United States Patent

Hong

[15] **3,688,227**

[45] **Aug. 29, 1972**

[54] IMPEDANCE PROTECTOR

[72] Inventor: **Kyonghi Hong**, 9722 Gwynn Park Dr., Ellicott City, Md. 21043

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[52] **U.S. Cl.** **335/7**, 335/178

[51] **Int. Cl.** **H01h 83/20**

[58] **Field of Search** 335/7, 6, 20, 178

[56] **References Cited**

UNITED STATES PATENTS

779,003	1/1905	Scott	335/7
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Primary Examiner—Harold Broome
Attorney—Le Blanc & Shur

[57] **ABSTRACT**

Disclosed is a circuit breaker whose trip characteristic is a function of both current and voltage. A single armature is acted on by both a current coil having a delay and a voltage coil without delay. As a result, trip time for overcurrents accompanied by undervoltage is substantially reduced. The breaker or impedance protector is particularly adapted for use in "soft" power systems such as those employing fuel cells or engine generators.

9 Claims, 6 Drawing Figures

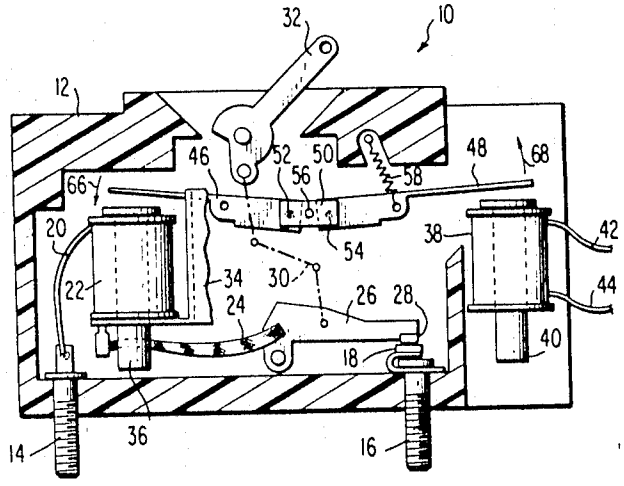


FIG. 1

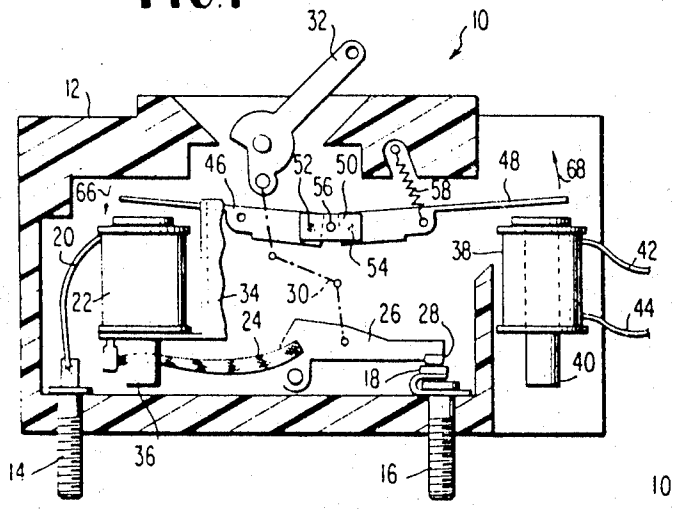


FIG. 2

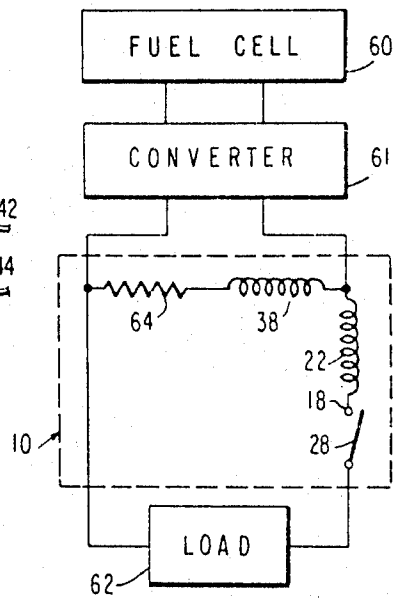
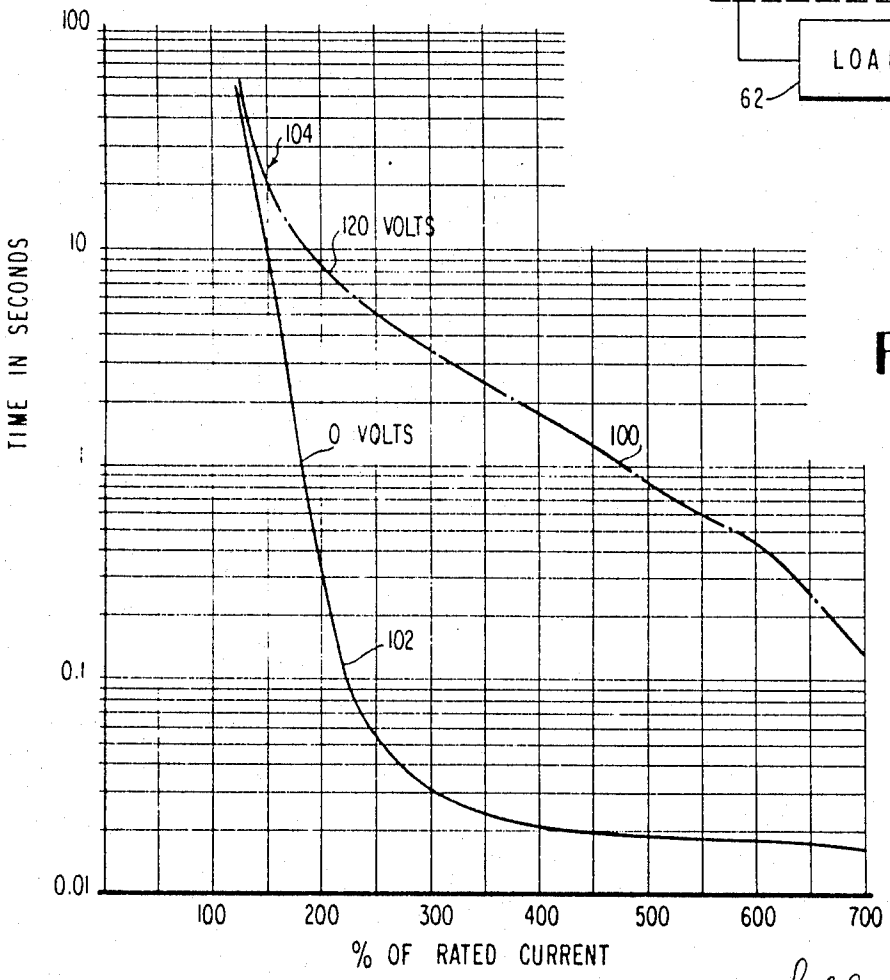


