United States Patent

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[33] **Japan**
[31] **44/56270 and 44/98500**

[54] **AUTOMATIC CIRCUIT BREAKER WITH MAGNETIC LATCHING MEANS**
4 Claims, 9 Drawing Figs.

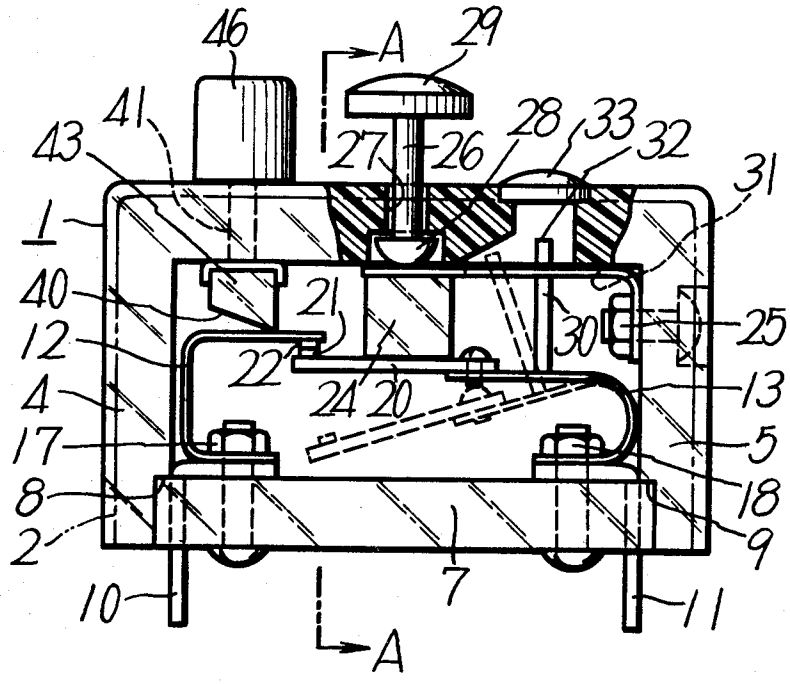
[52] **U.S. Cl.** **335/1,** 335/166, 335/170
[51] **Int. Cl.** **H01h 9/16**
[50] **Field of Search** 335/170, 168, 166, 174, 178, 185, 195, 205, 177

[56] **References Cited**
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3,453,566 7/1969 Kasahara 335/16

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Assistant Examiner—Harvey Fendelman
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ABSTRACT: A compact circuit protector comprises first and second conductive leaf springs secured in a casing at their one ends, which are held in contact with first and second terminals leading to the exterior of the casing. The leaf springs are bent toward each other, and a conductive, magnetic plate is secured to the second leaf spring and extend between the free ends of the leaf springs. First and second contacts are mounted on the free ends of the first leaf spring and the conductive, magnetic plate in opposing relationship. A permanent magnet carried by a third spring is arranged adjacent the magnetic plate to attract and hold it magnetically, thereby keeping the both contacts in engagement. An overcurrent through the magnetic plate across the terminals diminishes the magnetic attraction to move the plate away from the magnet by the resilience of the second leaf spring, providing the circuit interruption.



