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(71) Applicant: **Starkstrom-gerätebau GmbH**
93055 Regensburg (DE)

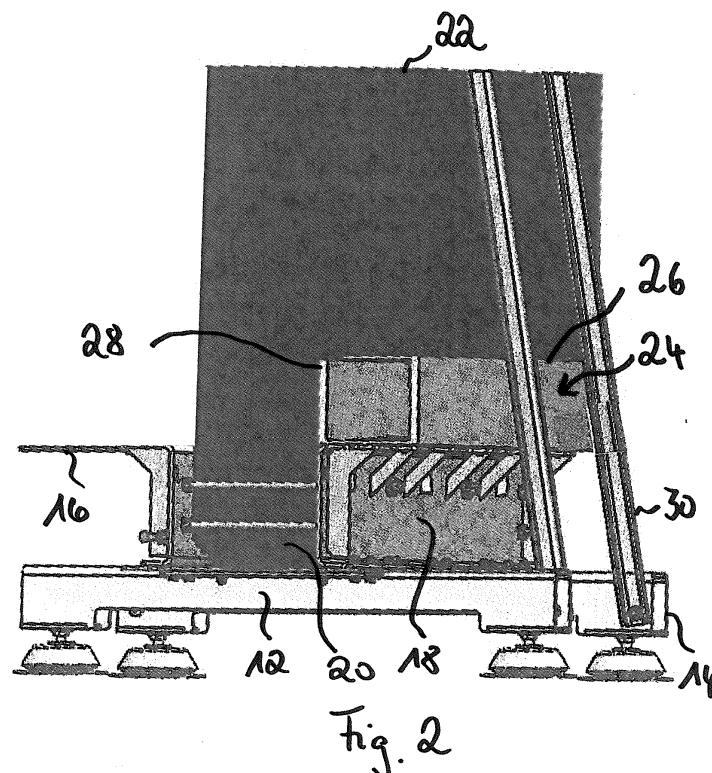
(72) Inventor: **Schwaiger, Arnold**
93055 Regensburg (DE)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **TRANSFORMER WITH WINDING SUPPORT HAVING COOLING FUNCTIONALITY**

(57) The present invention is to provide an improved approach to cooling functionality for transformers while at the same time decreasing space requirements. A winding support (24) comprises a hollow traverse body (26) adapted to space a winding body (22) and a core clamp (16, 18) of the transformer (10). The winding support (22) at the same time guides a cooling fluid to the winding

body. The hollow traverse body (26) has at least one fluid exchange opening for exchange of a cooling fluid between an exterior and an interior of the hollow traverse body. Further, the hollow traverse body (26) has at least one cooling cutout adapted to exchange cooling fluid between the interior of the hollow traverse body and a cooled surface of the at least one winding body (22).



Description

TECHNICAL FIELD

[0001] The present invention relates to a transformer with winding support having a cooling functionality, in particular to a winding support with cooling functionality for at least one winding body of a transformer system using the winding support.

BACKGROUND ART

[0002] Fig. 1 shows a perspective view of a typical transformer 100 as known in the art, e.g. a dry type or cast resin transformer.

[0003] As shown in Fig. 1, the transformer 100 comprises trucks 102, 104 supporting lower core clamps 106, 108 fixing a magnetic core, in particular a lower yoke of the magnetic core. On the upper side, there are provided upper core clamps 110, 112 for fixing the magnetic core, in particular an upper yoke of the magnetic core.

[0004] As shown in Fig. 1, with respect to three phases there are provided high voltage windings 114 and low voltage windings 116. Further, at the high voltage side there are provided delta connections 118. For the low voltage windings there are provided low voltage connections 120.

[0005] As shown in Fig. 1, lower spacers 122 enable a spacing between the lower core clamps 106, 108. Similarly, upper spacers 124 enable a spacing between the windings and the upper core clamps 110, 112.

[0006] To achieve a cooling functionality for the transformer there is provided additional equipment like temperature monitoring equipment and fans. Such fans will then be operated through temperature dependent control in line with the operative load of the transformer to provide capacity reserves and to cover peak load periods.

[0007] However, in view of constantly increasing performance requirements for transformers and new technical fields of use for transformers, e.g., in on shore and off shore windmills, the combined use of spacers and temperature controlled fans is requiring too much space. Also, the achievable cooling performance is falling behind actual cooling requirements.

SUMMARY OF INVENTION

[0008] In view of the above, the object of the present invention is to provide an improved approach to cooling functionality for transformers while at the same time decreasing space requirements.

[0009] According to a first aspect of the present invention this object is achieved by a winding support with cooling functionality for at least one winding body of a transformer. The winding support comprises a hollow traverse body adapted to space the at least one winding body and a core clamp of the transformer. The winding support is also adapted to simultaneously guide a cooling fluid to

the at least one winding body. The hollow traverse body has at least one fluid exchange opening for exchange of a cooling fluid between an exterior and an interior of the hollow traverse body. Further, the hollow traverse body has at least one cooling cutout adapted to exchange cooling fluid between the interior of the hollow traverse body and a cooled surface the at least one winding body.

[0010] According to a second aspect of the present invention the object outlined above is achieved by a transformer system, comprising a transformer having at least one winding body being arranged around a magnetic core, extending between a lower yoke and an upper yoke of the transformer, upper core clamps for fixing the upper yoke, and lower core clamps for fixing the lower yoke. Further, the transformer system comprises at least one winding support according to the first aspect of the present invention which is attached to at least one lower core clamp to space the at least one winding body and the at least one lower core clamp and to exchange a cooling fluid with at least one cooling channel of the at least one winding body.

DESCRIPTION OF DRAWING

[0011] In the following there will be given a detailed explanation of the present invention with reference to the drawing in which

Fig. 1 shows a perspective view of a typical transformer seeing as known in the art, e.g., a cast resin transformer;

Fig. 2 shows of an exemplary winding support according to the present invention;

Fig. 3 shows a perspective view of an exemplary winding support according to the present invention;

Fig. 4 shows and exemplary spatial relationship between a winding and a cooling cutout according to the present invention;

Fig. 5 shows a further exemplary spatial relationship between a winding body and a cooling cutout according to the present invention;

Fig. 6 (a) and (b) show a top view on a transformer system using the winding support according to the present invention and a side view on a transformer system using the winding support according to the present invention;

Fig. 7 (a) and (b) show a sectional view of a transformer system using two winding supports according to the present invention and the supply of cooling fluid to the two winding supports;

- Fig. 8 (a) and (b) show the provision of a dedicated cooling channel to at least one internal target point of a winding body;
- Fig. 9 shows a basic configuration of a transformer using a winding support with cooling functionality according to the present invention;
- Fig. 10 shows further details of a winding body, in particular with respect to a low voltage winding and a high voltage winding and related cooling channels;
- Fig. 11 summarizes measurement results achievable with respect to a plurality of internal points of a winding body and with respect to the basic configuration of the transformer shown in Fig. 9;
- Fig. 12 (a) and (b) illustrate the use of an envelope around a winding body for improved convection of cooling fluid around the winding body;
- Fig. 13 shows an optimization of an air gap provided at the circumference of the winding body with respect to the cooling cutout of the winding support;
- Fig. 14 shows a cross-sectional view through a transformer using the winding support according to the present invention and spacer sections for improvement of cooling fluid convection;
- Fig. 15 summarizes measurement results to illustrate improvements achievable with the optimization measures illustrated with respect to Fig. 12 to 14;
- Fig. 16 shows a cross sectional view of a magnetic core provided with an interior cooling plate having cooling channels;
- Fig. 17 shows a perspective view of the interior cooling plate;
- Fig. 18 shows a transformer system according to the present invention wherein the transformer using the winding support according to the present invention is accommodated in a housing and thermally coupled to a heat exchanger; and
- Fig. 19 shows a cross-sectional view through the transformer system shown in Fig. 18.

DETAILED DESCRIPTION

[0012] In the following of the present invention will be

described with reference to the drawing and examples thereof. Insofar as specific features of the present invention are described with respect to the examples it should be understood that these features are not to construed in isolated manner and may be easily combined with further features of the present invention.

[0013] Fig. 2 shows of a transformer using a winding support according to the present invention.

[0014] Generally, a typical example for the transformer may be a dry type transformer which is however non limiting for the scope of the present invention.

[0015] As shown in Fig. 2, the transformer 10 comprises trucks 12 and 14 that support lower core clamps 16 and 18 fixing a magnetic core 20, in particular a lower yoke of the magnetic core 20. The transformer 10 has at least one winding body 22.

