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(54) **Switching device with thermal balancing equipment**

Schaltgerät mit Temperatenausgleich

Dispositif de commutation doté d'un équipement d'équilibrage thermique

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Description

[0001] The invention relates to a switching device, in particular for gas insulated switch gears, a medium or high voltage substation and a thermal balancing method.

[0002] A switching device for high current switching is known for example from EP 1 863 052 A1. Within a common housing, there are arranged two conductor parts. Said conductor parts are electrically connectable to each other. The two conductors are arranged in a common housing that is filled with insulating gas. It is known for such switching devices to perform an electrical connection between the two conductor parts by means of a movable conductor. The problem is that due to different cross-sectional areas, resistances and distribution of current density, an unequal temperature distribution occurs. In particular in an area near the so-called nominal current contact of a circuit-breaker, a temperature rise will occur. As particularly this region has a larger distance to a heat sink such as the housing for example, dissipating heat might be problematic.

[0003] US-A-3662137 discloses a switching device including a first conductor part being electrically connectable to a second conductor part, the first conductor part and the second conductor part being arranged in an open volume inside a housing which is filled with an insulating medium.

[0004] Thus, it is an object of the invention to improve the dissipation of heat generated inside such switching devices or substation using such switching devices thereby extending the temperature range for use of the switching device.

[0005] The problem is solved by a switching device comprising the features set out in claim 1, the substation according to claim 14 and the thermal balancing method according to claim 15.

[0006] According to the invention, the switching device includes a first conductor part and a second conductor part being electrically connectable. The first and second conductor part are arranged in a volume of a housing which is filled with an insulating gas as insulating medium. The term conductor part is to be understood hereinafter broadly as an electrically active part exposed to at least one of a high voltage or a high current. A first region of said first conductor part is connected to a second region of said first conductor part by means of a heat pipe arrangement, such that a thermal connection between the first region and the second region is formed by at least one heat pipe arrangement. The second region is located at a distance from the first region, such that the second region is located offset of the first region with respect to a direction of a current. The first and second region of said first conductor part are at different temperature levels when a current flow, in particular a nominal current flow, traverses the switching device along a current path during the operating state of the switching device. Thus, the heat pipe arrangement will improve the temperature distribution of the switching device. Contrary to the prior

art, conduction of the heat generated inside the switching device is not only performed by thermal conduction within the conductor part itself and convective flow of heat but is significantly enhanced by means of the heat pipe arrangement. Temperature hotspots are avoided and a larger area can effectively contribute to heat dissipation.

[0007] The problem is solved further by a medium or high voltage substation according to claim 14, in particular gas insulated substations, comprising at least one switching device as described before.

[0008] The problem is solved as well by a thermal balancing method of a switching device according to claim 15.

[0009] The thermal balancing method comprises the following steps. A first conductor part and a second conductor part are provided in a connectable manner inside a volume within a housing which is filled with an insulating medium. In addition, a thermal connection between a first region of the first conductor part and a second region of the second conductor part is provided. The second region is located at a distance from the first region and the first and second region of said first conductor part are at different temperature levels when a current flow traverses the switching device along a current path during an operating state of the switching device. At the first region a working medium is evaporated in the at least one heat pipe arrangement. The phase transition temperature of the working medium inside the heatpipe arrangement is preferably about ninety degree Celsius to one hundred fifteen degree Celsius. The working medium is then cooled down at a second region and condenses again. Thus, the first region is cooled down in the operating state of the switching device by means of the at least one thermal connection formed by at least one heat pipe arrangement and the second region is heated up. Thus, the heat pipe arrangement will improve the temperature distribution of the switching device.

[0010] A heat pipe arrangement within the meaning according to the present invention is any kind of closed volume connecting two areas being at different temperature levels. The closed volume includes at least one capillary tube connecting the cold and hot end of the heat pipe arrangement. At the hot end of the heat pipe arrangement, a working medium inside the volume evaporates. The vapor will flow to the cold end of the heat pipe arrangement where it condenses. After condensation of the vapor, the liquid will be transferred back to the hot end by means of the capillary tube. Such heat pipe arrangements allow although functioning pretty similar to thermosyphons an arrangement in any orientation.

[0011] Further advantageous aspects are set forth in the dependent claims.

[0012] It is in particular advantageous to have a further heat pipe arrangement being arranged in connection with the second conductor part as well. Usually, the hot regions are near the electrical contact between the first and second conductor part. As for the heat pipe arrangement of the first conductor part already explained, the first and

second region of the second conductor part are also at different temperature levels when a nominal current flows during operation of the switching device. As both of the conductor parts show an improved temperature distribution due to their respective heat pipes, the compensation of temperature differences is further improved. It is furthermore specifically advantageous to locate the at least one heat pipe arrangement and/or the at least one further heat pipe arrangement inside the first and/or second conductor part which is/are hollow. The integration into the inside volume of the hollow conductor part contributes to a small overall size of the switching device. In particular, housings which are already used can be used in the future as well without the need of a new design.

[0013] Preferably, the at least one heat pipe arrangement and/or at least one further heat pipe arrangement is/are mainly arranged on a first or a second side of a plane running through a longitudinal axis of the first and/or second conductor part, in particular through a longitudinal axis defined by the current path. Mainly arranged means that at least sixty percent, preferably at least seventy percent, more preferably at least eighty percent, in particular hundred percent of the at least one heat pipe arrangement and/or at least one further heat pipe arrangement is/are arranged on the first or second side of said plane. In particular, the at least one heat pipe arrangement and/or at least one further heat pipe arrangement is/are arranged at the upper side in a mounting position of the switching device where a longitudinal axis corresponding to a current path is orientated horizontally.

[0014] As in most cases, the highest temperature appears near movable parts of the electrically conductive connection between the first conductor part and the second conductor part, it is advantageous to have a contact between the evaporator side of the at least one heat pipe arrangement and/or the at least one further heat pipe arrangement and the first and/or the second conductor parts, respectively, near the electrically conductive connection of a movable contact. In particular, the at least one electrically conductive connection allows for carrying a nominal current in the operating state of the switching device. Furthermore, it is advantageous to locate the condenser side of the heat pipe arrangement and/or of the further heat pipe arrangement near a heat dissipation device or a heat sink. This is especially advantageous, when the heat dissipation device is in electrical contact to the conductor part. Such a heat dissipation device or heat sink can be any element which is suitable for dissipating heat to the environment. This can either be a further conductor being in electrical and thermal connection to the conductor part, a cooling element or the housing if the switching device is a so-called gas insulated switch gear. In that case, heat will be transferred to the housing by convective flow of heat from the conductor part by means of the insulating gas. Finally, the heat is dissipated by the housing of the switching device. In that case, it is advantageous to connect the condenser side to the first

and/or second conductor part respectively in a region which enables a smooth convective flow. In another case, it is advantageous to connect the condenser to a region of the first and/or second conductor part, which is close to the contact between the first and/or second conductor part and a further succeeding conductor part in switching device. In this case, the heat is dissipated over the contact to the further succeeding conductor part.

[0015] The application of the present invention is in particular advantageous for use in gas insulated switch gear. The switching device thus includes preferably at least a circuit-breaker and at least one disconnecter.

[0016] Gas insulated switch gears are commonly known for use in high power circuits for switching currents of e. g. up to 5,000 ampere. It is advantageous that the at least one heat pipe arrangement and/or the at least one further heat pipe arrangement is/are electrically on high voltage or on high-current path in the operating state of the switching device. Since, the heat pipe arrangements connect conductor parts at the same potential, they can be made off cheap electrically conductive materials like copper which has good heat transportation characteristics and do not have to insulate.