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SHEET 1 OF 2

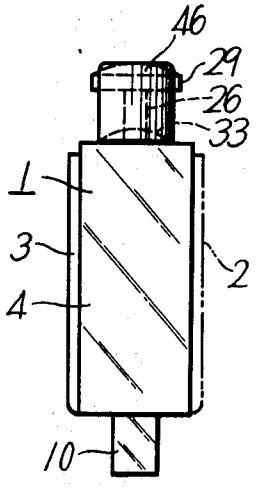


Fig. 2

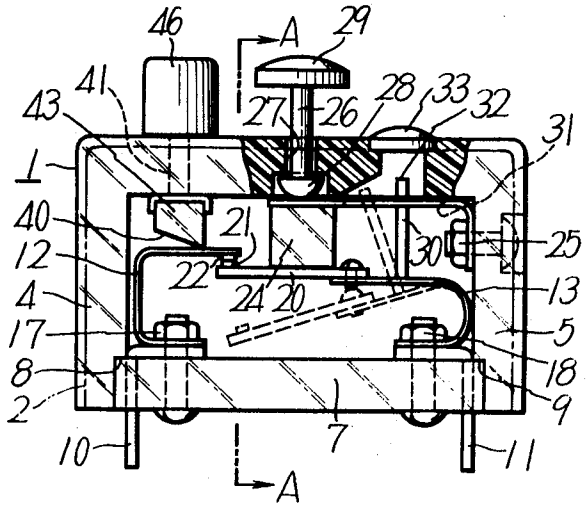


Fig. 1

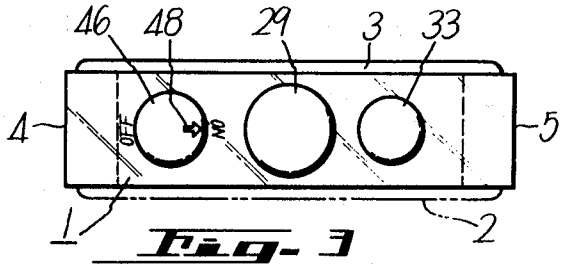


Fig. 3

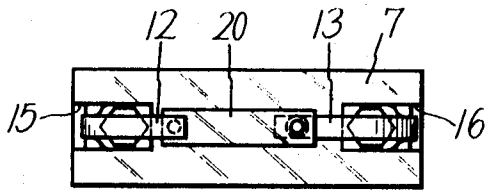


Fig. 4

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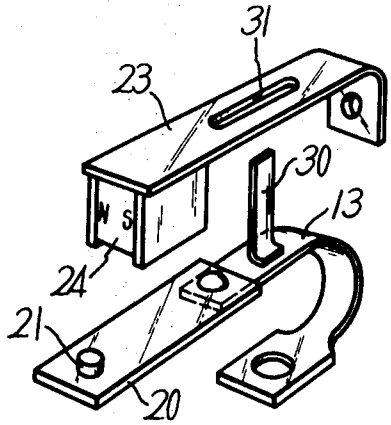


Fig. 5

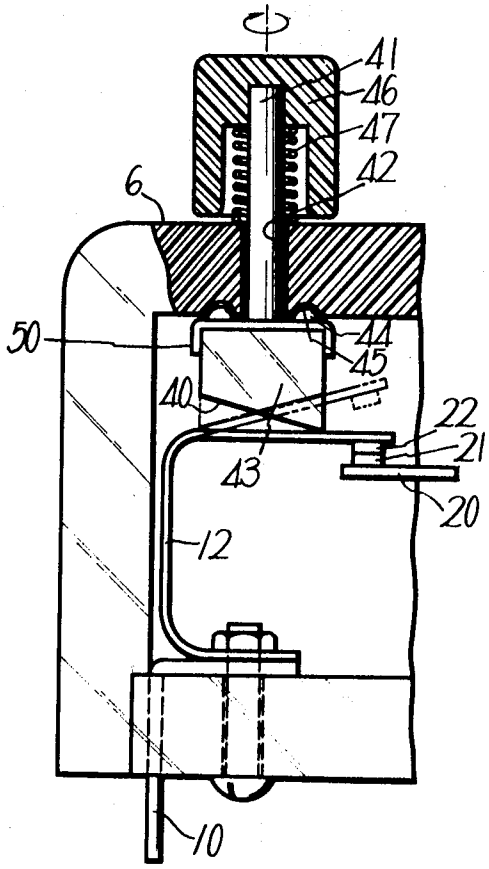


Fig. 6

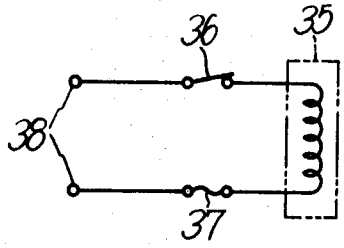


Fig. 7

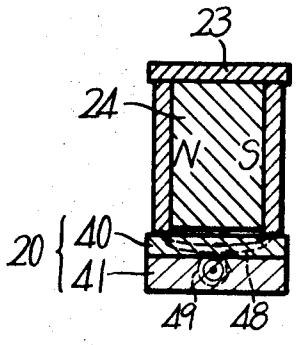


Fig. 8

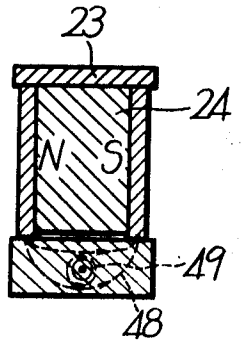


Fig. 9

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AUTOMATIC CIRCUIT BREAKER WITH MAGNETIC LATCHING MEANS

The invention relates to a compact circuit protector adapted to be connected in an electrical circuit for interrupting the circuit upon occurrence of an abnormal current flow.

