

(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199873965 B2
(10) Patent No. 731133

(54) Title
Single-phase circuit breaker

(51)⁷ International Patent Classification(s)
H01H 071/74 H01H 071/16

(21) Application No: **199873965**

(22) Application Date: **1998.06.30**

(30) Priority Data

(31) Number	(32) Date	(33) Country
1190/97	1997.07.10	AT

(43) Publication Date : **1999.01.21**

(43) Publication Journal Date : **1999.01.21**

(44) Accepted Journal Date : **2001.03.22**

(71) Applicant(s)
Felten and Guilleaume Austria AG

(72) Inventor(s)
Tibor Polgar

(74) Agent/Attorney
DAVIES COLLISON CAVE,GPO Box 3876,SYDNEY NSW 2001

(56) Related Art
EP 338250
US 3943477

ABSTRACT

Single-phase circuit breaker having a switching mechanism (2) which can be operated at least by an overload tripping element (1) it being possible to couple at least one further such single-phase circuit breaker, and preferably two, to the said circuit breaker in such a manner that, as a result of the coupling, all-pole disconnection of all the circuit breakers takes place in the event of an overload on one circuit breaker and, a current-range setting device may be provided, if required, which has an operating element (5) and a current scale (33) associated with this operating element (5), an adjustment member (4) in the form of a wedge being arranged between the overload tripping element (1) and a bracket (3) which acts on the switching mechanism (2), the adjustment member (4) in the form of a wedge being firmly connected by means of an elastically flexible spring (13) to an intermediate guide piece (6), and the intermediate guide piece (6) being mounted in the enclosure of the circuit breaker such that it can be displaced in the operating direction of the overload tripping element (1).

Fig. 1c

AUSTRALIA

Patents Act 1990

**ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT**

Applicant(s): Felten & Guillaume Austria AG
Eugenia 1
A-3943 Schrems
AUSTRIA

Address for Service: DAVIES COLLISON CAVE
Patent & Trade Mark Attorneys
Level 10, 10 Barrack Street
SYDNEY NSW 2000

Invention Title: Single-phase circuit breaker

The following statement is a full description of this invention, including the best method of performing it known to me:-

Single-phase circuit breaker

The invention relates to a single-phase circuit breaker having a switching mechanism which can be operated at least by an overload tripping element it being possible to couple at least one further such single-phase circuit breaker, and preferably two, to the said circuit breaker in such a manner that, as a result of the coupling, all-pole disconnection of all the circuit breakers takes place in the event of an overload on one circuit breaker and, a current-range setting device may be provided, if required, which has an operating element and a current scale associated with this operating element.

Conventional circuit breakers have a specific rated current, which is predetermined in the course of production by suitable selection of the material and by suitable structural design of the overload tripping element, and which can no longer be varied retrospectively. A specific circuit breaker type therefore has to be produced for each desired rated current.

In the case of circuit breakers of this generic type, it is now intended to provide a capability to adjust the circuit breaker rated current - in a similar manner to the known change in the case of motor circuit breakers as well. This has the production-engineering advantage that the number of circuit breaker types can be reduced, and the rated current required in the respective application can be selected, in the specified range, by the user himself.

Such a circuit breaker has already been disclosed in **EP-B1-338 250**. This document describes a multiphase circuit breaker whose individual pole paths are formed by individual circuit breakers. Each pole path thus has its own switching contacts, its own breaker mechanisms which operate these switching contacts, and its own overload and short-circuit tripping elements which operate the breaker mechanisms. The pole paths are in this case coupled to one another in such a way

that, when a single breaker mechanism trips, all the other pole paths are also tripped.

The overload tripping element is formed by a bimetallic strip, whose first end is fixed in the circuit breaker and whose second end can move towards the breaker mechanism as a result of the bimetallic strip bending due to heating caused by the current to be monitored, and can trip this breaker mechanism when it touches it.

In order to achieve the desired adjustment of the rated current, an adjustment member in the form of a wedge is arranged between the free end of the bimetallic strip and the switching mechanism in each individual switch. The free end of the bimetallic strip therefore does not need to travel through the entire distance between its rest position and the switching mechanism in order to initiate the tripping process, but only through the difference between this total distance and the wedge thickness which is acting at that moment between the free end of the bimetallic strip and the breaker mechanism. The effective wedge thickness is achieved in a simple manner by translational displacement of the adjustment member, which is in the form of a wedge.

In order to make it possible to carry out this displacement, a single intermediate guide piece, which is common to all the pole paths, is provided according to **EP-B1-338 250**. The individual adjustment members are suspended on this intermediate guide piece such that they can move relative to one another in the operating direction of the bimetallic strip, with the aid of joints.

The intermediate guide piece itself is mounted in the individual enclosures such that it can be displaced transversely with respect to the operating direction of the bimetallic strip, as a consequence of which the wedge surfaces also run approximately transversely with respect to the bimetallic strip operating direction.

The intermediate guide piece is moved via a central operating element which is formed as a cylindrical rotating knob, which is mounted, such that it can pivot about its longitudinal axis, in a common enclosure part which covers the intermediate guide piece. This rotating knob has at its end facing the intermediate guide piece an eccentrically arranged pin, which engages in an elongated hole arranged in the intermediate guide piece.