[0016] As shown in Fig. 2, according to the present invention there is provided a winding support 24 with integrated cooling functionality for at least one winding body 22 of a transformer 10.

[0017] As shown in Fig. 2, the winding support 24 comprises a hollow traverse body 26. The hollow traverse body 26 has at least one fluid exchange opening 28 for exchange of a cooling fluid, e.g., air between an exterior and an interior of the hollow traverse body 26. Further, optionally there may also be provided support pillars 30 for fixing the at least one winding body 22.

[0018] Operatively, the winding support 24 supports the at least one winding body 22 and is fixed to the core clamp 18 of the transformer 10. Also, the winding support 22 guides the cooling fluid to at least one cooled surface of the at least one winding body 22, e.g., a cooling channel of the at least one winding body 22.

[0019] Overall, the present invention is particularly suited to air forced cooling. It significantly increases cooling efficiency as cooling fluid like air may not escape, e.g., from the space between the winding body 22 and a magnetic core of the transformer 10. Also cooling fluid, e.g., air is guided in a directed manner the surface area where it is applied at the winding body 22.

[0020] Further, the present invention enables an even and direct supply of cooling fluid over the complete surface and also through cooling channels of the winding body 22. The concept is applicable at the lower side of a winding body 22 by blowing cooling fluid from the bottom side to the top side or at the upper side of the winding body by suction of cooling fluid from the bottom side to the top.

[0021] Further, the present invention allows for reduced use of material for the transformer and for reduced power consumption of cooling blowers. The combination of support and cooling functionality leads to reduction of number of parts to be handled during manufacturing as a plurality of spacers and cooling fans are integrated into one winding support 24 having cooling functionality. Cooling fluid plates provided separately from the transformer become optional or even obsolete. Further, a plurality of winding bodies may be assembled simultane-

ously on the winding support and the magnetic core facilitating the manufacturing process significantly.

[0022] Still further, the increase of cooling capacity allows for an increased induction in the magnetic core of the transformer.

[0023] Fig. 3 shows a perspective view of an example of the winding support 24 according to the present invention.

[0024] As shown in Fig. 3, the hollow traverse body 26 has at least one cooling cutout 32-1 to 32-3 adapted to exchange cooling fluid between the interior of the hollow traverse body 26 and a cooled surface of the winding body 22, e.g., a cooling channel of the winding body 22.

[0025] As shown in Fig. 3, the hollow traverse body 26 is a parallelepiped having a rectangular cross section and longitudinal corner lines. The at least one cooling cutout 32-1 to 32-3 is provided at a side surface of the hollow traverse body 26 which supports the at least one winding body 22. The at least one cooling cutout 32-1 to 32-2 has a base line arranged along one longitudinal corner line of the right parallelepiped.

[0026] Here it should be understood that the arrangement of cooling cutouts at the side of the of the hollow traverse body is a preferred realization and that also different types of cutouts at the interface between the hollow traverse body 26 and the winding body 22 are covered by the scope of the present invention.

[0027] As shown in Fig. 3, the hollow traverse body may comprise an interior partition wall 34 extending a longitudinal axis of the hollow traverse body 26. The interior partition wall 34 divides the interior space of the hollow traverse body 26 into a first partial interior space and a second partial interior space.

[0028] Further, each of the first partial interior space and/or the second partial interior space may itself be divided into a plurality of channels to assure consistent distribution of the cooling fluid along the longitudinal extension of the hollow traverse body 26, e.g., to winding bodies of different phases of the transformer 10.

[0029] As shown in Fig. 3, operatively the first partial interior space and the second partial interior space and/or related channels may be used to guide cooling fluid, e.g. air, to different interior parts of the winding body 22, e.g., to spaces between a low voltage winding and a high voltage winding and further to a space between a low voltage winding and a magnetic core of the transformer 10.

[0030] As shown in Fig. 3, operatively the interior partition wall 34 also forms the mechanical bearing by being exposed to the exterior of the hollow traverse body 26 across the at least one cooling cutout 32-1 to 32-3.

[0031] Fig. 4 shows an exemplary spatial relationship between a winding body 22 and a cooling cutout 32 according to the present invention.

[0032] As shown in Fig. 4, the cooling cutout 22 is larger than an overlap area formed between the hollow traverse body 26 and the winding body 22 while the interior partition wall 34 of the hollow traverse body 26 supports the winding body 26.

[0033] It should be noted that the interior partition wall 34 is only one option for supporting the winding body 22. In the most general form the winding body 22 is supported by any type of mechanical bearing which is provided within the hollow traverse body 26 for exposure to the exterior of the hollow traverse body 26 in an subarea of the cooling cutout 32 which is intended for overlap with the at least one winding body 22.

[0034] As shown in Fig. 4, the cooling cutout 32 has the form of a segment of a circle having a radius being larger than the radius of the cross section of the winding body 22. Thus, an air gap is formed along the circumference of the winding body 22 by arranging the at least one winding body 22 with respect to the hollow traverse body 26 such that the segment of the circle forming the cutout 32 and that of the circle representing the cross section of the winding body 22 are co-centric.

[0035] Further, it should be noted that while the cutout section 32 is shown as segment of a circle in Fig. 3 the present invention is not restricted thereto. I.e., as long as the functionality of cooling fluid supply to the winding body 22 is achieved any other form may be suitably selected, e.g., triangular, rectangular, polygonal, ellipsoid, etc.

[0036] Fig. 5 shows a further exemplary spatial relationship between a winding body 22 and a cooling cutout 32 according to the present invention.

[0037] As shown in Fig. 5, the cooling cutout 32 is a segment of a circle having smaller radius than the cross section of the winding body 22.

[0038] As shown in Fig. 5, a bearing area 36 is formed between the hollow traverse body 26 and the winding body 22 by arranging the winding body 22 with respect to the hollow traverse body 32 such that the arrangement is co-centric.

[0039] Figure 6 (a) and (b) show a top view on a transformer 10 using the winding support 24 according to the present invention and a side view on a transformer 10 using the winding support 24 according to the present invention.

[0040] As shown in Fig. 6 (a) the transformer is a three phase cast resin transformer having three winding bodies 22-1 to 22-3.

[0041] As shown in Fig. 6 (b), one lower winding support 24 is attached to a lower core clamp to space the three winding bodies 22-1 to 22-3 and the lower core clamp.

[0042] As shown in Fig. 6 (a) and (b), the lower winding support 24 is connected to a cooling fluid supply 38 for supply of cooling fluid to the cooling channels of the three winding bodies 22-1 to 22-3. For supply of cooling fluid any appropriate means may be applied according to the present invention, e.g., a blower unit or a fan.

[0043] Fig. 7 (a) and (b) show a sectional view of a transformer 10 using two winding supports 24-1, 24-2 according to the present invention and the supply of cooling fluid to the two winding supports 24-1, 24-2.

[0044] As shown in Fig. 7 (a) the transformer 10 may

comprise two lower winding supports 24-1, 24-2 which are attached to two lower core clamps 16, 18 of the transformer 10. A blower unit or a fan may be used for supply of cooling fluid to the two lower winding supports 24-1, 24-2.

[0045] As shown in Fig. 7 (b), a distributor 40 may be used for splitting a cooling fluid flow supplied by the blower unit or fan through a connection pipe 42 to the two lower winding supports 24-1, 24-2.

[0046] Fig. 8(a) and (b) show the provision of a dedicated cooling channel to at least one internal target point of a winding body.

[0047] As shown in Fig. 8 (a), the winding body 22 is supported by the winding support 24 having the interior partition wall 34. The winding body 22 has a high voltage winding 44, a low voltage winding 46, and the magnetic core 48.

[0048] As shown in Fig. 8(b), one partial space of the hollow traverse body 26, e.g., the outer partial space may have a partition 50 for establishment of a dedicated cooling channel 52. The partition wall 34 comprises a cooling outlet 54 provided in relation to at least one predetermined cooled surface of the at least one winding body 22.

[0049] Operatively, the dedicated cooling channel 52 connects the exchange opening 28 of the hollow traverse body 26 and the cooled surface of the winding body 22.

[0050] It should be noted that according to the present invention there exists not restriction for the position of a cooled surface and a related cooling fluid supply target point. It may be located to guide cooling fluid to an air gap provided around the circumference of the winding body 22, to the space between the high voltage winding 44 and the low voltage winding 46, and/or to the space between the low voltage winding and the magnetic core 48. The latter does not apply should the space between the magnetic core 48 and the low voltage winding be filled with casting compound.

