

Feb. 9, 1937.

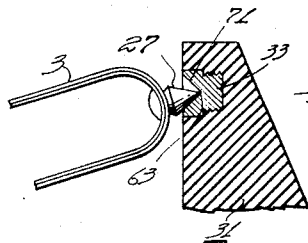
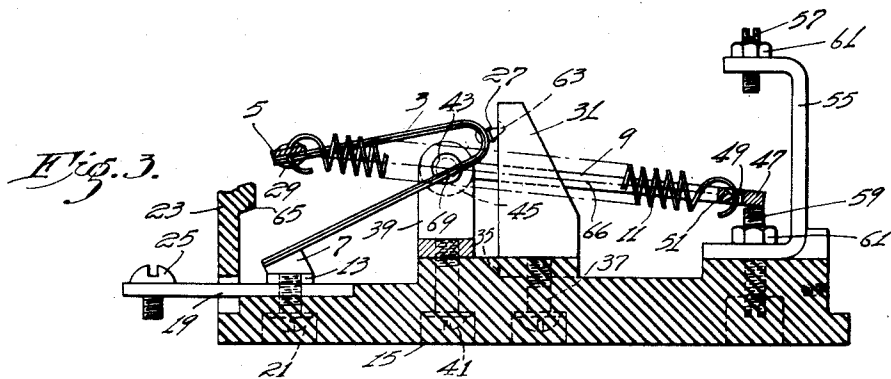
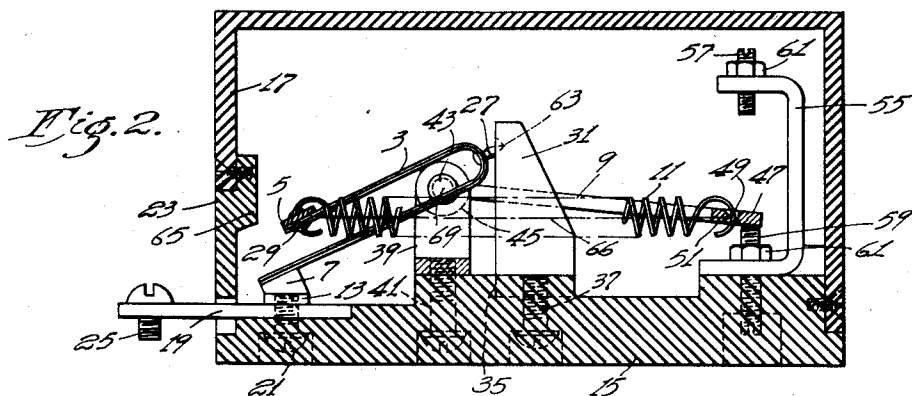
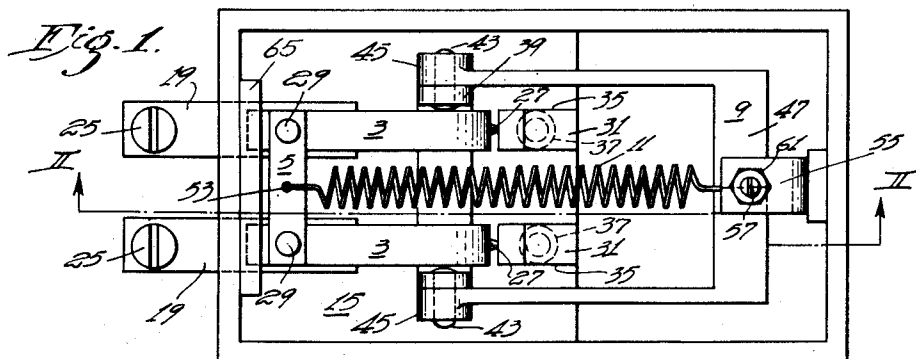
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2,070,305

CIRCUIT INTERRUPTER

Original Filed Jan. 3, 1934

3 Sheets-Sheet 1



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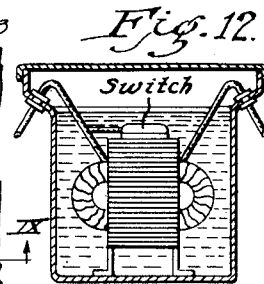
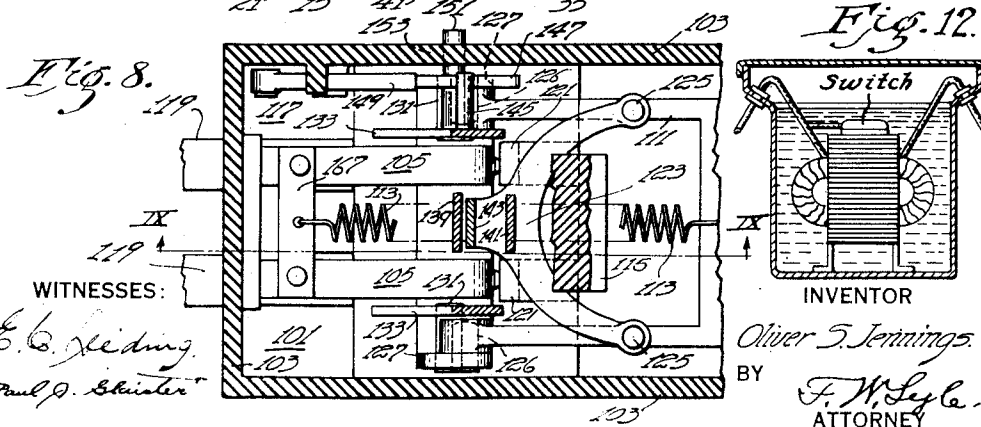
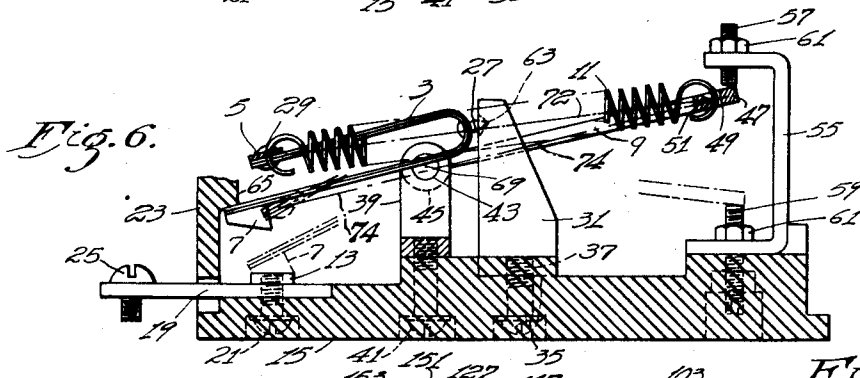
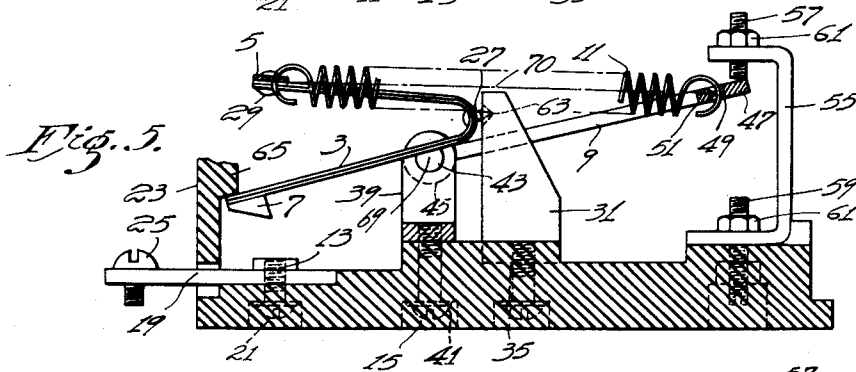
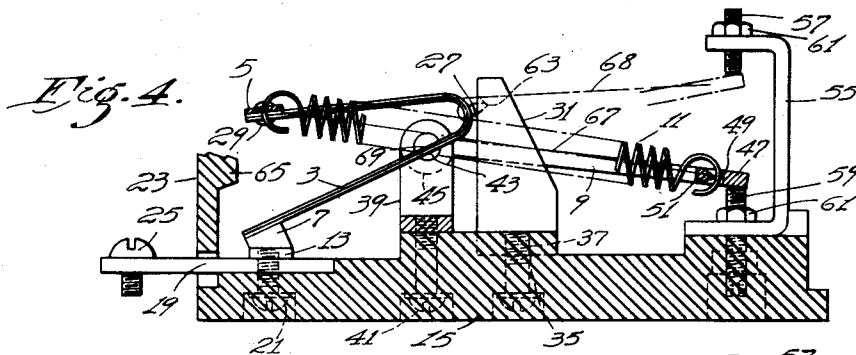
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2,070,305

