April 29, 1947. H. C. GRAVES, JR 2,419,892

CIRCUIT BREAKER-BALANCED ARMATURE

Filed Oct. 12, 1943 4 Sheets-Sheet 1

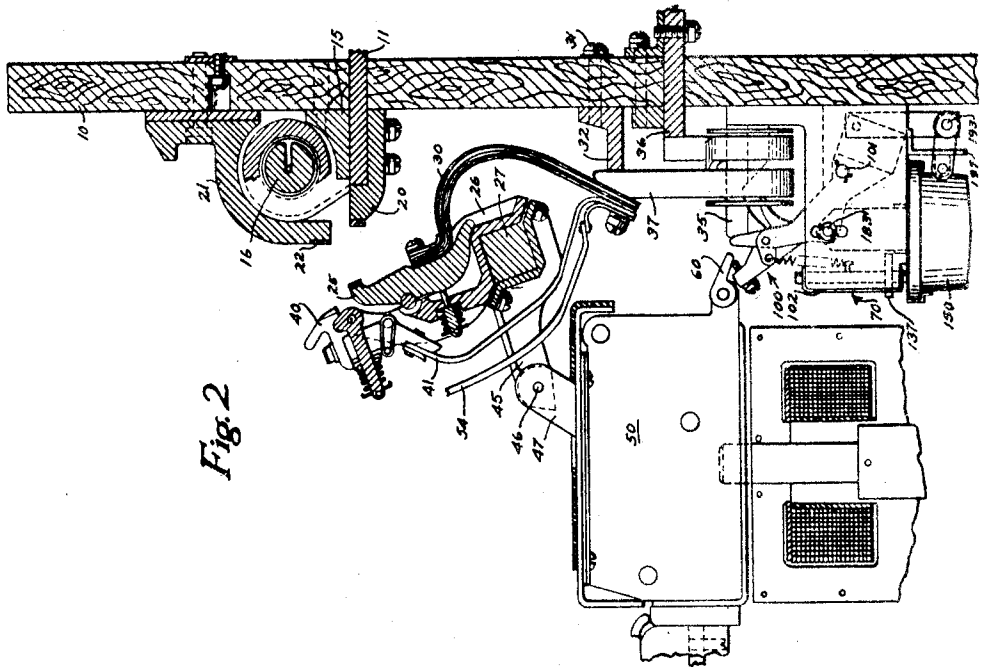


Fig. 2

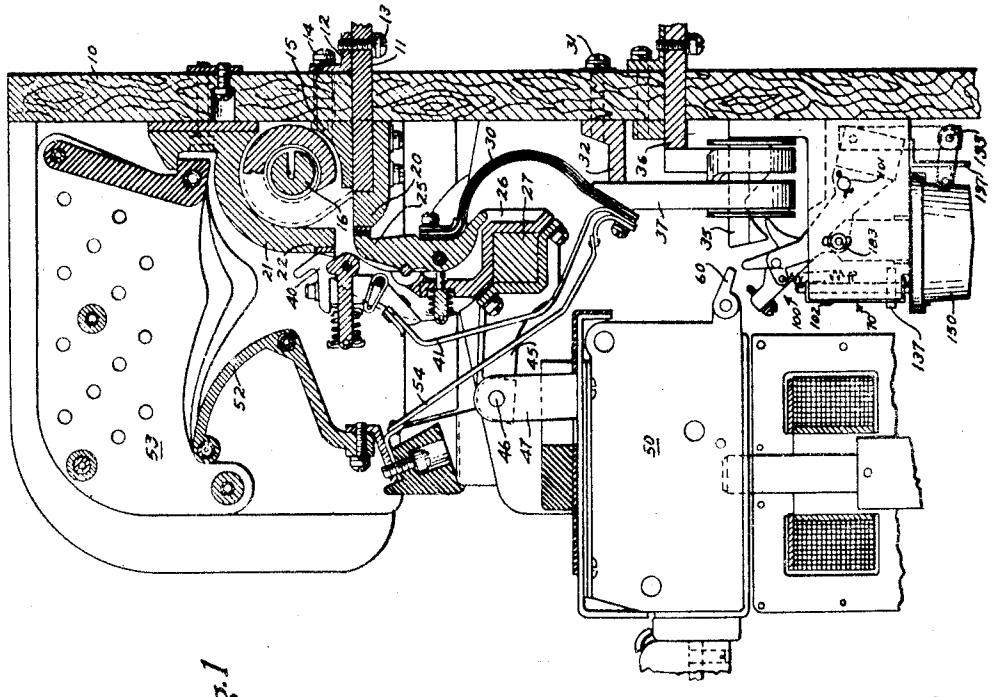


Fig. 1

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CIRCUIT BREAKER-BALANCED ARMATURE

