May 25, 1954

H. THOMPSON

2,679,561

CIRCUIT BREAKING DEVICE

Filed June 17, 1952

2 Sheets-Sheet 1

Fig: 1

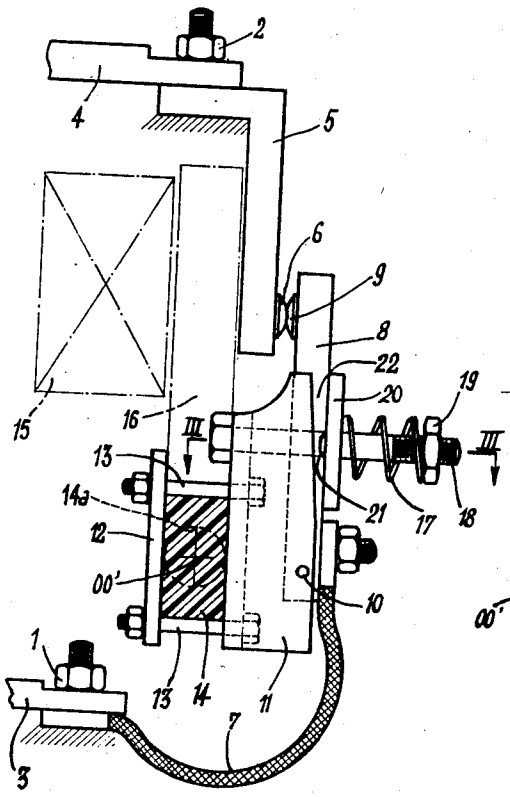


Fig: 2

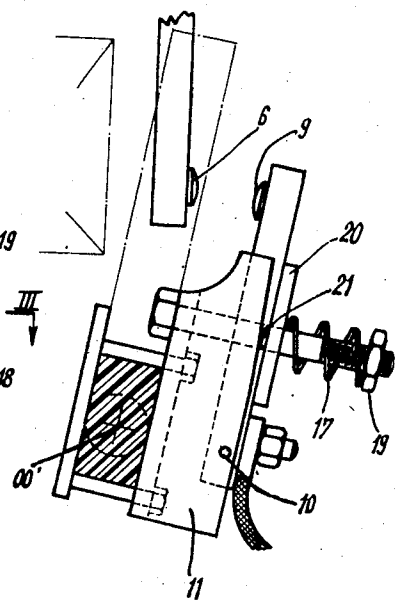
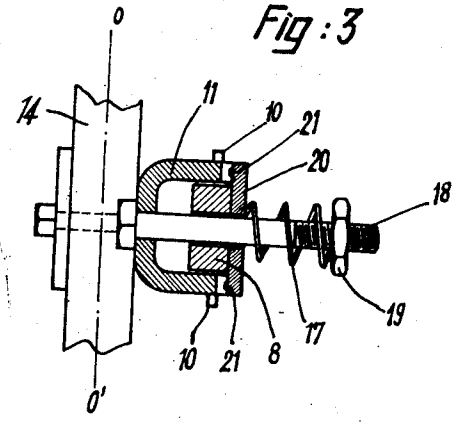


Fig: 3



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2 Sheets-Sheet 2

Fig: 4

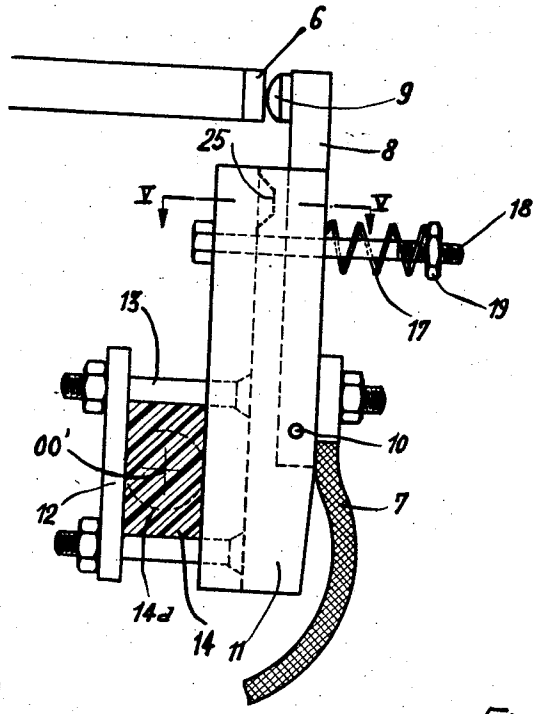
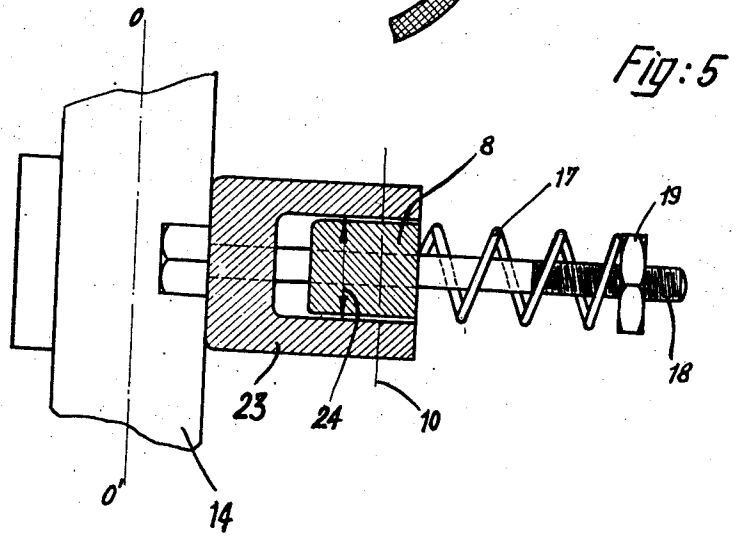


