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(54) **Air break switch.**

(57) An air break switch (10) comprising one or more fixed contacts (11, 12) and one or more movable contacts (15,16) which are movable between open and closed positions, and a coil (20) which, preferably in conjunction with magnetically susceptible material (26,27) acting as a flux director, provides a magnetic field in the vicinity of the separable contacts (11, 15 and 12,16) in a direction which is substantially normal to a shock front which tends to be set up by establishment of an arc between the separable contacts (11,15 and/or 12,16) and has a value such as to cause the Alfven speed, at least in the vicinity of plasma associated with the arc, to be significantly in excess of the air speed attainable by such shock front, in order to hinder or prevent establishment of such shock front. The coil (20) may surround an arc chamber (17) containing runners (19) defining chutes (18) into which the arc moves under the normal blow-out magnetic field set up by the current through the contacts (11,15 and/or 12,16) and in the arc.

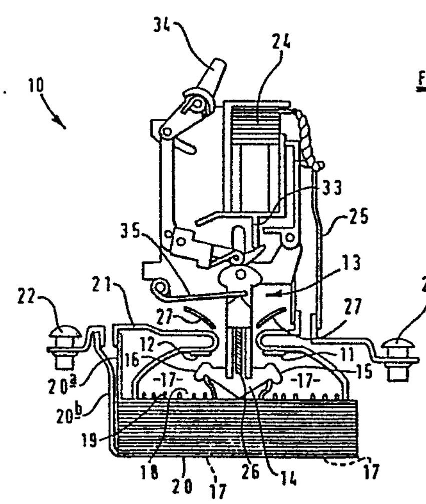

FIG 1

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Title: Air Break Switch

This invention relates to an air break switch, and to a method of reducing shock wave generation in operation of such switch.

Previous air break switches have suffered from the disadvantage that when separate contacts of the switch are opened, an electrical arc can occur within the switch casing, this arc generating (air) shock fronts within the switch, often causing considerable damage to the switch.

Switches have been proposed (GB-A-1,499,486) in which flow of arc current through conductive parts of the switch provides a blow-out magnetic field which causes the arc to move with high velocity away from the contacts in order to avoid damage to the contacts. However, such high velocity movement of the arc tends to maintain or augment air shock fronts generated by the arc, and such shock fronts may damage the switch.

Switches have also been proposed (GB-A-267,515) in which magnetically susceptible material is positioned in the switch so as to deflect the magnetic field due to flow of arc current, the deflected field being capable of acting as a blow-out field.

It is an aim of this invention to provide an air break switch in which such shock fronts are prevented from attaining sufficient strength to damage the switch.

According to a first aspect of the invention I provide an air break switch comprising two electrical contacts which can undergo relative motion between open and closed positions, and a coil through which at least part of the current undergoing interruption flows and which, preferably in conjunction with magnetically susceptible material, provides a magnetic field in the vicinity of at least one of the contacts, characterised in that the magnetic field is substantially normal to a shock front which tends to be set up by establishment of an arc between the contacts and has a value such as to cause the Alfven speed, at least in said vicinity in plasma associated with the arc, to be significantly in excess of the air speed attainable by such shock front.

The coil may be connected in series with the contacts.

Alternatively or additionally the coil may be powered by an energy source other than the switched current, and derived from or controlled by other contacts of a circuit and said switch operating in timed relation to those between which it is desired to reduce shock wave generation.

Current flow in the electrical arc which occurs between the contacts has a magnetic effect which tends to aid development of any shock front associated with such an arc. With the establishment of a field as provided by the invention, a significant fraction of energy released by any such arc can be dispersed mainly by relatively harmless oscillations of the plasma rather than mainly (as would occur in prior art switches) by one or more potentially damaging air shock fronts.

The switch may have an arc chamber for containing the arc while the energy thereof is dispersed, and in said vicinity the field may be directed transversely to the length of the arc (along the direction of relative separating motion of the contacts) between the contacts and lengthwise of a path of arc travel extending from said vicinity into the chamber.

In any such arrangement the field may be directed transversely of the shortest path between the contacts when they are separated.

Air-occupied space encompassed by part or all of the coil may provide at least a part of the arc chamber. This ensures the presence of the field within the arc chamber.

Alternatively or additionally, at least a part of the coil may lie around at least one other switch component defining the arc chamber.

The arc chamber may be provided with chutes and/or runners which help to disperse the energy of the arc by operating to sub-divide the arc.