CIRCUIT INTERRUPTER

Original Filed Jan. 3, 1934

3 Sheets-Sheet 2



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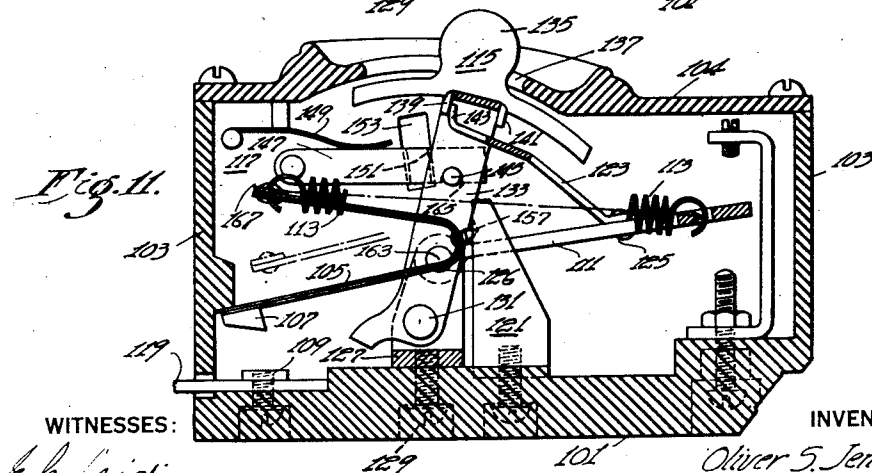
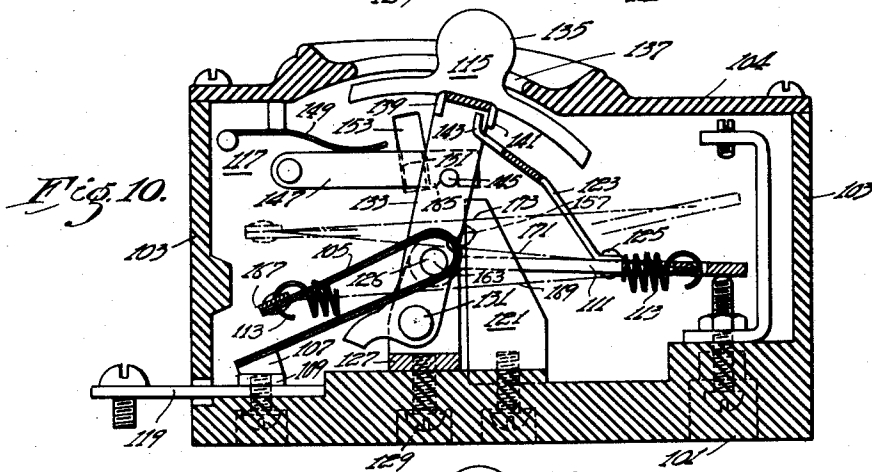
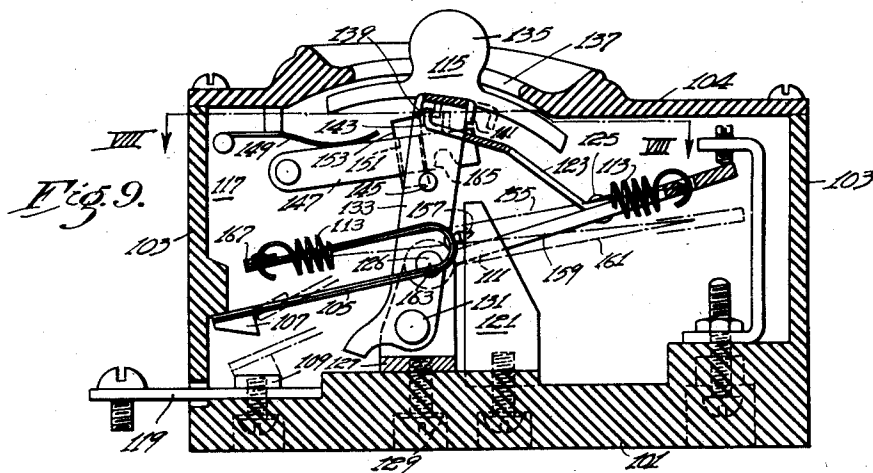
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2,070,305

CIRCUIT INTERRUPTER

Original Filed Jan. 3, 1934

3 Sheets-Sheet 3



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2,070,305

CIRCUIT INTERRUPTER

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Application January 3, 1934, Serial No. 705,071
Renewed July 11, 1936

31 Claims. (Cl. 200—116)

My invention relates generally to electrical apparatus of the type wherein a sequence of operations takes place automatically following the occurrence of predetermined conditions. More specifically, my invention relates to circuit interrupters of the so-called automatically reclosing type and is an improvement on the device of my application Serial No. 712,577, filed February 23, 1934, to make it reclose automatically.

Circuit interrupters of this type usually comprise a contact means, normally held in the open or the closed circuit position by a suitable biasing means, and means operable upon the occurrence of overloads or other conditions to cause the contact means to move from one position to the other position, to stay in the other position for a predetermined period of time, and then to return, automatically, to the original position. In the past, these breakers have been used quite extensively for controlling low voltage, moderate power circuits, such as those used with heating apparatus, signal and alarm systems, and the like. In recent years, however, it has been found desirable to utilize automatically reclosing breakers with high voltage apparatus which may be connected in systems or networks having considerable available power.

