Dec. 27, 1966 L. PERAS 3,295,023

CIRCUIT-BREAKER DEVICES, ESPECIALLY FOR SEMI-CONDUCTOR CIRCUITS

Filed Dec. 17, 1962 3 Sheets-Sheet 1

Fig. 1

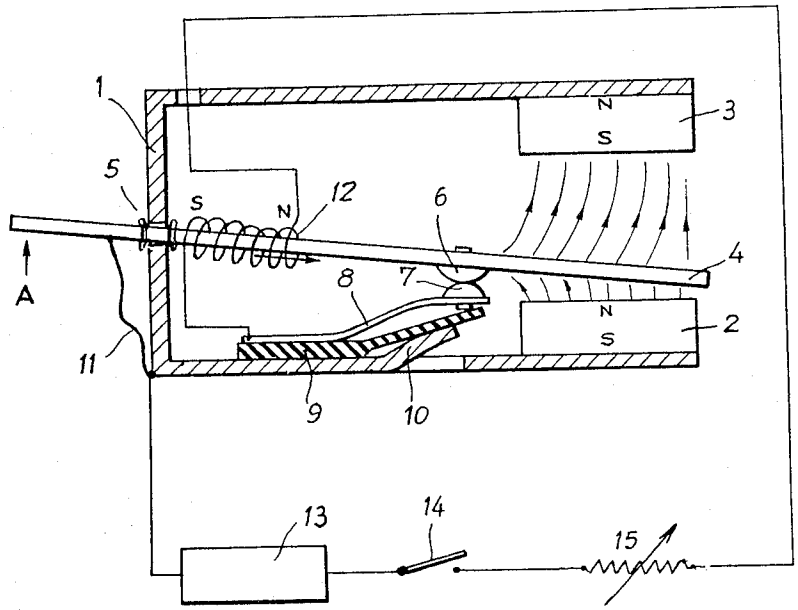
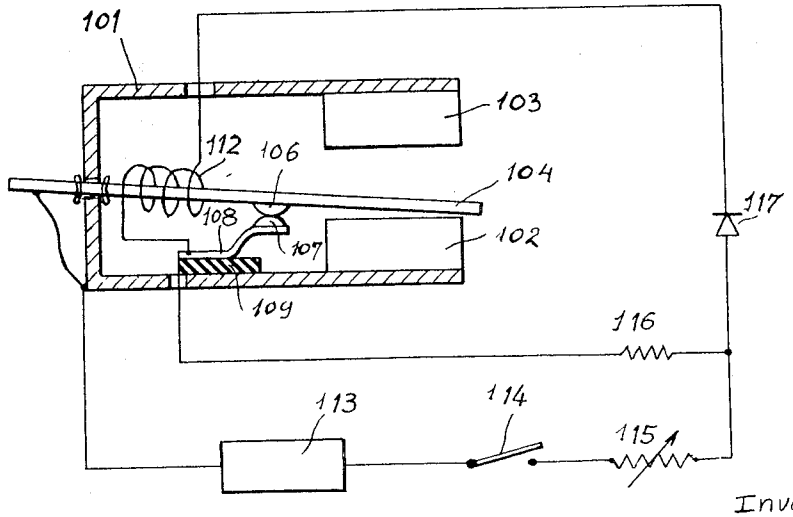


