United States Patent

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Philadelphia, Pa.
Continuation-in-part of application Ser. No. 754,644, Aug. 22, 1968.

[54] **CIRCUIT BREAKER TRIP UNIT ASSEMBLY WITH AUXILIARY TIME DELAY ARMATURE**
7 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **335/176,** 335/265
[51] **Int. Cl.** **H01h 7/00**
[50] **Field of Search** ..... 335/176, 174, 42, 258, 273, 274, 236, 237, 239, 242, 265; 200/166 (M)

[56] **References Cited**

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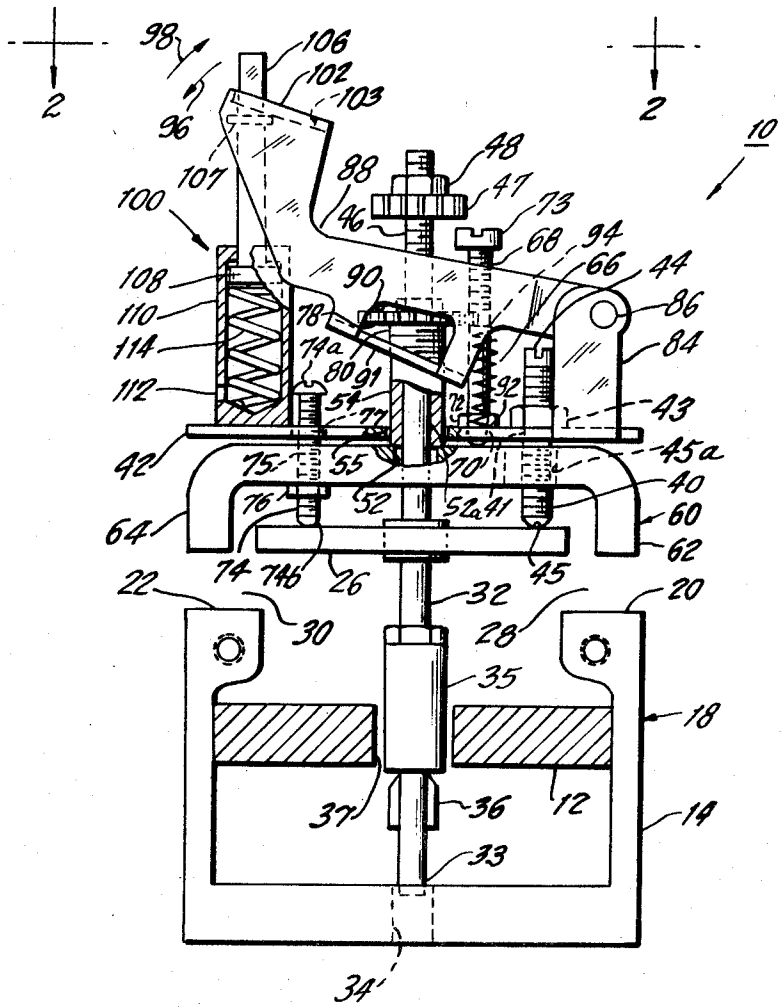
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ABSTRACT: A circuit breaker magnetic trip unit assembly including a magnet core adjacent a conductor in the circuit being protected; a main armature which is separated by a predetermined air gap from the pole faces of the magnet core; the pole faces magnetically attract the main armature when the magnetic flux across the air gap elevates sufficiently; a separately movable auxiliary armature spaced away from the pole faces of the magnet and movable toward the pole faces upon the occurrence of magnetic attraction insufficient to move the main armature but sufficient to move the auxiliary armature; the auxiliary armature including an abutment for engaging and shifting the main armature toward the pole faces as the auxiliary armature moves until the magnetic attraction on the main armature is sufficient to pull the main armature to the pole faces; and a time delay device slowing the movement of the auxiliary armature thereby delaying tripping caused by shifting of the auxiliary armature.



Patented March 9, 1971 3,569,879

FIG. 2.

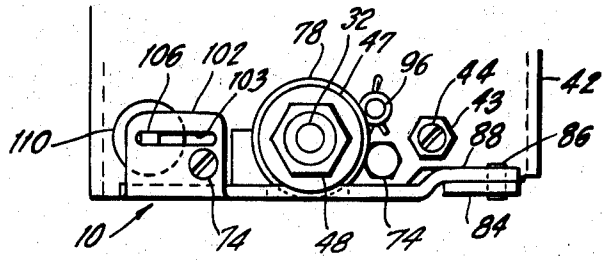
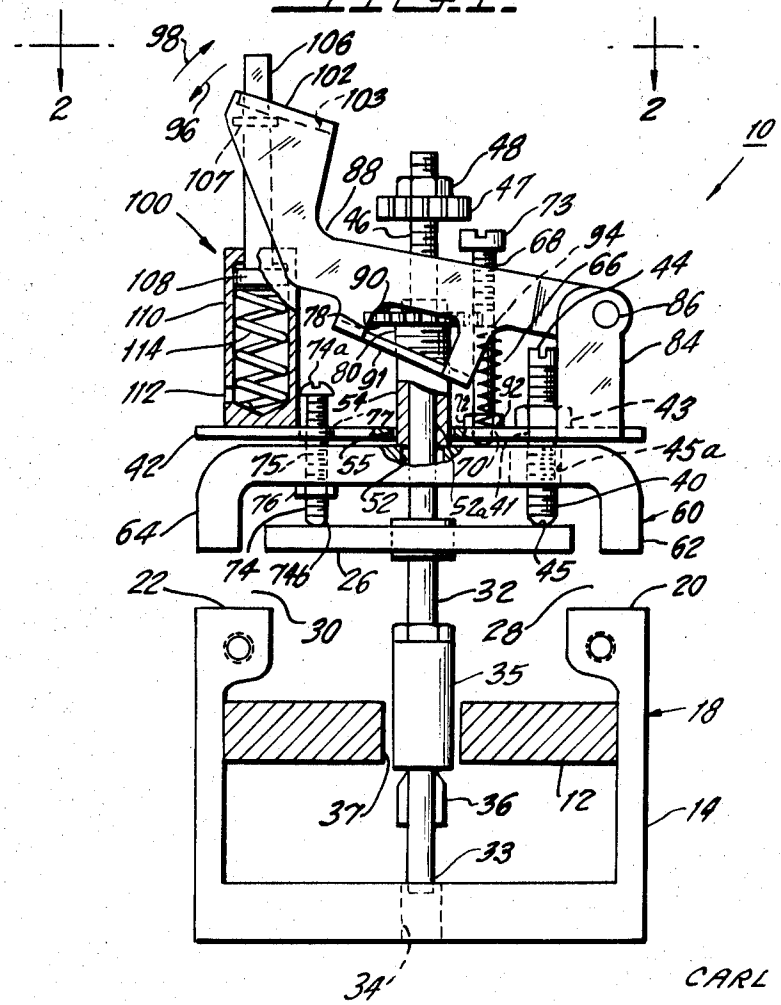


FIG. 1.



