(54) Title: AN ELECTRIC SWITCHING DEVICE, A METHOD FOR CONTROLLING THE DEVICE AND A USE OF THE SWITCHING DEVICE

(57) Abstract: An electric switching device for switching over a current path from a first electric conductor (7) to a second electric conductor (8), comprising a first contact member (1) and a set of second contact members (2, 3, 4, 5), which are arranged after each other along a path. The first contact member (1) is movably arranged in relation to the second contact members along said path for the achievement of an electric connection with each of these. The set of second contact members comprises two main contact members (2, 5), each of which being connected to one of said conductors (7, 8), and at least one switching contact member (3, 4) arranged between the main contact members. The first contact member (1) is arranged to allow the simultaneous contacting of two adjacent second contact members. The switching device further comprising an arrangement (10) connected to said switching contact member (3, 4) and said two conductors (7, 8) for connecting and disconnecting said switching contact member (3, 4) to and from, respectively, said two conductors (7, 8).
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
An electric switching device, a method for controlling the device and a use of the switching device

FIELD OF THE INVENTION AND PRIOR ART

The present invention relates to an electric switching device for switching over a current path from a first electric conductor to a second electric conductor, comprising a first contact member and a set of second contact members, which are arranged after each other along a path, the first contact member being movably arranged in relation to the second contact members along said path for the achievement of an electric connection with each of these, said set of second contact members comprising two main contact members, each of which being connected to one of said conductors, and at least one switching contact member arranged between the main contact members, and the first contact member being arranged to allow the simultaneous contacting of two adjacent second contact members.

The switching device is particularly intended for switching over a current path between two electric conductors in such a case when the current should not be broken during the switching over. The switching device is more closely intended to be used for switching over a current path in components in electric power plants or electric power networks. The switching device is intended to be used for system voltages exceeding 1 kV. The switching device is particularly intended for use as a load coupler in a tap changer for a transformer. Here, a so-called dry transformer is particularly referred to. Such a transformer is de-
scribed in the document WO 97/45847. The windings here consist of a cable with an electrically conductive conductor, a semiconducting inner layer surrounding the conductor, an electrically insulating cable body surrounding the inner layer, and a semiconducting outer layer surrounding the cable body. The inner layer is in electric contact with the conductor and has the same potential as this. The potential of the outer layer is controllable and is normally set to zero by grounding of the outer layer. Such a winding has the characteristic that it, in the cable body between the inner and the outer layer, encloses the electrical field that surrounds the conductor of the cable. Since the outer layer has a constant potential, adjacent turns of the winding do not have to be insulated from each other. If the potential of the outer layer furthermore is connected to ground, the windings do not have to be insulated from the transformer core and the transformer can operate without any electrically insulating transformer oil, which results in a number of technical and environmental advantages.

Furthermore, the invention relates to a method for controlling the switching device according to the preamble of subsequent claim 16.

When using the invention as a load coupler in a tap changer for a transformer, the switching over of the current path should be carried out in such a way that neither current interruption ensues nor step short-circuiting of the transformer takes place. According to an example of a known such load coupler in a tap changer for a transformer with the windings arranged in transformer oil, two switching contact members are arranged between the main contact members along said path. Each of these switching contact members is connected to the conductor from the adjacent main contact member via a resistor. The contact members are furthermore arranged in said transformer oil. Arcs ensue during the movement of the first contact member, which has a destructive influence on the oil and wears out contact
parts. Due to the generation of power loss in the resistor when a large current flows through it, a very rapid movement of the first contact member is required. Such a movement is normally denominated a changing-over. The movement is effectuated by means of a spring unit. A further disadvantage of the known load coupler is that contact parts are worn out during the rapid movement.

SUMMARY OF THE INVENTION

A primary purpose of the invention is to provide ways to design the device and the method so that the occurrence of arcs and problems related thereto are reduced in relation to previous technique during the switching over of a current path between two conductors. A further purpose of the invention is to create prerequisites for a more controlled switching over of the current path.

The primary purpose is achieved in that the switching device comprises an arrangement, connected to said switching contact members and said two conductors, for connection and disconnection of said switching contact members to and from, respectively, said two conductors. By a suitable control of said connection and disconnection, the occurrence of arcs during the movement of the first contact member can be eliminated or at least strongly reduced. In that an electric connection between said switching contact members and each of said conductors can be achieved and broken, prerequisites are furthermore created for carrying out the movement of the first contact member with a lower velocity in relation to the second contact members as compared to previous technique. This results in a reduced wear on the contact parts and possibilities of, for instance, interrupting the movement in case of an error.

