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(54) **A medium-voltage vacuum circuit breaker and a related medium-voltage switchboard**

(57) A medium-voltage vacuum circuit breaker (100) comprising:

- a plurality of interruption poles (1) each having two connection terminals, and a vacuum envelope (4) which contains a fixed contact and a mobile contact electrically coupled each to a corresponding terminal;
- an operating mechanism (200) which has a front panel (7) and is suitable to supply actuating energy for moving the mobile contacts of the interruption poles between a circuit breaker closed position where they are each electrically coupled with the corresponding fixed contact and a circuit breaker open position where they are disengaged therefrom;

- means (300) for transmitting the actuating energy from the operating mechanism to the mobile contacts; characterized in that each interruption pole comprises an insulating box delimiting an internal free volume which accommodates a corresponding vacuum envelope, said interruption poles being aligned each other and being arranged so as the respective mobile contacts are movable, during actuation, along a substantial vertical axis, with the vertical axes of the interruption poles lying in a common vertical plane which is substantially perpendicular to the front panel, and in that said transmission means are positioned on a side of the aligned interruption poles.

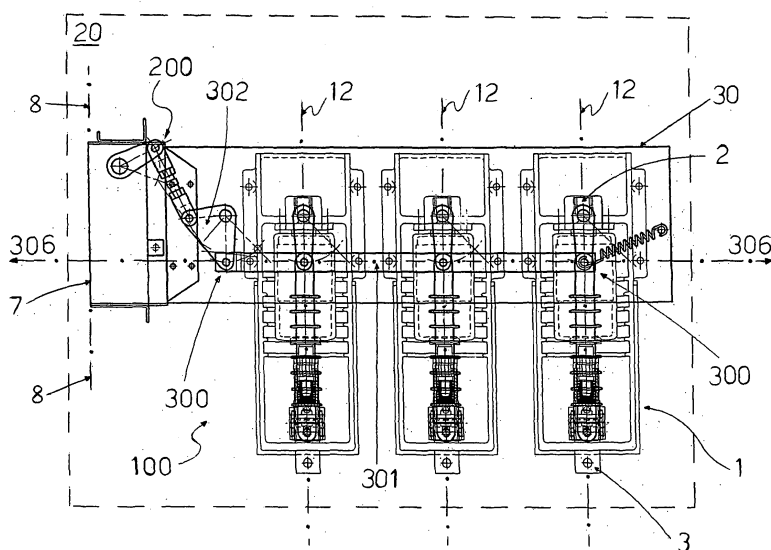


Fig. 1

Description

[0001] The present invention relates to a medium-voltage vacuum circuit breaker, in particular for applications with rated voltages up to 24 kV, having an extremely compact structure and improved functions and characteristics.

[0002] The medium-voltage circuit breaker according to the present invention is particularly suitable for use inside electric switchboards, preferably for secondary distribution applications; therefore, the present patent application also concerns a medium-voltage switchboard comprising a medium-voltage vacuum circuit breaker as defined in the claims.

[0003] In the field of electric power distribution, it is well known the use of medium voltage circuit breakers whose main task is to intervene in case of abnormal operating conditions, such as in presence of short-circuits, in order to prevent an electric line and the various equipments connected thereto from severe damages.

[0004] Usually, medium voltage circuit breakers are used inside switchboards or panels which are positioned at the points of the distribution network where the voltage of the electric power is lowered from high or very high values typical of the primary distribution, to values up to few tens of kV; from a constructive point of view, known switchboards have a substantially parallelepiped metallic structure whose internal space is divided into different compartments suitable to accommodate various components, e.g. a bus-bars compartment, a low-voltage compartment, a circuit breaker compartment, and so on.

[0005] One important aspect to be satisfied in practical applications, is to realize units with overall dimensions as much as possible reduced and with a simplified structure; to this end, many solutions have been proposed to the market offering circuit breakers with a compact structure and capable of guaranteeing the required dielectric strength among their live parts, and between these live parts and the metallic walls of the switchboard once a circuit breaker is positioned inside the dedicated compartment. For example, known solutions propose to enclose at least some live parts of the circuit breakers inside an enclosure filled with a gas having a dielectric capacity higher than air, or immersing them in appropriate insulating materials. Other solutions have been conceived trying to improve the constructive layout of the circuit interruption elements, and/or of the mechanical components of the circuit breakers, e.g. the operating/drive mechanism, and/or the transmission system between the operating mechanism and the interruption components.

[0006] At the present state of the art, prior solutions are not entirely satisfying, in particular as regard to the construction of the circuit breakers which still have a quite bulky and relatively complicated structure, thus having a negative impact also on the size of the accommodating switchboards.

[0007] The main aim of the present invention is therefore to provide a medium-voltage vacuum circuit breaker

- and a relative switchboard- which allow some improvements over prior art solutions, and in particular as regard to overall compactness and optimization of the structure.

