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POLARIZED SENSITIVE CIRCUIT BREAKER
UTILIZING A MAGNETIC REED SWITCH
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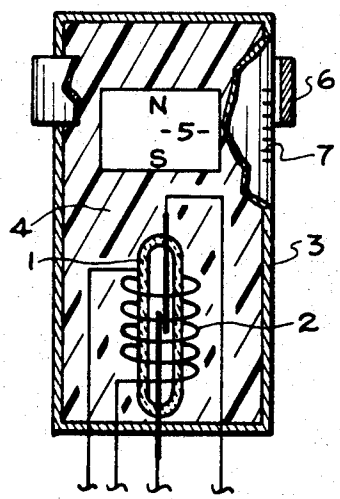


FIG. 1

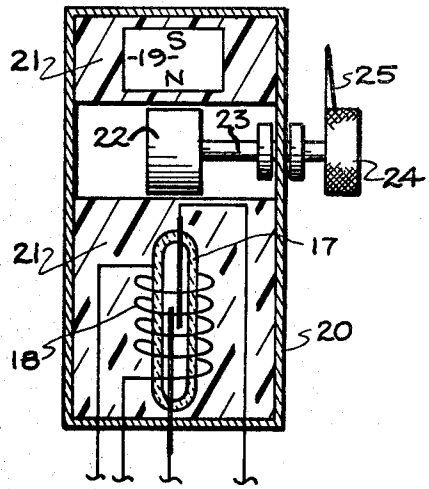


FIG. 2

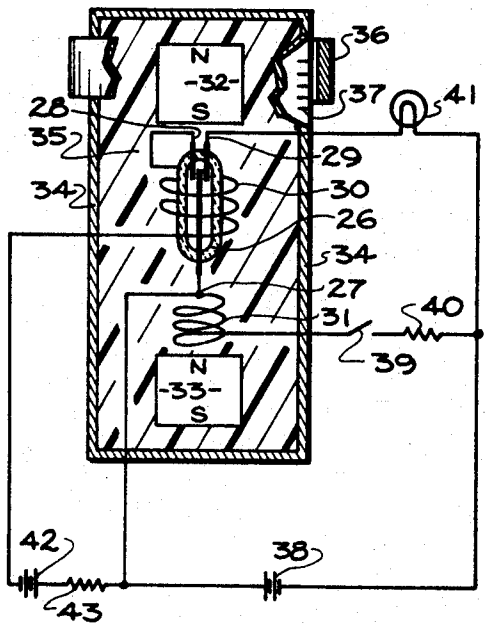


FIG. 3

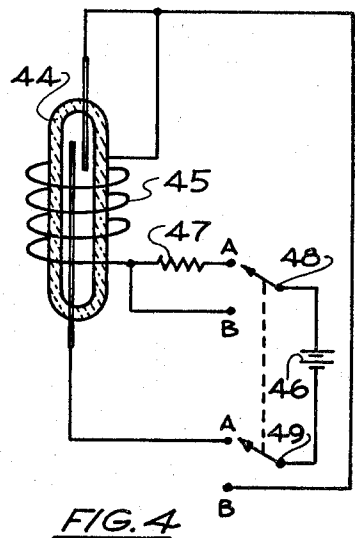


FIG. 4

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ABSTRACT OF THE DISCLOSURE

A sensitive circuit breaker comprises a reed relay with contacts biased closed by a permanent magnet located in a fixed position external to the relay, the contacts opening when current through the relay coil is excessive. Contacts are re-closed by a manually controlled variable magnetic field.

This is a continuation-in-part of applications Ser. No. 131,383, filed Aug. 14, 1961 and Ser. No. 217,764, filed Aug. 17, 1962.

This invention relates to ultrasensitive electromagnetic circuit breakers with particular respect to improvements in an ultrasensitive circuit breaker disclosed in the above-cited application Ser. No. 131,383.

In the above previously disclosed circuit breaker certain shortcomings are evident, notably: (1) inability of the breaker to indicate when an overload has caused breaker action, (2) the possibility of resetting the breaker when a dangerous overload condition still exists, (3) inability to reset the breaker from a remote location, (4) inability to adjust the sensitivity of the breaker to operate at a predetermined current value without experimentation, (5) difficulty in adjusting sensitivity to a critical level, and (6) susceptibility of the breaker to deviations in sensitivity due to temperature fluctuations.

