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(54) **A METHOD OF MANUFACTURING A CIRCUIT BREAKER**

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## Description

The invention relates to circuit breakers and, more particularly, to an improved method of manufacturing a circuit breaker.

Circuit breakers function to interrupt electrical current flow between a source of electricity and a load in response to an over-current condition. They are typically manufactured in standard sized housings and include a movable blade carrying a contact (movable contact) that is generally connected to the electrical source, a mechanism carrying a stationary contact and a spring for biasing the movable contact away from the stationary contact. A releasable latch mechanism opposes the spring bias to physically couple the movable contact and the stationary contact to permit current flow from the source to the load. A trip lever releases the latch mechanism, permitting the spring bias to separate the movable contact and the stationary contact to prevent current flow from the source to the load.

Prior art circuit breaker assemblies normally have one or more points of attachment to the housing, although US-A-4 079 346 discloses a circuit breaker in which the parts are attached to a plate to be located in a housing without attachment thereto. Preassembly of the breaker mechanism is difficult when it is held together by the housing. US-A-4 752 755 discloses a method of manufacturing a circuit breaker by preassembling a structure which is adjusted and tested before a cover is secured thereto. The manufacture of prior art circuit breakers has also been difficult to automate because parts need to be assembled along three orthogonally related axes. The present invention provides a solution to these problems.

### Summary of the Invention

It is an object of the invention to provide an improved method of manufacturing a circuit breaker.

Another object of the invention is to provide a reliable, low cost method of manufacturing a circuit breaker.

A feature of the invention is the provision of a modular subassembly of the operating parts of a circuit breaker that may be tested and adjusted prior to installation in the breaker housing.

According to one aspect of the invention there is provided a method of manufacturing a circuit breaker having a movable load contact and a stationary load contact comprising the steps of preassembling a module comprising movable parts of said circuit breaker, and said stationary load contact by supporting between a pair of side plates, said module being capable of being adjusted and tested before installation in a housing providing a housing defining at least one compartment configured to support said module without attachment thereto; testing said module; placing said tested module into said compartment; and securing a cover to said housing.

According to a further aspect of the invention there is provided a circuit breaker having a movable load contact, a stationary load contact and a housing wherein, the movable parts of the circuit breaker and the stationary load contact are located within a pre-assembled module by supporting between a pair of side plates and located in the housing without attachment thereto, the module being capable of independent testing and adjustment prior to installation in the housing.

### Brief Description of Drawings

Other objects, features and advantages of the invention will be apparent from reading the following description in conjunction with the drawings, in which

Figure 1 is a view of a circuit breaker constructed in accordance with one aspect of the invention; Figure 2 is a partial view of the unitary breaker assembly of Figure 1 in a closed position; Figure 3 is a partial view of the unitary breaker assembly of Figure 1 in an open position; Figure 4 is a view of the operating handle mechanism of the unitary breaker assembly as viewed from behind; Figure 5 is an exploded perspective showing assembly of the circuit breaker of Figure 1; Figure 6 is a view of a circuit breaker constructed in accordance with another aspect of the invention; and FIG. 7 is an exploded perspective showing assembly of the circuit breaker of FIG. 6.

### Description of the Preferred Embodiments

A circuit breaker 10 constructed in accordance with the first aspect of the invention is illustrated in FIG. 1. An additional description of the general features of a similar type circuit breaker can be found in the following patents, the specifications of which are incorporated herein by reference:

- (a) Westermeyer, U.S. Patent No. 4,617,540, entitled "Automatic Switch, Rail-Mounted",
- (b) Westermeyer, U.S. Patent No. 4,614,928, entitled "Automatic Switch with an Arc Blast Field",
- (c) Westermeyer, U.S. Patent No. 4,609,895, entitled "Automatic Switch with Integral Contact Indicator", and
- (d) Westermeyer, U.S. Patent No. 4,608,546, entitled "Automatic Switch with Impact-Armature Tripping Device".

The circuit breaker 10 has a housing 11 and includes a resilient clamp type line terminal 12 for connection to a source of electricity (not shown) and a screw type load terminal 14 for connection to a load circuit (not shown). A current path is established between the line

terminal 12 and the load terminal 14 which includes a line conductor 16, a support 18 for a bimetal thermal element 20, a braided pigtail 22, and a blade 24 including a movable contact 26. Continuing from the movable contact 26, the current path includes a stationary contact 28, a trip coil 31 and a load conductor 32.