The inventor has previously proposed in U.S. Pat. No. 3,453,566 a circuit protector which includes a current-carrying conductor of magnetic material subjected to a force of attraction from a magnet normally and which operates to interrupt the associated circuit by its instantaneous movement allowed upon occurrence of a current flow above a given level, which substantially diminishes the force of attraction. The circuit protector described provides an instantaneous interruption as well as trip-free action, whereby circuit protection is assured.

While the circuit protector operates satisfactorily it requires a pivotal mounting of the conductor and the magnet which makes the structure relatively complex, and hence does not lend itself to mass production. In addition, a biasing force had to be applied to the conductor of magnetic material by a spring which was separate from the conductor, and this also added to the assembling trouble. Furthermore, the protector was incapable of indicating whether the circuit was interrupted or conductive, and of being used as a manually operable switch.

It is an object of the invention to provide a compact circuit protector of the type above described which is simple in structure and lends itself to mass production.

It is another object of the invention to provide a compact circuit protector capable of indicating whether or not the circuit is interrupted.

It is further object of the invention to provide a compact circuit protector which can also be used as a manually operable switch.

Briefly, in accordance with the invention, first and second leaf springs are provided with their one end secured within a casing and with their other end bent and extending toward each other after having extended a certain length in the same direction. A conductive, magnetic plate extends between the free ends of these leaf springs, and has its one end secured to one of the leaf springs while its other end is arranged opposite the free end of the other leaf spring. First and second contacts are attached to the opposing portions.

A permanent magnet is located opposite the conductive, magnetic plate so as to hold the latter by attraction, where by the first and second contacts are brought into contact with one another. Although the conductive, magnetic plate is urged away from the magnet by the resilience of that conductive leaf spring to which is secured, the first and second contacts remain in engagement for a current flow through the conductive plate which is below a given level. First and second terminals which are in electrical contact with the first and second conductive leaf springs, respectively, are led out of the casing for external connection of the protector with a current to be protected.

When the current flow through the conductive, magnetic plate exceeds a given level, the force of attraction acting between the conductive, magnetic plate and the permanent magnet diminishes to cause the biasing force of the conductive leaf spring to move the first and second contacts apart, whereby the circuit is interrupted. When this occurs, it is possible to restore the conductive, magnetic plate to its original position by moving the permanent magnet toward the conductive, magnetic plate which had travelled apart, against the biasing action of a third spring, thereby causing the magnet to capture the conductive plate. If then the external circuit condition is such as to cause an overcurrent flow across the first and second terminals, the circuit is again interrupted in the manner described above, thereby providing a trip-free action.

An index member is attached to a swingable part of the conductive plate or the conductive leaf spring to which the conductive, magnetic plate is secured, and the casing is formed with a window opposite the index member. This gives, by sight from the exterior, an indication as to whether or not the path between the first and second terminals is interrupted.

One of the conductive leaf springs which is not used as a support for the conductive, magnetic plate is normally urged, by its own resilience, in a direction to move the first and second contact away from one another. This conductive leaf spring is held in its strained position by a manual switch member having a ramp surface which abuts against said one conductive leaf spring. The switch member is rotatable so that in one position, the ramp surface forms an angle with the surface of said one conductive leaf spring, while in the other position, the ramp surface is moved into facial contact with the latter, thereby causing engagement and disengagement of the first and second contacts.