[0017] Gas insulated switch gears commonly have conductor parts which are basically shaped like a hollow cylinder. The at least one heat pipe arrangement and/or the at least one further heat pipe arrangement arranged inside such hollow cylinders are advantageously basically shaped as a hollow truncated cone or a segment thereof. As a connection between the first conductor part and the second conductor part is performed by a movable conductor arranged inside one of the hollow cylinders, this improves space efficiency of the switching device. In particular, one wider end gives the opportunity to arrange components of the driving mechanism of a movable conductor inside that area.

[0018] Alternatively, the at least one heat pipe arrangement and/or the at least one further heat pipe arrangement includes/include a plurality of separate tube-like pipes that are in particular distributed alongside the circumference of the conductor part.

[0019] It is advantageous that the at least one heat pipe arrangement and/or the at least one further heat pipe arrangement comprises/comprise at least one essentially tubular heat pipe with its evaporator side and its condenser side being closed for fluidly sealing the at least one heat pipe. It is in particular advantageous that the evaporator and condenser side is closed respectively by squeezing the at least one essentially tubular heat pipe and that the squeezed ends constitute a flange for fixing said heat pipe to the first and second conductor part respectively.

[0020] Preferred embodiments of the invention are shown in the drawings and will be explained in the following description in detail. The drawings show:

Fig. 1 a schematic illustration of a gas insulated switch gear according to the invention;

- Fig. 2 a temperature profile along the current path for illustration of the significant temperature differences;
- Fig. 3 a cross-sectional drawing of a circuit-breaker of the gas insulated switch gear according to the invention;
- Fig. 4 an inventive embodiment of a disconnecter of the gas insulated switch gear;
- Fig. 5 a cross-sectional view along line A-A of the circuit-breaker, illustrating a first heat pipe arrangement;
- Fig. 6 a second cross-sectional drawing illustrating another embodiment of a heat pipe arrangement;
- Fig. 7 a perspective drawing of the heat pipe arrangement of fig. 6;
- Fig. 8 a cross-sectional drawing of the heat pipe arrangement of fig. 6 along line C-C; and
- Fig. 9 a cross-sectional drawing for illustrating the distributed arrangement of separate heat pipes inside disconnecter of fig. 4.

[0021] In fig. 1 a simplified illustration of a gas insulated switch gear 1 of a medium or high voltage substation for example or as a switching device is shown partly as a cross-sectional view. The gas insulated switch gear 1 comprises at least one circuit-breaker 2 for connecting or disconnecting two ends of the gas insulated switch gear 1 electrically. The gas insulated switch gear 1 as disclosed in fig. 1 is for switching current of one phase only. In an operating state the connection is established as illustrating in fig. 1.

[0022] The gas insulated switch gear 1 as illustrated in fig. 1 discloses in addition to the circuit-breaker 2 a first disconnecter 3 and a second disconnecter 4. The first and second disconnecter 3, 4 are provided for maintenance operation to ensure that a disconnected side is voltage-free.

[0023] Switching during normal operation of a gas insulated switch gear 1 integrated in a system is performed by establishing an electrically conductive connection between a first conductor part 7 and a second conductor part 8. Between first conductor part 7 and second conductor part 8, an insulating part 10 is arranged. As it will be apparent from more detailed fig. 3 which will be described hereinafter, inside first conductor part 7 and insulating part 10, a movable conductor is arranged. The movable conductor is in a permanent electrical connection with first conductor part 7 and can be moved in an axial direction in order to establish an electrically conductive connection with second conductor part 8.

[0024] In order to switch between a connected state and a disconnected state, a driving means 9 is arranged outside of a housing 6 and able to move the movable conductor in the axial direction. Housing 6 is comprised of a plurality of sections which are connected to each other. The inner volume established by the plurality of the sections of housing 6 is filled with an insulating gas.

[0025] Heat pipes 18.1, 18.2, 19.1, 19.2, 27.1 and 27.2 are arranged as heat pipe arrangements 18, 19 and 27 inside the conductor parts 7, 8 of the circuit-breaker 2 and the conductor part of the disconnecter 3 according to the invention, which will be described later with the more detailed fig. 3 and 4.

[0026] As the ohmic resistance over the current path, indicated as a dash-dotted line 5, in fig. 1, is not constant, there are regions of higher temperature which are denoted by A, B and C in the gas insulated switch gear of fig. 1. The components where the high temperature spots occur on the other hand have regions which are cooler. These regions are denoted with the respective characters A', B' and C'. Fig. 2 shows a temperature profile along the current path in the gas insulated switch gear 1 and indicated by the dash-dotted line 5 in fig. 1. Dashed line 11 is a temperature profile of a gas insulated switch gear 1 without the present invention. The dashed line 11 shows that there are some regions A, B and C with particularly high temperatures. On the other hand, in respective regions A', B' and C' offset to the highest temperature point of the same element, there are lower temperatures explicitly shown in fig. 2. Using the present invention, it is possible to improve thermal conduction between corresponding points AA', BB' and CC' and thereby reducing the temperature differences between first regions of the hotspots and cooler second regions of the same components by connection of the first and second regions by heat pipe arrangements.

[0027] A temperature profile when using the present invention in the gas insulated switch gear 1 of fig. 1 is shown by solid line 12. On the one hand, it can be seen that the temperature distribution is more equal and on the other hand also lower maximum temperatures occur. This results in an extended range for safe use of the gas insulated switch gear 1.

[0028] A cross-section through an exemplary circuit-breaker 2 of fig. 1 is shown in fig. 3. The circuit-breaker 2 comprises as already said on its respective in-and-out-end a first conductor part 7 and a second conductor part 8. For switching, the electrically conductive connection between first and second conductor part 7, 8 is established or interrupted. The first conductor part and the second conductor part have a respective front end 15, 17 that are opposed to each other. Between the front ends 15, 17 the insulating part 10 is arranged. Inside insulating part 10 and with a smaller diameter, a movable conductor 12 is arranged. The movable conductor 12 as well as first conductor part 7 and second conductor part 8 which are arranged fixedly inside housing 6 has a basically circular cross-section. The movable conductor 12 is sup-

ported by a movable slide 13. The movable slide 13 is arranged inside first conductor part 7 and slides on conductive pole 28 in a left and right direction in fig. 3.

[0029] The diameter of the largest part of the movable conductor 12 corresponds to a diameter of contacting element 16 which is fixed to front end 15 of first conductor part 7 constituting a first region 7.1. In a direction towards second conductor part 8, a radial dimension of movable conductor 12 is reduced. Thus, movable conductor 12 consists of a conical part and two cylindrical parts at the first and second ends. While first cylindrical part is in contact with contacting element 16, second cylindrical part is electrically connectable to its counterpart 14. Counterpart 14 is supported in a fixed manner to front end 17 of second conductor part 8 and also denoted as first region 8.1 of second conductor part 8. When first conductor part 7 and second conductor part 8 are connected to each other electrically conductive, the second cylindrical part of the movable conductor 12 touches counterpart 14 in the shown way. For disconnecting the circuit-breaker 2, movable slide 13 is pulled to the left thereby disconnecting movable contact 12 and counterpart 14 first. Movable contact 12 and counterpart 14 together constitute so-called nominal current contact. After disconnecting movable contact 12 and counterpart 14, there is still a conductive connection established by conductive pole 28 and conductive counter pole 20. For disconnecting first conductive part 7 and second conductor part 8 in a second step, conductive pole 28 is also and independently of movable slide 13 pulled to the left.

[0030] First conductor part 7 and second conductor part 8 with respect to their length have a relatively constant ohmic resistance as well as cross-sectional area. But as the nominal current is flowing through movable contact 12 and counterpart 14 when the switch is closed the current flows also through areas with a higher ohmic resistance. This is in particular the first region 7.1 around contact 16 on the side of first conductor part 7 and counterpart 14 as first region 8.1 on the side of second conductor part 8. Thus, in regions with a higher ohmic resistance, heat is generated which has to be conveyed and finally dissipated. Thus, the point of first conductor part 7 with highest temperature is located near the front end 15 in the first region 7.1. This corresponds to point B with respect to figures 1 and 2.