According to a further aspect of the invention, I provide a method of at least reducing the generation of a shock wave at the site of an arc established between separable contacts of a switch as these contacts open, said method comprising causing the current feeding the arc to flow in a configuration establishing, preferably in conjunction with magnetically susceptible material, a magnetic field at the site of the arc, characterised in that such field is substantially normal to any shock front which would otherwise tend to be set up by the establishment of the arc and the field is of a form and strength to cause the Alfven speed, at least in the vicinity of said site and in plasma associated with the arc, to be significantly in excess of the air speed attainable by such shock front.

Two embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings wherein:-

FIGURE I is a diagrammatic side elevation of a first air break switch embodying the invention;

FIGURE 2 is a diagrammatic enlarged sectional side elevation of a portion of the switch shown in side elevation in Figure I; and.

FIGURE 3 is a diagrammatic partially sectional side elevation of a portion of a further air break switch embodying the invention.

Figure 1 of the drawings shows an air break switch 10 comprising a pair of electrical contacts 11 and 15 and a further pair of electrical contacts 12 and 16. An operating means for making and breaking an electrical connection between the two contacts of each pair is indicated at 13.

In order to permit current flow through the switch, operating means 13 is used to move an electrically conductive connecting member 14 which carries or incorporates contacts 15 and 16 so that contacts 15 and 16 conductively abut fixed contacts 11 and 12 respectively, to permit a current flow through the switch via member 14 and both pairs of contacts.

During movement of member 14, at stages when there is only a small air gap between contact 11 and contact 15 and/or there is only a small air gap between contact 12 and contact 16, it is possible that an electrical arc will occur in any such gap, said arc ionising the air along its path to form a plasma. The arc thus effectively continues to form a conductive link between the contacts. Such an arc generates intense heat and tends to generate shock fronts in the surrounding air.

In order to limit the development of such shock fronts, an electrically conductive coil 20 which may be of an elongate essentially rectangular form, as viewed in plan, is provided around the perimeter of an arc chamber 17 and is seen in Figure 1 from a direction perpendicular to one of its longer sides. If desired, said coil may surround more of said switch than is the case in Figures 1 and 2 and said coil may, for example, extend further in a direction towards the operating means 13 up to or beyond said contacts so that a part of said coil lies around said contacts.

One end 20a of said coil is conductively connected to contact 12 by connector 21, and the other end 20b of said coil is connected to a terminal 22. Contact 11 is conductively connected to a further terminal 23 via a solenoid 24 and a bi-metallic strip 25. In use, the air break switch is connected into an external circuit using terminals 22 and 23.

Coil 20 is thus in series with contacts 11 and 15, member 14, and contacts 16 and 12, and carries all the current which flows through the switch either via only the contacts and member 14 or via the contacts and member 14 and an arc or arcs between contacts of either pair. As a result of carrying said current, coil 20 generates a magnetic field which occupies said chamber 17 and extends into the vicinities of contacts 11, 12, 15, and 16.

A biasing spring 26 is provided which may be made of a magnetically susceptible material, such as steel for example, and consequently serves a dual purpose of urging contacts 15 and 16 on member 14 to make good electrical contact with contacts 11 and 12 respectively, when required, and of acting as a flux director which causes said field to pass through a gap between the two contacts of each pair when current flows through the switch due to the establishment of an arc between those contacts.

All of the contacts 11, 12, 15 and 16 in the embodiment illustrated in Figures 1 and 2 lie between said biasing spring 26 and said coil 20.

Additionally, flux directors 27 are provided specifically in order to direct said flux between said contacts located between flux directors 27 and coil 20 in the embodiment illustrated in Figures 1 and 2. Flux directors 27, as illustrated, are each in the form of a plate, but each may alternatively be in the form of a rod or may have any other suitable form.

Figure 2 shows the lines of force of said magnetic field in a part of said arc chamber and in the vicinities of the contacts, member 14, connector 21 (of negligible magnetic susceptibility), spring 26 and one of the flux directors 27. Dashed lines 28 and 29 are typical of these field lines, and all of these lines are substantially parallel until they emerge from chamber 17.

A possible path along which an arc could occur between contact 12 and contact 16 is indicated at 30.

Dashed lines 31 and 32 and similar lines represent successive positions which may be occupied by a shock front (generated initially by an arc along path 30) as it travels, by reason of the known magnetic blow-out effect, towards and into chamber 17. The flux directors have sizes, shapes and positions such that said field is approximately normal to path 30 and subsequent shock front positions, and such that said field is enhanced in the vicinity of said contacts.

