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(54) **An automatic circuit breaker with a thermal protection unit**

Selbstschalter mit einem Thermoschutzbauteil

Disjoncteur automatique avec une unité de protection thermique

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Description

The present invention relates to automatic circuit breakers with a thermal protection unit, according to the preamble of claim 1, as for example known from DE-A-3514390.

Automatic circuit breakers, for example, of the modular type used for protecting electrical installations comprise complex contact-opening and -closing mechanisms.

The contacts are closed by a manual arming device which can also open them upon manual operation and the contacts have to open automatically as a result of excess currents passing through the circuit breaker, in order to protect the electrical installations against overloads and short-circuits.

For this purpose, protection of two types is generally provided:

- overload protection,
- short-circuit protection.

Overload protection is ensured by a bimetal element through which the load current passes and which is heated, owing to the Joule effect, by the current flowing through it and bends until it acts on a release device and thus causes the contacts to open.

Unlike the short-circuit protection for which only speed of operation is essential, the overload or thermal protection requires precision and repeatability of operation and has to ensure that, for a predetermined overload condition corresponding, for example, to a current of 20 amperes lasting for a predetermined period, for example, of 30 seconds, the contacts will open.

The thermal protection for an automatic circuit breaker therefore requires a calibration operation which has to be carried out on each individual circuit breaker and which then has to ensure repeatability of operation and prevent possible loss of calibration.

The bimetal element which constitutes the overload sensor generally forms a rigid member cantilevered on a relatively flexible support the free end of which acts on the release device.

A calibration screw accessible from outside the circuit breaker acts on the flexible support at the joint where the member is fixed and enables the angle of the joint to be changed so as to pivot the member on the joint and bring about a travel of the free end of the member.

Since current has to pass through the member and, at the same time, the member must not be stressed mechanically but must be free to deform thermally, its ends have to be connected electrically to the electrical circuit by flexible elements such as copper braids.

Alternatively, the flexible support of the member, which is made of conductive material, may form an electrical connection with other parts of the circuit to which it is fixed mechanically by crimping, riveting or welding which also ensure electrical continuity.

However correctly they are carried out, these operations always give rise to local increases in resistivity which may vary over time in dependence on the load, adversely affecting the repeatability of operation of the thermal protection.

Moreover they involve a relatively complex construction and assembly with fairly long and expensive production processes.

A further disadvantage is constituted by the bulk represented by these connection elements which, although flexible, must not interfere with the thermal deformations of the bimetal member.

The present invention solves this problem and provides an automatic circuit breaker with a thermal protection unit constituted by a small number of elements and fixed directly by electric welding to a terminal of the circuit breaker having an integral appendage which acts as a fixed support for the bimetal member and which can be calibrated.

The number of operations necessary to ensure electrical continuity between physically discontinuous elements and the number of possible causes of localised resistance are thus reduced to a minimum.

The number of components to be assembled is also reduced to a minimum, the production process is simplified and size is reduced with clear advantages in terms of cost and compactness.

An arc-switching or arc-guide electrode is also advantageously fixed to the connection terminal by the same electric welding operation as the bimetal member.

The characteristics and advantages of the invention will become clearer from the following description of a preferred embodiment given with reference to the appended drawings, in which:

Figure 1 is an overall, sectioned view of an automatic circuit breaker incorporating a thermal protection unit according to the present invention,

Figure 2 is an exploded, perspective view of a preferred embodiment of the thermal protection unit according to the present invention,

Figure 3 shows a preferred embodiment of a flat blank for producing a terminal block of the unit of Figure 2,

Figure 4 is a static diagram of the structure formed by the thermal protection unit according to the invention when it is housed in a circuit-breaker casing,

Figure 5 is a static diagram of the improved structure formed by the thermal protection unit of Figure 2.

With reference to Figure 1, an automatic circuit-breaker incorporating a thermal protection unit according to the invention comprises a generally rectangular parallelepipedal casing 50 constituted by two coupled half-shells one of which is shown in section in the coupling plane in order to place greater emphasis on the internally ribbed structure of the half-shells.

The frames and internal ribs of the two half-shells interpenetrate in a suitable manner and precisely position the two half shells and the various components housed in the casing relative to one another.

The two half-shells are fixed together by means of screws or rivets extending through holes 51, 52, 53, 54, 55 perpendicular to the plane of the drawing.

The circuit breaker shown is a modular circuit breaker for installation on a rail with several modules arranged side by side along the faces of the casings parallel to the coupling plane of the half-shells or side faces.