Objects of this invention therefore are to provide an ultrasensitive circuit breaker that: (1) can give a visual indication when the breaker contacts open, (2) will not reset to a closed condition unless the current being broken has been reduced to a safe value, (3) is capable of being reset from a remote location, (4) can readily be reset to any of a number of specific sensitivities without experimentation, (5) is easier to adjust sensitivity, and (6) is more stable to ambient temperature fluctuations. Besides these advantages the new breaker is ultrasensitive and very rapid in response.

With these objects in view the purpose of this invention is accomplished by mounting a magnetic reed switch within a solenoid and biasing the switch by use of one or more permanent magnets to remain in a closed position when no current flows through the solenoid, the bias produced by the magnet opposing that produced by the solenoid, with provision to reset the breaker to a closed condition by the temporary use of additional flux produced by moving a magnet, moving a magnetic shunt, or by passing current through the solenoid. The status of the breaker is shown by additional contacts on the reed switch which actuate a signalling device. Resetting under unsafe loads is prevented by restricting the resetting bias to a safe value. Remote resetting is attained when the solenoid is used for reset bias. Resetting to specific sensitivities is accomplished by indexing means. Improvement in ease of adjustment and in reducing sensitivity changes under temperature variation is accomplished by employing more than one magnet.

All figures in the accompanying drawing show circuit breakers or portions of breakers in section through the midsection of the breakers, and represent various embodiments of the invention. FIGURE 1 shows a magnet-biased switch with variation in bias accomplished by a movable

external shunt. FIGURE 2 shows a switch biased by a stationary magnet with a movable soft iron mass to alter the projected flux of the magnet. FIGURE 3 shows the use of a double throw switch biased by two fixed magnets with shunt means to vary the projected flux of one magnet. Also shown in FIGURE 3 is a second solenoid for resetting purposes and a means of indicating the status of the breaker. FIGURE 4 shows a portion of a breaker including a switching circuit that can be used to reset the breaker.

In every instance a magnetic reed switch serves as the output control for the breaker, the normally open contacts always serving to break the load current. Such switches are well known to industry. They comprise at least two overlapping ferromagnetic reeds that are normally open in the absence of a magnetic field and closed in the presence of a magnetic field. In some instances a third contact is present which contacts one of the moving ferromagnetic reeds in the absence of a magnetic field, thus constituting two normally closed contacts. In the presence of magnetic flux these normally closed contacts open. The reeds often are sealed hermetically in glass. Reed switches characteristically have a wide deadband, requiring a considerable change in flux for opening and closing.

All circuit breakers embodied in this invention are polarity sensitive, but will operate on alternating current if the frequency is less than approximately 1000 cycles per second. They operate extremely rapidly, in the microsecond range, and can break power as low as 10 microwatts. The low moment of inertia of the reeds makes the switches resistant to shock and vibration.

In FIGURE 1 is shown a magnetic reed switch **1**, housed within a solenoid, **2**. A remotely located permanent magnet **5**, is placed at such distance from the switch that its flux is sufficient to close the switch. The magnet, solenoid and switch are mounted in a fixed position within a container **3**, which preferably should be made of nonferromagnetic material. A potting compound **4**, holds the above components securely, but other methods of mounting may be employed. Slidingly mounted on the outside of the container is a ferromagnetic sleeve **6**, made of soft iron or the like which serves as a magnetic shunt to divert a portion of the field projected by the magnet away from the switch. When the sleeve is moved to a position opposite the center of the magnet, it bypasses much of the flux from the magnet and produces the lowest flux at the switch. When in a higher position, as shown, it allows the magnet to project more flux towards the switch. The sleeve is closely fitted to the container so that it can be manually relocated but so that it will stay in position after moving, due to friction. If desired, it may be sealed in place with adhesive.

In use, the solenoid may be shunted across a voltage source that is to be controlled, and the contacts of the switch may be connected in series with the source so that when the switch opens it breaks the current from the source. Or the switch and solenoid may be connected in series with a current source and a load as is shown in application Ser. No. 217,764, and thus the load is disconnected when the switch opens.

After opening, the switch must be closed before current can flow again. This resetting is accomplished by moving the shield upward or by completely removing the shield, thus allowing the full flux of the magnet to be projected toward the switch. Or the switch may be reset by passing a current momentarily through the solenoid that produces a flux at the switch that re-inforces the flux of the magnet. The current through the solenoid during the protective cycle of the breaker must produce a flux at the switch that opposes that of the magnet at the switch.

A marked scale **7**, engraved into the container, serves

as an index for adjusting the sensitivity of the breaker to a pre-determined level, by allowing the operator to return the shield to a precalibrated position after moving it. The most sensitive position is that which will produce the weakest flux at the switch and still hold the switch closed. Such flux will of course not be sufficient in itself to close the switch because of the wide dead band, and will have to be temporarily augmented by additional flux as described above when resetting the breaker.