Fig. 2



Inventor
Lucien Peras
By Stevens, Davis, Miller & Mosher
Attorneys

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Fig. 3

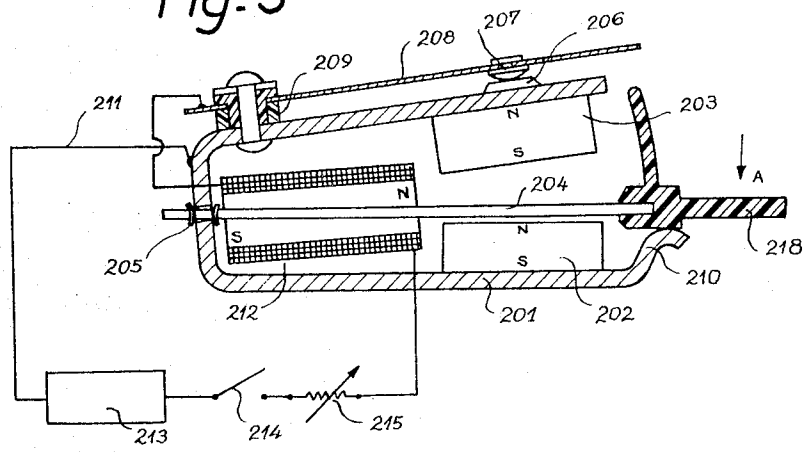
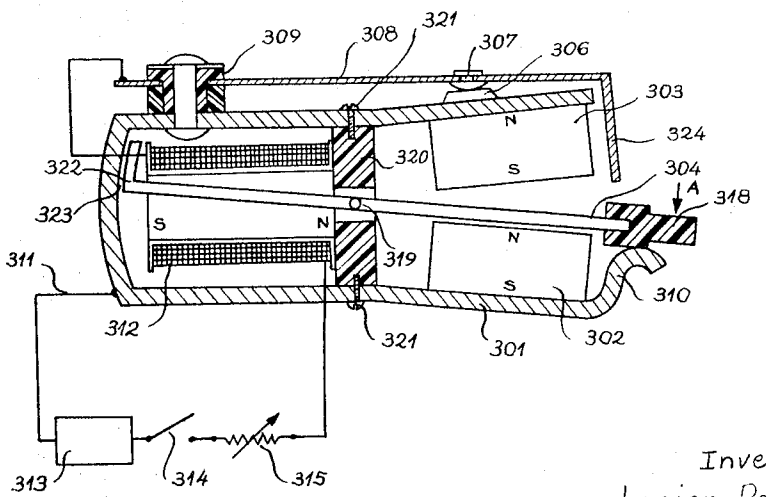


Fig. 4



Inventor
Lucien Peras
By Stevens, Davis, Miller & Mosher
Attorneys

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CIRCUIT-BREAKER DEVICES, ESPECIALLY FOR SEMI-CONDUCTOR CIRCUITS

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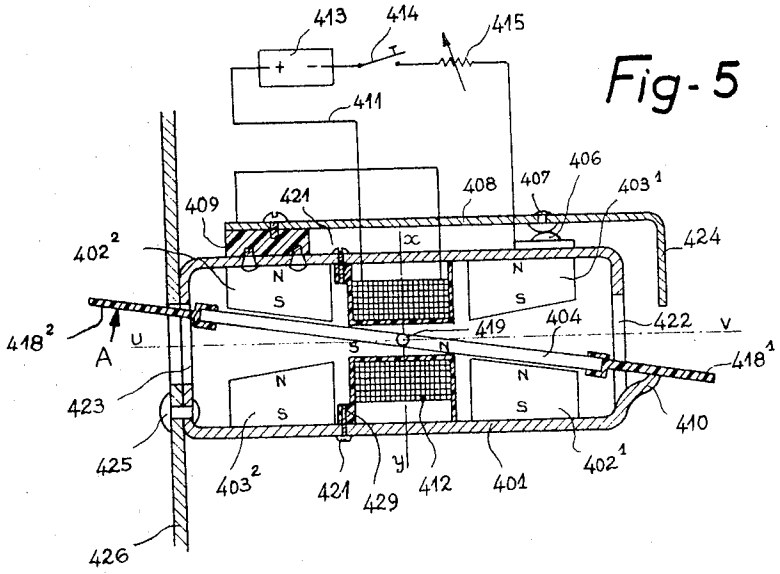