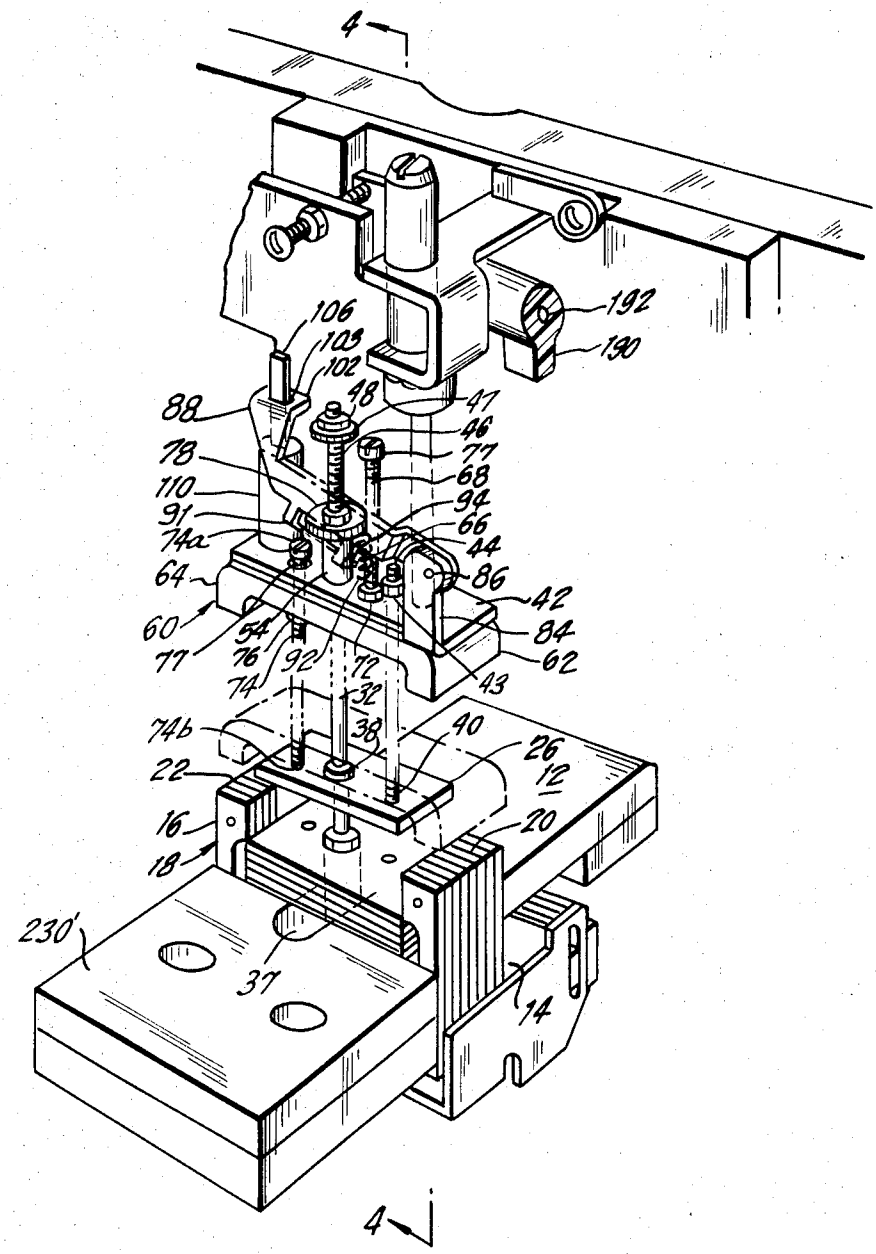
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FIG. 3



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FIG. 4

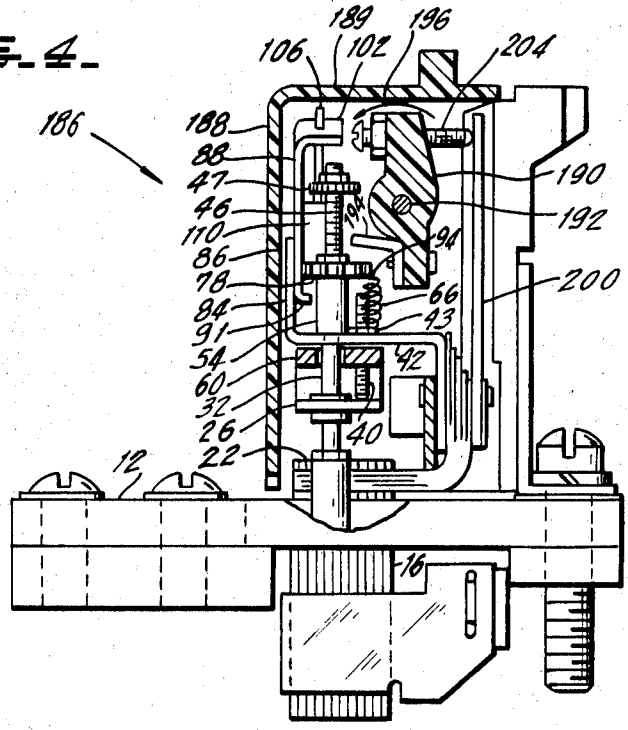


FIG. 5

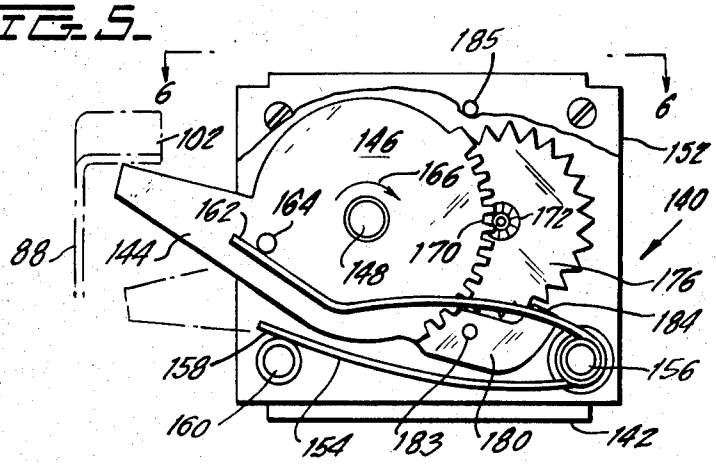
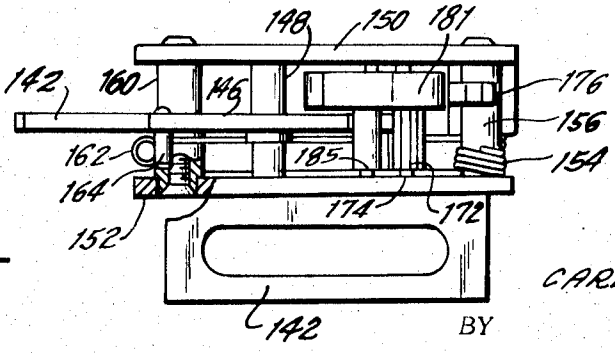