According to a preferred embodiment of the invention, the device comprises two switching contact members arranged be-
tween the main contact members, and the switching arrangement being arranged for connecting and disconnecting each of these to and from, respectively, only one of said two electric conductors. To be precise, each of the switching contact members is arranged for connection and disconnection to and from, respectively, the conductor that connects to the main contact member that is arranged adjacent to the switching contact member. When using the switching device as a load coupler in a tap changer for a transformer, the risk is hereby reduced of the switching arrangement short circuiting the winding section of the transformer that is connected to the conductors and being damaged by transients of the current.

According to another preferred embodiment of the invention the switching arrangement comprises two switching members, which are arranged for breaking and closing, respectively, the current paths between said switching contact members and the electric conductors. Each of the switching members comprises an electric circuit, which connects two poles, a first of which is electrically connected to the switching contact member and a second of which is electrically connected to said conductors. By a suitable design of the electric circuit, the switching member can rapidly be made to close and break, respectively, an electric current path between the poles.

According to a particularly preferred embodiment of the invention, each switching member comprises a controllable power semiconductor device arranged to be controllable between said states of closing and breaking current paths. In this connection, it is especially advantageous if the power semiconductor device also can be turned-off. Such a power semiconductor device can for instance be an IGBT. In previously known devices of the kind defined by way of introduction, such as the one known from DE 2 209 500, so called vacuum bottles are used instead of such power semiconductor devices, which implies that resistors have to be connected in series for the current to take the correct way
and be limited in the respective state. The losses in these resistors are considerable. Thanks to the invetional arrangement of a controllable power semiconductor device instead of such vacuum bottles, the necessity of such resistors disappears and the losses in the switching arrangement itself can be reduced considerably.

According to a further development of the abovementioned embodiment, the device comprises at least one arrangement for proving the function of one of said switching members. The proving arrangement comprises a current source connected to the switching member and a means for current detection connected in series with the current source. In this way, by a suitable design of the proving arrangement as to the rest, it can be proved that the switching member is functioning. The proving of the function is suitably carried out before as well as after the closing and breaking operation, respectively.

According to a further development, the device comprises a power member, suitably in the form of an electric motor, for the achievement of the movement of the first contact member in relation to the second contact members. The power member is connected to a network. Furthermore, the device comprises a member for storing electric energy, which is connected in parallel with the power member. In case of drop of the supply voltage from the network to the motor, the risk of the first contact member ending up in a position between the two main contact members is thereby reduced. In this way, the movement of the first contact member can be controlled in such a way that the different parts of the movement operation can be carried out in optimal time intervals.

The connection and disconnection of said switching contact members to the first conductor and from the second conductor, respectively, is carried out at least essentially while the current through these, which is an alternating current, has a zero-
crossing. Zero-crossing here refers to that the current through said switching contact member goes towards zero and changes polarity, which takes place twice every twentieth millisecond in a 50 Hz-network. The changing-over of said switching contact member from the first conductor to the second conductor is preferably carried out essentially instantaneously at the zero-crossing. In this way, the risk of arcs ensuing at the changing-over operation is practically eliminated.

10 Further advantages and features of the invention, in particular concerning the invention's method, appear from the following description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

15 With reference to the enclosed drawings, a more specific description of an embodiment example of the invention will follow hereinafter:

20 Fig 1 illustrates schematically the switching device according to the preferred embodiment.

Fig 2 illustrates an example of an arrangement comprised in the switching device for proving the function of a switching member.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Fig 1 illustrates a switching device according to a preferred embodiment. A first switching member 1 is displaceably arranged in relation to a set of stationary, second contact members 2, 3, 4, 5. The first contact member 1 is more specifically displaceably arranged on a contact means 6 in electrical contact with the same. The contact means 6 here consists of an electric contact rail and defines an essentially rectilinear movement path for the first contact member 1.
Said set of second contact members comprises two main contact members 2, 5. The main contact member 2 being the left one in the figure is constantly connected to a first electric conductor 7 and the main contact member 5 being the right one in the figure is constantly connected to a second electric conductor 8. The contact means 6 is connected to a further electric conductor 9. In the example illustrated in Fig 1, there is a current path from the conductor 9 via the contact means 6, the first contact member 1, the left main contact member 2 and the first conductor 7. After a terminated movement of the first contact member 1 from the left to the right in the figure, the first contact member 1 will be arranged in electric connection with the second main contact member 5. The current path has then been switched over from the first conductor 7 to the second conductor 8.