The blade 24 is shown in a closed position with the movable contact 26 engaging or mating with the stationary contact 28. The blade 24 is pivotable between the closed position shown and an open position, wherein the movable contact 26 is separated from the stationary contact 28 to prevent current flow. The stationary contact 28 comprises a layer of copper 28a laminated to a layer of steel 28b with a silver/graphite composition contact 28c welded to the copper. The blade 24 is an element of a unitary breaker assembly, generally designated 40, which controls the position of the blade 24 relative to the stationary contact 28.

The circuit breaker 10 also includes a line-side arc arresting plate 29a, a load-side arc arresting plate 29b and a stack of deionization plates, or arc stack, 30, which cooperate to break the electrical arc formed when the circuit breaker 10 is opened while supplying current to a load. The specific operation of the arc arresting plates 29a, 29b and the arc stack 30 is disclosed in greater detail in the above incorporated patents. The elements 16, 18, 20 and 29a are joined together by welding at their various interfaces.

In FIG. 2, unitary breaker assembly 40 includes a first frame member or plate 42 having first, second and third upright members 43, 44, 45, respectively. A pivot pin 48 extends upwardly through a hole in the first frame plate 42. A trip lever 50 is pivotally supported on the pivot pin 48. The trip lever 50 includes a solenoid actuator surface 52 and a bimetal actuator surface 54. The blade 24 includes an elongated slot 24a for receiving the pivot pin 48. The blade 24 further includes a notch 56 to which a first end of a toggle spring 58 is attached.

A latch spring 60 is disposed about the pivot pin 48 between the trip lever 50 and the blade 24. The latch spring 60 includes a first end 62 which engages the first upright member 43 and a second end 63 which engages the solenoid actuator surface 52 of the trip lever 50. The latch spring 60 provides a counterclockwise bias to the trip lever 50.

A cam 64, having an operating handle 65 attached thereto, includes a recessed portion 66 in which a cam spring 68 is placed. Referring also to FIGS. 3 and 4, a first cam spring end 69a extends from recessed portion 66 and engages the third upright member 45. A second cam spring end 69b engages a wall of the recessed portion 66. The cam spring 68 imparts a clockwise bias to the cam 64 as viewed in FIG. 2. A link 70 couples the cam 64 to a pawl 72. The pawl 72 is pivotally connected to a flag end 74 of the blade 24 by a pin 76. The flag end is visible through a window 75 in the housing 11 (FIG. 1) and indicates the status of the circuit breaker contacts, i.e. whether they are opened or closed. The trip

lever 50 further includes an engaging surface 78 which engages the pawl 72.

When in the closed position, the movable contact 26 is physically coupled to the stationary contact 28. The pin 76 operates as a fulcrum on the blade 24, causing the toggle spring 58 to keep the movable contact 26 and the stationary contact 28 closed.

Referring again to FIG. 1, the blade 24 can be moved to the open position by operation of the bimetal thermal element 20, by action of a spring loaded rod 80 disposed within the operating or trip coil 31, or by manipulation of operating-handle 65. Load current passing through the bimetal thermal element 20 heats the bimetal thermal element 20 which deflects downwardly in the direction of the arrow 82. The amount of deflection depends upon the temperature reached by the bimetal thermal element 20, which is a function of the magnitude and duration of the load current. When the bimetal thermal element 20 deflects sufficiently, a calibration screw 84 engages the bimetal actuator surface 54 of the trip lever 50, causing the trip lever 50 to rotate clockwise about the pivot pin 48 and against the bias of the latch spring 60 (FIG. 3), tripping the circuit breaker 10 as discussed in greater detail below.

The circuit breaker 10 can also be tripped by the trip coil 31. The rod 80 is downwardly biased by a solenoid spring 86. Rod 80 may be coupled to, or a part of (or simply in gravitational contact with), a movable armature in coil 31. Load current passes through the coil 31 (one end of which is welded to stationary contact 28), establishing an electromagnetic field that affects the coil armature (and hence rod 80). When the electromagnetic force in coil 31 exceeds the biasing force of the solenoid spring 86, the rod 80 is moved (up) to engage the solenoid actuator surface 52, causing the trip lever 50 to rotate clockwise, tripping the circuit breaker 10, as discussed below.