FIG. 6



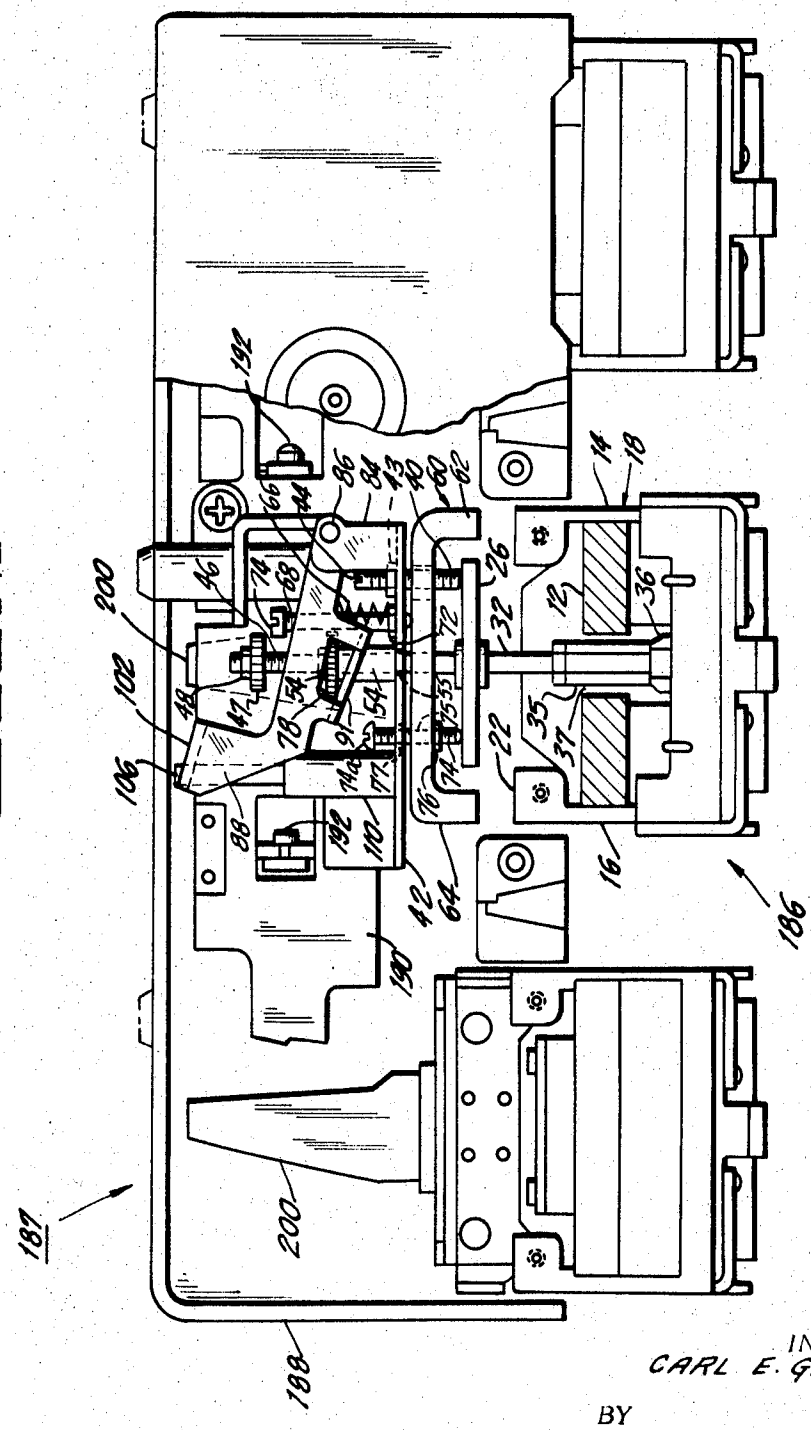
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FIG. 7



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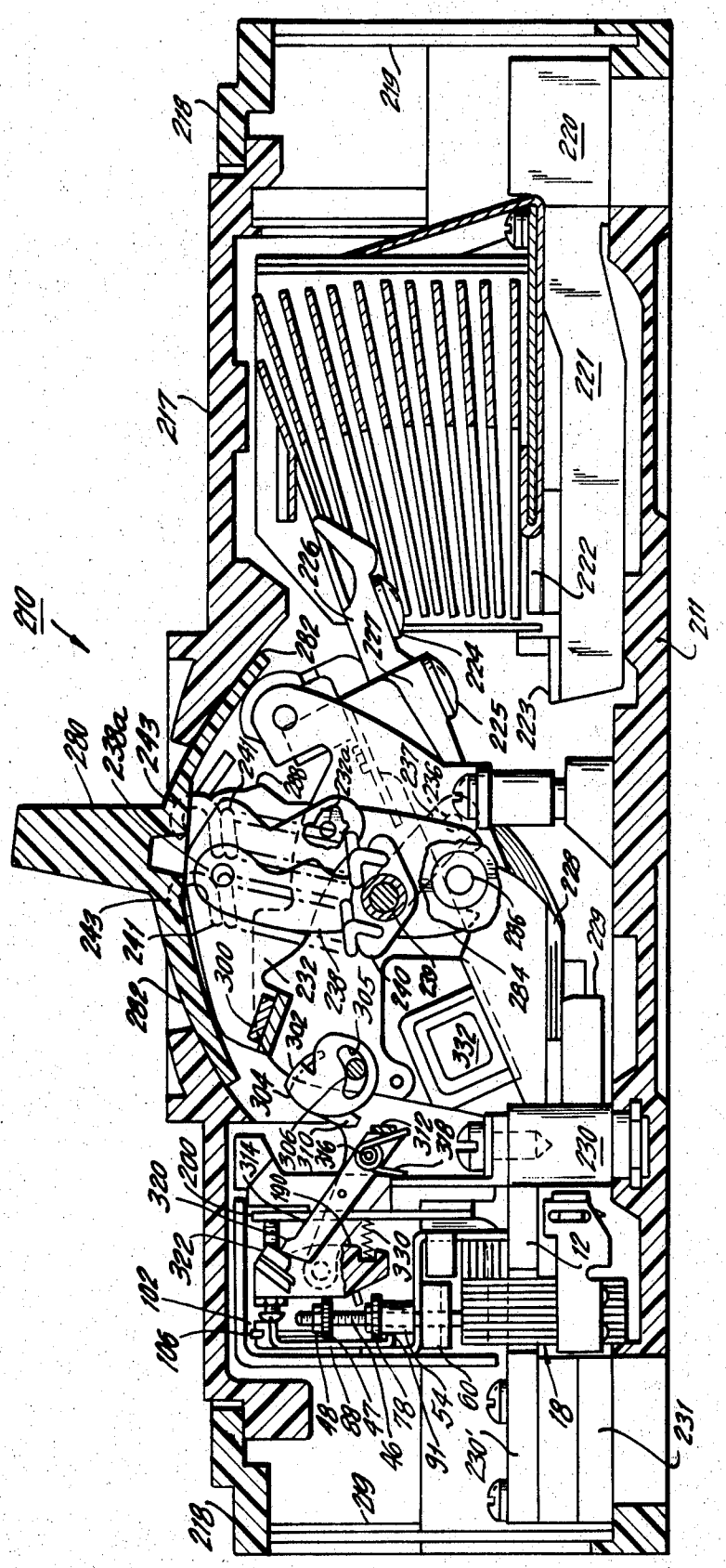

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FIG. 8.

CIRCUIT BREAKER TRIP UNIT ASSEMBLY WITH AUXILIARY TIME DELAY ARMATURE

This is a continuation-in-part of Ser. No. 754,644, filed Aug. 22, 1968.

This invention relates to circuit breakers in general, and more particularly to an improved magnetic trip unit assembly therefor which provides instantaneous circuit breaker tripping in the event of a high overload current and slightly delayed tripping in the event of a less high overload.