Fig: 5



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UNITED STATES PATENT OFFICE

2,679,561

CIRCUIT BREAKING DEVICE

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Claims priority, application France September 19, 1951

4 Claims. (Cl. 200—87)

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In circuit-breaking devices having solid contacts, each of the movable contacts is pressed against the corresponding fixed contact, generally by a spring force. Now, principally by reason of the necessity for extinguishing the arc which is set up between the contacts at the instant when they are opened, the direction in which the movable contact is opened is towards the outside of the loop formed by the conductors leading to the contacts, so that the consequent electromagnetic forces set up by the current in these conductors tend to separate the contacts. These forces, which are proportional to the square of the current, assume such a value in the event of a short-circuit that it tends to annul the contact pressure, so that all the conditions favourable to the fusing of the contact studs are present in such an event.

The currents which the device is capable of interrupting thus have an upper limit which may be lower than the possible values of the short-circuit currents met with in practice which results in serious difficulties.

In order to overcome these difficulties, the present invention has for an object to provide a device for compensating for the electromagnetic repulsion force acting on the movable contacts of circuit breakers.

According to the invention, a member through which the current flows and on which a movable contact is mounted is subjected, in the direction of a co-operating fixed contact, to the magnetic action of an electromagnet in which the magnetomotive force is set up by the actual current which flows through the said contacts.

In one embodiment of the invention, the member on which the movable contact is mounted is secured to a magnetic armature adapted to be attracted by the electromagnet in the direction of the fixed contact.

Thus, as long as the magnetic material of the electromagnet and of the armature has not reached saturation, the said attraction, which tends to bring the contacts together, follows the same law as the repulsion force which tends to separate these contacts, whereby the said repulsion force is compensated for.

The electromagnet and its armature preferably form a magnetic circuit in which, by reason of the considerable currents concerned, the magnetomotive force is produced by current passing through one of the conductors leading to the contacts and forming part of the loop formed by the electric circuit.

The simplest constructions are obtained by

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using, as the conductor producing the magnetomotive force, the member on which the movable contact is mounted. If the induction is insufficient, this conductor could obviously be made to form one or more turns around one of the branches of the magnetic circuit.

In order to set up forces of electromagnetic origin on the member on which the movable contact is mounted, it is not essential to provide this movable member with an armature, because the current which passes through it imparts magnetic. properties thereto. The electromagnet may therefore act directly on the said conductor.

To this end, according to a further feature of the invention, the member on which the movable contact is mounted passes at least once through an air gap in a magnetic element by which it is partially surrounded and which constitutes the core of the electromagnet, and the said member is movable in relation to the said element in the said air gap in a direction parallel to the surfaces defining the air gap, the said element being so positioned that the relative movement of the member on which the movable contact is mounted takes place in the direction in which the contacts move towards one another and in which the magnetic flux generated in the said element by the current flowing through the said member increases.

Calculations and experience show, in this case also, that the current flowing through the member on which the movable contact is mounted sets up on this member an attractive force proportional to the square of the current, which tends to urge the contacts one against the other.

This phenomenon is readily explained by the fact that a current flowing through an electric circuit develops, on each of the elements of the said circuit, forces which tend to displace or deform this element in the direction of an increase of the inductance of the circuit. It will also be noted that it is by reason of this general phenomenon that the repulsion between the contacts is set up which it is proposed to counteract by means of the present invention.

In the compensating device according to the invention, the direction of the forces which are set up on the member on which the movable contact is mounted corresponds to an increase in the self-induction of this section of the conductor by an increase in the magnetic flux which surrounds it.

