

Dec. 10, 1957

H. D. EPSTEIN
CIRCUIT BREAKER

2,816,191

Filed Nov. 3, 1953

4 Sheets-Sheet 1

Fig. 2.

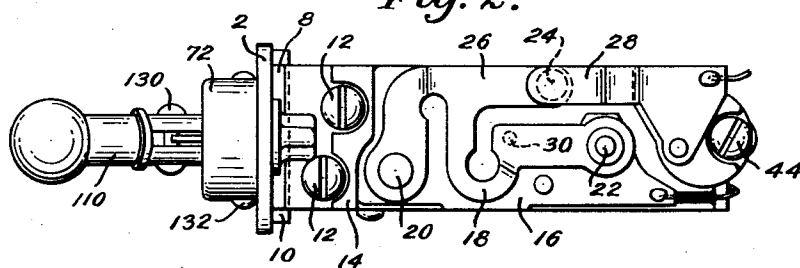


Fig. 1.

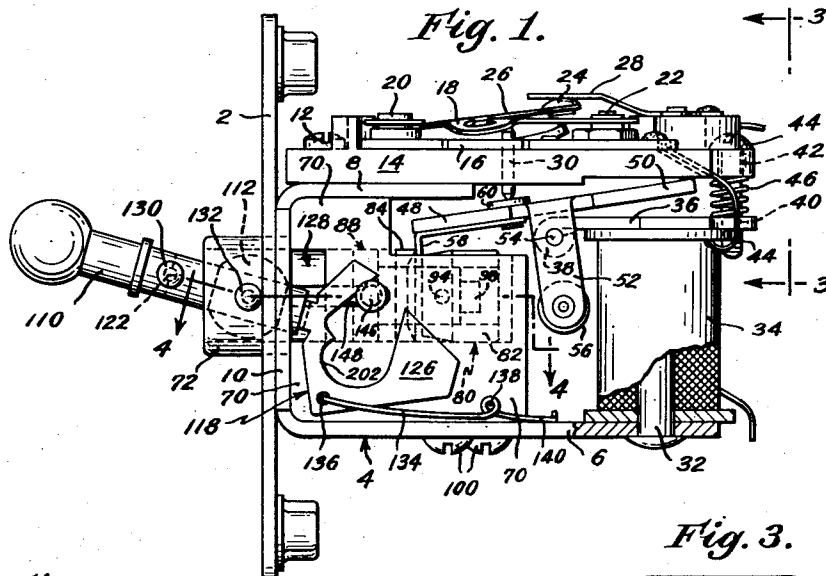


Fig. 3.

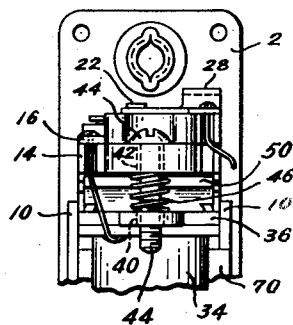


Fig. 4.

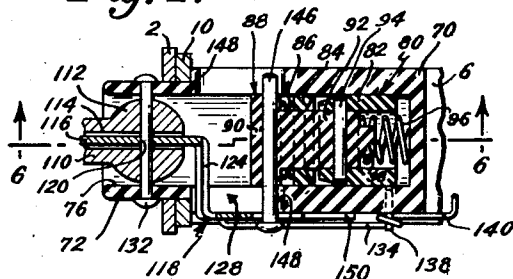
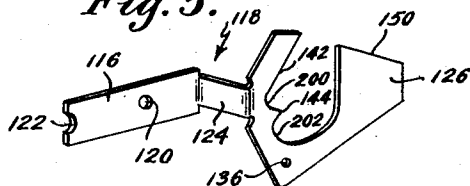


Fig. 5.



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Fig. 9.

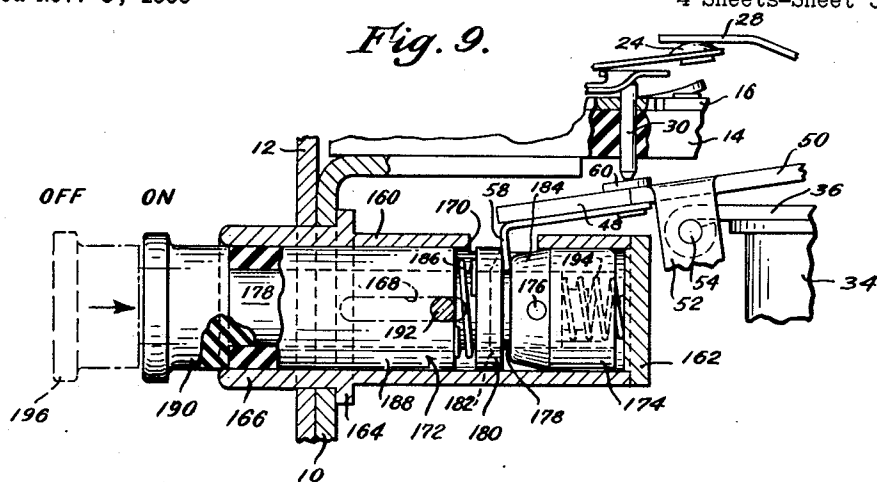


Fig. 10.

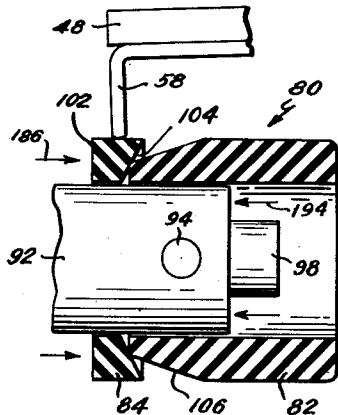


Fig. 11.