A circuit breaker is a protective device which is connected into a circuit to be protected and which has a trip unit assembly connected with it to cause the breaker to open the circuit in the event that an undesirable current overload condition develops. At very high fault currents, it is desirable to have the trip unit assembly trip open the circuit breaker instantaneously. To obtain instantaneous tripping, an electromagnet core is placed adjacent a conductor in the circuit being protected in a manner such that the magnetic flux surrounding this conductor as current flows through it is directed through and surrounds the magnet core. In the event of a very high overload, the magnetic flux around the magnet core attracts a nearby armature to it, and the movement of the armature operates a tripping mechanism. The armature movement is instantaneous since it begins immediately upon the occurrence of the very high overload.

It is undesirable to have circuit breakers trip unnecessarily and interrupt the operation of an installation protected by the circuit breaker. Restarting of temporarily shutdown equipment may be difficult and time-consuming. While equipment connected with a power source through a circuit breaker may be damaged by an overload condition, if the overload is moderate and lasts for a short time, no harm will come to the equipment if it operates for a short period in an overload condition.

Therefore, in addition to the instantaneous tripping obtained through the magnetically operated armature at very high overloads, circuit breaker trip units are also often provided with a time delay trip mechanism for moderate overloads. This might include a bimetallic strip or other deflecting thermal element which is positioned in or adjacent a conductor in the circuit being protected and is heated sufficiently to deflect when the circuit being protected operates at a moderate overload for a predetermined period of time. The deflecting bimetal eventually operates a trip mechanism which trips open the circuit breaker. See, for example, U.S. Pat. No. 3,319,195, issued May 9, 1967, entitled "Breaker Trip Unit Assembly," and assigned to the assignee hereof. With the slightly delayed tripping of the circuit breaker, if an operator is aware of the fault condition before the circuit breaker trips, the fault condition may be corrected without the circuit breaker tripping. This results in a saving in time due to not having to restart the equipment protected. In the event of a very high overload, the instantaneous trip mechanism operates long before the moderate overload trip mechanism can operate.

In the event of a high, but not excessively high, overload current condition, for which it would be unsafe to wait until the moderate overload tripping mechanism, i.e., the bimetallic strip, operates, a slight time delay would not be harmful to the circuit breaker, to the circuit, or to the equipment protected by the circuit breaker. Perhaps the high overload condition will rapidly correct itself or there will be sufficient time for an operator to correct the condition before tripping occurs.

Furthermore, it is often desirable where a number of circuit breakers are protecting equipment, to trip the circuit breakers in a predetermined sequence, in order to best protect the equipment. For example, one circuit breaker might be connected between the power source and the entire equipment installation being serviced by the power source and another circuit breaker might be connected within one element of the installation. It would be desirable to trip open the former circuit breaker first, so that upon tripping of the latter circuit breaker, the system power would have markedly reduced and no harm would have been suffered by the delicate equipment as a result of a circuit carrying very high overload current being broken within the equipment being serviced.

The present invention provides a selective time delay device for a magnetic trip unit assembly which device responds to high, but not unduly high, overloads by causing the instantaneous trip armature to operate only after a predetermined period of time, much shorter than the period of time that elapses before the bimetallic strip or moderate overload trip mechanism has an opportunity to operate.

The present invention accomplishes the foregoing by providing, in addition to the main armature, a separate magnetic reluctance adjustment means for decreasing the reluctance of the gap between the main armature and the magnet to which it is attracted due to current overloads. Such means comprises an auxiliary armature coupled with a time delay device.

The auxiliary armature is separately movable with respect to the main armature and is spaced away from the magnet pole faces. The auxiliary armature is comprised of material which concentrates magnetic flux in its vicinity. Its magnetic reluctance is lower than that of the magnetic reluctance gap. A separate biasing means biases the auxiliary armature toward a position away from the magnet core pole faces. The biasing force of this biasing means is so related to the force exerted by the separate biasing means which forces the main armature away from the pole faces that the auxiliary armature begins to move toward the magnet core under a lesser fault current than is required to move the main armature.

Connected with the auxiliary armature is an abutment means for engaging the main armature such that when the auxiliary armature moves toward the magnet core, the engaging means engages the main armature and moves it toward the pole faces of the core. As the main armature approaches the pole faces, the reluctance gap between them decreases in size, the reluctance of the gap decreases, and the main armature is eventually "tricked" into acting as though an overload condition, high enough to activate the main armature, has occurred. Then the main armature completes its movement into engagement with the pole faces without assistance.

The initial position of the auxiliary armature with respect to the pole faces of the magnet core is adjustable. The closer the auxiliary armature to the pole faces, the lower is the reluctance of the gap between itself and the pole faces and the lesser is the level of the current overload needed to cause the auxiliary armature to shift, to cause operation of the main armature.

Also, the initial position of the main armature with respect to the pole faces is adjustable. The closer this armature is to the pole faces, the smaller the distance that the auxiliary armature must shift the main armature before the main armature itself is attracted to the pole faces under the influence of the overload. This calibrates the time it takes for a main armature response to an overload and also the level of very high overload required to activate the main armature independent of the auxiliary one.

Finally, the initial positions of the main and auxiliary armatures with respect to each other are adjustable through an adjustable initial spacing means. This spacing means also provides a lost motion connection so that there is a built-in calibratable time delay before the auxiliary armature moves sufficiently to engage the main armature and initiate movement of the latter toward the pole faces.

One purpose of the auxiliary armature is to provide a time delay in the operation of the main armature in the event of a high, but not unduly high, overload. Accordingly, a time delay device is associated with the auxiliary armature to slow its rate of travel toward the magnet pole faces, whereby the reluctance of the reluctance gap is decreased gradually through only gradual movement of the main armature being imparted by the auxiliary armature.

One type of time delay device includes a piston connected with the auxiliary armature. On movement of the auxiliary armature toward the pole faces, the piston moves into and

through a closed end cylinder with a small air exit bleed. The air exits slowly from the bleed and the back pressure of the air in the cylinder prevents the piston from moving rapidly. A spring beneath the piston returns it to its original position.

An alternate form of time delay might make use of friction to slow the movement of the auxiliary armature.

As a further alternative, the descending auxiliary armature may press a lever which is connected to and rotates a gear train. A fixed position means engages the teeth of one of the gears of the train and is rocked in and out of the notches between the gear teeth. In the normal mechanical delays arising from the limited speed of the rocking motion, the speed of movement of the lever is restrained, whereby the speed of movement of the auxiliary armature is restrained.

A circuit breaker trip unit assembly as described herein may be used in conjunction with a circuit breaker, such as that shown in U.S. Pat. No. 3,319,195, issued to Albert Strobel and John C. Brumfield, on May 9, 1967, entitled "Circuit Breaker Trip Unit Assembly," and assigned to the assignee hereof or that shown in U.S. Pat. application Ser. No. 690,878, now Pat. No. 3,484,726 filed Dec. 15, 1967 in the name of Albert Strobel, entitled "Trip Unit Latch Positioning Means for Constant Latch Bite," and assigned to the assignee hereof. The main armature of the trip unit assembly has a means connected with it which engages and rotates a tripper bar when the armature moves toward the pole faces of the magnet body. When the tripper bar rotates, it causes the operating mechanism of the circuit breaker to operate, and snaps the cooperating contacts of the circuit breaker apart.

It is a primary object of the present invention to provide an improved magnetic trip unit assembly for a circuit breaker.

It is another object of the present invention to provide such an assembly which instantaneously trips the circuit breaker in response to a very high overload current condition.