Such a design has a number of major disadvantages:

Owing to the use of a common intermediate guide piece for all three pole paths, the assembly of this multiphase circuit breaker essentially involves two operations: firstly, the individual switches must be fixed to one another and, secondly, the common intermediate guide piece must be inserted into this assembly.

Since the adjustment members, which are actually fixed on the common intermediate guide piece, are not yet present in the unassembled state, the individual switches cannot operate on their own. They can thus be used only together, but not to protect individual lines.

Furthermore, it is impossible to check the individual pole paths separately in the state before assembly. A functional check of the individual pole paths can, in fact, be carried out only in the assembled state, by applying a test current to in each case one pole path. If one pole path is found to be defective in this process, the switch must be dismantled into its individual parts (individual switches and the common intermediate guide piece), the faulty individual switch must be replaced, and the circuit breaker must be assembled once again.

Furthermore, the number of poles in the circuit breaker is limited by the design of the common intermediate guide piece. Specific intermediate guide pieces therefore have to be provided for each desired number of poles.

The operation of the breaker mechanism by the bimetallic strip itself results in the following difficulties: during its normal operation, the bimetallic strip is heated up to 250°C. The breaker mechanism part which is touched directly by the bimetallic strip and whose shape is often complex and relatively voluminous, must be manufactured from appropriately temperature-resistant and thus relatively expensive plastic or metal. Furthermore, the direct operation of the breaker mechanism results in low resistance to vibration and shock, since the bimetallic strip oscillations are transmitted directly to the breaker mechanism.

The suspension of the adjustment members which are in the form of wedges, on joints which are rigidly fixed to the intermediate guide piece makes it necessary for these joints to be fixed very accurately with respect to one another at the intended distance apart and to the edges of the intermediate guide piece. Any incorrect positioning of a joint would lead directly to a change in the rest position of the wedge mounted on it and thus to an inadvertent change in the response sensitivity of the associated pole path. The intermediate guide piece therefore has to be produced with very tight tolerances, and thus linked to high cost.

The object of the invention is to specify a single-phase circuit breaker of the type explained in more detail initially, which is fully operable on its own and can be assembled with any desired number of identical single-phase circuit breakers, without the addition of further components, to form a multiphase circuit breaker. The circuit breaker is furthermore intended to have good resistance to shocks and vibrations and to be relatively non-critical with regard to inaccuracies in the positioning of the connecting points of the adjustment member and intermediate guide piece.

This is achieved according to the invention in that an adjustment member in the form of a wedge is

arranged between the overload tripping element and a bracket which acts on the switching mechanism, in that the adjustment member in the form of a wedge is firmly connected by means of an elastically flexible spring to an intermediate guide piece, and in that the intermediate guide piece is mounted in the enclosure of the circuit breaker such that it can be displaced in the operating direction of the overload tripping element.

Each single-phase circuit breaker according to the invention thus has its own intermediate guide piece with an adjustment member fixed to it. It can thus be operated independently of other components, that is to say it can be used on its own to protect an individual current-carrying line, or can be coupled to any desired number of identical further single-phase circuit breakers and used to protect a multiphase conductor system.

The indirect effect of the bimetallic strip on the switching mechanism by means of a bracket means that only this component - which is physically relatively simple and requires little material - need be manufactured from a temperature-resistant material. Furthermore, a correctly designed bracket has a vibration-damping effect, considerably improving the resistance of the circuit breaker to vibration.

The elastic spring which is selected to connect the adjustment member, in the form of a wedge, to the intermediate guide piece can accommodate a slight lateral offset in its mounting points on the intermediate guide piece and on the adjustment member, so that such production inaccuracies do not lead to displacement of the adjustment member in its operating direction but only to minor twists which do not, however, change the effective width between the overload tripping element and the bracket.

In a further refinement of the invention, it can be provided for it to be possible to connect the intermediate guide piece firmly to the intermediate

guide piece of a further circuit breaker which is coupled to the said circuit breaker.

This results in simultaneous adjustment of the rated currents of all the single-phase circuit breakers which are coupled to one another, as a result of which this adjustment can, on the one hand, be carried out quickly while, on the other hand, ensuring that all the individual circuit breakers are set to the same rated current.

10 In this context, it can be provided in a development of the invention for the intermediate guide piece to have on those ends which face a further circuit breaker coupled to it, a recess and/or a projection which is congruent to this recess, which projection projects through the enclosure of the circuit breaker.

15 This type of design allows the intermediate guide pieces of circuit breakers that are coupled to one another to be connected in a positively locking manner, thus not involving any aids such as adhesives, screws or the like.

20 In the process, it has been found to be particularly advantageous for the projection and the recess to have side surfaces which run at right angles to the movement direction of the intermediate guide piece.

25 If the intermediate guide pieces of two adjacent individual circuit breakers are correctly positioned, they just need to be placed one against the other, and the connection of their intermediate guide pieces, that is to say the engagement of the projection on the one intermediate guide piece into the recess in the other, is produced automatically in the process. There is no need for any separate connection of the intermediate guide pieces, which would be necessary if projections and recesses provided with undercuts were used.

