May 31, 1932. H. MILLIKEN 1,861,129

CIRCUIT BREAKER

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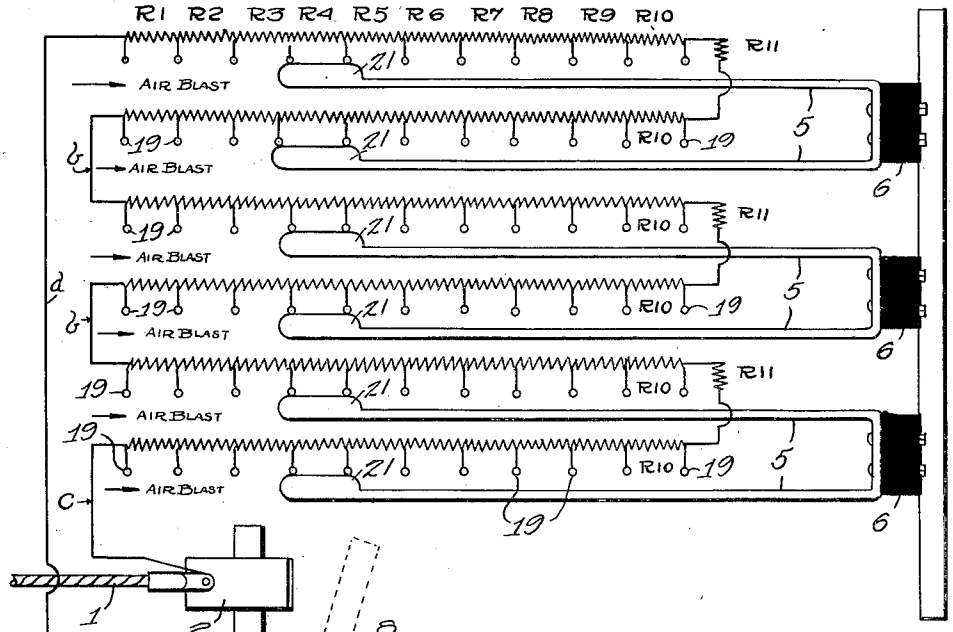
Fig. 1.



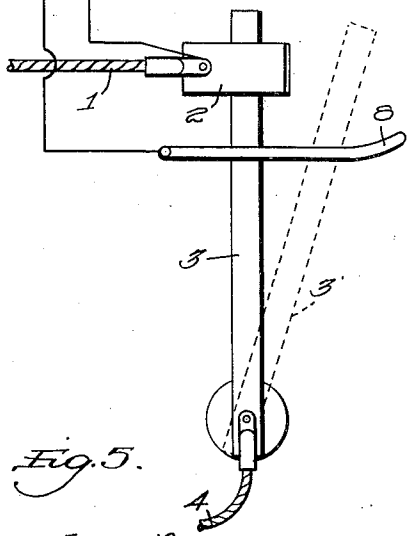
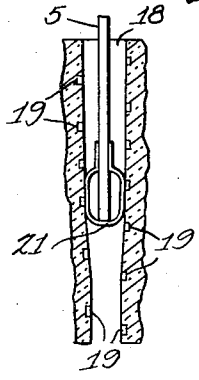


Fig. 5.



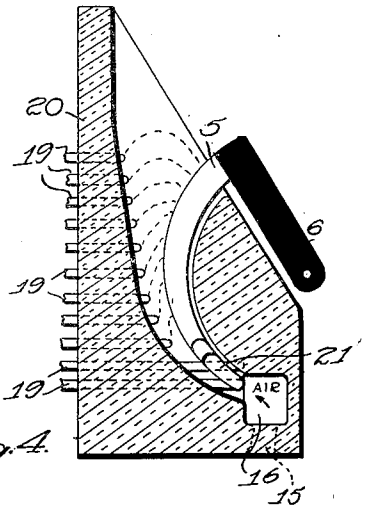


Fig. 4.

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Fig. 2.

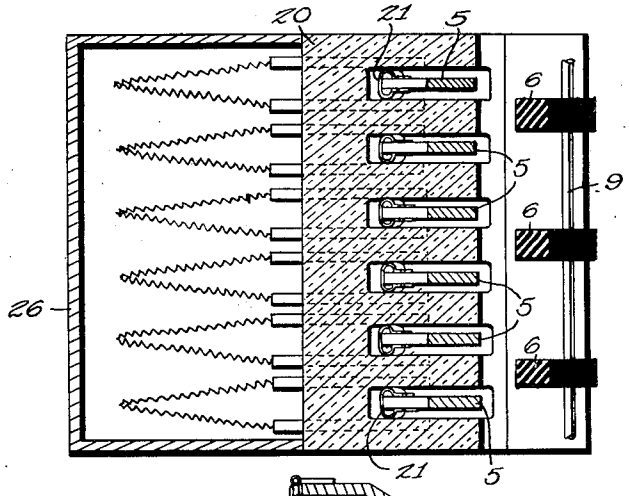

Fig. 3.