It is another object of the present invention to provide such an assembly where in the event of a high, but not unduly high, overload condition, there is a short time delay before the circuit breaker trip unit assembly trips the circuit breaker.

It is another object of the present invention to provide such an assembly which, in the event of a high, but not unduly high, overload condition, permits a plurality of circuit breakers to be tripped in a predetermined sequence, instead of tripping simultaneously.

It is another object of the present invention to provide such an assembly which provides a time delay in the operation of the instantaneous trip mechanism through the use of a means that slowly decreases the reluctance of the magnetic reluctance gap between the main armature of the trip unit assembly and the magnet pole faces in the trip unit assembly until the main armature is attracted sufficiently to cause tripping of the breaker.

It is another object of the present invention to accomplish the foregoing objects through the use of both a main armature and a separate auxiliary armature which engages and shifts the main armature toward the pole faces until the main armature shifts by itself.

These and other objects of the present invention will become apparent when the following description is read in conjunction with the accompanying drawings, in which:

FIG. 1 is an elevation of one embodiment of a trip unit assembly designed in accordance with the present invention;

FIG. 2 is a top view of the assembly of FIG. 1 in the direction of arrows 2 in FIG. 1;

FIG. 3 is an exploded perspective view of the assembly of FIG. 1 as mounted in a trip unit;

FIG. 4 is an elevation view in cross section of the trip unit assembly in the direction and along the line 4–4 of FIG. 3;

FIG. 5 is an elevation view of an alternate form of time delay device for the assembly of FIGS. 1—4;

FIG. 6 is a plan view in the direction of arrows 6 of the time delay device of FIG. 5;

FIG. 7 is a fragmentary elevation view of a multiphase trip unit containing the assembly of the invention; and

FIG. 8 is a cross section through a circuit breaker containing the trip unit assembly of the invention.

Referring to the FIGS., and particularly to FIGS. 1—4, a magnetic trip unit assembly is there shown. A trip unit conductor strap 12 which is a conductor in the circuit being protected, passes through the U formed by the arms 14 and 16 of magnet core 18. Core 18 is U-shaped and is comprised of a metal, such as iron or steel, which concentrates in its vicinity and conducts through itself magnetic flux which is in its vicinity. As current flows through the trip unit conductor strap 12, magnetic flux automatically surrounds the conductor strap and varies in strength with the current passing through the strap 12. The magnetic flux is concentrated about magnet core 18. Each leg 14, 16 of the core is provided, respectively, with a pole face 20, 22 which faces toward the main armature 26 and auxiliary armature 60, to be described.

A main trip unit assembly armature 26 comprised of a magnetic flux conductive material, such as steel, is provided. Armature 26 is spaced away from pole face 20 by a magnetic reluctance gap 28 and from pole face 22 by a magnetic reluctance gap 30. In the device illustrated, the magnetic flux reluctance gaps 28, 30 are simply air gaps. The length of air gaps 28, 30 is identical.

Armature 26 is fixedly secured to shaft 32. Shaft 32 has a lower end 33 which freely passes through clearance opening 34 in the base of the magnet core. Shaft 32 passes through a clearance aperture 52 in the auxiliary armature 60, to be described, and passes through a clearance aperture 52*a* through sleeve 54 which is secured to auxiliary armature 60 for reasons to be described. Accordingly, main armature 26 moves independently of the auxiliary armature and does not interfere with auxiliary armature 60. Additionally, the auxiliary armature moves independently of main armature 26 until screw 74, described below, engages the main armature.

Also on shaft 32 is a means 35 for being acted upon by a biasing device 36, that is more fully described in copending application Ser. No 744,166, filed Jul. 11, 1968, now U.S. Pat. No. 3,505,626 entitled "Electromagnetic Device for Circuit Breaker Trip Unit Assembly," and assigned to the assignee hereof. Device 36 includes a spring means that presses on means 35 to move the armature 26 away from pole faces 20, 22.

Means 35 passes through a clearance opening 37 in conductor strap 12 so that strap 12 does not interfere with the movement of armature 26.

A screw 40 is provided which passes through a threaded aperture 41 through stationary mounting bracket 42, to be described further below. Screw 40 also passes through threaded locknut 43. Screw 40 is rotated by means of its adjustment slot 44 until a predetermined axial position is obtained. The lower end 45 of screw 40 determines the normal or rest position of the main armature 26, since the biasing means 36 biases the armature 26 against this end of screw 40. Once the position of screw 40 has been adjusted, the locknut 43 is tightened with respect to bracket 42 and the position of screw 40 is fixed.

The auxiliary armature 60, to be described further below, has a clearance aperture 45*a* extending therethrough through which screw 40 freely passes without interfering with the auxiliary armature.

Upon a very high overload condition in the trip unit conductor strap 12, the magnetic flux in the vicinity of the magnet core 18 and across the air gaps 28, 30, is sufficient to attract the armature 26 toward the pole faces 20, 22. Adjustment of the initial position of the main armature determines the level of the very high overload which will attract the main armature and instantaneously trip the breaker without any interference by or cooperative operation by the auxiliary armature 60.

When armature 26 moves downward, as viewed in FIG. 1, it draws shaft 32 along with it. The upper portion of shaft 32 is screw threaded at 46 and has an adjustable position nut 47 positioned thereon. Turning to FIG. 4, for the moment, the adjustable nut 47 is designed to engage a tab 194 on a tripper bar

190 of the circuit breaker trip unit by striking same, in a manner to be described further below. Adjustment of the initial main armature 26 position will vary the height of nut 47. To reposition the nut the proper distance from tripper bar tab 194, the nut is made adjustable. A locknut 48 is tightened to hold nut 47 stationary. The engagement of tripper bar 190 by nut 47 during downward movement of armature 26 eventually causes tripping of the circuit breaker, whereby movement of the armature causes tripping of the circuit breaker, as will be described below.

Beneath fixed bracket 42 is positioned the auxiliary armature 60 which is comprised of material that conducts and is attracted by magnetic flux, e.g. steel. Armature 60 is a magnetic reluctance gap adjustment means, as will be described. As shown, the body of the auxiliary armature is further from the pole faces 20, 22 than is the main armature 26 and is spaced away from armature 60. Thus, auxiliary armature 60 can be move down while main armature 26 does not, without touching armature 26. While the body of the auxiliary armature 60 is shown as being positioned above and generally further away from the pole faces 20, 22 than the main armature 26, a trip unit assembly may be designed in accordance with the teachings of the instant invention where the auxiliary armature is not above the main armature or is not spaced away from the pole faces of the magnet core in the same direction as the main armature is spaced.

The auxiliary armature 60 is shaped, U-shape being illustrated, to be able to move toward the pole faces 20, 22 without physically contacting or interfering with main armature 26 until abutment means 74, described below, on auxiliary armature 60 engages main armature 26. The auxiliary armature has legs 62, 64, which extend outward beyond the edges of the armature 26 and which are, respectively, opposite pole faces 20, 22.

A biasing means, like compression spring 66, is linked to auxiliary armature 60 by means to be described further below. For the present, it is sufficient to point out that biasing means 66 biases the armature 60 upward away from pole faces 20, 22.