For these applications, the previously known devices have proven quite unsatisfactory. Their interrupting capacity is usually limited, particularly on highly inductive circuits; few of these breakers positively open the circuit with a snap action of the moving contacts; practically none of the devices are capable of distinguishing between large and moderate current overloads; and in addition substantially all of the previously known devices are costly to manufacture. It is an object of my invention, therefore, to provide an improved automatically reclosing circuit interrupter that shall be capable of positively interrupting large amounts of power, that shall actuate the contact means with a snap action in both directions of motion, and that shall be simple in structure and inexpensive to manufacture.

Another object of my invention is to provide an improved automatically reclosing circuit breaker that shall utilize the minimum possible number of parts and that shall be as nearly fool-proof as is possible.

A further object of my invention is to provide an improved automatically reclosing circuit breaker that shall include means for causing the actuation of the circuit breaker substantially instantaneously upon the occurrence of predeter-

mined conditions, and after a predetermined time delay upon the occurrence of other predetermined conditions.

A still further object of my invention is to provide an improved circuit breaker that shall include means operable in response to the movement of a handle member to cause the actuation of the interrupter, that shall include actuating means for causing the interrupter to operate as an automatically reclosing breaker, and that shall include means for selecting one or the other of the two actuating means.

An ancillary object of my invention is to provide a manually operable, trip-free circuit breaker that shall include selective means actuable to cause the breaker to operate as an automatically reclosing device.

These and other objects of my invention will be made more apparent by reference to the following drawings and description of two preferred embodiments of my invention. The first of these preferred embodiments is a circuit breaker of the automatically reclosing type, and the second is a circuit breaker which includes means selective to cause the actuation of the contacts either in response to movement of the operating handle or through the operation of automatic reclosing means.

Figure 1 is a plan view of a single pole, double break circuit interrupter of the automatically reclosing type, wherein are embodied the principal features of applicant's invention; the cover has been removed to more clearly illustrate the various structural elements.

Figs. 2 to 6, inclusive, are sectional views on the line II—II of Fig. 1, and show the moving parts of the circuit breaker illustrated in Fig. 1 in various positions assumed during the operation of the device.

Fig. 7 is a fragmentary view showing the details of the means used for supporting the switch members of both modifications of applicant's invention.

Fig. 8 is a fragmentary view of a single pole double break circuit interrupter which includes means responsive to the movement of an operating handle for causing the actuation of the contacts, and which also includes automatic means for causing the interrupter to operate as an automatically reclosing device. The view is taken on the line VIII—VIII of Fig. 9.

Figs. 9, 10 and 11 are sectional views on the line IX—IX of Fig. 8 and show the moving parts of the circuit interrupter illustrated in that figure in various positions, and

Fig. 12 is a sectional view showing a circuit interrupter embodying the features of my invention in use with a transformer, the entire interrupter structure being positioned within the transformer tank beneath the normal level of the cooling liquid disposed therein.

The automatically reclosing circuit breaker illustrated in Figs. 1 to 6, inclusive, includes a pair of looped switch arms 3, preferably of bimetallic material, which are mechanically connected to each other at one end by a suitable tie link 5, and which include contact means 7 supported at the other end; means for pivotally supporting the assemblage formed by the two interconnected switch arms 3; a pivotally supported actuating member 9 movable between two positions; a spring means 11 for operatively connecting the assemblage of switch arms and the actuating member; and a pair of stationary contacts 13 for cooperating with the moving contacts 7 to open and to close the circuit. In the illustrated embodiment, the cooperating contacts are normally held in the circuit closed position. Upon the occurrence of predetermined conditions, the bimetallic switch arms 3 are adapted to cause sufficient relative movement between the line of action of the over-center spring 11, which connects the switch arms 3 and the actuating member 9, and the pivot points of the actuating member and the switch arms to cause the contacts to be moved to the open circuit position. The contacts then remain in this position for a predetermined period of time, following which the interrupter is automatically restored to the closed circuit position. The pivot points of the assemblage of switch members and the actuating member are spaced from each other in such manner that the contacts are moved to both the circuit closed position and to the open circuit position with a snap action.

The various parts of the circuit breaker are mounted upon a base 15 which is preferably of molded insulating material, and, if desired, a cover 17 such as that shown in Fig. 2 may be provided for enclosing the moving parts of the device. The cover is likewise preferably of molded insulating material. Two strips of conducting material 19 are supported on the base 15 by means of screws 21. A portion of each of these conducting strips 19 extends through the upstanding side portion 23 of the base member 15 in order to provide terminals for the breaker, suitable screws 25 being provided for connecting the line conductors thereto. One of the stationary contacts 13 is affixed to the other end of each of these conducting strips 19, in order to cooperate with the similarly proportioned contact 7 affixed to one end of each of the bimetallic switch arms 3.

Each of the bimetallic switch arms 3 comprises a substantially flat strip of bimetallic material which is looped back upon itself, and which is provided with a pivot pin 27 affixed to the central portion of the loop (Fig. 7). The ends of each of the two looped switch members opposite to the ends whereon the contacts 7 are supported are electrically and mechanically connected by means of the tie member 5, which comprises a flat strip of conducting material riveted thereto by two rivets 29.

The inter-connected switch arms 3 are adapted to be pivotally supported upon two upstanding members 31 of insulating material each of which is provided with a suitable bearing portion 33 (Fig. 7) for engaging one of the pivot pins 27 affixed to the central portion of each of the looped

switch arms 3. Each of these upstanding members 31 engages a suitable recess 35 in the base 15 of the circuit breaker and is adapted to be retained therein by means such as the screws 37. A U-shaped support member 39, which is likewise affixed to the base 15 by means of suitable screws 41, is provided for supporting the actuating member 9, two pivot pins 43 being provided for engaging the two bearing portions 45 of that member.

The actuating member 9 is substantially U-shaped and the portion 47 which connects the two side portions of the U is provided with an opening 49 for engaging one end of the overcenter spring 11. In order to facilitate the operation of the interrupter, the portion of the actuating member which directly engages the spring 11 is preferably formed as is shown in Figs. 2 to 6 with a knife edge 51. The other end of the overcenter operating spring 11 is adapted to engage a suitable opening 53 (Fig. 1) and similar knife edge (not shown) provided in the tie member 5 which connects the two pivoted switch arms 3.

A bracket member 55, which is fastened to the base 15 by suitable means (not shown), is provided for defining the limits of motion of the actuating member 9, these limits being adjustable by means of the set screws 57 and 59 and their associated nuts 61. The limit of motion of the interconnected switch arms 3 in a counterclockwise direction about their pivot point 53 is defined by the engagement of the moving contacts 7 with the stationary contacts 13, and the movement of the switch arms 3 in a clockwise direction is defined by the engagement of the upper side of the contact end of each of those members with the projection 65 that extends outwardly from the upstanding portion 23 of the base 15, as is shown particularly in Figs. 5 and 6.

