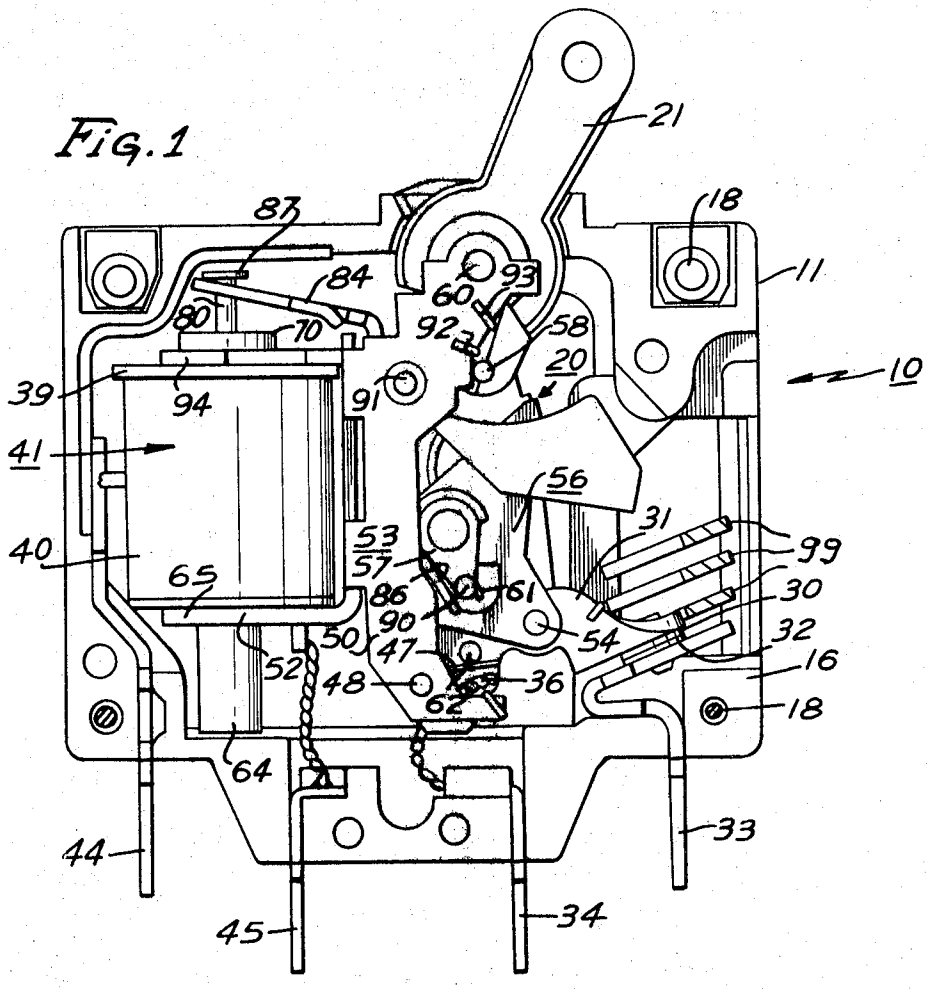
Jan. 26, 1971 A. T. ELLIS, JR 3,559,125

CIRCUIT BREAKER WITH AN UNDERVOLTAGE TRIP DEVICE

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Fig. 1



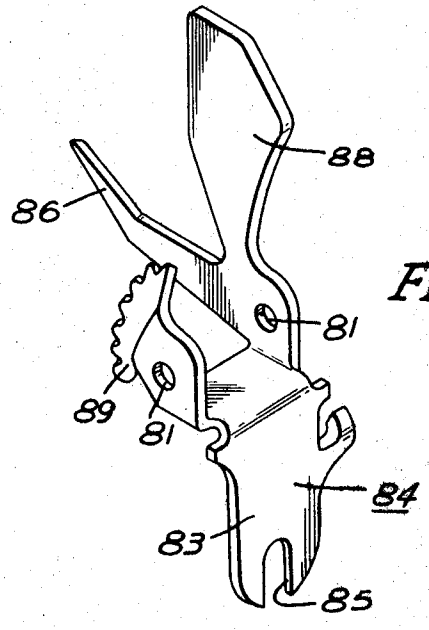


Fig. 6

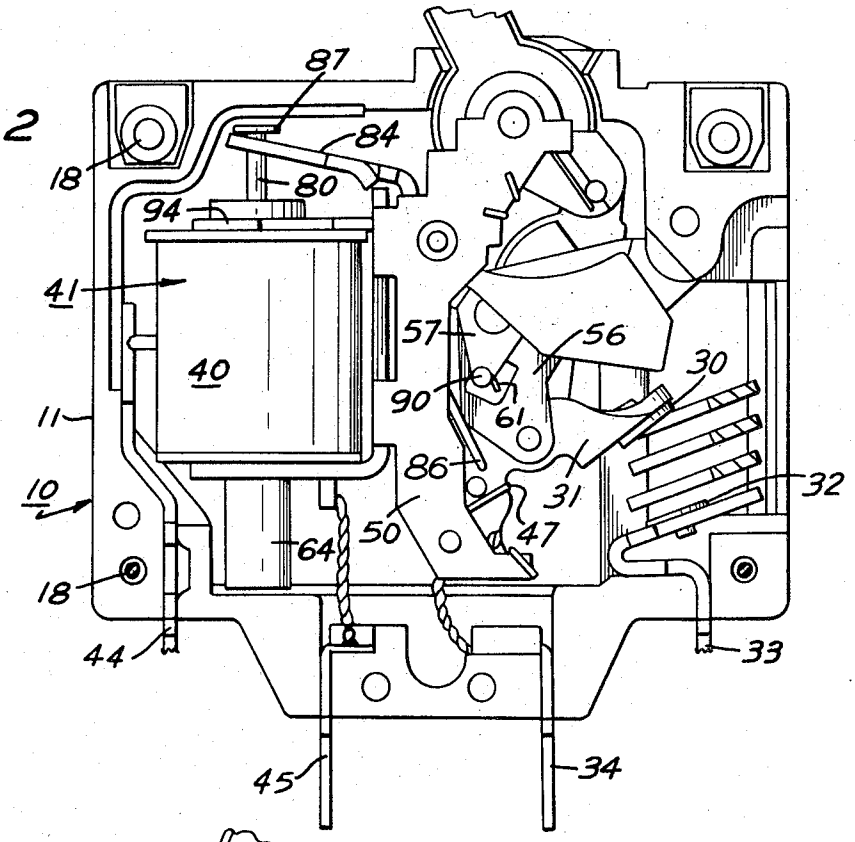
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CIRCUIT BREAKER WITH AN UNDERVOLTAGE TRIP DEVICE

