical contact, means for effecting movement of the contact members to make and break electrical contact therebetween and thereby respectively to allow current to flow in the circuit and to interrupt the flow, a heat sink baffle disposed about the contact members and having a plurality of spaced fins which extend radially inward toward the contact members, means for providing background magnetic field in the region of the contact members and having an axial component parallel to the direction of the flow of electric current in said members at the point of contact and in the region therebetween at the instant the circuit is interrupted to create a kink instability in the arc created upon interruption and having a radial component orthogonal to said direction, interaction between the axial and radial components of the background magnetic field and arc current acting to cause the arc to twist into a helical shape between the contacts as the distance therebetween widens, to move radially outward to contact the fins and transfer arc energy thereto and to move azimuthly thereby to sweep the fins.

3. A circuit breaker as claimed in claim 2 in which the heat sink baffle comprises an evaporable material adapted to absorb heat from the arc, which absorbed heat effects evaporation of a portion of the material thereby to dissipate arc energy.

4. A circuit breaker as claimed in claim 2 in which the magnetic field creating means includes a coil disposed about the contact members, the axis of the coil being oriented substantially parallel to said direction to create a magnetic field having its major component in the axial direction, said coil being non-uniformly wound to provide in addition a minor component of magnetic field in the radial direction.

5. A circuit breaker as claimed in claim 4 which includes a source of electric power connected across the breaker to provide a flow of electric current upon the making of electrical contact between said contact members, said coil being connected in series with the contact members in order that the background field will exist in the region occupied by the contact members and said region therebetween at all times in which there is electric current flow in said circuit and in proportion to the magnitude of current flow.

6. A circuit breaker as claimed in claim 2 in which: the contact members are rod-shaped elements adapted to move along an axis toward and away from each other, the baffles are composed of an evaporable material adapted to dissipate arc energy by evaporation of material at the fin surfaces, and in which the fins have aligned openings along said axis to receive the rod-shaped members, the openings being only slightly larger in cross dimensions than the cross dimensions of the members.

7. A circuit breaker for use in an electrical circuit to interrupt substantial magnitudes of electric current in the circuit, that comprises, a pair of contact members disposed to move toward and away from one another respectively to make and break electrical contact, means for moving the members to make and break electrical contact therebetween and thereby respectively to allow current to flow in the circuit and to interrupt the flow, an electric coil wound to provide upon energization a high-intensity magnetic background field throughout the region of the contact members, said field having an axial component in the direction parallel to the flow of electric current in the contact region of said members and in the region therebetween at the instant the circuit is interrupted to create a kink instability in the arc created upon interruption and having a radial component orthogonal to said direction, reaction between the axial and radial components of magnetic field interacting with the arc current acting to cause the arc to twist into a helical shape between the contacts as the distance therebetween widens, to move radially outward and to revolve relative to the fins.

8. A circuit breaker as claimed in claim 7 in which the coil is connected electrically in series with said contact members.

9. A method of interrupting substantial magnitudes of electric current in a circuit breaker that includes a pair of contacts disposed to move toward and away from one another respectively to make and break electrical contact therebetween and thereby respectively to allow current to flow in the circuit and to interrupt the flow, said breaker including, also, a baffle having a plurality of axially-spaced fins which are disposed about said contacts and directed radially inward toward said contacts, that comprises, establishing a high-intensity magnetic background field in the region of the contact members, said magnetic field having an axial component and a radial component, said axial component being oriented parallel to the flow of electric current in the contact region of said members and in the region therebetween at the instant the circuit is interrupted to create a kink instability in the arc created upon interruption, reaction between the axial and radial components of magnetic field interacting with the arc current acting to cause the arc to twist into a helical shape between the contacts as the distance therebetween widens, to move radially outward to contact said fins and to rotate relative thereto.

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