[0051] Fig. 9 shows a basic configuration of a winding support with cooling functionality according to the present invention in line with the setup explained with respect to Fig. 7.

[0052] As shown in Fig. 9, the basic configuration provides for move winding supports 24-1, 24-2. A winding body 22 is arranged such that an air gap 55 is provided at the circumference of the winding body 22.

[0053] As shown in Fig. 9, each of the one supports 24-1, 24-2 has six dedicated supply channels 52 so as to supply cooling fluid like air to three winding bodies according to three phases of the transformer 10.

[0054] As shown in Fig. 9, with respect to each phase there are provided two dedicated channels 52 so as to guide cooling fluid to the air gap 55 formed at the circumference of each of three winding bodies according to three phases. Also, cooling fluid is guided to the space between the high voltage winding 44 and the low voltage winding 46.

[0055] Overall, the provision of dedicated channels with respect to the different winding units of the mul-

tiphase transformer allows to supply the same amount of cooling fluid to different winding units of different phases. Optionally, cooling fluid guiding plates or jets may be used for supplementary cooling of different winding units, e.g. for improved cooling in particular of the magnetic core.

[0056] While Fig. 9 shows one example of a basic configuration for the use of the winding support 24 according to the present invention it should be noted that also modifications are conceivable.

[0057] E.g., the provision of dedicated cooling channels 52 may be provided with respect to only a subset of winding bodies in a multiphase transformer.

[0058] Similarly, it is conceivable that cooling fluid is supplied only to the space between the high voltage winding 44 and the low voltage winding 46 or only to the air gap 55.

[0059] Thus, clearly all permutations and variations of the different principles outlined above are deemed to be covered by the scope of the present invention.

[0060] Fig. 10 shows further details of a winding body 22, in particular with respect to a low voltage winding 46 and a high voltage winding 44 and related cooling channels.

[0061] As shown in Fig. 10 the winding body 22 has the high voltage winding 44 and the low voltage winding 46 provided with additional dedicated cooling channels. This allows to further increase convection of cooling fluid through the winding body 22.

[0062] Further, the provision of dedicated cooling channels as outlined above may as well be applied to such cooling channels being provided in either the high voltage winding 44 and/or the low voltage winding 46.

[0063] Fig. 11 summarizes measurement results achievable with respect to a plurality of internal points of a winding body and with respect to the basic configuration of the winding support shown in Fig. 9.

[0064] The measurement results shown in Fig. 11 have been generated using a blower unit operating with 3 kW at approximately 2880 U/min.

[0065] As shown in Fig. 11, measurement points are placed around the circumference of the winding body 22 according to A to L and further along the radial direction of the winding body as indicated by numerals 1 to 4, wherein 1 identifies a cooling channel in the high voltage winding 44, 2 identifies space between high voltage winding 44 and low voltage winding 46, 3 identifies a cooling channel in the low voltage winding, and 4 identifies a cooling channel between the low voltage winding 46 and the magnetic core 48.

[0066] As shown in Fig. 11, the use of the winding support 24-1 and 24-2 generates convection throughout the winding body 22. Such convection is larger for measurement points, e.g. A-1 to C-1 or H-1, which are in direct communication with the interior of the hollow traverse body 26.

[0067] Further, it has been observed that convection velocity decreases when the flow resistance increases,

e.g., at in cooling channels of the high voltage winding or low voltage winding, see G-1.

[0068] Still further, convection velocity may even be zero at measurement points where no convection is possible, e.g., due to contact between the winding body and the internal partition wall 34 of the hollow traverse body 26.

[0069] In the following additional options to improve the performance of the cooling functionality will be explained with respect to Fig. 12 to 14.

[0070] Fig. 12 (a) and (b) illustrate the use of an envelope 56 around the winding body 22 for improved convection of cooling fluid around the winding body 22.

[0071] As shown in Fig. 12 (a) the envelope 56 is adapted to the outer circumferential shape of the winding body 22, e.g., a cylindrical shape.

[0072] As shown in Fig. 12 (b), the diameter of the envelope 56 is selected to fully extend across an air gap 55 formed around the circumference of the winding body 22.

[0073] As shown in Fig. 12 (a) and (b), there are provided two lower winding supports 24-1, 24-2, and the outer cylindrical surface of the winding body 22 is covered by a cylindrical envelope 56 having a radius to cover the circular air gaps 55-1, 55-2 for generation of a cooling fluid stream along the outer surface of the winding body 22.

[0074] Fig. 13 shows an optimization of an air gap provided at the circumference of the winding body with respect to the cooling cutout of the winding support.

[0075] As shown in Fig. 13 an appropriate selection of the width of the air gap 55 allows for an optimized convection of cooling fluid at the outer circumferential surface of the winding body 22. Here, a spacing of 1 to 2 cm could be identified as appropriate geometry.

[0076] Fig. 14 shows a cross-sectional view through a transformer system using the winding support according to the present invention and spacer sections for improvement of cooling fluid convection.

[0077] As shown in Fig. 14, the interior partition wall 34 may have at least one spacer section 58-1, 58-2 extending to the exterior of the hollow traverse body 26 where the interior partition wall 34 crosses a cooling cutout 32.

[0078] The provision of spacer sections 58-1, 58-2 allows to achieve increased separation between the bearing provided by the hollow traverse body 26 and the winding body and therefore for an improvement of convection with the hollow traverse body 26. An exemplary spacing achievable by spacer sections 58-1, 58-2 is in the range of 1 to 2 cm.

[0079] Fig. 15 summarizes measurement results to illustrate improvements achievable with the optimization measures illustrated with respect to Fig. 12 to 14.

[0080] An explanation of the measurement positions and conditions is the same as outlined above with respect to Fig. 11.

[0081] As shown in Fig. 15, the optimization options explained with respect to Fig. 12 to Fig. 14 lead to further

improvements of cooling fluid convection.

[0082] E.g., the provision of the envelope 56 allows for a significant increase of convection around the outer surface of the winding body 22, see, A-1 or G-1.

[0083] Further, also the provision of spacer sections 58 optimizes convection underneath the winding body 22, see H 1-4.

[0084] Fig. 16 shows a cross sectional view of a magnetic core 48 provided with an interior cooling plate 60 having cooling channels for liquid cooling fluid, e.g., water.

[0085] As shown in Fig. 16, the interior cooling plate 60 is surrounded by metal sheets so as to form the magnetic core 44. Liquid cooling fluid, e.g., water may be guided through the cooling channels for additional cooling. Liquid cooling fluid may be supplied from outside the transformer 10 using supply hoses and/or supply pipes.

[0086] It should be noted that with liquid forced cooling no load losses of the transformer 10 may be used for heating of components outside of the transformer 10.

[0087] Further, it should be noted that the space between magnetic core 44 of the low voltage winding 46 may be filled with casting compound. This is preferable with a liquid cooling of the magnetic core 48 for simultaneous cooling of the magnetic core 48 and the low voltage winding 46 leading to an improved overall efficiency during transformer operation.

[0088] Fig. 17 shows a perspective view of the interior cooling plate.

[0089] As shown in Fig. 17, the cooling channels of the interior cooling plate 60 may be connected to outside supply pipes and/or supply hoses by use of liquid cooling fluid connections 62-1, 62-2.

[0090] Fig. 18 shows a transformer system 64 according to the present invention.

[0091] As shown in Fig. 18, in the transformer system 64 the transformer 10 using the winding support 24 according to the present invention is accommodated in a housing 66 and thermally coupled to a heat exchanger 68. It should be noted that according to the present invention there do not exist any restriction on the type of material used for the housing. E.g., it is possible to use safe to touch materials like metal. Alternatively one may use plastic material to reduce costs.

[0092] An advantage of the provision of the housing 66 is that a distance between the transformer and grounded parts may be reduced significantly. This also allows for a more compact realization of the transformer system 64, e.g., within a gondola of a wind mill. Optionally, the housing may be covered at its outer surface with a conductive or semi-conductive layer for an improved control of electric fields within the housing. This allows to further increase compactness of the overall design.

[0093] As shown in Fig. 18, generally a ventilator 70 is provided for establishment of a circulation of cooling fluid between the winding supports 24 of the transformer and the heat exchanger 70. Also, it should be noted that the use of a heat exchanger 68 is an option only. Alternatively

the convection of cooling fluid may as well be achieved by connecting the exchange openings of the winding supports to dedicated supply and discharge lines for cooling fluid to and from the winding supports 24.

[0094] Fig. 19 shows a cross-sectional view through the transformer system 64 shown in Fig. 18.