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Fig. 2



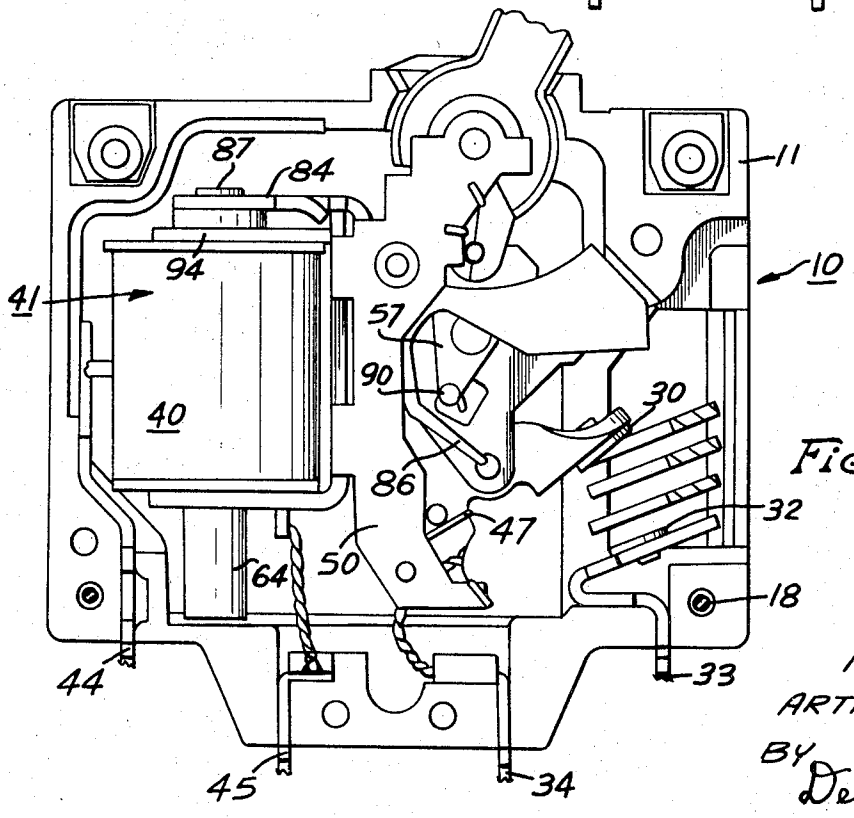


Fig. 3

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CIRCUIT BREAKER WITH AN UNDERVOLTAGE TRIP DEVICE

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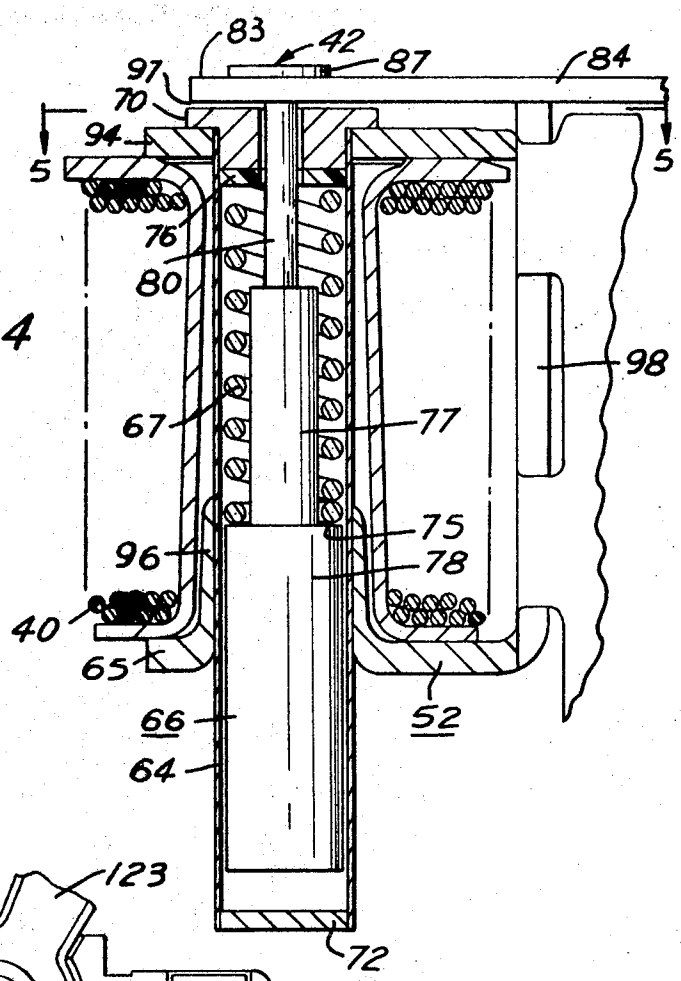


