Sept. 6, 1927. S. RUPPEL 1,641,201

AUTOMATIC EXCESS CURRENT SWITCH WITH ELECTROMAGNETIC AND THERMIC RELEASE

Filed May 1, 1926 2 Sheets-Sheet 1

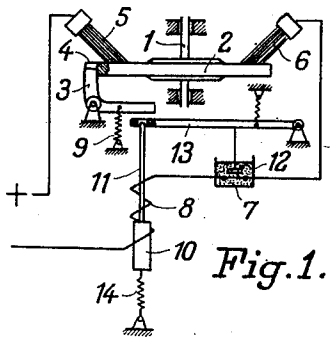


Fig. 1.

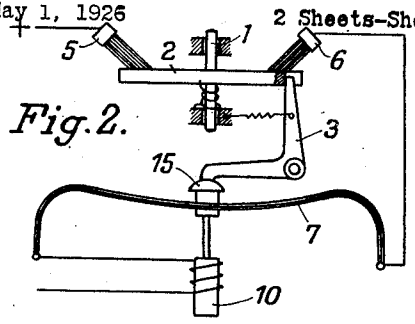


Fig. 2.

Fig. 5.

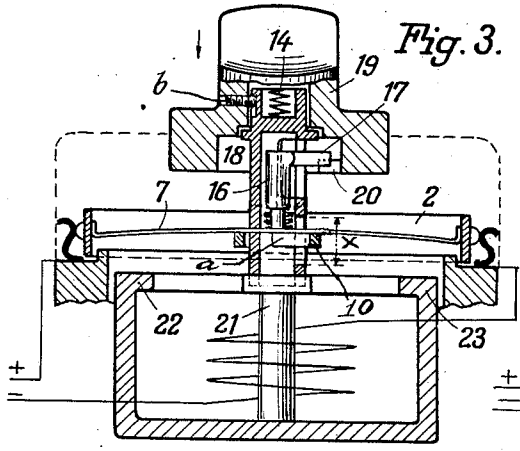


Fig. 3.

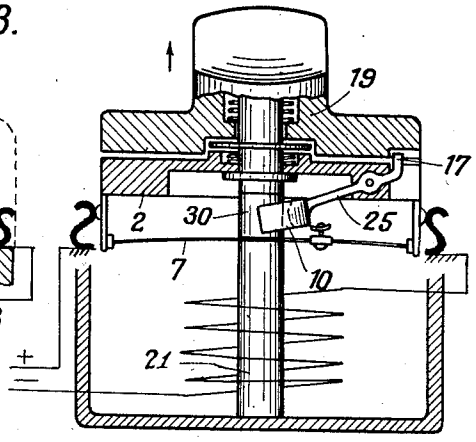


Fig. 4.

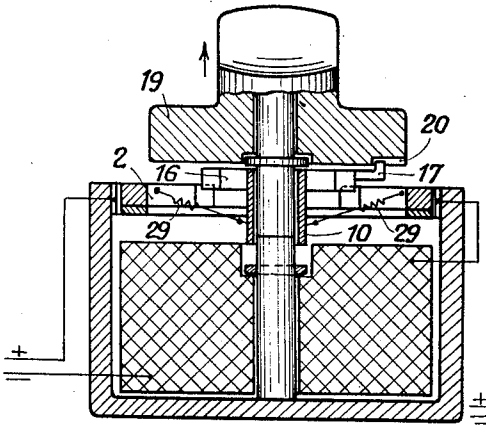
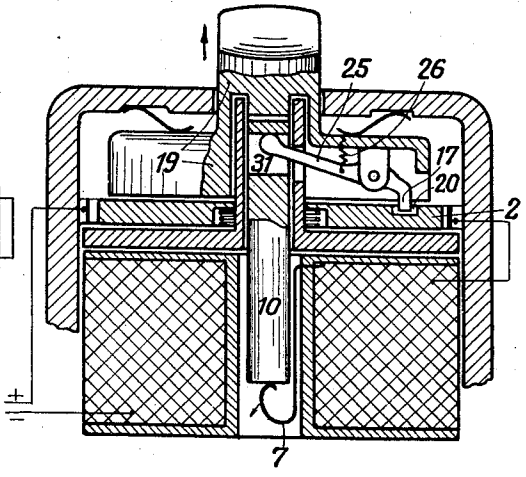


Fig. 6.