Referring to FIGS. 1, 2 and 3, when either the bimetal thermal element 20 or the rod 80 causes the trip lever 50 to rotate clockwise, the engaging surface 78 of trip lever 50 moves away from pawl 72 which permits cam spring 68 to rotate cam 64 in a clockwise direction. Cam 64 pulls downwardly on the link 70, causing counterclockwise rotation of pawl 72 about pin 76. When pawl 72 is released from engagement with the engaging surface 78, blade 24 moves downwardly at its right side due to the action of toggle spring 58, initially causing the pivot pin 48 to engage the upper surface of the elongated hole 24a, which operates as a floating point. The pivot pin 48 then operates as a fulcrum about which blade 24 rotates, causing the toggle spring 58 to move movable contact 26 away from stationary contact 28, thus opening the circuit.

In the event that the operating handle 65 is locked in its upward, or on, position and either bimetal thermal element 20 or rod 80 causes the trip lever 50 to rotate clockwise, link 70, which is under compression between cam 64 and pawl 72, causes the pawl 72 to rotate clock-

wise about pin 76, again releasing the engaging surface 78 from engagement with the pawl 72. When the engaging surface 78 no longer engages the pawl 72, the blade 24 lowers, causing the pivot pin 48 to operate as a fulcrum about which the blade 24 rotates, permitting the toggle spring 58 to move the movable contact 26 away from the stationary contact 28.

The cam 64 is shown from its reverse side in FIG. 4 to better illustrate the recessed portion 66 and cam spring 68. The cam spring 68 is centered on a cam pivot axis 88. The second cam spring end 69b is biased against wall 66a of the recessed portion 66. The first cam spring end 69a is biased by torsion loading against the third upright member 45. The torsion loading of the cam spring 68 urges the cam 64 and attached operating handle 65 in the downward position.

The circuit breaker 10 is illustrated in an exploded perspective view in FIG. 5. The first, second and third upright members 43, 44, 45 of the first frame plate 42 terminate in connecting tabs 43a, 44a, 45a, respectively. A second frame plate 89 includes corresponding tab receiving openings 43b, 44b, 45b which provide an interference fit with the respective connecting tabs 43a, 44a, 45a to secure the first frame plate 42 to the second frame plate 89. In this embodiment of the invention, the first and second frame plates 42, 89, respectively, are separate pieces; however it is to be understood that the frame plates could be formed from a single piece folded over to form the opposing frame surfaces.

With the first frame plate 42 secured to the second frame plate 89, it will be noted that all elements of the unitary breaker assembly 40 are secured together. As illustrated, the unitary breaker assembly and other individual components of the circuit breaker 10 are simply installed into the circuit breaker base 11a and require no attachments thereto.

The housing 11 has a base 11a and a cover 11b. The base 11a defines x, y and z axis supporting elements and surfaces. These include internal and external walls and parts that are perpendicular to the base 11a, i.e. extend along the z-axis. The elements define an arc stack section 90, a unitary breaker assembly section 92 and a coil section 94 as well as support slots such as 96a and 96b.

End portions 18a and 18b of the bimetal support 18 are slid into and retained within respective support slots 96a and 96b. The line-side arc arresting plate 29a is slid into and retained within an arc runner slot 98. The unitary breaker assembly 40 is then simply placed in the unitary breaker assembly section 92, and requires no attachments to the housing 11. Suitably placed and configured additional indentations and protrusions (not shown) may be incorporated in base 11a and cover 11b for assuring adequate support for the various elements, if desired. The load terminal 14 is slid into and retained in a load terminal compartment 99. Suitable fasteners, not shown, are used to secure cover 11b in place on base 11a and thereby retain the elements of the circuit

breaker in housing 11. The blade 24 is a tapered plate on edge, operating structurally as a beam so as to prevent flexing. If additional current carrying capacity is required, the width of the blade 24 may simply be increased.