Another method of magnetically resetting the breaker is shown in FIGURE 2. Here magnetic reed switch **17** is housed within solenoid **18** which in turn is potted in container **20** using potting resin **21**. A permanent magnet, **19**, is potted in the upper section of the container leaving an air space between the magnet and the switch-solenoid assembly. In this air space is located a rotatable soft ferromagnetic member, such as soft iron, which is attached to shaft **23** which is in turn coupled to knob **24** having an indexing pointer, **25**. By turning knob **24** to align the major axis of member **22** with the major magnetic axis of magnet **19**, the flux of magnet **19** is intensified at the switch, thus resetting the breaker by closing the contacts of switch **17**. Knob **24** may then be turned to move member **22** from this position of maximum flux transmission to one of lesser flux transmission, thus weakening the flux holding the contacts closed and increasing the sensitivity of the breaker. Then when current flows through solenoid **18** in a direction to counteract the flux of magnet **19** at the switch, the circuit breaker switch will open.

In FIGURE 3 is shown a circuit breaker that can be reset electrically from a remote location, it incorporates a lamp to indicate the status of the breaker, and can be adjusted readily and repetitively to critical sensitivities. Here a double throw magnetic reed switch, **26**, is mounted within solenoid **30** and potted within a container, **34**, with potting resin, **35**. Also potted is a second solenoid, **31**, together with two remotely located permanent magnets, **32** and **33**. The normally open contacts of the reed switch, **27** and **28**, are connected in series with a battery, **42**, and a load, **43**, with the object of restricting the current through the load to a predetermined maximum. The second solenoid, **31**, is connected in series with a switch, **39**, a resistor, **40**, and a direct current power source, battery **38**, for purposes of resetting the breaker. The normally closed contacts **27** and **29**, which remain normally closed in the absence of a magnetic field, are connected in circuit with a power source **38**, and a signalling device such as lamp **41**, to serve as an indicator of the status of the breaker. A soft ferromagnetic cylindrical shield **36**, slides movably on the outside of the container and serves to divert the flux of magnet **32** from being projected toward switch **26**. This shield is frictionally fitted to the container, so that it will remain stationary after moving. Any mass of soft ferromagnetic material may be used instead of a cylinder, provided it intercepts some of the magnetic flux. Graduations **37**, etched on the side of the container, serve as an index to indicate the relative position of the shield with respect to the magnet. The shield is used in the manner heretofore described to vary the sensitivity of the breaker.

The purpose of the second magnet **33**, is to re-inforce the flux of magnet **32** at the switch, and thus enable both magnets to be located further from the switch. This more remote location makes adjustment less critical in view of the inverse square law and for this reason reduces the effect of ambient temperature changes on sensitivity in that a small change in distance between the magnets and the switch with temperature variation results in a lesser change in flux at the switch than when the magnets are close to the switch. However, only one magnet is essential to the switch.

The breaker is reset by closing switch **39**, thus passing a current through solenoid **31** that re-inforces the net flux at the switch of the two magnets. It is desirable that this current be restricted by means of a selected resistor **39**, to prevent it from closing the breaker when an excessive current is still flowing through solenoid **30** and the load. This current should be adjusted so that it will just close the breaker when the maximum allowable current is flowing through the load. Since the current flowing through solenoid **31** must produce at the switch a flux that is opposite in polarity to that produced by the current flowing through solenoid **30**, it is desirable that the reset current applied to solenoid **31** be increased whenever a larger tolerable current flows through the load, or in other words, whenever the sensitivity of the breaker is decreased. When the reset current is properly adjusted, it will then be impossible to reset the breaker until the current flowing through the load has been reduced below the maximum tolerable.

Once the breaker is closed the load current flowing through solenoid **30** will flow until it exceeds the tolerable maximum, which is governed by the sensitivity setting of the breaker. This current must be of such polarity that it will produce a flux at the switch that will oppose the net flux of the two magnets. When it exceeds the tolerable maximum, it overcomes the net flux of the magnets holding contacts **27** and **28** closed and these contacts then open very rapidly. Contacts **27** and **29** simultaneously close, thus lighting lamp **41** to indicate that the breaker has operated and is now open.