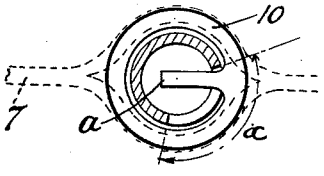


Fig. 3a

Inventor:
Sigwart Ruppel
By
Pennie, Davis, Marvin & Edmonds
his Attorneys

Sept. 6, 1927. S. RUPPEL 1,641,201

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Filed May 1, 1926 2 Sheets-Sheet 2

Fig. 7.

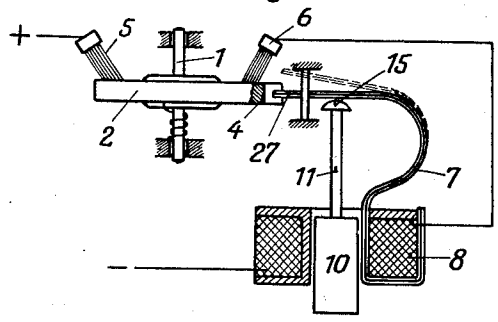


Fig. 8.

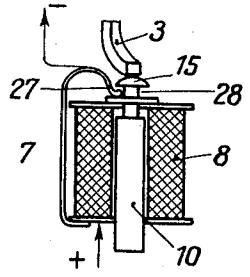


Fig. 9.

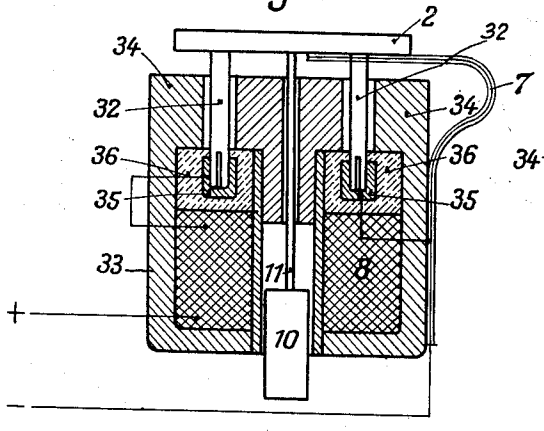


Fig. 11.

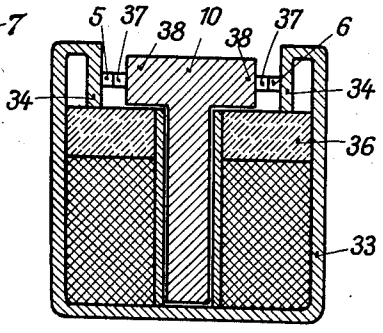


Fig. 10.

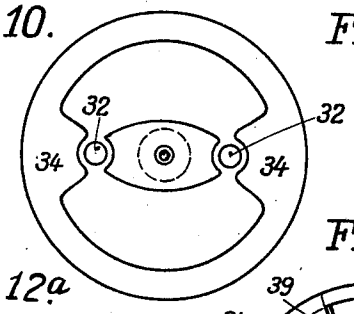


Fig. 13.

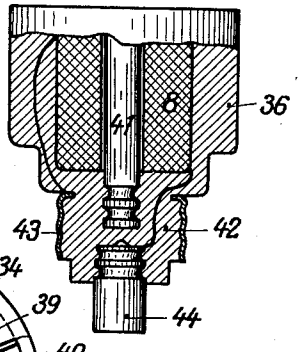


Fig. 12.

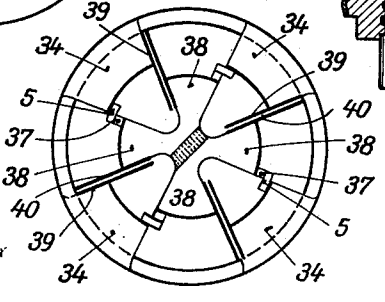
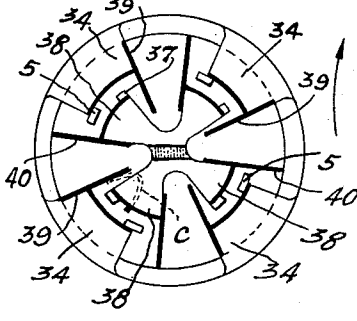


Fig. 12a



Inventor:
Sigwart Ruppel
By
Pennie, Davis, Marvin & Edmonds
His Attorneys

Patented Sept. 6, 1927. 1,641,201

UNITED STATES PATENT OFFICE.