The above and other objects, features and advantages of the invention will become apparent from the following description with reference to the drawings, in which:

FIG. 1 is a front view, partly cut away to show section, of a compact circuit protector according to the invention, with the front plate being removed,

FIG. 2 is an elevation, as viewed from the left-hand side in FIG. 1,

FIG. 3 is a top view,

FIG. 4 is a plan view of the bottom plate, as removed from the housing, with leaf springs and conductive, magnetic plate secured thereto,

FIG. 5 is an enlarged, exploded and perspective view showing the magnet and the conductive, magnetic plate,

FIG. 6 is a fragmentary front view to an enlarged scale illustrating the manual switch member and its related parts,

FIG. 7 is a wiring diagram for illustrating one application of the protector,

FIG. 8 is an elevation of a modified conductive, magnetic plate, and

FIG. 9 is an elevation of a conductive, magnetic plate in FIG. 1, as contrasted to the conductive, magnetic plate of FIG. 8.

Referring to the drawings, the compact circuit protector shown comprises casing 1 which consists of front plate 2, rear plate 3, left-hand sideplate 4, right-hand sideplate 5, top plate 6 and bottom plate 7. The casing may be formed as a combination of a part of nonframe shape including the bottom plate 7 and at least one other part. In the example shown, the casing 1 is formed in four parts, that is, by a channel-shaped part including the left- and right-hand sideplates 4, 5 and the top plate 6 integrally, bottom plate 7, front plate 2 and rear plate 3, which are formed from Bakelite plate, for example, and secured together by adhesion. The bottom ends of the left- and right-hand sideplates 4, 5 are internally cut thin at corresponding positions to form shoulders 8 and 9, respectively, against which the inner surface of the opposite ends of the bottom plate 7 abuts, the edge faces of the bottom plate 7 being positioned in contact with or adjacent the inner surfaces of the left- and right-hand side plates 4, 5.

First and second terminals 10, 11 are mounted in the casing 1 so as to extend to the exterior thereof, and electrically connected with the first and second terminals 10, 11 are first and second conductive leaf springs 12, 13, respectively, which extends in substantially parallel planes within the casing 1. In the example shown, notches 15 and 16 are formed in the opposite end faces of the bottom plate 7, and the terminals 10 and 11 extend through these notches 15, 16 (FIG. 4) and have their inner ends bent so as to extend toward each other along the inner surface of the bottom plate 7, these end extensions being secured to the bottom plate 7 by means of clamps 17 and 18, respectively, which may comprise threaded bolts and nuts, for example. The first and second leaf springs 12, 13 are disposed at intermediate positions between the top plate 6 and the bottom plate 7 substantially parallel thereto. The first leaf spring

12 is elongated along the inner surface of the left-hand sideplate 4 to reach the bottom plate 7, whereupon it is bent inwardly along the bottom plate 7 in order to be clamped together with the terminal 10 by the clamp 17 to thereby provide an electrical connection between the first terminal 10 and the first conductive leaf spring 12. Similarly, the second conductive leaf spring 13 is elongated along the right-hand sideplate 5 to reach the bottom plate 7, whereupon it is bent inwardly therealong in order to be clamped together with the second terminal 11 by the clamp 18, thereby providing an electrical connection between the second terminal 11 and the leaf spring 13.

A conductive, magnetic plate 20, which may be formed of Fe-Ni alloy (magnetic compensating steel) comprising 30 to 32 percent by weight of nickel and the remainder of iron, is secured to the free end of the second leaf spring 13 in alignment therewith. The conductive, magnetic plate 20 and the second conductive leaf spring 13 can be secured together integrally by providing aligned holes in their ends through which a pin is passed and then swaged at its opposite ends, followed by soldering. The second leaf spring 13 is constructed so that it normally urges the conductive, magnetic plate 20 toward the bottom plate 7. The free end of the conductive, magnetic plate 20 is provided on its upper surface with a second contact 21, which forms a pair with a first contact 22 that is attached to the lower surface of the free end of the first conductive leaf spring 12.

There is provided a permanent magnet 24 which is operable to attract and hold the conductive, magnetic plate 20 against the urging force exerted by the leaf spring 13 so as to bring the first and second contacts 22, 21 into engagement, the permanent magnet 24 being carried by the free end of a third spring 23 which has its other end secured to the casing 1.