FIG. 4

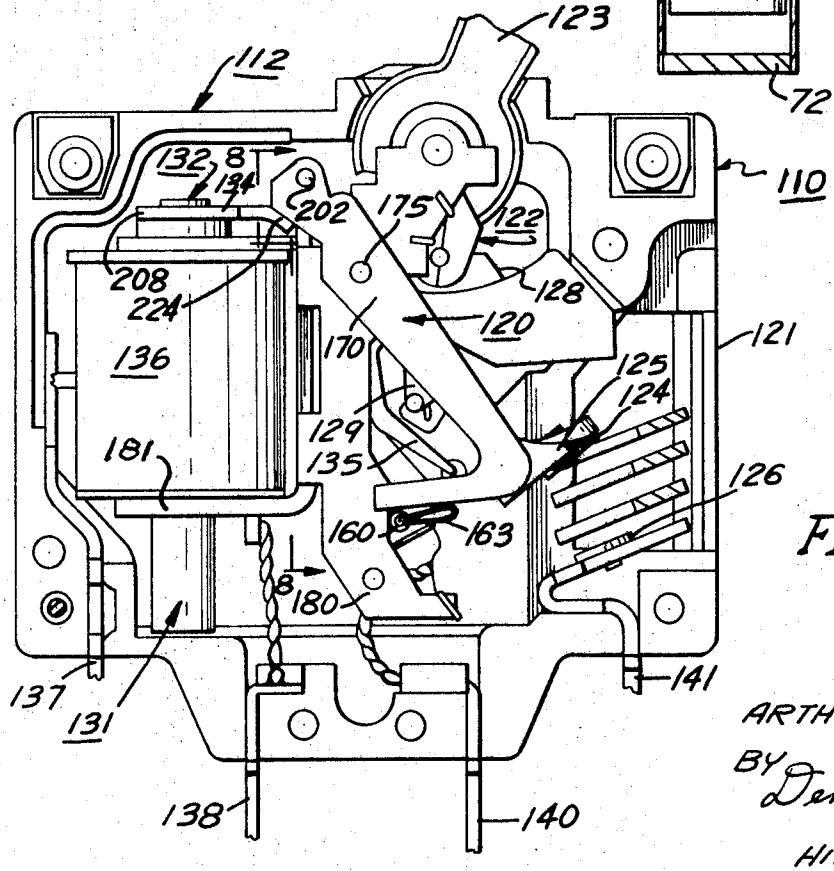


FIG. 7

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CIRCUIT BREAKER WITH AN UNDERVOLTAGE TRIP DEVICE

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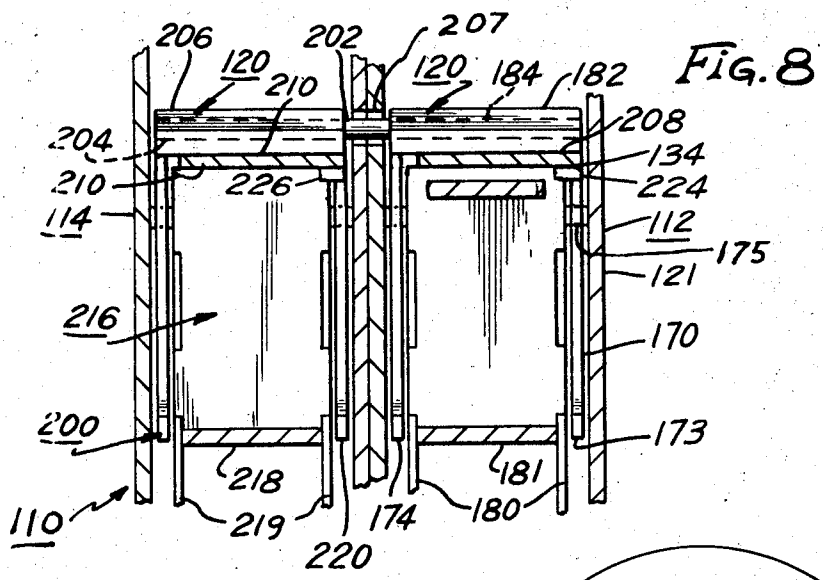


FIG. 8

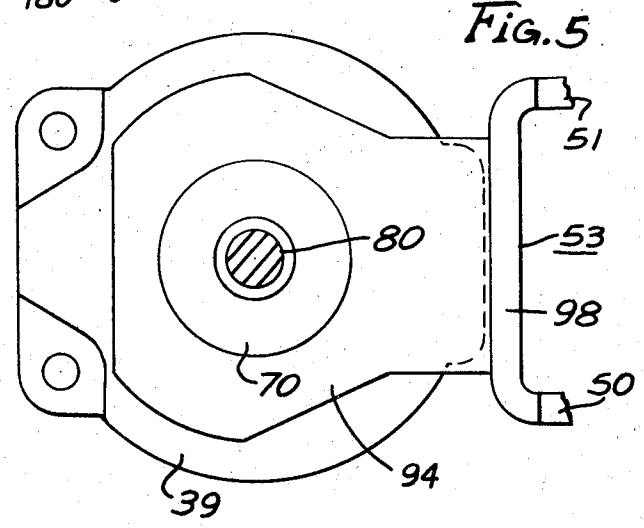


FIG. 5

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United States Patent Office 3,559,125 Patented Jan. 26, 1971

3,559,125

CIRCUIT BREAKER WITH AN UNDERVOLTAGE TRIP DEVICE

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Filed Jan. 15, 1969, Ser. No. 791,397
Int. Cl. H01h 83/06
U.S. Cl. 335—20 18 Claims

ABSTRACT OF THE DISCLOSURE

A circuit breaker comprising a pair of separable contacts and an automatically resettable mechanism, including a latch, for opening and closing the contacts. An electromagnetic device associated with the mechanism for tripping the latch and automatically opening the contacts. The electromagnetic device comprising a solenoid coil and an armature-like member engageable with the latch to unlatch the mechanism when the contacts are closed. A magnetizable core device actuatable by the coil to release the armature-like member and permit it to move away from the latch when the coil is energized above a predetermined level and for moving the armature-like member into engagement with the latch when the coil is energized below a predetermined level and the contacts are closed. Further, such circuit breaker may be used in combination with a known circuit breaker which senses an increase in energization to provide a two pole unit one of which is sensitive to an increase in energization and the other which is sensitive to a decrease in energization.