The electrical circuit through the breaker is comparatively direct: Beginning with the lower conducting strip 19 (Fig. 1) the current flows successively through the lower stationary contact 13, the cooperating moving contact 7, the associated looped switch arm 3, thence through the tie member 5 which connects one end of each of the looped switch members, the other looped switch member 3 and its associated contact 7 to the secondary stationary contact 13, and thence through the second conducting strip 19 to the other terminal portion. It will be noted, as is shown particularly in Fig. 1, that the space between the two switch members is entirely clear in order to permit free motion of the overcenter operating spring 11 therebetween.

The circuit breaker is shown in the closed circuit position in Fig. 2. Upon the occurrence of an overload condition, of sufficient magnitude and duration to cause appreciable heating of the bimetallic switch arms 3, those members begin to move the tie member 5 in a direction away from the base 15 of the interrupter. So long as this movement does not bring the line of action of the overcenter spring (indicated by the line 66 in Figs. 2 and 3) to a position above the pivot point 69 of the actuating member 9—the center of the pins 43—(i. e., above the position shown in Fig. 3) the breaker will remain in the closed circuit position. If, however, the overload is of sufficient magnitude and duration to cause the tie member 5 to be moved to the position shown in Fig. 4, it becomes immediately apparent that the circuit interrupter is in an unstable position, due to the fact that the overcenter spring 11 now exerts a component of force tending to bias the

actuating member 9 in a counterclockwise direction about its pivot point 69. This component of force causes the actuating member 9 to move from the position shown in full in Fig. 4 to the position indicated by the dotted lines in that figure. The movement once initiated takes place with a progressively increasing acceleration due to the fact that any movement of the actuating member 9 from the lower position toward the upper position results in a progressive increase in the component of force tending to produce that movement.

When the actuating member moves, as described above, from the lower position to the extreme upper position, the line of action of the overcenter spring 11 is moved from the position indicated by the line 67 in Fig. 4 to the position indicated by the line 68. That is, the line of action of the spring 11 is moved above the pivot point 63 of the inter-connected switch members 3 thereby producing a component of force tending to move those members in a clockwise direction about their pivot. This results in the immediate movement of the switch members from the closed-circuit position to the open-circuit position (illustrated in Fig. 5) where it will be noticed that the overcenter spring 11 exerts a component of force biasing both the actuating member 9 and the interconnected switch members 3 to the position shown.

If the circuit opening producing movement of the bimetallic switch arms 3 has been caused by the flow therethrough of overload currents, the opening of the interrupter will immediately cause the interruption of the controlled circuit, and the switch arms will begin to cool and return to their normal cooled position (Fig. 2). The cooling of the bimetallic switch members 3 moves the tie member 5 and with it the line of action of the overcenter spring 11 from the position indicated by the line 70 in Fig. 5 to the position indicated by the line 72 in Fig. 6. In this position, the overcenter spring 11 exerts a component of force tending to move the interconnected switch members 3 in a counter-clockwise direction about their pivot point 63, and since there is no force opposing this component, the breaker is again in an unstable position and the interconnected switch arms 3 will begin to move toward the closed circuit position. This movement will take place with a progressively increasing acceleration, exactly similar to that accompanying the opening movement of the actuating member 9 and the switch members, due to the fact that any additional movement of the switch members results in a progressive increase in the component of force tending to produce that movement. Thus, the interconnected switch members move to the closed circuit position (shown by dotted lines in Fig. 6) with a snap action. The movement of the switch members 3 to the closed-circuit position causes the line of action of the overcenter spring 11 to be brought to a position beneath the pivot point 69 of the actuating member, as is indicated by the line 74 in Fig. 6, thereby producing a component of force tending to move the actuating member 9 in a clockwise direction about its pivot point. The ultimate result of this is to cause the actuating member to return to the position shown in Fig. 2.

It will be noted that during the operation of this embodiment of my invention the contacts of the circuit interrupter are held in the closed circuit position with a definite force up until the instant that the line of action of the overcenter

spring 11 crosses the pivot point of the inter-connected switch members 3. However, since this movement of the line of action across the pivot point of the switch members takes place at comparatively high speed, due to the rapid acceleration previously imparted to the actuating member 9, and due to the fact that the contact means immediately thereafter begin to move to the open-circuit position with a snap action, it is proper to state that the moving contacts are held in the closed circuit position up until the instant of contact separation with a definite force.

In the above description of the operation of a preferred embodiment of my automatically reclosing circuit interrupter, it has been assumed that the movement of the bimetallic switch members 3 occurred in response to internal heating produced by the flow therethrough of overload current. It is quite possible, however, to cause automatic operation of the device to take place as a result of changes in the temperature of the medium surrounding the breaker. Thus, if the automatically reclosing circuit breaker is disposed within a transformer tank in such manner that the bimetallic switch arms are in contact with the oil used for insulating the transformer (as is shown in Fig. 12), the operation of the breaker might result from increases in the temperature of the oil which were produced by internal arcing due to localized insulation breakdown, or by prolonged small overloads, themselves not capable of causing sufficient internal heating of the bimetallic switch arms to effect an opening of the breaker. If the operation of the circuit breaker is effected by the heating of a surrounding medium, such as oil, the breaker will probably remain in the open circuit position for a very considerable period of time, due to the fact that the cooling of a large body of oil such as is found within a transformer tank will take place comparatively slowly. This arrangement is very desirable in that it permits the use of the transformer or like device up until the heating induced by the overload reaches a dangerous point, and after operation, it removes the transformer or other equipment from the circuit for a sufficient period of time to assure the overload condition being brought to the attention of the proper parties.

The amount of movement of the tie member 5 necessary to cause the actuation of the breaker may be readily adjusted through the set screws 57 and 59 and their associated nuts 61 which together define the limitations of motion of the pivoted actuating member 9. These adjusting screws permit the breaker to be calibrated over a reasonably wide range of current or temperature values and in addition permit changes or adjustments in the calibration of the device to be readily made at any time.

The details of the method which I prefer to use for pivotally supporting the assemblage of switch arms is shown in detail in Fig. 7. The pivot pin 27, which is riveted or otherwise securely fastened to the closed portion of each of the looped switch arms 3, is preferably formed of a hard bearing material. The pivot pin 27 is, as discussed previously, adapted to engage the cooperating member 33 disposed in the upper portion of each of the support members 31, a suitable threaded opening being provided therein. The cooperating member 33 comprises a substantially cylindrical means preferably of hard material having a conical shaped recess 71 therein for engaging the pointed end of the pivot pin.

The second preferred embodiment of my invention which is illustrated in Figs. 8 to 11, inclusive, is essentially similar to the previously described device in that it includes means for causing automatic reclosing of the breaker upon the occurrence of predetermined conditions. In addition, however, this modification includes a handle member which is manually or otherwise movable to cause the circuit breaker to be moved to either the open or the closed-circuit position, and selective means for determining whether the operation of the interrupter shall be in response to movement of the operating handle or shall be automatic.

