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Taylor

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[54] **CIRCUIT BREAKER TRIPPING DEVICE OPERABLE FROM A LOW ENERGY TRIPPING SIGNAL**

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[52] **U.S. Cl.** **335/174,** 335/179, 335/229
[51] **Int. Cl.** **H01h 9/20**
[58] **Field of Search** 335/174, 179, 229, 335/230, 234, 26; 317/155.5

[56] **References Cited**

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Primary Examiner—Harold Broome
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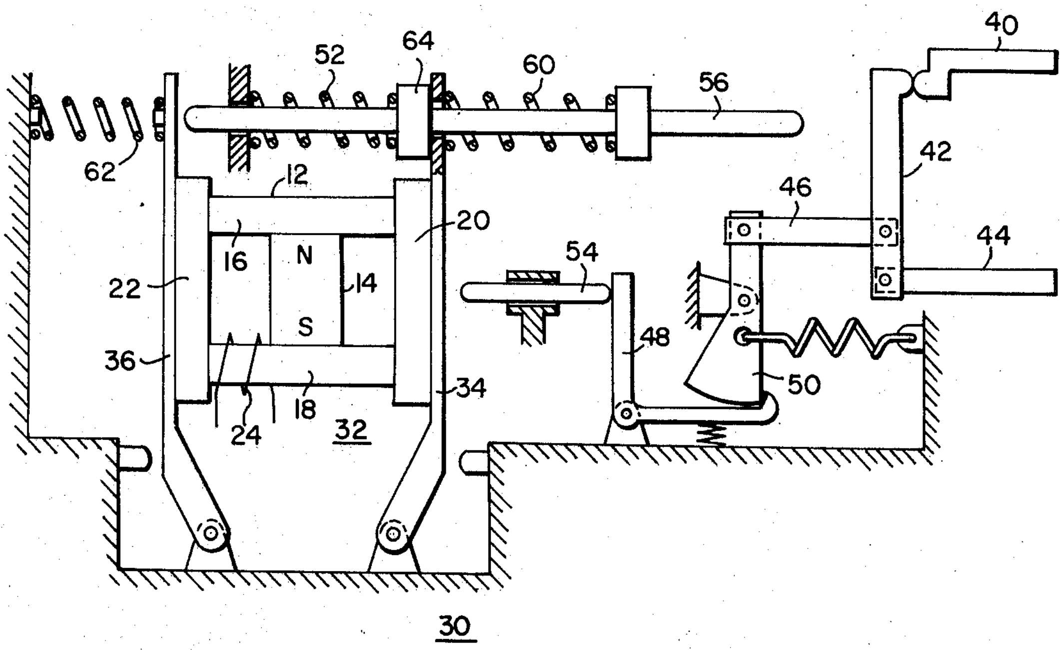
[57] **ABSTRACT**

An electric circuit breaker comprising an electromagnetic tripping device. The electromagnetic tripping device comprises an H-shaped structure which is constructed of a permanent magnet disposed between two pole pieces. A trip keeper is releasably held to the pole faces on one end of the H-shaped structure and a reset keeper is movably held to the pole faces at the other end of the H-shaped structure. A winding means encircles one leg of the H-shaped structure and when energized bucks the flux through the magnetic path closed by the trip keeper and boosts the flux through the reset keeper so as to release a trip arm and trip the circuit breaker.

6 Claims, 7 Drawing Figures



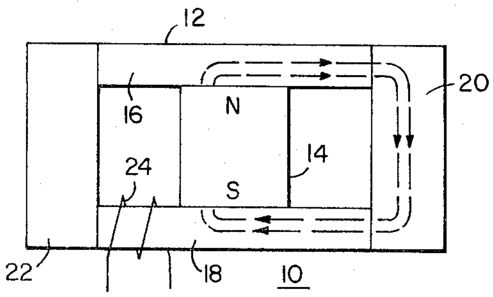


FIG. 1.

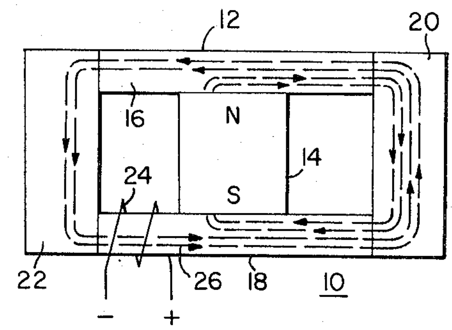


FIG. 2.