[0031] According to the present invention inside, the hollow first conductor part 7 comprises a heat pipe arrangement 18. In fig. 3, the heat pipe arrangement 18 is comprised of two heat pipes 18.1 and 18.2. More pipes can be arranged and be distributed over the circumference of first conductor part 7. The hot end of the heat pipe arrangement 18 is thermally conductive connected to first region 7.1 on an inner radial step which is supposed to support contacting element 16. This inner radial step is thus a first region 7.1 that is near the electrically conductive connection to second conductor part 8, in the shown embodiment of movable conductor 12. This end of the heat pipe arrangement 18 is the evaporator side.

The opposite end of the heat pipe arrangement 18 is the condenser side which is connected thermally to a second, cooler region 7.2 of the first conductor part 7 located at a distance from the first region 7.1.

[0032] Preferably, the second conductor part 8 surrounds a further heat pipe arrangement 19, too, comprising at least two separate heat pipes 19.1 and 19.2. The evaporator sides of heat pipes 19.1 and 19.2 are connected to counterpart 14 which is part of second conductor part 8 and constitutes a first region 8.1 of second conductor part 8. As being fixedly connected to front end of rigid part 8' the first region is on the same electrical potential. The condenser sides of pipes 19.1 and 19.2 are connected to a second region 8.2 being offset to first region 8.1 and being cooler than the first region 8.1.

[0033] Thus, heat pipe arrangements 18 and 19 improve heat flow from hotspots of first conductor part 7 and second conductor part 8 to respective cooler areas of the same conductor parts 7 or 8.

[0034] In an alternative embodiment, in case of a free air contacting, connecting contacts 201.1 and 201.2 of a circuit-breaker 2 are arranged contacting the first and second conductor part 7 and 8 in an angulated orientation pointing away from the contacting parts 12 and 14 of the circuit-breaker 2. Preferably, the connecting contacts 201.1 and 201.2 are arranged at an upper side of the conductor parts 7 and 8 and are traversed such through the housing 6, that the volume inside the housing 6 is still insulated from the outside. The connecting contacts 201.1 and 201.2 are used for supporting/removing the current to/from the conductor parts 7 and 8 and also to conduct away heat produced in the conducting parts 7 and 8. Therefore, for life/dead tank breakers, it is advantageous to provide the second regions 7.2 and 8.2 of the conductor parts 7 and 8 near the connecting contacts 201.1 and 201.2. Consequently, the heat from the first regions 7.1 and 8.1 is conducted via the heat pipe arrangements 18 and 19 to the connecting contacts 201.1 and 201.2 working as a heat sink. The connecting contacts 201.1 and 201.2 are drawn dashed as they refer to an alternative embodiment.

[0035] In fig. 4, a cross-section of a disconnecter 3 is shown. The disconnecter 3 comprises a first conductor part 70 and a second conductor part 80 which is the so-called disconnecter contact. First conductor part 70 and second conductor part 80 are similar to the ones of the circuit breaker of fig. 3 and already explained with respective fig. 3 for the circuit-breaker 2. First and second conductor part 70 and 80 are arranged fixedly with respect to housing 6. First conductor part 70 and second conductor part 80 are hollow and may be connected to each other by means of a further movable conductor. Further movable conductor comprises two conductive hollow cylinders 22 and 23. The conductive cylinders 22 and 23 are fixed to a spindle nut 24. Spindle nut 24 is arranged in relationship to spindle 21 which can be operated from outside housing 6. When turning spindle 21, spindle nut 24 and consequently conductive elements 22

and 23 can be moved in the axial direction of spindle 21. The spindle nut 24 is supported by guiding rods 25 and 26.

[0036] Conductive cylinders 22 and 23 are arranged on opposite sides of spindle 24. While conductive cylinder 22 is electrically conductive in contact with a further contacting element 160 arranged at an inner edge of first conductor part 70 constituting a first region 70.1, further conductive cylinder 23 may be in contact with a ground contacting element 161 being arranged at an opposite end of first conductor part 70. When spindle 21 is turned clockwise, spindle nut 24 will be moved to the left side in the drawing until ground contacting elements 161 are in connection with grounding contact 162 by further conductive cylinder 23. Grounding contact 162 may be also including a special contacting element being in permanent contact with housing 6. It is evident that a similar contacting element 164 is arranged at second conductor element 80.

[0037] Heat pipe arrangement 27 at least consisting of two separate heat pipes 27.1 and 27.2 in the drawing is connected with its evaporator side to the first region 70.1 of first conductor part 70 being near to contacting element 160. Condenser side of the heat pipe arrangement 27 on the other hand is thermally connected to first conductor part 70 at a point distant to the first region 70.1 and constituting a cooler second region 70.2. The cooling performance of the heat pipe arrangement 27 can be improved by supporting the first conductor part 70 at the outside wall with an additional cooling element 200 near the second region 70.2 of the first conductor part 70. Consequently, the heat transported to the second region by the heat pipe arrangement 27 from the connecting element 160 can be efficiently dissipated.

[0038] Further, heat pipe arrangement 29 at least consisting of two separate heat pipes 29.1 and 29.2 in the drawing is connected with its evaporator side to the first region 80.1 of second conductor part 80 being near to contacting element 164 of the second conductor part 80. Condenser side of the heat pipe arrangement 29 on the other hand is thermally connected to second conductor part 80 at a point distant thereto constituting a cooler second region 80.2. The first region 80.1 is displaced about a distance from the second region 80.2 along the current path 5 for balancing the temperature between the first and second region 80.1 and 80.2.

[0039] In fig. 5 there is shown a cross-sectional view across the line A-A as shown in fig. 3. It can be seen that the heat pipe arrangement 30 consists of a plurality of separate heat pipes 30.1 to 30.5. The separate heat pipes 30.1 to 30.5 are connected to the first conductor part 7, e.g. by means of a cable shoe. The cable shoe is built preferably by pressing the ends of the tube-like heat pipes and inserting at least one hole. Thereby, easy mounting of the heat pipe arrangement 30 is achieved. As it can be seen in fig. 3, the evaporator side of the heat pipe arrangement 30 is connected to a radial step at the front end 15 of first conductor part 7 all of the separate heat

pipes 30.1 to 30.5 are arranged alongside a lateral area of a hollow truncated cone. Preferably, the plurality of separate heat pipes 30.1 to 30.5 is mainly arranged on a first or a second side of a plane running through a longitudinal axis of the first conductor part 7. Mainly in this context means that at least sixty percent, in particular at least seventy percent, in particular at least eighty percent, at least ninety percent, in particular hundred percent of the pipes 30.1 to 30.5 as shown are on said side. Preferably, this is an upper half of the inner volume of the first conductor part 7 if the longitudinal axis is arranged in a horizontal direction during operation. Even more preferably, the plurality of pipes 30.1 to 30.5 are arranged with the same distance to each other.

[0040] Fig. 6 shows another preferred embodiment of a heat pipe arrangement. The heat pipe arrangement 31 this time is a segment of a hollow truncated cone which is shown in fig. 7 in a perspective view. The heat pipe arrangement 31 itself extends alongside to a segment of the lateral area of the hollow truncated cone with its narrower end directed to the hot side, i.e. to the first region 7.1. At both ends, there are arranged flanges 32, 33 respectively. Within the flanges, holes have been arranged in order to join the heat pipe arrangement 31 to first conductor part 7. Flange 32 and flange 33 are oriented at right angles to each other.

[0041] Fig. 8 shows a cross-section in the longitudinal direction of heat pipe arrangement 31. As it can be seen in the cross-sectional drawing, the flanges 32, 33 are only made of plate material in order to join the heat pipe 31 to first conductor part 7. It is evident that the particular construction of the heat pipes can easily be adapted in order to join the heat pipe to second conductor part 8. In the cross-sectional drawing according to fig. 8, it can be seen that within the volume enclosed by the heat pipe 31 with top plate 34 and bottom plate 35 made of copper e.g., a material with capillary tubes 36 is arranged. If heat is applied at flange 32, liquid which fills the volume will evaporate at the hot end. Between the material with the capillary tubes 36, the vapor will flow to the cold end of the heat pipe arrangement 31. At the cold end which is the side of flange 33, the liquid will condense back again and will be transported by capillary forces inside material 36 to the hot end again.