A branching 7a of the first conductor 7 leads via a switching arrangement 10 to a switching contact member 3 located between the main contact members 2, 5. The switching contact member 3 is more specifically connected to the branching 7a via an electrically controlled switching member 11. In a corresponding way, a further switching contact member 4 is connected to a branching 8a from the second conductor 8 via an electrically controlled switching member 12. Each of the switching members 11, 12 mechanically connects two poles 13, 14, a first 13 of which is electrically connected to the switching contact member 3 and 4, respectively, and a second 14 of which is electrically connected to said conductors 7 and 8, respectively. Closing and breaking, respectively, of each of the switching members 11, 12 is controlled by a control unit 15.

A power member 16, for instance in the form of an electric motor, is arranged for the movement of the first contact member 1. The electric motor 16 is connected to a network 17 for voltage supply. A member 18 for storage of electric energy is connected in parallel with the electric motor 16. The energy storage mem-
ber consists, in the preferred example, of a capacitor, but can of course also consist of any other energy storage component, such as a battery. The capacitor is chosen with a sufficient energy storage capability for being able to provide the electric motor 16 with sufficient electric energy for this to be able to move the first contact member 1 from the left main contact member 2 to the right main contact member 5. In this way, it is guaranteed that the first contact member 1 will not stop in a position between the main contact members 2, 5 in case of a voltage drop off from the network 17.

According to an example of an operation for switching over the current path from the first conductor 7 to the second conductor 8, the switching device is controlled in the following way:

The switching member 11 is made to electrically connect the switching contact member 3 and the first conductor 7. Thereafter, the first contact member 1 is moved to a position, in which it contacts the switching contact member 3. When the first contact member 1 drops the contact with the main contact member 2, the current path is led only to the first conductor 7 via the switching contact member 3 and the switching member 11. Thereafter, the first contact member 1 is moved to a position, in which it is in electric contact with the left switching contact member 3 as well as the right switching contact member 4. When the current, which is an alternating current, has a zero-crossing, or at least within a relatively short time interval around the zero-crossing, the switching member 11 is made to break the current from the switching contact member 3 to the first conductor 7 and the switching member 12 is made to essentially simultaneously close the electric contact between the switching contact member 4 and the second conductor 8. In this way, the current path has now been switched over from the first conductor 7 to the second conductor 8. Hereafter, the first contact member 1 is moved into electric contact with the right main contact member 5. Then the switching member 12 is suitably
made to break the electric connection between the switching contact member 4 and the second conductor 8. In order to eliminate the risk of current interruption during the switching operation, the first contact member is arranged to contact to adjacent second contact members 2, 3, 4, 5 simultaneously during the movement.

Fig 2 illustrates an arrangement 19 for proving the function of one of said switching members 11. The proving arrangement 19 comprises a current source 20 and a current detection means 21, connected in series with the current source 20. In the embodiment illustrated in Figs 1 and 2, the switching member 11 comprises a transistor 22 for effectuating said breaking and closing. The transistor 22 more specifically consists of a so-called IGBT (Insulated Gate Bipolar Transistor). The power source 20 consists of a transformer, which generates alternating current. A rectifier diode 23 is connected in series with the transformer 20 between the transformer 20 and the current detection means 21. The diode 23 prevents voltages lying across said IGBT from carrying a current through the current detection means 21, when the first contact member 1 is electrically connected with the pole 13 and said IGBT breaks the electric connection between the poles 13 and 14. The current source 20 is connected to an input terminal in the form of a collector 25 in said IGBT 22. An output terminal in the form of an emitter 25 in said IGBT is connected to the current detection means 21. The control unit 15, see Fig 1, is connected to a signal input terminal in the form of the gate 26 in said IGBT. The switching member 11 comprises a member 27 for achieving that said IGBT in case of applied load current on the poles 13 and 14 only is traversed by a current in one direction. The rectifier member consists of a rectifier bridge 27. A diode 28 is connected in parallel with the current detection means 21 and is orientated in the opposite direction in relation to the diode 23. The alternating current generated by the transformer 20 is semi-rectified by the diode 23 and the current is detected by the current detection means 21.
The current detection means 21 consists of a so-called optoswitch. The optoswitch in its turn comprises a light emitting diode 30. The optoswitch furthermore comprises a photosensitive member 31 in the form of a phototransistor. The phototransistor 31 in its turn generates a square wave when said current flows through the light emitting diode 30. Furthermore, a resistance 32 is connected in series with the light emitting diode 30 in order to limit the current through the light emitting diode. The diode 28 connected in parallel with the current detection means 21 makes sure that the voltage during loading of said IGBT 22 via the poles 13 and 14 is not lying across the current detection means 21. Thanks to the above described internal constitution of the function proving arrangement 19, it is possible to prove said IGBT during load current via the poles 13, 14 as well as without connected load current.