[0095] As shown in Fig. 19, the transformer 10 has three winding bodies being arranged around a magnetic core, each extending between a lower yoke and an upper yoke of the transformer 10. Upper core clamps fix the upper yoke and lower core clamps fix the lower yoke.

[0096] As shown in Fig. 19, the transformer system 64 further comprises at least one lower and upper winding support 24 as explained above with respect to Fig. 2 to 17 which is respectively attached to the lower core clamp(s) and/or the upper core clamp(s) to space the three winding bodies, the lower core clamp(s) and the upper core clamp(s). The winding supports 24 allow for exchange of cooling fluid with cooling channel(s) of the three winding bodies.

[0097] As shown in Fig. 19, the housing 66 accommodates the transformer 10. The housing has a cooling fluid inlet 72 for supply of cooling fluid to cooling fluid exchange opening of the lower winding support 24. Also, the housing 66 has a cooling fluid outlet 74 for carrying away cooling fluid from the exchange opening of the upper winding support 24. This circulation is established from bottom to top. It should be mentioned that according to the present invention convection may as well be established from top to bottom.

[0098] As shown in Fig. 19, the heat exchanger 68 is attached to the housing 68 and connected to the lower winding support(s) and upper winding support (s) via the cooling fluid inlet 72 and the cooling fluid outlet 74 of the enclosure housing 66 for cooling of cooling fluid carried away from the enclosure housing 66 via the cooling fluid outlet 74 and for supply of cooling fluid cooled by the heat exchanger 68 to the cooling fluid inlet 72 of the housing 66.

[0099] As shown in Fig. 19, the cooling of the transformer 10 with cooling fluid like air may be combined with the liquid cooling of the magnetic core of the transformer 10 as explained above with respect to Fig. 16 and 17. Heretofore, connectors 62-1 to 62-6 may be provided to the outside of the housing 66 for supply of liquid cooling fluid to the internal cooling channels of the magnetic core.

[0100] It should be noted that the combination of, e.g. cooling fluid cooling, e.g. with air, with the liquid cooling of the magnetic core allows for an increase of induction of in the magnetic core in combination with a compact construction of the transformer system 64.

[0101] Further, the heat generated during cooling of the magnetic core may also be used for heating of components outside the transformer system, irrespective of whether the housing 66 is provided or not.

[0102] Still further, the combined cooling fluid/liquid cooling allows for improved efficiency of the transformer system 64 and makes cooling by fans during no load

operation of the transformer system 64 optional.

Claims

1. Winding support (24) with cooling functionality for at least one winding body (22) of a transformer (10), comprising:

a hollow traverse body (26) adapted to space the at least one winding body (22) and a core clamp (16, 18) of the transformer (10) and adapted to simultaneously guide a cooling fluid to at least one winding body (22); wherein the hollow traverse body (26) has at least one fluid exchange opening (28) for exchange of a cooling fluid between an exterior and an interior of the hollow traverse body (26); the hollow traverse body (26) has at least one cooling cutout (32-1, 32-2, 32-3) adapted to exchange cooling fluid between the interior of the hollow traverse body (26) and a cooled surface of the at least one winding body (22).

2. Winding support according to claim 1, wherein the hollow traverse body (26) is a right parallelepiped having a rectangular cross section and longitudinal corner lines; the at least one cooling cutout (32-1, 32-2, 32-3) is provided at a side surface of the hollow traverse body (26) which supports the at least one winding body (22); the at least one cooling cutout (32-1, 32-2, 32-3) has a baseline arranged along one longitudinal corner line of the right parallelepiped; the at least one cooling cutout (32-1, 32-2, 32-3) is larger than an overlap area formed between the hollow traverse body (26) and the at least one winding body (22) when the hollow traverse body (26) supports the at least one winding body (22); and the at least one winding body (22) is supported by a mechanical bearing provided within the hollow traverse body (26) for exposure to the exterior of the hollow traverse body (26) in an subarea of the at least one cooling cutout (32-1, 32-2, 32-3) intended for overlap with the at least one winding body (22).

3. Winding support according to claim 2, wherein the at least one winding body (22) is a cylindrical body having a cross section being a first circle with a first radius, wherein the at least one cooling cutout (32-1, 32-2, 32-3) has the form of a segment of a second circle having a second radius which is larger than the first radius.

4. Winding support according to claim 3, wherein an cooling fluid gap (55) is formed along the circumference of the at least one winding body (22) by arrang-

ing the at least one winding body (22) with respect to the hollow traverse body (26) such that the first circle is co-centric to the second circle.

5. Winding support according to one of the claims 2 to 4, which comprises an interior partition wall (34) extending a longitudinal axis of the hollow traverse body (26) and adapted to divide the interior space of the hollow traverse body (26) into a first partial interior space and a second partial interior space; wherein the interior partition wall (34) forms the mechanical bearing by being exposed to the exterior of the hollow traverse body (26) across the at least one cooling cutout (32-1, 32-2, 32-3).
6. Winding support according to claim 5, wherein the interior partition wall (34) is provided with at least one spacer section (58-1, 58-2) extending to the exterior of the hollow traverse body (26) where the interior partition wall (34) crosses the at least one cooling cutout (32-1, 32-2, 32-3).
7. Winding support according to claim 1, wherein the hollow traverse body (26) is a right parallelepiped having a rectangular cross section and longitudinal corner lines; the at least one cooling cutout (32-1, 32-2, 32-3) is provided at a side surface of the hollow traverse body (26) which supports the at least one winding body (22); the at least one cooling cutout (32-1, 32-2, 32-3) has a baseline arranged along one longitudinal corner line; the at least one cooling cutout (32-1, 32-2, 32-3) is a subarea of an overlap area formed between the hollow traverse body (26) and the at least one winding body (22) when the hollow traverse body (26) supports the at least one winding body (22).
8. Winding support according to claim 7, wherein the at least one winding body (22) is a cylindrical body having a cross section in the form of a third circle with a third radius, wherein the at least cooling cutout (32-1, 32-2, 32-3) has the form of a segment of a fourth circle having a fourth radius which is smaller than the third radius; wherein a bearing area is formed between the hollow traverse body (26) and the at least one winding body (22) by arranging the at least one winding body (22) with respect to the hollow traverse body (26) such that the third circle is co-centric to the fourth circle when the hollow traverse body (26) is in engagement with the at least one winding body (22).
9. Winding support according to one of the claims 1 to 8, wherein the hollow traverse body (26) comprises at least one cooling fluid outlet (54) provided in re-

lation to at least one predetermined cooling fluid supply point of the at least one winding body (22) and at least one dedicated cooling channel (52) adapted to connect the exchange opening (28) and the at least one predetermined cooling fluid supply point.

10. Transformer system, comprising:

a transformer having

at least one winding body being arranged around a magnetic core, extending between a lower yoke and an upper yoke of the transformer;
upper core clamps for fixing the upper yoke;
lower core clamps for fixing the lower yoke;

at least one lower winding support (24) according to one of the claims 1 to 9 being attached to at least one lower core clamp to space the at least one winding body and the at least one lower core clamp and to exchange a cooling fluid with at least one cooling channel of the at least one winding body (24).

11. Transformer system according to claim 10, which comprises two lower winding supports (24-1, 24-2) being attached to two lower core clamps of the transformer and a distributor (40) for splitting a cooling fluid stream for supply to the two lower winding supports (24-1, 24-2).

12. Transformer system according to claim 11, wherein circular cooling fluid gaps are formed between the circumference of the at least one winding body and the two lower winding supports and that the outer cylindrical surface of the at least one winding body is covered by a cylindrical envelope (56) having a radius to cover the circular cooling fluid gaps for generation of a cooling fluid stream along the outer surface of the at least one winding body.

13. Transformer system according to claim 11, wherein the transformer further comprises at least one upper winding support according to one of the claims 1 to 9 being attached to at least one upper core clamp to space the at least one winding body and the at least one upper core clamp and to exchange a cooling fluid with at least one cooling channel of the at least one winding body;
a housing (66) for enclosure of the transformer having

a cooling fluid inlet (72, 74) for supply of cooling fluid to the at least one cooling fluid exchange opening of the at least one lower winding support or the at least one upper winding support; and
a cooling fluid outlet (74, 72) for carrying away

cooling fluid from the at least one cooling fluid exchange opening of the upper winding support or the lower winding support.