BACKGROUND OF THE INVENTION

This invention relates to electromagnetic devices and, in particular, to circuit breakers in which the sensing of an electrical condition is accomplished electromagnetically by a device which includes an armature pivoted in tripping relation with a mechanism to open its contacts at such time. Such devices are illustrated, for example, in United States Pat. No. 2,360,922, issued to Kurt W. Wilckens, and United States Pat. No. 3,329,913, issued to William W. Camp.

These prior patents relate to an electromagnetic sensing device including a solenoid coil, a time delay tube housing a movable core of magnetizable material movable against the retarding action of a liquid and a pivotal, spring biased, armature to provide a time delay upon the occurrence of an overload which, if below a certain value and if it does not persist for a predetermined time, will not cause the tripping by the armature of the circuit breaker's operating mechanism and will not open the circuit breaker contacts, thereby avoiding nuisance tripping. In this type of circuit breaker if the overload current is sufficiently high, the resulting magnetic flux will substantially instantaneously cause the pivotal armature to pivot and trip the circuit breaker operating mechanism and will open the circuit breaker contacts substantially instantaneously, i.e., with no intentional time delay.

It is an object of this invention to modify this type of electromagnetic device mechanism so as to provide a circuit breaker which is sensitive to a drop in the level of energization of the coil and to provide for the opening of the contacts at such time.

It is another object of this invention to modify this type of electromagnetic device in such a way that the resulting circuit breaker may be associated with the previously known type to provide a multipole circuit breaker one of whose poles will be sensitive to an increase in energization and the other of whose poles will be sensitive to a decrease in energization thereof.

BRIEF SUMMARY OF THE INVENTION

This invention is embodied in an electrical circuit breaker having separable contacts actuatable by a linkage including a toggle and a latch. The latch, on predetermined current conditions, is tripped by a pivotal, armature-like member. The armature-like member forms part of the electromagnetic device which further comprises a frame and a solenoid coil. The solenoid coil partially surrounds a tube housing a core of magnetizable material which is biased toward one end, the rear end, of the tube. The other, or forward, end of the tube includes a magnetizable pole piece toward which the core moves upon sufficient energization of the coil.

The armature-like member biased away from the pole piece and away from engagement with the latch, but is connected to the core so that the core may move the armature-like member into tripping engagement with the latch.

The core is biased away from the pole piece by a compression spring. The core is moved by the coil toward the pole piece upon energization of the coil above a predetermined level to compress the spring and release the armature-like member, permitting it to move away from the latch. Upon a subsequent predetermined drop in the level of energization of the coil, the compression spring forces the core away from the pole piece and the core at such time actuates the armature-like member causing it to trip the latch and open the contacts.

The foregoing and other objects of this invention, the principles of this invention and the best modes in which I have contemplated applying such principles will more fully appear from the following description and accompanying drawings in illustration thereof.

BRIEF DESCRIPTION OF THE VIEWS

In the drawings, FIG. 1 is a side elevation view of a circuit breaker incorporating the invention, one of the half-cases of the circuit breaker being removed to show the internal parts of the circuit breaker, the contacts being shown in the closed position and the coil being fully energized;

FIG. 2 is a view similar to FIG. 1, but the contacts are shown in the open position, while the coil is fully energized;

FIG. 3 is a view similar to FIG. 1 but showing the trip-free position, i.e., the coil has been deenergized sufficiently to pivot the armature-like member toward the pole piece, the handle is held in the "On" position of the contacts, but the toggle mechanism has collapsed, and the contacts are open;

FIG. 4 is a partial sectional view taken through the coil, partially showing the frame and partially showing the armature-like member in the position corresponding to that shown in FIG. 3;

FIG. 5 is a top view taken along the line 5—5 in FIG. 4;

FIG. 6 is a perspective view of the armature-like member;

FIG. 7 is a view similar to FIG. 3 of the invention as embodied in a two pole circuit breaker but showing only the circuit breaker pole which senses deenergization of the coil below a predetermined level; and

FIG. 8 is a partial sectional view taken along the line 8—8 in FIG. 7 and showing the common trip means connecting the two poles of the two pole circuit breaker.

DETAILED DESCRIPTION

Referring to the drawings, a circuit breaker 10 is shown comprising a case 11 formed by two juxtaposed,

approximately half-cases **16**, only one of which is shown in FIG. 1, secured together by rivets **18**, the case **11** being formed of suitable electrical insulating material.

The circuit breaker **10** includes an automatically resettable linkage mechanism **20** which is mounted within the case **11** and a handle **21** extends through the case **11** and forms part of the linkage mechanism **20**.

The mechanism **20** further includes a movable contact **30** carried by a movable arm **31** and engageable with a stationary contact **32**, the latter being carried by a terminal **33**. The movable arm **31** is connected by a flexible conductor **36** to another terminal **34**, as shown. A coil **40**, formed about a spool **39**, forms part of an electromagnetic device **41** which is also enclosed by the case **11** and which is associated with the linkage mechanism **20** to trip open the contacts **30** and **32** on a predetermined level of deenergization of the coil **40**, i.e., on predetermined undervoltage or no voltage conditions. The coil **40** has its end portions connected to terminals **44** and **45**, as shown. The terminals **33**, **34** and **44**, **45** extend outwardly from the base of the circuit breaker as more fully described in connection with Pat. No. 3,329,793 and FIG. 6 thereof.