[0042] In fig. 9, another cross-sectional drawing is shown. This time the drawing is intended to illustrate the arrangement in the disconnecter 3 of fig. 4. Contrary to the disconnecter 3 shown in fig. 4, spindle nut 24 is arranged on the left end side of fig. 4. Thus, in the cross-sectional drawing, the spindle nut 24 can be seen. In order to avoid unintended rotation of the spindle nut 24, spindle nut 24 is guided by three guiding rods 25, 26 and 37. The shape of spindle nut 24 is basically triangular with one angle being located at the top side. Thus, the pipes 38.1 to 38.4 of heat pipe arrangement 38 which are similar to the pipes 30.1 to 30.5 of fig. 5 are arranged in an upper left side or an upper right side according to the cross-sectional drawing.

[0043] Preferably, a housing of the heat pipe arrangements 18, 19, 27, 29, 30, 31, 38 are electrically conductive such that cheap metal materials can be used for producing the heat pipe arrangements 18, 19, 27, 29, 30, 31, 38.

[0044] The temperature of a working medium of the heat pipe arrangements 18, 19, 27, 29, 30, 31, 38 is at the evaporating side in a range of about 90 to about 115 °C, preferably about 105 °C, and at a condensing side in a range of about 50 °C to about 75 °C, preferably about 65 °C.

[0045] It is to be noted that the illustrated embodiments regarding the heat pipes are chosen only for illustration reasons. In particular, it is possible to have not only a small segment of a truncated cone but a larger one extending to the second side of a plane through the longitudinal axis as well or that small the shape of the heat pipe corresponds to a full lateral area of a truncated cone. In that case, the reservoir which is the inner volume of the heat pipe arrangement is enlarged compared to the segment of truncated cone shown in fig. 6 and compensation drift is further enhancing an equal temperature distribution.

[0046] Furthermore, it is to be noted that it is preferred that the heat transfer to housing 6 is performed by convective flow of heat. The illustration is based on a dead tank arrangement but is also applicable for free air contacting.

Claims

1. Switching device including a first conductor part (7, 70) being electrically connectable to a second conductor part (8, 80), the first conductor part (7, 70) and the second conductor part (8, 80) being arranged in a closed volume inside a housing which is filled with a gaseous insulating medium
characterized by
a thermal connection formed by a heat pipe arrangement (18, 30, 31) that is thermally connecting a first region (7.1, 70.1) of the first conductor part (7, 70) and a second region (7.2, 70.2) of the first conductor part (7, 70) only, which second region (7.2, 70.2) is located at a distance from the first region (7.1, 70.1), wherein the first region (7.1, 70.1) and the second region (7.2, 70.2) of said first conductor part (7, 70) are at different temperature levels when a current flow traverses the switching device along a current path (5) during the operating state of the switching device, wherein both the first region (7.1, 70.1) of the first conductor part (7, 70) and a second region (7.2, 70.2) of the first conductor part (7, 70) are arranged in the volume inside said closed housing.
2. Switching device according to claim 1,
characterized in that
the first conductor part (7, 70) is hollow and that the

heat pipe arrangement (18, 30, 31) is arranged inside the hollow conductor part (7, 70).

3. Switching device according to claim 2,
characterized in that
at least sixty percent of the pipe arrangement (18, 30, 31) is arranged on a first or on a second side of a plane running through a longitudinal axis of the first and/or second conductor part.
4. Switching device according to any one of claims 1 to 3,
characterized in that
an evaporator side of the heat pipe arrangement (18, 30, 31) is in thermal contact to said first conductor part (7, 70) near an electrically conductive connection of a moveable contact (12, 22) and said first conductor part (7, 70), wherein the at least one electrically conductive connection allows for carrying a current in the operating state of the switching device.
5. Switching device according to any one of claims 1 to 4,
characterized in that
a condenser side of the at least one heat pipe arrangement (18, 30, 31) is connected to said first conductor part (7, 70) near a heat dissipation device (200, 201.1) being in thermal contact to the conductor part (7, 70).
6. Switching device according to any one of claims 1 to 5,
characterized in that
said switching device (1) includes at least one of a circuit-breaker (2) and a disconnecter (3, 4).
7. Switching device according to any one of claims 1 to 6,
characterized in that
the heat pipe arrangement (18, 30, 31) is electrically on high voltage potential or on high-current path in the operating state of the switching device.
8. Switching device according to any one of claims 1 to 7,
characterized in that
the at least one heat pipe arrangement (18, 20, 31) comprises a heat pipe which is shaped as a hollow truncated cone or a segment thereof.
9. Switching device according to any one of claims 1 to 8,
characterized in that
the at least one heat pipe arrangement (30) includes a plurality of separate tube like heat pipes (30.1 - 30.5; 38.1 - 38.4).
10. Switching device according to any one of claims 1

to 9,

characterized in that

the at least one heat pipe arrangement comprises an essentially tubular heat pipe with its evaporator side and its condenser side being closed.

11. Switching device according to claim 10,

characterized in that

the squeezed ends each constitute a flange (32, 33) for fixing said heat pipe (31) to the first and second conductor part (7, 70, 8, 80) respectively.

12. Switching device according to any one of claims 1 to 11,

characterized in that

the first region (7.1, 70.1) is displaced by a distance from the second region (7.2, 702.) along the current path.

13. Switching device according to any of the preceding claims,

characterized in that

a first region (14) of said second conductor part (8, 80) is connected to a second region (8') of said second conductor part (8, 80) being located offset of the first region (14) with respect to a direction of a current by means of further heat pipe arrangement (19, 29), the first and second region of said second conductor part (8, 80) being at different temperature levels when a nominal current flows during the operating state of the switching device.

14. Medium or high voltage substation comprising at least one switching device according to any one of claims 1 to 13.

15. Thermal balancing method in a switching device, comprising the following steps:

providing a first conductor part (7, 70) being electrically connectable to a second conductor part (8, 80) in a closed volume inside a housing which is filled with a gaseous insulating medium, **characterized by**

providing a thermal connection between a first region of the first conductor part (7, 70) and a second region (7.2, 70.2) of the first conductor part only, which second region is located at a distance from the first region (7.1, 70.1), wherein the first region (7.1, 70.1) and the second region of said first conductor part (7, 70) are at different temperature levels when a current flow traverses the switching device along a current path (5) during an operating state of the switching device, and wherein both the first region (7.1, 70.1) of the first conductor part (7, 70) and a second region (7.2, 70.2) of the first conductor part (7, 70) are arranged in the volume

inside said closed housing, and by cooling the first region (7.1, 701) in the operating state of the switching device by means of a thermal connection formed by a heat pipe arrangement (18, 30, 31) that thermally connects the first region (7.1, 70.1) and the second region of said first conductor part (7, 70) by means of reducing a temperature difference between the first region and the second region.

16. Thermal balancing method according to claim 15, **characterized in that**

the at least one heat pipe arrangement (18) is electrically on high voltage potential or on high current potential in the operating state of the switching device.

17. Thermal balancing method according to claim 15 or 16,

characterized by

evaporating a working medium in the at least one heat pipe arrangement (18, 30, 31) at the first region (7.1, 70.1, 80.1) at a first phase change temperature of the working medium being in a range of ninety degrees Celsius to one hundred fifteen degrees Celsius, and by condensating the working medium in the at least one heat pipe arrangement at the second region (7.2, 702, 80.2) at a second phase change temperature of the working medium being in a range of fifty degrees Celsius to seventy five degrees Celsius.