The circuit breaker has a recess 56 in its rear wall for housing a standard DIN rail on which the circuit breaker is engaged by means of toothed engagement slides not shown.

A plurality of mechanical and electrical components is housed and precisely positioned in the casing; in particular, these are:

- first and second terminals 57, 58, respectively, for electrical connection to ends of external leads,
- a bimetal plate 10 with one end connected electrically and mechanically to an appendage 9 of the terminal 57 which operates as a cantilevered support for the plate 10,
- an arc-extinguishing cell 60,
- a manual arming lever 61 articulated on a pin 62 in a fixed position in the casing and connected to an arming rod 2,
- a fixed contact 3 supported by a rigid metal appendage 69 of the electromagnet 59 electrically connected to a terminal of the electromagnet winding, the other terminal being connected to the terminal 58,
- a movable contact 4 on the end of a contact arm 5 of conductive material electrically connected by a flexible copper braid 6 to the bimetal plate near the opposite end of the plate to that which is anchored to the support,
- a release device including the contact arm 5 and other elements collectively indicated 6 and having a pivot pin 7 engaged in a fixed position on the casing;

since the release device falls outside the scope of the present invention and its structure is not essential for an understanding of the invention, a detailed description thereof is not supplied and it is indicated simply that it may constitute, in known manner, a unitary subassembly which can easily be installed in the casing by the engagement of the ends of the pin 7 in suitable seats in the two half-shells;

- a slide 8 for unidirectional mechanical coupling between the bimetal plate 10 and the release device,
- a switching and arc-guide electrode 11,
- a thermal protection calibration screw 12.

The overall view gives an idea of the structural complexity of the circuit breaker, of the assembly difficulties, of the compactness requirements and of the small size which the various components have to have in order to be housed in a casing of limited dimensions.

The operation of a circuit breaker of this type is known:
when the release device is armed manually, the two contacts 3 and 4 are closed and electrical continuity between the terminals 57 and 58 is ensured.

In the event of a short-circuit, the energized electromagnet 59 throws a striker against the release device activating it and causing the contacts to open.

In the event of overloading, owing to the Joule effect, the current passing through the contact breaker and flowing in the bimetal plate causes heating thereof, which is not compensated for by the heat dissipation of the circuit breaker, and a consequent bending which moves the free end of the bimetal plate away from a rest position.

The free end of the plate 10 then interferes with a tooth of the slide 8 bringing about translation thereof and a second tooth of the slide 8 interferes with a tooth of the release device causing activation thereof and consequent opening of the contacts.

The electric arc which develops between the contacts 3 and 4 upon opening travels from the contact 4 to the arc-guide electrode 11 which conveys it towards the arc-extinguishing cell 60.

Due to the travelling of the arc, the arc-guide electrode has to be connected electrically to the movable contact 4.

As shown clearly in Figure 1, the number of connections which require welding or crimping of parts in order to ensure electrical continuity is reduced to a minimum by the provision, on the terminal 57, of an integral appendage 9 which acts as a cantilevered support for the bimetal plate to which one end of the plate is fixed by electric welding.

The braid 6 is fixed, again by electric welding, near the free end of the bimetal plate and is connected to the movable contact arm 5 by a third electrical weld.

The number of electrical connections and of physically separate components is thus reduced.

The arc-guide electrode 11 is advantageously also connected mechanically and electrically to the plate by the same electric welding operation which connects the bimetal plate 10 mechanically and electrically to the appendage 9 of the terminal 57, further reducing the number of welding operations.

Figure 2 is an exploded perspective view of a preferred embodiment of the thermal protection unit formed according to the present invention.

Starting with a flat and elongate blank 19 shown in Figure 3, produced by blanking/punching of tinned copper strip or plate, a terminal block 20 is produced by successive bending operations and is constituted by two perpendicular pairs of faces 21, 22, 23, 24 the faces of each pair being parallel with one another.

A face 22 formed by the end of the blank constitutes one jaw of the terminal.

A face 21 parallel to the face 22 has a hole 25 through which a clamping screw 26 of the terminal can pass freely.

The face 22 is connected to the face 21 by a front block face 23 of the block and by the rear face 24 on which the face 22 is engaged by a tooth 27.

Lateral undercuts are formed near the bent portions of the blank with the dual effect of facilitating the bending operation and forming, on the sides of the front and rear faces, anchoring teeth 28, 29, 30, 31 which, by engaging in suitable slots in the casing, position the block correctly and firmly in the casing.