Filed Oct. 12, 1943 4 Sheets-Sheet 2

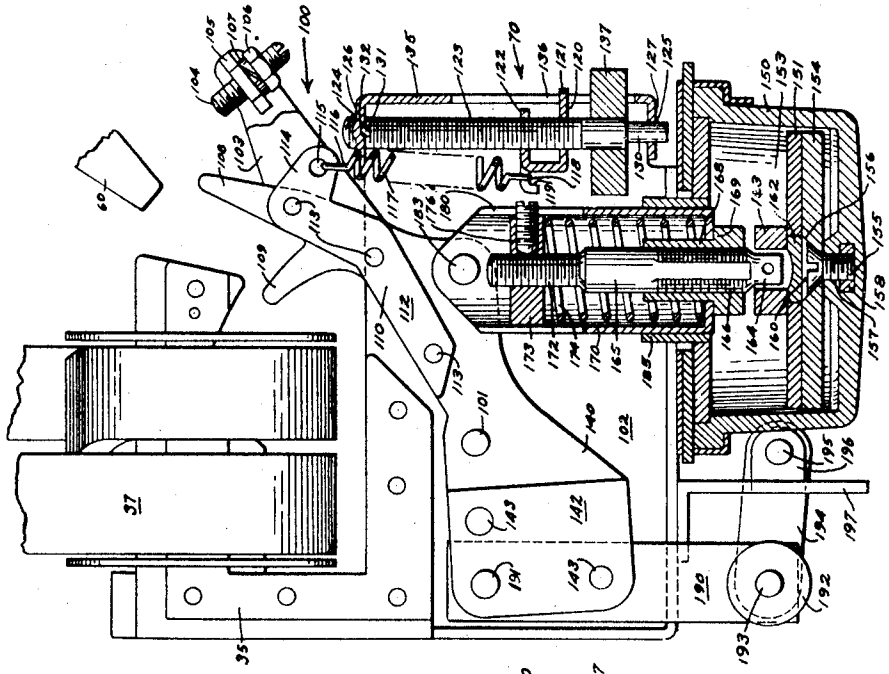


Fig. 3

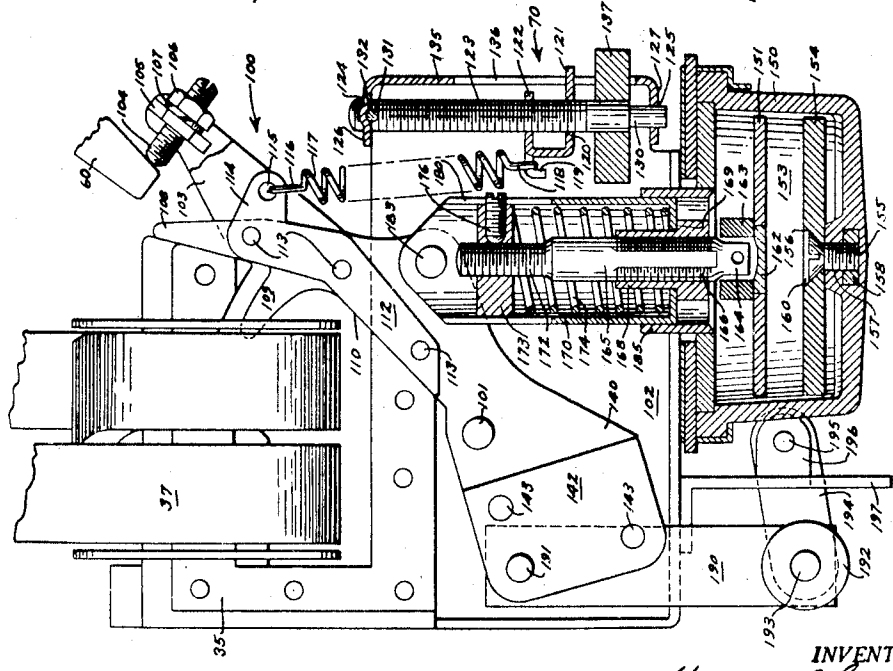


Fig. 4

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CIRCUIT BREAKER-BALANCED ARMATURE

Filed Oct. 12, 1943 4 Sheets-Sheet 3

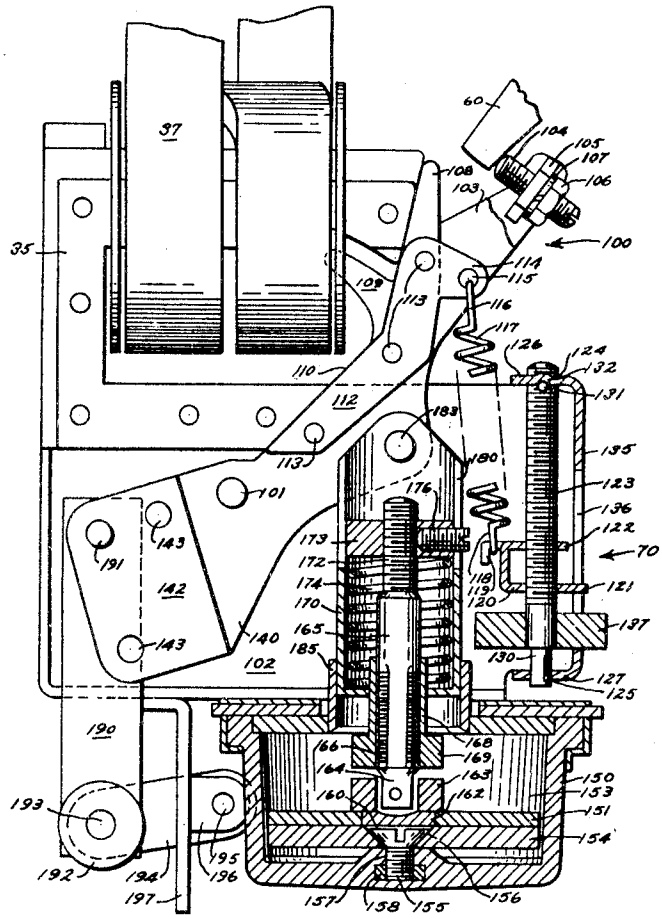


Fig. 3A

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CIRCUIT BREAKER-BALANCED ARMATURE