Further, the movable arm **31** is biased by a spring **47** toward the open position of the contacts **30** and **32** and the movable arm **31** is mounted on a pin **48** about which it pivots, the pin **48** having end portions carried by two spaced frame plates **50** and **51** which are integral with an L-shaped member **52** and jointly form a frame **53** carrying the spool **39** and the coil **40**. (FIGS. 1, 2 and 3 show only the frame plate **50**, both frame plates **50** and **51** being partially shown in FIG. 5.) The end portions of the pin **48** extend into holes (not shown) formed in the opposed side walls of the case **11** to locate the mechanism relative thereto.

The movable arm **31** is also connected by a pin **54** to an automatically relatchable toggle assembly **56**, the latter being in turn connected to the handle **21** by a pin **58**. The automatically relatchable toggle assembly **56** is provided with a lock assembly **57**, including a spring **61** to bias the lock assembly to the latching position, as described in greater detail in Camp Pat. No. 3,329,913. The handle **21** pivots about a pin **60** having end portions carried by the spaced frame plates **50** and **51**, the end portions of the pin **60** extending beyond the frame plates into holes (not shown) formed in the opposed side walls of the case **11** to locate the mechanism relative thereto. Also, the pin **60**, for the handle **21**, also carries a coil spring **93** biasing the handle to the contacts open position.

The movable arm **31** also carries a pin **62** having end portions which engage the frame plates **50** and **51** to limit opening movement of the arm **31**, as shown in FIG. 2.

The structure heretofore generally described is disclosed in greater detail in Camp Pat. No. 3,329,913. This invention is concerned with modifying the electromagnetic device **41** so as to provide a core device **42** (FIG. 4) that will trip the mechanism **20** when the coil **40** is deenergized to a predetermined level, i.e., to sense an undervoltage or no voltage condition, as hereinafter described in further detail.

The core device **42** (FIG. 4) includes a tube **64** extending through the horizontal leg **65** of the frame **52**, the tube **64** (FIG. 4) housing a core or plunger **66** biased toward the lower end of the tube **64** by a spring **67**, the core **66** being of magnetizable material and being movable upwardly against the retarding bias of the spring **67** upon sufficient energization of the coil **40** by the electromagnetic flux created at such time.

The tube **64** carries a pole piece **70** of magnetizable material at its upper end and is closed at its lower end by a cap **72**, both being preferably soldered to the tube **64**, the tube **64** and cap **72** being preferably of non-magnetizable material. Also, the tube **64** is secured to the horizontal leg **65** of the frame **53** such as by being soldered thereto.

The core **66** is biased away from the pole piece **70**, i.e., downward as viewed in FIG. 4, by a compression spring **67**. The compression spring **67** has one end seated on a shoulder **75** formed at the jointure between the larger, lower end portion **78** of the core **66** and the upper smaller end portion **77** thereof.

The upper end of the spring **67** is seated against a washer **76** which is in turn biased by the spring **67** against the pole piece **70**. The washer **76** fits loosely within the tube **64** and is held in place by the spring **67**, the washer **76** being preferably of a plastic material, such as Teflon. The washer **76** cushions the impact of the core **66** when it is moved upward toward the pole piece **70** on sufficient energization of the coil **40** and also provides a magnetic gap between the pole piece **70** and the core **66**. Such a magnetic gap assures that the core **66** will move away from the pole piece **70** quickly, without hesitation, when the energization of the coil **40** is reduced sufficiently. Otherwise, residual magnetism may slow down the movement of the core **66** at such time or if the drop in energization is not too great, it might keep the core **66** from moving at all.

The core **66** is connected to an armature-like pivotal member **84** by a pin **80**, the pin **80** being preferably of non-magnetizable material, such as brass, and carried by the upper, forward core portion **77**. The pin **80** may be pressed into a suitable hole in the forward core portion **77** and extends loosely through suitable aligned holes in the washer **76** and the pole piece **70** and through a slot **85**, FIG. 6, in a head **83** of the armature-like member **84** to actuate the latter when the energization of the coil **40** drops below a predetermined level. To actuate the armature-like link **84** the pin **80** has secured to its upper end portion, above the head **83**, a collar **87**, the collar **87** being secured to the pin **80** such as by being soldered thereto.

The armature-like member **84**, in addition to the head **83**, comprises an integral trip finger **86**, a balance arm **88**, and a sprocket arm **89**, FIG. 6. The armature-like member **84** has suitable holes **81** through which extends a pin **91**, FIG. 1, which has end portions supported by the spaced frame plates **50** and **51**, the armature-like member **84** being biased clockwise by a spring **92** which is carried by the pin **91** and which has one end secured to the sprocket arm **89**, FIG. 6, and its other end hooked over the frame plate **50**, FIG. 1.

It will be understood that the various parts are proportioned so that when the core **66** is in its lowest position, FIG. 4, the collar **87** has moved the head **83** of the armature-like member **84** toward the pole piece **70** sufficiently for the trip finger **86** to be moved into unlatching position with the lock arm **90**. Similarly, when the core **66** is raised by the coil **40** to its highest position, FIGS. 1 and 2, the collar **87** is raised sufficiently to release the head **83** of the armature-like member **84** and permit the member **84** to pivot clockwise sufficiently to move the trip finger **86** out of its unlatching position with the lock arm **90**, whereby the contacts **30** and **32** may be closed.

When the handle **21** is rotated clockwise, FIG. 2, the toggle assembly **56** and the movable arm **31** all move down, against the bias of the opening spring **47**, and move the contact **30** into engagement with the stationary contact **32**, achieving the closed contacts position, illustrated in FIG. 1.