FIG. 6



INVENTOR
KYONGHI HONG
BY LeBlanc & Shur
ATTORNEYS

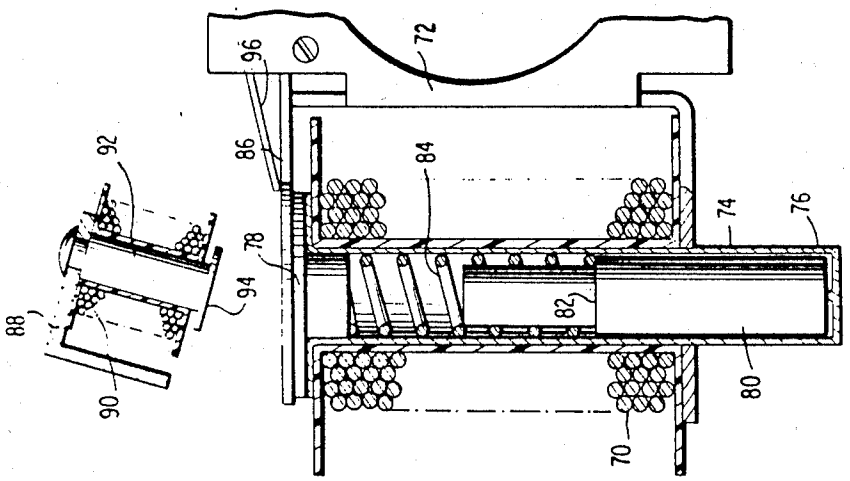


FIG. 5

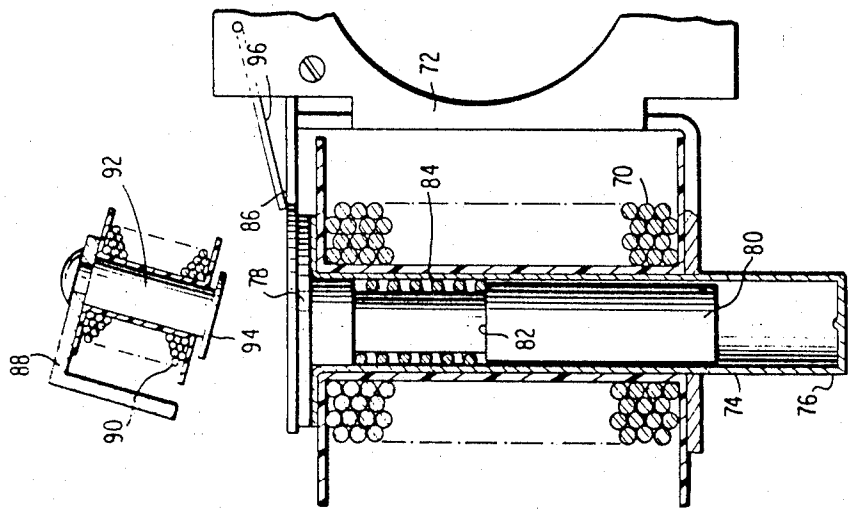


FIG. 4

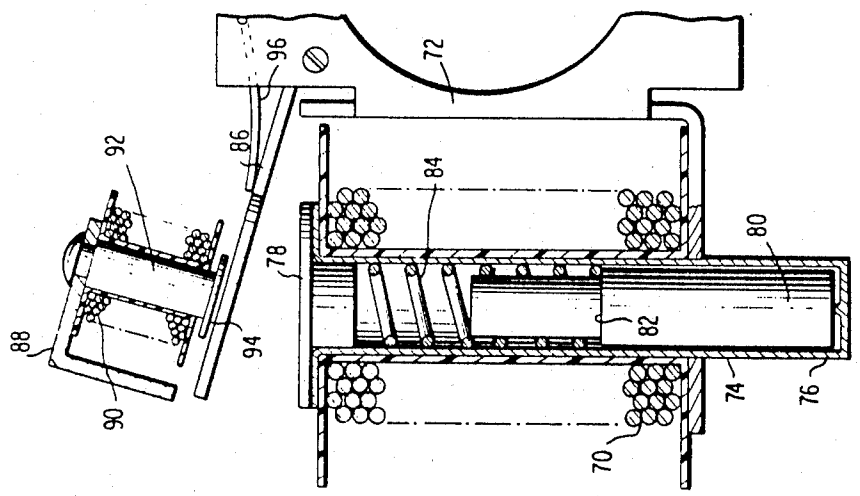


FIG. 3

IMPEDANCE PROTECTOR

This invention relates to a circuit breaker and more particularly to a dual function breaker whose tripping characteristics are a function of two electrical parameters, such as both current and voltage. The breaker is particularly designed for use with so-called "soft" power systems where high fault current is not available.

As is well known, conventional magnetic circuit breakers are basically overcurrent devices and conventionally trip after a short time delay in the presence of relatively high fault currents. Conventional breakers of this type do not function adequately to rapidly break or open the circuit in the so-called "soft" power systems, such as those involving fuel cells and engine generators, where the system cannot supply the necessary high currents to rapidly trip the breaker when a fault occurs.

It has been proposed in the past to provide a circuit breaker with both current and voltage coils which act independently of a circuit breaker mechanism to open the same pair of contacts. However, these devices trip the breaker whenever excessive current or a low voltage exists, one independently of the other even though both may occur at the same time. They do not provide a tripping characteristic which is a function of both voltage and current and, likewise, are not suited for use in "soft" power systems to provide rapid breaker operation.

The present invention is directed to a novel circuit breaker construction which overcomes these and other problems. In the present invention, a single armature is simultaneously subjected to the magnetic field of both a current coil and a voltage coil. By proper coil design, it is possible to connect one coil directly across the power supply so that the current through this coil is a function of the power supply voltage. The current coil is placed in series with the power supply as is customary with conventional magnetic breakers. With the breaker of the present invention so connected, the time to trip is a function of a combination of both the line current and line voltage.

Important features of the breaker of the present invention include the fact that it may be formed of relatively simple and inexpensive construction completely compatible with existing magnetic circuit breaker designs. While its primary purpose is to reduce the trip time when small overcurrent is accompanied by undervoltage, as occurs in fuel cell and other electrical systems, the impedance protector of the present invention can be used to replace a single function breaker if delay time longer than instantaneous but shorter than the shortest available is desired. By suitably modifying the spring tension on the armature, the dual function breaker can be converted to an undervoltage or overcurrent breaker if desired. In any case, the breaker operates completely independently of phase relationship.