Energy released by said arc would, in prior art switches, have been carried away from said arc mainly by (air) shock fronts in the air within the switch. However, energy can also be carried away from the arc via oscillations of the plasma of ionised air produced by the arc.

In the air break switch in accordance with the invention illustrated in Figures 1 and 2, the magnetic flux is so strong in the region of path 30 that the Alfven speed (i.e. the speed at which plasma oscillations perpendicular to the field propogate along the field lines) is so much in excess of any speed of travel attainable by an air shock front, that the effect of the flux is to bring about dispersal of said energy by way of oscillations rather than by a unidirectionally travelling shock front. Said energy is thus very rapidly conveyed by waves of plasma oscillations along said field lines into chamber 17, where the field lines are more widely spaced than in said region, and very little energy remains in the vicinity of the arc path at 30 for the generation of any air shock front. Most of an arc's energy is in fact dispersed by waves of plasma oscillations before enough time has elapsed for such a shock front to be generated.

Thus the generation of air shock fronts which could damage said switch is severely hindered or prevented in this air break switch.

The arc passes down chutes 18 between runners 19 in said arc chamber parallel to the magnetic field in said arc chamber. Said runners help to conduct away said energy, and each runner comprises a plate of thermally conductive/absorptive material arranged so that its plane is approximately parallel to the magnetic field in the arc chamber. The runners 19 are not shown in Figure 2, but have end portions which are indicated in Figure 1.

The magnetic field produced by the flow of said current in coil 20 which, as mentioned, is substantially normal to the shock front is arranged to be sufficiently strong to have a greater effect on the plasma than that due to the known blow-out field set up by the current flowing in the arc itself.

A bi-metallic strip 25 is arranged for use in conjunction with solenoid 24 to stop current flow in said switch when the current becomes too high (the current flows through the bi-metallic strip, which is heated by the current to a temperature - and consequently to a deflection - dependent upon the magnitude of that current). Solenoid 24 operates a plunger 33 which in turn acts on operating means 13.

A manually operable release lever 34 is provided to allow the switch to be switched off and/or on manually.

A speed-controlling spring 35 is used to exert, on operating means 13, a force which ultimately acts on member 14 to cause the connection between contacts 11 and 15 and the connection between contacts 12 and 16 to be broken rapidly so as to minimise the duration of any arcs which may occur.

Figure 3 shows a portion of a further air break switch 110 in accordance with the invention.

Switch 110 comprises a fixed contact 108 and a movable contact 106 on a movable conductive member 101. Contact 108 is conductively connected via a conductive element 140 to one end 120<u>a</u> of an electrically conductive coil 120, and the other end 120b of coil 120 is conductively connected via a further conductive element 141 to a further fixed contact 109 and thence to a terminal 122.

Suitable insulating portions 142, 143 serve to insulate conductive elements 140, 141 and the coil ends 120a, 120b from each other.

Conductive member 101 is T-shaped, with contact 106 located on its central stem portion 104 (seen from one side in Figure 3) and a further movable contact 107, fixed with respect to movable contact 106, on its cross-member 105 (seen end-on in Figure 3), and is conductively connected to another terminal 100. Terminals 100 and 122 are used for connecting switch 110 into an external circuit, and the switch 110, when thus connected, is used to control current flow between those terminals.

Member 101 is mounted, via a spring 103, on a movable arm 102 which is in turn mounted on a pivot, said pivot being located at an end (not shown) of arm 102 distant from spring 103. Figure 3 shows the contacts at their open positions.

In order to move member 101 to its closed position so as to permit current flow between terminals 100 and 122, arm 102 is lowered so as to lower member 101 in the direction indicated by arrow A. Member 101 is mounted and/or balanced in such a way that contacts 106 and 108 conductively abut each other and establish current flow before contacts 107 and 109 abut each other. During opening of the switch no arc occurs between contacts 107 and 109 since contacts 106 and 108 are still in abutting relation and provide a short circuit across contacts 107, 109. When contacts 106 and 108 begin to separate and are only a short distance apart, an electrical arc will occur through the air between them. The coil 120 is effectively in series between contacts 109 and 108 and will carry the arc current thereby generating a magnetic field in the vicinity of said arc. This magnetic field is sufficiently strong, and suitably directed (i.e. approximately normal to any shock front that may be generated by said arc) to hinder or prevent development of potentially damaging air shock fronts by said arc, said magnetic field having this effect for the same physical reasons as those given in the description of the switch 10 of Figures 1 and 2. Any suitably positioned part of the switch may be made of magnetically susceptible material, if necessary, in order to cause the magnetic field to have a suitable strength and direction at least in the vicinity of contact 108.