Patentansprüche

1. Schaltvorrichtung, die einen ersten Leiterteil (7, 70), der mit einem zweiten Leiterteil (8, 80) elektrisch verbindbar ist, enthält, wobei der erste Leiterteil (7, 70) und der zweite Leiterteil (8, 80) in einem geschlossenen Volumen innerhalb eines Gehäuses, das mit einem gasförmigen isolierenden Medium gefüllt ist, angeordnet ist,

gekennzeichnet durch

eine thermische Verbindung, die **durch** eine Wärmerohranordnung (18, 30, 31) gebildet wird, die nur einen ersten Bereich (7.1, 70.1) des ersten Leiterteils (7, 70) und einen zweiten Bereich (7.2, 70.2) des ersten Leiterteils (7, 70) thermisch verbindet, wobei der zweite Bereich (7.2, 70.2) in einem Abstand von dem ersten Bereich (7.1, 70.1) angeordnet ist, wobei sich der erste Bereich (7.1, 70.1) und der zweite Bereich (7.2, 70.2) des ersten Leiterteils (7, 70) auf verschiedenen Temperaturhöhen befinden, wenn während des Betriebszustands der Schaltvorrichtung ein Stromfluss die Schaltvorrichtung entlang einem Stromweg (5) überquert, wobei sowohl der erste Bereich (7.1, 70.1) des ersten Leiterteils (7, 70) als auch der zweite Bereich (7.2, 70.2) des ersten Leiterteils

- (7, 70) in dem Volumen innerhalb des geschlossenen Gehäuses angeordnet sind.
2. Schaltvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** der erste Leiterteil (7, 70) hohl ist und dass die Wärmerohranordnung (18, 30, 31) innerhalb des hohlen Leiterteils (7, 70) angeordnet ist.
 3. Schaltvorrichtung nach Anspruch 2, **dadurch gekennzeichnet, dass** mindestens sechzig Prozent der Rohranordnung (18, 30, 31) auf einer ersten oder auf einer zweiten Seite einer Ebene, die durch eine Längsachse des ersten und/oder zweiten Leiterteils verläuft, angeordnet sind.
 4. Schaltvorrichtung nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** sich eine Verdampfungsseite der Wärmerohranordnung (18, 30, 31) in einem thermisch Kontakt mit dem ersten Leiterteil (7, 70) in der Nähe einer elektrisch leitfähigen Verbindung eines beweglichen Kontakts (12, 22) und des ersten Leiterteils (7, 70) befindet, wobei mindestens eine elektrisch leitfähige Verbindung einen Stromtransport im Betriebszustand der Schaltvorrichtung ermöglicht.
 5. Schaltvorrichtung nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** eine Dampfkondensatorseite der mindestens einen Wärmerohranordnung (18, 30, 31) mit dem ersten Leiterteil (7, 70) in der Nähe einer Wärmeableitungsvorrichtung (200, 201.1), die in einem thermischen Kontakt mit dem Leiterteil (7, 70) steht, verbunden ist.
 6. Schaltvorrichtung nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die Schaltvorrichtung (1) einen Ausschalter (2) und/oder einen Trennschalter (3, 4) enthält.
 7. Schaltvorrichtung nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** sich die Wärmerohranordnung (18, 30, 31) im Betriebszustand der Schaltvorrichtung elektrisch auf einem hohen Spannungspotential oder auf einem Hochstromweg befindet.
 8. Schaltvorrichtung nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die mindestens eine Wärmerohranordnung (18, 30, 31) ein Wärmerohr umfasst, das als ein hohler Kegelstumpf oder als ein Segment desselben geformt ist.
 9. Schaltvorrichtung nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** die mindestens eine Wärmerohranordnung (30) mehrere getrennte schlauchförmige Wärmerohre (30.1 - 30.5; 38.1 - 38.4) enthält.
 10. Schaltvorrichtung nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** die mindestens eine Wärmerohranordnung ein im Wesentlichen schlauchförmiges Wärmerohr umfasst, wobei dessen Verdampfungsseite und dessen Dampfkondensatorseite verschlossen sind.
 11. Schaltvorrichtung nach Anspruch 10, **dadurch gekennzeichnet, dass** jedes der gedrückten Enden einen Flansch (32, 33) bildet, um das Wärmerohr (31) an dem ersten bzw. an dem zweiten Leiterteil (7, 70, 8, 80) zu befestigen.
 12. Schaltvorrichtung nach einem der Ansprüche 1 bis 11, **dadurch gekennzeichnet, dass** der erste Bereich (7.1, 70.1) um einen Abstand von dem zweiten Bereich (7.2, 70.2) entlang dem Stromweg verschoben wird.
 13. Schaltvorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** ein erster Bereich (14) des zweiten Leiterteils (8, 80) mit einem zweiten Bereich (8') des zweiten Leiterteils (8, 80), der von dem ersten Bereich (14) in Bezug auf eine Richtung eines Stroms mittels einer weiteren Wärmerohranordnung (19, 29) versetzt angeordnet ist, verbunden wird, wobei sich der erste und der zweite Bereich des zweiten Leiterteils (8, 80) auf verschiedenen Temperaturhöhen befinden, wenn während des Betriebszustands der Schaltvorrichtung ein Nennstrom fließt.
 14. Mittel- und Hochspannungsschaltanlage, die mindestens eine Schaltvorrichtung nach einem der Ansprüche 1 bis 13 umfasst.
 15. Temperatenausgleichsverfahren in einer Schaltvorrichtung, das die folgenden Schritte umfasst:
Bereitstellen eines ersten Leiterteils (7, 70), der mit einem zweiten Leiterteil (8, 80) in einem geschlossenen Volumen innerhalb eines Gehäuses, das mit einem gasförmigen isolierenden Medium gefüllt ist, elektrisch verbindbar ist, **gekennzeichnet durch**
Bereitstellen einer thermischen Verbindung nur zwischen einem ersten Bereich des ersten Leiterteils (7, 70) und einem zweiten Bereich (7.2, 70.2) des ersten Leiterteils, wobei der zweite Bereich in einem Abstand von dem ersten Bereich (7.1, 70.1) angeordnet ist, wobei sich der erste Bereich (7.1, 70.1) und der

zweite Bereich des ersten Leiterteils (7, 70) auf verschiedenen Temperaturhöhen befinden, wenn während eines Betriebszustands der Schaltvorrichtung ein Stromfluss die Schaltvorrichtung entlang einem Stromweg (5) überquert, und wobei sowohl der erste Bereich (7.1, 70.1) des ersten Leiterteils (7, 70) als auch der zweite Bereich (7.2, 70.2) des ersten Leiterteils (7, 70) in dem Volumen innerhalb des geschlossenen Gehäuses angeordnet sind, und

durch Kühlen des ersten Bereichs (7.1, 70.1) in dem Betriebszustand der Schaltvorrichtung mittels einer thermischen Verbindung, die **durch** eine Wärmerohranordnung (18, 30, 31) gebildet wird, die den ersten Bereich (7.1, 70.1) und den zweiten Bereich des ersten Leiterteils (7, 70) mittels des Verminderns einer Temperaturdifferenz zwischen dem ersten Bereich und dem zweiten Bereich thermisch verbindet.

16. Temperatenausgleichsverfahren nach Anspruch 15, **dadurch gekennzeichnet, dass** sich die mindestens eine Wärmerohranordnung (18) im Betriebszustand der Schaltvorrichtung elektrisch auf einem hohen Spannungspotential oder auf einem Hochstromweg befindet.