The function of said IGBT is proved according to the following: said IGBT is arranged in such a state that it breaks an electric connection between the collector 24 and the emitter 25. The current source 20 is connected for generation of the current. Since said IGBT does not close any electric connection between the collector 24 and the emitter 25, no current is detected by the current detection means 21 if said IGBT 22, the bridge 27 and the function proving arrangement is functioning. If, after all, the current detection means 21 detects a current, this indicates that said IGBT 22 conducts a current and that an error is present in the control unit or said IGBT.

When said IGBT 22 is arranged in a position, in which it closes the electric connection between the collector 24 and the emitter 25, the current detection means 21 will however detect a current if said IGBT 22, the bridge 27 and the components comprised in the function proving arrangement 19 are functioning when the current source generates a current. If no detection of current takes place in the current detection means 21, this indicates that
said IGBT, the bridge 27 or any of the components in the function proving arrangement 19 is not functioning.

That the switching members 11 and 12 closes is suitably proved by means of the function proving arrangement 19 before the first contact member 1 is moved out of contact with the main contact member 2. Thereafter, the right switching member 12 is made to break and the first contact member 1 is moved to the switching contact member 3. Then the first contact member 1 is moved into the position, in which it is in contact with both switching contact members 3 and 4. The left switching member 11 is made to break and the right switching member 12 is made to close. Should the switching member 11 not function, the first contact member 1 is brought back into contact with only the switching contact member 3. In case of an error message for any of the switching members 11 and 12, the movement of the first contact member 1 can consequently be reversed. In order to achieve the above described controlling of the movement of the first contact member 1, the control unit 15 is also arranged to control the power transmission from the electric motor 16 to the first contact member 1.

The switching device comprises members 33 for detecting the position of the first contact member 1. The detection members 33 are arranged to detect that the first contact member 1 is in contact with the switching contact member 3 and the switching contact member 4, respectively. In this way the function of the switching members 11 and 12, respectively, can be proved at the very same moment as the first contact member 1 has been brought into electric contact with the switching contact member 3 and the switching contact member 4, respectively. Said detection members can be designed in a number of different ways and the detection can for instance be carried out optically or mechanically.
The denomination switching member refers to different types of switches and said IGBT is only to be considered as an example of such a switch. There is a requirement of a relatively large rapidity of the switch for the achievement of the above described switching over of the current path during the zero crossing of the current. Therefore, a switch is preferably used which does not require a galvanic separation of two metallic contacts. Therefore, an electric circuit with a semiconductor based switch for effectuating said breaking and closing is preferably used. In this connection, it is in particular advantageous to use an electric circuit having a power semiconductor component, such as a thyristor, MOSFET, GTO, IGCT or the above described IGBT, for effectuating said breaking and closing.

The above described electric switching device is preferably used as a load coupler in a tap changer for a transformer. It is in particular preferred to use the switching device in a dry transformer environment. Dry transformer environment refers to that the transformer winding is not arranged in any dielectric liquid, such as oil. By connecting a dry tap changer comprising the invention load coupler to such a dry transformer, an arrangement is obtained which does not need said electrically insulating oil. This results in environment technical as well as maintenance technical advantages.

In the description above, the invention has been described in relation to the case when the current path is switched over from the first conductor 7 to the second conductor 8. It is of course within the scope of the invention to claim that the current path instead is switched over from the second conductor 8 to the first conductor 7.