Filed Oct. 12, 1943 4 Sheets-Sheet 4

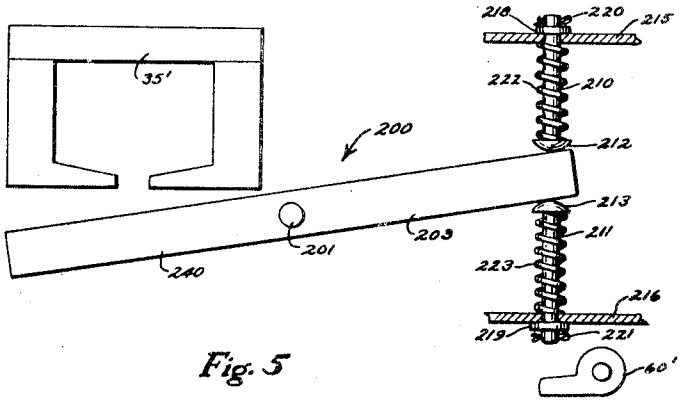


Fig. 5

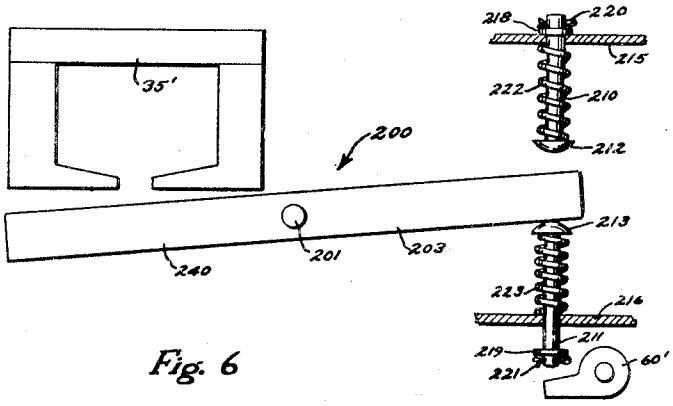


Fig. 6

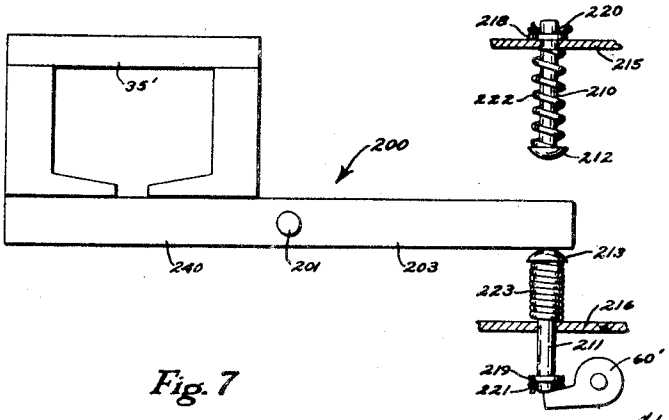


Fig. 7

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2,419,892

UNITED STATES PATENT OFFICE

2,419,892

CIRCUIT BREAKER-BALANCED ARMATURE

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Application October 12, 1943, Serial No. 505,896

7 Claims. (Cl. 175—372)

1

My present invention relates to circuit interrupters, and more particularly to the overcurrent feature thereof which is intended to be responsive to predetermined currents of selected intensity and duration automatically to trip the circuit breaker.

More specifically, my invention relates to a novel means for balancing the armature of the overcurrent feature of circuit breakers so that the armature will be unresponsive to sharp physical shocks of short duration without interfering with its responsiveness to overcurrents of selected intensity and duration.

My invention contemplates that the armature of the overcurrent feature of the circuit breaker be balanced in all respects around its pivot point so that the moment of inertia on either side will be exactly the same.

The problem of balancing an armature in this manner becomes greatly complicated when time-delay elements are added to the armature. While the armature itself may be prefectly balanced, the time-delay element secured to one side thereof necessarily tends to counteract or destroy this balance owing to the weight of the time delay sucker disc and the members which connect the same to the armature.

According, my invention contemplates not only the exact balancing of the armature itself, but also the provision of means for balancing the additional load of the time-relay sucker disc so that a true dynamically balanced condition may exist.

Since the time-delay sucker disc is restricted in its manner of travel by the dashpot in which it rides, my invention also contemplates that the means utilized for balancing the weight of the time-delay sucker disc be likewise restricted in the path which it may follow so that a balanced condition may be obtained at every position of the armature—at least up to the time it reaches the tripping position.

Thus, instead of a mere balance which may steadily and progressively be destroyed by the shifting of the weights with respect to their distance from a fulcrum, my armature may be balanced to such an extent that at every position thereof the load on either side of the pivot point will be exactly the same.

A primary object therefore of my invention is the provision of means for balancing a rotating armature of an overcurrent feature so that all parts thereof and attachments thereto are at all times perfectly counterbalanced in every position of the armature.

2

Such balancing of the armature is useful and indeed necessary wherever circuit breakers are to be used in installations which are subject to extremely rapid movements or physical shock conditions.

Thus, in naval combat vessels, the effect of a broadside or of the impact of gun fire or of a near miss of an aerial bomb may be such as to transmit a physical shock of tremendous intensity through the hull of the ship from the point of initial impact of the shock to any structure including circuit breakers which are secured to the hull of the ship.

The type of shock here contemplated is not the mere heeling, skidding, or turning of the vessel itself, but the shock transmitted by a wave motion through the metallic hull of the ship at a speed of approximately 16,000 feet per second and which is thus impacted on the circuit breaker structure itself long before the vessel begins to move as a whole in response to the overall effect of the shock.

Since the pivot pin of the armature is secured to some stationary portion of the circuit breaker which, in turn, is necessarily secured to some portion of the vessel, the pivot pin receives the impact of this shock and transmits it to the armature.

Should the armature be in any degree unbalanced, this shock will initiate its rotation; and should the armature be balanced in only one position but on movement to another position become unbalanced, vibration may perhaps occur whereupon the physical shock will be impacted on the armature in its unbalanced position and will then be effective to rotate it sufficiently to trip the circuit breaker.