14. Transformer system according to claim 13, which comprises a heat exchanger (68) attached to the housing (66) and connected to the at least one lower winding support and the at least one upper winding support via the cooling fluid inlet (72, 74) and the cooling fluid outlet (74, 72) of the housing (66) for cooling of cooling fluid carried away from the housing (66) via the cooling fluid outlet (74, 72) and for supply of cooled cooling fluid to the cooling fluid inlet (72, 74) of the housing (66).
15. Transformer system according to one of the claims 10 to 14, wherein the magnetic core of the at least one winding body comprises a cooler (60) having at least one cooling channel for cooling of the magnetic core with a cooling liquid.
16. Transformer system according to claim 15, wherein the space between magnetic core of the at least one winding body and a low voltage winding of the at least one winding body is filled with casting compound.

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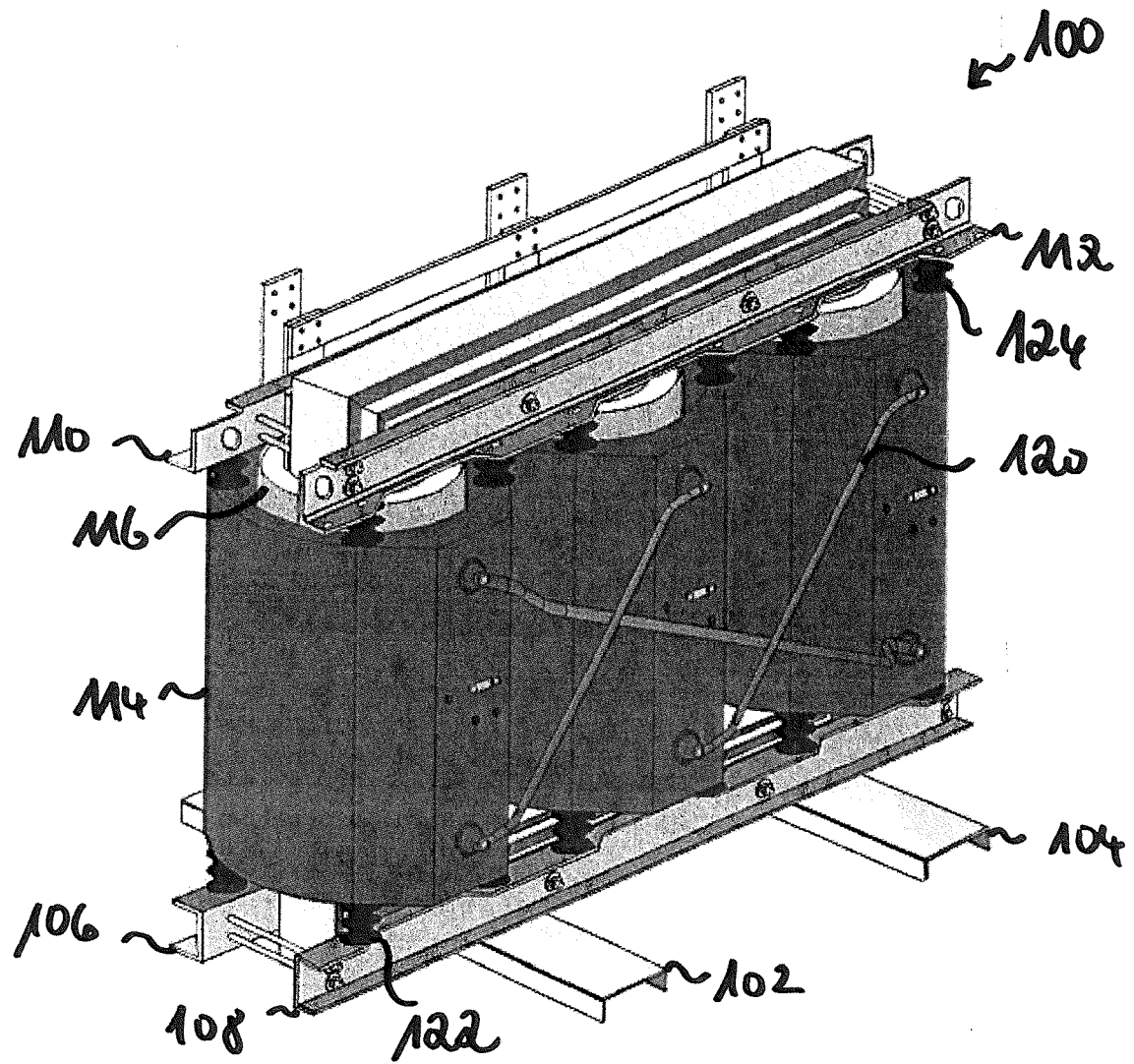
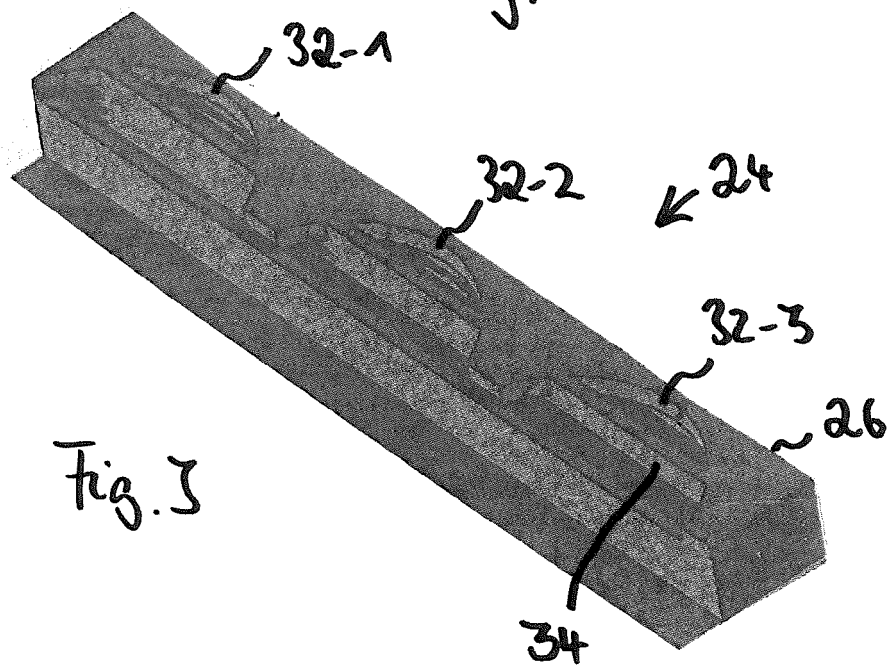
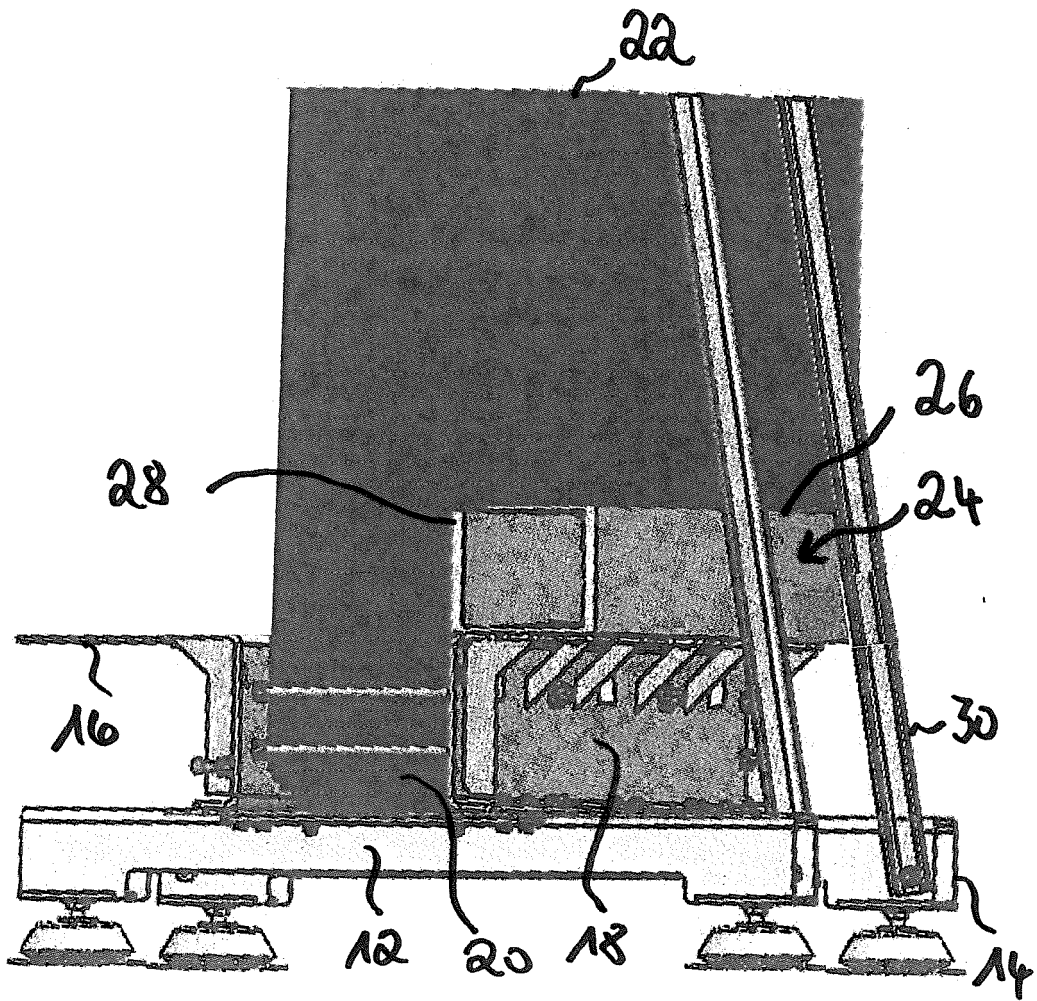
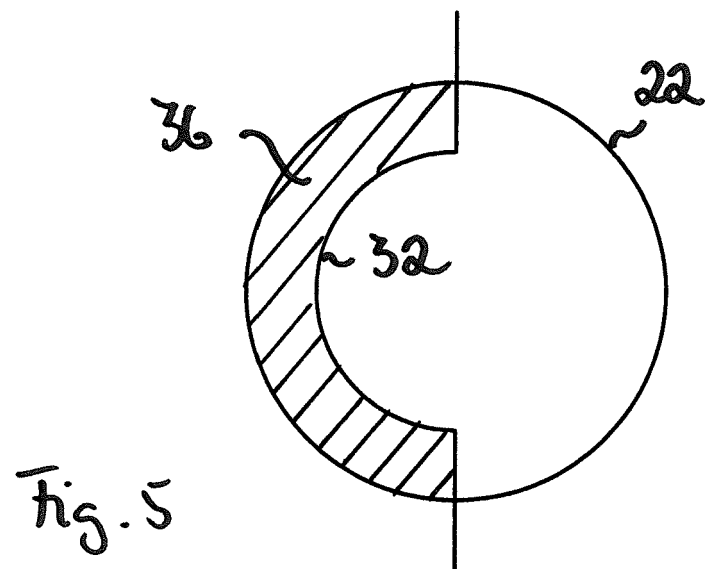
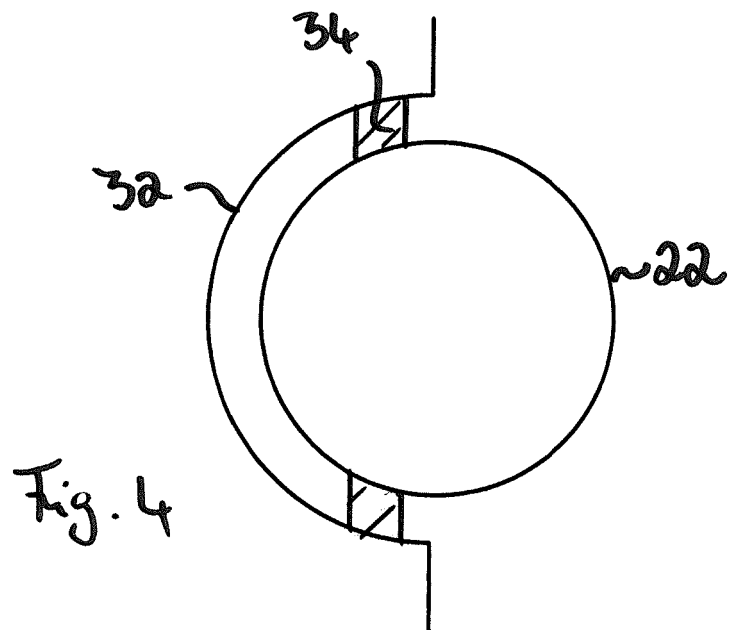