Auxiliary armature 60 is of such flux attracting and concentrating material, is of such thickness and dimensions, and is biased upward with a force relative to the upward biasing force on main armature 26, so that it requires a lower level magnetic attraction by magnet core 18 to start armature 60 moving toward the core than to start armature 26. In the event of a very high overload current through conductor strap 12, the magnetic attraction exerted by magnet 18 will draw down armature 26. A lesser high overload will draw only armature 60 down at the outset. The legs 62, 64 of the armature move alongside air gaps 28, 30, respectively.

An auxiliary armature initial position adjusting screw 68 is provided which passes through a threaded aperture 70 in bracket 42 and through a locknut 72. Screw 68 is rotated by means of its head 73 until its proper axial position is obtained. Then locknut 72 is tightened against bracket 42 which locks screw 68 in position. The lower end of screw 68 has the upper surface of armature 60 biased against it by biasing means 66. In this manner, the initial or starting position for the auxiliary armature 60 is obtained. The initial position of armature 60 determines at which moderately high overload current level the auxiliary armature will begin to descend.

By adjustment of the main armature position adjusting screw 40 and the auxiliary armature position adjusting screw 68, the relative initial positions of these two elements with respect to core 18 and their initial spacing with respect to each other may be adjusted.

In order for auxiliary armature 60 to serve as a reluctance gap adjustment means, it operates to shift the position of main armature 26 and in shifting the armature toward pole faces 20, 22, it adjusts the reluctance gaps 28, 30.

For shifting main armature 26, a screw 74 is threadedly received in a cooperating threaded opening 75 in armature 60. Through rotation of screw 74 by its head 74*a*, the length of the portion of screw 74 extending beneath armature 60 toward armature 26 can be adjusted. Locknut 76 is tightened to hold screw 74 in the desired position. Screw 74 passes through clearance opening 77 in fixed bracket 42 so that the shifting of armature 60, and of screw 74 which shifts with armature 60, is not impeded.

It is only when armature 60 has shifted sufficiently downward that the lower abutment end 74*b* of screw 74 engages armature 26 and initiates downward movement thereof. When armature 26 descends, reluctance gaps 28, 30 are gradually decreased, the magnetic attraction on armature 26 by core 18 is gradually increased, and eventually, the attraction on armature 26 is great enough to cause that armature to independently descend and trip the breaker.

A time delay between initiation of the operation of auxiliary armature 60 and initiation of movement of main armature 26 is obtained by adjustment of a lost motion means formed by the joint action of screws 40 and 74. Screw 40 is secured in fixed bracket 42 and is adjusted to define the upper limit of movement of main armature 26. Screw 74 is secured in armature 60 and the length of its portion beneath armature 60 determines the distance armature 60 must travel before screw abutment surface 74*a* abuts armature 26. If the lower portion of screw 74 is shortened while screw 40 is left unadjusted, it will require a correspondingly longer descent by armature 26 before screw 74 first contacts armature 26. This is a built-in lost motion time delay.

Secured to the upper surface of auxiliary armature 60 is a sleeve 54 through which shaft 32 passes with clearance. The sleeve 54 moves up and down with the armature 60. It passes through a clearance aperture 55 through bracket 42. Mounted on the sleeve 54 is a pickup nut 78 which rides on a threaded surface 80 of the sleeve 54 and, therefore, is adjustable as to its axial position along the sleeve 54. As will become apparent below, the nut 78 operated by downward movement of armature 60 into engagement with a time delay device 100 for the auxiliary armature, which device is mounted upon the bracket 42. The bracket 42 is not adjustable vertically in its initial position, while the auxiliary armature is so adjustable. After the initial position of the auxiliary armature 60 is determined, nut 78 on sleeve 54 is repositioned so that it will properly engage the time delay device 100 at bar 91, as will be described, when the auxiliary armature 60 begins to move.

One form of time delay device for slowing the movement of armature 60 is illustrated in FIG. 1 It includes the lever support 84 which is secured to bracket 42 and to which is pivotally mounted, at 86, a lever 88. Lever 88 has a cutout section 90 in it with a lower bar 91 closing it. Nut 78 extends into cutout 90.

Biasing spring 66, mentioned above, seats at one of its ends 92 upon bracket 42 and at the other of its ends 94 presses against the underside of nut 78. Biasing spring 66 is, therefore, continuously biasing nut 78, sleeve 54 and armature 60 upward, as viewed in FIG. 1.

Lever 88 has an outwardly extending tab 102 (see FIG. 2), which has a slot 103 in it through which a piston rod 106 passes. On rod 106 is affixed a shelf 107 against which tab 102 presses as it moves down to move the piston rod 106 down. Piston rod 106 is rigidly connected with a piston 108. When the armature 60 moves downward and pivots the lever 88 counterclockwise in the direction of arrow 96, tab 102 on lever 88 engages shelf 107 and pushes piston 108 downward in its cylinder 110. Cylinder 110 is closed except for a small air bleed 112. As the piston 108 moves through cylinder 110, it builds up air pressure in front of it which slows its downward movement. The slow escape of the air under pressure through bleed 112 permits piston 108 to descend only slowly, which enables lever 88 to pivot only slowly, which, therefore, enables the auxiliary armature 60 to move slowly only.

When auxiliary armature 60 moves downward, nut 78 within cutout 90 pulls down on bar 91 and thereby on lever 88, and pivots the lever around its pivot 86 in the counterclockwise direction of arrow 96. The downward movement of

armature 60 also compresses compression spring 66. When the magnetic attraction on auxiliary armature 60 ceases, or becomes insufficient to draw the armature toward pole faces 20, 22, the biasing spring 66 biases nut 78 upward which moves the auxiliary armature up.

The spring 114 in cylinder 110 presses to piston 108 and drives it back again to the upper end of its cylinder 110, where it is now ready for another descent. This pivots lever 88 clockwise in the direction of arrows 98. Were there no separate means to move lever 88 up, the nut 78 would press against the upper edge of cutout 90 and push lever 88 up.

An alternate form of time delay device 140 usable in conjunction with the present invention is illustrated in FIGS. 5 and 6. Device 140 may be mounted on the fixed position bracket by means of its own mounting bracket 142.

All parts of the time delay device are sandwiched between two plates 150, 152, which support them.

Tab 102 of lever 88 engages the outwardly extending arm 144 of the time delay device. Arm 144 is integral with gear 146 which pivots around shaft 148.

A torsion spring 154 is coiled about post 156 and has one end 158 which abuts a fixed post 160 and another end 162 which rests against a stud 164 that is eccentric on gear 146 and extends sideways outward therefrom. Spring 154 is biased to cause its ends 158, 162 to separate. The biasing force on stud 164 normally biases gear 147 clockwise, in the direction of arrow 166. Spring 154 is a return spring for gear 146 and arm 144 after the magnetic attraction on auxiliary armature 60, which has moved lever 88, tab 102 and arm 144 downward and has rotated gear 146 counterclockwise around its pivot.

As discussed above, the descent of lever 88 should be delayed to slow the movement of auxiliary armature 60 toward the magnet pole faces 20, 22. A time delay for movement of arm 144 is needed. Gear 146 has teeth at 170 which mesh with the teeth of smaller diameter gear 172. Gear 172 is fixed on a shaft 174 that is supported between plates 150, 152. Also fixedly secured to shaft 174 is large diameter gear 176, whereby rotation of gear 146 is directly translated through gear 172 into rotation of gear 176. The existence of the above described gear train serves to slow the pivoting of gear 146.