Generally, this modified form of my invention comprises a base 101 of molded insulating material having four upstanding side portions 103 integral therewith, a pair of looped switch members 105 of bimetallic material each of which is provided with a movable contact 107 affixed to one end thereof, stationary contacts 109 for cooperating with the moving contacts, a pivoted switch actuating member 111, an overcenter spring 113 for operatively connecting the pivoted switch members 105 and the actuating member 111, an operating handle 115, and a latch means 117 for holding the operating handle in one position so as to cause the interrupter to operate as an automatically reclosing breaker. The stationary contacts 109 and their associated conducting strips 119 which form the terminals of the device are exactly similar to the conducting strips and contacts shown in the embodiment disclosed in Figs. 1 to 7. Likewise, the assemblage of switch members 105 and the support means therefor, which includes the two support members 121 are essentially the same as the similar members disclosed in the above described embodiment of my invention.

The actuating member 111 is likewise similar to the actuating member 9 described previously. It includes, however, an additional portion 123, which is adapted to be operatively engaged by the operating handle 115. This portion 123 is substantially Y shaped, as is shown in Fig. 8, and is mechanically connected to the side portions of the actuating member 111 by means of two rivets 125. The actuating member 111 is pivotally supported, through the agency of two pivot pins 126 on a substantially U-shaped frame member 127 which, in turn, is affixed to the base 101 by a pair of suitable screws 129. In addition to the pins 126 which are used for supporting the actuating member, a second pair of pivot pins 131 is supported on the U-shaped frame member. These pins 131 are adapted to pivotally support the bifurcated portion 133 of the operating handle 115, as is shown particularly in the drawings.

The operating handle 115, in addition to the bifurcated portion 133 which engages the pivot pins 131 is provided with a handle portion 135 of insulating material adapted to extend through a suitable opening 137 in the cover 104, and a pair of downwardly projecting portions 139 and 141 which are adapted to provide surfaces for cooperating with the end portion 143 of the member 123 affixed to the actuating member 111. The surfaces provided by these downwardly projecting portions 139 and 141 are spaced some distance from each other and thereby permit the actuating member 111 to move independently of the operating handle once the mechanism of the interrupter has been set in motion. This arrangement is of particular value in assuring the

opening and closing of the circuit breaker contacts with a snap action, and adds much to the reliability of operation of the device.

A latching pin 145 (Fig. 8) extends outwardly from the upper side portion 133 of the operating handle 115. This pin is adapted to cooperate with a pivotally supported latching member 147, biased to the latched position by a suitable spring 149, to hold the operating handle in the closed circuit position. The latching member 147, in turn, is provided with a projecting member 151 of insulating material which extends through a slotted opening 153 in one of the upstanding side portions 103 of the base 101. This member 151 permits the latching member 147 to be moved so as to disengage the operating handle and permit manual operation of the interrupter.

The circuit breaker is shown in the normal open-circuit position in Fig. 9. To close the contacts, the operating handle 115 is moved from the position shown in Fig. 9 to the position shown in Figs. 10 and 11. This movement of the operating handle causes the downwardly projecting portions 139 and 141 and the actuating member 111 to move from the position shown in full lines in Fig. 9 to the position shown in dotted lines in Fig. 9. It will be noted that the line of action of the over-center spring 113 has thereby been moved from a position above the pivot point 157 of the assemblage of switch members (indicated by the line 155) to a position below that pivot point (indicated by the line 159, the interrupter is thus in an unstable position, mechanically, and the switch members 105 immediately begin to move to the closed circuit position with a constantly increasing acceleration; due to the fact that any movement of the switch members causes a progressive increase in the force producing that movement. The contacts are thus closed with a snap action, and in moving to the closed position, carry the line of action of the over-center spring 113 from the position indicated by the line 159 to the position indicated by the line 161, or, in other words, carry the line of action beneath the pivot point 163 of the actuating member 111. The result of this is to cause the actuating member 111 to likewise move to the fully closed position (Fig. 10), independently of the operating handle 115.

The spacing of the surfaces provided by the downwardly projecting portions 139 and 141 is such that once the actuating member 111 has been moved to a position where the closing operation begins (that is, to a position where the portion 143 of the actuating member disengages the downwardly projecting portion 139 which initiated the movement) that member is free to move, independently of the operating handle to the closed circuit position, in which position the actuating member 111 is completely disengaged from the operating handle 115, as is shown in Fig. 10.

In the above description of the operation of the breaker, the movement of the assemblage of switch members to the closed circuit position and the movement of the actuating member 111, from the position shown in dotted lines in Fig. 9 to the position shown in full lines in Fig. 10 has been described as taking place in two steps. Actually, these movements are carried out substantially instantaneously, due to the fact that each member once set in motion proceeds with a constantly increasing acceleration to its final position.

Under normal conditions, when the handle 115 is moved to the closed-circuit position, it is

latched-in through the engagement of the slot 166 in the latching member 147 with the pin 145 affixed to one of the side portions 133 of the handle. If it is desired to manually open the circuit controlled by the interrupter, the latching member 147 is lifted and the handle is moved in a counter-clockwise direction from the position shown in Fig. 10. During this movement, the downwardly projecting portion 141 engages the portion 143 of the member 123 rigidly affixed to the actuating member 111 and moves that member a sufficient distance to cause the line of action of the overcenter spring 113 to move above the pivot point of the actuating member, the center of the pin 126. The portion 143 of the actuating member 111 then disengages the downwardly projecting portion 141 and moves automatically, under the biasing action of the overcenter spring 113 to the position shown in Fig. 9. In moving to this position, the line of action of the overcenter spring 113 is carried across the pivot point 157 of switch member 105 and those members likewise move to the open circuit position, as shown in Fig. 9, with a snap action. The fact that the line of action of the over-center spring 113 has been carried across the pivot point 157 of the switch member causes the switch member to remain in its open-circuit position until the handle is moved to closed-circuit position. This is the case even though, as described later, the interrupter is made to automatically return to closed-circuit position when opened in response to an over-load.

When the circuit breaker is in the position shown in Fig. 10, in which position the handle is held against motion in either direction by the latch member 147, and an overload, or increase in the temperature of the ambient medium occurs, the bimetallic switch arms 105 expand in such manner that the tie member 167 is moved away from the base 101 of the circuit breaker. If the overload or increase in ambient temperature is of sufficient magnitude and duration to cause the tie member 167 to be moved from the position shown in full lines in Fig. 10 to a position substantially coinciding with that shown in dotted lines in Fig. 10, the line of action of the overcenter spring 113 will be carried across the pivot point of the actuating member 111 (that is, from the position indicated by the line 169 to the position indicated by the line 171) and the spring will exert a component biasing that member in a counter-clockwise direction. The immediate result is to cause the actuating member 111 to move from the position shown in Fig. 10 to the position shown in Fig. 11, the limit of the counter-clockwise motion being defined by the engagement of the portion 143 of the actuating member with the downwardly projecting member 139 which comprises a part of the operating handle 115. As the actuating member 111 moves about its pivot point, the line of action of the overcenter spring is carried above the pivot point of the assemblage of switch members (that is, from the position indicated by the line 171 to the position indicated by the line 173) thereby causing those members to be moved from the closed circuit position (Fig. 10) to the open circuit position (Fig. 11) with a snap action. The various elements of the interrupter are then in the position shown in Fig. 11.