If, prior to the closing of the contacts **30** and **32**, the coil **40** is sufficiently energized to pull the core **66** up against the bias of the spring **67** from the position shown in FIG. 4 to that shown in FIG. 1, the armature-like member **84** will have been moved from the position shown in FIGS. 3 and 4 to that shown in FIG. 1 in which position the trip finger **86** is slightly spaced from, or barely touching, the arm **90** of the latch or lock assembly **57**.

However, if the coil **40** is not sufficiently energized to

pull the core **66** up against the bias of the springs **67** sufficiently to release the armature-like member **84**, the closing of the contacts **30** and **32** will not take place, or if it takes place will not be maintained, as the trip finger **86** will then engage the arm **90** and pivot it in the direction to unlatch the lock assembly **57**.

Assuming that the coil **40** is sufficiently energized to pull the core **66** up to the position shown in FIGS. 1 and 2, when the handle **21** is moved to the contacts closed position, the circuit breaker will assume the position illustrated in FIG. 1. If now the coil **40** is deenergized to a level such that the magnetic flux thereby created is insufficient to maintain the core **66** raised against the downward force thereon of the spring **67**, the core **66** will move downward (under pressure of the spring **67**) and the collar will engage the head **83**, pivoting the armature-like member **84** counterclockwise from the position shown in FIGS. 1 and 2 to that shown in FIGS. 3 and 4. Such pivoting of the armature-like member **84** causes the trip finger **86** to engage the arm **90** rotating the latter in the direction to unlatch the toggle assembly **56**, whereupon the toggle assembly **56** collapses under pressure of the opening spring **47** and the contacts **30** and **32** open, the handle **21** pivoting to the open position of the contacts.

A shunt plate **94** may be added to the frame **53** to increase the magnetic force on the core **66** for a given energization of the coil **40**. The frame **53** may also be of the type in which the horizontal leg **65** has an upstanding tubular portion **96** which extends centrally into the spool **39**.

The armature-like member **84** should preferably come to rest, when in the position shown by FIG. 4, with a slight space **97**, FIG. 4, between the undersurface of the head **83** and the upper surface of the pole piece **70**. Such slight space **97** may be provided by limiting counterclockwise (FIG. 4) movement of the head **83** by having it engage with the upper end portion of the vertical leg **98** of the frame **53**. The space **97** is provided, to prevent a magnetic coupling from developing between the head **83** and the pole piece **70** tending to retain the armature in the position shown in FIG. 4 after energization of the coil. Providing the space **97** between the armature-like member **84** and the pole piece **70** applies when the armature-like member **84** is of magnetizable material such as steel, but is not applicable if the armature is made of a non-magnetic material such as brass. As the armature-like member **84** is usually made of steel in other type circuit breakers, I prefer the use of steel.

It has been previously stated that the trip finger, when in the position of FIG. 1, should be close to or barely touching the arm **90** of the lock assembly **57**. Likewise, the collar **87**, carried by the pin **80** should also be close to or barely touching the upper surface of the head **83**. The reason for this is that the force stored and provided by the compression spring **67** is at a maximum when the core **66**, FIG. 4, pin **80** and collar **87**, FIG. 1, first start to move down. By providing no clearance, or a minimum clearance, between the collar **87** and the head **83**, FIG. 1, and between the trip finger **86** and the arm **90**, the maximum spring force is used to unlatch the toggle assembly **56**.

Referring to FIGS. 4 and 5, the shunt plate **94** is made sufficiently large to shunt the magnetic flux from the armature-like member **84**. The shunt plate **94** is preferably abutted against the vertical leg **98** to thereby close the magnetic circuit about three sides of the coil **40**, as shown in FIG. 4.

Preferably the core **66** has a stepped cylindrical shape, as shown, and fits sufficiently loosely within the cylindrical tube **64** to create no dash pot action which would tend to retard movement of the core **66**. The pole piece **70** and washer **76** are also circular in shape and are provided preferably with circular holes through which the cylindrical pin **80** loosely extends.

To minimize and/or extinguish any arc that may form between the contacts **30** and **32** whenever the contacts are opened, assuming the contacts to be energized, a stacked array of three magnetizable, metal grids **99** are supported within the case **11** and about the stationary contact **32**, as known in the art.

Thus, if the terminals **44** and **45** are first connected to a source of potential to be monitored which is sufficient to energize the coil **40** to a level which creates a sufficient electromagnetic flux to raise the core **66** against the downward bias of the spring **67**, and to thereby raise the pin **80** and the collar **87** to the position shown in FIGS. 1 and 2, thus permitting the armature-like member **84** to be pivoted by its spring **92** from the position shown in FIG. 3 to that shown in FIG. 1, the handle **21** may then be moved from the position shown in FIG. 2 to that shown in FIG. 1 and the contacts **30** and **32** will be closed.

When the energization of the coil **40** reduces to a predetermined level, i.e., when an undervoltage occurs, as when the power supply thereto is interrupted for any reason, the electromagnetic flux produced by the coil **40** decreases. When the electromagnetic flux decreases to an extent that the magnetic force holding the core **66** up, in the position of FIG. 4, is less than the force downwardly exerted on the core **66** by the spring **67**, the core **66** will move downwardly. The downward movement of the core **66** carries with it the pin **80** and the collar **87** which in turn engages the head **83** and pivots the armature-like member **84** from the position shown in FIG. 1 to that shown in FIG. 3, moving the head **83** toward the pole piece **70** and the trip finger **86** into engagement with the arm **90** of the lock assembly **57** to turn the latter so as to unlatch the toggle assembly **56**, whereupon the toggle assembly **56** collapses under pressure of the opening spring **47** and the contacts **30** and **32** open.

So long as the power is interrupted to the coil **40**, i.e., so long as the coil **40** is energized below a predetermined level, the circuit breaker contacts **30** and **32** cannot be reclosed. If the handle **21** is moved to the closed contacts position at such time, since the trip finger **86** is in its unlatching position, it will trip the lock assembly **57**, causing the toggle assembly **56** to collapse, and this position is shown in FIG. 3.