But, when the armature and all of its elements and attachments are constantly balanced in every position thereof, then the impact on the pivot pin transmitted to the armature will be transmitted equally on either side of the pivot pin, and the armature will, by its own balanced condition, be prevented from rotating falsely.

The structure is so arranged that the tripping of the circuit breaker in response to an overcurrent of predetermined intensity and duration will not be affected in any way by this shock-proof balancing feature. This is so because the energization of the magnet to attract the armature will at that time create an unbalanced condition on one side of the armature, since to the weight of the armature on this side will be added the attraction of the magnet itself, and the armature will be enabled readily to trip.

Accordingly, still a further object of my invention is the provision of a statically balanced armature which will be unresponsive to physical shocks of momentary duration but which will be responsive to a sustained pull owing to the energization of a magnet in the event of an overcurrent or short circuit condition.

In addition to balancing the armature by means of equalizing the moment of rotation of all the elements and attachments on either side of the armature, the armature may be balanced as efficiently by the use of balancing springs which oppose each other and which are free to adjust each other to equal tension or compression.

Another object of my invention, therefore, is the provision of means for balancing an armature by means of opposing forces (such as springs) which are free to adjust themselves to equalize each other at all positions of the armature.

Still another and important feature of my invention is the arrangement of a time-delay element in connection with my armature where the armature may automatically be in effect disconnected therefrom in the event of excessive overcurrents or short circuits.

My invention contemplates the attachment of a time-delay sucker disc and dashpot to the overcurrent armature in such a manner that in the event of overcurrents of relatively low intensity, the time-delay will be effective to permit the circuit breaker to trip only if the low intensity overcurrent condition persists for a predetermined period of time.

My time-delay feature is, however, so connected to the armature that in the event of an excessive overcurrent condition, the armature may respond instantaneously and thus be automatically disconnected from the time-delay device.

For this purpose, a specific object of my invention includes the provision of a spring member between the sucker disc of the time-delay device and the armature—the said spring being so arranged that it will act essentially as a rigid structure in the event of overcurrents of relatively low intensity, but so that it will act as a structure the length of which may be changed (i. e., by compression) in the event of excessive overcurrents or of short circuits.

These and many other objects of my invention will become apparent in the following description and drawings in which:

Figure 1 is a cross-sectional view of a typical circuit breaker in the closed position showing my improved balanced overcurrent feature mounted therein.

Figure 2 is a view corresponding to that of Figure 1 with portions of the circuit breaker of Figure 1 removed showing the overcurrent feature attracted to the tripped position and the circuit breaker open.

Figure 3 is a view partly in vertical cross section of the overcurrent feature of Figure 1 showing the same in the at-rest or unattracted position.

Figure 3*a* is a view corresponding to that of Figure 3 showing the arrangement of the parts in the event of a greatly excessive overcurrent or short circuit.

Figure 4 is a view similar to that of Figure 3 showing the position of the overcurrent feature when attracted to the tripped position of Figure 2.

Figure 5 is a schmatic view of a spring balanced tripping mechanism for a circuit breaker.

Figure 6 is a view corresponding to that of Figure 5 showing the position of the trip unit of Figure 5 in response to shock.

Figure 7 is a view corresponding to those of Figures 5 and 6 showing the condition of the trip unit in response to an overcurrent condition.

In Figures 1 and 2 I have shown rather schematically a type of circuit breaker with respect to which my balanced overcurrent feature may advantageously be used. This circuit breaker is more fully described in my application Ser. No. 384,245, now Patent No. 2,338,715, dated January 11, 1944, and also in application Ser. No. 339,687 of William M. Scott, Jr., filed June 10, 1940, now Patent No. 2,348,223, dated May 9, 1944.

A brief preliminary description of the circuit breaker itself will aid in the understanding of the operation of the overcurrent feature.

The circuit breaker parts are mounted on an ebony asbestos panel **10**. Current enters through an upper back connection stud **11**, which passes through an opening in the panel **10** and which is secured to the panel **10** by means of the angle member **12**, the bolt **13**, and the bolt **14**, which latter bolt passes through the panel **10** and engages the terminal block **15** of the blow-out coil **16**.

Current passes from the back-connection stud **11** to the main stationary contact member **20** and simultaneously through the blow-out coil **16** to the arcing horn **21** and thence to the stationary arcing contact **22**. Current from the main stationary contact **20** passes to the main movable contact **25** mounted on the movable contact carrying arm **26** which in turn is mounted on the shaft **27**. Current then flows from the main movable contact **25** through the pigtail **30** to the terminal block **32** which is secured on the panel **10** by means of the bolt **31**.

From the terminal block **32** current then passes through the overcurrent magnet **35** to the lower back connection stud **36** which is secured to the panel **10** in the same manner as is upper back connection stud **11**.

From the arcing horn **21** and the arcing contact **22**, current passes through the movable arcing contact **40** to the pigtail **41**, then to the terminal block **32**, and likewise through the overcurrent magnet **35** to the lower back connection stud **36**.

The shaft **27**, which operates the movable arcing and main contacts, is provided with a crank **45** to which is secured, by means of pin **46**, the link **47** of insulating material which, in turn, may be moved up or down by means of the operating mechanism contained in the housing **50**.

When the circuit breaker is tripped from the position of Figure 1 to the position of Figure 2, the link **47**, which has been supported in the housing **50**, is permitted to drop, and the shaft **27** rotates in response to any suitable spring bias applied thereto, thus moving the contact elements to the position shown in Figure 2, whereupon current from the movable arcing contact is transferred to the arcing horn **52** of the arc extinguisher **53**.

The current path through the arc thus drawn is maintained by the pigtail **54** between the arcing horn **52** and the lower terminal block **32**. The arc is then blown out and extinguished by means of a blow-out coil **16** and the arc extinguisher **53**.