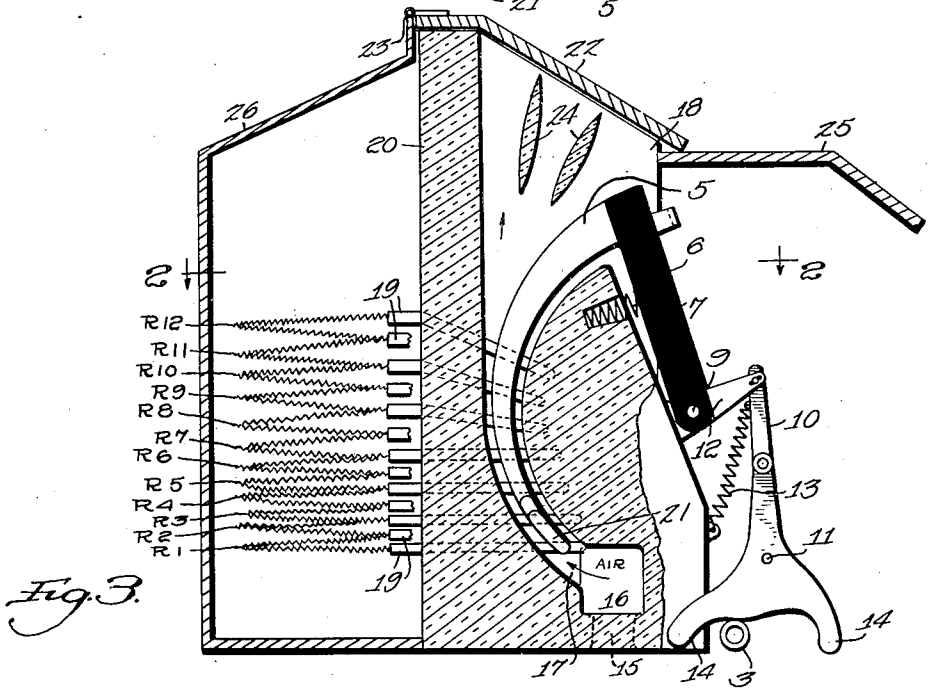

Fig. 6.