Fig. 1





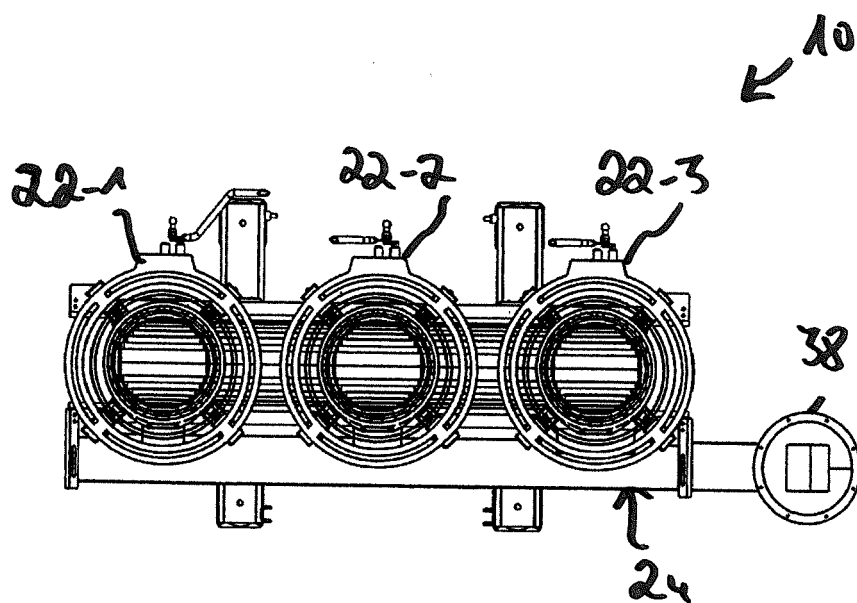


Fig. 6(a)

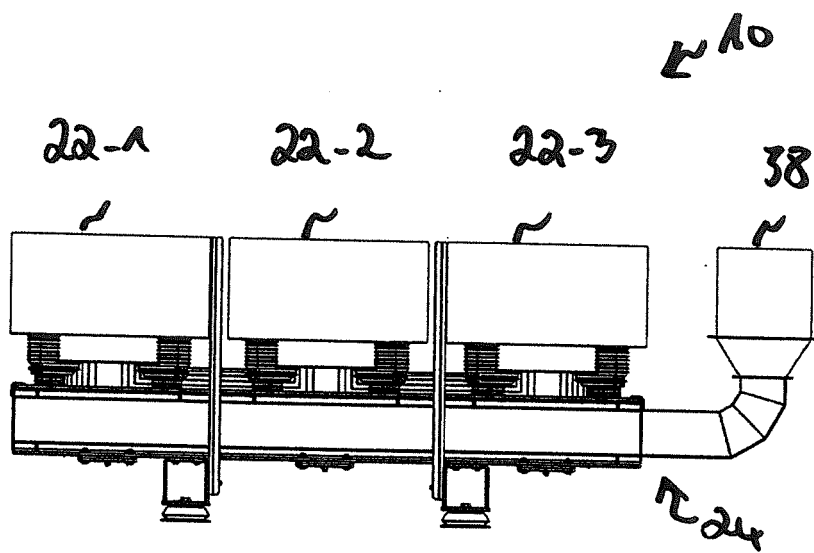
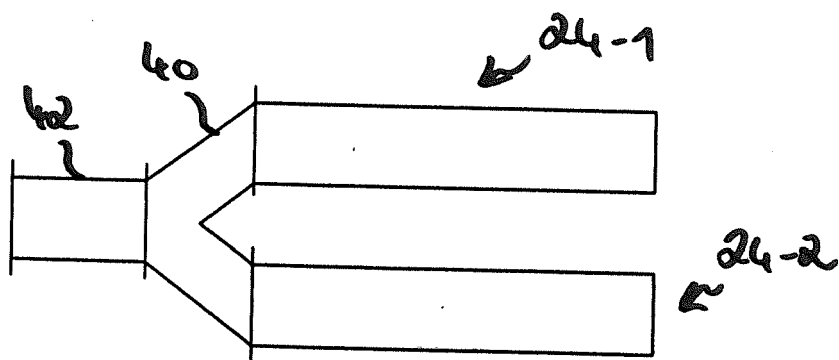
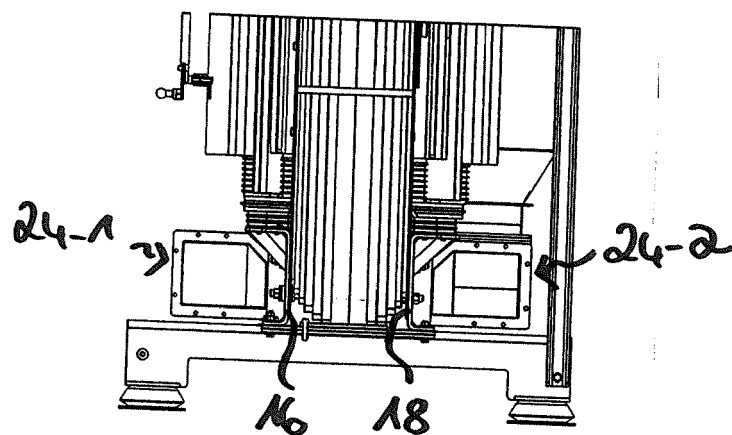