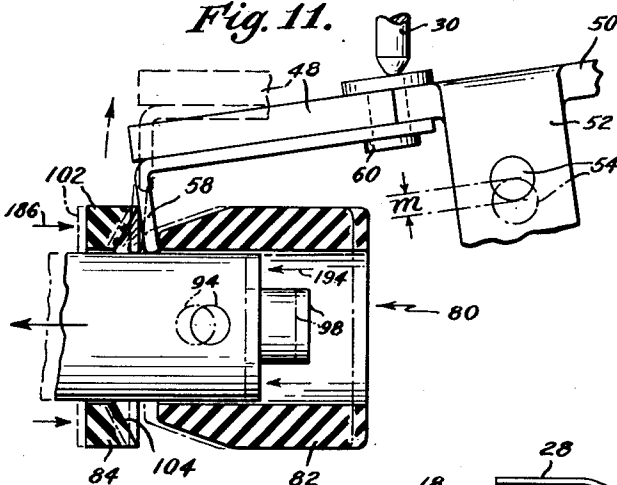


Fig. 13.

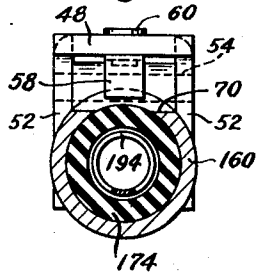
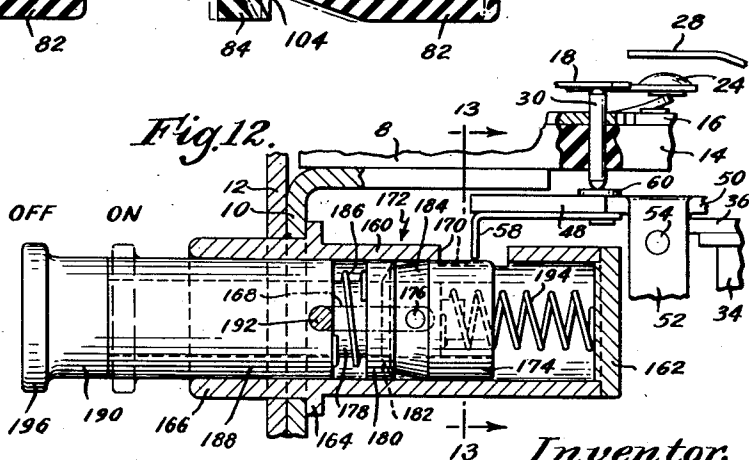


Fig. 12.



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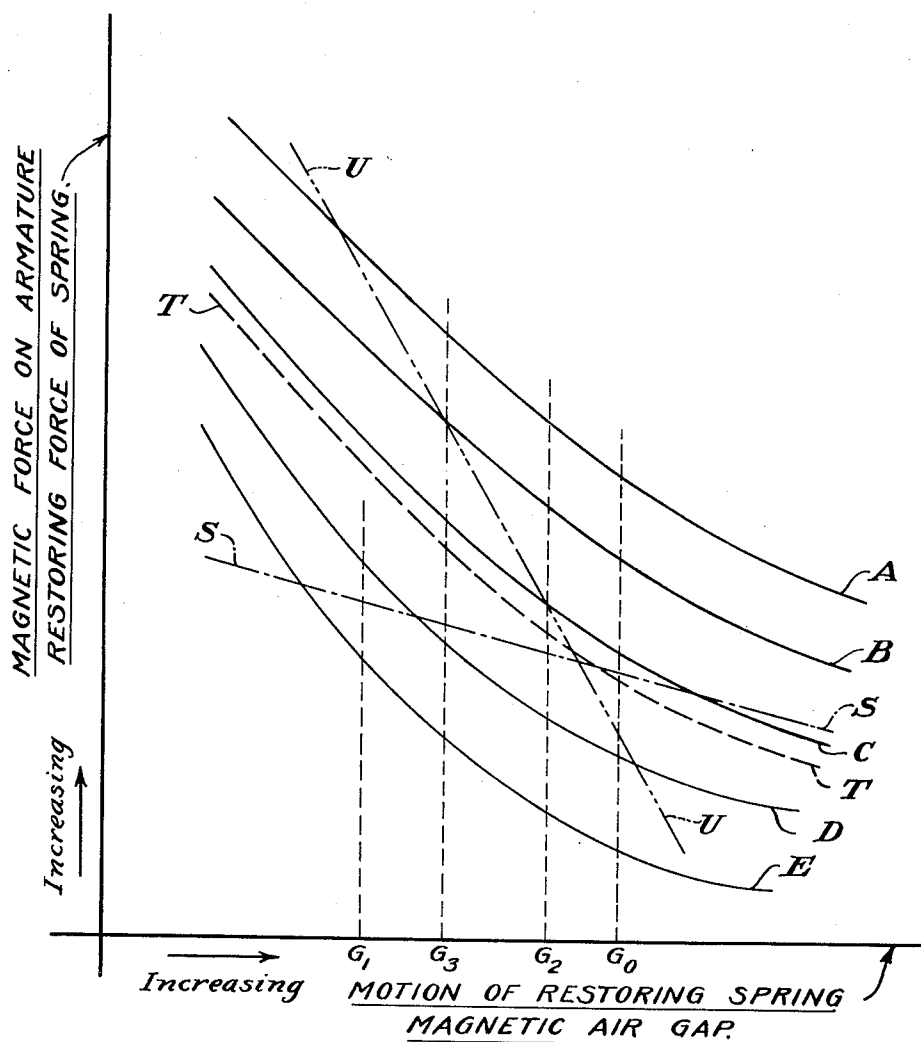
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Fig. 14.