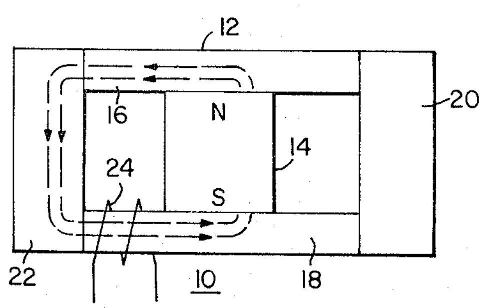


FIG. 3.

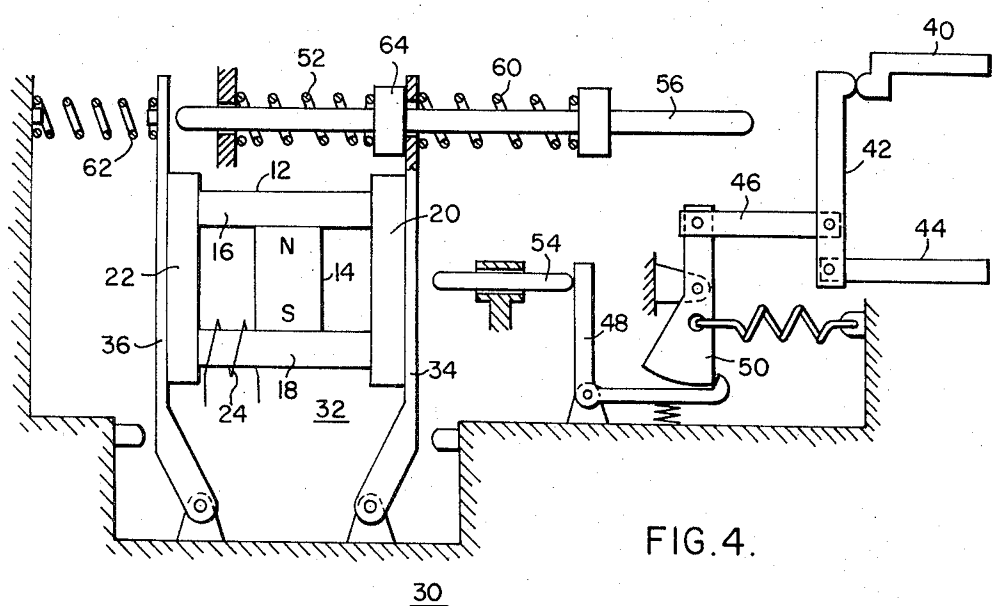


FIG. 4.

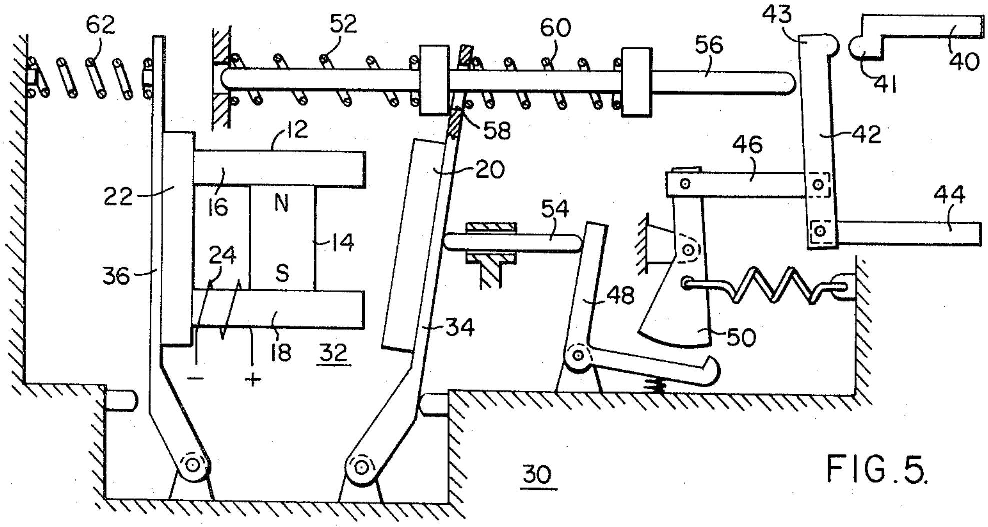


FIG. 5.