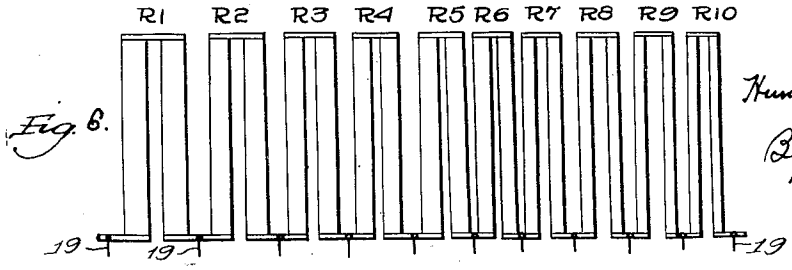

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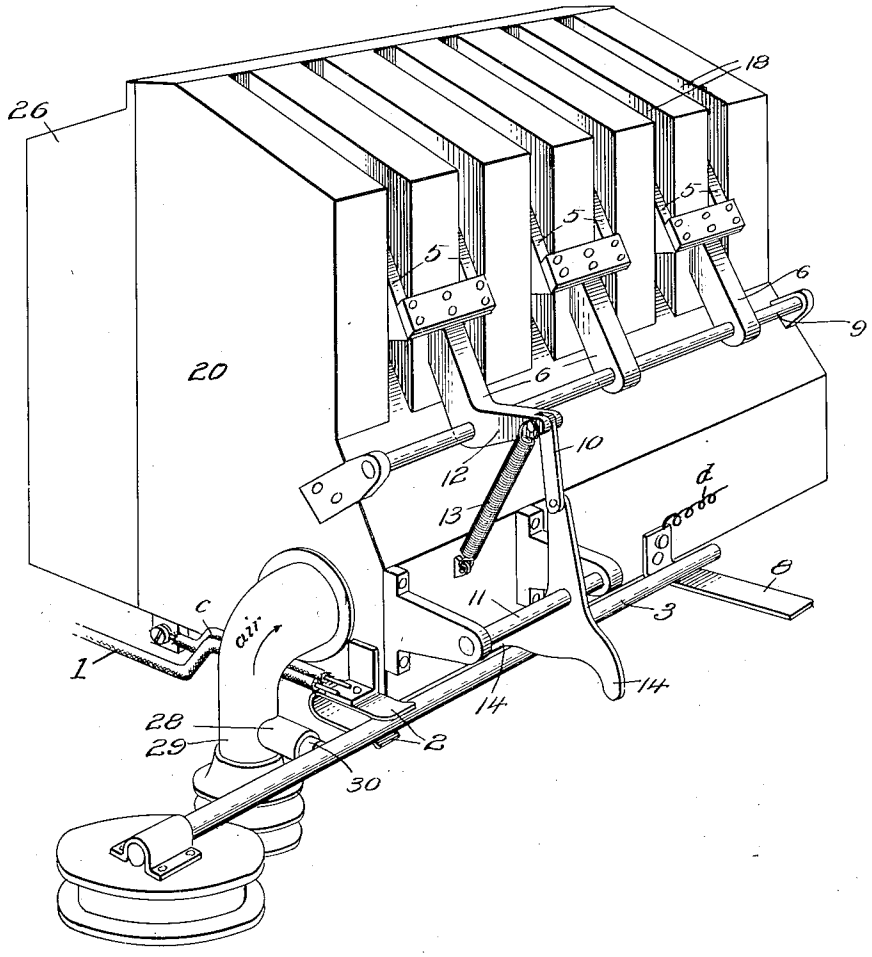
Fig. 7.



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Patented May 31, 1932

1,861,129

UNITED STATES PATENT OFFICE

HUMPHREYS MILLIKEN, OF MONTREAL, QUEBEC, CANADA

CIRCUIT BREAKER

Application filed August 26, 1929. Serial No. 388,566.

This invention has relation to circuit breakers adapted for use on high power circuits, and the object of the invention is to avoid the formation of destructive arcs when the circuit is opened, as more fully hereinafter set forth.

In the drawings annexed—

Fig. 1 is a diagram showing the circuit arrangement;

Fig. 2 is a horizontal sectional view through the circuit breaker on the line 2—2 of Fig. 3;

Fig. 3 is a vertical sectional view through the apparatus shown in Fig. 2;

Fig. 4 is a detail sectional view showing a slight modification.

Fig. 5 is a detail sectional view showing the formation of the blast channels.

Fig. 6 is a detail diagrammatic view of one of the banks of resistors.

Fig. 7 is a perspective view showing one possible arrangement of my device.

The invention will be best understood by first describing the diagram, Fig. 1. In this diagram, the current enters by lead 1, the usual main blade 3 and out by lead 4. When the main blade 3 is opened to the dotted-line position, current cannot pass from contact 2 to blade 3, and hence it flows through a shunt path consisting of a supplemental or shunt-contact-horn 8 and a series of resistors hereinafter described. At the instant that blade 3 breaks contact with 2, all the resistors are short circuited by conductor-bars 5, assuming that these bars are in their extreme left-hand position and that, therefore, no arc is drawn between 2 and 3 when they separate. Immediately after the separation of 2 from 3, 3 trips a mechanism (hereinafter described) which starts all the conductor-bars 5 moving toward the right, to thereby introduce resistors R', R^2, R^3, etc. successively.

Just before blade 2 opens, an air blast is opened so as to play across all the contacts 19 of the resistors. Hence the separation of conductors 5 from the contact points of these resistors takes place within a strong blast of air, which blows away the ionized atmosphere and the hot air and thus minimizes the arcing. All of the conductors 5 move together, thereby introducing a large quantity of resistance with a small motion within a short time, thus minimizing heating and the required size of the resistors. As will be observed, the resistors are arranged in a plurality of rows connected together electrically at their alternate ends by conductors *b*, the row at one end being connected by conductor *c* to the main contact 2, and the row at the other end of the series being connected by conductor *d* to the usual shunt-horn 8, with which the blade 3 maintains contact for a short distance after it leaves the jaws 2.