It is obvious that solenoid **31** can be wound concentric with solenoid **30**, in which instance less current will be required for resetting than when solenoid **31** is located more remotely from the switch. The breaker also can be reset by passing the reset current directly into the operating solenoid **30**, in which instance solenoid **31** need not be used. This is illustrated in FIGURE 4, where is shown the switch-solenoid portion of a circuit breaker. Here reed switch **44** is connected in series with solenoid **45**, load **47** and battery **46** through contacts A of coupled switches **48** and **49**. When the reed switch opens, the breaker can be reset by throwing dual switch **48** and **49** to the B position thus disconnecting the load and causing the battery current to flow through the coil in a reverse direction. Then upon returning the dual switch to the A position, the load is again connected to the breaker contacts and if it is still excessive it will immediately open them again.

It is obvious that the breaker of FIGURE 3 does not need two magnets, magnet **32** being sufficient. Also, magnet **33** need not re-inforce the flux of magnet **32**, as by making magnet **33** large, magnet **32** can still operate at a considerable distance from the switch even though its flux counteracts that of magnet **33**, and thus the adjustment of the sensitivity will still remain easy. Also, in place of using a magnetic shunt, **36**, to adjust sensitivity, the sensitivity may be adjusted in the manner shown in FIGURE 2, wherein the reluctance of the path between the magnet and the switch is varied by member **22**. If an indication of the status of the breaker is not required, a single pole single throw reed switch could be used in the device of FIGURE 3, dispensing with items **29**, **41**, **40** and **39**.

In all embodiments of this invention the reed switch need not be placed within the actuating solenoid, although this placement gives the greatest sensitivity. The switch must however be operable by the flux from the actuating solenoid in any instance. Unless there is a fairly large low reluctance path between the switch and the container, it has been found best to use a non-ferromagnetic container to avoid bypassing much of the bias flux. Although potting compound was shown in all embodiments to hold the stationary components in place, other methods of attaching the components to the container may be used.

It is also obvious that features shown in FIGURE 4, such as the method of indicating the status of the breaker, the use of more than one magnet or the use of the electrical method of resetting, can be applied to the devices of FIGURES 1, 2 and 3.

It should be noted that the flux pattern of the permanent magnet in FIGURES 1 to 3 extends over practically the entire switch. Hence, the bypassing shield, such as

member 6 in FIGURE 1, can operate over most of the area of the container to control sensitivity.

What is claimed is:

1. A polarized current-limiting device designed to be inserted in an electrical circuit to prevent a current of pre-established polarity and maximum value from flowing through a load, said device comprising in combination: a non-ferromagnetic framework; at least one solenoid firmly attached to said framework; a magnetic reed switch containing at least two normally open reed contacts, said switch being immovably housed within said solenoid; means to connect said contacts to said circuit to control the current through said load; at least one permanent magnet immovably attached to said framework and located at such distance from said switch and solenoid to define a high reluctance magnetic gap between said magnet and said switch-solenoid combination and to hold said contacts in a closed position when no current flows through said solenoid; means to connect said solenoid in said circuit, the flux from said solenoid opening said contacts and simultaneously limiting the flow of current through said load when the voltage across said solenoid produced by a current of a given polarity exceeds a predetermined maximum value, said value varying directly with the working flux of said magnet at said switch; and manually operated resetting means to momentarily produce an increase of magnetic flux of the proper polarity at said switch to close said contacts after they open.

2. A device according to claim 1 including means to alter said working flux of said magnet, said means comprising a magnetic shunt affixed to said framework to distort the projected flux pattern of said magnet at said switch.

3. A device according to claim 2, including means to manually change the position of said shunt means with respect to said switch.

4. A device according to claim 3, including indexing means to indicate the relative position of said shunt means with respect to said switch.

5. A device according to claim 1, including manually controlled switching means to momentarily pass a current of proper polarity through said solenoid to reset said contacts to a normally closed position.

6. A device according to claim 1, wherein said solenoid and contacts are connected in electrical series with said load.

7. A device according to claim 1, wherein said switch includes two contacts that are normally closed in the absence of a magnetic field, said normally closed contacts being connected in circuit with a power source and a signaling means to provide a signal when said normally closed contacts close.

8. A polarized current-limiting device comprising in combination: a first given solenoid; a second given solenoid; a magnetic reed switch comprising at least two normally open reed contacts, said switch being located in a fixed position with respect to said solenoids and in flux coupling relationship with said solenoids; at least one permanent magnet located in a fixed position with respect to said switch and spaced apart from said switch to define a high reluctance magnetic gap between said switch and magnet, said magnet being located at such distance from said switch that its projected flux will hold said normally open contacts in a closed position when no current flows through either solenoid; means to connect said first given solenoid and said reed contacts to a circuit to be controlled; and resetting means to close said contacts after they open, said resetting means comprising a switch and a power source connected in circuit with said second given solenoid.

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