In the example shown, a third leaf spring 23 is attached to the casing 1 so as to extend close and parallel to the inner surface of the top plate 6 and in the same direction as the leaf springs 12 and 13. The permanent magnet 24 may be fixed on the free end of the third leaf spring 23 as by adhesive. The other end of the third leaf spring 23 is bent along the right-hand sideplate 5 to be secured thereto by a clamp 25 which may comprise a threaded bolt and a nut. As shown in FIG. 5, the permanent magnet 24 has its magnetization, indicated by designations N and S, in a direction at right angles to the length of and parallel to the major surface of the conductive magnetic plate 20.

An operating rod 26 to move the permanent magnet 24 toward the bottom plate 7, and an opening 27 which permits access of the operating rod 26 into the interior of the casing 1 is formed therein or in the top plate 6 in the present example. Thus, a through hole 27 is formed in the top plate 6 in vertical alignment with the free end of the third leaf spring 23 where the magnet 24 is mounted. In this manner, the rod 26 is vertically slidable in the hole 27. The operating rod 26 is formed with a flange 28 at its inner end, and the inner portion of the hole 27 is enlarged to a greater diameter so as to form a chamber housing the flange 28, thereby preventing withdrawal of the operating rod 26 out of the casing. The operating rod 26 is provided with a knob 29 at its outer end. It will be appreciated that the operating rod 26 may be pushed into the casing to drive the magnet 24 toward the bottom plate 7 against the resilience of the third leaf spring 23.

The circuit protector may be provided with an indicator, which is illustrated in FIGS. 1 and 5 as comprising a pin-shaped index 30 secured to and extending upright from the second leaf spring 13. An elongate slot 31 is formed in the third leaf spring 23 at a position on top of the index 30, the slot 31 being elongate lengthwise of the leaf spring 30.

A peep hole 32 is formed in the top plate 6 vertically above the index 30, and is fitted with a convex lens 33 which may be formed of acryl resin, for example. The arrangement is such that when the conductive, magnetic plate 20 has been displaced toward the bottom plate 7, as shown in broken lines, the index 30 undergoes a corresponding angular movement so that the top of the index 30 moves out of sight from the indicator hole 32. Preferably the top face of the index 30 is suitably colored for the ease of sight.

Referring to FIGS. 1 and 6, the first leaf spring 12 is constructed so as to urge the first contact 22 in a direction away from the second contact 21. There is provided a manually operable switch member for operative association with the first leaf spring 12, and it comprises a ramp surface 40 located for selective engagement with the major surface of the leaf spring 12. As will be explained later, the ramp surface 40 is formed on a member 43 which is attached with an operating shaft 41, which extends through a hole 42 formed in the top plate 6 and projects externally of the casing 1. The shaft 41 is rotatable within the hole 42.

The angle of inclination of the ramp surface 40 with respect to the shaft 41 is such that in one angular position of the shaft 41 shown in solid line in FIG. 6, the lower edge of the ramp surface 40 engages the major surface of the first leaf spring 12 to bend it against the resilience thereof to thereby press the first contact 22 against the second contact 21, while in another position, in which the shaft 41 has rotated an angle from 90° to 180° from said one position, the leaf spring 12 moves into facial engagement with the ramp surface 40 by its own resilience to thereby cause the first contact 22 to be separated from the second contact 21.

Such another position of the shaft is shown in broken lines in FIG. 6 as spaced by an angle of 180° from said one position. To provide a smooth rotating movement of the ram surface 40 on the leaf spring 12, the latter is made to have a lateral width which is equal to or greater than that of the ramp surface member, in its part designed for sliding contact with ramp surface 40. Positioning means is provided on the manual switch member to give a touch of on-and-off positions of the contacts 21, 22 to an operator's hand. At this end, in the example shown, a metal plate 50 is fitted on top of the member 43 about the operating shaft 41 and positioned to lie against the inner surface of the top plate 6.