Conductor-bars 5 are supported on insulating arms 6 which insulate each conductor-bar separately. When the conductors 5 have reached their extreme open position, all of the resistors are in circuit in the series, which reduces the current to a small value, which small current is broken by the separation of the blade 3 from the usual horn 8, no air blast being required to break any arc that might be formed between 3 and 8 by this small current. As shown in Fig. 1, resistors R^{11} are connected alternately between adjacent resistors R^{10} so as to maintain a closed circuit after all of the resistors are inserted, these resistors R^{11} having a much higher resistance than resistors R^{10}. Resistor R^{11} might be omitted entirely, leaving the circuit open at these points, but it is better to provide a very high resistance R^{11} so as to equalize the potential and stress on the insulation of the structure which carries the resistors. Resistor R' has the least resistance and R^{10} the highest resistance, intermediate resistors having intermediate values of resistance. Resistor R' has the highest current capacity and R^{10} the least current capacity, intermediate resistors having intermediate current capacities. The current is reduced step by step by the introduction of each resistor. The resistances are so proportioned that the product of current times resistance increases as the current decreases, to thereby equalize the arcing at the successive contact-points.

One advantage of this construction is that a very large current resulting from a short circuit on the system is quickly reduced to

a small current before the circuit is opened, thereby avoiding the damaging effect of drawing an arc carrying the entire short-circuit current. Another advantage is that the reduction of current before breaking the circuit avoids the objectionable voltage surges which are well known to result from the usual methods of switching large currents. Still another advantage is that with this construction circuit breakers designed for a very large interrupting capacity can be tested with a power supply of only a small fraction of the capacity, as is obvious.

One practical embodiment of the diagram shown in Fig. 1 is illustrated in Figs. 2, 3 and 5. In these figures, six sections are shown in series, but it will be understood that I might have ten sections in series for use on a circuit of 66,000 volts, if desired. One section can be tested separately on 6,600 volts, and the results will be the same as if ten sections were tested on 66,000 volts. The capacity of ten sections might be 1,000,000 kilo-volt-amperes. It is a very difficult matter to arrange for such a large supply of power for tests, but one section will require only one-tenth, i. e., 100,000 k. v. a., supply for testing.

The conductor-bars 5 are preferably made in tapered form and they are affixed to a rock-shaft 9 by means of the aforesaid insulating arms 6. A crank 12 and spring 13 impart quick motion to the set of bars 5 when toggle 10 is opened inwardly by the blade 3 striking a finger 14 on one arm of the toggle. The air blast shown by the arrows enters opening 15 to passage 16 and out through orifices 17 and arc-chutes 18, these passages being formed in a block or mass of suitable insulating material 20. Contact-bars 19 embedded in the sides of the arc-chutes 18 make contact with bars 5 and are connected to the resistors R', etc. Desirably, the bars 19 are inclined with respect to the spring contact 21 carried by each of the bars 5, so as to assist in causing the arcs to be blown away from parts 21 and 19 when they separate. Also, desirably, the bars 19 are made straight so that they can be pulled out and renewed readily, if burned.

Only half of the bars 19 are shown in Fig. 3; the other bars 19 are at the near side of the orifice 17 and blast-chutes 18. A spring 7 assists in imparting a quick start to the set of contact-bars 5. The air blast also assists in accelerating the conductors 5 by blowing against the ends thereof as these bars leave the chutes 18. It is very desirable to bring into the shunt circuit all of the resistors in the shortest possible time.

In closing the main contacts, blade 3 strikes arm 14' of the toggle and closes the toggle and thus throws the contact-bars 5 back into the arc-chutes against the action of springs 7 and 13. A lid 22 secured to wall 20 by hinges 23 protects the interior from weather. The air blast opens lid 22 against the action of a spring on hinge 23, the lid being returned to closed position by said spring after the air blast is cut off. The numeral 25 indicates the stationary cover to exclude the weather, and 26 is a housing for the resistors. The body of the apparatus is made of arc-resisting, insulating material, such, for instance, as asbestos board. The contacts 21, on each of the bars 5, are of spring metal and they are long enough to span at least two of the contacts 17 so as to avoid opening the circuit before all the resistors are inserted. Arc-splitting partitions 24 in the path of the air blast after it issues from the arc-chutes 18, serve to cut the arc at several points, thereby assisting in extinguishing it. I have not shown any means for producing an air blast, but it will be understood that any suitable means may be employed for this purpose. It will be understood also that this air blast is turned on an instant before the movable resistor-contacts 21 leave the first set of stationary resistor-contacts 19 and is continued until these movable resistor-contacts 21 pass off the last contact-bars 19. In Fig. 7 I have shown one convenient way of actuating the movable parts of my apparatus; I do this by connecting a cylinder 28 to the air blast pipe 29 and by means of a piston 30 in said cylinder 28, which is actuated when the air blast is turned on, I throw open the main blade 3, which blade, as heretofore set forth, actuates a toggle device which in turn withdraws the bars 5.