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2,816,191

CIRCUIT BREAKER

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Application November 3, 1953, Serial No. 389,992

14 Claims. (Cl. 200—166)

This invention relates to electrical devices, and in particular to electrical devices such as circuit breakers which may be both manually opened and closed, and such as relays which open or close automatically.

Among the several objectives of the invention may be noted the provision of a combination automatically opening circuit breaker and switch; the provision of an electrical device of the class described which has a high degree of calibration accuracy, as well as a high degree of shock and vibration resistance; the provision of a circuit breaker of the class described which is trip-free in the sense that if the device is closed on the over-load circuit, the contacts will close instantaneously and then open and remain locked open irrespective of the position of the reset knob or handle; the provision of a circuit breaker and/or relay of the class described which indicates whether or not it has tripped to the "off" position; the provision of a circuit breaker and/or relay of the class described in which a magnetic armature serves to operate an independent snap-acting spring switch; the provision of a circuit breaker of the class described in which a lock-out slide is provided to prevent chatter of the circuit contacts; the provision of a circuit breaker of the class described in which the actuating point of the reset detent and the reset detent pivot are so arranged as to provide a mechanical moment which aids in opening the circuit breaker; the provision of a circuit breaker and/or relay of the class described in which simple and fool-proof adjustable means are provided to adjust the relationship between the operating parts of the device; the provision of a circuit breaker of the class described in which the calibration and adjustment are virtually independent of the latch friction; and the provision of an electrical device of the class described which is economical to manufacture.

Other objects and advantages of the invention will be apparent as pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated:

Fig. 1 is a side view of a circuit breaker according to one embodiment of this invention, showing the parts in the contact-closed position;

Fig. 2 is a plan view of the Fig. 1 embodiment;

Fig. 3 is an end view taken in the direction of sight lines 3—3 on Fig. 1, showing an adjusting means;

Fig. 4 is a plan view in section taken on sight lines 4—4 of Fig. 1, showing certain constructional details of the actuating mechanism of this invention;

Fig. 5 is a perspective view of a portion of a toggle switch mechanism;

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Fig. 6 is a cross sectional elevation of a portion of the Fig. 1 embodiment taken in the direction of sight lines 6—6 on Fig. 4, and showing the circuit breaker parts in the "on" position;

Fig. 7 is a view similar to Fig. 6, but showing the parts in the "off" position;

Fig. 8 is a view similar to Figs. 6 and 7, but showing the circuit breaker parts in an intermediate position, which position they occupy when the device has tripped automatically;

Fig. 9 is a view similar to Fig. 6, but showing another embodiment of this invention;

Fig. 10 is a greatly enlarged view of a portion of the circuit breaker embodiment of Fig. 1, showing certain constructional details, and showing certain parts in their trip-free position;

Fig. 11 is a view similar to Fig. 10, but showing three positions of certain operational parts;

Fig. 12 is a view similar to Fig. 9, but showing the parts of the circuit breaker in a different operating position;

Fig. 13 is a sectional end view taken in the direction of sight lines 13—13 on Fig. 12; and

Fig. 14 is a graph of curves used in explaining certain characteristics of the present invention.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to the drawings for a detailed description of the invention, and referring specifically to Figs. 1 and 2, there is shown a framework comprising the mounting plate 2 and the magnetic yoke 4, yoke 4 being in the form of a U-shaped structure having a long leg 6 and a short leg 8. The bight 10 of the U-shaped frame is welded or otherwise fastened to the mounting plate 2 as shown. Mounted by means of screws 12 to the short leg 8 is a plate 14 of insulating material such as Bakelite or some other molded synthetic resin. Mounted on plate 14 is a steel plate 16. On plate 16 are mounted the working parts of a switch member which is actuated by the armature of the magnetic relay. The switch member should be one having a differential force-motion characteristic. As an example of such a differential type switch, the snap-acting spring-type blade 18 which is constructed and mounted as shown in the Burch United States Letters Patent No. 2,630,504 may be used.

Inasmuch as said Burch patent describes the construction of this snap-acting switch in detail, only the following general constructional details will be given, as follows: The snap-acting blade 18 is mounted under tension by means of the mounting posts 20 and 22, the post 22 being made with an eccentric thereon so as to tension adjustably the blade 18. A contact 24 is provided on the blade switch arm 26 and with the parts in the Fig. 1 position, contact 24 makes electrical contact with stationary contact 28, the latter being fastened to the plate 14 at one end thereof as shown, so as to be insulated from the plate 16. A push pin 30 is provided which works through a suitably provided hole in both the plates 14 and 16 to connect operatively the spring blade 18 with other parts of the relay, as will be described later. In operation, an upward motion of the push pin 30 will cause the spring 18 to snap into a position of opposite configuration, in which position the contact arm 26 will snap downwardly thus separating contact 24 from stationary contact 28.

Mounted at the end of long leg 6 is a soft iron pole 32, this being fastened to the leg 6 by any conventional method, such as by riveting. Surrounding the pole 32 is the coil assembly 34, the latter being held on the pole 32 by means of the top pole piece 36. Pole piece 36 extends to the left, as shown, and has the turned over

end 38 which serves as a hinge for the armature of the relay.

At this point, one of the adjustments of the relay may aptly be described, as follows: The right-hand end of pole piece 36 is provided with a threaded hole 40, and a corresponding hole 42 is provided at the end of plate member 14. A screw 44 is provided which threads into hole 40. A spring 46 is provided between the end of plate member 14 and pole piece 36. By tightening screw 44, the end of member 14 is brought nearer to pole piece 36. This obviously lessens the distance between the point of the spring 18 (on which push pin 30 bears) and the armature of the relay. Thus variations in the length of the thrust pin 30 can be compensated for.