The embodiment of the invention illustrated in FIGS. 6 and 7 provides a very attractive solution for a circuit breaker manufacturer who wishes to do final assembly of circuit breakers at different locations. The operative parts of the circuit breaker, including the unitary breaker assembly and the trip coil and stationary contact, are preassembled into a module that may be tested and calibrated before final installation in the breaker housing. Therefore, the critical manufacturing steps may be carefully controlled where the modules are constructed.

In FIG. 6, circuit breaker 10' has a base 111 that is modified to accept a module 100 without the need of fasteners. Module 100 has a pair of supporting side plates or frame members (only one of which-105-is visible) that function to support the movable elements for operation as was accomplished by the frame members 42 and 89 above. That is, one of the side plates of module 100 has an internal configuration that cooperates with the other side plate to operatively support the working elements of the circuit breaker. As illustrated by the dotted line wall portions 103 and the fastener points 102, the frame members are configured to provide suitable openings for parts of the circuit breaker that extend outside the module which includes the unitary breaker assembly and the trip coil assembly. These parts include the cam 64, operating handle 65, line terminal 12, load terminal 14, flag end 74, calibration screw 84 and line and load side arc plates 29a and 29b. Thus the essential mechanism of the breaker may be handled and tested as a separate module 100. The frame members are preferably made of plastic with suitable interior coatings or barrier plates adjacent to the contact areas to withstand the effects of heating due to opening and closing of the contacts under load. The frame members also support the pivot pins 48 and define the pivot axis 88. The differences between this embodiment and that described in FIGS. 1-5 are that the stationary contact and trip coil and the bimetal and calibration screw are also secured in their final positions by the module 100, which permits full operation and adjustment of the breaker before installing it in housing 111. All that needs to be added during final assembly is the arc chute 30. Securing the trip coil and stationary contact and the thermal element support 18 in module 100 renders the unitary breaker assembly capable of full operation apart from housing 111 and cover 112 and represents a preferred implementation of the invention.

In FIG. 7, the internal configuration of base 111 for supporting module 100 (without fasteners) is shown. It will be appreciated that suitable fasteners (not shown) are used to secure module 100 between base 111 and cover 112 via apertures 104 and 105. It will also be noted

that the particular configuration of the base, cover and module is dependent upon the specific breaker construction.

Thus it can be seen that a unitary breaker assembly has been provided which can be preassembled and which requires no attachments to secure it within a circuit breaker housing. In addition, assembly of the unitary breaker assembly can readily be automated, because the assembly steps are performed along a single axis.

## Claims

1. A method of manufacturing a circuit breaker (10) having a movable load contact (24) and a stationary load contact (28) comprising the steps of:

preassembling a module (40, 100), comprising movable parts of said circuit breaker (10), and said stationary load contact (24) by supporting between a pair of side plates (105), said module being capable of being adjusted and tested before installation in a housing;  
 providing a housing (11a, 111) defining at least one compartment (92) configured to support said module (40, 100) without attachment thereto;  
 testing said module (40, 100);  
 placing said tested module (40, 100) into said compartment (92);  
 and securing a cover (11b, 112) to said housing (11a, 111).

2. A method as claimed in claim 1 characterised in that said housing (111) includes a second compartment (90) for supporting an individual component (30) of said circuit breaker (10) and further including the step of placing said individual component (30) of said circuit breaker (10) in said second compartment (90) before securing said cover (11b, 112).

3. A method as claimed in claim 2 characterised in that said individual component comprises a deionization plate assembly (30).

4. A method as claimed in any preceding claim characterised in that a stationary electrical connector (14) is connected to said module (40, 100) and wherein said housing (11a, 111) includes support means for supporting said stationary electrical connector (14).

5. A circuit breaker (10) having a movable load contact (24), a stationary load contact (28) and a housing (11a, 111) wherein, the movable parts of the circuit breaker (10) and the stationary load contact (28) are located within a pre-assembled module (40, 100) by supporting between a pair of side plates (105)

and located in the housing (11a, 111) without attachment thereto, the module (40, 100) being capable of independent testing and adjustment prior to installation in the housing (11a, 111).