The invention will be explained in more detail in the following text with reference to the preferred

embodiments which are illustrated in the drawings, in which:

Fig. 1a shows a side view of a single-phase circuit breaker according to the invention, with the upper shell removed;

Fig. 1b shows a plan view of the circuit breaker according to Fig. 1a;

Fig. 1c shows a side view, on a larger scale, of the rated current adjustment device of the circuit breaker according to Figs. 1a, b, with the upper shell removed;

Fig. 2 shows a plan view in detail of the intermediate guide piece with the operating element of the circuit breaker according to Figs. 1, 2;

Fig. 3a shows a plan view, in detail, of the intermediate guide pieces of three single-phase circuit breakers according to Figs. 1, 2 which are coupled to one another;

Figs. 3b, c show a side view of the rated current adjustment device of the single-phase circuit breakers denoted by L1 and L3 in Fig. 3a, with the upper shell removed;

Fig. 4a shows a plan view, on a larger scale, of the intermediate guide pieces of the single-phase circuit breakers denoted by L1 and L2 in Fig. 3a, and

Fig. 4b shows the intermediate guide pieces according to Fig. 4a, illustrated in the same way, with their projection and recess designed in a different manner.

As is best shown in Fig. 1a, the single-phase circuit breaker according to the invention is designed in a similar manner to a conventional circuit breaker. Essentially, it comprises two screw terminals 14, 15 for connection of the line to be monitored, an overload tripping element 1 as well as a short-circuit tripping device 16, as well as a switching mechanism 2 which can move the moving contact 17 into an open position from the closed position illustrated in Fig. 1a.

In this circuit breaker, the current to be monitored first of all flows, starting from the first screw terminal 14, through the overload tripping element 1, passes via a moving conductor cable 19 and the contact carrier 20 to the moving contact 17, after which it flows via the stationary contact 18 to the short-circuit tripping device 16 and, finally, to the second connecting terminal 15.

The switching mechanism 2 can be operated both by the short-circuit tripping device 16 and by the overload tripping element 1, in the ways described below.

The short-circuit tripping device 16 is formed in a manner known per se by a solenoid coil with a moving armature, which armature strikes against the contact carrier 20 of the switching mechanism 2 when appropriately high short-circuit currents occur.

The overload tripping element 1 comprises a bimetallic strip which is heated by the current to be monitored. The first end 21 of the bimetallic strip is fixed in the enclosure of the circuit breaker, while the second end 22 is kept such that it moves freely. The bending of the bimetallic strip caused when it is heated thus leads to the second end 22 moving in the direction of the arrow 23. If the heating is sufficiently severe, the free end 22 of the bimetallic strip comes into contact, during this movement, with the bracket 3 which acts on the contact carrier 20, drives this bracket 3 in the movement direction, and thus causes the switching mechanism 2 to respond.

The contact carrier 20 is prestressed by means of a spring 24 in the direction of the open position of the moving contact 17. The slight deflections of the contact carrier 20 (which have been explained) by the armature of the short-circuit tripping device 16 and/or by the overload tripping element 1 via the bracket 3 are increased by means of this spring 24 so that the contact carrier 20 pivots completely into the open position of the moving contact 17.

A manually operable lever 25, which is accessible from the outside, is provided in order to switch the circuit breaker on, that is to say to pivot the contact carrier 20 back into the closed position of the moving contact 17.

The enclosure of the circuit breaker according to the invention is designed in a manner known per se in two parts, comprising a lower shell 26 and an upper shell 27 (cf. Fig. 1b).

The particular feature of the circuit breaker according to the invention comprises a device for adjusting the response sensitivity of the overload tripping element 1, that is to say a rated current adjustment device, which is illustrated in detail in Fig. 1c.

The most important component in this adjustment device is the adjustment member 4 which is in the form of a wedge and is arranged between the overload tripping element 1 - to be precise between its free end 22 - and the bracket 3 which acts on the switching mechanism 2. Furthermore, an intermediate guide piece 6 is provided which is mounted in the enclosure of the circuit breaker such that it can be displaced in the direction of the arrow 28, that is to say in the operating direction of the overload tripping element 1 - symbolized by the arrow 23.

The adjustment member 4 which is in the form of a wedge is firmly connected to the intermediate guide piece 6 by means of an elastically flexible spring 13, which is held in a guide 29. In the case of the embodiment of the invention illustrated in the drawings, the spring 13 is riveted both to the adjustment member 4 and to the intermediate guide piece 6, but this should not be understood as being a limiting factor, and other types of connection such as bonding, welding, etc. could also be used.

The movement of the spring 13 caused by the displacement of the intermediate guide piece 6 in the operating direction of the overload tripping element 1,

that is to say in the direction of the arrows 23, 28, is deflected through about 90° in the region of the guide 29, so that the adjustment member 4 is displaced in the direction parallel to the overload tripping element 1 (symbolized by the arrow 30).

The free end 22 of the overload tripping element 1 does not, in this arrangement, need to travel through the entire distance between its rest position and the bracket 3 in order to touch this bracket 3 and thus to cause tripping of the switching mechanism 2. This distance is reduced by the straight-line width of the adjustment member 4 between the free end 22 and the bracket 3. In order not to impede the movement of the free end 22, the adjustment member 4 must be capable of pivoting as easily as possible, and this is achieved by the spring 13 being as elastic as possible. For this purpose, the spring 13 can be manufactured as a thin strip or as a thin cable made of metal or plastic.