Fig-5

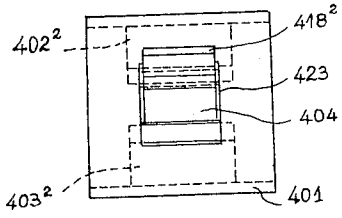


Fig-6

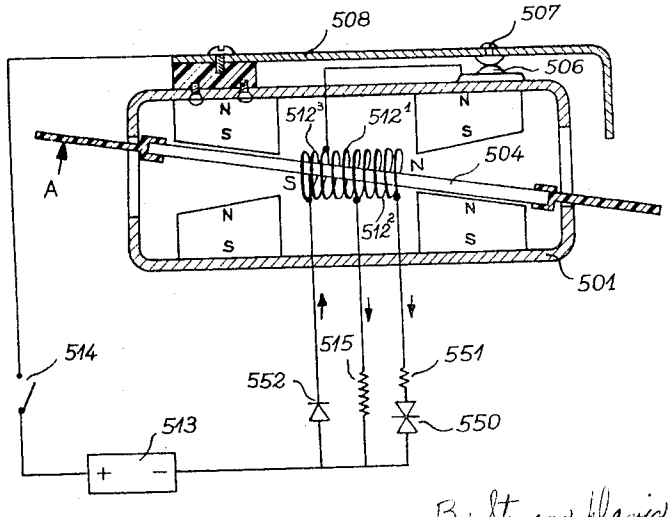


Fig-7

Inventor
Lucien Peras
By Stevens, Davis, Miller & Mosher
Attorneys

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CIRCUIT-BREAKER DEVICES, ESPECIALLY FOR SEMI-CONDUCTOR CIRCUITS

Lucien Peras, Billancourt, France, assignor to Regie Nationale des Usines Renault, Billancourt, France

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Claims priority, application France, Dec. 19, 1961, 882,497, Patent No. 1,322,838; Nov. 15, 1962, 915,553, Patent No. 82,590

15 Claims. (Cl. 317—54)

The present invention has for its object a simplified form of magnetic circuit-breaker with rapid action and resetting, mainly intended for circuits utilizing semi-conductors. The device is intended to be as economical as possible by the simplification of its form and of the design of the magnetic circuit, which comprises essentially a soft iron blade excited by a solenoid and arranged to pivot between permanent magnets.

Polarized relays which could carry out the same functions have been known for a long time, but they employ a different magnetic circuit. The precautions taken in these relays to separate the control functions by winding and magnetic return are such that on the one hand these relays are very expensive and on the other their contact pressures are very small.

In order to avoid these drawbacks, a circuit-breaker switch according to the invention is characterized by a magnetic frame constituted by a strip having at least two opposite faces, provided internally with stabilized magnets having a large attractive field, between which pivots a blade of soft iron, the opposite faces of the magnets being opposite poles and the distance between these faces being such that the blade has only two stable positions of equilibrium, against the magnets. A coil, constituted by at least one separate winding, surrounds the blade and for the purpose of the protection to be ensured, provides ampere-turns of such direction that they tend to detach the blade from the magnets against which it is applied. One or a number of electric contacts are actuated by the blade in at least one of its positions of equilibrium. The device is set by mechanical action on a portion of the blade which passes outside the apparatus.

The set of moving electric contacts of the circuit-breaker may be carried by the blade. In this case, the pressure applied between these contacts is a function of the current passing through the solenoid, and it becomes smaller as the value of this current becomes closer to the point of break or separation. This possible drawback can be remedied by placing the electric contact on the side of the magnet which holds the device in the open-circuit position, so that the pressure in the normal position (that is to say with the contacts closed) is effected solely by a spring.

In accordance with a first form of embodiment of the invention, the strip forming the magnetic frame has the shape of a U, and there are two magnets, fixed to the inner extremities of the arms of the U, the pivotal axis of the blade being close to the base of the U.

As an alternative to the preceding form, the blade can pivot about its center of gravity on an axis located substantially in the center of the U.

According to a further form of embodiment of the invention, the magnetic frame is a closed strip having a rectangular profile and the magnets are four in number, symmetrical in form and in position with respect to the central planes of the sides of the rectangular profile, the blade pivoting about the intersection of the two central planes referred to above.

The excitation coil of the blade may be carried by the latter or alternatively may be fixed to the frame. It may be constituted by a single winding when it is only necessary to protect one semi-conductor circuit against short-circuits which may take place in the utilization apparatus. It may however comprise a number of windings or parts of windings when it is desired to extend the protection, that is to say the circuit-breaker action, to the cases of over-voltage and connection of the source of direct-current the wrong way around. In addition, the release current may be made dependent on the supply voltage.