The rear face 24 is extended, via a first connecting elbow 32 with a hole for the insertion and engagement of the tooth 27, by an appendage 33 terminating, via a second connecting elbow 34, in a welding plate 35 with a welding surface parallel to the face 24 but advantageously spaced from the plane of the face 24.

The appendage 33 also advantageously has opposed anchoring teeth 48, 49 which engage in suitable seats in the casing for the reasons which will be explained below.

The appendage 33, which has to operate as a cantilevered support for the bimetal plate which is subjected to bending stress by a calibration screw, advantageously has a hole 36 which reduces its cross-section and its moment of inertia upon bending and at the same time limits its thermal conductivity and the heat dissipation from the bimetal plate towards the support.

The hole 36 may be replaced or combined for the same purpose with a reduction in thickness of the appendage formed by the removal of material or by pressing.

The terminal block thus formed is associated with a movable jaw 37 also produced from an elongate, flat blank by successive bending operations which form a rectangular ring linked with the block 20.

The upper face 38 of the ring formed by the superimposition of the two ends of the blank has a threaded hole 39 into which the screw 26 is screwed.

By pushing with its end against the lower face 22 of the block 20, the screw pulls the upper face 38 of the ring towards the upper face 21 of the block forcing the lower face 40 of the ring alongside the lower face of the block 22 and clamping any interposed lead ends.

A resilient tongue 24A is advantageously formed by blanking in the face 24 of the block and interferes with the edge of the upper face 38 of the clamping ring, keeping it in the maximum closure position by friction. This facilitates the use of the terminal as a two-connection terminal, that is, as a terminal which can receive both an electrical terminal between the face 22 of the block and the face 40 of the clamping ring and a flat fork terminal inserted between the head of the screw 26 and the upper face 21 of the block.

For this purpose (Figure 1), the casing of the circuit breaker has a hole 70 for admitting the fork terminal.

The end 41 of a straight bimetal plate or member 42 is then fixed to the plate 35 by electric spot welding.

The end 43 of the switching electrode 44, which is also produced by suitable bending from a flat blank, is fixed by the same welding operation on the opposite face of the plate to that which contacts the plate 35.

The thickness, and hence the stiffness, of the switching electrode 44 is advantageously less than the stiffness of the appendage 33.

The end 46 of a flexible conductive braid 47 is welded electrically near the free end 45 of the bimetal member, its other end being welded electrically to the contact arm 5 which can be assembled in the release device in known manner to form a unitary subassembly which can easily be installed in the casing.

The terminal, the bimetal member and the switching electrode thus form an extremely simple and functional thermal protection unit which can be installed in the casing together with the tripping device by only two easy steps of engagement in suitable seats.

The function of the teeth 48, 49 of the appendage 33 will now be explained.

For reasons of the overall construction and arrangement of the components which cannot be changed, the appendage 33 has to have a predetermined length since it has to extend from the terminal block to interfere with the calibration screw 12 (Figure 1).

Owing to the inevitable presence of play and in the absence of teeth such as 48, 49, the teeth 29, 30 of the block, which are engaged in the casing, act more as supports for a cantilevered member formed by the face 24 and by the appendage 33 than as a fixed joint for the appendage 33.

Figure 4 shows in a static diagram the structure thus obtained.

The length of the cantilevered appendage 33 is indicated C, the length of the teeth 29, 30, which virtually corresponds to the distance of the bearing constraints formed in the casing, is indicated l and the length l + C is indicated L.

If a force F is applied to the end of the cantilevered appendage by the calibration screw, the member bends and the cantilevered end moves with a deflection f undergoing a pivoting movement α from the rest position.

As a result of this pivoting, the free end of a straight rigid element of length L1 such as the bimetal plate with its other end fixed to the end of the cantilevered appendage moves with a deflection $f1 = \alpha.L1 - f$ from the rest position.

Since the ratio α/f is inversely proportional to C if other conditions remain the same ($\alpha/f = K/C$ where K is a suitable coefficient):

$$f1 = L1 \cdot K \cdot f/C - f = (K \cdot L1/C - 1) \cdot f$$

Clearly, therefore, the smaller C is, the larger the deflection f1 (or change in deflection $\Delta f1$) is for a given deflection f (or change of deflection Δf).

On the other hand for $C = K \cdot L1$ the deflection f1 would be zero for any value of f.