Energy released by any arc in switch 110 is dispersed (by plasma oscillations) along chutes 118 situated between the base portions 119*b* (seen in cross-section in Figure 3) of runners 119 which are U-shaped as viewed in plan. Each said runner 119 comprises a base portion 119*b* and two side limbs 119*a* connected to opposite ends of base portion 119*b*.

Coil 120 lies around runner base portions 119b, said limbs having their lengths extending longitudinally of the coil axis and hence approximately parallel to said magnetic field generated by coil 120.

Central stem portion 104 of member 101 moves within a part of an arc chamber 117 located between the side limbs 119*a* of runners 119.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, or a class or group of substances or compositions, as appropriate, may, separately or any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS:

1. An air break switch (10;110) comprising two electrical contacts (11,15 and/or 12,16; 106,108) which can undergo relative motion between open and closed positions, and a coil (20;120) through which at least part of the current undergoing interruption flows, which, preferably in conjunction with magnetically susceptible material (26,27), provides a magnetic field in the vicinity of at least one of said contacts (11 or 15, 12 or 16; 106 or 108), characterised in that the magnetic field is substantially normal to a shock front which tends to be set up by establishment of an arc between the contacts (11,15 and/or 12,16; 106,108) and has a value such as to cause the Alfven speed, at least in said vicinity in plasma associated with the arc, to be significantly in excess of the air speed attainable by such shock front.

2. An air break switch (10;110) according to claim 1 wherein the coil (20;120) is connected in series with the contacts (11,15 and/or 12,16; 106,108).

3. An air break switch (10;110) according to claim 1 or claim 2 wherein the direction and strength of the field in said vicinity causes a significant fraction of energy released by the arc to be dispersed mainly by oscillations of said plasma rather than mainly by one or more potentially damaging air shock fronts.

4. An air break switch (10;110) according to any one of the preceding claims wherein the switch has an arc chamber (17;117) for containing the arc while the energy thereof is dispersed, and wherein in said vicinity, the field is directed transversely to the length of the arc between the contacts (11,15 and/or 12,16; 106,108) and lengthwise of a path of arc travel extending from said vicinity into the chamber (17;117).

5. An air break switch (10;110) according to claim 4 wherein part or all of the coil (20;120) provides at least a part of the arc chamber (17;117).

6. An air break switch (10;110) according to claim 4 or claim 5 wherein at least a part of the coil (20;120) lies around at least one other switch component defining the arc chamber (17;117).

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7. An air break switch (10;110) according to any one of the preceding claims wherein the switch includes chutes (18;118) or runners (19;119) for sub-dividing the arc and wherein the magnetic field set up by the coil (20;120) extends lengthwise of the chutes (18;118) or runners (19;119).

8. An air break switch (10;110) according to claim 7 wherein the coil (20;120) is wound around at least portions of the chutes (18;118) or runners (19;119) with its axis parallel, or approximately parallel, to the lengths of the chutes (18;118) or runners (19;119).

9. An air break switch (110) according to any one of the preceding claims wherein the contacts (106 to 109) comprise a first cooperative pair (107,109) connected in parallel through said coil (120) with a second co-operative pair (106,108), which latter pair (106, 108) are arranged to open after the first pair (107,109) has opened, the arc being established between the second pair (106,108).

10. An air break switch (110) according to claim 9 wherein one of the contacts (106) of the second pair (106,108) is carried on the stem (104) of a T-shaped contact member (101), the cross piece (105) of which acts as one of the contacts (107) of the first pair (107,109), the other contact (108) of the second pair (106,108) and the other contact (109) of the first pair (107,109) being spaced from each other so that the pairs of contacts (107,109 and 106,108) open in the required sequence and being electrically connected to each other through said coil (120).