As the bimetallic switch arms cool, either due to the interruption of an overload current flowing therethrough, or because of changes in the ambient temperature, the tie member 167, and with

it the line of action of the overcenter spring, is moved from the position shown in full lines in Fig. 11 to the position shown in dotted lines in Fig. 11. In this latter position, the assemblage of switch members is biased to the closed circuit position, and, of course, begins to move immediately to that position. As this movement progresses, the line of action of the overcenter spring 113 is carried beneath the pivot point of the actuating member and that member disengages the operating handle and moves automatically back to the position shown in Fig. 10. The breaker thus operates as an automatically reclosing breaker when the handle 115 is latched in the closed-circuit position.

Both the opening and closing operations once initiated take place substantially instantaneously, thus the contacts are held in the closed circuit position by a definite force up until the final stages of the circuit opening operation and are then moved from the closed position to the open circuit position with a snap action. Likewise, the contacts are closed with a snap action and once they have engaged, are held in such engagement with a very appreciable force, comparable in magnitude to the normal contact pressure securing force. Through this arrangement, I have made possible a thermally responsive circuit breaker which is capable of carrying reasonably high currents, and which is capable of interrupting very considerable amounts of power.

The downwardly projecting portions 139 and 141 which provide opposed surfaces for engaging the actuating member comprise in effect a lost motion connection between the operating handle 115 and the actuating member 111. Thus, even though the handle 115 is held in the closed-circuit position, manually or through the agency of the latching means 117, the breaker will open automatically upon the occurrence of overload or other conditions. The interrupter may be said, therefore, to be entirely trip free of the operating handle.

One feature of my invention which is common to both embodiments of my invention and which has not previously been discussed, is the arrangement of the looped switch arms (3 and 105) and the effect thereon of the magnetic reactions resulting from the flow therethrough of heavy overload currents. It will be noted, as is shown particularly in the drawings, that the current path through both of these members is, by virtue of their looped construction, substantially in opposite directions. Thus, when very heavy overload currents flow therethrough the magnetic repulsion existing between the opposed side portions of the switch arms may be sufficient to move the tie member to a position where automatic operation of the breaker will be caused to take place. In the automatic reclosing breaker, this arrangement gives added protection to the connected equipment due to the fact that the breaker will open substantially instantaneously upon the occurrence of transient overloads of very large magnitude, thus limiting the current flow in the protected equipment and preventing damage thereto, and yet at the same time will reclose almost immediately thereafter unless the duration was sufficient to overheat the bimetal. Discontinuities of service are thereby reduced to a minimum, and in addition a maximum of protection is given to the connected equipment. Similarly, in the modification illustrated in Figs. 8 to 10, inclusive, the breaker will open substantially instantaneously upon the occurrence of heavy mag-

nitide overload conditions and will remain open if the handle has not been latched in the open circuit position, or will reclose within a short period of time if the handle is latched in the position for causing automatic operation of the device.

The magnetically produced movement of the tie member (5 or 167), is opposed by the inherent resiliency of the switch members themselves and thus is not readily adjustable when the design has been decided upon. However, it rarely occurs that much flexibility in this regard is either desired or necessary, because overloads upon which instantaneous operation is desired are ordinarily of a magnitude many times the maximum safe overload that the protected device can carry for any appreciable length of time.

From the above, it will be seen that I have disclosed a new and improved automatic reclosing circuit interrupter which is simpler in design and more reliable in operation than the previously known devices of this type, which opens and closes the cooperating contacts with a snap action and which is responsive either to the current flowing in the control circuit or to the temperature of the ambient medium.

In addition, I have disclosed an automatically reclosing breaker, having the above-described desirable characteristics, which include an operating handle manually or otherwise movable to effect operation of the breaker, and which includes selective means whereby the operation of the interrupter may be effected in response to movement of the operating handle or automatically as an automatically reclosing breaker. Furthermore, the automatically reclosing breaker, according to my invention is entirely trip free of the operating handle and is as substantially fool proof in operation as is known in the art at the present time.

While, in accordance with the patent statutes, I have disclosed the details of two preferred embodiments of my invention, it is to be understood that many of the details disclosed are merely illustrated and that variations in their precise form will be both necessary and desirable in certain applications. I desire, therefore, that the language of the accompanying claims shall be accorded the broadest reasonable construction and that my invention shall be limited only by what is expressly stated therein and by the prior art.

I claim as my invention:

1. In a thermostatic device, a member having at least a portion thereof of thermally responsive material, one end of said member being movable between two extreme positions during the operation of said device, means for pivotally supporting said member intermediate its ends, the other end of said member being movable, upon the occurrence of predetermined conditions, without moving said first-mentioned end to actuate said device, and means operable in response to the movement of said other end to cause said first-mentioned end to move from one extreme position to the other with a snap action and to automatically return to its original position.

2. In a thermostatic device, a member having at least a portion thereof of thermally responsive material, one end of said member being movable between two extreme positions during the operations of said device, means for pivotally supporting said member intermediate its ends, the other end of said member being movable, upon the occurrence of predetermined conditions, with-

out moving said first-mentioned end to actuate said device, and means, including an overcenter spring, operable in response to the movement of said other end to cause said first-mentioned end to move from one extreme position to the other, with a snap action, and to automatically return, likewise with a snap action, to its original position after a predetermined time interval.

3. In a circuit interrupter, a member having at least a portion thereof of bimetallic thermally responsive material, contact means supported adjacent one end of said member, said end being movable between two extreme positions in order that said contact means may be moved to an open-circuit position and to a closed-circuit position, means for pivotally supporting said member intermediate its ends, the other end of said member being movable, upon the occurrence of predetermined conditions, without causing substantial movement of said end upon which said contact means is supported, and means operable in response to the movement of said other end to cause said contact supporting end to move said contact means from one position to the other and to automatically return said contact means to its original position upon the occurrence of a predetermined condition.

4. In a circuit interrupter, a switch member comprising a flat strip of bimetallic material, contact means supported adjacent one end of said member, said end being movable between two extreme positions to effect the movement of said contact means to the open-circuit and to the closed-circuit position, means for pivotally supporting said member intermediate its ends, the other end of said member being movable, upon the occurrence of predetermined conditions, independently of said end upon which said contact means is supported, and means operable in response to the movement of said other end to cause said contact supporting end to move said contact means from one position to the other with a snap action and to automatically return said contact means to its original position likewise with a snap action.