As shown in the static diagram of Figure 5, the teeth 48, 49 form a bearing constraint much closer to the point of application of the force exerted by the calibration screw, reducing the cantilevered length C.

A suitable amplification of the deflection f1 relative to the deflection f imposed is thus achieved.

The amplification is limited exclusively by the maximum resilient stresses withstood by the cantilevered appendage and by the economic advantage of using a standard threaded calibration screw rather than a more expensive fine-pitch micrometric screw which might be required in order to reconcile too large an amplification factor with adequate calibration sensitivity.

As a further advantage, the teeth 48, 49 form a bearing constraint which practically eliminates the undesired pivoting effects induced on the support arm by the mechanical stresses exerted on the terminal by the ends clamped therein.

Claims

1. An automatic circuit breaker with a thermal protection unit in which a clamping terminal (20) with a movable jaw (37) establishes mechanical anchorage and electrical connection with external lead ends and a bimetal plate (42) acting on a release device (6, 8) is electrically connected to the terminal (20, 37) and to a movable contact (5) of the circuit breaker, and through which a current passing through the circuit breaker flows, said clamping terminal (20) having a conducting support (33) integral with the terminal (20), one end (41) of the bimetal plate (42) being welded electrically to said support, said terminal (20) comprising a plurality of teeth (28, 29, 30, 31) for locating the terminal (20) in a circuit-breaker casing (50) by the insertion of the teeth in corresponding seats of the casing,

   characterised in that it comprises,

   a cantilevered conducting appendage (33) integral with the terminal (20), forming said support and terminating at its free end, via an elbow (34), in a welding plate (35), one end of the bimetal plate (42) being welded electrically to said welding plate (35),

   said appendage comprising a pair of teeth (48, 49) for insertion in corresponding seats in the casing, the pair of teeth forming a support of the appendage (33) which defines the length of the cantilevered extension of the appendage, said cantilevered extension of said appendage, up to said welding plate having a lower moment of inertia upon bending, than that of the remaining portion of the appendage.

2. An automatic circuit breaker according to claim 1 comprising an arc-switching electrode (44) welded to said end (35) of the bimetal plate (42) on an opposite face of the bimetal plate to the weld between the bimetal plate and the conducting appendage (33) said arch-switching electrode having a stiffness lesser than the stiffness of said appendage.

3. An automatic circuit breaker according to the preceding claims, comprising a calibration screw (12) acting on the free end plate (35) of the cantilevered support (33) in order to pivot the free end resiliently.

Patentansprüche

1. Ein automatischer Schaltungsunterbrecher mit einer thermischen Schutzeinheit, bei der ein Klemmanschluß (20) mit einer bewegbaren Klemmbacke (37) eine mechanische Verankerung und eine elektrische Verbindung mit externen Anschlußleitungsenden herstellt, und bei der eine Bimetallplatte (42), die auf eine Lösevorrichtung (6, 8) wirkt, mit dem Anschluß (20, 37) und einem bewegbaren Kontakt (5) des Schaltungsunterbrechers elektrisch verbunden ist, und durch die ein Strom fließt, der durch den Schaltungsunterbrecher läuft, wobei der Klemmanschluß (20) einen leitenden Träger (33) aufweist, der einstückig mit dem Anschluß (20) angeordnet ist, wobei ein Ende (41) der Bimetallplatte (42) an den Träger elektrisch angeschweißt ist, wobei der Anschluß (20) eine Mehrzahl von Zähnen (28, 29, 30, 31) zum Positionieren des Anschlusses (20) in einem Schaltungsunterbrechergehäuse (50) durch Einfügen der Zähne in entsprechende Sitze des Gehäuses aufweist,

   dadurch gekennzeichnet, daß derselbe folgende Merkmale aufweist:

   einen einseitig-eingespannten leitenden Ausleger (33), der einstückig mit dem Anschluß (20) angeordnet ist und den Träger bildet und an seinem freien Ende über einen Winkel (34) in einer Schweißplatte (35) endet, wobei ein Ende der Bimetallplatte (42) elektrisch mit der Schweißplatte (35) verschweißt ist,

wobei der Ausleger ein Zähnepaar (48, 49) zum Einfügen in entsprechende Sitze in dem Gehäuse aufweist, wobei das Zähnepaar einen Träger des Auslegers (33) bildet, der die Länge des einseitig-eingespannten Fortsatzes des Auslegers definiert, wobei der einseitig-eingespannte Fortsatz des Auslegers bis zu der Schweißplatte beim Biegen ein kleineres Trägheitsmoment als der verbleibende Abschnitt der Auslegers aufweist.