All the various elements of the circuit breaker

above indicated are described more specifically in the applications above mentioned and thus require no further description here.

It is sufficient to note, however, for purposes of the present description that the lever 60 is secured to a latch member contained in the housing 50, and when this lever 60 is lifted slightly, the latch trips and the circuit breaker may move from the closed position of Figure 1 to the open position of Figure 2.

The overcurrent feature 70, more specifically described in connection with Figures 3 and 4, is designed to lift the lever 60 in response to overcurrent conditions of predetermined intensity and duration.

As will be seen from a comparison of Figures 1 and 2, the armature 100 is shown in the unattracted untripped position of Figure 1, and in the fully attracted tripped position of Figure 2.

The overcurrent feature 70 with the armature 100 and the overcurrent magnet 35 constitute the essential elements of my present invention and are more specifically shown in Figures 3 and 4 where it will be seen that the armature 100 is rotatably mounted on pin 101 supported in the housing 102 of the overcurrent feature 70.

The arm 103 of the armature 100 on the right side of the pin 101 (with respect to Figure 3) is provided with a tapped hole in the bridging member 105 through which is threaded the adjustable screw 104. Screw 104 is held in its adjusted position by the lock nut 106 and the spring washer 107.

When the armature 100 is attracted from the position of Figure 3 to the position of Figure 4, screw 104 strikes the lever 60 and lifts the same in order to trip the circuit breaker. It will be obvious, therefore, that screw 104 is adjusted so that the lever will be contacted substantially just before the armature 100 reaches the fully tripped position of Figure 4, so that the additional movement between the point of contact of screw 104 with the lever 60 to the completed movement of Figure 4 will be just sufficient to lift the lever 60 to the predetermined extent necessary to effect the tripping operation.

The overcurrent magnet 35 and the coil 37, which energizes the same, have a form well-known in the art and need no further description.

Likewise, the elements 108, 109 and 110 of the arm 103 of armature 100, which are attracted by magnet 35, are also of a form well-known in the art and require no further description.

It is sufficient to note for purposes of the present description that when magnet 35 is energized to a sufficient extent to overcome the inertia of the armature 100 and the time-delay mechanism herein described and the adjusting spring 117, the elements 108, 109 and 110 of the arm 103 of the armature 100 are attracted by the magnet 35, and thus the screw 104 is brought into contact with the lever 60 to trip the circuit breaker.

A bracket member 112 is secured to the arm 103 of the armature 100 in any suitable manner as, for instance, by the rivets 113 and is provided with an extension 114 having an opening 115 within which one end 116 of the tension spring 117 is captured.

The opposite end 118 of tension spring 117 is secured to the extension 119 of the slide member 120.

Slide member 120 has a pair of flanges 121 and 122 which are provided with threaded openings and are in screw-threaded arrangement with the adjusting screw 123.

Adjusting screw 123 is rotatably mounted in openings 124 and 125 in the top wall 126 and the bottom wall 127 respectively of the housing 102. The lower end of the screw 123 is provided with an extension 130 passing through and registering with the opening 125. The upper end of the screw 123 just beneath the undersurface of the top wall 126 of the housing 102 is provided with a pin 131 passing through the screw in registry with the groove 132 in the undersurface of the top wall 126 of the housing 102.

The tension of spring 117 pulling between the extension 119 of the slide member 120 and the extension 114 of the armature 100 pulls the screw 123 upwardly so that the pin 131 is caused to bear in the groove 132—this prevents false rotation of the screw 123 in response to jars or shocks which occur during tripping or owing to any other physical cause.

The front wall 135 of the housing 102 is provided with a slot 136 through which projects the adjustng knob 137 of insulating material secured to the screw 123 and rotatable therewith. In order to rotate the screw 123 to adjust the position of the slide member 120, it is necessary to depress the adjusting knob 137 and rotate the same. Depressing the knob will pull the pin 131 out of the groove 132 and make it possible to rotate the screw 123.

At each 180° turn, the pin 131 will snap into the groove 132 once more so that the knob 137 must be depressed again to continue the rotation; or if a substantial turn is desired, the knob 137 must be continuously depressed during rotation.

As the screw 123 is thus manually rotated, the slide member 120 will move up or down in accordance with the direction of rotation of screw 123 to adjust the tension of the spring 117.

The flange member 121 of the slide 120 projects through the slot 136, and an appropriate scale may be mounted alongside the slot 136 so that the extension 121 of the slide may act as a pointer to indicate the adjustment for which the spring 117 is set.

The arm 140 of the armature 100 on the left side of the pin 101 (with respect to Figure 3) is provided with a weight 142 secured thereto in any suitable manner, preferably by means of the rivets 143. This weight is designed to cooperate with the extension 140 of the armature 100 to counterbalance all of the members of the extension 103 of the armature 100 on the right side of the pivot 101 so that the armature 100 is accurately balanced.

The adjustment of the spring 117 determines the intensity of energization of the magnet 35 necessary to attract the armature 100 to effect the tripping. The pull exerted by this spring 117 is for obvious reasons not counterbalanced; since, if it were, the armature 100 would be sensitive to current no matter how minute; and since the tension of the spring 117 is unaltered by physical shock.

Since, by means of the weight 142, section 140 of the armature 100 on the left side of pin 101 is exactly equal in weight and mass to section 103 of the armature 100 on the right side of pin 101, any shock transmitted from the hull of the vessel to the pin 101 will be transmitted equally on either side of the pin 101 to equal masses on each side.

Should the force exerted by pin 101 be in an upward direction, then the side 140 and the side

103 of the armature 100 will tend to move upwardly with equal moment, and the armature 100 will, therefore, not rotate about the pin 101—this is obviously so since the armature 100 as a whole is a single rigid unit and both sides thereof cannot move upwardly simultaneously, unless it should break at the pivot pin 101.