Fig. 6(b)



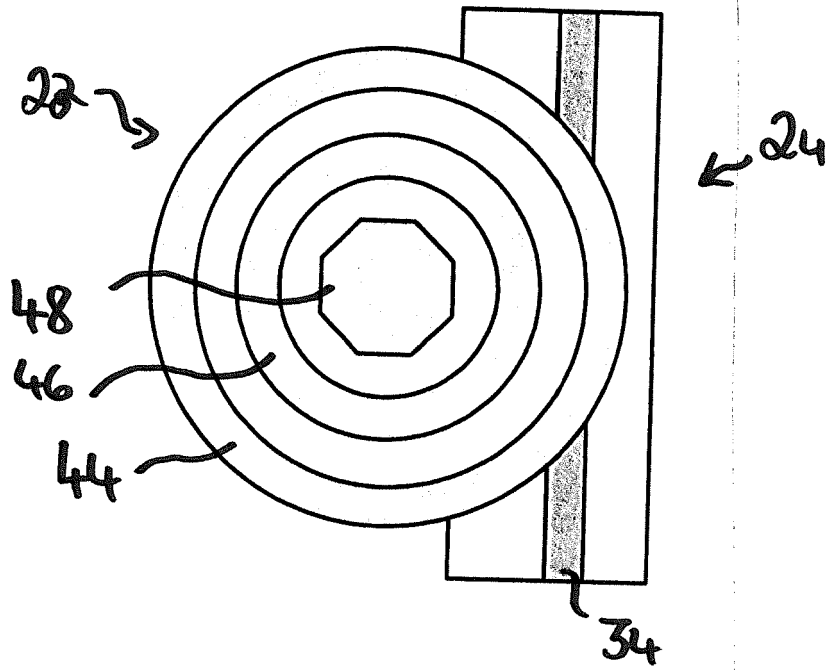


Fig. 8(a)

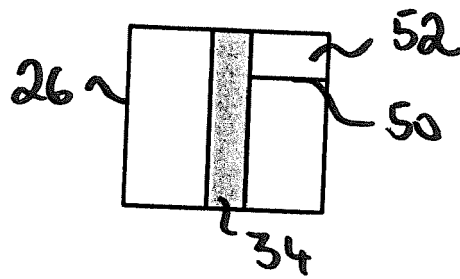
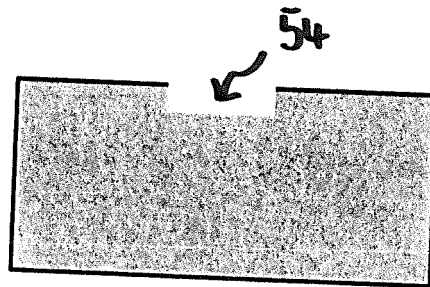
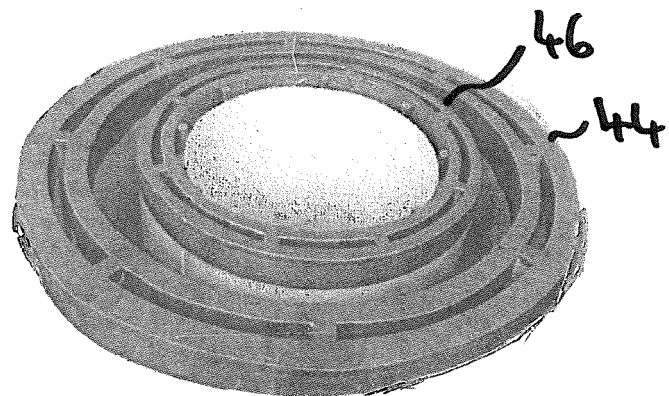
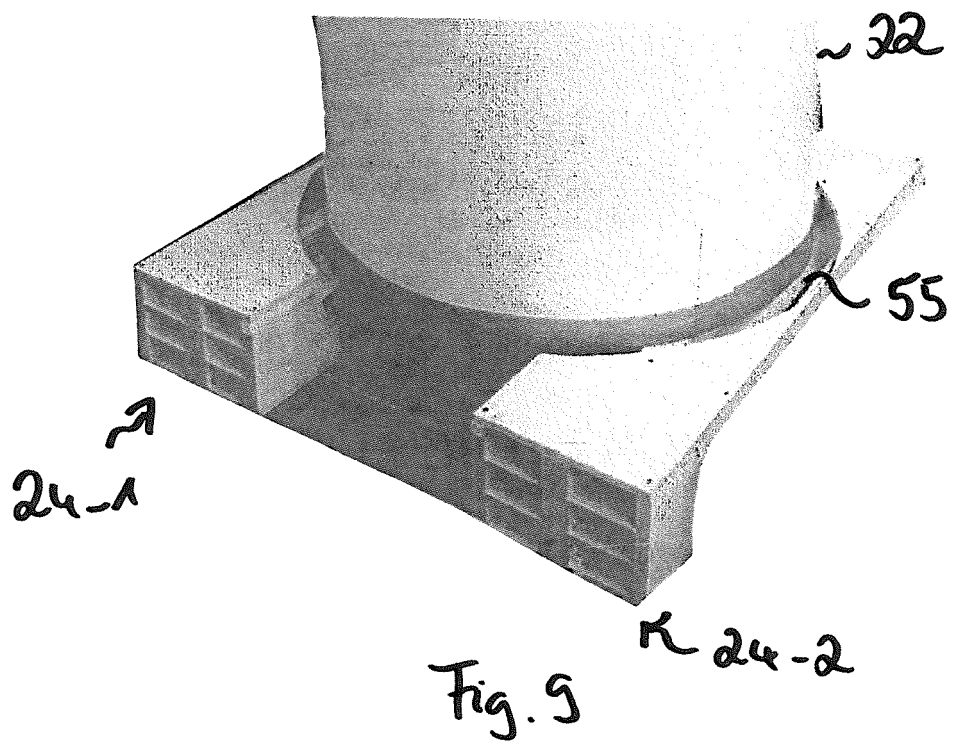
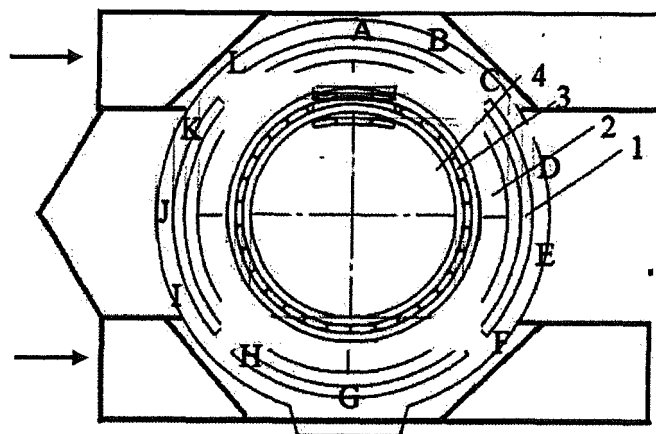


Fig. 8(b)





Nr.	1	2	3	4
	V (m/s)	V (m/s)	V (m/s)	V (m/s)
A	2,135	0,65	1,145	1,87
B	0,65	0,65	0,65	2,09
C	1,825	1,505	0,65	2,17
D	1,615	1,495	1,105	2,16
E	0,65	1,725	0,65	2,15
F	0	0,905	0,65	2,54
G	0	0,98	1,705	2,145
H	1,915	0,65	0,94	1,96
I	0	1,59	0	1,705
J	0,695	1,305	0,65	2,09
K	0	1,31	1,125	2,13
L	2,15	0	0	2