[0008] This aim, is achieved by a medium voltage vacuum circuit breaker comprising:

- a plurality of interruption poles each comprising a first connection terminal and a second connection terminal, and a vacuum envelope which contains a fixed contact electrically coupled to said first connection terminal and a corresponding mobile contact electrically coupled to said second connection terminal;
- an operating mechanism which is provided with a front panel and is suitable to provide actuating energy for moving the mobile contacts of said plurality of interruption poles between a circuit breaker closed position where they are each electrically coupled with the corresponding fixed contact and a circuit breaker open position where they are disengaged therefrom;
- transmission means for transmitting the actuating energy from the operating mechanism to the mobile contacts; characterized in that each interruption pole comprises an insulating box delimiting an internal free volume which accommodates a corresponding vacuum envelope, said interruption poles being aligned each other and arranged so as the respective mobile contacts are movable, during actuation, along a substantial vertical axis, with the vertical axes of the interruption poles lying in a common vertical plane which is substantially perpendicular to the front panel, and in that said transmission means are positioned on a side of the aligned interruption poles.

[0009] This aim is also achieved by a medium voltage switchboard as defined in the related claims.

[0010] Further characteristics and advantages of the invention will become apparent from the description of preferred but not exclusive embodiments of a medium-voltage vacuum circuit breaker according to the invention, and a related medium-voltage switchboard comprising such a circuit breaker, illustrated only by way of non-limitative examples in the accompanying drawings, wherein:

Figure 1 is a side view illustrating an embodiment of a medium-voltage vacuum circuit breaker according to the invention;

Figure 2 is a perspective view illustrating the medium voltage vacuum circuit breaker according to the invention;

Figure 3 is a view illustrating the interruption poles and the operating mechanism of the circuit breaker of Figure 2 from a different perspective;

Figure 4 is a cross-section partially showing an interruption pole of the circuit breaker of figures 1-3;

Figure 5 is a schematic perspective view of a medi-

um-voltage switchboard comprising the medium voltage vacuum circuit breaker according to the invention.

[0011] Figures 1-3 show a medium-voltage vacuum circuit breaker, generally indicated by the reference numeral 100, which comprises a plurality of interruption poles 1; in the embodiment illustrated in the figures, the circuit breaker 100 comprises three interruption poles 1, but the number of interruption poles could be varied according to various applications or in case of specific needs.

[0012] Each interruption pole 1 comprises: a first connection terminal 2 and a second connection terminal 3 which are suitable to allow input/output electrical connections of the pole 1, for example with a power feeding line and a load, not illustrated in the figures; and a vacuum envelope 4, e.g. a vacuum bottle, or vessel or bulb or equivalent term, which contains a fixed contact, schematically illustrated in figure 4 by the reference number 5, which is electrically connected to the first connection terminal 2, and a corresponding mobile contact 6, schematically illustrated in figure 4 by the reference number 6, which is electrically connected to the other connection terminal 3.

[0013] The circuit breaker 100 further comprises an operating mechanism, overallly indicated by the reference number 200 in figures 1-2, which is provided with a front panel 7; the front panel 7 has a front face lying on a substantial vertical plane, indicated in figure 1 by the reference 8. As roughly illustrated in figure 1, on said front face there might be provided some functional components, such as for example, opening and closing push-buttons 9, an operation counter 10, a handle 11, et cetera, suitable for direct vision or intervention of users.

[0014] The operating mechanism 200 is suitable to supply the actuating energy required for moving the mobile contacts 6 of the plurality of interruption poles 1, between a circuit breaker closed position where each mobile contact 6 is electrically coupled with the corresponding fixed contact 5, and a circuit breaker open position where each mobile contact 6 is instead electrically disengaged from the corresponding fixed contact 5. The construction and functioning of the operating mechanism 200 are well known in the art and are not part of the innovative aspects of the circuit breaker 100 according to the present invention, and therefore it will not be described in more details hereinafter; for example, it is possible to use a known operating mechanism of the so-called EL type, which is already available on the market and is used by the same applicant in other types of medium voltage circuit breakers.

[0015] The circuit breaker 100 further comprises transmission means indicated in figure 1 by the overall reference 300 for transmitting the actuating energy from the operating mechanism 200 to the mobile contacts 6 of the interruption poles 1.

[0016] As better illustrated in figures 1 and 3, in the

circuit breaker 100 according to the invention, the interruption poles 1 are advantageously aligned each other behind the operating mechanism 200 along a direction perpendicular to the front panel 7; in particular, the interruption poles 1 are arranged so as the respective mobile contacts 6 are movable, during actuation, along a substantial vertical axis 12, with the vertical axes 12 of the various interruption poles 1 which lie in a common vertical plane indicated in figure 2 by the reference number 20 (which practically coincides with the sheet of figure 1); said vertical plane 20 is substantially perpendicular to the vertical plane 8 on which the front face of the front panel 7 lies.