As a result of the explained displacement of the adjustment member 4, it is possible to vary its effective width at any given moment and thus to vary the deflection movement of the free end 22 required to trip the breaker mechanism. The deflection movement of the free end 22 is dependent on the instantaneous intensity of the current to be monitored, so that, in the final analysis, displacement of the adjustment member 4 makes it possible to adjust the response current intensity, that is to say the rated current of the overload tripping device 1.

An operating element 5 is provided in order to allow the said displacement of the intermediate guide piece 6 to be carried out (cf. Fig. 2). This operating element 5 is designed as a cylindrical rotating knob and is mounted in the circuit breaker enclosure such that it can pivot about its longitudinal axis.

At its end facing the intermediate guide piece 6, the operating element 5 has an eccentrically arranged pin 7 which engages in an elongated hole 31 arranged in the intermediate guide piece 6.

The rotary adjustment movement (symbolized by the arrow 32), which is preferably applied to the operating element 5 by means of a screwdriver, is converted via the pin 7 and the elongated hole 31 into a translational movement of the intermediate guide piece 6, running in the operating direction of the overload tripping element 1.

In order that it is possible to see the actual setting of the rated current from the outside, a current scale 33, which is allocated to the operating element 5, is fitted on the outer wall of the enclosure, in the region of said operating element 5 (cf. Fig. 1b).

The circuit breaker described up to this point is a single-phase device, that is to say it is suitable for monitoring only a single current-carrying line. However, in most applications, circuit breakers are designed to be multiphase, so that they can monitor a plurality of current-carrying lines at the same time. Two-phase, three-phase or four-phase circuit breakers (for monitoring a system comprising L and N, L1, L2 and L3 or L1, L2, L3 and N) are generally used in a normal three-phase system.

According to the invention, circuit breakers are designed such that a plurality of such single-phase circuit breakers can be coupled to one another in such a manner that all-pole disconnection of all the circuit breakers takes place as a result of the coupling in the event of an overload on one circuit breaker. Each circuit breaker according to the invention is fully operable on its own, as described in detail above, so that a multiphase circuit breaker can be formed just by placing individual switches alongside one another.

The coupling of the individual switching mechanisms 2 can most easily be achieved by mechanically connecting to one another the levers 25 (which are provided for manual switching-on) of the individual circuit breakers. As an alternative to this, it is also possible to provide each of the switching mechanisms 2

with a finger (which is not illustrated in the drawings, for the sake of clarity), which projects at the side through the enclosure of its circuit breaker as well as the enclosure of the adjacent circuit
5 breaker, engages in the switching mechanism 2 of the adjacent circuit breaker, and likewise operates this circuit breaker when its own switching mechanism 2 responds. Arranging the single-phase circuit breakers alongside one another as mentioned and as shown in
10 Figs. 1 and 2 would result in each pole path of the multiphase circuit breaker produced in this way having its own rated current adjustment device, separate from that of all the other pole paths. This is undoubtedly quite a feasible design for a multiphase circuit
15 breaker but, in practice, it would be impractical since the user would have to adjust each pole path separately.

The invention thus provides for the intermediate guide pieces 6 of circuit breakers that
20 are coupled to one another to be firmly connected to one another. In order to allow this connection to be produced, the enclosures of the relevant switches must be accessible in the region of the intermediate guide pieces 6, that is to say, for example, they must be
25 provided with apertures 10.

In principle, any desired type of connection may be chosen; two adjacent intermediate guide pieces 6 can, for example, be fixed to one another by bonding, welding, riveting or by additional components which
30 engage in both intermediate guide pieces 6 in a positively locking manner, such as pins.

One particularly preferred type of connection is illustrated in Figs. 3, 4 on the basis of a three-phase circuit breaker, and this will be explained in more detail
35 in the following text.

The intermediate guide piece 6 of the middle circuit breaker L2 has a projection 12 on the end facing the circuit breaker L1, which projection 12 extends through an aperture 10 in the lower shell 26 and thus projects

through the enclosure of the circuit breaker L2. The upper shell 27 of the circuit breaker L1 likewise has an aperture 10 which, when the two circuit breakers L1, L2 are joined to one another, comes to rest above the aperture 10 of the circuit breaker L2. The projection 12 can thus also project through the enclosure of the circuit breaker L1 and extend into its interior.

The intermediate guide piece 8 of the circuit breaker L1 has a recess 11 which is congruent to the projection 12 and in which the projection 12 engages, by which means the intermediate guide pieces 6, 8 are connected to one another in a positively locking manner.

The intermediate guide pieces 6, 9 of the circuit breakers L2 and L3 are connected to one another by precisely the same design measures - namely the projection 12 on the first intermediate guide piece and the recess 11 congruent to it in the second intermediate guide piece. In contrast to the connection of the intermediate guide pieces 6, 8 of the circuit breakers L1, L2, the intermediate guide piece 9 of the circuit breaker L3 in this case has the projection 12, and the intermediate guide piece 6 of the circuit breaker L2 has the recess 11.

The projections 12 and the recess 11 have side surfaces 34 which run at right angles to the movement direction of the intermediate guide piece 6 (cf. Fig. 4a). This method of construction has the major advantage that the circuit breakers L1, L2, L3 just need to be placed against one another in the illustrated manner during assembly. The described positively locking connection of the intermediate guide pieces 6, 8, 9 thereof, that is to say the engagement of the projection 12 of the one intermediate guide piece in the recess 11 in the other intermediate guide piece, in this case takes place automatically.