To this end, auxiliary windings are provided on the coil and are connected in series with devices sensitive to the voltage and to the direction of the current, these windings being wound in such a direction that they act in the sense of or in opposition to the interruption of the circuit, depending on the effect desired. When so required, one winding may be coupled directly to the current source through the break contact in order to make the point of interruption dependent on the voltage of the source.

However, in order that the invention may be more clearly understood, its various forms and alternatives referred to above will now be described, by way of example and without any limitative sense, reference being made to the accompanying drawings, in which are shown, in diagrammatic section:

In FIGURE 1, a circuit-breaking switch is illustrated according to the invention with a U-shaped magnetic frame carrying two magnets and with moving electric contacts carried by the blade;

FIGURE 2 shows an alternative form of the previous embodiment;

FIGURE 3 shows a circuit-breaker, also with a U-shaped frame, but in which the moving contacts are carried by the U;

FIGURE 4 shows an alternative form of the preceding embodiment, with a balanced blade;

FIGURE 5 shows a circuit-breaker with a closed, symmetrical, magnetic frame, carrying four magnets and with a balanced blade, while FIGURE 6 is an end-view of this form;

FIGURE 7 shows an alternative form of the preceding, with a coil made in several parts for the purpose of multiple protection.

In the circuit-breaker shown in FIGURE 1, a magnetic frame **1** in the shape of a U carries magnets **2** and **3** fixed on its extremities and facing towards the interior, the magnets having a large attractive field and being generally of barium ferrite. These magnets are arranged in such manner that their magnetizing fields are perpendicular to the large sides of the U, of which they constitute a kind of closure, the oppositely-facing poles being of opposite sign.

A moving blade **4** of soft iron, pivoted at **5** on the magnetic circuit at the base of the U, gives the assembly the shape of a capital E. This blade is subjected to the action of a magnetic field created in the air-gap. It carries a contact **6** which faces another contact **7** carried by a flexible blade **8** which is electrically insulated from the U by a deformable insulating plate **9**.

The flexibility of the blade **8** tends to accompany the blade **9** when the latter passes from the magnet **2** to the magnet **3**, this association being however limited to about half the travel.

The side of the U which carries the magnet **2** and the contact **7** is cut-out in such manner that a tongue **10**, obtained by deformation of the frame by a tool, serves as a support for the contact **7** through the intermediary of the insulating plate **9** when the blade **4** approaches the magnet **2**.

A flexible electric connection **11** connects the blade **4** to one of the terminals of the source of direct or pulsating current **13**, the other terminal of which is connected through a contact key **14** and the utilizing apparatus **15**

to one of the extremities of a coil **12** wound round the blade **4**, the other extremity of the winding being connected to the flexible blade **8**. The direction of the winding of the coil **12** is chosen in such manner as to produce, on the side facing the magnets, a pole of the same sign as the magnet **2**.

The operation is as follows:

If it is assumed that the voltage delivered by the source **13** is small or zero, a thrust applied to the blade **4** at the point A and in the direction of the arrow, causes the attraction and the holding of the blade by the magnet **2**. The device being thus set and the electrical connection established, the apparatus **15** can be energized. If the current increases beyond a certain critical value, the blade **4** will be abruptly repelled by the magnet **2** and attracted by the magnet **3**, against which it comes into abutment.

The apparatus **15** is no longer energized. The elasticity of the contact **7**, carried by the blade **8**, prevents a premature interruption of the current before the blade **4** has crossed the central zone between the magnets **2** and **3**. Without this arrangement, there would be a risk of oscillation at currents in the vicinity of the tripping current. After opening the key **14**, the apparatus can be again re-set by a mechanical action on the blade, for example at the point A.

FIGURE 2 relates to the use of the apparatus on alternating current.

In this figure, **113** is a source of alternating current, **116** is a resistance of low value and **117** is a rectifying device with a voltage threshold such as a silicon diode junction. The current return passing through the apparatus **115** is effected on the one hand through the resistance **116** and on the other through the rectifier element **117** and the coil **112**.