17. Temperatenausgleichsverfahren nach Anspruch 15 oder 16, **gekennzeichnet durch** Verdampfen eines Arbeitsmediums in der mindestens einen Wärmerohranordnung (18, 30, 31) an dem ersten Bereich (7.1, 70.1, 80.1) bei einer ersten Phasenwechseltemperatur des Arbeitsmediums, die in einem Bereich von neunzig Grad Celsius bis einhundertfünfzehn Grad Celsius liegt, und **durch** Kondensieren des Arbeitsmediums in der mindestens einen Wärmerohranordnung an dem zweiten Bereich (7.2, 70.2, 80.2) bei einer zweiten Phasenwechseltemperatur des Arbeitsmediums in einem Bereich von fünfzig Grad Celsius bis fünfundsiebzig Grad Celsius.

Revendications

1. Dispositif de commutation, comportant une première pièce conductrice (7, 70) apte à être reliée électriquement à une deuxième pièce conductrice (8, 80), la première pièce conductrice (7, 70) et la deuxième pièce conductrice (8, 80) étant agencées dans un volume clos à l'intérieur d'un boîtier rempli d'un milieu gazeux isolant, **caractérisé par** une liaison thermique formée par un agencement de caloducs (18, 30, 31) reliant thermiquement une première région (7.1, 70.1) de la première pièce conductrice (7, 70) et une deuxième région (7.2, 70.2)

de la première pièce conductrice (7, 70) uniquement, laquelle deuxième région (7.2, 70.2) est placée à une certaine distance de la première région (7.1, 70.1), dispositif dans lequel la première région (7.1, 70.1) et la deuxième région (7.2, 70.2) de ladite première pièce conductrice (7, 70) se trouvent à des niveaux de température différents lorsqu'un courant circule dans le dispositif de commutation suivant un chemin de courant (5) à l'état de marche du dispositif de commutation, dispositif dans lequel la première région (7.1, 70.1) de la première pièce conductrice (7, 70) et la deuxième région (7.2, 70.2) de la première pièce conductrice (7, 70) sont toutes deux agencées dans le volume au sein dudit boîtier clos.

2. Dispositif de commutation selon la revendication 1, **caractérisé en ce que** la première pièce conductrice (7, 70) est creuse et l'agencement de caloducs (18, 30, 31) est agencé à l'intérieur de la pièce conductrice creuse (7, 70).
3. Dispositif de commutation selon la revendication 2, **caractérisé en ce que** au moins soixante pour cent de l'agencement de caloducs (18, 30, 31) sont agencés d'un premier côté ou d'un deuxième côté d'un plan passant par un axe longitudinal de la première et/ou de la deuxième pièce conductrice.
4. Dispositif de commutation selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** un côté évaporateur de l'agencement de caloducs (18, 30, 31) est en contact thermique avec ladite première pièce conductrice (7, 70) à proximité d'une liaison électriquement conductrice d'un contact mobile (12, 22) et ladite première pièce conductrice (7, 70), dispositif dans lequel ladite au moins une liaison électriquement conductrice permet la conduction d'un courant à l'état de marche du dispositif de commutation.
5. Dispositif de commutation selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** un côté condenseur dudit au moins un agencement de caloducs (18, 30, 31) est relié à ladite première pièce conductrice (7, 70) à proximité d'un dispositif de dissipation de chaleur (200, 201.1) en contact thermique avec la pièce conductrice (7, 70).
6. Dispositif de commutation selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** il comporte un disjoncteur (2) et/ou un sectionneur (3, 4).
7. Dispositif de commutation selon l'une quelconque

des revendications 1 à 6,

caractérisé en ce que

l'agencement de caloducs (18, 30, 31) se trouve électriquement sur un potentiel haute tension ou sur un chemin de fort courant à l'état de marche du dispositif de commutation.

8. Dispositif de commutation selon l'une quelconque des revendications 1 à 7,
caractérisé en ce que
ledit au moins un agencement de caloducs (18, 30, 31) comprend un caloduc prenant la forme d'un cône tronqué creux ou d'un segment de celui-ci.
9. Dispositif de commutation selon l'une quelconque des revendications 1 à 8,
caractérisé en ce que
ledit au moins un agencement de caloducs (30) comporte une pluralité de caloducs du type tube distincts (30.1 - 30.5 ; 38.1 - 38.4).
10. Dispositif de commutation selon l'une quelconque des revendications 1 à 9,
caractérisé en ce que
ledit au moins un agencement de caloducs comprend un caloduc essentiellement tubulaire dont le côté évaporateur et le côté condenseur sont fermés.
11. Dispositif de commutation selon la revendication 10,
caractérisé en ce que
les extrémités comprimées constituent chacune une bride (32, 33) servant à fixer ledit caloduc (31) respectivement à ladite première et ladite deuxième pièce conductrice (7, 70, 8, 80).
12. Dispositif de commutation selon l'une quelconque des revendications 1 à 11,
caractérisé en ce que
la première région (7.1, 70.1) est déportée d'une certaine distance par rapport à la deuxième région (7.2, 70.2) suivant le chemin de courant.
13. Dispositif de commutation selon l'une quelconque des revendications précédentes,
caractérisé en ce que
une première région (14) de ladite deuxième pièce conductrice (8, 80) est reliée à une deuxième région (8') de ladite deuxième pièce conductrice (8, 80) située en décalage de la première région (14) relativement à une direction d'un courant au moyen d'un autre agencement de caloducs (19, 29), la première et la deuxième région de ladite deuxième pièce conductrice (8, 80) se trouvant à des niveaux de température différents lorsqu'un courant nominal circule à l'état de marche du dispositif de commutation.
14. Sous-station moyenne ou haute tension comprenant au moins un dispositif de commutation selon l'une

quelconque des revendications 1 à 13.

15. Procédé d'équilibrage thermique dans un dispositif de commutation, comprenant l'étape suivante consistant à :

procurer une première pièce conductrice (7, 70) apte à être reliée électriquement à une deuxième pièce conductrice (8, 80) dans un volume clos à l'intérieur d'un boîtier rempli d'un milieu gazeux isolant,

caractérisé par les étapes consistant à procurer une liaison thermique entre une première région de la première pièce conductrice (7, 70) et une deuxième région (7.2, 70.2) de la première pièce conductrice uniquement, laquelle deuxième région est placée à une certaine distance de la première région (7.1, 70.1), procédé dans lequel la première région (7.1, 70.1) et la deuxième région de ladite première pièce conductrice (7, 70) se trouvent à des niveaux de température différents lorsqu'un courant circule dans le dispositif de commutation suivant un chemin de courant (5) à l'état de marche du dispositif de commutation, et procédé dans lequel la première région (7.1, 70.1) de la première pièce conductrice (7, 70) et la deuxième région (7.2, 70.2) de la première pièce conductrice (7, 70) sont toutes deux agencées dans le volume au sein dudit boîtier clos, et refroidir la première région (7.1, 70.1) à l'état de marche du dispositif de commutation au moyen d'une liaison thermique formée par un agencement de caloducs (18, 30, 31) reliant thermiquement la première région (7.1, 70.1) et la deuxième région de ladite première pièce conductrice (7, 70) au moyen d'une réduction d'un écart de température entre la première région et la deuxième région.

16. Procédé d'équilibrage thermique selon la revendication 15,
caractérisé en ce que
ledit au moins un agencement de caloducs (18) se trouve électriquement sur un potentiel haute tension ou sur un chemin de fort courant à l'état de marche du dispositif de commutation.
17. Procédé d'équilibrage thermique selon la revendication 15 ou 16,
caractérisé par les étapes consistant à faire évaporer un milieu actif dans ledit au moins un agencement de caloducs (18, 30, 31) au niveau de la première région (7.1, 70.1, 80.1) à une première température de changement de phase du milieu actif dans une plage allant de quatre-vingt dix degrés Celsius à cent quinze degrés Celsius, et condenser le milieu actif dans ledit au moins un

agencement de caloducs au niveau de la deuxième région (7.2, 70.2, 80.2) à une deuxième température de changement de phase du milieu actif dans une plage allant de cinquante degrés Celsius à soixante-quinze degrés Celsius.