SIGWART RUPPEL, OF FRANKFORT-ON-THE-MAIN, GERMANY.

AUTOMATIC EXCESS-CURRENT SWITCH WITH ELECTROMAGNETIC AND THERMIC RELEASE.

Application filed May 1, 1926, Serial No. 105,914, and in Germany January 24, 1924.

This invention relates to interrupters for electric circuits, and particularly to those provided with electromagnetic and thermal releasing devices.

The electric circuits such as those of transmission lines, domestic lighting systems, dynamo-electric machines, and translation devices, are subject to damage from two sorts of overload currents. The first is the overload of relatively high current value, such as that caused by short circuit, and which must be removed substantially instantaneously to prevent damage to the circuit. The second is the overload of relatively low current value which can endure for considerable periods of time without in any way injuring the circuit, but which, if sustained for too long a time will cause a dangerous rise in the temperature of the circuit.

It is impossible arbitrarily to set a current value which represents the boundary between these two overloads, as it varies with every individual circuit, depending upon such factors as the size of the conductors, the protection from heat radiation by the electric insulation, etc. The engineer, however, readily understands the distinction between these two overloads and the importance of protecting electric circuits against both. This maximum sustained relatively low overload current is that which corresponds to the fusing current of the appropriate safety fuse for the particular circuit, and will be referred to in the description which follows as the "limit current".

For reasons of economy to reduce the cost of production of commercially practicable circuit interrupters it is important that they be constructed with a minimum amount of material. However, as heretofore customary, if a simple juxtaposition of the electro-magnetic and the thermal releasing devices is used, each acting independently to open the interrupter, each device has to be constructed to withstand a definite maximum current just as though the other device were not present. This is not only wasteful of material but it is disadvantageous as to both the cooperative action and the arrangement of the various parts. Without regard to whether the thermal or the electro-magnetic release comes into action, the other device must quite needlessly be taxed as well.

According to the present invention, both releasing devices are arranged the one to complement the other. Thus the interrupter is constructed with a switch blade or other switch member which is latched in the closed position but biased to the open position, and the thermally actuated releasing device for this switch member is operative by sustained relatively low overload currents. The electro-magnetically actuated releasing device is however inoperative by such relatively low currents, but is operative by instantaneous overload currents of greater value.

The interrupter of the present invention also involves certain features of construction which improve the operation of the apparatus and tend to reduce the cost of manufacture. For instance, the thermally actuated device and the electro-magnetically responsive device are operatively associated with one another and act upon a common latch member for releasing the switch member. Moreover, under certain conditions the two releasing devices are arranged to oppose each other in their movements so that the thermal release acts to move the latch member in one direction, while the electro-magnetic release acts to move it in the opposite direction, either of which movements will release the switch member and open the interrupter. Certain advantages can also be obtained in the construction of interrupters which are provided with rotatable switch members by mounting the switch handle on the axis of the switch member in axially spaced relation thereto, and placing the latch member between the handle and the switch member. In this construction the latch member is arranged to move axially within a recess in the operating handle and releasably engages the handle within this recess. A desirable form of such construction includes a projection on the latch member which engages a lug formed on the handle within the recess and so constructed that the projection can move in either axial direction to disengage the lug and allow the switch member and handle to move to open the interrupter.