## Patentansprüche

1. Ein Verfahren zur Herstellung eines Schutzschalters (10), der einen beweglichen Belastungskontakt (24) und einen feststehenden Belastungskontakt (28) besitzt, das folgende Schritte umfaßt:

vorherige Zusammenstellung eines Moduls (40, 100), das bewegliche Teile des genannten Schutzschalters (10) und den genannten feststehenden Belastungskontakt (24) umfaßt, indem es zwischen zwei Seitenplatten (105) gehalten wird, wobei das genannte Modul vor der Installation in einem Gehäuse ausgerichtet und geprüft werden kann;  
 ein Gehäuse (11a, 111) zu schaffen, das mindestens einen Sektor (92) besitzt, der so beschaffen ist, daß er das genannte Modul (40, 100) halten kann, ohne daß dieses in ihm befestigt werden muß;  
 Überprüfung des genannten Moduls (40, 100);  
 die Platzierung des genannten überprüften Moduls (40, 100) in den genannten Sektor (92);  
 und die Befestigung einer Abdeckung (11b, 112) an dem genannten Gehäuse (11a, 111).

2. Ein Verfahren wie nach Anspruch 1 dadurch charakterisiert, daß das genannte Gehäuse (111) einen zweiten Sektor (90) beinhaltet, der einen einzelnen Bauteil (30) des genannten Schutzschalters (10) hält und weiterhin den Schritt umfaßt, diesen genannten einzelnen Bauteil (30) des genannten Schutzschalters (10) in dem genannten zweiten Sektor (90) zu platzieren, ehe die genannten Abdeckung (11b, 112) befestigt wird.

3. Ein Verfahren wie nach Anspruch 2, dadurch charakterisiert, daß der genannte einzelne Bauteil einen Entionisierungsplattenbausatz (30) umfaßt.

4. Ein Verfahren wie nach einem der vorhergehenden Ansprüche, dadurch charakterisiert, daß ein elektrischer Festverbinder (14) mit dem genannten Modul (40, 100) verbunden wird, und worin das genannte Gehäuse (11a, 111) eine Halteeinrichtung zum Halten des genannten elektrischen Festverbinders (14) beinhaltet.

5. Ein Schutzschalter (10), der einen beweglichen Belastungskontakt (24), einen feststehenden Belastungskontakt (28) und ein Gehäuse (11a, 111) besitzt, worin die beweglichen Teile des Schutz-

schalters (10) und der feststehende Belastungskontakt (28) sich innerhalb eines vorher zusammengestellten Moduls (40, 100) befinden, indem sie zwischen zwei Seitenplatten (105) gehalten werden und in ein Gehäuse (11a, 111) gesetzt werden, ohne daß sie daran angebracht werden, wobei das Modul (40, 100) vor der Installation in dem Gehäuse (11a, 111) unabhängig überprüft und ausgerichtet werden kann.

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charge fixe (28) sont disposés dans un module préassemblé (40, 100) de façon à être supporté entre une paire de plaques latérales (105) et aménagé dans ledit boîtier sans moyen de fixation tel que ledit module peut être testé et réglé avant d'être installé dans le boîtier (11a, 111).

## Revendications

1. Un procédé de fabrication d'un disjoncteur (10) comportant un contact de charge déplaçable (24) et un contact de charge fixe (28), comprenant les étapes suivantes:
  - préassemblage d'un module (40, 100), comportant les parties déplaçables du dit disjoncteur (10) ainsi que le dit contact de charge fixe (24) de façon que ledit module soit supporté entre une paire de plaques latérales (105) de manière que ledit module puisse être réglé et testé avant d'être installé dans un boîtier; fournissant un boîtier (11a, 111) délimitant au moins un compartiment (92) aménagé de façon à supporter le dit module (40, 100) sans moyen de fixation; testant ledit module (40, 100); disposant ledit module testé (40, 100) dans ledit compartiment (92); et mettant un couvercle (11b, 112) sur ledit boîtier (11a, 111).
2. Un procédé selon la revendication 1, caractérisé en ce que ledit boîtier (111) comporte un deuxième compartiment (90) pour supporter un seul élément (30) dudit disjoncteur (10) et consistant en outre de l'étape par lequel ledit seul élément dudit disjoncteur soit placé dans ledit deuxième compartiment (90) avant de mettre ledit couvercle (11b, 112).
3. Un procédé selon la revendication 2, caractérisé en ce que ledit seul élément comprend un ensemble de plaques de désionisation (30).
4. Procédé selon l'une quelconque des revendications précédentes, caractérisé par le fait qu'un connecteur électrique immobile (14) est connecté audit module (40, 100) et dans lequel ledit boîtier (11a, 111) comporte des moyens de support pour ledit connecteur électrique immobile (14).
5. Un disjoncteur (10) comprenant un contact de charge déplaçable (24), un contact de charge fixe (28) et un boîtier (11a, 111), dans lequel les parties déplaçables dudit disjoncteurs (10) et le contact de