The operation is as follows:

After setting the device as in the case of FIGURE 1, an excessive value of the current in the apparatus **15** causes a voltage drop in the resistance **116** sufficient to bring the rectifier element **117** out of its direct conduction bend. There is then a current circulating in the winding **112** and, if this is sufficient, the blade **104** is displaced and the circuit is interrupted.

This arrangement has the advantage of creating a threshold in the appearance of current in the coil, thus avoiding reduction of the pressure of contact between **106** and **107**, provided that the current is not too close to the nominal release or tripping value.

The action of the apparatus is sufficiently rapid for the half-wave rectification system to be found satisfactory in most cases, as shown in FIGURE 2.

In the form of embodiment given in FIGURE 3, there is again found the magnetic frame **201** in the form of a U, its magnets **202** and **203** and the blade **204** pivoted at **205** on the circuit **201**. In this case, however, the blade **204** carries at its free extremity a non-magnetic and insulating piece **218** which rests in its normal position against a stop **210**, obtained by deformation of the frame **201** by a tool and located on the side of the magnet **202**. The other arm of the U carries a flexible conducting blade **208**, fixed by an insulator **209** towards the base of the U. This blade carries a contact **207** by which (when the blade **204** is close to the magnet **202**) it rests elastically against a contact **206** rigidly fixed to the U.

The solenoid **212** is traversed by the current of the utilization apparatus **215** supplied by the source of direct-current **213** through the contacts **206** and **207** of the circuit-breaker switch, the connection **211** and the key **214**. The magnetization induced in the blade **204** by the solenoid **212** produces, at the movable extremity of the said blade, a pole of the same sign as that of the magnet **202**.

The operation of this apparatus is as follows:

In setting the circuit-breaker switch by actuating the blade **204** in the direction of the arrow A, the insulating piece **218** comes against the stop **210** and the blade **204** comes close to the magnet **202**. The contact is made between **206** and **207** and current flows in the apparatus **215** if the key **214** is closed. If the current in the solenoid reaches a sufficient value, the blade **204** is repelled by the magnet **202** and attracted by the magnet **203**, against which it comes into abutment, and the piece **218** comes into contact with the extremity of the blade **208** which bends and separates the contact **207** from the contact **206**. The current ceases to flow in the apparatus **215**.

The contact pressure between **206** and **207** in the normal position only depends on the elasticity of the blade **208**. The strength of the blade **208** will be chosen so that it can be pushed back under all conditions of temperature by the force of attraction applied by the magnet **203** on the blade **204**. Since there is no fine adjustment to be provided, the magnet **203** can work without an air-gap when the blade **204** comes in contact with it. By way of example, a circuit-breaker switch having a magnetic frame of 40 mm. in length and 20 mm. in width can readily produce, with cheap magnets, contact pressures of the order of 150 grams, it being possible to increase this value very considerably in this same dimension with magnets of higher quality.

This circuit-breaker switch is in general slightly less rapid than that described with reference to FIGURE 1 or FIGURE 2, but it will be preferred for large currents.

In this form of embodiment, as in that preceding, the working air-gap, regulated by the stop **210**, may be small, which results in a truly irreversible operation, the displacement force which is applied on the blade **204** by the effect of the solenoid **212** increasing very rapidly as the air-gap increases, contrary to other devices in which one of the air-gaps diminishes while the other increases.

In addition, there is no longer any current return through the blade **204**, which makes it possible, if required, by isolating the contact **206**, to avoid having any point of the U or of the blade connected to the electric circuit.

In a further alternative form of embodiment, more particularly intended to mobile applications and shown in FIGURE 4, the moving blade **304** can rotate about an axis **319** perpendicular to the plane of the drawing, so that the weights located on each side of the axis are substantially balanced.

This pivot **319** rotates in a housing forming part of a non-magnetic part **320** held on the U by fixing means **321** and supporting the coil, these fixing means **321** being of small section compared with the U. From the base side of the U, the blade **304** is bent at **322** in order to increase the surface facing the base of the U and to reduce the air reluctance **323** of the magnetic circuit without producing substantial friction.