[0017] Advantageously, the first connection terminal 2 and the second connection terminal 3 of each pole 1 are arranged at the ends of the interruption pole itself; according to a particularly preferred embodiment, as illustrated in figure 4, the connection terminals 2 and 3 of each interruption pole 1 are arranged so as at least their portions 2a, 3a which are suitable to be structurally connected to other conducting elements, e.g. for input/output electrical connections, extend along vertical directions substantially parallel to the vertical axis 12 of the related corresponding pole 1. In this way, by exploiting the vertical dimension for both connections, it is possible to optimize the space occupation and the mutual distances in the transversal direction.

[0018] As an example, in the embodiment illustrated in figure 4, the first terminal 2 has an L-shaped configuration while the second terminal 3 is rectilinear and completely positioned vertically.

[0019] Preferably, as better evidenced in figure 2, the interruption poles 1 are formed each by a single module, with the various modules which are structurally separated from each other and are fixed, e.g. by means of screws 13, to an elongated supporting member 30; advantageously, as shown in figures 2 and 3, the elongated supporting member 30 is positioned on a side of and parallel to the aligned interruption poles 1, in correspondence of one of their end portions.

[0020] Advantageously, each interruption pole 1 comprises an insulating box which is formed by two separate parts, e.g. a cover piece 14 and a base piece 15 connected together, and is fixed, through the screws 13, to the elongated supporting member 30. The insulating box 14-15 has an internal free volume inside which the vacuum envelope 4 is positioned; in particular, as shown in figure 3 wherein the box is represented cut for the sake of clarity of illustration, one of the two forming pieces, e.g. the piece 15 has a shaped body formed monolithically which comprises two internal walls 16 which are spaced from each other and protrude transversally, preferably horizontally, from the lateral sides of the box towards the inside; said walls 16 are provided each with a corresponding slot 17. As illustrated in figure 3, each vacuum envelope 4 is inserted inside a corresponding box and fixed to the walls 16 with its end portions accommodated within and passing through the slots 17; accord-

ingly, the vacuum envelopes 4 are arranged in a substantial vertical position directly in a dedicated air environment, i.e. without the need of insulating gases.

[0021] With further advantages in terms of proper electrical insulation, the piece 15 is provided with a series of ribs 18 which are positioned on the internal side and allow increasing the creepage distance.

[0022] According to a preferred embodiment, the transmission means 300 are in turn positioned on a lateral side of and preferably parallel to the aligned interruption poles 1; advantageously, in the circuit breaker 100 according to the invention, the transmission means 300 comprise at least one actuating rod 301 which is common to all the interruption poles 1 and is positioned between the poles themselves and the supporting elongated member 30. In the embodiment illustrated, as shown in figure 4, in the circuit breaker 100 there are provided two parallel actuating rods 301 which are common to all the interruption poles 1, and are mechanically coupled to each other so as to move together as a unique body. The actuating rods 301 are mechanically coupled to the operating mechanism 200, for example by means of a coupling lever 302, and to the mobile contacts 6 of each interruption pole 1, e.g. by means of suitable elements, such as a transmission lever 303, an insulating connecting rod 304, and a rocking lever 305, illustrated in figure 4. Preferably, the actuating rods 301 are arranged so as to transmit the actuating energy from the operating mechanism 200 to the movable contacts 6 through a rectilinear movement along an axis 306 which virtually intersects the front face of the front panel 7; in particular, as shown in figure 1, the actuating rods 301 are arranged parallel to the aligned interruption poles 1 (i.e. parallel to the vertical plane 20) at a region comprised between the end portions of the poles themselves, and in such a way that the axis 306 lies in a substantially horizontal plane, schematically represented in figure 3 by the reference number 307, is perpendicular to the vertical axes 12 along which the movable contacts 6 move, and intersects the front face of the panel 7 at a right angle.

[0023] According to a particularly preferred embodiment illustrated in figures 3 and 4, the actuating rods 301 are arranged so as to cross transversely the insulating boxes 14-15 in correspondence of suitable holes 19 provided on their body.

[0024] It has been found that the medium-voltage vacuum circuit breaker according to the invention fully achieves the intended aim providing some significant advantages and improvements over the known solutions. Indeed, as above described, the circuit breaker 100 thanks to the constructive layout and positioning of the various components, in particular; of the aligned interruption poles 1 with the respective connection terminals 2, 3 positioned vertically and parallel to the axes 12 of movements of the mobile contacts 6; of the adoption of the translating rods 301 and their arrangement relative to the aligned poles 1 and to the front panel 7; of the supporting member 30; and also of the insulating boxes

14-15; has a whole structure which is extremely compact, sturdy, and functionally effective at the same time. To this end, further improvements and significant advantages are achieved by the adoption of the insulating boxes which perform at the same time a structural function in supporting the components of the poles and an electrical insulating task; indeed, the boxes 14-15 constitute an insulating barrier between the vacuum envelopes and among them and the other elements, in particular the transmission means 300. Further, the insulating box 14-15, thanks to their structure, ease the operations for installing the interruption poles, as well as for possible maintenance interventions.