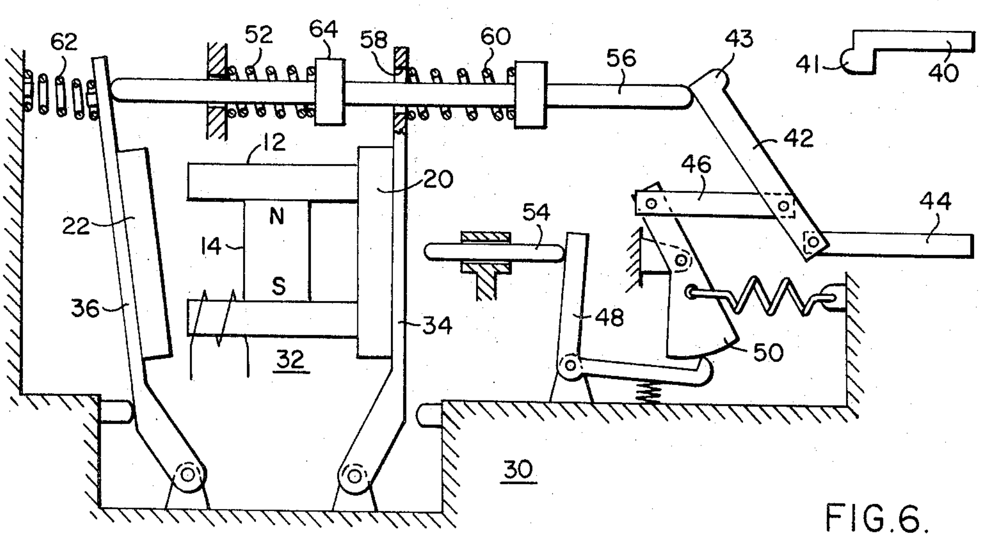


FIG. 6.

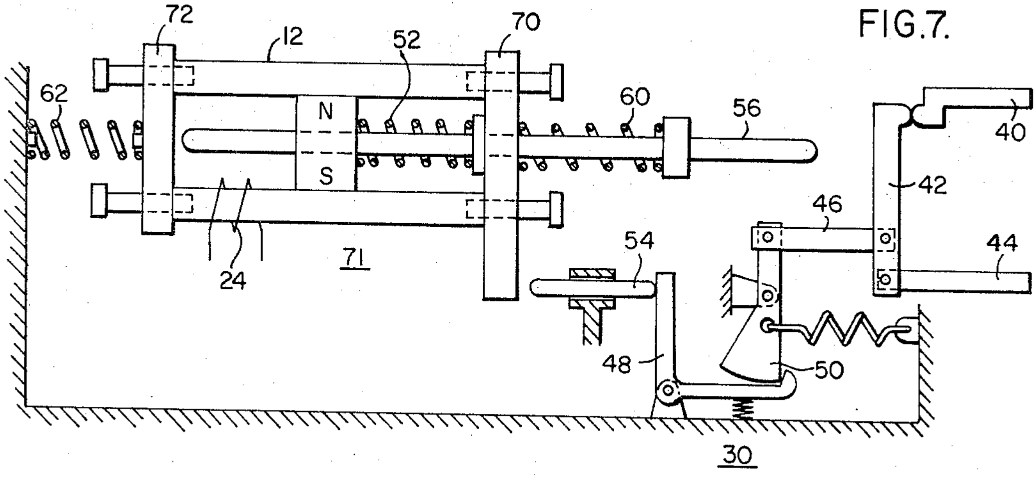


FIG. 7.

CIRCUIT BREAKER TRIPPING DEVICE OPERABLE FROM A LOW ENERGY TRIPPING SIGNAL

BACKGROUND OF THE INVENTION

This invention relates generally to circuit breakers and more particularly to circuit breakers of the type having electromagnetic tripping means.

Magnetic tripping devices for circuit breakers are well known to those skilled in the art and are illustrated typically in U.S. Pat. No. 3,450,955 issued June 17, 1969 to F. D. Johnson and assigned to the same assignee as the present application. Static or solid state devices which operate at a low power level are being used increasingly, for sensing and control, in circuit breakers. The output energy from the solid state devices to trip a circuit breaker is relatively low, and prior art tripping circuit units have encountered difficulties in matching these low energy components. It is desirable to have an electromagnetic tripping device which can be operated from a low energy tripping signal.