5. In a circuit interrupter, contact means movable between two extreme positions to open and to close the circuit, and operating means for causing said movable means to move from one extreme position to the other extreme position upon the occurrence of predetermined conditions, and to automatically return to the original position upon the occurrence of other predetermined conditions, said operating means including a pivoted contact actuating member having at least a portion thereof of thermally responsive material, and an overcenter spring for moving said actuating member to the open-circuit and to the closed-circuit position with a snap action, said portion of thermally responsive material being movable when heated to cause relative movement between the line of action of said spring and the pivot point of said actuating member.

6. In a circuit interrupter, contact means movable between two extreme positions to open and to close the circuit, and operating means for causing said contact means to move from one extreme position to the other, with a snap action, upon the occurrence of predetermined conditions, and to automatically return to the original position, likewise with a snap action, upon the occurrence of other predetermined conditions, said operating means including a pivoted contact actuating member having at least a portion thereof of bimetallic material, a second pivoted member, and an over-

center spring connected intermediate said pivoted members, said portion of bimetallic material being movable upon the occurrence of predetermined conditions to cause sufficient relative movement between the line of action of said spring and the pivot point of said actuating member to effect the actuation of said interrupter.

7. In a circuit interrupter, contact means movable between two extreme positions to open and to close the circuit, and operating means for causing said contact means to move from one extreme position to the other, with a snap action, upon the occurrence of predetermined conditions, and to automatically return to the original position, likewise with a snap action, upon the occurrence of other predetermined conditions, said operating means including a pivoted, contact actuating member having at least a portion thereof of bimetallic material, a second member pivotally supported at a point spaced some distance from the point of support of said actuating member, and an over-center spring means connected at one end to each of said pivoted members, said portion of bimetallic material being movable upon the occurrence of predetermined conditions to cause sufficient relative movement between the line of action of said spring and the pivot points of said pivoted members to effect the actuation of said interrupter.

8. In a circuit interrupter, contact means movable between two extreme positions to open and to close the circuit, and actuating means for said contact means, said actuating means including an operating handle movable, through the application thereto of a suitable force, to cause said contact means to move from one position to the other, and means automatically operable, independently of said operating handle, upon the occurrence of predetermined conditions to cause said contact means to move from one position to the other and to automatically return to the original position after a predetermined time delay.

9. In a circuit interrupter, contact means movable between two extreme positions to open and to close the circuit, and actuating means for said contact means, said actuating means including an operating member movable, through the application thereto of a suitable force, to cause said contact means to move from one position to the other, automatic means operable upon the occurrence of predetermined conditions to cause said contact means to move from one position to the other and to automatically return to the original position after a time delay, and selective means for causing the operation of said interrupter to be in response to movement of said operating member or in response to the actuation of said automatic means.

10. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including a handle means movable to cause said contact means to move from one position to the other, electro-responsive means operable upon the occurrence of predetermined conditions to cause said interrupter to move from one position to the other, irrespective of the position of said handle means, and means automatically operable to cause said interrupter to return to said first position, upon the occurrence of other predetermined conditions, following the operation of said electro-responsive means.

11. In a circuit interrupter, contact means mov-

able to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including a handle means movable to cause said contact means to move from one position to the other, electro-responsive means operable upon the occurrence of predetermined conditions to cause said interrupter to move from one position to the other, irrespective of the position of said handle means, means, operable when said handle means is held in a predetermined position, to cause said interrupter to return automatically to said first position, following the operation of said electro-responsive means, and releasable means for holding said handle means in said predetermined position.

12. In a circuit interrupter, contact means movable between two positions to open and to close the circuit, and actuating means for said contact means, said actuating means including a handle member movable to cause said contact means to move from one position to the other, means for restraining said handle in one position, and means operable upon the occurrence of predetermined conditions, when said handle is held in one position by said restraining means, to cause said contact means to move from one position, to the other and to automatically return to the original position upon the occurrence of other conditions.

13. In a circuit interrupter, contact means movable between two positions to open and to close the circuit, and actuating means for said contact means, said actuating means including a handle member movable to cause said contact means to move from one position to the other, with a snap action, releasable means for restraining said handle in one position, and means operable upon the occurrence of predetermined conditions, when said handle is held in one position by said restraining means, to cause said contact means to move from one position to the other with a snap action and to automatically return to the original position likewise with a snap action after the occurrence of other conditions.

14. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including means which is operable upon the occurrence of predetermined conditions to cause said contact means to move from one position with a snap action to the other position, to remain in said other position for a predetermined short interval of time, and to then return to said first position, likewise with a snap action, and which is operable upon the occurrence of other predetermined conditions to cause said contact means to move from one position to the other position with a snap action, to remain in said other position for a predetermined longer interval of time, and to then return to said first position also with a snap action.

15. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including a handle means movable to cause said contact means to move from one position to the other and spring means operatively interposed between said handle means and said contact means for causing said contact means to move with a snap action to each of said positions upon movement of said handle means, electroresponsive means operable upon the occurrence of predetermined conditions to cause said interrupter to move from

one position to the other, irrespective of the position of said handle means, and means automatically operable to cause said interrupter to return to said first position, upon the occurrence of other predetermined conditions, following the operation of said electro-responsive means.

16. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including a handle means movable to cause said contact means to move from one position to the other, electro-responsive means operable upon the occurrence of predetermined conditions to cause said interrupter to move from one position to the other, irrespective of the position of said handle means, means automatically operable to cause said interrupter to return to said first position, upon the occurrence of other predetermined conditions following the operation of said electro-responsive means, and said handle means being incapable of returning said contact means to said first position after the occurrence of the first said predetermined conditions until the occurrence of said other predetermined conditions.

17. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including a handle means movable to cause said contact means to move from one position to the other and spring means operatively interposed between said handle means and said contact means for causing said contact means to move with a snap action to each of said positions upon movement of said handle means, electro-responsive means operable upon the occurrence of predetermined conditions to cause said interrupter to move from one position to the other, irrespective of the position of said handle means, means automatically operable to cause said interrupter to return to said first position, upon the occurrence of other predetermined conditions, following the operation of said electro-responsive means, and said handle means being incapable of returning said contact means to said first position after the occurrence of the first said predetermined conditions until the occurrence of said other predetermined conditions.

18. In a circuit interrupter, contact means movable between two extreme positions to open and to close the electrical circuit through said interrupter, and actuating means for said contact means, said actuating means including an operating member, an over-center spring associated therewith, said operating member being movable to cause said over-center spring to move said contact means from one position to the other with a snap action, and automatic means operable upon the occurrence of predetermined conditions to cause said over-center spring to move said contact means from one position to the other, irrespective of the position of said operating member, with a snap action, and to automatically return said contact means to the original position after a time delay.