A generally T-shaped armature is provided, in which the top of the T comprises a single bar of magnetic material having the ends 48 and 50 with the dependent parallel legs 52. Parallel legs 52 straddle the hinge 38 described above at the left-hand end (as drawn) of pole piece 36, and a pintle 54 rotatably anchors legs 52 to hinge 38. A weight 56 is mounted between the lower ends of legs 52 and serves to counterbalance the whole armature structure against the effects of shock. Mounted on the under side of end 48 of the armature is a latch member 58, the fastening being done by the rivet 60, the top of rivet 60 serving as a plate against which the lower end of push pin 30 presses.

With the construction thus described, it will be observed that if current is introduced in coil 34 so that end 50 of the armature is drawn downwardly flush against the pole piece 36, this will result in lifting the rivet 60 upwardly, which in turn pushes the push pin 30 upwardly, and this upward motion of the pin serves to actuate the snap spring 18 to separate contacts 24 and 28. If the current is now shut off, the normal bias of the snap spring 18 toward the contact closing position will push pin 30 downward, and this in turn pushes the armature end 48 downward to raise end 50 from pole piece 36.

Mounted between short leg 8 and long leg 6 is the block 70 of molded plastic (such as Bakelite). Block 70 serves to house certain operating parts of the device as will now be described. Block 70 is provided with a neck portion 72 which extends through holes 74 suitably provided in the mounting plate 2 and the bight 10. A cylindrical recess 76 is drilled or otherwise provided within block 70 as shown, and a portion of block 70 is cut away partially to relieve this cylindrical hole at the top thereof as shown generally at 78. It is through this relieved portion that access to working parts of the relay within recess 76 is provided.

Sliding within recess 76 in a horizontal direction (as drawn) is a plunger assembly, indicated generally by numeral 80, comprising the plug 82, lock-out ring 84, lock-out spring 86 and push button 88. Push button 88 comprises a head 90 and a stem portion 92, stem portion 92 fitting snugly into plug 82, the two being held together by means of pin 94. Lock-out ring 84 slides on stem 92, and is actuated toward plug 82 by means of lock-out spring 86 which is of the compression type. A spring 96 of the compression type serves to push the complete assembly (comprising the elements 82, 84, 86, 90, 92 and 94) to the left (as drawn), spring 96 fitting around a suitably provided boss 98 at the end of stem 92. Block 70 is held in position by means of the mounting screws 100.

Referring particularly to Fig. 10, there is shown in greatly enlarged detail a portion of the lock-out assembly 80 described above. This drawing is given to show the particular construction of the lock-out ring 84. The left-hand face 102 of lock-out ring 84 is perpendicular to the axis of the ring. However, the right-hand face 104 (that is, the face towards the plug 82) is concaved inwardly, as shown. The left-hand portion 106 of plug 82 is tapered (see Fig. 10), with the result that when the lock-out ring 84 is pressed against the end of the plug as

shown in this drawing, the face 104 overhangs the end of the plug. It is this feature which gives an anti-chattering effect, because once the latch 58 has lifted from out between the lock-out ring 84 and the plug 82 to permit the lock-out ring to be moved by spring 86 against the end of the plug, then the aforesaid overhang of the ring 84 prevents any further entry of the latch between the two. The last-mentioned position, when the latch 58 is between the lock-out ring and the plug, is shown in Fig. 6, and it will be observed that when the latch is in this position the push pin 30 has been allowed to travel far enough down so that the contact 24 has been snapped upwardly to engage contact 28. However, as shown in Fig. 7, when the latch 58 has moved from its position between the lock-out ring and the plug so that it rides either on top of the lock-out ring or on top of the plug, then push pin 30 has been thrust upwardly sufficiently to cause disengagement of contacts 24 and 28.

There will now be described the construction of the manual reset means, and it will be observed that the two embodiments shown in the drawings are different constructions of the manual reset feature, all other parts of the devices being the same. Referring now to Figs. 1 and 4 for one embodiment of the invention, a handle 110 is provided ending in the ball 112 which rotates freely in the recess 76 as shown. Handle 110 and ball 112 are provided with a slot 114 adapted to receive the tongue 116 of the link member indicated generally in Fig. 5 by numeral 118. Link 118 is provided with a hole 120 in the tongue 116, and at the end of tongue 116 is the notch 122. Tongue 116 is joined by connecting portion 124 to the cam member 126, the purpose of which will be described below.

Tongue 116 and connecting portion 124 are inserted as shown into the recess 76 through an opening 123 provided in block 70, and tongue 116 fits into slot 114. Notch 122 engages a stud 130 provided in the handle 110 at the inner end of slot 114, and a pin 132 passes through suitably provided holes in the neck 72, ball 112, and through hole 120 to lock securely the member 118 to the handle 110. With this construction, it will be observed that as the handle 110 is moved up and down (as drawn) the cam member 126 moves vertically up and down adjacent to the face of block 70. A spring 134 has one end anchored in a hole 136 provided on cam member 126, and the spring is wrapped around a pin 138 in block 70, with the other end of the spring 140 bearing against leg 6, in order to bias member 126 downward.

Member 126, it will be observed, has two cam lobes, indicated by numerals 142 and 144. These lobes operate in conjunction with a pin 146 which extends through the head 90 of push button 88. Pin 146 slides in slots 148 provided in the sides of block 70, slots 148 opening into recess 76.

There will now be described the operation of that embodiment so far described and which is shown in Figs. 1-8, 10 and 11.