SUMMARY OF THE INVENTION

The present invention provides a circuit breaker comprising an improved electromagnetic tripping device. The tripping device operates from a low energy input signal and is automatically reset when the circuit breaker is tripped open.

The present invention is particularly concerned with magnetic memory characteristics and utilizes an electromagnetic controlled magnetic memory device for tripping a circuit breaker. A magnetic memory is an inherent characteristic of soft ferromagnetic material. The ferromagnetic material must have atoms whose electron arrangement is such that magnetism is created. The atoms having these magnetic characteristics are grouped into regions called domains. In these domains it is equally probable that magnetism will occur in any one of six directions. In unmagnetized ferromagnetic materials the domains are randomly oriented and neutralize each other. Application of an external magnetic field causes magnetism in the domains to be aligned so that their magnetic moments are added to each other and to that of the applied magnetic field.

With soft magnetic materials such as iron, small external magnetic fields will cause most of the magnetic domains to align, but because of the small restraining force only a little of the magnetism will be retained when the external magnetic field is removed. With hard magnetic materials a greater external force must be applied to cause orientation of domains, but most of the orientation will be retained when the field is removed, thus creating a strong permanent magnet which will have one north pole and one south pole.

The materials which may be classified as soft ferromagnetic materials range from cast iron which is one of the poorest to the iron-nickel alloys which rank among the best. The present invention utilizes the inherent memory characteristics of soft ferromagnetic materials to provide a low energy circuit breaker tripping unit. The unit has two ferromagnetic paths each having a portion common to the other. A source of magnetomotive force such as a permanent magnet, is used to supply flux to each of the paths. If one path has less reluctance than the other path, the majority of the magnetic flux will be in the path having the lowest reluctance. The majority of the flux continues to pass through the

low reluctance path until some external energy is applied to realign magnetic domains in both paths and force the direction of magnetic flux to change. Control of the external energy source, required to rotate the magnetic domain orientation in both portions is obtained through the use of an electromagnetic control winding or coil.

In accordance with one embodiment of the invention, a circuit breaker is provided comprising an electromagnetic tripping device that embodies a generally H-shaped structure of magnetic material, such as soft iron, having a permanent magnet disposed between its legs. A trip keeper is releasably held to the pole faces of one end of the H-shaped structure and is spring biased away from this structure. A reset keeper is pivotally held to the pole faces of the other end of the H-shaped structure and is spring biased towards the end of the H-shaped structure. The electromagnetic tripping device comprises two magnetic circuits. One of the magnetic circuits passes through the permanent magnet and the trip keeper. The magnetic flux in this magnetic circuit works to hold the trip arm to the H-shaped structure. The other magnetic circuit passes through the permanent magnet and the reset keeper. An electric coil is provided around one leg of the H-shaped structure. This coil when energized with direct current of the correct polarity shifts the magnetic flux from the trip keeper to the reset keeper. When the circuit breaker is in the closed position and the flux is shifted from the trip keeper to the reset keeper, the trip arm is released from the H-shaped structure and trips the circuit breaker. When the trip keeper is held to the H-shaped structure the circuit breaker latch means can be in a latching position. When the trip keeper is released it releases the latch means to affect a tripping operation. In this embodiment of the invention, both the reset keeper and the trip keeper are pivotally supported so that when the circuit breaker trips open the trip keeper is forced to engage one end of the H-shaped structure and the reset keeper is mechanically spaced from the other end of the H-shaped structure. Spacing the reset keeper from the H-structure causes a majority of the flux from the permanent magnet to flow through the trip keeper so that when the circuit breaker is closed the low reluctance path is through the trip keeper.

In another embodiment of the invention a circuit breaker is provided comprising an electromagnetic latching device that embodies a generally H-shaped structure comprising two legs of magnetic material such as soft iron and a permanent magnet connecting the two legs. Operation of the magnetic circuits is the same as described for the first embodiment of the invention. However, in this embodiment the reset keeper and the trip keeper are mounted for rectilinear movement along the longitudinal axis of the H-shaped structure. A reset plunger extends through the center of the trip keeper and the permanent magnet which connects the two legs of the H-shaped structure. A coil is wound around one leg of the H-shaped structure for operating the magnetic tripping device.