19. In a circuit interrupter, a stationary contact means, a pivotally supported switch arm for cooperating therewith to open and to close the electrical circuit through said interrupter, and actuating means for said switch arm, said actuating means including an operating handle, an over-center spring intermediate said operating handle and said switch arm, said operating han-

dle being movable to cause said over-center spring to move said switch arm to either the open circuit or the closed circuit position with a snap action, and automatic means operable independently of said operating handle, upon the occurrence of predetermined conditions to cause said over-center spring to move said switch arm from one position to the other and to automatically return said switch arm to the original position after a predetermined time delay, said automatic means including a thermally responsive bimetallic means which is movable to cause a displacement, relative to the pivot point of said switch arm, of the line of action of said over-center spring.

20. In a circuit interrupter, a stationary contact means, a pivotally supported switch arm for cooperating therewith to open and to close the electrical circuit through said interrupter, and actuating means for said switch arm, said actuating means including an operating member, an over-center spring intermediate said operating member and said switch arm, said operating member being movable to cause said over-center spring to move said switch arm to either the open circuit or the closed circuit position with a snap action, and automatic means operable upon the occurrence of predetermined conditions to cause said over-center spring to move said switch arm from the closed-circuit position to the open-circuit position with a snap action, irrespective of the position of said operating member, and to automatically return said switch arm to the closed-circuit position following a predetermined time delay, said automatic means including a current-carrying bimetallic means which is movable to cause a displacement, relative to the pivot point of said switch arm, of the line of action of said over-center spring, and means for causing said current carrying bimetallic means to be energized in response to the current flowing in the circuit controlled by said interrupter.

21. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including an over-center spring, a handle means movable to cause said over-center spring to move said contact means from either position to the other with a snap action, current-carrying bimetallic means operable upon the occurrence of predetermined conditions to cause said over-center spring to move said contact means from the closed-circuit position to the open-circuit position, irrespective of the position of said handle means, and means automatically operable to cause said over-center spring to return said contact means to said first position upon the occurrence of predetermined conditions following the operation of said electro-responsive means.

22. In a circuit interrupter, a contact means movable to an open circuit and to a closed circuit position, an actuating means for said contact means including a handle, means operable in response to movement of said handle to move said contact means from one position to the other with a snap action, electro-responsive means operable upon the occurrence of predetermined conditions to cause said contact means to be moved from one position to the other, irrespective of the position of said handle means, and means automatically operable to cause said contact means to be returned to said first position upon the occurrence of other predetermined con-

ditions following the operation of said electro-responsive means.

23. In a circuit interrupter, a contact means movable to an open and to a closed circuit position, an actuating means for said contact means including a handle, means operable in response to movement of said handle to move said contact means from one position to the other with a snap action, electro-responsive means operable upon the occurrence of predetermined conditions to cause said contact means to be moved from the closed circuit position to the open circuit position with a snap action, irrespective of the position of said handle, and means automatically operable to cause said contact means to be returned to said closed circuit position, likewise with a snap action, upon the occurrence of other predetermined conditions following the operation of said electro-responsive means.

24. In electrical apparatus, means movable between two extreme positions to effect the operation of said apparatus, and actuating means for said movable means, including a current-carrying, thermally responsive means operable upon the occurrence of predetermined conditions to cause said movable means to move from one of said two extreme positions to the other and to automatically return to the initial position after a predetermined time delay, the current-carrying path through said thermally responsive element being so arranged that upon the occurrence of other predetermined conditions said actuating means is caused to move said movable means from one of said two extreme positions to the other and to automatically return to the initial position after a different predetermined time delay.

25. In electrical apparatus, means movable between two extreme positions to effect the operation of said apparatus, and actuating means for said movable means, including means operable upon the occurrence of predetermined conditions to move said movable means from one of said two extreme positions to the other with a snap action, to cause said movable means to remain in said other position for a predetermined short interval of time, and to then return said movable means to said first position, likewise with a snap action, and operable upon the occurrence of other predetermined conditions to move said movable means from one position to the other with a snap action, to cause said movable means to remain in said other position for a predetermined longer interval of time, and to then return said movable means to said first position also with a snap action.

26. In electrical apparatus, means movable between two extreme positions to effect the operation of said apparatus, and actuating means for said movable means, including means for establishing a looped current-carrying path through said interrupter, at least a portion of said path comprising a member of thermally responsive material, which is movable from a normal inoperative position to an operative position, and means operable in response to movement of said member to said operative position to cause said movable means to be moved from one of said two positions to the other and to be returned automatically to the initial position, said movable portion being movable to said operative position either in response to the heating effect of the current flowing through said electro-responsive element or in response to the mag-

netic effect resulting from said looped current carrying path.

27. In a circuit interrupter, contact means movable to an open-circuit and to a closed-circuit position, and actuating means for said contact means, said actuating means including a handle means movable to cause said contact means to move from one position to the other, thermally responsive means heated upon the occurrence of predetermined conditions to cause said interrupter to move from one position to the other, irrespective of the position of said handle means, and said thermally responsive means being operable to cause said interrupter to return to said first position, upon cooling.

28. In a circuit interrupter, separable contacts for opening and for closing the electrical circuit through said interrupter, actuating means for said separable contacts including an operating member movable to normally cause said contacts to move either to the open or to the closed-circuit position, electro-responsive means operable upon the occurrence of predetermined conditions to cause said actuating means to move said contacts to the open circuit position, and means operable only after said contacts have been moved to the open-circuit position as a result of the actuation of said electro-responsive means, for causing said actuating means to return said interrupter automatically to the closed-circuit position.

29. In an automatically reclosing circuit breaker, contact means movable to an open and to a closed-circuit position, actuating means for said contact means including an operating member which is movable between two positions to cause said contact means to be moved to the open or to the closed-circuit position, electro-responsive means operable upon the occurrence of predetermined conditions to cause said actuating means to move said contact means to the open-circuit position, and means for causing said actuating means to automatically reclose said contact means following each opening operation which is caused by said electro-responsive means, said means for causing automatic reclosing being inoperative when said contacts are moved to the open-circuit position by movement of said operating member.

30. In a circuit interrupter, contact means movable to an open and to a closed-circuit position, actuating means for said contact means including manually operable means for causing said contact means to be moved to the open or to the closed-circuit position, electro-responsive means operable upon the occurrence of predetermined conditions to cause said actuating means to move said contact means to the open-circuit position independently of the position of said manually operable means, and means for causing said actuating means to automatically return said contact means to the closed-circuit position following each opening operation caused by the operation of said electro-responsive means, said means for causing automatic reclosing being operable only after those opening operations which are caused by said electro-responsive means.

31. In a circuit interrupter, contact means movable to an open and to a closed-circuit position, actuating means for said contact means including an over-center spring means and an operating member, which is movable to cause said over-center spring means to move said contact means from one position to the other with

a snap action, electro-responsive means operable upon the occurrence of predetermined conditions to cause said actuating means to move said contact means to the open-circuit position, likewise
5 with a snap action, and means for causing said actuating means to return said contact means

automatically to the closed-circuit position upon the occurrence of a predetermined condition following each opening operation which is caused by the operation of said electro-responsive means.

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