With the parts in the position shown in Fig. 1, it will be observed that contact 24 engages contact 28, push pin 30 is in its downward position, leg 50 of the armature is away from pole piece 36, and the latch 58 is between the lock-out ring 84 and the plug 82. Handle 110 is in the upper position because spring 134 is urging cam member 126 downward. Handle 110 is now moved downward manually to the position shown in Fig. 7. In this position, it will be observed that the cam member 126 has been moved upward to a position such that the upper edge 150 of member 126 has engaged leg 48 of the armature to move the latter upward to rest (as shown in Fig. 7) against the underneath surface of leg 8. In this position leg 50 is moved downward to contact pole piece 36. By this means push pin 30 is actuated upward to cause separation of contacts 24 and 28. This draws latch 58 out from between plug 82 and lock-out ring

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84 to allow these two parts to come together. Also, spring 96 has urged the plunger assembly 80 to the left (as shown in Fig. 7) until the pin 146 engages the bottom 202 of lobe 144. Motion, now, of handle 110 upwardly causes the lobe 142 to bear against pin 146 to move it inwardly (to the right as drawn) until the end of latch 53 catches on the projecting lip of lockout ring 84, holding it stationary while plug 82 moves further to the right under the influence of pin 126 and lobe 142. Latch 53 now drops between the plug and lock-out ring, this additional motion allowing push pin 30 to move downward sufficiently to release the snap spring 18 so that contact 24 will again engage contact 28. The operation thus far described is for operation as a switch.

The device is used as a circuit breaker as follows: With the parts in the position shown in Fig. 1, the current from the source to be controlled (or a shunt circuit thereof to bring the current to the right value) is fed through the coil 34. The contacts 24 and 28 control the main line current. If now the current in the main line exceeds a predetermined value, coil 34 will become energized sufficiently to attract end 50 of the armature to the pole piece 36. This will move push pin 30 upward to cause separation of contacts 24 and 28 to interrupt the current in the main line. As latch 58 leaves plug 82, spring 96 pushes the plug leftward (as drawn), since the plug is no longer controlled by latch 58. This in turn pushes the pin 146 to the left and the latter coacts with the lobe 142 to cause the cam member 126 to move upward. Thus the handle 110 will be in an intermediate position indicating that the circuit breaker has been tripped, pin 146 coming to rest at the bottom 200 of lobe 142. In this position, which is shown most clearly in Fig. 8, it will be observed that the end of latch 58 is riding on the plug 82. If, now, handle 110 is moved upward to close contacts 24 and 28 again by permitting latch 58 to drop between lock-out ring 84 and plug 82, two things can happen depending on the condition of the circuit: (1) If the trouble has been cleared, then normal current conditions exist in the circuit, and not enough current will flow through coil 34 to cause the device to trip again; thus the device resets with latch 58 remaining in place between lock-out ring 84 and plug 82. (2) If there is still a fault in the line so that the tripping current still flows through coil 34 when contacts 24 and 28 close, then again armature 50 is attracted to pole piece 36 and latch 58 is again pulled from between the lock-out ring 84 and the plug 82. This tripping of the relay will occur instantaneously and probably while the handle 110 is still being held in its upward position by the operator. However, the device cannot chatter by intermittent opening and closing of the contacts 24 and 28, because just as soon as the latch 58 is pulled from between the lock-out ring 84 and plug 82, spring 86 will push the lock-out ring to the right, and the aforesaid overhang will prevent re-entry of latch 58 between these two members. Thus contacts 24 and 28 will be held in the open position even though the handle 110 is in its upward position. This position of the latch 58, the lock-out ring 84 and the plug 82 is shown clearly in Fig. 10. It is to be noted that if the handle 110 is released, it will return to the indicating position shown in Fig. 8.

Thus, in the above embodiment it will be observed that actuation of the device manually is done by means of the cam member 126 pushing end 48 of the armature upward, thus to actuate pin 30 and the latch 58. Similarly, the reverse actuation is caused to take place by the lobe 142 of member 126 moving the pin 146 inwardly until latch 53 slips between the lock-out ring and the plug.

It will be noted that when the device is in its "off" position due to manual switching, pin 146 rests in the bottom 202 of lobe 144 to hold the switch arm 110 in the Fig. 7 position. This is to be contrasted with the "off" position of the switch arm when such is caused by

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magnetic action. This is shown in Fig. 8 with pin 146 resting in the bottom 200 of lobe 142. This construction gives an indication of whether an "off" position of the contacts was caused by an overload in the circuit, or by manual actuation.

At this point, it is well to point out another relationship of the working parts of this device, as follows: If one plots the relationship between the pull exerted by the coil 34 on the armature 50 against the amount of air-gap for a given ampere-turn parameter, it will be observed that the resulting relationship follows in general an inverse square law for a large part of the curve. At one end of the curve, saturation effects are observed, and at the other end, leakage effects. In view of the fact that it is desired to have the relay calibration as independent of shock as possible, it is within the scope of this invention to use on the armature a restoring force which has a force-motion relationship which approximates that of the armature. That is, if the force and motion of the restoring spring are plotted on the same graph as the above-mentioned force-air gap (for the armature) curve, for the best results, the two curves should be parallel over the working range of parameters encountered whereby the force of the restoring spring is substantially uniformly greater than the pull of the coil for the different positions of movement of the armature.

It is for this reason, among others, that a differential type snap-mechanism 18 is chosen. The spring force of the snap spring 18 or of a snap spring such as shown in the Spencer United States Patent No. 1,448,240, when plotted against the deflection of the spring, results in a curve which approximates in a fair degree the above mentioned force-air gap curve. Obviously, the spring force of the snap spring 18 provides nearly all, if not all, of the restoring force on the armature, and hence the above discussed desideratum is obtained.