Briefly, owing to the local concentration, produced by means of a suitably disposed electro-

magnet, of a part of the magnetic flux developed by the current in the circuit which is formed by the contactor, the effects of the remainder of this magnetic flux on the member supporting the movable contact are counteracted.

In a preferred embodiment of the invention, the member on which the movable contact is mounted is pivoted to the movable part of the contactor and the core of the electromagnet is also mounted on this part.

Thus, the attractive force created by the electromagnet not only does not oppose the opening of the contacts, but promotes it. In fact, when the contacts touch one another, the member supporting the movable contact is held fast and the attractive force therefore tends to drive the movable part of the contactor in the opposite direction, that is to say, in the direction of the opening of the contactor. Under these conditions, both with a view to increasing the contact pressure and in order to promote this phenomenon, it may be desirable to so dimension the device according to the invention as to overcompensate for the electromagnetic repelling forces acting on the contacts, which are inherent in the design of contactors.

In the accompanying drawing, there is shown by way of non-limitative example, two embodiments of the invention. In the drawing:

Figure 1 shows in side view, partly in diagrammatic form, a unipolar contactor according to the invention, the contactor being in the closed position.

Figure 2 is a partial view similar to that of Figure 1 showing the contactor in the open position.

Figure 3 is a section taken along the line III—III of Figure 1.

Figure 4 is a side view similar to that of Figure 1, showing a modified form of construction, and

Figure 5 is a section taken along the line V—V of Figure 4 and drawn to an enlarged scale.

The contactor shown in Figures 1, 2 and 3 comprises two fixed terminals 1 and 2, to which lead in and lead out conductors 3 and 4 are connected. The terminal 2 is secured to a rigid right-angled member 5 which carries a fixed contact stud 6, while the terminal 1 is connected by a flexible conductor 7 to an arm 8 on which a movable contact stud 9 is mounted. The arm 8 is pivoted on a pin 10 in a U-shaped element 11 of magnetic metal which, by means of a plate 12 and bolts 13, is fixedly secured to an insulating shaft 14 of the contactor. The said shaft, which is of rectangular section, comprises cylindrical portions 14a which are journalled in bearings not shown. The shaft is adapted to be rotated by an electromagnet, diagrammatically illustrated at 15, which acts on an armature 16 secured to the said shaft.

The arm 8 is acted upon by a spring 17 surrounding a bolt 18 extending both through the U-shaped element and the said arm, a nut 19 on the said bolt permitting adjustment of the force excited by the spring 17. The thrust of the spring is transmitted to the arm 8 by a plate 20 of magnetic material, the edges of which tie opposite the arms of the U-shaped element 11. Stops 21 prevent any possible contact between the edges of the plate and those of the U-shaped element.

It will be understood that a multipolar contactor may be constructed in a similar manner, each of the poles of the contactor being arranged in the manner hereinbefore described.

The contactor hereinbefore described operates in the following manner:

Starting from the open position illustrated in Figure 2, when the electromagnet 15 is energised, the movable equipment, that is to say, all the parts mounted on the shaft 14, pivots about the axis O—O' in a direction which moves the movable stud 9 towards the fixed stud 6. After the studs 6 and 9 have come into contact one with the other, the remainder of the travel of the movable equipment produces compression of the spring 17, thereby exerting pressure on the two contacts. The contactor is held operated by the magnet 15 and current passes from the conductor 3 to the conductor 4.

By reason of the fact that the various parts through which this current flows are arranged in loop form, the arm 8 in particular is subjected to an electromagnetic force which tends to move it away from the fixed contact 6. For intense values of current as in the case of a short-circuit, this force may become equal to that of the spring 17, whereby the contact pressure would be nullified and fusing of the contacts would be promoted. However, the current flowing through the arm 8 produces in the magnetic circuit formed by the U-shaped element 11 and the plate 20 a magnetomotive force which acts on the plate 20 across the air gaps 22 to attract the plate towards the element 11 and thus compensate for the said repulsion force between the contacts.

This attractive force, which tends, by reaction, to drive the element 11 in a clockwise direction as viewed in Figure 1, also combines with an external force, acting on the movable equipment in such manner as to cause opening of the contacts. The movement of this equipment, in the case of tripping due to excess current, is therefore accelerated, which accelerated movement assists in preventing fusing of the contacts.

In the constructional example illustrated, the said external force is provided by a return member (not shown) of the movable equipment, which acts in opposition to the attraction of the electromagnet 15, the energisation of which is interrupted at the instant of the short-circuit. The contact opening force may also be supplied by other mechanical means or electromagnetically as in the case of circuit breakers for example.

The stops 21 limit the compression stroke of the spring 17 against the U-shaped element and also increase the reluctance of the magnetic circuit consisting of the U-shaped element 11 and the plate 20, so that although the current may be sufficient to exert a strong pull at the instant when the contacts are closed, the elements 11 and 20 do not stick, which might interfere with the operation of the device.