The flexible blade **308** is bent at **324** in order to eliminate the nipple previously provided on the part **318** and thus to reduce the inertia of the moving member.

The operation remains identical with that of the device described with reference to FIGURE 3, except for the presence of the small permanent air-gap **323** of constant reluctance. If necessary, the device may be made symmetrical by providing a blade **308** on each side of the U.

The mechanical setting may be replaced by an electrical setting obtained by means of a small auxiliary solenoid placed at the same point as the break solenoid and disconnected after setting.

The adjustment of sensitivity may also be made by acting on the air-gap **323**.

A further form of embodiment shown in FIGURE 5 is somewhat less economical than those preceding, but makes it possible to obtain readily a balancing of the moving parts while taking advantage of a magnetic circuit which is symmetrical and very rigid in its external portion. In addition, the accessibility of the setting lever and fixing on a wall are facilitated.

To this end, the magnetic frame **401** is a closed strip

having a substantially rectangular profile, thus giving the apparatus the external shape of a parallelepiped rectangle. The two small sides of this frame are provided respectively with two openings 422 and 423, though which pass the extremities 418^1 and 418^2 of a magnetic blade 404 pivoting on a pin 419 close to the center of symmetry of the strip. The extremities 418^1 and 418^2 are preferably of non-magnetic and insulating material.

Four magnets 402^1, 403^1, 402^2, 403^2 are arranged inside the strip 401 in order to be symmetrical in position, in shape and in magnetic polarity with respect to the central plane *xy* of the large sides of the rectangle formed by the magnetic frame in FIGURE 5.

With respect of the center line *uv* of the small sides, this symmetry is limited to the position and to the shape of the magnets, the magnetic polarities of the magnets being opposite.

The magnetization of the magnets is substantially perpendicular to the planes of the large sides of the frame. When the blade 404 is in the end position shown in FIGURE 5, the magnetomotive force of the magnet 402^1 is added to that of the magnet 402_2 located on the opposite large side, and their common flux is closed through the blade 404 and the frame 401.

In the same way, in the other end position of the blade 404, the magnetomotive forces of the magnets 403^1 and 403^2 are additive. These two positions are therefore stable. The normal position of the blade is that shown in FIGURE 5, the extremity 418^1 resting against a stop 410 produced by deforming the strip 401 with a tool.

In this position, an elastic blade 408 fixed on an insulating support 409 brings its contact 407 against a fixed contact 406 carried by the strip 401, these contacts 407 and 406 closing the electric circuit, which is composed of a direct current source 413, a contact key 414, the apparatus 415, the consumption of which is to be verified, and a coil 412 connected to the current source by the return connection 411. The support 429 of the coil 412 is held on the strip 401 by fixing means 421. For convenience of operation of the lever 418^2, this strip may be fixed by fastenings 425 to a wall 426 provided with a window corresponding to the opening 423 and permitting the passage of the setting lever 418^2.

After setting the lever 418^2 (in the direction of the arrow A) and closing the key 414, when the consumption of the apparatus 415 approaches the value of the regulation, the magnetization induced in the blade 404 produces poles at the extremities of this latter which are respectively identical to those of the magnets 402^1 and 402^2, but opposite to those of the magnets 403^1 and 403^2, and there comes a moment when the blade pivots and comes up against the magnets 403^1 and 403^2 by pushing back the extension 424 of the elastic blade 408, separating the contacts 406 and 407 and interrupting the current in the apparatus 415 until the device has been reset.

The magnets will preferably have a shape such that their surfaces are parallel to the blade 404 in its extreme positions. The same result can obviously be obtained with magnets having parallel faces and special profile of the blade 404.

According to another form of the invention illustrated in FIGURE 7, the field winding of the blade comprises three elements 312^1, 312^2, 312^3, connected in series and making it possible to obtain multiple protections, taking account of the external circuit employed.