Presented in Fig. 14 are a set of schematic curves to illustrate the above discussion. Curves A, B, C, D and E comprise a family of curves in which each curve approximates the force-air gap relationship for a fixed value of ampere turns in the coil, curve A being for the largest ampere-turns and curve E for the smallest.

Dotted curves S, T and U are plots of the restoring spring force against motion of the spring. Curve S is for a weak spring, curve T is for the ideal spring, and curve U is for a stiff spring. Referring to curve S, and assuming that G_0 is the initial air gap, if a current overload condition results in C ampere turns being applied to the coil, then the armature will pull in to actuate the relay, because the build-up of magnetic force on the armature is greater than the build-up of opposing restoring spring force. Thus the relay contacts will open satisfactorily. But suppose that under normal operating conditions D ampere turns are present, and the relay is subjected to shock to the point that the air gap momentarily closes to point G_1 , then the D ampere turns will set up a magnetic force on the armature greater than the restoring spring force, and the relay will trip. This is undesirable, of course, since it is intended that the relay contacts of the circuit breaker remain closed under normal operating conditions.

Consider, now, curve U; and assume again an initial air gap of G_0 . The C ampere turns will close the gap until point G_2 is reached. At this point (which is where curves C and U intersect), the forces involved reach equilibrium, and the relay again will not trip. If B ampere turns are now set up, the point of equilibrium shifts to G_3 , and so forth.

The ideal curve, T, approximately parallels the C ampere turns curve, it being noted that the restoring spring force along curve T is substantially uniformly greater than the magnetic force along curve D. C ampere turns or more will trip the relay and, of course, D ampere turns will not. In a state of shock, there is no crossing of the

restoring spring force by an ampere-turn curve, and hence (unless the shock is such as to close completely the air gap, or as to reach into the saturation point on the relay coil), the relay is comparatively free from shock effects.

It is to be noted that use of a restoring spring following Hooke's law will not give the desired relationships expressed above.

By thus matching the restoring spring characteristics to the particular air-gap magnetic force relationship, the calibration of the device remains the same regardless of the vibration to which the device is subjected.

In both the embodiment so far described, and in the one described below, it will be noticed that a snap-acting spring mechanism 13 has been used to actuate the contacts directly, this snap-acting spring mechanism itself being actuated by the armature end 48. This combination of snap-acting spring having an inherent deflection-force differential and an electromagnetic relay actuating an armature is provided for a definite purpose, the purpose being to enable the operating or tripping current values to be nearer to the reset current values. That this combination accomplishes this purpose will be apparent when it is realized that because of the inherent differential characteristics of the snap spring 13, the armature will be almost completely in its closed position against the pole piece of the electromagnet before it has moved the snap spring to its snapping point to open the contacts. On the reverse part of the armature motion, the full magnetic air gap is almost established before the spring has been allowed to move in an opposite direction to its reverse snapping position to close the contacts and cause current to flow through the coil of the electromagnet again. In addition to this, because the armature has to be in its almost fully closed or fully open position before the snapping points of the snap spring are reached, the combination has a greater vibration-resistance than previously-known circuit breakers.

Referring now to Figs. 9, 12 and 13, another embodiment of this invention is shown, in which the magnetic, snap switch, and detent construction of the circuit breaker is the same as the aforesaid embodiment. However, the construction of the switch for manual actuation is different, as follows: Instead of the block 70, a metallic cylinder 160 is provided having a closed end 162, and this cylinder is attached by means of a shoulder 164 to the bight 10 of the magnetic yoke. A neck 166 (which, as shown, might be an integral part of the cylinder) is provided and projects through suitably provided holes in the mounting plate 2 and bight 10 as shown. Slots 168 are provided in the sides of the cylinder or barrel 160. A portion 170 of the top of the barrel is open to allow access (as before) to the interior of the barrel.

Sliding in the barrel is the plunger construction indicated generally by numeral 172, in this embodiment comprising the plug 174 which is mounted by means of pin 176 at one end of the stem 173. A lock-out ring 180 slides on stem 173 as before, and has the concaved face 182 which co-operates with the tapered end 184 of plug 174 as described above for the Fig. 1 embodiment. Spring 186 is used to press lock-out ring 180 against the end of plug 174, the other end of spring 186 pushing against a sleeve 188 which is mounted on stem 173. The other end of sleeve 188 rests against the head 190 which is formed as an integral part of the stem 173. A pin 192 is inserted in stem 173 and projects outward through slots 168, thus serving to hold the completed plunger assembly in the barrel 160, and to act as a stop.

In its circuit breaker operation, this device functions as does the first embodiment described. With the parts shown in the Fig. 9 position, the latch 53 is shown engaged between plug 174 and lock-out ring 180, which means that thrust pin 30 is in its downward position and contact 24 engages contact 28. If now excess current flows through the coil 34, the end 50 of the armature is attracted to pole piece 36, which raises the end 48. This

pushes thrust pin 30 upwardly to disengage contacts 24 and 28 and pull latch 53 out from between the lock-out ring and plug. Disengagement of the plug allows spring 194 to push the entire plunger assembly to the left to indicate the "off" position as shown by dotted lines 195 (of Fig. 9) or in full lines 196 of Fig. 12. In this position (as shown in Fig. 12) latch 53 rides on plug 174, thus maintaining contact 24 disengaged from contact 28.