The diodes 23 and 28 are of such a type that they will not break down in case of a high voltage, such as several thousands of volts.
It is emphasized that the embodiment dealt with above and illustrated in the drawing is only to be considered as exemplifying. Consequently, the invention can be implemented in other ways with the basic inventional idea being retained. It is particularly pointed out that men skilled in the art after having obtained knowledge about the inventional solution of course will be capable of performing different transformations of the exemplifying embodiment without for that sake going beyond the scope of the patent protection.
Claims

1. An electric switching device for switching over a current path from a first electric conductor (7) to a second electric conductor (8), comprising a first contact member (1) and a set of second contact members (2, 3, 4, 5), which are arranged after each other along a path, the first contact member (1) being movably arranged in relation to the second contact members along said path for the achievement of an electric connection with each of these, said set of second contact members comprising two main contact members (2, 5), each of which is connected to one of said conductors (7, 8), and at least one switching contact member (3, 4) arranged between the main contact members, and the first contact member (1) being arranged to allow the simultaneous contacting of two adjacent second contact members, characterized in that the switching device comprises an arrangement (10), connected to said switching contact member (3, 4) and said two conductors (7, 8), for connecting and disconnecting said switching contact member (3, 4) to and from, respectively, said two conductors (7, 8).

2. A device according to claim 1, characterized in that the device comprises two switching contact members (3, 4) arranged between the main contact members (2, 5), and that the switching arrangement (10) is arranged for connecting and disconnecting each of these switching contact member (3, 4) to and from, respectively, only one of said two electric conductors (7, 8).

3. A device according to claim 1 or 2, characterized in that the switching arrangement (10) comprises two switching members (11, 12), which are arranged for breaking and closing the current paths between said switching contact member(-s) (3, 4) and the electric conductors (7, 8).
4. A device according to claim 3, characterized in that each of the switching members (11, 12) are arranged in such a way that it always mechanically connects to poles (13, 14), a first (13) of which always being electrically connected to the switching contact member (3 and 4, respectively) and a second (14) of which being electrically connected to said conductor (7 and 8, respectively).

5. A device according to claim 3 or 4, characterized in that each of the switching members (11, 12) comprises an electric circuit, which connects two poles (13, 14), a first (13) of which being electrically connected to the switching contact member (3 and 4, respectively) and a second (14) of which being electrically connected to said conductor (7 and 8, respectively).

6. A device according to any of claims 3-5, characterized in that each switching member (11, 12) comprises a controllable power semiconductor device (22) arranged to be controllable between said states of closing and breaking current paths.

7. A device according to claim 6, characterized in that the power semiconductor device (22) can be turned-off.

8. A device according to claim 6 or 7, characterized in that the power semiconductor device (22) is a thyristor or transistor, such as an IGBT, MOSFET, GTO or IGCT.

9. A device according to any of claims 3-8, characterized in that the switching arrangement (10) comprises a control unit (15) connected to the switching members for controlling said breaking and closing.

10. A device according to claim 9 and one of claims 6-8, characterized in that the control unit (15) is arranged to control each power semiconductor device (22) between said states of closing and breaking the current paths.
11. A device according to any of claims 3-10, characterized in that the device comprises at least one arrangement (19) for proving the function of one of said switching members (11, 12), that the proving arrangement (19) comprises a current source (20) connected to the switching member and a means (21) for current detection connected in series with the current source.

12. A device according to claim 11, characterized in that the current source (20) is arranged to generate an alternating voltage, that the proving arrangement (19) comprises a member (23) for blocking the current in one direction, said member being arranged in series with the current source, and that the current detection means (21) is arranged for the detection of a pulse train.

13. A device according to claim 12, characterized in that the proving arrangement (19) comprises a member (28), arranged in parallel with the current detection means (21), for reducing a voltage across the current detection means (21) produced at an electric connection between the first contact member (1) and said switching contact member (3 and 4, respectively).

14. A device according to any of the preceding claims, characterized in that the device comprises at least one member (33) for detecting the position of the first contact member (1), and that the detection member is connected to the switching arrangement (10).

15. A device according to any of the preceding claims, characterized in that the device comprises an electrically conductive contact means (6), which defines said path, and that the first contact member (1) is connected to the contact means in an electrically conductive way and displaceably arranged along said contact means for the achievement of an electric connec-
tion between the contact means (6) and said second contact members (2, 3, 4, 5).

16. A device according to any of the preceding claims, characterized in that the device comprises a power member (16) for the achievement of the movement of the first contact member (1) in relation to the second contact members (2, 3, 4, 5).

17. A device according to claim 16, characterized in that the power member (16) is connected to a network, and that the device comprises a member (18) for storing electric energy, which is connected in parallel with said power member (16).