[0025] The circuit breaker 100 according to the invention, is particularly suitable for use and realization of very compact medium voltage switchboards, an example of which is schematically indicated with the reference number 50 in figure 5; therefore, a further object of the present invention is constituted by a medium voltage switchboard of the type having a top wall 51, a bottom wall 52, a back wall 53, a front wall 54, and two side walls 55 all together defining an internal space suitable to accommodate electrical/electronic devices, characterized in that it comprises a medium voltage circuit breaker 100 as previously described and defined in the claims, and in particular with a rated voltage of 24kV. According to a particularly preferred embodiment, the switchboard 50 has a frontal width, measured as the distance 56 between the external surface of the two side walls 55 which is equal or less than 500 mm. Medium voltage switchboards having such a reduced width and including a medium voltage circuit breaker 100 with rated voltage up to 24 KV, and in particular with a specific rated voltage of 24 kV, without gas insulation are not available at the present state of the art.

[0026] The medium voltage vacuum circuit breaker thus conceived -and the related switchboard- are susceptible of modifications and variations, all of which are within the scope of the inventive concept as defined in the claims and the above description; all the details may furthermore be replaced with technically equivalent elements. In practice, the materials used, as well as the dimensions, may be any according to the requirements and the state of the art so long as they are compatible with the specific use and allow to achieve the intended results.

Claims

1. A medium-voltage vacuum circuit breaker comprising:

- a plurality of interruption poles each comprising a first connection terminal and a second connection terminal, and a vacuum envelope which contains a fixed contact electrically coupled to said first connection terminal and a correspond-

ing mobile contact electrically coupled to said second connection terminal;

- an operating mechanism which is provided with a front panel and is suitable to supply actuating energy for moving the mobile contacts of said plurality of interruption poles between a circuit breaker closed position where they are each electrically coupled with the corresponding fixed contact and a circuit breaker open position where they are disengaged therefrom;

- transmission means for transmitting the actuating energy from the operating mechanism to the mobile contacts;

characterized in that each interruption pole comprises an insulating box delimiting an internal free volume which accommodates a corresponding vacuum envelope, said interruption poles being aligned each other and being arranged so as the respective mobile contacts are movable, during actuation, along a substantial vertical axis, with the vertical axes of the interruption poles lying in a common vertical plane which is substantially perpendicular to the front panel, and **in that** said transmission means are positioned on a side of the aligned interruption poles.

2. The circuit breaker according to claim 1, **characterized in that** said transmission means comprise an actuating rod which is mechanically coupled to the operating mechanism and to the movable contact of each of the interruption poles, said actuating rod being arranged so as to transmit the actuating energy from the operating mechanism to the movable contacts by moving along a rectilinear axis.

3. The circuit breaker according to claim 2, **characterized in that** said actuating rod is arranged so as to cross transversely the insulating box of each interruption pole.

4. The circuit breaker according to one or more of the preceding claims, **characterized in that** said actuating rod is positioned parallel to the aligned poles with its axis of movement which intersects the front panel at right angle and is perpendicular to said vertical axes.

5. The circuit breaker according to one or more of the preceding claims, **characterized in that** each insulating box comprises two separate parts coupled together, the insulating boxes being fixed to an elongated supporting member which is positioned on a side of and parallel to the aligned interruption poles with said actuating rod interposed therebetween.

6. The circuit breaker according to one or more of the preceding claims, **characterized in that** said first and second connection terminals of each pole are

arranged at the end portions of the corresponding interruption pole.

7. The circuit breaker according to claim 6, **characterized in that** said first and second connection terminals both have at least a connection portion which extends parallel to the corresponding vertical axis.

8. The circuit breaker according to claim 5, **characterized in that** one of said two parts comprises a monolithic body having two internal walls which are spaced from each other and protrude transversally from the side walls of the box towards the inside of said free volume, said internal walls being provided each with a corresponding slot.

9. The circuit breaker according to claim 8, **characterized in that** said part provided with the internal walls comprises a plurality of ribs which are positioned along the internal faces of the side walls.

10. The circuit breaker according to one or more of the preceding claims, **characterized in that** each vacuum envelope is positioned in a substantially vertical position in air inside a respective insulating box, with its end portions connected to said internal walls.

11. A medium voltage switchboard comprising a frame having a top wall, a bottom wall, a back wall, a front wall, and two lateral walls all together defining an internal space suitable to accommodate electrical/electronic devices, **characterized in that** it comprises a medium voltage circuit breaker according to one or more of the preceding claims which is positioned inside said internal space.