Also in accordance with the invention, a bimetallic thermostatic spring is employed as the thermally actuated release, and this spring is preferably constructed with one of its metals of magnetic material, and forming part of the magnetic circuit of the electro-magnetically responsive device. In order to facilitate the extinction of the arc at the interrupter contacts, the invention also pro-

vides for employing the magnetic field of the coil of the electro-magnetically responsive device for aiding in the extinction of the arc. In addition to this, one modification of the improved circuit interrupter includes insulating barriers movable relative to one another by the movement of the switch contacts to promptly extenuate the arc between them and thus aid in its destruction. A better understanding of the invention will be had by a study of the accompanying drawings showing by way of example various modifications of the invention. In these drawings

Fig. 1 is a diagrammatic view showing the relative action of the various parts of the improved circuit interrupter;

Fig. 2 is a similar view of a modified form of interrupter employing a bimetallic spring as the thermally actuated device;

Fig. 3 is a transverse section showing the structure of one form of the circuit interrupter;

Figure 3ª is a cross-sectional view showing the arrangement of the armature 10 with respect to the core 21;

Figs. 4, 5 and 6 are similar views showing modified forms of construction;

Fig. 7 is a diagrammatic view showing the relation of parts of another modification in which the bimetallic thermally actuated device acts directly as the release for the switch member, this device being indirectly heated by the coil of the electro-magnetic release;

Fig. 8 is a transverse section of still another modification;

Fig. 9 is a transverse section of an interrupter in which the switch member moves axially of the coil, the magnetic field of the coil acting to extinguish the arc between the switch contacts;

Fig. 10 is a plan view of the device shown in Fig. 9 with the movable switch member removed;

Fig. 11 is a transverse section of a modification somewhat similar to that shown in Fig. 9 and Fig. 10 but having the switch member rotatable;

Fig. 12 is a plan view of another modification which is in general similar to the one shown in Fig. 11 with the addition of insulating barriers aiding in the extinguishing of the arc;

Figure 12ª is a plan view similar to Figure 12 which shows the switch in position of disc connection; and—

Fig. 13 is a partial elevation and partial section of a form of interrupter adapted for the protection of domestic circuits and provided with a screw base which is receivable within a standard screw receptacle in place of a safety fuse.

Referring first to Fig. 1, the switch member or bridge 2 carrying the movable contacts is rotatable about the axis 1, and is maintained in the connected or closed position, counter to the action of a spring (not shown in the drawing), by means of the snapping of the catch lever 3 into a notch 4. The current passes from the lead-in, by way of the fixed contact 5 and the switch bridge 2, to the opposite contact 6, thence through the thermostat 7 and the magnet winding 8 to the lead-off.

The catch lever 3 is subject to the action of a spring 9 which tries to lay the lever into the notch 4. Upon the catch lever 3 there acts, furthermore, in a releasing direction, the magnet armature 10 by means of the prolongation rod 11, as well as the thermostat 7. The latter consists of a melting pot in which a heating-wire or the like heats a melting-composition. When the melting-composition is solidified, it holds fast the releasing lever 13, which is subject to the action of a spring, by means of the plate 12. The thermostat and the armature accordingly act upon the same releasing device 3; in the specimen form of construction the armature 10 or its prolongation rod 11 extends through an aperture in the releasing lever 13 of the thermostat, but the armature and the thermostat may also move past one another or again may be positively connected with one another as will hereinafter appear.

In case of a load to the amount of the limit current the armature 10 is held back by the retention spring 14, since at this load the hitherto developed magnetic energy is not yet sufficient to overcome the spring 14. In case of sufficient duration of the load, however, the composition in the melting-pot melts, the releasing lever 13 becomes free, turns clockwise under the action of its spring, and finally pushes the catch lever 3 out of its notch 4; the switch bridge 2 is then free and snaps into the off position.

In Fig. 2 there is employed as the thermostat 7 a bimetallic spring which is directly traversed by the current and which consists of two superimposed spring lamellæ of different material having coefficients of expansion that differ from one another (for example, iron and zinc). This bimetallic spring serves directly as a holding device for the pivoted magnet armature 10, which it grasps by an enlarged knob 15. The mode of operation of this arrangement is the same as that shown in Fig. 1.

The mutual complementing of the releasing devices is possible also in the case of releasing forces that act counter to one another. The construction shown in Fig. 3 is arranged in such a way that the thermostat, in case of long-continued heating, moves the catch lever 16, 17 out of the connected position counter to the action of the magnet. In this practice one starts from the fact that to a preponderant extent all lines and pieces of apparatus can stand an overload up to a

certain extent and that an incomplete utilization of the line and the apparatus would result, if in case of increasing current the magnet action were to add itself to the heat action.