As shown in Fig. 5, it is desirable that the arc-chutes 18 shall be made to widen toward their exit-ends for the purpose of reducing friction by reducing the pressure of spring contacts 21 on the side-walls of chutes 18, thereby reducing the time of operation.

In Fig. 4, an alternative construction is shown. In this figure, the first two or three contact-bars 19 make contact with spring-contacts 21, but the remainder of the bars 19 do not touch 21. When contacts 21 separate from the second one of the bars 19, each arc is blown upwardly, one end running along curved contact-bar 5 and the other jumping from one bar 19 to the next above, thus inserting the resistors in the same manner as if contact 21 made contact with all the bars 19. The advantage of this construction is that the resistors are inserted much more quickly than is possible by a mechanical motion of the conductor-bars 5, thereby reducing the heating of the resistors or increasing the interrupting capacity of the circuit breaker. It will be understood that those of the bars 19 shown in Fig. 4 which do not make actual direct contact with the horn 5 are nevertheless "contacts" within the meaning of the claims.

I am aware of the fact that resistance has been used in circuit breakers before, but so far as I am aware it has not been used in conjunction with an air-blast circuit breaker nor arranged in the advantageous manner herein set forth. Also, I am aware that oil circuit breakers having a resistance or reactance have been used before, but this type of circuit breaker has not met with much favor, principally because accidents have occurred whereby the resistance or reactance was left in the circuit continuously, becoming hot and igniting the oil, causing serious fires. My construction avoids the possibility of having the resistor in circuit continuously and, also, I avoid the use of oil or other inflammable substance. My resistors are desirably made of graphite and clay products, so as to be incombustible.

Instead of air alone for the blast, the conductivity of the arc per unit volume may be reduced by injecting into the air blast gases or finely divided material, either solids or liquids, serving to cool the arc or otherwise reduce its conductivity. Also compressed carbon dioxide, either in liquid or gaseous form, may be used for the purpose of providing a non-oxidizing atmosphere to extinguish flame due to burning of metal vapor; any other non-oxidizing material may be used, such as carbon tetrachloride.

What I claim as new is:

1. In a circuit breaker, a main circuit means including a main switch, a shunt circuit associated therewith and including a plurality of rows of resistors, each resistor having a stationary-contact, an insulating structure having open-ended air channels, one for each row of said stationary contacts, the contacts being located in the channels, the inlet ends of said channels being connected to an air-blast conduit, a conductor-bar adapted to pass into each of said channels and carrying a movable resistor-contact positioned to cooperate with said stationary-contacts as the conductor-bar is withdrawn from the channel to thereby successively cut in the resistors in the shunt circuit, and means whereby all said conductor-bars are quickly withdrawn from said channels in the direction of the air-blast upon the opening of the main switch, whereby a multiplicity of resistors are brought into action almost instantaneously after the opening of said main switch.

2. The structure recited in claim 1, the channels in which stationary-contacts are arranged being tapered outward so that as the conductor-bars move out of the channels, the movable contact carried by each conductor-bar will have actual contact with only the contact stationary at the inner end of its channel.

3. In a device of the class described, an electric circuit embodying a plurality of rows of resistors, each resistor having a stationary contact, an insulating structure having open ended air channels, one for each row of said stationary contacts, the inlet ends of said channels being connected to an air-blast conduit so that air blasts may be sent through said conduits simultaneously, a conductor-bar adapted to pass into each of said channels and carrying a movable resistor-contact positioned to co-operate with said stationary contacts as the conductor-bar is withdrawn from its channel to thereby successively cut in the resistors, and mechanical devices whereby all said conductor-bars are quickly withdrawn from said channels in the direction of the air blasts, whereby a multiplicity of resistors are brought into action almost simultaneously, the speed being augmented by said air blasts.

4. In a device of the class described, an electric circuit including a plurality of rows of resistors, each resistor having a stationary contact, a plurality of movable resistor-contacts adapted when moved to successively cut in said resistors, means whereby said movable resistor-contacts are simultaneously moved to cut in said resistors, and additional high-resistance potential-equalizing-resistors in position to be cut into said circuit by said movable resistor-contacts after the resistors of lower resistance have been cut into said circuit.

In testimony whereof I hereunto affix my signature.

HUMPHREYS MILLIKEN.