It is therefore one object of the present invention to provide an improved impedance protector particularly suited for use with "soft" power supply systems in which high fault currents are not available.

Another object of the present invention is to provide an improved dual function circuit breaker.

Another object of the present invention is to provide a dual function circuit breaker having increased versatility and one that is fully compatible with existing circuit breaker designs.

Another object of the present invention is to provide a dual function circuit breaker of relatively inexpensive and simplified construction.

Another object of the present invention is to provide a dual function circuit breaker in which a single armature is acted upon by the magnetic fields of both a current coil with delay and a voltage coil without delay.

Another object of the present invention is to provide a dual function, delay type magnetic circuit breaker particularly designed for use in electrical systems such as those employing fuel cells or engine generators where very high fault currents to provide fast opening of the breaker are not available.

These and further objects and advantages of the invention will be more apparent upon reference to the following specification, claims, and appended drawings, wherein:

FIG. **1** is a cross-sectional view showing principal parts of the dual function circuit breaker constructed in accordance with the present invention;

FIG. **2** is a simplified circuit diagram showing the manner of connecting the current and voltage coils in a fuel cell system;

FIG. **3** is a cross section showing a portion of a preferred embodiment of a dual function circuit breaker constructed in accordance with the present invention;

FIG. **4** is a view similar to FIG. **3** showing the armature of the circuit breaker in the tripped position;

FIG. **5** is a view similar to FIG. **3** showing the breaker after rapid tripping; and

FIG. **6** is a plot of trip time in seconds as a function of percent of rated current of a circuit breaker constructed in accordance with the embodiment of FIGS. **3–5**.

Referring to the drawings, the novel dual function circuit breaker of the present invention is generally indicated at **10** in FIG. **1**. The breaker or impedance protector comprises an electrically insulating housing **12** in one wall of which are mounted a pair of line terminals **14** and **16**. Terminal **16** is electrically connected to a stationary switch contact **18** suitably mounted within housing **12**. Terminal **14** is connected by a short lead **20** to one end of a delay current coil **22** having its other end connected by a braided conductive wire **24** to a contact bar **26** carrying a movable contact **28** adapted to move into and out of engagement with stationary contact **18**. Contact bar **26** is mechanically connected through a collapsible toggle mechanism, indicated by dashed lines at **30**, to an actuating handle **32** which may be manually moved to open and close the breaker contacts **18** and **28**. This portion of the breaker is of more or less conventional construction and may take any well known form and, by way of example only, may be constructed in the manner disclosed in assignee's U.S. Pat. No. 3,412,351, issued Nov. 19, 1968.

Current coil **22** is mounted on a suitable frame **34** within the housing and surrounds a core **36**, preferably constructed in the form of a well known delay tube. Also mounted within housing **12** is a second coil **38** forming a voltage coil which surrounds a solid magnetic core **40**. The opposite ends of voltage coil **38** are connected to the external circuit by way of leads **42** and **44**.

Positioned adjacent one end of core 36 is a movable armature 46 and a similar armature 48 is positioned adjacent the end or polepiece of voltage coil core 40. The two armatures 46 and 48 are preferably welded together by a pair of flat plates, one on each side of the armature, as illustrated by the plate 50, spot welded to the armatures as at 52 and 54. By this connection, the two armatures 46 and 48 are in effect a single armature and move as a single unitary structure about a central pivot axis 56 perpendicular to the plane of the paper in FIG. 1. Armature 48 is preferably biased away from core 40 by a suitable tension spring 58.

FIG. 2 shows the manner of connecting the circuit breaker 10 into an external circuit. The circuit breaker is indicated by a dashed box 10 in FIG. 2 and connects a power supply in the form of a fuel cell 60 through a DC to AC converter 61 to an electrical load 62. Current coil 22 is connected in series with the power supply line, while voltage coil 38 is connected across the power supply line along with a suitable resistance 64 which may be the inherent resistance of coil 38 or, if desired, a separate resistor may be used. The connection is such that the current through current coil 22 is proportional to the line current and the current through coil 38 is proportional to the line voltage.