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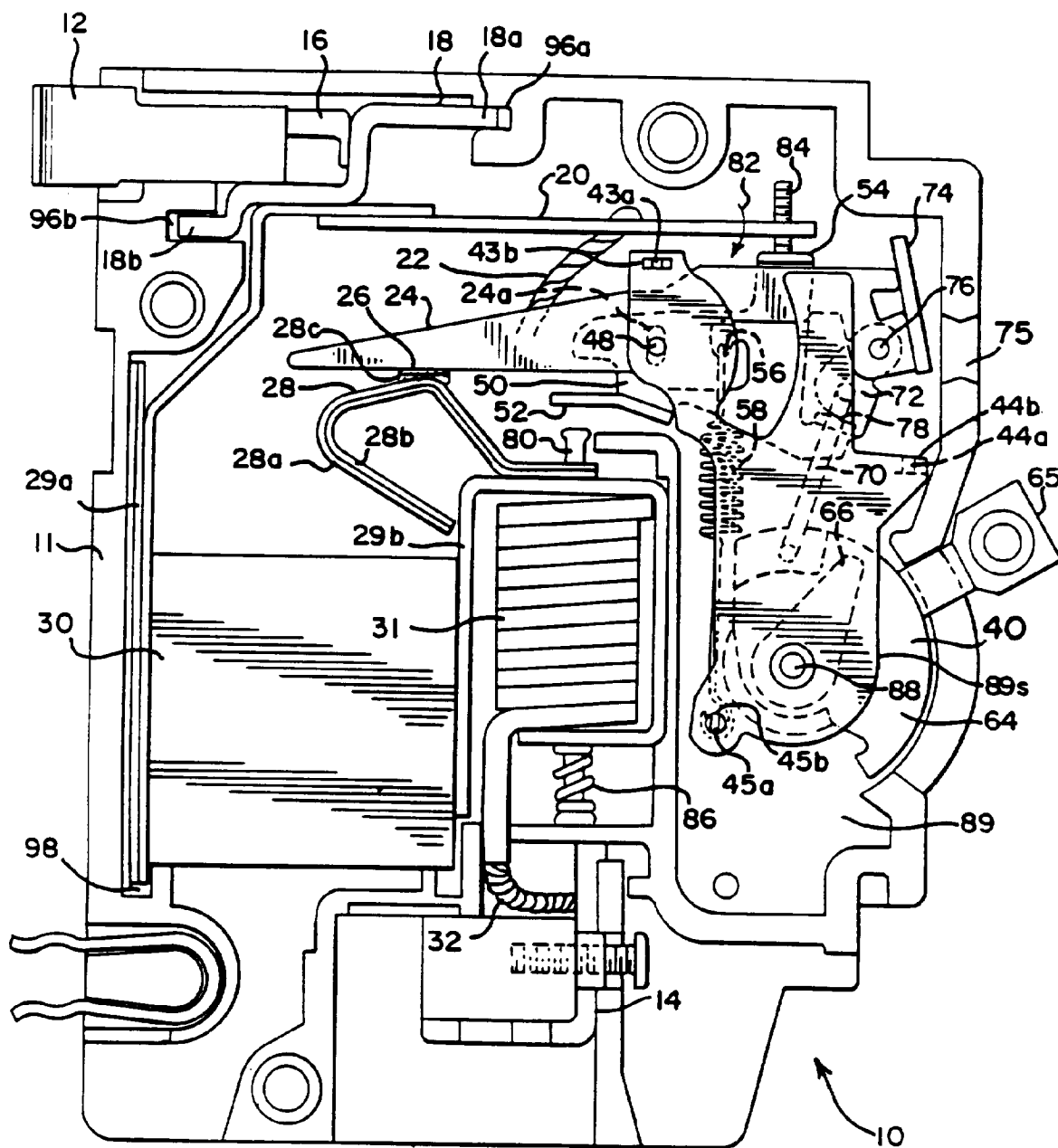
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