If, now, the plunger 190 is pushed inwardly, latch 53 will engage the overhanging lip of lock-out ring 180 to slide the ring backwards until the latch moves down far enough to engage the end of plug 174. This locks the plunger assembly in its right-hand (or Fig. 9) position, while causing reengagement of contacts 24 and 28. If the circuit still has the fault existing so that the excess current still flows through coil 34, then immediately the armature will be actuated again to raise latch 53 and open contacts 24 and 28. The lock-out ring 180 will again be urged to the right-hand position shown in Fig. 10 under the influence of spring 186 to prevent chattering of the relay contacts, just as described in the above embodiment.

In manual actuation, the knob 199 is merely pulled to the left, and a reference to Fig. 11 (the parts shown in Fig. 11 being identical in structure and function to their counterparts as shown in Fig. 12) will show that the pivot point of the latch 53 (which is the pintle 54) is above the point at which the latch end engages plug 174 so that a moment, indicated by the small letter "m," is provided. This moment "m" is exerted in a clockwise direction, and as the pull is continued to the left as indicated by the arrow, the latch itself bends outward further increasing the clockwise component of force until it is released from the end of the plug 174 and is caused to ride up the inclined or tapered end thereof to the contact-opening position. This bending of latch 53 gives rise to tangential forces which assist the clockwise rotation of the armature.

In dotted lines in Fig. 11 is shown the progression of the plunger assembly under such pulling, showing how the bending of the latch takes place, and how the clockwise moment becomes effective to assist in opening the switch.

Under circuit breaker operation, this clockwise moment is effective, since under the influence of the spring 194 a clockwise moment is provided in exactly the same way to assist in overcoming the latch friction that exists between the end of latch 53 and the plug 174.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A trip-free circuit breaker comprising a fixed contact; a movable contact; switch means for actuating the movable contact; an electromagnet; an armature positioned for motivation by the electromagnet; said armature being operatively connected with said switch means to move said movable contact into and out of engagement with said first contact; latch means carried by said armature; manually actuable slidable means movable to a first position to permit said latch means to move to latched position; and lock means movable with respect to said slidable means and cooperable therewith to prevent relatching of said latch means when the latter has moved to unlatched position while said slidable means is retained in said first position.

2. A trip-free circuit breaker comprising a fixed contact; a movable contact; switch means for actuating the movable contact; an electromagnet; an armature posi-

tioned for motivation by the electromagnet; means operatively connecting said armature and said switch means; latch means carried by said armature; manually actuable slidable means positioned to be engaged by said latch means when said slidable means is in one of its positions; and lock means moving with respect to said slidable means and cooperating therewith to prevent re-engagement of said latch when the latter has moved out of engagement with said slidable means; said manually slidable means comprising a slidable plunger, said plunger having a reduced diameter portion thereon and a shoulder; and said lock means comprising a ring encircling the reduced portion of the plunger and biased toward said shoulder, the face of the ring adjacent the shoulder being recessed to permit said ring to overhang said shoulder when in engagement therewith.

3. In combination: a base having a fixed contact mounted thereon; a movable contact movably mounted on said base and cooperating with said fixed contact to make and break an electrical circuit; electromagnetic means on said base; an armature movably mounted on said base in position to be actuated in one direction by said electromagnetic means; and snap-acting biasing means having a differential deflection-force characteristic for biasing said armature in the opposite direction with a force substantially uniformly greater than the force exerted on the armature by said electromagnetic means during deflection of said armature under normal operating conditions whereby unintentional tripping of said armature due to shock is resisted; said movable contact being operatively associated for movement with respect to said fixed contact upon tripping of said armature due to the flow of sufficient current through the electromagnetic means to overcome the force of said biasing means on said armature.

4. A trip-free circuit breaker comprising a base having a fixed contact mounted thereon; a movable contact mounted on said base; an electromagnet mounted on the base; an armature pivoted on the base and positioned to be motivated in one direction by the electromagnet; snap-acting spring means having a differential force-deflection characteristic for biasing said armature in the opposite direction with a force substantially uniformly greater than the force exerted on the armature by said electromagnet during deflection of said armature under normal operating conditions whereby unintentional tripping of said armature due to shock is resisted; said movable contact being operatively associated with said snap-acting spring means for movement with respect to said fixed contact upon tripping of said armature due to the flow of sufficient current through the electromagnet to overcome the force of said snap-acting spring means on said armature; latch means positioned to be moved by said armature; manually actuable slidable means movable to a first position to permit said latch to move to latched position; and lock means movable with respect to said slidable means and cooperable therewith to prevent relatching of said latch means when the latter has moved to unlatched position while said slidable means is retained in said first position.

5. A trip-free circuit breaker comprising a U-shaped metal frame; an electromagnet mounted on one leg of said frame and having a core magnetically connected to the frame and ending in a pole face; an armature pivoted to the other leg of the frame and positioned to be rotated by said electromagnet, said armature carrying a latch member; a fixed contact mounted on said frame; a snap-spring mounted on the frame; a movable contact carried by said snap-spring and movable thereby into and out of engagement with said fixed contact; means operatively connecting said armature and snap-spring; a sleeve member provided on said frame; a manually-actuable plunger slidable in said sleeve member and having a shoulder thereon engageable by said latch when said plunger is in one of its positions, said plunger being biased

outwardly; and a lock-ring encircling said plunger and being slidable thereon, said lock ring being biased toward said shoulder and being recessed on the side next said shoulder to provide an overhanging engagement therewith, the overhanging engagement of said lock-ring and said shoulder preventing direct entry of said latch therebetween.