Assuming for the moment that the armature 100 were not counterbalanced in the manner herein described, and the pivot pin 101 should transmit a shock in an upward direction, the armature 100 would rotate clockwise. This may result in a rebound with sufficient force to trip the circuit breaker, depending, of course, on the relationship between the force of the shock and the resistance offered by the dash-pot.

Consequently, the balancing of the armature 100 in the manner herein described creates a condition which resists downward movement as well as upward movement of the armature 100 owing to physical shock transmitted thereto by the pivot pin 101, and the armature 100 will not trip in that event either. The armature, indeed, as will be obvious, is balanced with respect to shock transmitted thereto in any direction.

It is well-known in the operation of circuit breakers that the energization of the tripping magnet 35 may vary within rather wide limits without effecting a tripping of the circuit breaker.

Thus, assuming that the circuit breaker is to operate on 600 volts, 100 amperes, it may be desired that the circuit breaker be adjusted so that it will trip the currents in excess of, say, 150 amperes.

Obviously, of course, the attraction exerted on the armature 100 by the magnet 35 varies in accordance with the amount of current passing therethrough. Consequently, it may be argued from a theoretical point of view that if the system be adjusted for operation at a particular current value, that an unbalanced condition may perhaps be obtained at different current values.

This, however, is not so. Since the attraction of the magnet 35 and the tension of the spring 117 are without mass and are therefore not affected by shock forces, they will maintain their relative tensions and the tripping point will not be altered.

In balancing the armature 100, it is therefore necessary to consider only the moving parts attached to it that have mass, and it is not necessary to consider those forces exerted on the armature 100 that do not have any mass since they will not be affected by shock and therefore will not tend to overbalance the armature 100.

One other source of unbalanced force under shock conditions, is the contact between the moving dash pot disc 151 and the stationary disc 154. But, since these discs are immersed in oil and adhere to each other with a force greater than the shock forces, they may be neglected as a cause of tripping under shock conditions.

In the present invention, it is desired for practical operation to cause the armature 100 to trip not merely on a current of predetermined intensity, but only where this current is maintained over a predetermined time interval. For this purpose, it is necessary to provide a time-delay mechanism.

In the present case, the time-delay mechanism, shown in the dashpot 150, is secured in any suitable manner to the underside of the housing 102 and the sucker disc 151, which is secured to the arm 103 of the armature 100.

The dashpot 150 comprises a chamber 153,

which is preferably filled with oil, and is provided with a steel plate 154 secured adjacent to the bottom of the dashpot chamber 153 by means of the screw 155 passing through the opening 156 of the steel plate 154 and entering the tapped opening 157 and metal insert 158 in the base of the dashpot chamber.

The head of the screw 155 is recessed beneath the upper surface of the steel plate 154 to provide a relatively small depression or chamber 160 in the center of the upper surface of steel plate 154.

The sucker disc 151 is made preferably of steel with a central section 162 also of steel material.

A collar 163 is secured in any suitable manner as, for instance, by brazing to the upper surface of the sucker disc 151; and the end 164 of connecting link 165 is secured in the collar 163.

The lower end of the connecting link 165 is threaded at 166 and is secured in the tapped opening of the tubular member 168. Tubular member 168 is provided with a flange 169 which bears against the lower outside surface of the tubular member 170.

The upper end of the connecting link 165 is also threaded at 172 and passes through the nut 173 in the tube 170.

A compression spring 174 is mounted in the tube 170 between the base thereof and the underside of nut 173, and thus forces the nut 173 upwardly to force the flange 169 of the tubular member 168 against the bottom of the spring tube 170.

A set screw 176 passes diametrically through the nut 173 and bears against the threaded end 172 of the connecting link 165 to maintain the adjustment of the nut 173.

The set screw 176 passes through slot 180 in the side of tube 170 and may be removed therethrough in order to permit rotation of the nut 173 to adjust the compression of the spring 174. In the event such adjustment is desirable, the set screw may be removed; the nut may then be rotated to the appropriate adjustment; and the set screw 176 may then be replaced to maintain the adjustment.

The upper end of the spring tube 170 is connected by means of the pin 183 to the armature 100.

The spring tube 170 is guided in its upper and downward movement by a tubular insert 185 in the top of the housing of the dashpot 150.

This resilient interconnection between the sucker disc 151 and the armature 100 may be utilized for the purpose of making the armature 100 instantaneous on overcurrent values above a predetermined intensity.

Thus assuming, for instance, that the circuit breaker is to protect a circuit carrying 600 volts, 100 amperes, and that it is intended to trip with a time-delay, should the current rise to 150 amperes, and assuming further that it is intended to trip instantaneously when the current value reaches 1000 amperes—then, the adjustment of the spring 174 of the dashpot mechanism together with the adjustment of spring 117 may be made to effect these various results.

The spring 117 should, in the first instance, in this case be adjusted so that it will resist the attraction of the armature 100 at any current value below 150 amperes but will permit the magnet 35 to be effective to attract the armature 100 above 150 amperes.

The spring 174 should be adjusted so that a force exerted by the magnet 35 on the armature 100 below 1000 amperes will be substantially in-

effective to compress the spring 174; while a force exerted thereon by the magnet 35, owing to a current in excess of 1000 amperes, will be sufficient to compress the spring 174.

Assuming, in this example, that an overcurrent should exist of more than 150 amperes, but less than 1000 amperes, then the spring 117 will no longer resist the attraction on the armature 100; but the magnetic attraction, owing to a current of this value, will not be sufficient to compress the spring 174.

Accordingly, the connection from the armature 100 to the time-delay sucker disc 151 in this case is substantially rigid, and a time-delay will be effected by the sucker disc 151 holding back the armature 100.