As the core **66** moves up and down it may have a tendency to rotate relative to the tube **64**. By providing a circular collar **87** of a diameter larger than the width of the slot **85**, in the head **83** of the armature-like member **84**, should rotation of the core **66** take place, the pin **80** and the collar **87** will rotate freely without jamming in the slot **82**.

Also, by sloping the trip finger **86** downwardly, away from the lock arm **90**, a sufficient amount, if the linkage mechanism is attempted to be reclosed, while the core is in the position shown in FIG. 4, i.e., while holding the armature-like member **84** rotated counterclockwise to its full extent, the arm **90** will freely ride off the trip finger **86**.

It has been found that the invention is applicable to alternating current, rectified direct current or direct current for use in the coil **40**.

Also, it will be noted that the invention provides an arrangement which is operative no matter in what position the circuit breaker is mounted.

Referring to FIGS. 7 and 8 the invention is embodied in a two pole circuit breaker **110** comprising a voltage sensing circuit breaker **112** and a series, overload current sensing circuit breaker **114**, the latter being only partially shown in FIG. 8, but the two circuit breakers **112** and **114** being placed in side-by-side relation, as shown in Camp et al. Pat. No. 3,299,231. The voltage sensing circuit breaker **112** shown in FIG. 7 is constructed essentially the same as that described previously in connection with FIGS. 1 to 6, but is in addition provided with a common trip means **120** for interconnecting the two circuit breakers **112** and **114** and providing for the tripping of one of the circuit breakers when the other circuit breaker trips.

While not illustrated in detail, the circuit breaker **114** is constructed similar to the circuit breaker illustrated and described in connection with Camp Pat. No. 3,329,913.

The circuit breaker **112** is generally similar to that described in connection with FIGS. 1 to 6 and comprises a case **121** enclosing an automatically resettable linkage mechanism **122** and a handle **123** extending through the case **121**, as shown in FIG. 7. The linkage mechanism **122** includes a movable contact **124** carried by a movable arm **125** and engageable with a stationary contact **126**. The linkage mechanism **122** includes a toggle assembly **128** and a lock assembly **129**, the same as that described in connection with FIGS. 1 to 6.

The circuit breaker **112** also includes an electromagnetic device **131** constructed in accordance with the description of the electromagnetic device illustrated in connection with FIGS. 1 to 6. The electromagnetic device **131** includes a coil **136**, a core device **132** and an armature-like member **134** having a trip finger **135** engageable with the lock assembly **129**.

The coil **136** is connected to the circuit which is to be monitored by terminals **137** and **138**, and the movable and stationary contacts **124** and **126** are connected to another circuit by terminals **140** and **141**, respectively.

The circuit breaker **112** has a spring pin **160** carried by the movable arm **125** to limit pivotal motion of the arm **125** by abutment with the frame plates **180**, as shown in FIG. 7. The spring pin **160** has a slot within which are inserted leaf actuators **163** at opposite ends of the pin **160**, only one actuator being shown in FIG. 7. The leaf actuators **163** abut a common trip member **170** to transmit the opening movement of the movable arm **125** to the common trip means **120**. The common trip member **170** is mounted on the outer sides of the frame plates **180**, as shown in FIG. 8, and is pivotally carried by a pin **175**, FIG. 7, about which also pivots the armature-like member **134**. The common trip member **170** comprises two arms **173** and **174** on opposite sides of the frame plates **180**, the latter being part of the frame **181**, and the leaf actuators **163** engage the arms **173** and **174** on opposite sides of the frame plates **180**. The arms **173** and **174** are interconnected by a bar **182** which has a hole **184**, FIG. 8, extending through it.

The circuit breaker **114** has a common trip member **200** constructed, supported and actuated the same as the common trip member **170**.

A rod **202** interconnects the common trip members **170** and **200** for joint rotation upon the pivotal movement of one of them, the rod **202** extending through the hole **184** in the bar **182** and a similar hole **204** in the corresponding bar **206** of the common trip member **200**, and through suitable openings **207** in the cases.

Referring to FIG. 8, in which the coils and spools of the electromagnetic devices have been omitted for clarity, it will be noted that the bars **182** and **206** rest upon the heads **208** and **210** (FIG. 8) of the armature-like members **134** and **210** of the circuit breakers **112** and **114**. Insofar as the circuit breaker **114** is concerned the member **210** is in fact an armature, of an electromagnetic device **216** including a frame **218** and frame plates **219**, most of the electromagnetic device **216** not being shown, but being illustrated and described in Camp Pat. No. 3,329,913. Further, the arms **173** and **220** engage ears **224** and **226**, respectively, formed on the heads **208** and **210**, so that when the actuators rotate the common trip members **170** and **200**, the motion of the common trip members is transmitted to the armature-like members.

Preferably, the common trip members **170** and **200** are made of electrical insulating material, such as the plastic Lexan and the interconnecting rod **202** is also preferably of electrical insulating material, such as a phenolic plastic.

The common trip means **120** briefly described heretofore is of the type described in detail in Schwartz Pat. No. 3,098,910, Schwartz et al. Pat. No. 3,098,911 and Sprague Pat. No. 3,098,912.

Having described this invention, what I claim is:

1. A circuit breaker comprising:
- a pair of separable contacts,
- a mechanism for manually opening and closing said contacts,
  - said mechanism including an opening spring for biasing said contacts to the open position,
  - said mechanism including a lock assembly to maintain said mechanism latched when said contacts are closed,
- electromagnetic means associated with said mechanism for tripping said lock assembly and automatically opening said contacts,
  - said electromagnetic means comprising:
    - a solenoid coil,
    - a member engageable with said lock assembly to unlatch said mechanism when said contacts are closed,
    - a magnetizable frame about said coil, and
    - a magnetizable core means actuatable by said coil to release said member and permit said member to move away from said lock assembly when said coil is energized above a predetermined level and for moving said member into engagement with said lock assembly when said coil is energized below a predetermined level and said contacts are closed.