18. A device according to claim 17, characterized in that the energy storage member (18) consists of a capacitor.

19. A method for controlling an electric switching device for switching over a current path from a first electric conductor (7) to a second electric conductor (8), comprising a first contact member (1) and a set of second contact members (2, 3, 4, 5), which are arranged along a path, said set of second contact members comprising two main contact members (2, 5), each of which is connected to one of said conductors (7, 8), and at least one switching contact member (3, 4) arranged between the main contact members (2, 5), the first contact member (1) being arranged to allow the simultaneous contacting of two adjacent second contact members, the first contact member (1) being moved in relation to the second contact members (2, 3, 4, 5) along said path while successively contacting each of these, from a first (2) of the main contact members to a second (5) of the main contact members, characterized in that said switching contact member (3, 4) is connected to electric connection with the first conductor (7), and that the switching over of the current path between said conductors (7, 8) is thereafter achieved while the first contact member (1) only connecting said switching contact member (3, 4) in that said switching contact member is
disconnected from electric connection with the first conductor (7) and connected to electric connection with the second conductor (8).

20. A method according to claim 19, characterized in that the device comprises two switching contact members (3, 4) arranged between the main contact members (2, 5), and that a first (3) of these switching contact members is disconnected from electric connection with the first conductor (7) and that the second (4) of these switching contact members is connected to electric connection with the second conductor (8) while the first contact member (1) is contacting both of the switching contact members (3, 4).

21. A method according to claim 19 or 20, characterized in that said switching contact member (3, 4) is connected to electric connection with the first conductor (7) before the first contact member (1) releases the contact with the first main contact member (2).

22. A method according to any of claims 19-21, characterized in that said switching contact members (3, 4) are disconnected from electric connection with the second conductor (8) after the first contact member (1) having been brought into contact with the second main contact member (5).

23. A method according to any of claims 19-22, characterized in that said connection and disconnection of said switching contact members (3, 4) to the second conductor (8) and from the first conductor (7), respectively, is carried out at least essentially during a zero-crossing of the current.

24. A method according to any of claims 19-23, characterized in that the device comprises two switching members (11, 12), which are arranged for breaking and closing, respectively, the current paths between said switching contact members (3, 4)
and the conductors (7, 8), and that they are controlled via electric signals.

25. A method according to claim 24, characterized in that each switching member (11, 12) comprises a controllable power semiconductor device (22), which is controlled between two states in order to achieve closing and breaking, respectively, of said current paths.

26. A method according to claim 25, characterized in that it is a power semiconductor device (22) that can be turned-off that is controlled for the achievement of the closing and breaking, respectively, of said current paths.

27. A method according to claim 24, characterized in that the function of the switching members (11, 12) is proved before they are being activated, in that each of the switching members is supplied with a current and that the current is detected after passing the switching member.

28. A use of the electrical switching device according to any of claims 1-18 as a tap-changer for a transformer.

29. A use of the electrical switching device according to claim 28 in dry transformer environment.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

**IPC7: H01F 29/04**
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

**IPC7: H01F, H01H**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>DE 2209500 A (TRANSFORMATOREN UNION AG), 6 Sept 1973 (06.09.73), page 4, line 15 - page 6, line 10, figure 1</td>
<td>1-29</td>
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<tr>
<td>X</td>
<td>DE 1901105 A (SIEMENS AG), 2 October 1969 (02.10.69), page 4, line 27 - page 5, line 32, figures 1-3</td>
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<tr>
<td>A</td>
<td>DE 1803741 A (SIEMENS AG), 30 July 1970 (30.07.70), page 9, line 23 - page 10, line 20, figures 3,4</td>
<td>6-10,25,26</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

**Date of the actual completion of the international search**

17 January 2000

**Date of mailing of the international search report**

22-01-2001

Name and mailing address of the ISA:

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Authorized officer

Bertil Nordenberg/MN

Telephone No. +46 8 782 25 00

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<tr>
<td>A</td>
<td>US 3381213 A (L.R. RICE ET AL), 30 April 1968 (30.04.68), column 2, line 53 - column 6, line 41, figures 1-3</td>
<td>6-10, 16-18, 25, 26</td>
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<td>A</td>
<td>US 5574385 A (KENNETH J. MURPHY ET AL), 12 November 1996 (12.11.96), figure 1, abstract</td>
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