Thus, for an overcurrent value of between 150 amperes and 1000 amperes in this example, the sucker disc 151 will be effective to create the predetermined time-delay for which the dashpot 150 is set.

In the event that the current value, according to our example, should rise above 1000 amperes where an instantaneous trip becomes desirable, then, by reason of the adjustment of the spring 174 above pointed out, this spring will be compressible, and the spring tube 170 will be enabled immediately to rise and compress the spring 174 against nut 173, and the armature 100 which is secured to the tube alone and without substantial movement of the dashpot disc 151, will be able to rise as shown in Figure 3A.

In this case, the force exerted by the magnet 35 on the armature 100 will enable the tube 170, which is attached to the armature 100, to compress the spring 174 instantaneously.

Since the tube 170 in turn is connected to the connecting link 165, only through the spring 174, the fact that the connecting link 165 is held down by the sucker disc 151 will not affect the instantaneous operation of the armature 100 in response to an overcurrent of sufficient intensity to compress the spring 174.

The slot 180 in the side of the tube 170 which permits the set screw 176 to pass through should, accordingly, be sufficiently long not only to allow for adjustment of the compression of the spring 174, but also to allow the tube 170 to move with respect to the set screw and nut.

By this means, therefore, a dual overcurrent feature is obtained.

On relatively small overcurrents of relatively long duration, the circuit breaker will be enabled to trip only after the predetermined time-delay for which the dashpot 150 is set.

On substantial overcurrents or on short circuits, the circuit breaker will be able to trip instantaneously irrespective of the setting of the dashpot 150.

In order to maintain the dynamic balancing feature of the armature 100 and its consequent resistance to shock it is necessary not merely to counterbalance each of the elements of the armature itself, as above pointed out, but also to counterbalance the weight of the tube 170 and the elements associated therewith, as well as the connecting link 165 and the sucker disc 151—all of which are secured to the right hand side of the armature 100.

These elements, it is obvious, are not integrated with the armature 100 so that they maintain the same relative position with respect to the pivot point 101 of the armature 100 as do the elements mounted on the armature itself; but they are pivotally mounted on the armature 100 and,

while adding to the weight of the right-hand side thereof, assume different positions with respect to the other elements of the armature as the armature 100 moves from one position to another.

Accordingly, the counterbalancing means should likewise preferably be pivotally mounted to assume similar angular positions.

For this purpose, an additional weight 190 is pivotally hung on the pin 191 on the left-hand side of the pivot point 101 (with respect to Figure 3), and this weight 190 is added to by an additional weight 192 secured on the pin 193 at the lower end of the weight 190.

A link 194 is rotatably secured to the pin 193, and the opposite end is secured to the pin 195 carried by an extension 196 from the flange 197 secured to the underside of the housing 102.

The portion of link 194 supported by the pin 193, the additional weight 192, and the weight 190 are equally massed to the tube 170 and its associated elements; to wit, the nut 173, the spring 174, the connecting link 165, the tube 168, and the sucker disc 151.

Accordingly, all of the additional elements hung from the right side of the pivot 101 of the armature 100 are counterbalanced by elements of the same mass hung in the same manner from the left side of the armature 100. The continuous balancing of the armature 100 is maintained by this additional counterbalancing means.

In addition, it is obvious that the counterbalancing masses 190, 192 and 194 are maintained as far as possible in the same relative position with respect to the pivot pin 101 as are the tube 170 and other associated elements which they counterbalance.

In effect, the elements of the armature 100 and weights defined by pins 101, 191, 193 and 196 form a quadrature linkage or parallelogram, the sides of which always remain equal and the elements of which counterbalance,—the approximately parallelogram structure being defined by pins 101, 183 and the extension 166 of the link 165 and the sucker disc 151.

By means of the structures herein described, the overcurrent feature is not only rendered stable with respect to physical shocks, but is also so arranged that it may selectively respond in different ways to overcurrents of different intensities and durations.

Thus, as above pointed out, the shock from the pin 101 or from any other element in contact with the armature 100 is transmitted equally on both sides of the armature owing to the equal masses on each side.

Since the opposite sides of the armature 100 both tend to rotate in the same direction (up or down) on opposite sides of the pivot pin 101, such a shock is translated into counterbalancing forces on opposite sides of the pivot pin, thus leaving the armature 100 stationary irrespective of the intensity of the shock.

Also, as above pointed out, the overcurrent feature is so arranged that where the overcurrent is of relatively low intensity, the time-delay element will be effective so that tripping will occur only if the lower intensity overcurrent condition lasts for a predetermined length of time.

Where-however, the overcurrent is of a predetermined greater intensity, then the armature 100 may trip instantaneously and is, in effect, automatically disconnected on the occurrence of such a condition from the time-delay element.

In Figures 5, 6, and 7 I have shown a further modification of my invention wherein the balancing of the armature is obtained by the use of counterbalancing springs. The embodiment is here shown schematically, but the development of this embodiment into commercial form should be obvious to those skilled in the art.

The armature 200 in this embodiment is arranged pivotally mounted on the pin 201 and has a right-hand extension 203 and a left-hand section 240 preferably of equal mass. The armature 200, in the event of overcurrent conditions, may be attracted by the magnet 35'.

Extension 203 of the armature is captured between the two rods 210 and 211, each of which is provided with a head 212 and 213 respectively bearing against opposite sides of the arm 203 of the armature 200.

The rods 210 and 211 are each supported respectively from the upper and lower walls of the flanges 215 and 216 of any suitable housing in which the element herein described may be enclosed.

The rods 210 and 211 pass through suitable openings in each of the flanges 215 and 216 respectively and are each provided with washers 218 and 219 respectively limiting the inward movement of the said rods toward the armature 203.