11. A method of at least reducing the generation of a shock wave at the site of an arc established between separable contacts (11,15 and/or 12,16; 106,108) of a switch (10;110) as these contacts (11,15 and/or 12,16; 106,108) open, said method comprising causing the current feeding the arc to flow in a configuration establishing a magnetic field at the site of the arc, characterised in that such field is substantially normal to a shock front which tends to be set up by the establishment of the arc and is of a form and strength to cause the Alfven speed at least in the vicinity of said site and in plasma associated with the arc to be significantly in excess of the air speed attainable by such shock front.

12. A method according to claim 11 wherein the field is established by the current in conjunction with magnetically susceptible material (26,27).

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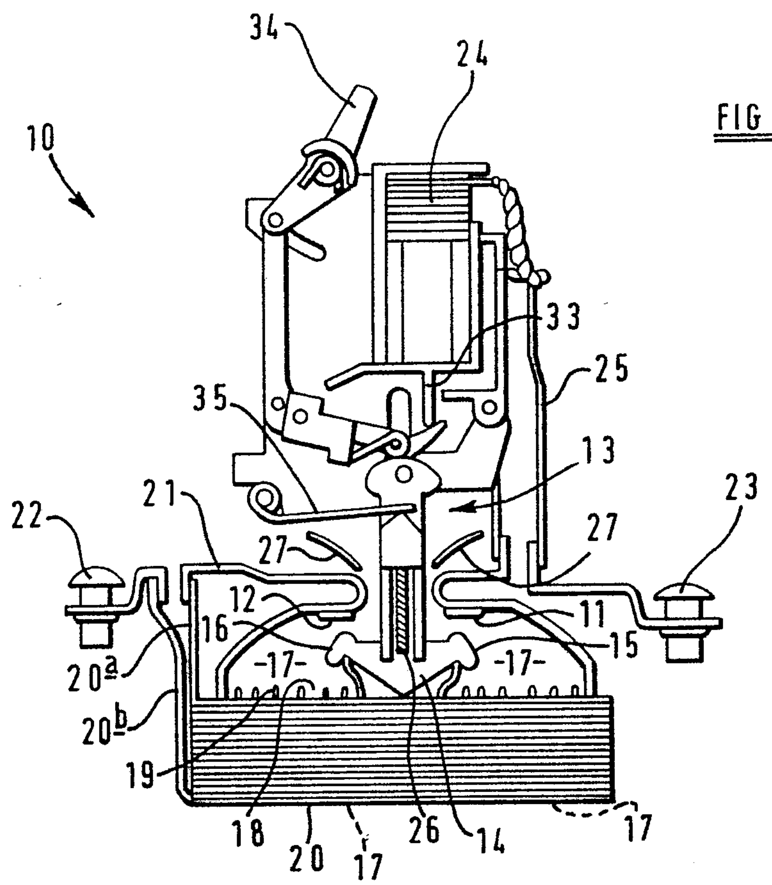