2. The combination recited in claim **1** wherein said mechanism is automatically resettable.

3. The combination recited in claim **2** wherein said coil includes a pole piece, said core means includes a core and a compression spring biasing said core away from said pole piece, said core being moved toward said pole piece upon energization of said coil above a predetermined level to compress said spring and release said member, whereby upon a subsequent predetermined drop in the level of energization of said coil, said compression spring forces said core away from said pole piece and said core at such time actuates said member causing said member to actuate said lock assembly to open said contacts.

4. The structure recited in claim **3** wherein said electromagnetic means further includes a tube of non-magnetizazle material within which said core is movable, said pole piece being secured to one end of said tube, and said compression spring being within said tube between said pole piece and said core.

5. The structure recited in claim **4** wherein said electromagnetic device further includes a washer of non-magnetic material between said pole piece and said core, said core seating against said washer when said core has moved its full extent toward said pole piece.

6. The structure recited in claim **5** wherein said washer is made of plastic material capable of cushioning the impact of said core against said washer and providing a magnetic gap.

7. The structure recited in claim **4** wherein said electromagnetic means includes a U-shaped frame on three sides of said coil for substantially shunting the electromagnetic flux from said member.

8. The structure recited in claim **4** wherein said electromagnetic means includes a connector secured to said core and extending through said pole piece, said member being biased away from said pole piece, said connector providing for joint movement of said core and said member when said core moves away from said pole piece, but releasing said member for movement away from said pole piece when said core moves toward said pole piece.

9. The structure recited in claim **6** wherein said electromagnetic means includes a U-shaped frame on three sides of said coil for shunting the electromagnetic flux from said member.

10. The combination of:
- a plurality of similar switch units,

each switch unit having a pair of relatively movable contacts,

an automatically resettable mechanism including:

a toggle linkage operatively connected between one of said contacts and a manual operator,

an electromagnetic toggle tripping device associated with each toggle linkage,

said toggle linkage being collapsible by said device to a position for opening said contacts,

an automatically resettable movable common trip means associated with all of the tripping devices and having a common trip member associated with each switch unit,

whereby the opening of said contacts of one switch unit moves the common trip members of the associated switch units in the direction necessary to cause their associated toggle linkages to also collapse and move to the contacts open position,

one of the electromagnetic toggle tripping devices of the switch units being responsive to a predetermined drop in energization thereof.

11. The structure recited in claim **10** wherein the electromagnetic tripping device responsive to a predetermined drop in energization thereof includes a coil and a core, a spring engaging said core, an armature-like member, said coil when sufficiently energized moving said core in one direction to a first position in which said core releases said armature-like member from tripping engagement with said mechanism, and when said coil is sufficiently deenergized, said spring moving said core in the opposite direction to a second position during which said core moves said armature-like member into tripping engagement with said mechanism.

12. The structure recited in claim **10** wherein another of the electromagnetic toggle tripping devices of the switch units is responsive to a predetermined increase in energization thereof.

13. The structure of claim **11** wherein another of the electromagnetic toggle tripping devices of the switch units is responsive to a predetermined increase in energization thereof.

14. The combination of:

a plurality of similar switch units,

each switch unit comprising an electromagnetic device including:

an armature-like member and

a coil for actuating said armature-like member upon predetermined electrical conditions,

relatively movable contacts,

an automatically resettable linkage mechanism movable to open and close said contacts and biased to the contacts open position,

said linkage mechanism including a latch for maintaining said linkage mechanism in the contacts closed position,

said armature-like member being movable upon predetermined electrical conditions to trip said latch,

an automatically resettable common trip member having a portion in the path of movement of said linkage mechanism and movable thereby upon the tripping of said latch,

means interconnecting the common trip members of the switch units so that movement of one common trip member causes the movement of the others,

each common trip member having a second portion adjacent the associated armature-like member for moving the armature-like member in the direction to unlatch its associated mechanism for opening the contacts of the switch units other than those of the switch unit which initiates the movement of the common trip member,

the electromagnetic device in one of the switch units actuating said armature-like member on a predetermined decrease in energization of its associated coil.

15. The combination recited in claim **14** wherein said electromagnetic device includes a pole piece, a core movable toward and away from said pole piece, a compression spring biasing said core away from said pole piece, said core being moved toward said pole piece upon energization of said coil above a predetermined level to compress said spring and release said armature-like member, whereby upon a subsequent predetermined drop in the level of energization of said coil, said compression spring forces said core away from said pole piece and said core at such time actuates said armature-like member causing said armature-like member to trip said latch to open said contacts, said electromagnetic device further including a tube of non-magnetizable material within which said core is movable, said pole piece being secured to one end of said tube, and said compression spring being within said tube between said pole piece and said core, a connector secured to said core and extending through said pole piece, said armature-like member being biased away from said pole piece, said connector providing for joint movement of said core and said armature-like member when said core moves away from said pole piece, but releasing said armature-like member for movement away from said pole piece when said core moves toward said pole piece.

16. The structure recited in claim **14** wherein another of the electromagnetic devices of the switch units actuates its associated armature-like member on a predetermined increase in energization of its associated coil.

17. The structure recited in claim **16** wherein said electromagnetic device further includes a washer of non-magnetic material between said pole piece and said core, said core seating against said washer when said core has moved its full extent toward said pole piece, said washer is made of plastic material capable of cushioning the impact of said core against said washer and providing a magnetic gap between said pole piece and said core.

18. The structure recited in claim **15** wherein another of the electromagnetic devices of the switch units actuates its associated armature-like member on a predetermined increase in energization of its associated coil.

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