This type of design of projection 12 and recess 11 should not, of course, be regarded as being a limitation and the side surfaces 34 could, for example,

form an acute angle with one another, with the projection 12 and the recess 11 thus forming a triangular shape when seen in plan view. A further option is for the projection 12 to be designed such that it broadens as the distance from the end of the intermediate guide piece 6 increases, and for the recess 11 to be designed such that it broadens in a corresponding manner with increasing depth (cf. Fig. 4b). However, with this type of design, it is necessary to attach the intermediate guide pieces 6, 8, 9 in one another in a separate operation.

The firm connection of the individual intermediate guide pieces 6, 8, 9 results in simultaneous adjustment of the rated current ranges of all the circuit breakers L1, L2, L3 when a single intermediate guide piece is displaced. It is thus unnecessary to provide the rated current adjustment devices of each circuit breaker L1, L2, L3 with their own operating element 5. These operating elements 5 have thus been omitted from the outer circuit breakers L1, L3 of the three-phase circuit breaker in Fig. 3. As a further consequence of this, no elongated holes 31 have been incorporated in the intermediate guide pieces 8, 9, and no current scales 33 have been fitted on the outside of their enclosures.

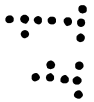
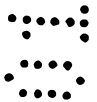
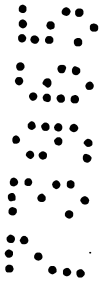
Furthermore, no repeated increase in the number of pole paths is provided, as a result of which the two outer circuit breakers L1 and L3 need no longer have the capability to be coupled to further circuit breakers. Their exposed enclosure shells - in the case of the circuit breaker L1 its lower shell 26, and in the case of the circuit breaker L3 its upper shell 27 - thus have no apertures 10 and, furthermore, their intermediate guide pieces 8, 9 in each case have only either a projection 12 (intermediate guide piece 9) or a recess 11 (intermediate guide piece 8).

- 14A -

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference numerals in the following claims do not in any way limit the scope of the respective claims.

- 10 The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that that prior art forms part of the common general knowledge in Australia.



The Claims defining the invention are as follows:

1. Single-phase circuit breaker having a switching mechanism (2) which can be operated at least by an overload tripping element (1) it being possible to couple at least one further such single-phase circuit breaker, and preferably two, to the said circuit breaker in such a manner that, as a result of the coupling, all-pole disconnection of all the circuit breakers takes place in the event of an overload on one circuit breaker and, a current-range setting device may be provided, if required, which has an operating element (5) and a current scale (33) associated with this operating element (5) **characterized in that** an adjustment member (4) in the form of a wedge is arranged between the overload tripping element (1) and a bracket (3) which acts on the switching mechanism (2), in that the adjustment member (4) in the form of a wedge is firmly connected by means of an elastically flexible spring (13) to an intermediate guide piece (6), and in that the intermediate guide piece (6) is mounted in the enclosure of the circuit breaker such that it can be displaced in the operating direction of the overload tripping element (1).
- 25 2. Single-phase circuit breaker according to Claim 1, **characterized in that** the intermediate guide piece (6) can be firmly connected to the intermediate guide piece (8, 9) of a further circuit breaker which is coupled to the said circuit breaker.
- 30 3. Single-phase circuit breaker according to Claim 2, **characterized in that** the intermediate guide piece (6, 8, 9) has, at those ends which face a further coupled circuit breaker, a recess (11) and/or a projection (12) which is congruent to this recess (11) and projects through the enclosure of the circuit breaker.
- 35 4. Single-phase circuit breaker according to Claim 3, **characterized in that** the projection (12) and the recess (11) have side surfaces (34) which run at right

- 16 -

angles to the movement direction of the intermediate guide piece (6, 8, 9).