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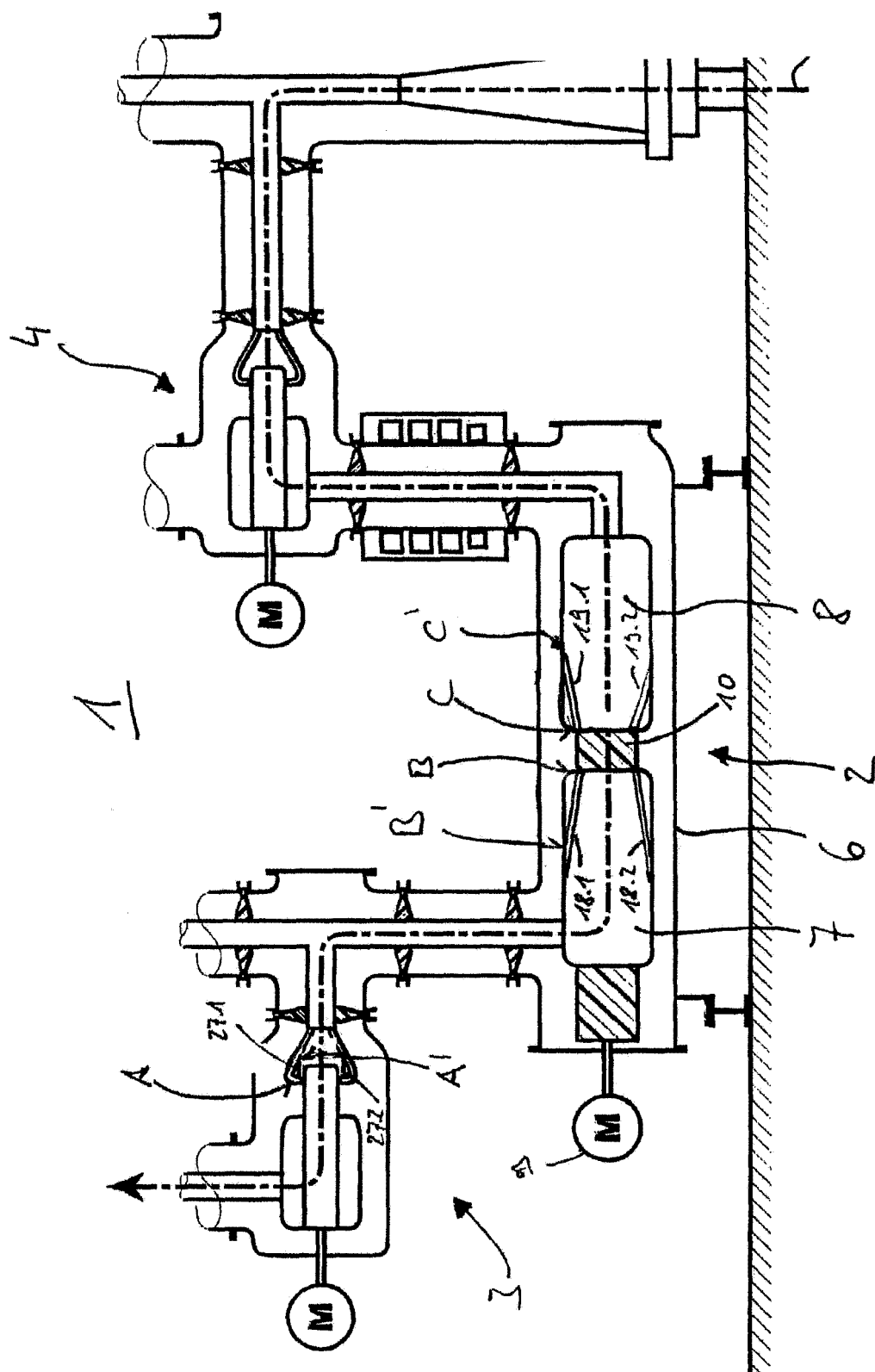
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Fig. 1



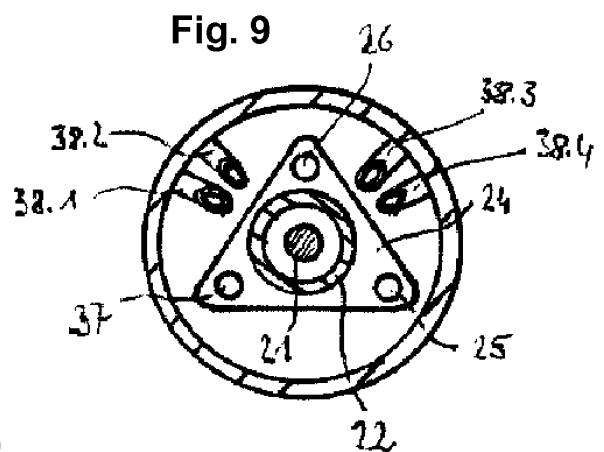
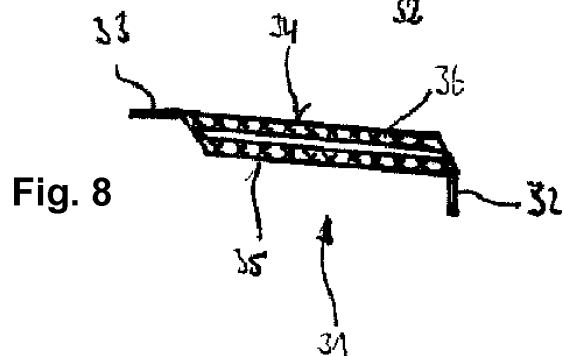
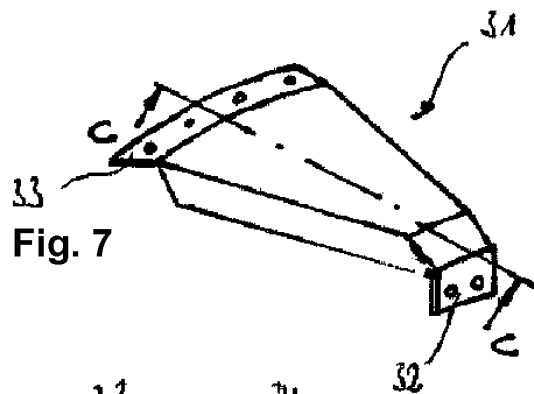
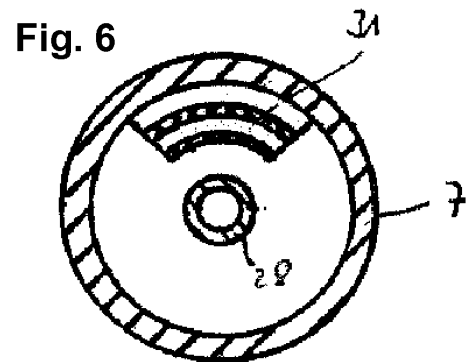
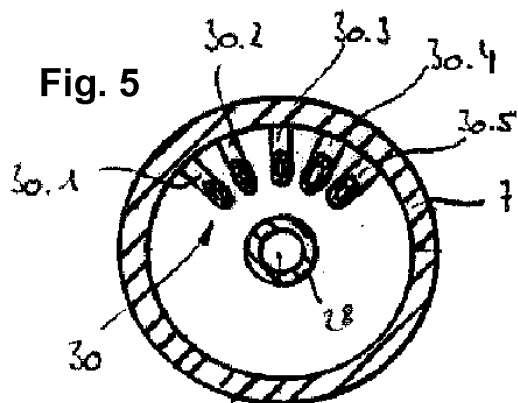
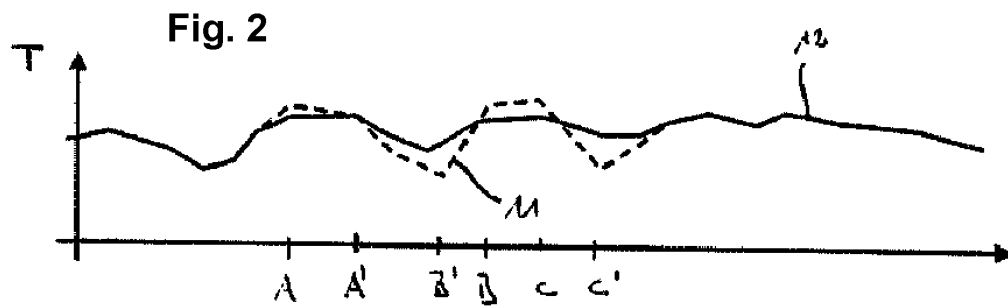