The construction shown in Figure 3 consists of a switch bridge 2 mounted on an armature 10 through a thermostatic element 7. The armature 10 is loosely mounted on a hollow extension of the central pole 21 of a magnet, said hollow extension which provides a switch axis, having a slot therein embracing an angle of about 100° (marked α in Fig. 3a) and of height x as shown in Fig. 3. The armature 10 is provided with a projection a extending into the slot beyond the center line of the switch axis and this projection has mounted thereon concentric with the axis, a coupling piece 16 having an engaging piece 17. A switch handle 19 which may be supported by a hood as shown in dotted lines and normally is held in the on position, has a recess 18 therein and a lug 20. The engaging piece 17 is adapted to project into the recess and engages with the notch 20.

If, in the case of an automatic circuit-breaker in accordance with Fig. 3, an excess current to the amount of the limit current-load occurs, then the bimetallic spring 7 bends upward and presses the armature 10 or the shoulder 16 further into the recess 18 of the switch handle 19, until the engaging piece 17 releases itself from the lug 20 and thereby disengages the coupling between the switch handle 19 and the switch bridge 2, whereby upon being released the switch bridge is revolved by means of a coil spring thus breaking the contact between the bridge and the stationary **S** contact members.

If, on the other hand, a short-circuit occurs, then the electro-magnet overcomes the force of the bimetallic spring, draws the armature 10 against itself and thereby draws the engaging piece 17 downward out of the recess 18. In this case also there results a disengaging of the coupling between the switch handle 19 and the switch bridge 2, so that the latter can move into the circuit-breaking position.

In order to insure the electro-magnetic releasing force also for the case in which the armature, in consequence of the bending of the bimetallic spring 7, has moved away from the pole of the magnet, the bimetallic spring 7 is provided with a layer of magnetic material (iron). The switch axis 1, furthermore, in that portion 21 which is surrounded by the magnet coil, consists of magnetic material and serves as a magnet pole. Upon the bimetallic spring 7 there act the laterally arranged poles 22, 23.

To provide for a re-setting of the interrupter, the switch handle 19 is provided with a set screw b which engages a small slot in the upper portion of the hollow extension of the pole 21. The spring 14 in the hollow extension tends to push the handle outwardly but is prevented from doing so by the screw b. The screw b being guided in a longitudinal groove, the handle may be pushed downwardly and turned slightly until the notch 20 and the extension 17 engage whereupon the switch bridge may be revolved to again contact with the stationary **S** contact members.

Finally, as shown in Fig. 4, the switch bridge 2 also may consist of magnetic material. The armature 10 with its shoulder 16 then moves in interruptions of the magnetic circuit, closes—the further it is drawn downward on the magnet pole—the magnetic flux, and thereby reinforces the action of the latter. In the construction in accordance with Fig. 4 the two releasing forces are likewise opposed to each other. In opposition to the magnetic energy stands that of the springs 29, which are constructed as a device that responds to heat (thermostat) and endeavor, in case of long-continued heating, to draw the armature 10 together with the shoulder 16 upward out of the switch bridge 2. The switch bridge is then free to rotate and this may be effected in a similar manner as described in the construction shown in Fig. 3. To re-set, the handle 19 is turned until the notch 20 engages with the projection 17 and the turning is continued until the shoulders again slip into the space provided for them in the switch bridge, whereupon all the parts so connected may be revolved until the contact portions of the bridge again contact with the stationary contacts in the casing.

In the case of the automatic circuit interrupter of Fig. 5 the armature 10 is supported in the switch piece 2, not so as to be axially displaceable, but so as to be rotatable. The armature 10 is located on one end of a pivoted lever 25, the other end of which carries the coupling nose 17. The switch bridge 2 consists in this case also of magnetic material, while the magnetic circuit is interrupted at the one pole 21 by the non-magnetic part 30. In case of overload the armature 10 is drawn upward into the magnetic field and thereby bridges the break 30 and the switch bridge thus becoming unlatched is revolved to the off position by means of a coil spring. The re-setting operation is similar to that of the construction shown in Fig. 4.