2. Ein automatischer Schaltungsunterbrecher gemäß Anspruch 1, mit einer Lichtbogenumschaltelektrode (44), die mit dem Ende (35) der Bimetallplatte (42) auf einer zu der Schweißnaht zwischen der Bimetallplatte und dem leitenden Ausleger (33) gegenüberliegenden Seitenfläche der Bimetallplatte verschweißt ist, wobei die Lichtbogenumschaltelektrode eine geringere Steifigkeit als der Ausleger aufweist.

3. Ein automatischer Schaltungsunterbrecher gemäß den vorhergehenden Ansprüchen, mit einer Kalibrierungsschraube (12), die auf die freie Endplatte (35) des einseitig-eingespannten Trägers (33) wirkt, um das freie Ende elastisch zu schwenken.

Revendications

1. Disjoncteur automatique comportant une unité de protection thermique, dans lequel une borne à serrage (20) ayant un mors mobile (37) établit un ancrage mécanique et une connexion électrique avec des extrémités de conducteurs extérieurs et une plaque bimétallique (42) agissant sur un dispositif (6, 8) de déclenchement est connectée électriquement à la borne (20, 37) et à un contact mobile (5) du disjoncteur, et à travers laquelle un courant passant dans le disjoncteur circule, ladite borne (20) à serrage ayant un support conducteur (33) réalisé d'une seule pièce avec la borne (20), une extrémité (41) de la plaque bimétallique (42) étant soudée électriquement audit support, ladite borne (20) comportant plusieurs dents (28, 29, 30, 31) destinées à positionner la borne (20) dans un boîtier (50) du disjoncteur par l'introduction des dents dans des sièges correspondants du boîtier,

caractérisé en ce qu'il comporte

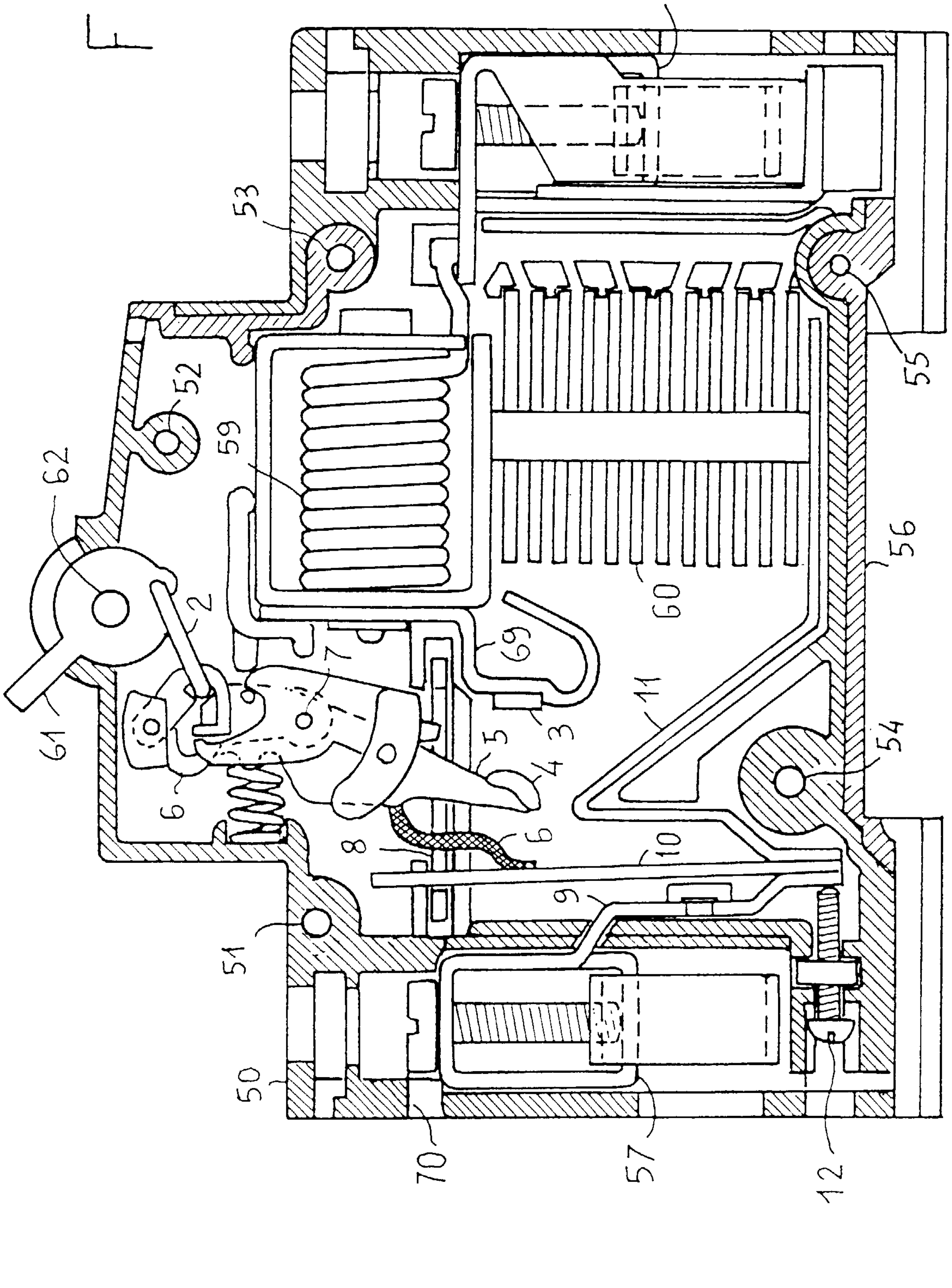
un appendice conducteur (33) en porte à faux réalisé d'une seule pièce avec la borne (20), formant ledit support et se terminant, à son extrémité libre, par l'intermédiaire d'un coude (34), par une plaque à souder (35), une extrémité de la plaque bimétallique (42) étant soudée électriquement à ladite plaque à souder (35),