A pair of gear motion retarding means 180, 181 is provided for engaging in the teeth of gear 176 to thereby slow its rotation. Gear retarding means 180 pivots around a shaft 183 supported between plates 150, 152. It has an arm 184 and another arm (not shown) symmetric around shaft 183. Retarding means 180 is so located that at any one time one of its arms must be in engagement with the teeth of gear 176. Thus, when arm 184 is in engagement with the teeth, the other arm has rocked free of the teeth. As gear 176 rotates, the incline of the walls of the notches between the teeth of that gear rocks the arm 184 out of the notch between two teeth, which rocks the other arm into a notch between two teeth. The normal mechanical delays resulting from the rocking of means 180 slows the rotation of gear 174. Retarding means 181, which pivots about its own support shaft 185, also engages the teeth of gear 174 and is structurally identical and operates in the same manner as retarding means 180. The retarding of the rotation of gear 174 through means 180, 181 slows the movement of arm 144 and thereby slows the descent of lever 88, whereby time delay device 140 prevents the rapid descent of the auxiliary armature 60.

Refer to FIGS. 3, 4 and 7. The trip unit assembly 186 may be a part of a three-phase unit 187 which would include three assemblies 186, designed in accordance with the invention. The number of phases is a matter of choice and forms no part of the invention. The multiphase trip unit assembly 187 of FIG. 7 and each trip unit assembly 186, includes a molded casing 188 having a roof 189. Within assembly 186 is a tripper bar 190, rotation of which, under the influence of the magnetic trip unit assembly of the invention, will trip as associated circuit breaker, as will be described. The tripper bar pivots around a pivot 192. As shown in FIG. 7, tripper bar 190 is a single unit extending through all the phases of a multiphase trip unit assembly, whereby tripping of one of the trip unit assemblies of a multiphase unit will cause tripping of all phases of the circuit breaker.

When the nut 47 on shaft 32 descends as the main armature 26 descends, the nut engages tab 194 on the tripper bar (FIG. 4) and pivots the bar counterclockwise, in the direction of arrow 196. This movement, as will be shown below, causes tripping of the circuit breaker.

A thermal trip unit assembly causing tripping of the circuit breaker under prolonged moderate overload conditions may be provided within the casing 188. It comprises a bimetallic strip 200 that is heated by conventional means as a result of the overload in conductor 12. Upon heating, strip 22 deflects to the left, as viewed in FIG. 4, against abutment 204 which is secured to tripper bar 190 and thereby causes tripper bar 190 to pivot counterclockwise in the direction of arrow 196.

The cooperation between the trip unit assembly 186 and a single phase of a circuit breaker, or between the multiphase trip unit assembly 187 and a multiphase circuit breaker, is shown in FIG. 8 herein and in U.S. Pat. application Ser. No. 690,878, filed Dec. 15, 1967, now U.S. Pat. No. 3,484,726 in the name of Albert Strobel, entitled "Trip Unit Latch Positioning Means for Constant Latch Bite," and assigned to the assignee hereof.

Circuit breaker 210, with which the present invention is used, is a three-phase molded case unit. It should be understood that the present invention may be incorporated in numerous other frame sizes and types with the three-phase unit being shown for illustrative purposes. The circuit breaker and trip unit assembly are assembled within a housing comprising molded base 211 which is separated into compartments for each phase. Only a single phase is shown in FIG. 8, it being understood that the other phases are substantially identical. There is a main cover assembly 217 for the circuit breaker including end covers 218, with end shields 219 being located at the line and load ends of the circuit breaker 210.

The current path through the circuit breaker extends from line terminal 220 through line terminal strap 221 to stationary contacts 222, 223, to movable contacts 224, 225, which cooperate, respectively, with stationary contacts 222, 223. The movable contacts 224, 225 are on movable contact arms 226, 227, respectively, and the current path extends from these arms through flexible braid 228 to the conductor strap 229. Conductor strap 229 is, in turn, electrically connected to load terminal strap 231 via the trip unit assembly conductive strap 230.

There are a pair of outer main movable contacts 225 which are each mounted to individual contact arms 227, each connected by an individual section of braid 228 to contact carrier strap 229, while a pair of cooperating stationary contacts 223 are mounted to line terminal strap 221. The single central movable contact 224 between contacts 225 is similarly mounted to its contact arm 226, which is connected by a braid section 228 to the strap 229. Its cooperating stationary contact 222 is also mounted to line terminal strap 221.

There is an operating mechanism for operating the above-described contacts apart and together. It is now briefly described.

The movable contact carrying arm 226, 227 is connected at pivotal connection 236 to toggle link 237 which meets the other toggle link 238 at a pivoting knee 239. A circuit breaker cradle 232 is pivotally mounted on a pivot 232*a* which is mounted on a fixed support, such as the frame or casing for the circuit breaker. Upper toggle link 238 is pivotally connected at 238*a* to cradle 232. Thus, the pivotal movement of cradle 232 around its pivot 232*a* also moves pivot 238*a* and the toggle comprising links 237, 238 and knee 239.

At knee 239 is a triangular support 240 which is pivotally mounted on the knee and which has hooked to it two tension springs 241 for drawing the knee 239 toward the handle 280, to be described. Hooks 243 secure the springs 241 to handle 280. As knee 239 moves up, toggle link 238 also moves up. This starts to move the pivot connection 238*a* between link

238 and toggle 232 upward. Because cradle 232 is pivotally mounted at 232*a*, as knee 239 moves up, cradle 232 pivots clockwise and pivot connection 238*a* moves along with it.

Operating handle 280 is manually operable. Secured to it are skirts 282 which serve as barriers to prevent the escape of gases formed during circuit interruption from within the breaker housing.

Handle 280 is fixedly connected to rigid link 284 which is pivotally mounted on the handle pivot 286. Handle pivot 286 is secured to a fixed support, such as the frame or the casing of the circuit breaker.

Handle 280 has a tab 288 secured thereto for engaging a knob that is extending outward from pivot 238*a* to be engaged by tab 288. Pivot 238*a* is affixed to cradle 232. When the handle 280 is pivoted counterclockwise, as viewed in FIG. 8, the tab 288 engages the knob at pivot 238*a*, and pivots the cradle counterclockwise around the cradle pivot 232*a* for relatching the circuit breaker.

Fixedly secured to the cradle 232 is a transverse plate 300 adapted to be hooked by the overhanging extension 302 of the circuit breaker cradle bracket 304. Bracket 304 has a slot 305 into which pivot 306 extends. The bracket rotates around pivot 306 in a manner which will be described. A biasing means (not shown) is provided to normally bias bracket 304 clockwise, as viewed in FIG. 8.

When the stationary contacts 222, 223 and the movable contacts 224, 225 are respectively in engagement, the cradle 232 is in its breaker closed position. See above noted application Ser. No. 690,878, now U.S. Pat. No. 3,484,726. The transverse plate 300 is hooked under the overhanging extension 302. The springs 241 are pulling the knee 239 upward and are pulling the shaft at knee 239 upward, thereby attempting to bias the cradle 232 clockwise around its pivot 232*a*. Thus, the plate 300 is pulling up on the overhanging extension 302 and biasing the bracket 304 counterclockwise. The biasing force of springs 241 far exceeds the force of the biasing means which is biasing bracket 304 clockwise, whereby the bracket 304 is exerting a counterclockwise biasing force.