5. Circuit breaker substantially as hereinbefore described with reference to the drawings.

5 DATED this 30th day of June 1998

FELTEN & GUILLEAUME AUSTRIA AG

By Its Patent Attorneys

DAVIES COLLISON CAVE

10

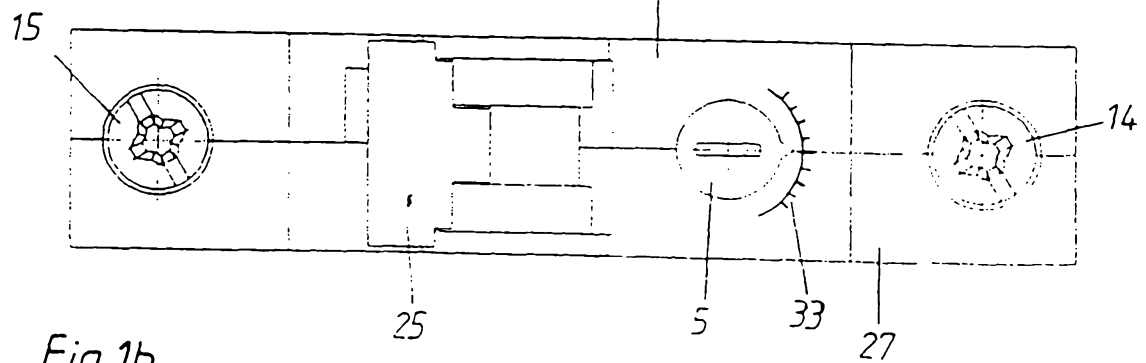
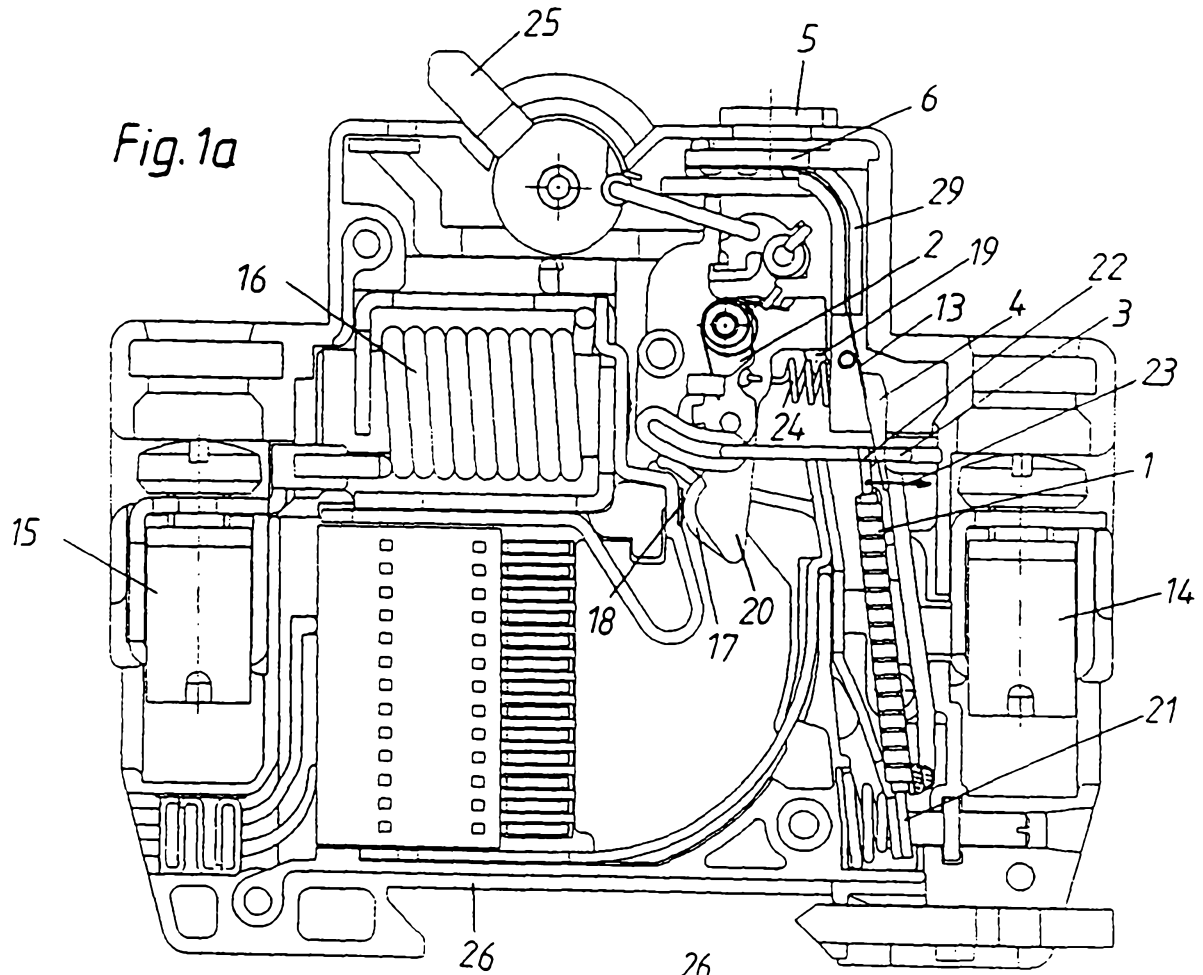
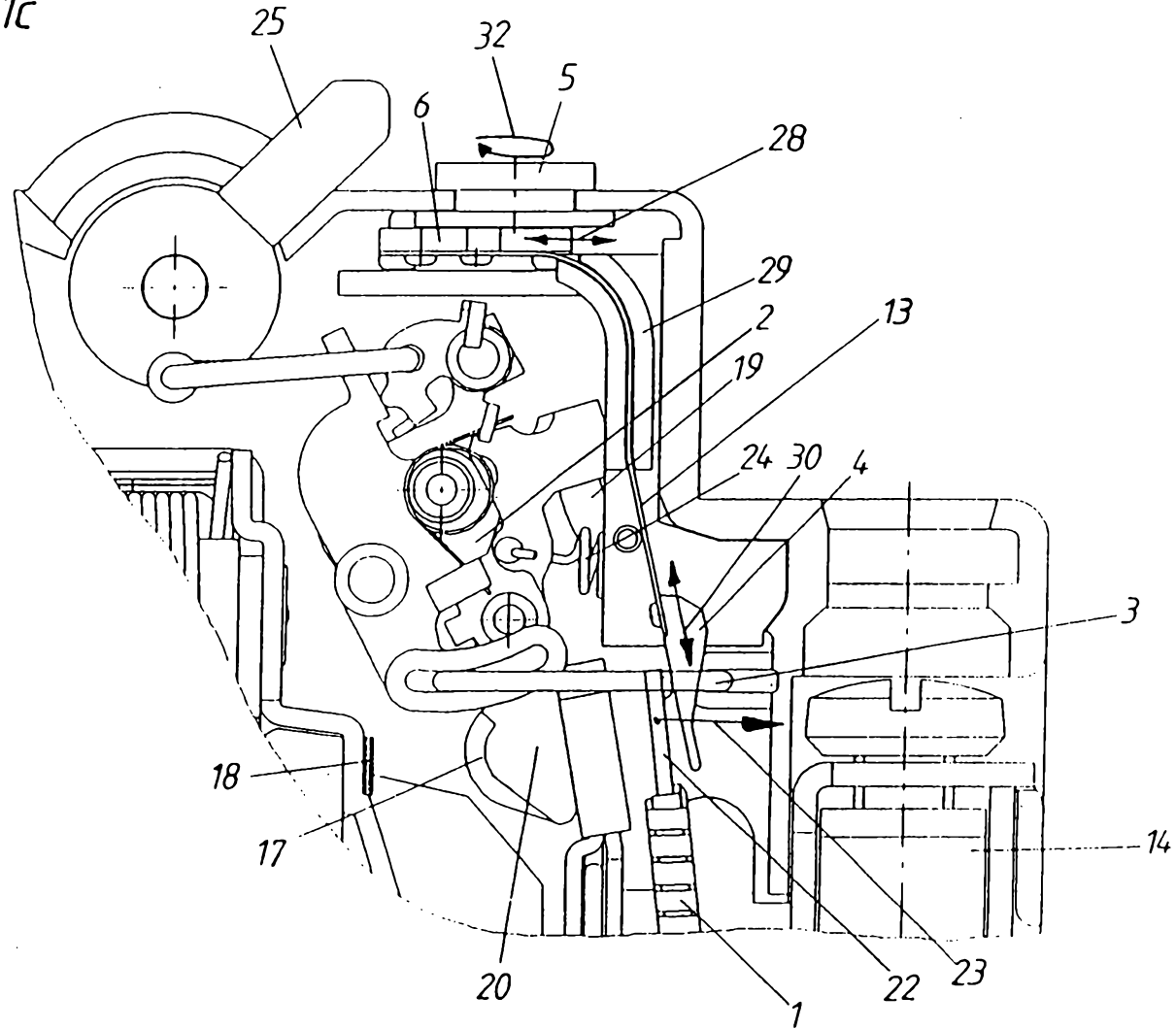