12. The switchboard according to claim 11 **characterized in that** it has a frontal width which is equal or less than 500 mm.

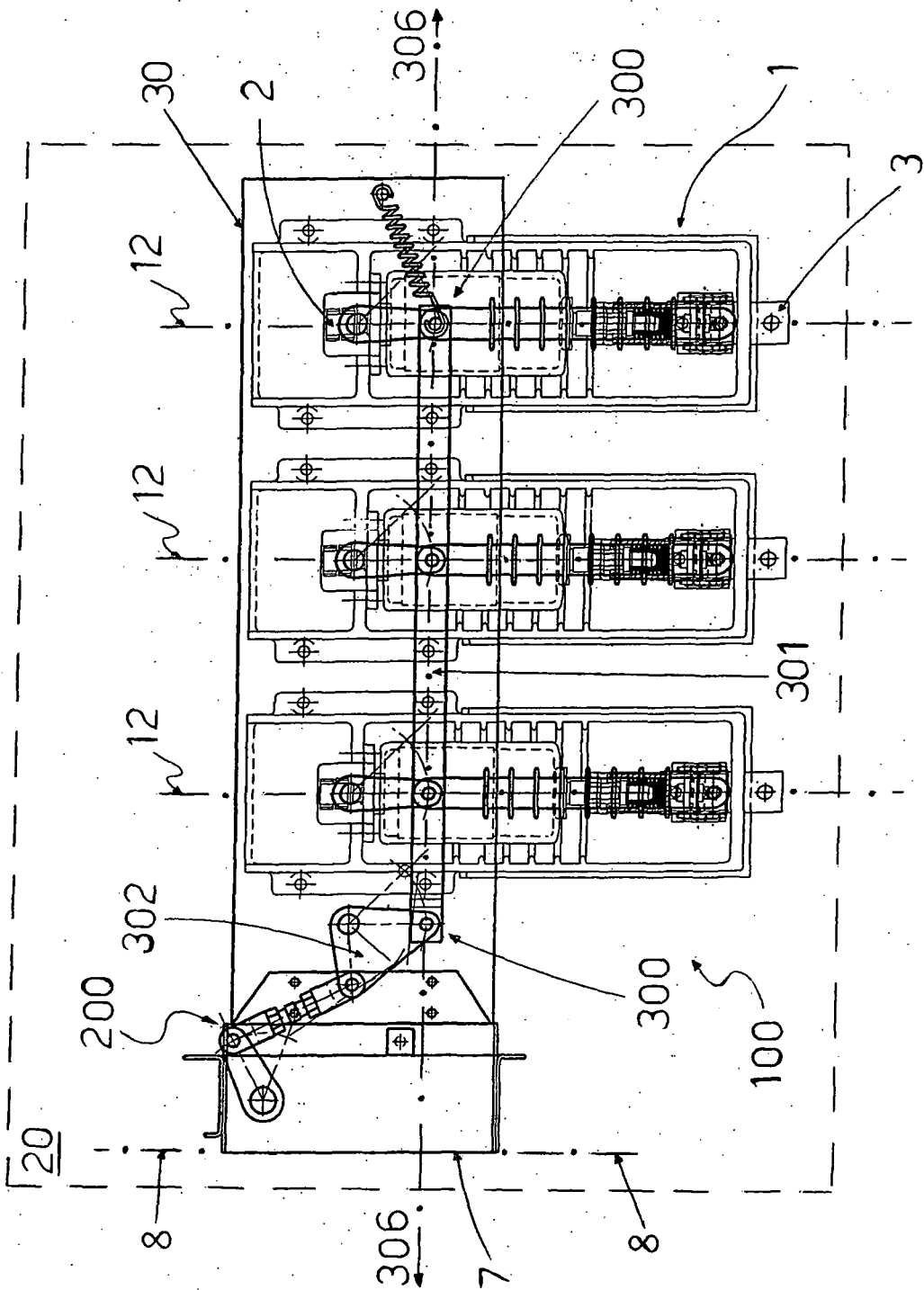


Fig. 1