Referring again to FIG. 1, the tension of spring 58 is such that during normal operation the armatures 46 and 48 assume the position illustrated in FIG. 1 spaced from the ends of cores 36 and 40. The effect of spring 58 is simply to resist the attraction force of coil 38 exerted on armature 48. As can be seen, the two coils 22 and 38 work in opposition to each other with coil 22 tending to attract armature 46 and coil 38 tending to attract armature 48. An increase in current through current coil 22 increases the attraction of this coil for armature 48 while a reduction in voltage on the line reduces the force of attraction of voltage coil 38 for armature 48. When a predetermined combination of increase in current and reduction in voltage is reached, the armatures 46 and 48 pivot or rotate as a unitary structure about central pivot 56 in the direction of arrows 66 and 68 in FIG. 1 until armature 46 engages the polepiece or adjacent end of core 36. Rotation of the armatures trips the toggle linkage 30 in a well known manner, causing the toggle to collapse and contact 28 to move away from stationary contact 18 so as to break or open the circuit to the load 62 in FIG. 2. As can be seen, movement of the combined armatures 46 and 48 is a function of both voltage and current since the two armatures in effect form a single armature and are simultaneously acted upon by the magnetic flux from both the coils 22 and 38.

FIG. 3 shows a modified construction for a dual function circuit breaker or impedance protector constructed in accordance with the present invention and constitutes a preferred embodiment. Only the coils, armature and associated structure are illustrated in FIG. 3, it being understood that the remaining portions of the circuit breaker are similar to those illustrated in FIG. 1, i.e., of conventional construction such as that shown by way of example only in assignee's previously mentioned U.S. Pat. No. 3,412,351. In FIG. 3, a current coil 70 is mounted on a frame 72 and is illustrated as wound about a core formed from a brass delay tube 74 closed at one end 76 and receiving a plug 78 at its other end, preferably formed of soft iron and forming a polepiece for the core. Positioned within delay tube 74 is a slug of magnetic material, preferably cold rolled steel, as indicated at 80, which acts as a piston and has a step or shoulder 82 against which bears one end of a coil compression spring 84. The other end of compression spring 84 bears against polepiece 78 and the remaining space within delay tube 74 is preferably filled with a suitable fluid, such as oil.

Pivoted to frame 76 is an armature, a portion of which is illustrated at 86. A second frame 88 supports a voltage coil 90 wound around a solid magnetic core 92 having an end or polepiece 94 located on the opposite side of armature 86 from the current coil polepiece 78.

A leaf spring 96, similar to the extension spring 58 in FIG. 1, is used to bias armature 86 in FIG. 3 so as to oppose the attraction force of voltage coil 90. In the preferred embodiment, the armature 86 is positioned approximately parallel to the end of polepiece 94 but spaced from the polepiece by an air gap of approximately 0.030 inch. The end of the armature is preferably approximately 0.115 inch from a plane containing the adjacent surface of current coil endpiece 78 and the centerline of the armature preferably forms an angle with the face of endpiece 78 of approximately 10°. Voltage coil 94, by way of example only, may have 14,400 turns of No. 49 wire and when so constructed may be connected directly across a 120 volt line with no external resistance required.

As in the previous embodiment, the coil operates in opposition or in bucking relation on armature 96 with the coil 90 ending to attract the armature toward core 92 and current coil 70 tending to attract the armature toward endpiece 78. FIG. 3 represents a neutral or operating position and obtains when the line voltage is at rated voltage, i.e., approximately 120 volts, and the line current is less than 100 percent of rated current.

FIG. 4 is a view similar to FIG. 3 but shows the armature moved into engagement with the face of polepiece 78 which represents the tripped position for the circuit breaker. The condition illustrated in FIG. 4 obtains for a line voltage of 120 volts and a line current greater than approximately 125 percent of rated current. In this case, the overcurrent through coil 70 has caused the slug 80 to move through the delay tube 76 into engagement with endpiece 78. The increased magnetic field resulting from the increased current through coil 70 has overcome the field from voltage coil 70, attracted the magnet to the polepiece 78 and tripped the circuit breaker after the time delay introduced by slug 80.

FIG. 5 is a view similar to FIGS. 3 and 4, again showing the armature 86 in the tripped position bearing against endpiece 78. This condition obtains for a line voltage of 0 volts (less than 60 percent of rated voltage) and for a line current greater than 125 percent of rated current. In this case, the reduced current flow through coil 90 resulting from the reduced voltage has weakened the field of coil 90, permitting the field of current coil 70 to overpower it and attract the armature 76 into engagement with endpiece 78. In this case, slug 80 has not been drawn through the delay tube to compress spring 84 and the breaker has been tripped without time delay.