Bracket 304 has a nose 310 which extends out to engage an extension 312 on a latch bar 314. Latch bar 314 is pivotable about pivot 316. A biasing means 318 is connected with the latch bar 314 for biasing same in a counterclockwise direction around its pivot 316. Nose 310 rests on extension 312 and biases the latch bar 314 clockwise around its pivot 316, against the force of biasing means 318. Latch bar 314 has a latch tip 320 at its forward end that engages tripper bar latch plate 322. So long as the tripper bar does not move, the latch bar 314 is not released and the circuit breaker trip unit assembly and the circuit breaker remain in equilibrium.

When a fault current condition develops in the circuit being protected, and the tripper bar 190 is pivoted counterclockwise, bar 190 frees latch tip 320 of latch bar 314 from latch plate 322. Nothing prevents the rotation of latch bar 314 in the clockwise direction under the biasing force exerted by nose 310 of bracket 304 on extension 312 of latch bar 314. The springs 241 continue to attempt to pivot cradle 232 clockwise. The clockwise movement of cradle 232 moves transverse plate 300 upward with respect to overhanging extension 302 of bracket 304 and pivots said bracket 304 further counterclockwise, pivoting the latch bar 314 further clockwise. Finally, the transverse plate 300 slips free of the overhanging extension 302 and the cradle continues to pivot clockwise to its trip position, illustrated in FIG. 8.

A spring 330 is provided which is connected to the tripper bar 190 to return the tripper bar clockwise to its untripped position after the fault current condition is removed.

Once the transverse plate 300 is free of the overhanging extension 302 bracket 304, the bracket is no longer affected by plate 300 and the biasing force of the biasing means connected with the bracket rotates the bracket clockwise around its pivot 306. This positions overhanging extension 302 so that transverse plate 300 may move beneath it when the circuit breaker is relatched. The clockwise pivoting of bracket 304 also frees latch bar 314 from contact with nose 310 of bracket 304 and the biasing means 318 is free to pivot latch bar 314 counterclockwise around pivot 316 to ready the latch bar to have renewed force exerted upon its extension 312 by bracket nose 310 to cause latch tip 320 to engage latch plate 322.

As cradle 232 is pivoting in the clockwise direction about its pivot 232*a*, pivot 238*a* on cradle 232 is also pivoting and pulling the toggle link 238 around until the knee 239 is to the left of the line between pivots 286 and 238*a*, whereupon the toggle collapses and the movable contacts snap apart from the stationary contacts, to the position shown in FIG. 8.

If the trip unit assembly of the present invention is to be used in conjunction with a multiphase circuit breaker, all phases of the circuit should be deenergized when a fault condition develops in a single phase. Accordingly, a tie bar 332 is provided which extends across all the phases and is mounted to the movable contact arm of every phase. When a single phase trips and the movable contact arm pivots as the contacts separate, all of the movable contact arms in each of the phases will move simultaneously.

The means for relatching and reclosing the circuit breaker do not form a part of the present invention and do not relate to the trip unit assembly of the invention. For an understanding of the relatching and reclosing operation, reference should be had to above noted application Ser. No. 690,878.

There has just been described a trip unit assembly employing a main armature which moves across a magnetic reluctance gap toward a magnet when a high overload condition develops. The assembly also employs an auxiliary armature that moves under a less high overload to reduce the magnetic reluctance of the gap between the main armature and the magnet. Such gap reluctance reduction is accomplished through the auxiliary armature pushing the main armature toward the magnet until the attraction of the latter is sufficient to pull the main armature. A time delay device for the auxiliary armature is included to slow the reaction of the main armature in the event of a not unduly high overload.

Although the invention has been described above with respect to its preferred embodiments, it will be understood that many variations and modifications will be obvious to those skilled in the art. It is preferred, therefore, that the scope of the invention be limited not by the specific disclosure herein but only by the appended claims.

I claim:

1. A circuit breaker trip unit assembly comprising:

a magnet core comprised of material which concentrates magnetic flux in its vicinity, said core having pole faces;

said core being positioned near a conductor in the circuit being protected by said trip unit assembly, whereby said core concentrates in its vicinity magnet flux surrounding the conductor;

a main armature comprised of material which is attracted toward said magnet pole faces by magnetic flux in the vicinity of said core; said main armature being normally spaced away from said pole faces by a magnetic reluctance gap;

a biasing means for normally biasing said main armature away from said pole faces and for permitting said main armature to move across said reluctance gap toward said pole faces upon the occurrence of a first fault current in the conductor of sufficient magnitude to attract said armature to said pole faces;

means connected with said main armature to be moved by movement of said armature to bring about tripping of a circuit breaker connected with said trip unit assembly;

magnetic reluctance adjustment means moving at a lower fault current than said first fault current with respect to said magnetic reluctance gap independently of said main armature to gradually reduce the reluctance of said gap until said main armature is attracted by said magnet core toward said pole faces; and

a time delay device connected with said magnetic reluctance adjustment means for slowing the movement

thereof thereby to provide a time delay in the operation of said trip unit assembly.

2. In the circuit breaker trip unit assembly of claim 1, the improvement further comprising:

said magnetic reluctance adjustment means comprising an auxiliary armature which is comprised of material that is attracted by magnetic flux concentrated in the vicinity of said magnet;

said auxiliary armature being movable separately from said main armature;

said auxiliary armature being normally spaced away from said pole faces;

second biasing means for biasing said auxiliary armature away from said pole faces and for permitting said auxiliary armature to move toward said pole faces upon the occurrence of a fault current of sufficient magnitude in the conductor in the circuit being protected;

both said auxiliary armature and said second biasing means for said auxiliary armature being chosen so that said auxiliary armature moves towards said pole faces at a lower fault current than would cause said main armature so to move; and

said auxiliary armature being so positioned with respect to said main armature and said pole faces that the movement of said auxiliary armature toward said pole faces causes said auxiliary armature to so move with respect to said magnetic reluctance gap as to increasingly reduce the reluctance of said gap.

3. In the circuit breaker trip unit assembly of claim 2, the improvement further comprising; said auxiliary armature including abutment means for abutting said main armature upon said auxiliary armature moving toward said main armature, and once abutting, for causing said main armature to move toward said pole faces until the magnetic attraction on said main armature is sufficient to draw same to said pole faces independently of the force applied by said auxiliary armature.

4. In the circuit breaker trip unit assembly of claim 3, the improvement further comprising; first spacing means for establishing the initial spacing between said main and said auxiliary armatures and for holding them at their original spacing until said auxiliary armature moves toward said main armature.

5. In the circuit breaker trip unit assembly of claim 4, the improvement further comprising; said abutment means being adjustable in length such that said abutment means will contact said main armature only after said auxiliary armature has traveled a preselected adjustable distance toward said main armature.

6. In the circuit breaker trip unit assembly of claim 3, said magnet body being U-shaped and having a pole face at the end of each leg of the U; said auxiliary armature being U-shaped, having two arms extending toward said pole faces; said arms of said auxiliary armature extending sideways beyond the ends of said main armature, so as not to physically interfere with the movement of said main armature.

7. In combination with the trip unit assembly of claim 2, the improvement comprising:

a circuit breaker, said circuit breaker having an electric circuit therethrough, cooperating contacts in said electric circuit, and an operating mechanism connected to said contacts for separating said contacts;

said main armature of said trip unit assembly being connected to said circuit breaker operating mechanism for causing separation of said circuit breaker contacts as a result of movement of said main armature toward said magnet pole faces of said trip unit assembly.