FIG 1

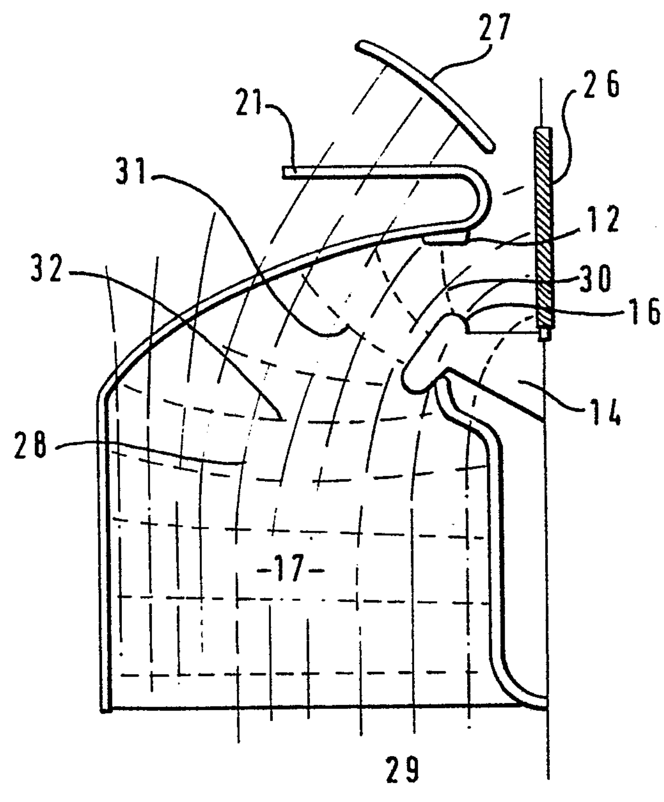
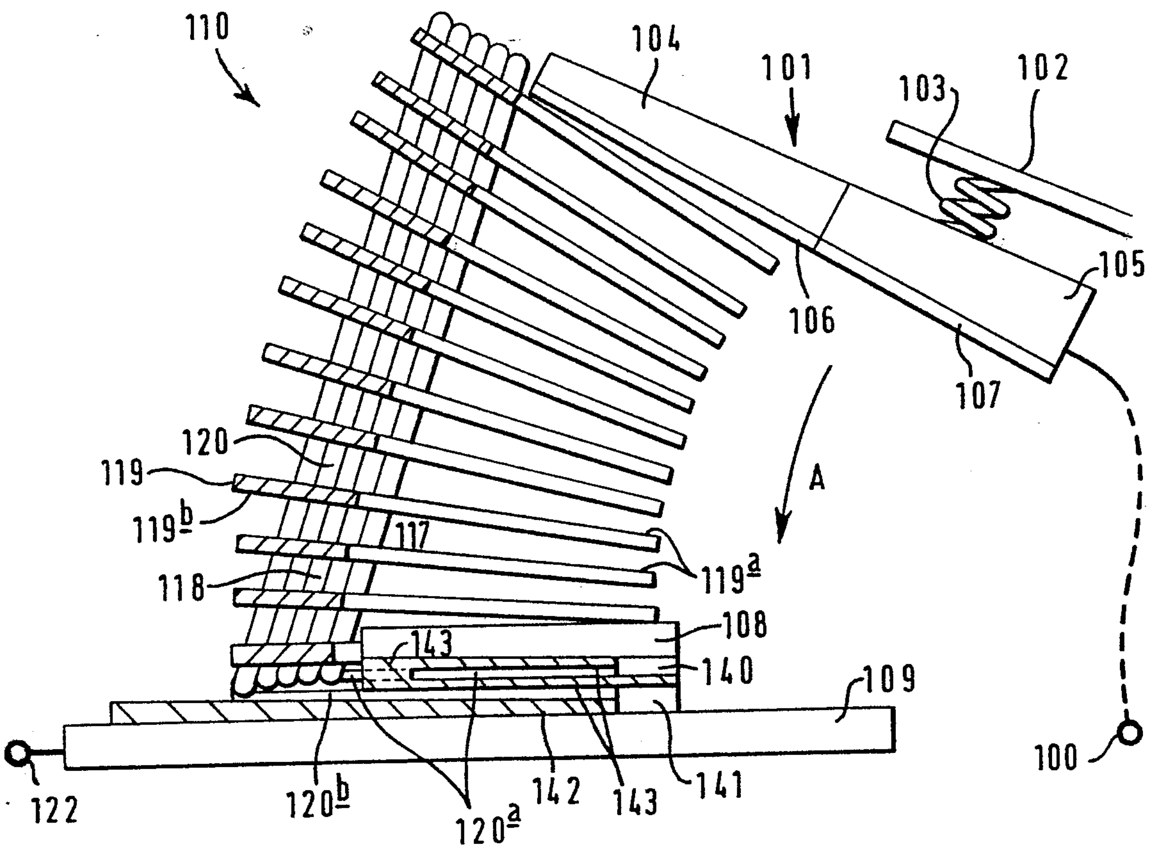


FIG 2


110
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120b
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FIG 3

European Patent Office

EUROPEAN SEARCH REPORT

0153433
Application number

EP 84 10 2154

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	FR-A-2 522 873 (COMPAGNIE GENERALE D'APPAREILLAGE ELECTRIQUE CGAE) * Page 1, lines 23-29; claims 1,4,10; figures 1,2 *	1,2	H 01 H 9/44
A	DE-C- 682 650 (AEG) * Page 1, line 25 - page 2, line 40; figures 1-4 *	1,2	
A	GB-A- 714 526 (SWITCHGEAR & COWANS LTD.) * Complete document *	1,7	
A	DE-A-2 700 117 (KLÖCKNER-MOELLER ELEKTRIZITÄTSGESELLSCHAFT MBH) * Page 3, paragraph 3 - page 4, figures *	7	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
D,A	GB-A-1 499 486 (HAZEMEIJER B.V.)		H 01 H 9/00 H 01 H 73/00
D,A	GB-A- 267 515 (SIEMENS-SCHUCKERTWERKE)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	18-10-1984	RUPPERT W

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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