The metal plate 50 is formed, as by extrusion, with two projections 44 on opposite sides of the shaft 41, these projections being directed toward the top plate 6. Corresponding recesses 45 are formed in the inner surface of the top plate 6 at positions in which they receive the projections 44 in the angular positions of the shaft 41 corresponding to the on-and-off positions of the contacts 21, 22. The free end of the operating shaft 41 is fitted with a cap-shaped knob 46, the knob being aligned with the shaft 41. The knob 46 contains a spiral spring 47 which is disposed around the shaft 41, the spring 47 normally urging the shaft 41 toward the exterior of the casing 1. An arrow 48 is marked on the top surface of he knob 46, and the upper surface of the top plate 6 is marked with "ON" and "OFF" symbols at positions which align with the arrow 48 when the knob 46 is turned to the on-and-off positions of the contacts 21, 22, respectively.

In stationary condition, the conductive, magnetic plate 20 is attracted by and held together with the magnet 24 by virtue of the magnetic interaction therebetween which overcomes the urging force exerted by the second leaf spring 13, so that the contacts 21 and 22 are held in contact. When using the circuit protector, all the necessary thing is the connect the terminals 10 and 11 with a circuit for which protection is desired. Then, an electrical interconnection is completed between the terminals 10 and 11 through the first conductive leaf spring 12, contact 22, contact 21, conductive, magnetic plate 20 and the second conductive leaf spring 13.

As long as the current flow through this path is below a given level, the path remains completed. However, when the current flowing through the path exceeds the given level, the current flow through the magnetic plate 20 produces a magnetic flux which appreciably diminishes the force of attraction acting between the conductive, magnetic plate 20 and the magnet 24, which force is overcome by the urging force exerted by the second leaf spring 13, so that the magnetic plate 20 moves away from the magnet 24 and toward the bottom

plate 7, thereby separating the contacts 21, 22 to interrupt the circuit for its protection. When it is desired to produce an electrical contact between he contacts 21 and 22 again, the operating rod 26 is pushed down until it captures the magnetic plate 20, whereupon the rod is lifted or allowed to lift automatically under the biasing force of the third spring 23, whereby the connection between the contacts 21 and 22 is resumed. If then the circuit condition remains unchanged, i.e. a current above the given level is still flowing, the circuit protector is immediately operated again. Thus the protector is capable of trip-free operation.

The contacts 21 and 22 can be switched manually from their on-state to off-state by turning the knob 46 which is normally located in its ON-position to its OFF-position. Thereupon, the first leaf spring 12 moves into facial contact with the ramp surface 40 as mentioned above with reference to FIG. 6, and the contact 22 moves out of contact with the contact 21 as shown in broken lines in that FIG. The manual switch can be reset by turning the knob 46 until the arrow 48 aligns with the symbol "ON" on the top plate 6. In this way, the circuit protector is operable to interrupt the path between the terminals 10 and 11 automatically when an abnormal current flows thereacross, and to provide a manual interruption and resetting between these terminals. One of the resulting advantages can be seen by reference to FIG. 7 in which a conventional arrangement to supply the circuit 35 of an electrical machine or instrument is shown as comprising a manual switch 36 and a fuse 37 connected between the circuit 35 and power source terminals 38. By contrast, according to the invention, the same functions or results can be achieved by simply connecting the circuit protector between the supply terminals 38 and the circuit 35, without resource to the provision of the fuse 37, since an abnormal current flow through the circuit 35 must take the way through the path between the terminals 10 and 11 with consequent interruption of the path and the knob 46 allows the path to be switched on and off by its turning manually, which is equivalent to the function of the manual switch 36.

It will be noted that the conductive, magnetic plate 20 is not pivotally mounted, but is fixedly carried by the conductive leaf spring 13, and is angularly moved toward the bottom plate 7, upon occurrence of an overcurrent, by the resilient urging force of the leaf spring 13. As a result, the construction to provide an angular movement of the magnetic plate 20 is much simplified without requiring a separate biasing means.

Similarly, the contact 22 is urged to move away from the contact 21 by the resilience of the conductive leaf spring 12 on which it is mounted, to thereby constitute manually operable switch means. As a result, the whole assembly can be constructed compactly and assembled easily. The assembling operation is further simplified by fabricating the casing 1 with a part which does not form a frame structure, that is, the bottom plate 7 in the above example, and with at least one other part, and by mounting the first and second terminals 10, 11 as well as the first and second conductive leaf springs 12, 13 on said part which does not form a frame structure, as mentioned above.