Any suitable means, as, for instance, the cotter pins 220 and 221, may be utilized to prevent the rods 210 and 211 from being unintentionally withdrawn from their mountings.

Compression springs 222 and 223 are mounted respectively on each of the rods 210 and 211 and are in each case captured between the heads of the rods and the flanges or walls in which they are mounted.

In the event of the occurrence of a shock tending to effect rotation of the armature 200, it will be clear that with the opposite sides of the armature equally balanced, such rotation, owing to shock, will always be resisted by the occurrence of equal forces in the same direction on opposite sides of the pivot pin 201.

In the event, however, that sufficient wear should occur to slightly unbalance the opposite sides of the armature 200 with respect to each other, and in the event of a combination of physical shocks tending to effect rotation of the armature 200 so that the end 240 moves upwardly and the end 203 downwardly, then, as will be seen in Figure 6, spring 211 will be compressed and will act as a shock absorber to absorb the rotative movement of the armature 200.

In the event of a combination of shocks and other circumstances which tend to produce a counterclockwise rotation of armature 200, then the upper spring 210 will be effective to absorb this rotation.

In the event, however, that the magnet 35' is energized sufficiently to attract the armature 200 to trip the circuit breaker, then, as shown in Figure 7, the end 203 of the armature 200 will strike the head 213 of the pin 211 to move the same downwardly and compress the spring 223.

The spring 223 will absorb this initial force; but, the resilience of the spring 223 to restore the armature 200 to its initial position is counteracted by the continuous steady pull on magnet 35', so that the spring 223 will now further be compressed until the pin 211 is forced down sufficiently to rotate the lever 60' to trip the circuit breaker.

Thus, the device is enabled to distinguish between short, sharp physical shocks and a steady pull exerted by magnet 35'.

In the event of such a short, sharp physical shock, the springs 223 or 222 will rebound to restore the armature 200 to its initial position from that, for instance, of Figure 6 to that of Figure 5.

In the event of a steady pull exerted by the magnet 35', the spring 223 will be steadily compressed to result in the tripping operation as shown in Figure 7.

Suitable adjustment springs may be provided in connection with the armature 200 to ensure its response to overcurrents of predetermined intensity. It is possible, however, to avoid the necessity for additional adjustment springs since spring 223 can act as such an adjustment spring in the embodiments shown in Figures 5, 6 and 7. The spring 223 is simply set initially for a predetermined adjustment.

However, the flange member or supporting members 215 and 216 may be made vertically adjustable in order to obtain an adjustment of spring 223—or the springs 222 and 223 may be made adjustable in any other suitable manner.

Similarly, suitable time-delay elements, as previously pointed out, may be secured to the armature 200 and may be counterbalanced also in the manner previously pointed out.

In the foregoing, I have described my invention only in connection with specific preferred embodiments thereof. Many variations and modifications should be obvious to those skilled in the art. Accordingly, I prefer to be bound not by the specific disclosures herein but only by the appended claims.

I claim:

1. In combination, a magnet winding, a pivoted armature rotated about its pivot in response to the energization of said magnet winding, said armature being mechanically balanced at all positions thereof about its rotating pivot, a time delay mechanism pivotally connected on one side of the pivot of said armature for extending the time of operation of said armature in response to a predetermined energization of said magnet winding and a weight pivotally connected to the other side of the pivot of said armature and balancing said time delay mechanism, the connection of the weight being such that balance is affected at all positions of said armature.

2. In combination, a magnet winding, a pivoted balanced armature rotated about its pivot in response to the energization of said magnet winding, and a time delay mechanism connected on one side of the pivot of said armature for extending the time of operation of said armature in response to a predetermined energization of said magnet winding, a counter-balance means connected on the opposite side of the pivot of said armature and maintaining the same relative position with respect to the armature pivot for each position of the armature as said time delay mechanism maintains, whereby said armature and time delay mechanism are balanced at all positions of said armature against vibrations.

3. In combination, a magnet winding, a pivoted armature rotated about its pivot in response to the energization of said magnet winding, a mass connected to one side of the pivot of said armature and a time delay mechanism secured to said armature on the other side of its point of pivot, the said first mass and the mass of said time delay mechanism being balanced with respect to each other on both sides of said pivot, and means for so connecting said mass and time

delay mechanism that they maintain the same relative positions with respect to said armature pivot for all positions of said armature.

4. In combination, a magnet winding, a pivoted armature rotated about its pivot in response to the energization of said magnet winding, and a time delay mechanism pivotally secured to said armature on one side of its point of pivot, the mass of said armature and said time delay mechanism being balanced on both sides of said pivot and means pivotally connected to said armature for self-adjusting said mass as said armature moves said time delay mechanism for maintaining said balance.

5. In combination, a magnet winding, a pivoted armature rotated about its pivot in response to the energization of said magnet winding, and a time delay mechanism secured to said armature on one side of its point of pivot, the mass of said armature and said time delay mechanism being balanced on both sides of said pivot, and a mass connected to the armature on the opposite side of said pivot and connected to said time delay mechanism for adjusting the balancing force thereof as said time delay mechanism shifts its position in response to the armature movement.

6. In combination; a magnet, a pivoted armature rotatable about its pivot; a time delay mechanism connected to said armature on one side of its pivot; a weight connected to said armature

on the opposite side of said pivot from said time delay mechanism, and a link on which said weight is pivotally mounted.

7. In combination; a magnet, a pivoted armature rotatable about its pivot; a time delay mechanism connected to said armature on one side of its pivot; a weight connected to said armature on the opposite side of said pivot from said time delay mechanism, and a link on which said weight is pivotally mounted, said link and weight being balanced against said time delay mechanism for all positions of said armature.

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