FIG. 6 is a plot of trip time in seconds as a function of percent of rated current. The trip time is plotted to a logrithmic scale as a function of percent of rated current and curve **100** is a plot of the circuit breaker tripping characteristics for a line voltage of 120 volts, whereas curve **102** shows a circuit breaker trip characteristic for a line voltage of 0 volts. As can be seen, tripping occurs in both instances when the line current reaches a minimum value of approximately 125 percent of rated current as indicated by the coextension of curve **100** and curve **102** in the area **104**. However, the 0 volt curve **102** falls off much more rapidly so that tripping time becomes quite short when line current reaches the neighborhood of 300 percent of rated current. With full line voltage, tripping time is still quite long at the 300 percent rated current value.

The operation of the dual function circuit breaker of FIG. 3 may be summarized by the following logic table:

TABLE

Condition	Line Voltage	Line Current	Circuit Breaker Operation
1	120 V (rated)	<100%	No trip
2	120 V	>125%	Time delay trip
3	<80%	<100%	No trip
4	<80%	>125%	Fast trip

As is apparent from the above, the present invention provides a novel dual function circuit breaker device in which trip time of the circuit breaker is a function of both line current and line voltage. Thus, a small increase in line current will not substantially decrease the tripping time of the circuit breaker. However, if the small increase in current is simultaneously accompanied by a significant decrease in line voltage, then the tripping time of the breaker is substantially reduced. Similarly, a small drop in voltage has little effect on the tripping time or tripping characteristics of the circuit breaker, but if the small drop in voltage is accompanied simultaneously by a substantial increase in line current, then the tripping time is again significantly reduced. The tripping time is an inverse function of the current, that is the tripping time is reduced as the current increases and is a direct function of the voltage since the tripping time is reduced with a drop or lowering in voltage. The circuit breaker is of simplified and inexpensive construction and requires a minimum of modification of a conventional circuit breaker in that it requires only the addition of a separate voltage coil adjacent the armature and acting in opposition to the conventional current coil. Further, by slight modification, i.e., by adjusting the bias spring tension, it is possible to convert the device to an undervoltage, overcurrent breaker where a drop in voltage alone or an increase in current alone is sufficient to cause the breaker to trip. It can be used as a single function breaker if a delay time longer than instantaneous but shorter than the shortest available is desired.

Important features of the invention include the fact that it comprises both a current coil with delay and a voltage coil with no or less delay, that these coils both act on a common armature, and that the resulting armature movement is a result of a combination of both increase in current and a reduction in voltage. The circuit breaker finds particular utility in so-called "soft" power systems, such as those involving fuel cells and engine generators, where the current delay permits motor startup and other short overcurrents without tripping but where very high fault currents to provide fast opening are not available from the power supply. Thus, the present invention makes possible rapid circuit breaker opening in fault environments of this type.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A circuit breaker comprising a movable armature for tripping the breaker, a current coil positioned adjacent said armature to exert a first attracting force on said armature urging said armature in the circuit breaker tripping direction, a voltage coil positioned adjacent said armature to exert a second attracting force on said armature urging said armature away from said circuit breaker tripping direction, means acting on said armature to bias it away from said tripping direction, and delay means coupled to said current coil, said current and voltage coils coacting on said armature to substantially reduce the trip time of said breaker for overcurrents accompanied by undervoltages.

2. A circuit breaker according to claim **1** wherein said delay means comprises a delay tube, said current coil being wound around said delay tube.

3. A circuit breaker according to claim **1** wherein said armature is mounted for pivotal movement.

4. A circuit breaker according to claim **3** wherein said coils exert a force in the same direction on opposite ends of said armature.

5. A circuit breaker according to claim **3** wherein said coils exert a force in opposite directions on the same end of said armature.

6. A circuit breaker comprising a pivotally mounted armature for tripping the breaker, a current coil having a first time delay positioned adjacent said armature to exert a first attracting force on said armature urging said armature in the circuit breaker tripping direction, a voltage coil having a second shorter time delay positioned adjacent said armature to exert a second attracting force on said armature urging said armature away from said circuit breaker tripping direction, and means acting on said armature to bias it away from said tripping direction, said current and voltage coils coacting on said armature to substantially reduce the trip time of said breaker for overcurrents accompanied by undervoltages.

7. A circuit breaker according to claim **6** wherein said coils are positioned on opposite sides of said armature.

8. A circuit breaker according to claim **6** including a delay tube, said current coil being wound around said delay tube.

9. A circuit breaker according to claim **8** including a solid core, said voltage coil being wound around said solid core.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,688,227 Dated August 29, 1972

Inventor(s) Kyonghi Hong

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Assignment by the inventor Kyonghi Hong in favor of Airpax Electronics Inc.,

Signed and sealed this 22nd day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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