Fig. 3

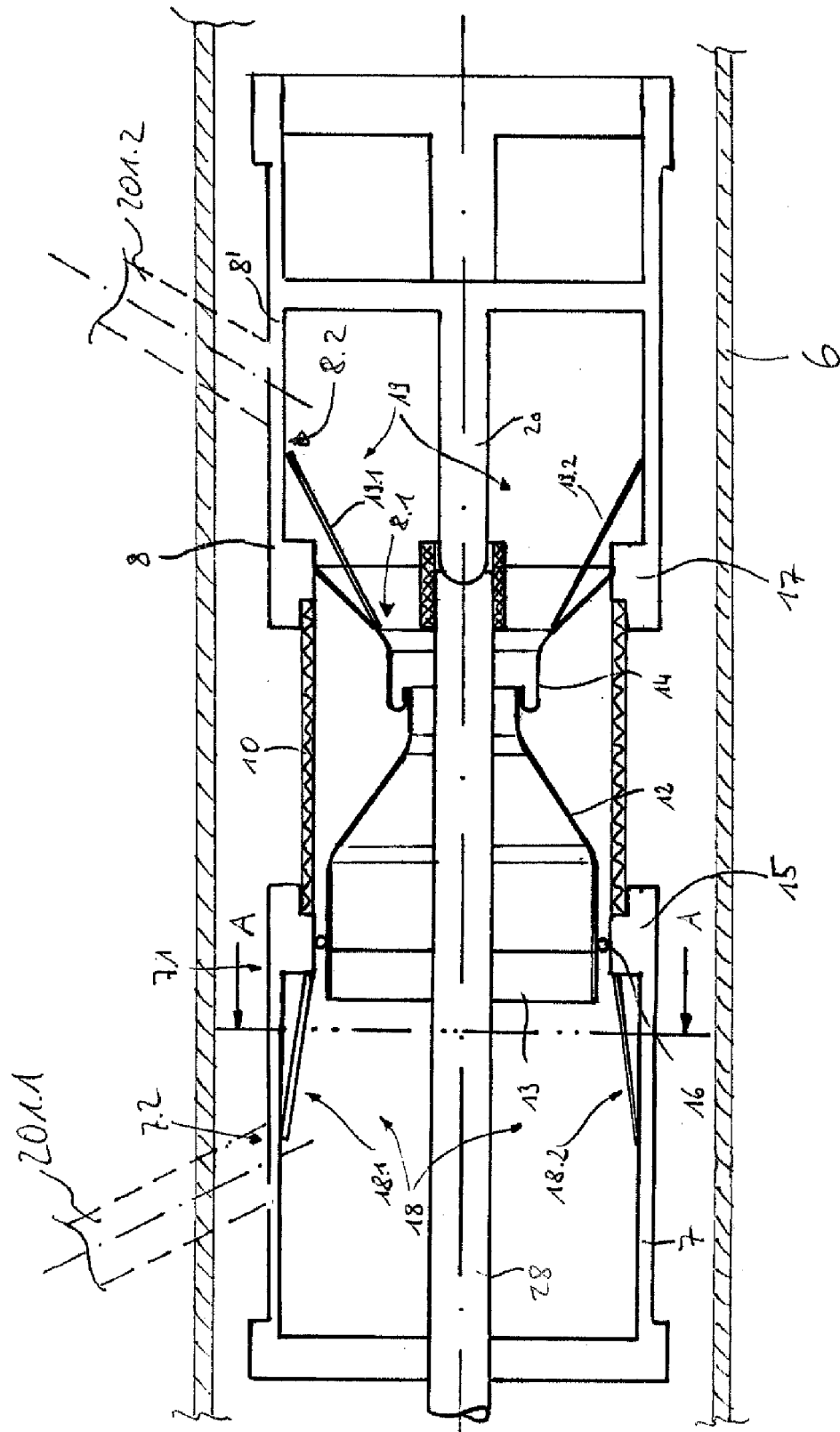
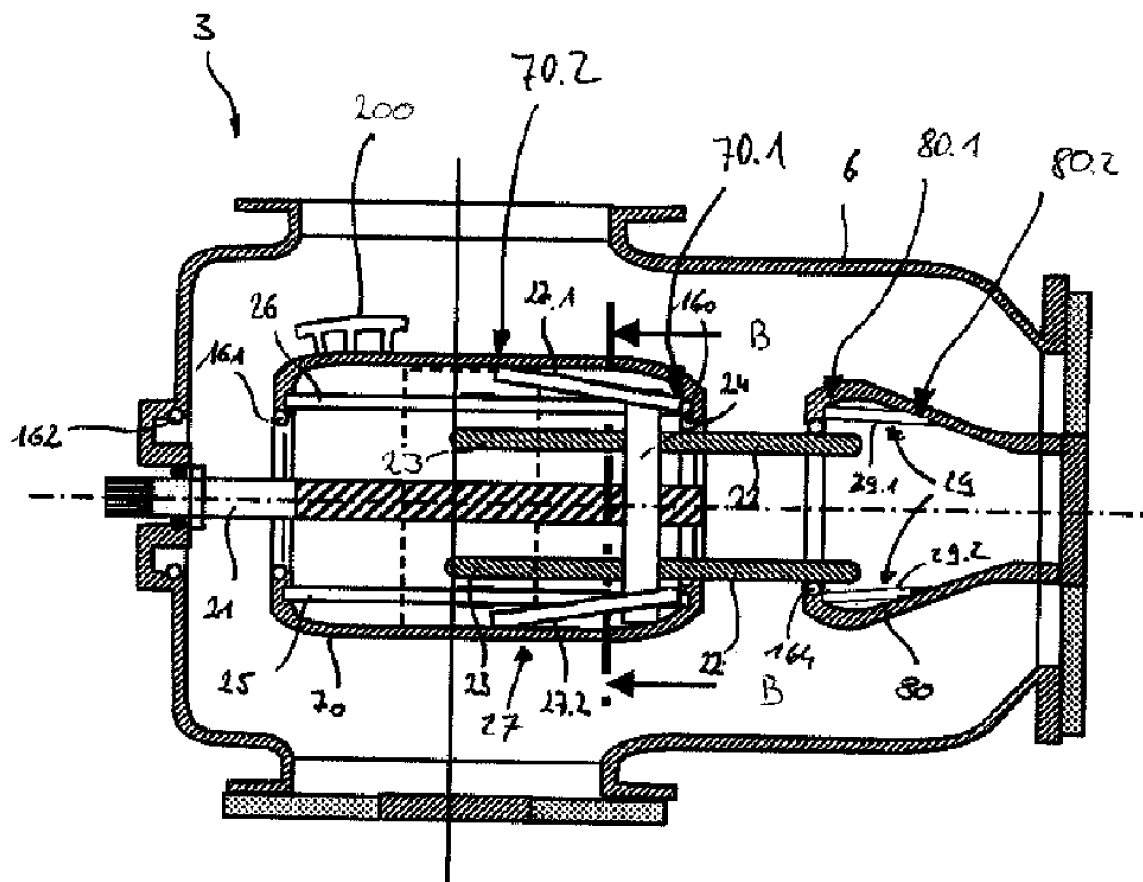


Fig. 4



REFERENCES CITED IN THE DESCRIPTION

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