This invention has several advantages over prior art magnetic tripping devices for example, only a low energy pulse is required to shift the flux from the trip keeper to the reset keeper thus permitting the circuit breaker to trip open. This low energy tripping requirement makes this device especially compatible with solid state control units having low power outputs. Another advantage of this invention is that only one tripping coil is required and the magnetic tripping device is automatically reset when the circuit breaker is tripped open.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages of the present invention will be readily apparent upon reading the following detailed description taken in conjunction with the drawings, in which:

FIG. 1 shows an H-shaped magnetic circuit with most of the flux passing through the right hand keeper;

FIG. 2 is similar to FIG. 1 but with the control coil energized;

FIG. 3 is similar to FIG. 1 but showing the flux shifted to the left hand keeper after the control signal is applied;

FIG. 4 is a diagrammatic view of a circuit breaker in the closed position embodying the teachings of the present invention;

FIG. 5 is a view similar to FIG. 4 with the circuit breaker in an intermediate open position;

FIG. 6 is a view of the structure shown in FIG. 4 with the circuit breaker in a fully open position;

FIG. 7 is a diagrammatic view of a structure showing another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and FIGS. **1, 2** and **3** in particular, there is shown a magnetic circuit **10** comprising an H-shaped structure **12** which has a permanent magnet **14** disposed between the legs **16** and **18.** Legs **16** and **18** are made from soft magnetic material. A soft iron keeper **20** is attached to one end of the H-shaped structure and an identical soft iron keeper **22** is attached to the other end. As shown in FIG. **1** when the reluctance of the magnetic path through keeper **20** is lower than the reluctance of the path through keeper **22** the majority of the magnetic flux, approximately 90 percent, will pass through the right hand keeper **20.** This will strongly hold the keeper **20** to the H-shaped structure **12.** The remaining magnetic flux takes the path of the second magnetic circuit through keeper **22.** A control winding **24** is wound around one leg of the H-shaped structure **12.** When a direct current control signal of the proper polarity is applied to the control winding **24** a magnetic flux is produced in keeper **20** which opposes the flux produced by the permanent magnet **14.** The magnetic flux **26** produced by control winding **24** also flows through keeper **22** and aligned the magnetic domains in keeper **22** to affectively reduce the reluctance path through keeper **22.** This alignment causes the majority of the flux produced by the permanent magnet **14** to shift from the magnetic path through keeper **20** to the magnetic path through keeper **22.** This superposition of the electromagnetic field upon the permanent magnetic field is such that the value of the electromagnetic field causes the effective reluctance of the path including keeper **22** and the permanent magnet **14** to be lower than the effective reluctance of the path including keeper **20** and permanent magnet **14.** As shown in FIG. **3** when the electromagnetic control winding no longer supplies magnetomotive force to the device **10,** the path including keeper **22** continues to have a lower reluctance than the path including keeper **20** and therefore most of the lines of flux continue to stay in the path through keeper **22.** Thus, it can be seen that, an electric pulse applied to the control winding **24** can be used to switch the lines of magnetic flux emanating from the permanent magnet **14** from the path through the keeper **20** to the path through keeper **22.** it is important to note that the magnetic field attains equilibrium after the flux transfer. Its stability is not destroyed when the electromagnetic field is removed. The majority of the flux continues to flow through the path including keeper **22.**

Referring now to FIG. **4** there is shown a circuit breaker **30** including a permanent magnet flux transfer tripping device **32.** The magnetic tripping device **32** comprises an H-shaped structure **12** which is constructed from a permanent magnet **14** disposed between the two legs **16** and **18.** Keepers **20** and **22** are mounted so that they can be moved into and out of engagement with the ends of the H-shaped structure **12.** Keeper **20** is rigidly attached to trip arm **34.** Trip arm **34** is pivotally attached to circuit breaker **30,** so that the keeper **20** can move into and out of contact with the H-shaped structure **12.** A reset arm **36** is pivotally mounted to circuit breaker **30** and keeper **22** is attached to the reset arm **36** so that keeper **22** can be pivoted into and out of engagement with one end of the H-shaped structure **12.**