6. A trip-free circuit breaker comprising a U-shaped metal frame; an electromagnet mounted on one leg of said frame and having a core magnetically connected to the frame and ending in a pole face; an armature pivoted to the other leg of the frame and positioned to be rotated by said electromagnet, said armature carrying a latch member; a fixed contact mounted on said frame; a movable contact carried by said snap-spring and movable thereby into and out of engagement with said fixed contact; a means operatively connecting said armature and snap-spring; a sleeve member provided on said frame; a manually-actuable plunger slidable in said sleeve member and having a shoulder thereon engageable by said latch when said plunger is in one of its positions, said plunger being biased outwardly; a lock-ring encircling said plunger and being slidable thereon, said lock ring being biased toward said shoulder and being recessed on the side next said shoulder to provide an overhanging engagement therewith, the overhanging engagement of said lock-ring and said shoulder preventing direct entry of said latch therebetween; and second manually actuable means for pivoting said armature to open said contacts and to lift said latch from between said shoulder and lock-ring.

7. A circuit breaker comprising a base having a fixed contact mounted thereon; a movable contact movably mounted on said base and co-operating with said fixed contact for making and breaking an electrical circuit; snap-acting spring means mounted on said base for actuating the movable contact, said spring means having a predetermined deflection-force differential; an electromagnet mounted on the base and having a pole face; an armature movably mounted on the base and positioned to be actuated by the electromagnet; means operatively connecting said armature and said spring means whereby the air gap between said armature and said pole face is approximately at a minimum before said spring means reaches its snapping point in one direction, and said air gap is approximately at a maximum before said spring means reaches its snapping point in the opposite direction; a latch actuated by said armature; manually actuable slidable means positioned to be engaged by said latch when said slidable means is in one of its positions; and lock means movable with respect to said slidable means and co-operating therewith to prevent re-engagement of said latch with said manually actuable sliding means when said latch has moved out of engagement therewith; said manually slidable means comprising a slidable plunger, said plunger having a reduced diameter portion thereon and a shoulder; and said lock means comprising a ring encircling the reduced portion of said plunger, and biased against said shoulder, the face of the ring adjacent the shoulder being recessed to permit said ring to overhang said shoulder when in engagement therewith.

8. In a circuit interrupter having latching means for holding an element of the interrupter in a pre-selected position and where said latching means comprises a latch and a movable element to be held thereby, that improvement in lock-out means for preventing re-engagement of said latch and said movable element once said latch has become disengaged from said movable element, which comprises first means on said movable element adapted to be engaged by said latch when said movable means is in one of its positions, and second means slidable with respect to and biased toward said first means, with at least a portion of said second means overhanging said

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first means to prevent re-engagement of said first means by said latch.

9. A circuit breaker comprising a base having a fixed contact mounted thereon; a movable contact mounted on said base; spring means mounted on said base for actuating said movable contact; slidable means mounted on said base and operatively connected with said spring means for actuating said movable contact; manually actuable cam means mounted on said base and operatively connected with said slidable means to operate, and to be operated, by said slidable means; latch means provided with respect to said slidable means for retaining the latter in a predetermined position; and manual means for actuating said cam means; said cam means having two lobes, with one of which said slidable means co-operates to move said manual means to a position indicating the circuit breaker has operated automatically, and with the other of which said slidable means co-operates to hold said manual means in a contact-open position.

10. In combination: a latch; first means movable with said latch between latched and unlatched positions; a pair of electrical contacts operatively connected to be mutually engaged when said first means is in latched position and to be mutually separated when said first means is in unlatched position; said first means being operatively connected for tripping from latched to unlatched position upon the flow of current of predetermined value through said contacts and for movement toward latched position upon mutual separation of said contacts; a member; means resiliently biasing said member from a first position to a second position; said member, in said first position, permitting movement of said first means to latched position and, in said second position, preventing movement of said first means to latched position; lock means movable to a first position for preventing movement of said first means to latched position; and means resiliently biasing said lock means for movement of the latter to said first position upon tripping of said first means while said member is retained in said first position.

11. The device as set forth in claim 10 wherein said means resiliently biasing said member exerts a force, when said latch and said first means are in said latched position, tending to move the said latch and said first means toward unlatched position.

12. The combination as set forth in claim 3 wherein said electromagnetic means provides a pole face adjacent said armature; the air gap between said armature and the pole face being approximately at a minimum before said snap-acting biasing means reaches its snapping point in one direction, and said air gap being approximately at a maximum before said snap-acting biasing means reaches its snapping point in the opposite direction.

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13. In combination: a latch; an armature movable with said latch between latched and unlatched positions; a pair of contacts operatively connected to be mutually engaged when said armature is in latched position and to be mutually separated when said armature is in unlatched position; an electromagnet electrically connected for energization by mutual engagement of said contacts to trip said armature to unlatched position upon the flow of current of predetermined value through the electromagnet; means resiliently biasing said armature toward latched position; latch-engageable means resiliently biased from a first to a second position; said latch-engageable means, in said first position, permitting movement of said armature to latched position and, in said second position, preventing movement of said armature to latched position; and lock means movable with respect to said latch-engageable means to prevent movement of said latch and said armature to latched position upon tripping of said armature while said latch-engageable means is retained in said second position.

14. In combination: a base having a fixed contact mounted thereon; a movable contact movably mounted on said base and cooperating with said fixed contact to make and break an electrical circuit; an armature movably mounted on said base; electromagnetic means for exerting a force in a first direction on said armature substantially inversely proportional to the square of the deflection of the armature from said electromagnetic means; and snap-acting spring means having a differential deflection-force characteristic for exerting a force on said armature in the opposite direction with a force-deflection curve substantially parallel with the force-deflection curves of said electromagnetic means; said movable contact being operatively associated for movement with respect to said fixed contact upon tripping of said armature due to the flow of sufficient current through the electromagnetic means to overcome the force of said spring means on said armature.

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