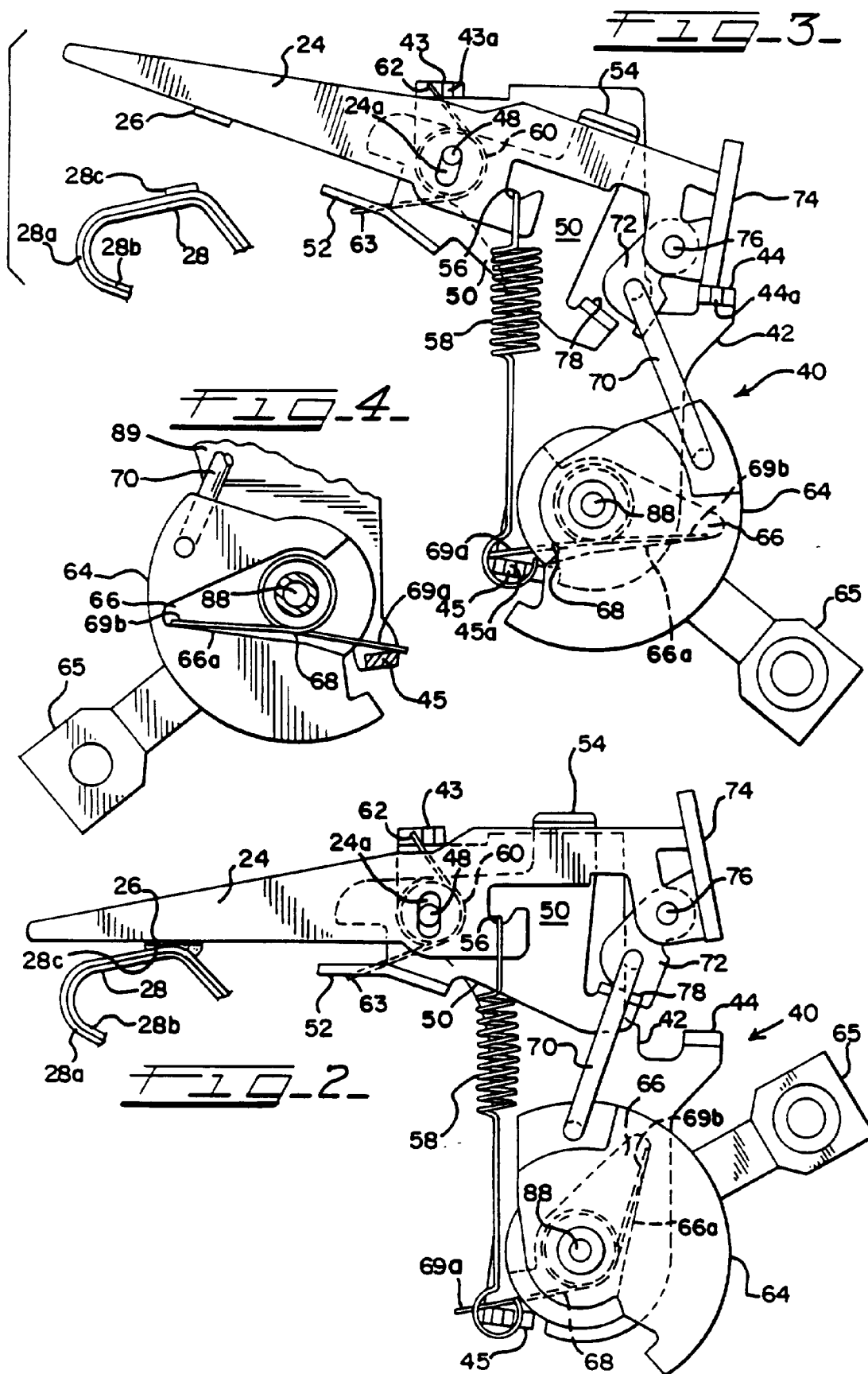
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Fig-1-