When circuit breaker **30** is in the closed position as shown in FIG. **4,** a continuous current path exists from the top stud **40** through the breaker contact arm **42** and out the lower stud **44.** An insulating member **46** is attached to the breaker contact arm **42** for moving the contact arm **42** from the closed position to the open position. Pinned to the other end of the insulating member **46** is an opening member **50.** The opening member **50** is pivotally mounted and spring biased in a counterclockwise direction. When the circuit breaker **30** is in the closed position as shown in FIG. **4,** the operning member **50** is prevented from moving by an L-shaped latching member **48.**

When the circuit breaker is in the closed position as shown in FIG. **4,** the majority of the magnetic flux from the permanent magnet **14** passes through keeper **20.** The trip arm **34** is spring biased in a clockwise direction by a tripping spring **52.** With the majority of the magnetic flux passing through keeper **20** the holding force on the keeper **20** is greater than the clockwise bias from spring **52.** The keeper **20** is thus held at the end of the H-shaped structure **12** and the trip arm **34** is held in the position shown in FIG. **4.** When it is desired to trip the breaker **30,** a lower energy direct current control signal is passed through the control winding **24** and this signal transfers the majority of the flux from keeper **20** to a path through keeper **22.** This causes the majority of the flux, approximately 90 percent, to pass through keeper **22** and the remaining flux passes through keeper **20.** The holding force on the keeper **20** is thus greatly reduced and is not strong enough to overcome the bias from spring **52.** Tripping spring **52** will rotate the trip arm **34** to strike a trip plunger **54.** The trip plunger **54** contacts and rotates the L-shaped latch **48** to release the spring biased operating member **50** which opens the circuit breaker **30.**

Referring now to FIG. **5** there is shown a circuit breaker **30** in an intermediate open position, just after latch **48** has released the opening member **50.** The contact **41** on the top stud **40** has just separated from the contact 43 on the breaker contact arm 42, and the breaker contact arm 42 is moving in a counterclockwise direction to the fully open position as shown in FIG. 6. As the breaker contact arm 42 moves the fully open position it engages a reset plunger 56. The reset plunger 56 passes through an opening 58 in the trip arm 34. The reset plunger 56 also passes through biasing spring 52 and return spring 60. As the breaker contact arm 42 moves towards fully open position it moves the plunger 56 towards the left. As the plunger 56 is moved towards the left, the trip arm 34 is moved in a counterclockwise direction by return spring 60 so that keeper 20 contacts the end of the H-shaped structure 12. At this instant, when keeper 20 contacts the H-shaped structure 12 and before the reset plunger 56 contacts the reset arm 36, the majority of the flux is still passing through keeper 22. As the breaker 30 continues to open, plunger 56 contacts the reset arm 36 and moves it in a clockwise direction separating keeper 22 from the H-shaped structure as shown in FIG. 6. As keeper 22 separates from the H-shaped structure almost all of the flux is shifted to the magnetic flux path through keeper 20. This flux shifting to the keeper 20 occurs automatically as the circuit breaker 30 opens and separates keeper 22 from the H-shaped structure. When the circuit breaker 30 is switched from the open position shown in FIG. 6 to the closed position as shown in FIG. 4 the reluctance of the magnetic path through keeper 20 remains less than the reluctance of the magnetic path through keeper 22. Due to the low reluctance through keeper 20 the majority of the flux from the permanent magnet 14 flows through the magnetic path including keeper 20. As the breaker 30 is closed a reset spring 62 moves the reset arm 36 in a clockwise direction until keeper 22 is in contact with the H-shaped structure 12. Also, as the circuit breaker 30 closes the contact arm 42 moves in a clockwise direction and this allows the biasing spring 52 to move the reset plunger to the right so that member 64 which is rigidly attached to plunger 56 is in contact with trip arm 34. The magnetic tripping mechanism 32 is now in a reset position with most of the flux passing through keeper 20. Mechanism 32 is now ready for another operation.