In FIGURE 7, there is again seen the frame 501 having a rectangular profile identical with that previously described and also carrying four magnets between which pivots the blade 504 of soft iron. After setting the blade in the direction of the arrow, the contacts 506 and 507 are applied against each other by the action of the spring blade 508 connected electrically through the key 514 to the positive pole of the current source 513, the negative pole of which is connected through the utilization apparatus 515 to the current coil 512^1 of the circuit-breaker switch, the other extremity of the said coil being connected to the contact 506.

In series with the coil 512^1 is connected a coil 512^2, the free extremity of which is connected to the negative pole of the battery through a resistance 551 and a Zener diode 550 which is either double (symmetrical) or single but connected in series with an ordinary diode which eliminates direct conduction.

Between the contact 506 and the negative pole of the battery there is also connected in series the winding 512^3 and the diode 552 connected in the non-conducting sense. The winding 512^3 will only receive current if the source 513 is connected the reverse way round, or again, with the normal connection, upon the break of the contacts 506–507 or 514 if the utilization apparatus 515 has a large inductance (the diode 552 then serving in recuperation). The direction of this winding 512^3 is such that it tends to cause the circuit to be broken when the current passing through it is in the direction of the arrow shown along the conductor which connects it to the diode 552.

The interruption of the circuit is thus obtained in the following cases:

(1) The current in the utilization apparatus, passing through the winding 512^1 exceeds the pre-determined value;

(2) The voltage of the Zener diode 550 is exceeded, the action being possibly made progressive by the effect of the resistance 551;

(3) The polarity of connection of the source 513 has not been observed.

The elimination of one or the other of the diodes 550 or 552 would render the circuit-breaker switch sensitive to the supply voltage either above or below.

The protection of the contacts by recuperation by the diode 552 would also be ensured by the Zener diode 550 in the event of elimination of the said diode 552 and the winding 512^3.

The key 514 may be an electronic apparatus supplying the apparatus 515.

I claim:

1. A circuit-breaker device having rapid action and resetting comprising a fixed magnetic frame constituted of a strip in a general U shape having two arms, at least one permanent magnet fixedly mounted on the inside of each of said arms, a blade movably supported between said magnets, the opposite faces of said magnets being opposite poles and the distance between such magnets being such that the blade has only two stable positions of equilibrium against either of said magnets, a coil constituted by at least one separate winding surrounding said blade, an electrical switch in series with said coil, said switch having at least two contacts at least one of which is flexibly supported on said fixed magnetic frame and at least one of which is actuated by said blade, the switch being opened when said blade is in one of said positions and shut when said blade is in the other of said positions, a circuit, to be broken comprising at least a source of current and a load apparatus in series with said coil and said switch, the device being set by mechanical actuation on a portion of said blade which extends out of said device.

2. A circuit-breaker device in accordance with claim 1 in which said switch has its movable contact carried by the blade itself, the pressure between the contacts being elastic and adjustable in such manner that the current in the coil is only interrupted about the middle of the travel of the blade.

3. A circuit-breaker device in accordance with claim 1 in which one of said contacts of said switch is arranged on the arm of the U-shaped frame opposite to that against which the blade is at rest when said contacts are closed, the other contact being supported by means of an auxiliary flexible blade so that, when the current in the coil exceeds the predetermined regulated value, the displacement of the

blade acts in opposition to said auxiliary blade and opens the contacts.

4. A circuit-breaker device in accordance with claim 3 in which the blade is pivotally supported about an axis in the vicinity of its center of gravity by a non-magnetic piece, said non-magnetic piece also supporting the coil and insuring the rigidity of the U-shaped frame.

5. A circuit-breaker device with rapid action and resetting comprising a fixed magnetic frame of a C shape, at least two permanent magnets having a large attractive field therebetween mounted on opposing arms of said frame, a movable blade of soft iron pivotally mounted between said magnets, the opposite faces of said magnets being opposite poles and the distance between the said magnets being such that the blade has only two stable positions of equilibrium, a coil constituted by at least one winding surrounding the blade and producing ampere turns of such direction that they tend to move the blade away from the magnet against which it is applied, at least one electric switch actuated by said blade in at least one of its positions of equilibrium, the switch being set by mechanical action of a portion of said blade, at least one contact of said switch being actuated by said blade, at least one contact being resiliently mounted on said frame, the pressure between the contacts being adjusted in such manner that the current in the coil is only interrupted about the middle of the travel of said blade.