ledit appendice comportant une paire de dents (48, 49) destinées à pénétrer dans des sièges correspondants dans le boîtier, la paire de dents formant un support de l'appendice (33) qui définit la longueur de l'extension en porte à faux de l'appendice, ladite extension en porte à faux dudit appendice, jusqu'à ladite plaque à souder, ayant un moment d'inertie inférieur, lors d'une flexion, à celui de la partie restante de l'appendice.

2. Disjoncteur automatique selon la revendication 1, comportant une électrode (44) de commutation d'arc soudée à ladite extrémité (35) de la plaque bimétallique (42) sur une face opposée de la plaque bimétallique à la soudure entre la plaque bimétallique et l'appendice conducteur (33), ladite électrode de commutation d'arc ayant une raideur inférieure à la raideur dudit appendice.

3. Disjoncteur automatique selon les revendications précédentes, comportant une vis (12) d'étalonnage agissant sur la plaque extrême libre (35) du support (33) en porte à faux pour faire pivoter élastiquement l'extrémité libre.

FIG. 1



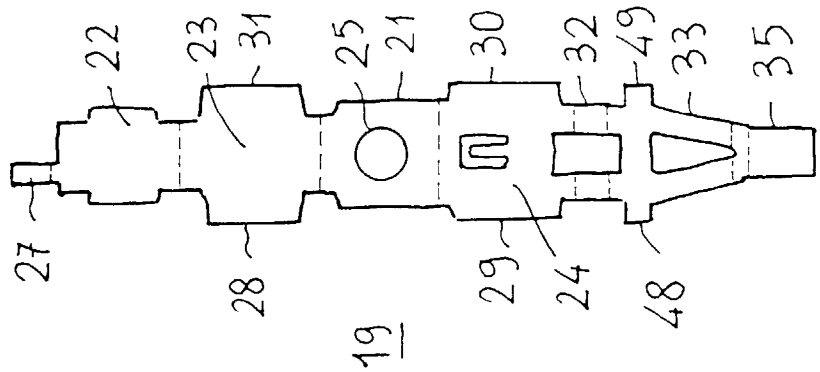

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FIG. 3

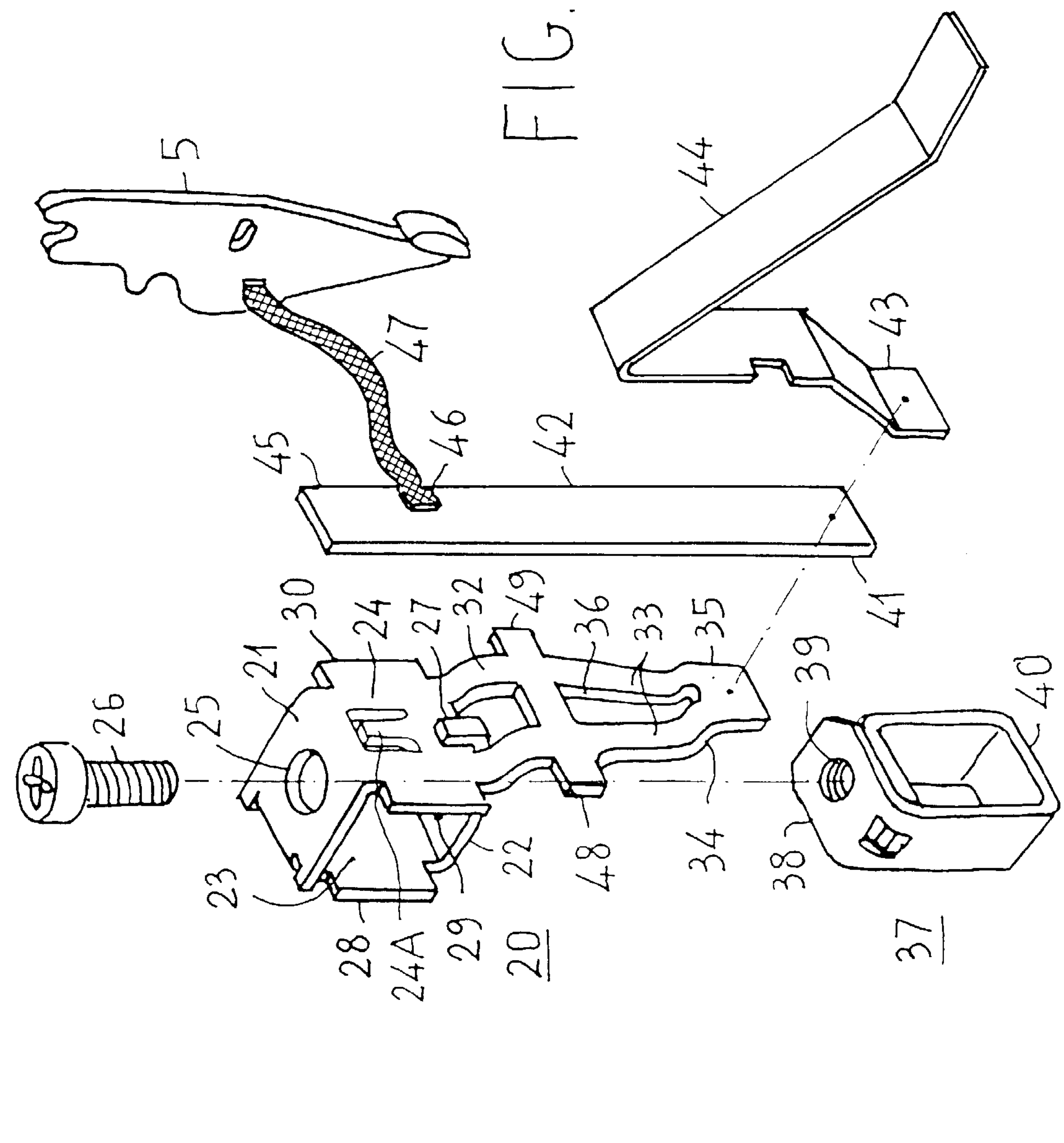
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FIG. 2