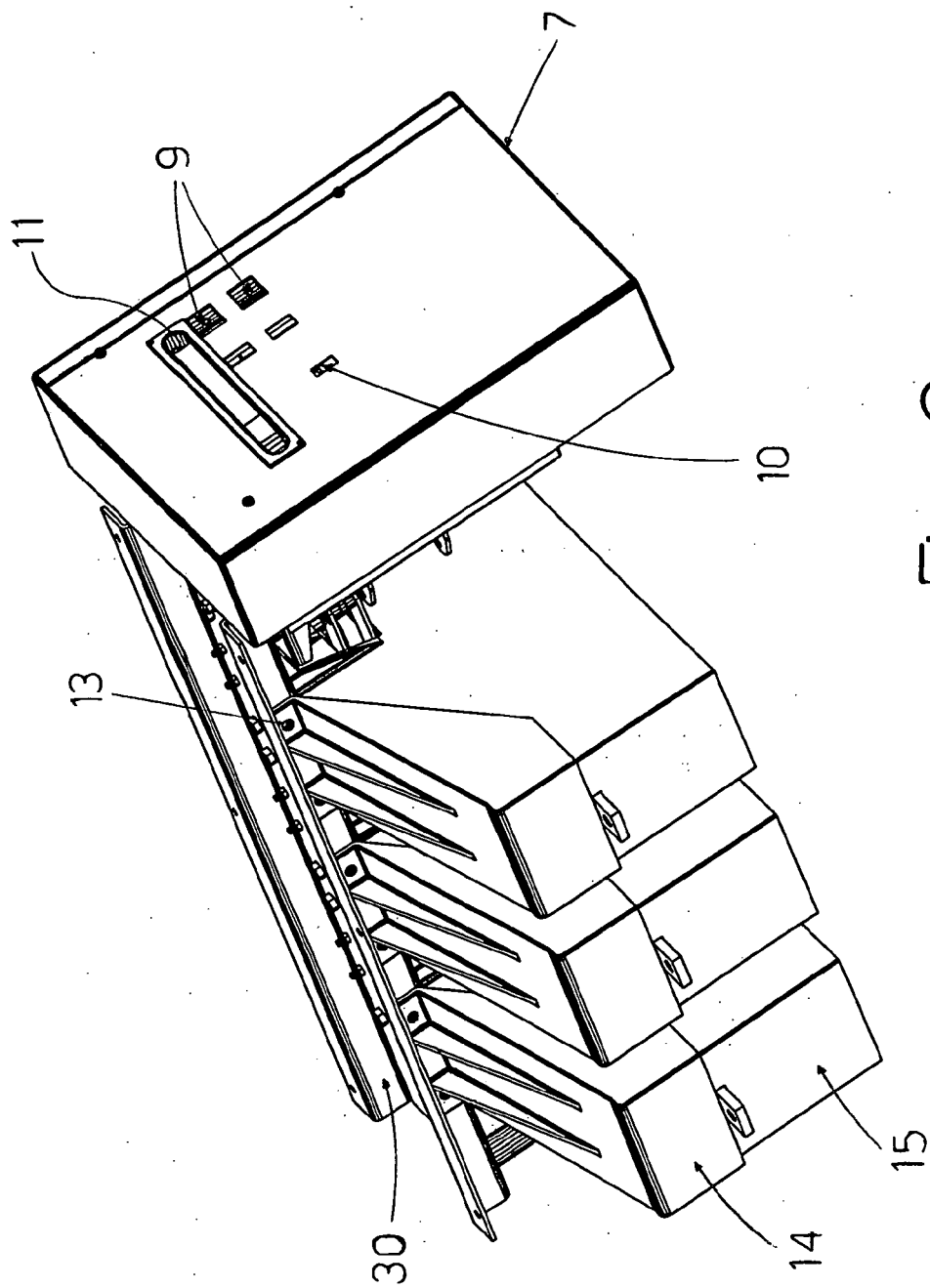


Fig. 2

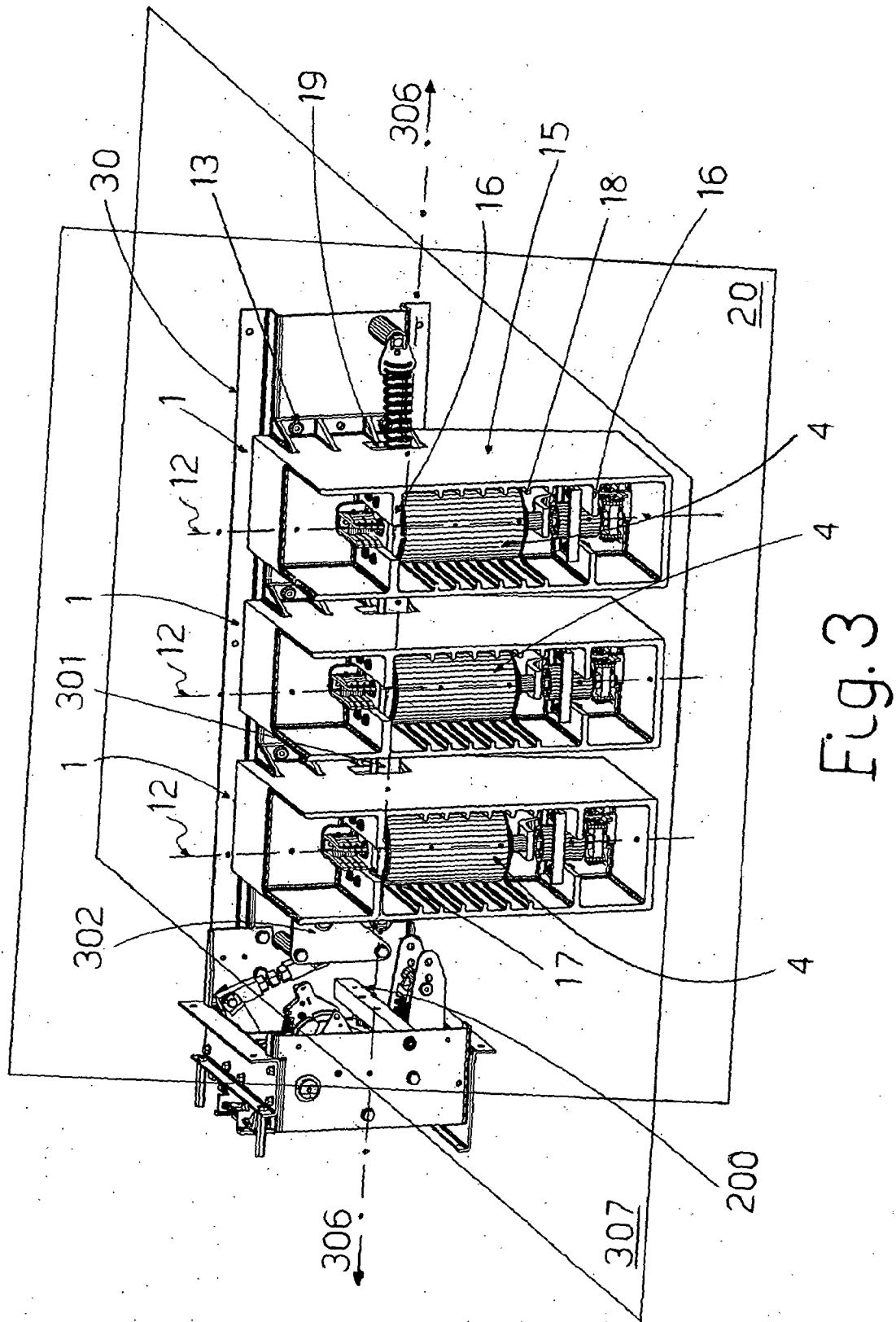


Fig. 3

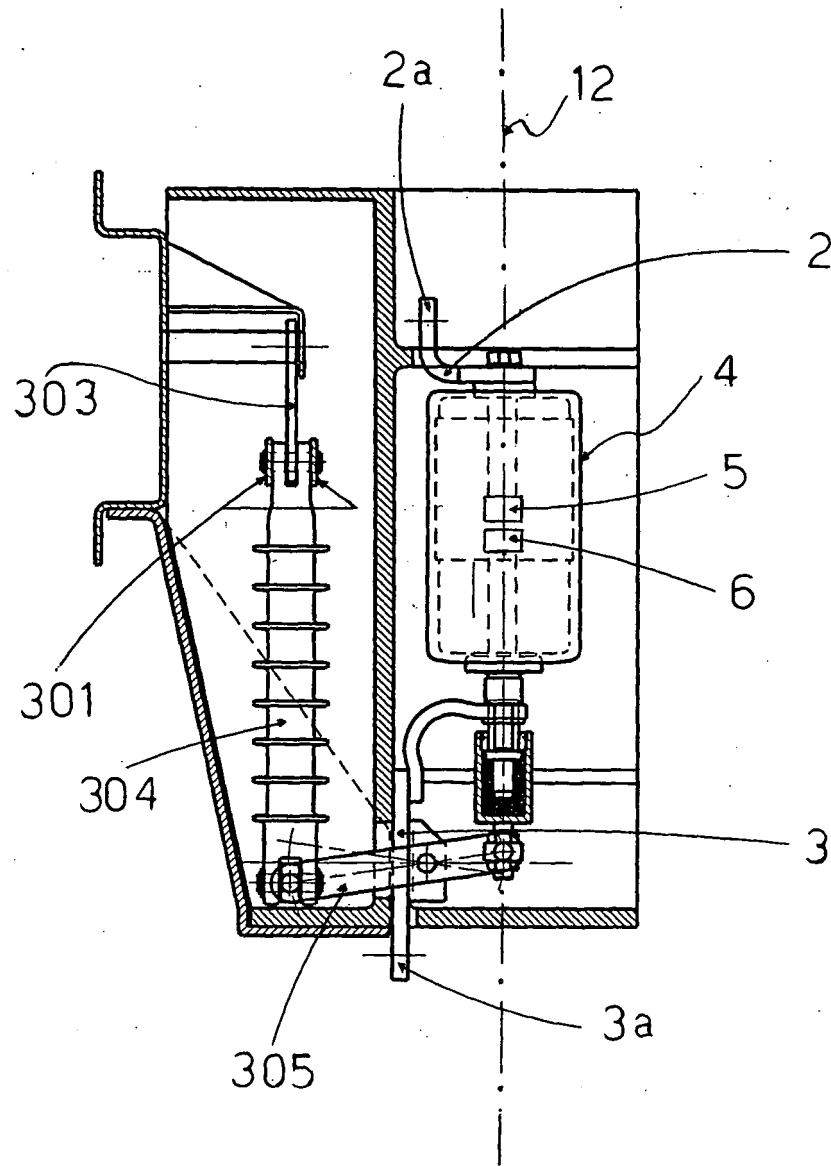


Fig. 4

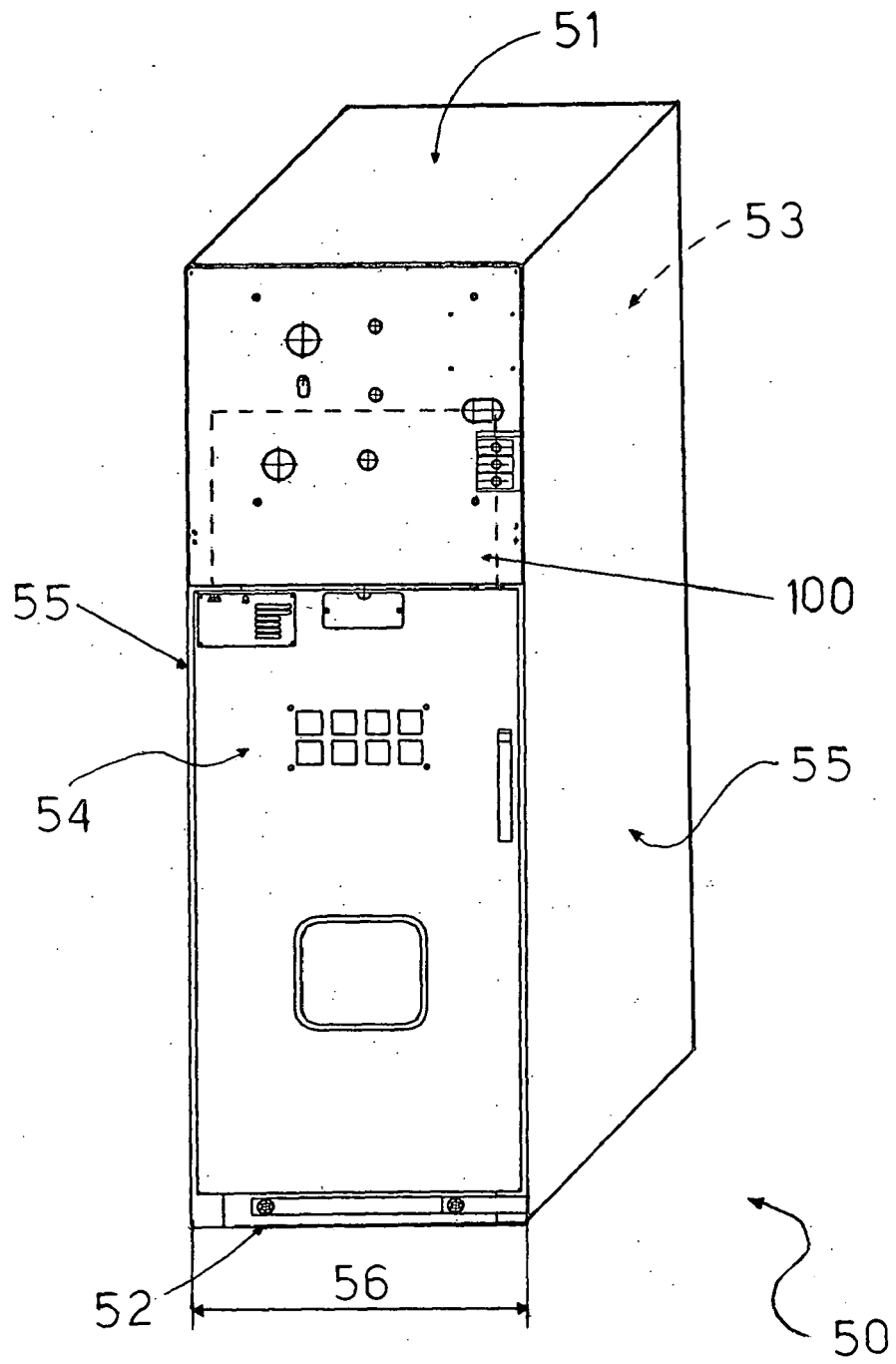


Fig. 5



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 05 07 7252

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 28 February 2006	Examiner Simonini, S
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 05 07 7252

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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