6. A circuit-breaker device in accordance with claim 5, in which said switch is arranged on the side of the U opposite to that against which the moving blade is at rest, with the contacts closed, the pressure necessary for the contacts being obtained by means of a spring, so that when the current in the coil exceeds the pre-determined regulated value, the displacement of the blade acts in opposition to the spring and opens the contacts.

7. A circuit-breaker device in accordance with claim 5, in which the magnetic frame is of U-shape and carries two magnets, the coil winding being in one single section, and the blade rotates about an axis in the vicinity of its center of gravity, a small reluctance in the magnetic return at the base of the U being effected by a widening of the facing surfaces between the blade and the U, especially by bending, without producing substantial friction between the said surfaces.

8. A circuit-breaker device in accordance with claim 7, in which a non-magnetic piece in which pivots the pin of the blade, also supports the coil and ensures the rigidity of the U.

9. A circuit-breaker device in accordance with claim 5, in which the outer magnetic circuit is a closed strip having a substantially rectangular profile and carrying on the internal faces of the large sides, four magnets which are geometrically symmetrical with respect to the two central lines of the rectangle, but the polarities of which are symmetrical only with respect to the central dividing line of the large size, the magnetic blade pivoting about an axis passing through its center of gravity and fixed on the axis of symmetry of the external magnetic circuit, the said blade having two stable positions of equilibrium in the absence of ampere-turns generated by the coil, on each side of the central dividing line of the small sides of the rectangle, while in each of its positions the blade is in proximity to two magnet faces of opposite polarity, the flux return being completed by the external circuit.

10. A circuit-breaker device in accordance with claim 9, in which the magnets have a shape such that their opposite faces are parallel to the blade in its end positions.

11. A circuit-breaker device in accordance with claim 9, in which the two extremities of the blade are fixed to insulating members provided for re-setting and which extend beyond the external magnetic circuit respectively through two windows formed in the small sides of the said circuit and the purpose of which is at the same time to permit the setting of the device and to push back, at the end of its travel, a flexible rod carrying the set of moving contacts of the said circuit-breaker switch.

12. A circuit-breaker device in accordance with claim 5, in which the winding is in a single section and in which the magnets are made of barium ferrite or the like having a temperature coefficient such that the tripping current varies with the temperature and follows substantially the variations of consumption with temperature of the utilization apparatus.

13. A circuit-breaker device in accordance with claim 5, in which the coil winding is in a plurality of sections and comprises a main winding traversed by the current of the utilization apparatus to be protected, and at least one auxiliary winding.

14. A circuit-breaker device in accordance with claim 13 in which the main winding in the auxiliary portion of the winding form portions of the same coil.

15. A circuit-breaker device with rapid action and resetting for use in circuits utilizing semiconductors, said semiconductor circuits comprising a source, a circuit switch, and a load in series with said circuit breaker, said circuit breaker comprising a fixed magnetic frame having at least two opposing arms, at least one permanent magnet mounted on each opposing arm of said frame, with a large attractive field therebetween, a movable blade of soft iron pivotally mounted between said magnets, the opposite faces of said magnets being opposite poles and the distance between said magnets being such that the blade has only two stable positions of equilibrium, a coil constituted by at least one winding surrounding the blade and producing ampere turns of such direction that they tend to move the blade away from the magnet against which it is at rest, an electric switch means mechanically actuatable by said blade in at least one of its positions of equilibrium, at least one contact of said switch being actuated by said blade, and the other contact being mounted on said frame, the pressure between said contacts being adjusted in such manner that the current in the coil is only interrupted about the middle of travel of said blade.

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MILTON O. HIRSHFIELD, *Primary Examiner.*

SAMUEL BERNSTEIN, *Examiner.*

L. T. HIX, *Assistant Examiner.*