Fig.1c



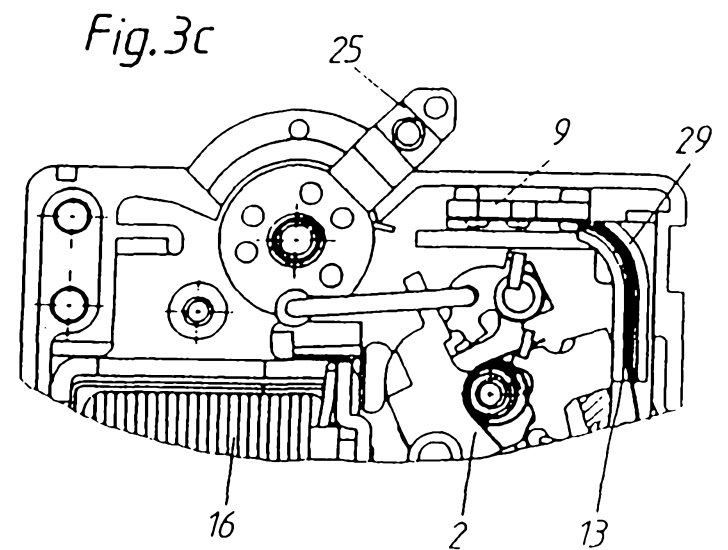
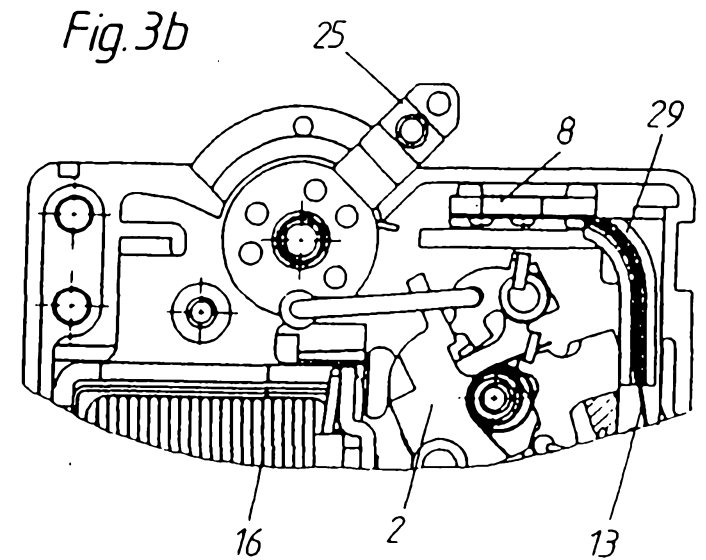
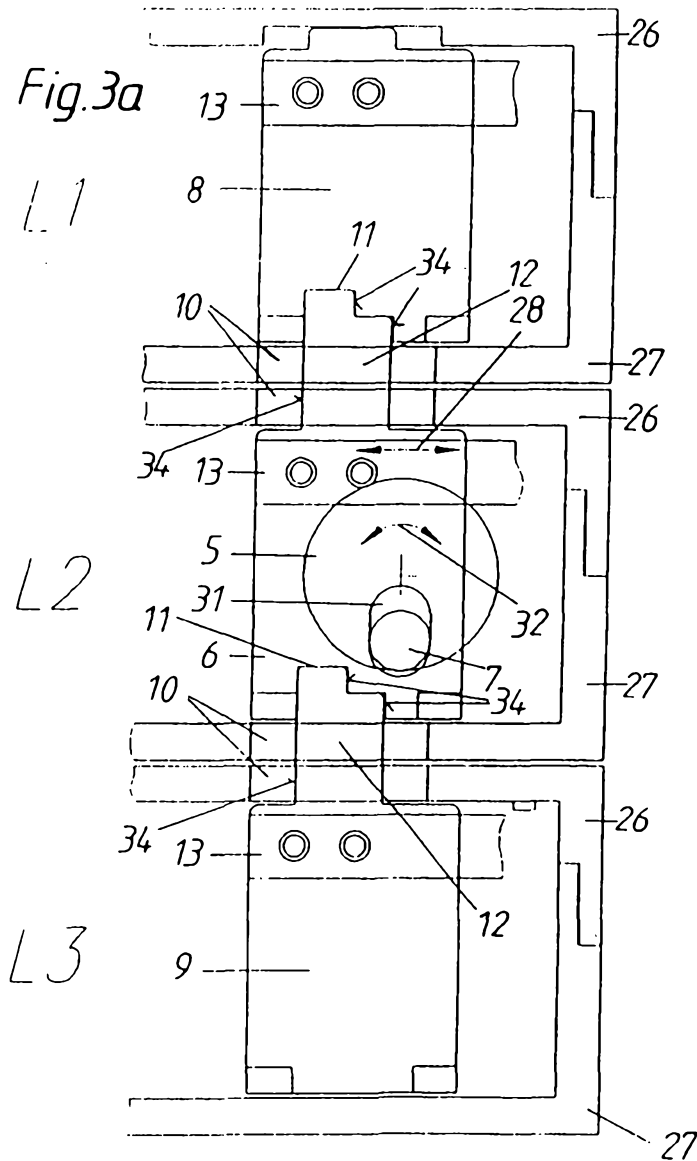
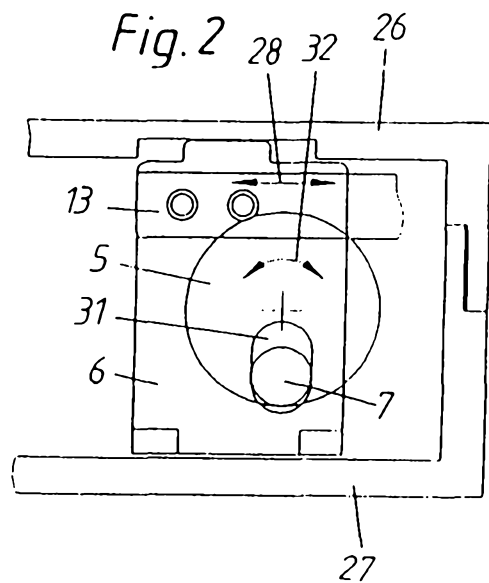


Fig.4a

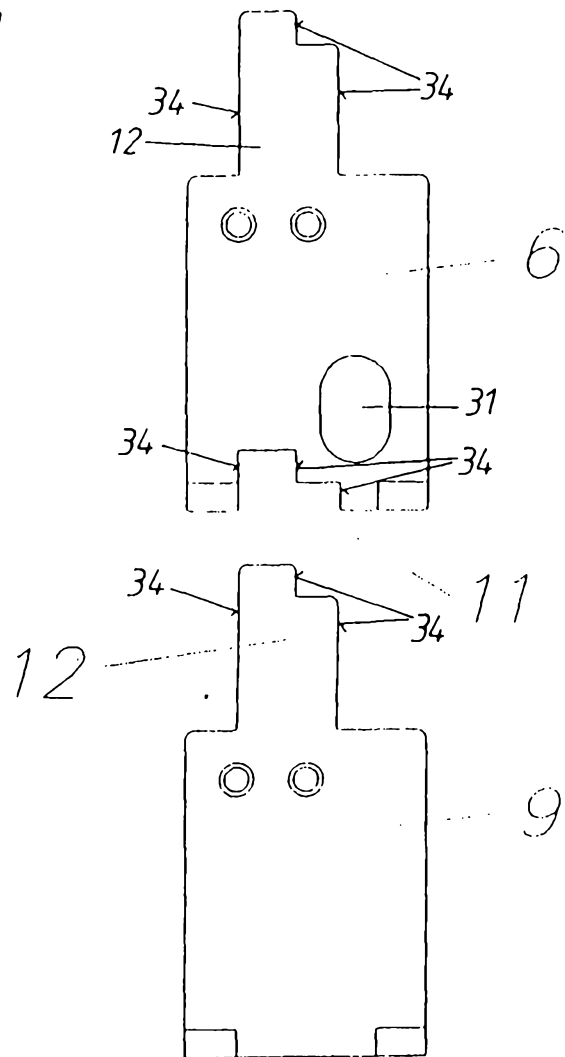


Fig.4b