In the modification shown in Fig. 6 the coupling 25 is rotatably pivoted, not on the switch bridge 2, as in Fig. 5, but on the switch handle 19. A spring 26 endeavors to turn the lever 25 clockwise and thereby brings the engaging piece 17 into engagement with the notch 20. The armature 10

has an aperture 31 into which the free end of the lever 25 projects, and therefore, when it is drawn downward, it carries the lever 25 along. The latter then turns counter-clockwise, opens the coupling 17, 20, and thereby releases the switch bridge 2. The switch bridge is then free to be turned out of engagement with the stationary contacts by the action of a coil spring. In this case, too, the thermostat 7 again serves as a holding device for the armature 10. In case of long-continued overload current, in which the magnetic energy does not suffice to cause the release of the switch, the free end of the bimetallic strip 7 bends in the direction of the arrow indicated and allows the armature to drop downward by its own weight. Since the thermostat becomes softer in case of long-continued overload and corresponding heating, and offers a constantly decreasing resistance to the armature, the engaging piece finally releases itself from the notch 20 and releases the switch bridge 2. The free end of the bimetallic spring 7 may also be firmly connected with the armature 10.

In the constructions shown in Figs. 3 to 6, circuit-breaking by hand is also possible, namely by this means, that the switch handle 19 is axially displaceable in the direction of the arrow, the engaging piece 17 thereby being disengaged from notch 20, thus disconnecting the switch handle 19 from the switch bridge 2 and releasing the latter for the circuit-breaking movement.

A very practical simplification of the automatic circuit-breakers hereinbefore described may be attained by this means, that the thermostat, constructed as a bimetallic spring, constitutes at the same time the catch lever which, in case of electro-magnetic release, is moved into the circuit-breaking position by means of the magnet armature. This form of construction is illustrated in Fig. 7. As in construction in accordance with Fig. 1, the switch bridge 2 turns about the axis 1, the current flows from the supply line across the contacts 5 and 6, through the magnet winding 8 into the lead-off line, the thermospring 7 being heated indirectly by winding 8. The bimetallic spring 7 engages with its free end 27 in the notch 4 of the switch bridge 2 and thereby replaces in this specimen form of construction the catch lever 3 that is necessary in Fig. 1.

A further very simple arrangement of the bimetallic spring is illustrated in Fig. 8. The armature 10 as well as the bimetallic spring 7 both act upon the catch lever 3; the free end 27 of the bimetallic spring 7 engages loosely in a groove 28 or the like below the head 15 of the armature 10. The end of the bimetallic spring may also completely surround the shaft of the armature 10, i. e. both the release parts may be positively connected. In Fig. 8 the bimetallic spring 7 is traversed by the current throughout its entire extent; it is, however, also possible to conduct the current only in part through the bimetallic spring and, aside from that, to heat the latter by means of the current heat only indirectly.

One of the principal difficulties in connection with the automatic circuit-breakers with which we are here concerned lies in the arcs that occur on breaking the circuit, and in their interruption. In order, in the first place, to render it impossible for any arcs that may possibly be formed to adhere to any metal parts, it is proposed, in accordance with the invention, to give the magnet or parts thereof that are, if necessary, utilized for the formation of a contact, as well as those metal parts which move in the magnetic circuit as armatures or as contact pieces, a pressed coating of insulating composition.

Such a construction is shown in Figs. 9 and 10, which illustrate an automatic circuit-breaker with an axially moved switch bridge 2 and contact pins 32 attached thereto. The magnet 33 is constructed as a pot-shaped magnet, as also in previous specimen forms of construction (Fig. 4), and has two projections 34 shaped like pole-shoes. These surround the contact pins 32. The opposite contacts 35 are embedded in a body of insulating composition 36 above the magnet coil 8. Against the switch bridge 2, which is furthermore also under the influence of the thermostat (not shown in the drawing), there applies loosely from below the prolongation rod 11 of the armature 10. In case of a short-circuit the armature 10, overcoming the bimetallic spring, is drawn into the coil. Thereby the switch bridge 2 is moved upward, and the contacts 32, 35 are separated from one another. In case of long-continued overload the bimetallic spring raises the switch bridge 2. The breaking of the circuit thus takes place in channels composed of insulating material; accordingly an arc that may possibly be formed cannot get a foothold. Furthermore, the breaking of the circuit takes place in the magnetic flux of the magnet 33, which passes through the arc in a direction perpendicular to the direction of motion of the contacts. In this manner a rapid extinguishing of the arc is assured.