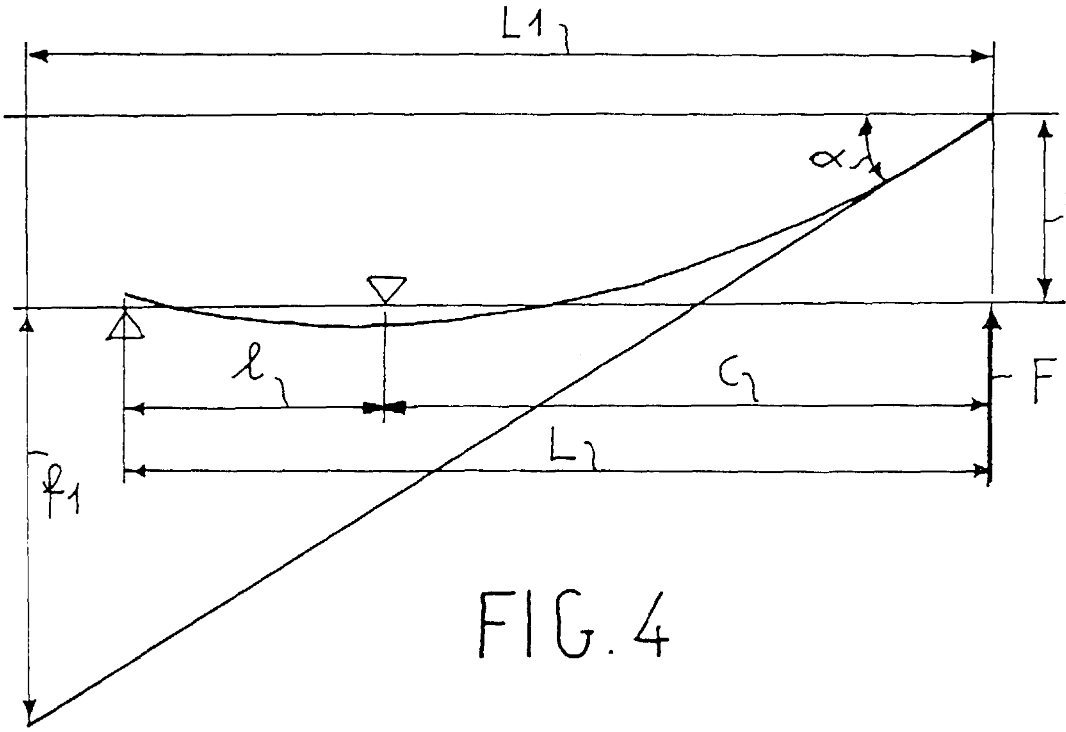

FIG. 4

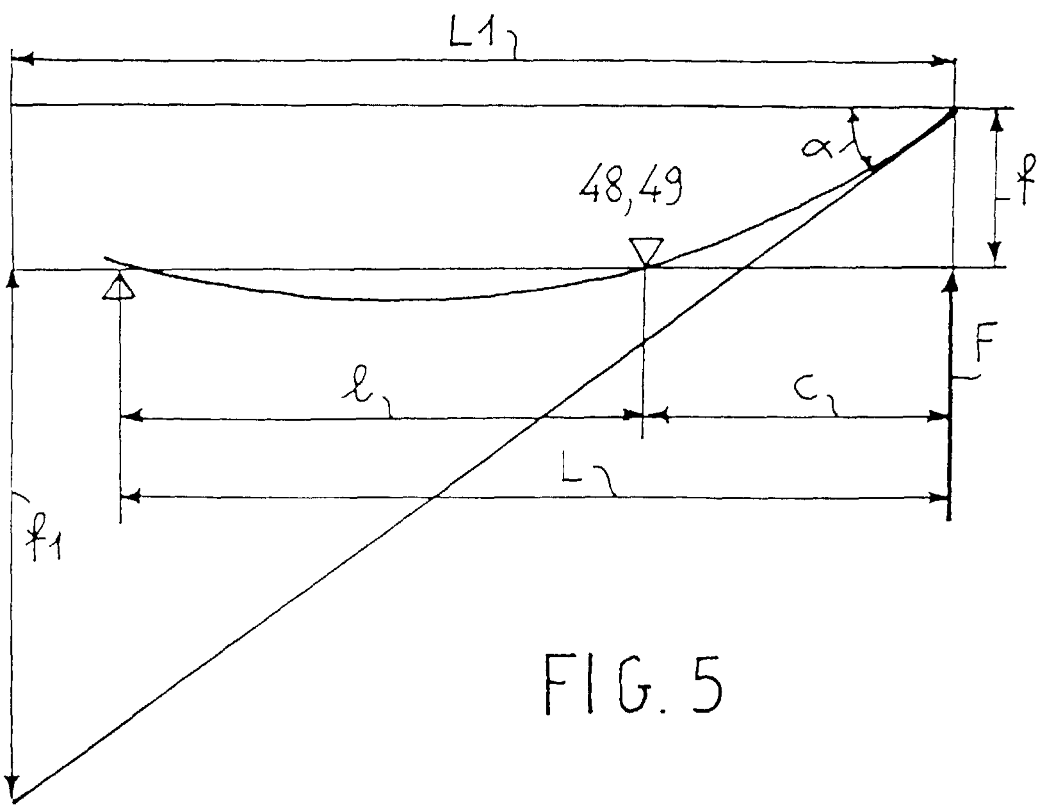

FIG. 5