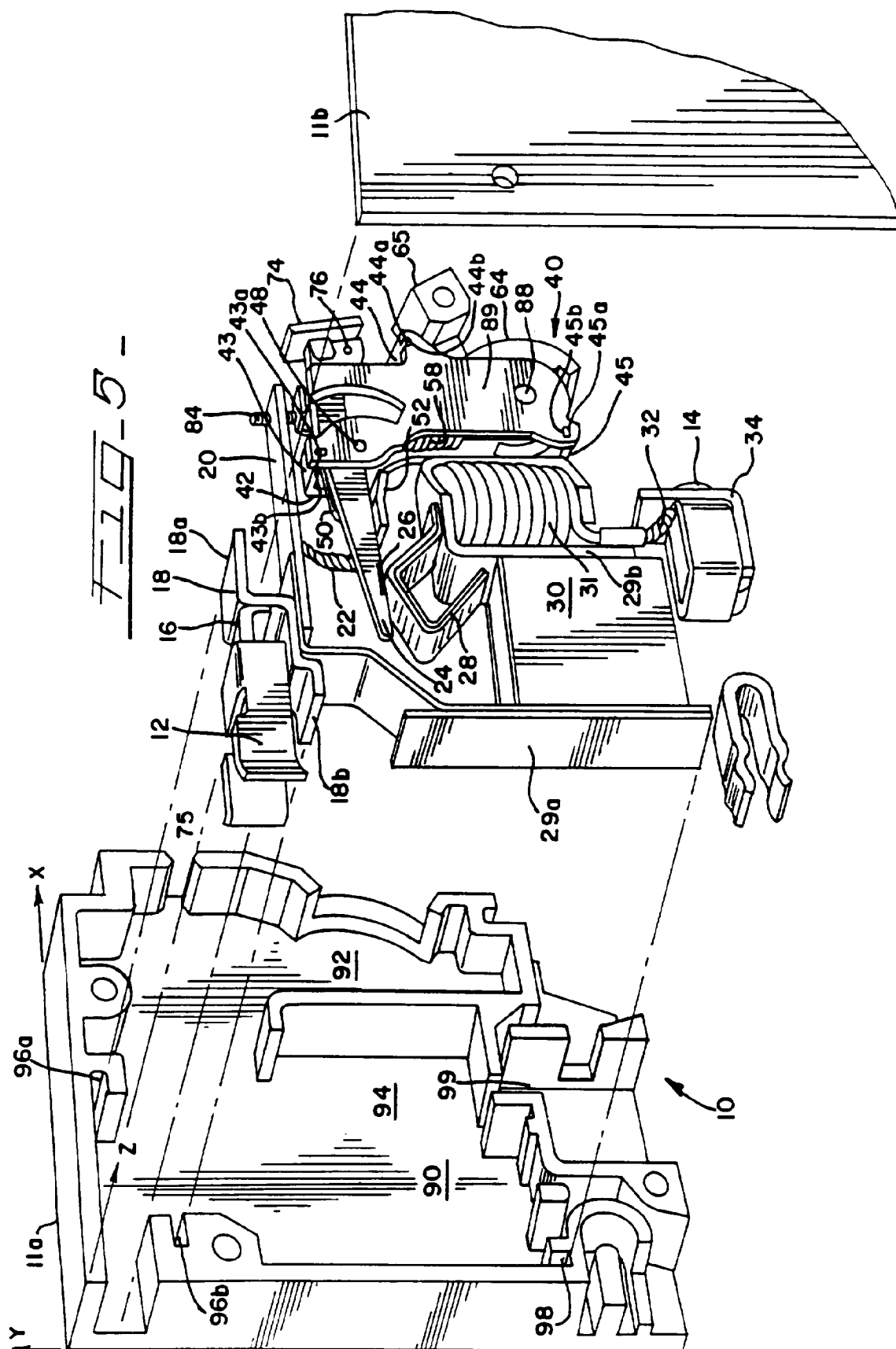


FIG. 6