The construction shown in Figs. 11 and 12 is distinguished from the preceding ones by the fact that the armature 10 executes a rotary movement as soon as the catch is released by the thermostat or by the magnet (see Figs. 1, 2, 7, etc.). This rotary movement is caused by a coil spring and shown in the diagram (Fig. 7), such diagram having been inserted herein for the purpose of showing such specific details as are not shown in the mechanical embodiments, the intention being to allow a consideration of

the diagram in connection with the consideration of the mechanical embodiments. In this case, too, the contacts 5, 6, as well as the opposite contacts 37, are subject to the influence of enlargements 34 shaped like pole-shoes, which are faced by the opposite poles 38 on the rotatable armature 10. Between these poles there is accordingly developed a very strong magnetic field, which passes perpendicularly through and blows out any arcs that may possibly be produced. In order that the arcs at break cannot jump over to a neighboring contact—a happening that is possible particularly in case of multipolar construction and closely adjacent contacts—there are provided, as is apparent from Fig. 11, stationary insulating walls 39 and movable insulating walls 40, which bring about not only a limitation, but also a compression of the arcs at the circuit-breaking process. The direction of rotation of the movable parts shown by the arrow, in which connection the interruption sparks that occur between the contacts 5 and 37 are in the first place brought under the influence of the poles 34, 38, and are compressed besides by the insulating walls 39, 40, which are moved toward each other. In this way the arcs are extenuated and then extinguished.

The insulating composition which is, as hereinbefore explained, employed for the purpose of protection from the arcs at break, may serve at the same time as an apparatus casing and thereby contain all the parts of the automatic circuit-breaker. This construction is indicated in Fig. 13. Inside of the coil 8 there is a tube 41, which is firmly embedded in the insulating composition 36 and in the interior of which the magnet armature moves. The insulating composition is modeled in the shape of an automatic plug device and forms the base 42, the walls of the casing, as well as the closure cover, (not shown in the drawing). The current enters at the base contacts 43, traverses the coil and the thermostat, and leaves the circuit-breaker through the foot contact 44.

I claim:

1. An interrupter for electric circuits comprising the combination of a switch member biased in the open position but normally held in the closed position, a thermally actuated device and an electromagnetically responsive device operatively associated with one another and acting in opposite directions to release the switch member.

2. An interrupter for electric circuits comprising the combination of a switch member biased to the open position, a latch member for holding the switch member in closed position, a thermally actuated device and an electro-magnetically responsive device operatively associated with one another and acting to move the latch member in opposite directions, said latch member serving to release the switch member in each direction of movement.

3. An interrupter for electric circuits comprising the combination of a rotatable switch member biased to the open position, an operating handle therefor spaced axially therefrom, a latch member for holding the switch member in the closed position disposed between the handle and the switch member, and a thermally actuated device and an electro-magnetically responsive device operatively associated with one another and acting to move the latch member in opposite directions, movement thereof in either direction causing the release of the switch member.

4. An interrupter for electric circuits comprising the combination of a rotatable switch member biased to the open position, an operating handle therefor spaced axially therefrom and provided with a recess, a lug on the handle within the recess, an axially movable latch member having a projection for engaging the lug to hold the switch member in the closed position, and a thermally actuated device and an electro-magnetically responsive device operatively connected to the latch member to move the same axially and thereby disengage said projection and lug to release the switch member.

5. An interrupter for electric circuits comprising the combination of a rotatable switch member biased to the open position, an operating handle therefor spaced axially therefrom and provided with a recess, a lug within the recess and spaced from the transverse wall thereof, an axially movable latch member having a projection for engaging the lug to hold the switch member in the closed position, and a thermally actuated device and an electro-magnetically responsive device operatively connected to the latch member to move the same axially, the thermally actuated device moving it in one axial direction and the electro-magnetically responsive device moving it in the opposite axial direction, either of such movements disengaging the coacting projection and lug to release the switch member.

In testimony whereof I affix my signature.

SIGWART RUPPEL.