The modified construction illustrated in Figures 4 and 5 is similar in its broad form to the construction illustrated in Figures 1, 2 and 3, and the corresponding members bear the same reference numerals. However, the arm 8 has no plate 20.

In this case, the air gap is formed by the distance separating the internal faces of a U-shaped element 23. When the current flows through the arm 8, the magnetic field set up by this current is, as in the previously described construction, concentrated in the U-shaped element and the lines of force of this field extend across an air gap 24 from one inner face to the other of the U-shaped element, perpendicularly to these faces.

It will be seen that, regardless of the direction of the current in the arm 8, this arm is subjected, by reason of this field, to a force which tends to move it inwards, towards the web of the U-shaped element, that is to say in a direction which tends to apply the contacts 6 and 9 one against the other.

It should be noted that the movement of the arm 8 in the direction of this force tends to increase the surface of the air-gap subjected to the magnetic field, that is to say, to reduce the reluctance of the magnetic circuit, and therefore to increase the flux circulating around the arm 8, which brings about a corresponding increase of the inductance of the conductor path constituted by the arm 8.

In the constructional example illustrated, the outer face of the arm 8 lies flush with the edges of the U-shaped element when the contactor is in the operative position. However, the arm may also project from the U-shaped element.

In order to increase the forces exerted on the arm 8, it is desirable to reduce the size of the air gap 24, which necessitates the use of movable arms the cross-section of which is elongated in the direction of movement of the movable contact towards the fixed contact.

While the width of the air gaps 22 of Figures 1, 2 and 3 is variable and comparatively small, the air gap 24 (Figure 5) remains constant and is fairly large. The reluctance of the magnetic circuit in the second construction described may therefore be greater than in the first.

Consequently, with equal current strength in the arm 8, saturation of the magnetic circuit may be less rapidly reached, so that it is possible to compensate for the repulsion between the contacts due to the higher currents. Conversely, this compensating force, which is always proportional to the square of the current, is lower in the second than in the first construction. The latter disadvantage may be obviated by increasing the leverage of this force, that is to say, by disposing the U-shaped element 11 at as great a distance as possible from the pivot of the arm 8 without interfering with the disposition of the contacts.

The construction illustrated in Figure 4 affords a further advantage. A stop 25 is provided on the element 11 so that when the contacts become worn, the travel of the movable contact under compression is limited by the stop 25. This does not however substantially modify the action of the compensating force, while the limit of travel by means of the stop 21, in the case of the construction of Figures 1 to 3, affects the air gap 22 and therefore the desired compensation.

It will be noted that in the constructions illustrated, the core of the compensating electromagnet constitutes the mechanical support for the movable arm 8.

The construction of the device is thus considerably simplified, but it will be understood that the core of the electromagnet could be a

member independent of the support of the movable arm. Similarly, in the case of Figure 1, the armature secured to the arm could have the sole function of co-operating with this core.

It will be likewise understood that modifications may be made in the constructions hereinbefore described, as for example by substitution of equivalent technical means, without departing from the scope of the present invention.

What I claim is:

1. A circuit-breaker comprising a fixed contact element; a pivotally mounted structure movable towards and away from said fixed contact element, including a U-shaped magnetic core having legs extending away from said fixed contact element; a movable contact arm pivotally connected to said structure and extending at least partly between the legs of said core; a contact element located on said arm beyond said core with respect to the pivotal connection between said structure and said arm, adapted to make contact with said fixed contact element; and resilient means interposed between said structure and said arm for urging said arm towards said fixed contact element.

2. A circuit-breaker as claimed in claim 1, wherein said movable contact arm carries a magnetic armature cooperating with the ends of the legs of the magnetic core.

3. A circuit-breaker as claimed in claim 1, wherein said resilient means comprises a coil-spring, one end of which engages said movable contact arm while the other end engages an adjustable stop carried by said structure.

4. A circuit-breaker comprising a fixed contact element; an insulating pivotally mounted structure movable with respect to said fixed element into a contact-making and a contact-breaking position, respectively towards and away from said fixed element; a magnetic U-shaped member secured to said insulating structure and having flanges extending perpendicularly to the pivoting axis thereof and away from said fixed element; an axle across said flanges; a movable contact arm pivotally mounted on said axle between said flanges and having a part extending beyond the end of said U-shaped member; a contact element located on said extending part of said arm, adapted to make contact with said fixed element; a bolt secured to said U-shaped member and extending across both the bottom of said U-shaped member and said contact arm; a coil-spring on said bolt, contacting the surface of said movable arm remote from said fixed element; and a nut screwed on said bolt for adjusting the stress of said coil-spring.

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