Referring now to FIG. 7 there is shown another embodiment of the invention in which the trip plunger 56 passes through the center of the H-shaped structure and the trip keeper 70 and reset keeper 72 are mounted for rectilinear motion. FIG. 7 shows a circuit breaker 30 in a closed position. In this position the majority of the flux is flowing througn trip keeper 70 and this is held tightly against the bottom of the H-shaped structure 12 overcoming the force of opening spring 52. When the circuit is to be interrupted a signal is applied to the control winding 24 and this transfers a majority of the flux from keeper 70 to keeper 72. When the major flux path is through keeper 72 the magnetic holding force on keeper 70 is less than the force of spring 52 and plunger 56 and keeper 70 are moved to the right. As trip keeper 70 moves to the right it contacts plunger 54 and trips open the breaker 30. As the breaker 30 opens, breaker contact arm 42 engages plunger 56 and moves it to the left. As plunger 56 moves to the left, trip keeper 70 engages the end of the H-shaped structure 12 and reset keeper 72 is spaced therefrom. When the reset keeper 72 is spaced from the H-shaped structure 12 almost all of the flux is forced to flow through the trip keeper 70 and the reluctance of this path is effectively lowered. As the circuit breaker 30 is closed, the reset spring 62 moves the reset keeper 72 into engagement with the H-shaped structure 12. The lower reluctance path still exists through keeper 70 and the majority of the flux can still flow through keeper 70. As plunger 56 is moved to the right, reset spring 62 biases the reset keeper 72 into the position as shown in FIG. 7 and the electromagnetic breaker tripping mechanism 71 is ready for another operation.

The embodiments of this invention have several advantages for example, the breaker 30 can be tripped from a low energy signal such as can be supplied by solid state components. Another advantage is that the tripping operation of the magnetic circuit can occur very rapidly since after the flux transfer is complete the magnetic tripping unit 32 or 71 must trip. Another advantage of the present invention is that only one tripping coil is required and the magnetic tripping unit 32 or 71 is reset automatically upon the breaker tripping open.

Since numerous changes may be made in the above described apparatus and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that off the matter contained in the foregoing description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A circuit interrupter comprising:
- a first contact which is stationary;
- a second contact which is movable between a first position in engagement with said first contact and a second position spaced from said first contact;
- operating means to affect opening of said first contact and said second contact;
- latching means to retain said operating means and prevent said circuit interrupter from opening;
- tripping means for disengaging said latching means from said operating means to open said circuit interrupter; and said tripping means comprising,
- a permanent magnet having a first pole piece and a second pole piece between which said permanent magnet is disposed;
- a trip keeper supported for movement between a closed position in engagement with one end of said pole pieces and a tripped position where said trip keeper engages said tripping means to open said circuit interrupter;
- biasing means to bias said trip keeper towards the tripped position;
- a reset keeper supported for movement into and out of engagement with the other end of said pole pieces;
- a first magnetic circuit through said trip keeper providing means to maintain said trip keeper in engagement with said pole pieces;
- a second magnetic circuit through said reset keeper;
- magnetic flux trnsfer means for transferring flux from said first to said second magnetic circuit to release said trip keeper permitting said biasing means to move said trip keeper to the tripped position to effect opening of said circuit interrupter; and,
- automatic reset means for moving said trip keeper into engagement with one end of said pole pieces and for separating said reset keeper from the other end of said pole pieces to shift a major portion of

the flux from said second magnetic circuit to said first magnetic circuit when said circuit breaker is opened.

2. A circuit breaker as claimed in claim **7** wherein said flux transferring means comprises a coil around one of said pole pieces and an electric signal input means for transferring the major portion of the flux from said first magnetic path to said second magnetic path.

3. The circuit breaker as claimed in claim **7** wherein said automatic reset means comprises a plunger, said plunger being supported so that when said circuit breaker is opened said trip keeper is mechanically moved into engagement with said pole pieces and said reset keeper is mechanically spaced from said pole pieces so that the major portion of the flux flows through said first magnetic circuit.

4. The circuit breaker as claimed in claim **7** including a trip arm pivoted about a point spaced from said pole pieces, said trip keeper being rigidly attached to said trip arm, a reset arm pivoted about a point spaced from said pole pieces, said reset keeper being rigidly attached to said reset arm, spring means for moving said reset keeper into engagement with said pole pieces when said circuit breaker is closed.

5. A circuit breaker as claimed in claim **3** wherein said reset plunger passes between said pole pieces and through said permanent magnet, through said trip keeper, and through said reset keeper.

6. A combination as claimed in claim **5** wherein said trip keeper and said reset keeper are supported for rectilinear motion parallel to the longitudinal axis of said first pole piece and said second pole piece.

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