In addition, it will be appreciated that a rotatable arrangement for the knob 46 to provide manual switching of the contacts 21, 22 is most advantageous to the compactness and simplicity of the structure, since an axially slidable arrangement of the operating shaft 41 into and out of the casing 1 would involve complex mechanism to retain it in two operative positions while a slidable arrangement of a certain operating member along one of the casing walls would require a large space therefore.

While in the foregoing, the conductive, magnetic plate 20 has been described as a wholly conductive and magnetic body, it may comprise a layer 40 of magnetic material, such as a soft iron, which exhibits little variation of magnetic permeability with temperature and disposed opposite the magnet 24, and a laminated layer 41 of conductive material such as copper, as shown in FIG. 8. Such modification presents the additional advantages of increased stability against temperature variation and of increased operational stability with opposing directions of current flow. This is illustrated in FIG. 9 which shows the conductive, magnetic plate 20 comprising a single member. In this instance, it will be noted that the interaction between the flux 48 from the magnet 24 and the flux 49 produced by the current flowing through the conductive, magnetic plate 20 will be acting in the opposite directions on opposite sides of the center of current flow, as considered in section. However, with the arrangement shown in FIG. 8, the majority of the flux from the magnet 24 will pass through the magnetic layer 40, so that its interaction with the flux produced by the current flow will be acting in one direction only, thereby contributing to an increase in the operational stability.

While the invention has been described with reference to a particular embodiment thereof, it should be understood that various modifications and changes can be made by those skilled in the art without departing from the spirit of the invention.

Having described the invention, what is claimed is:

1. A compact circuit protector comprising a casing, first and second conductive leaf springs spaced apart and secured within the casing at one end thereof, each of said leaf springs extending a length in the same direction from the secured end and then being bent to extend toward each other, first and second terminals secured to the casing in contact with said first and second conductive leaf springs and extending to the exterior of the casing, said terminals being adapted for connection with a circuit to be protected, a conductive, magnetic plate extending between the other ends of the first and second conductive leaf springs and mounted on the other end of the second conductive leaf spring, first and second contacts attached to the other end of the first conductive leaf spring and to the free end of the conductive, magnetic plate, respectively, at positions opposite each other, a permanent magnet disposed adjacent and opposite the conductive, magnetic plate for attracting and holding the magnetic plate magnetically so as to keep the second contact in electrical contact with first contact, a third spring secured to the casing for holding the permanent magnet in place, and an operating member mounted to the casing and operable to cause the permanent magnet to be displaced manually, said permanent magnet and said second conductive leaf spring being constructed and arranged such that in the event of an overcurrent above a given level flowing across the first and second terminals and through the conductive, magnetic plate, the magnetic attraction between the permanent magnet and the conductive, magnetic diminishes to cause the latter to move away from the permanent magnet by resilience of the second conductive leaf spring to thereby move the first and second contacts apart from each other, said operating member being thereafter operable to move the permanent magnet against the resilience of the third spring until it captures the conductive, magnetic plate again, whereupon the resilience of the third spring is effective to bring the conductive, magnetic plate back to its original position in which the second contact engages the first contact.

2. A compact circuit protector according to claim 1 in which the first contact is normally urged away from the second contact by the resilience of the first conductive leaf spring, further including a manual switch member rotatably carried by the casing and having a ramp surface which engages at its one end with the major surface of the other end of the first conductive leaf spring to prevent movement of the first contact away from the second contact when the switch member is in one position, said switch member being rotatable to another position in which the first conductive leaf spring is allowed by its own resilience to move into facial contact with said ramp surface, whereby the first contact is moved out of engagement with the second contact.

3. A compact circuit protector according to clam 1, in which the conductive, magnetic plate or a movable part of the second conductive leaf spring is provided with an index

member, and a window is formed in the casing opposite the index member to give an indication whether or not the circuit is interrupted by the circuit protector.

4. A compact circuit protector according to claim 1 in which the conductive, magnetic plate comprises a layer of nonmagnetic conductor and another layer of magnetic material having a magnetic permeability which is little influenced by temperature variations, said another layer being positioned opposite the permanent magnet.