Fig. M

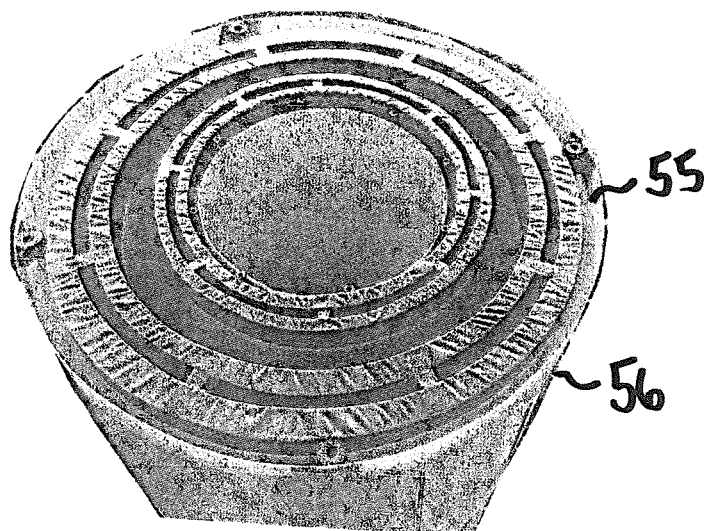


Fig. 12(a)

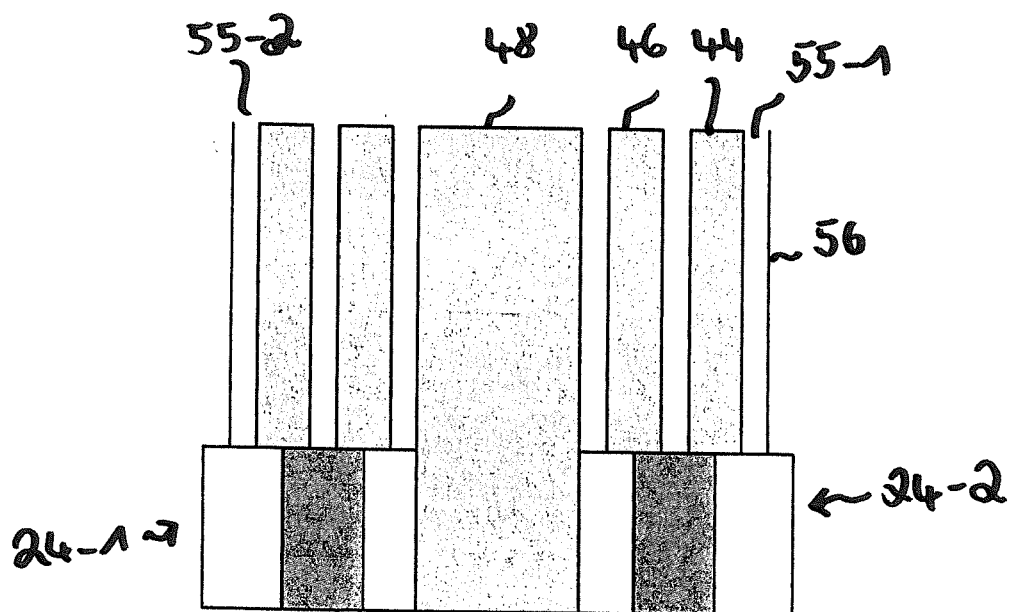


Fig. 12(b)

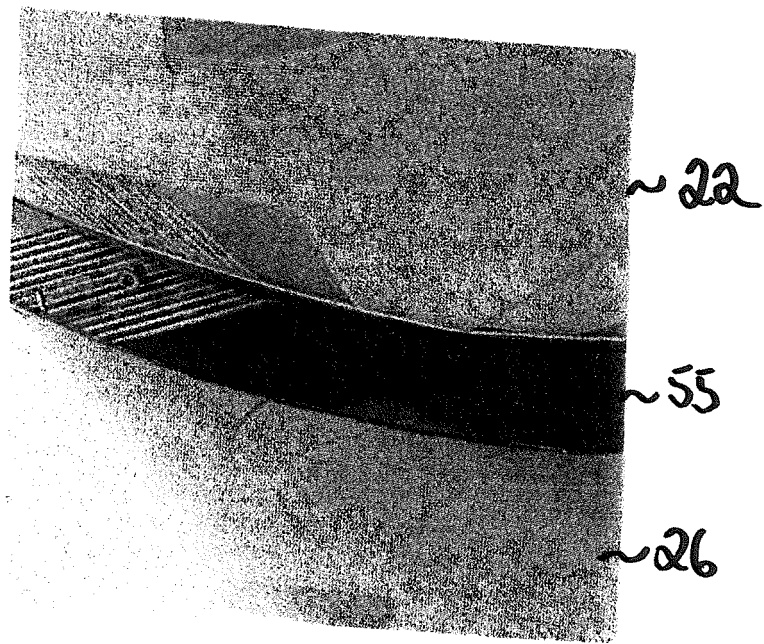


Fig. 13

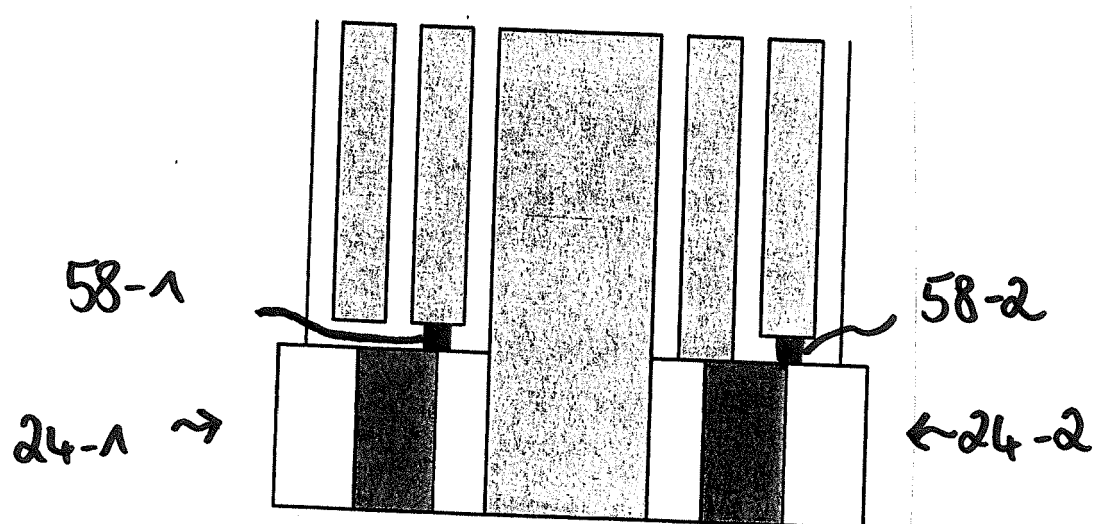
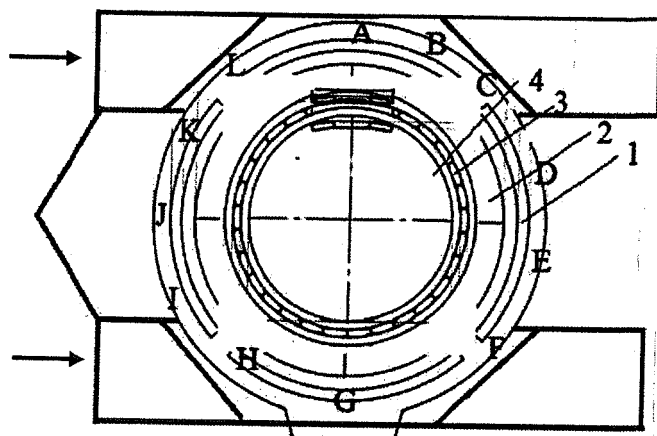


Fig. 14



Nr.	1	2	3	4
	V (m/s)	V (m/s)	V (m/s)	V (m/s)
A	6,915	7,02	5,07	3,88
B	7,24	8,32	3,655	3,94
C	6,555	9,955	0,65	4,355
D	5,515	8,465	2,05	5,52
E	4,41	5,915	1,27	6,03
F	6,165	4,615	6,785	6,335
G	6,715	0,675	5,905	5,32
H	3,455	2,345	6,87	4,08
I	0,65	1,85	1,505	4,875
J	0,65	1,85	1,2	3,09
K	2,77	2,9	3,94	3,74
L	2,225	3,555	4,715	4,04

Fig. 15

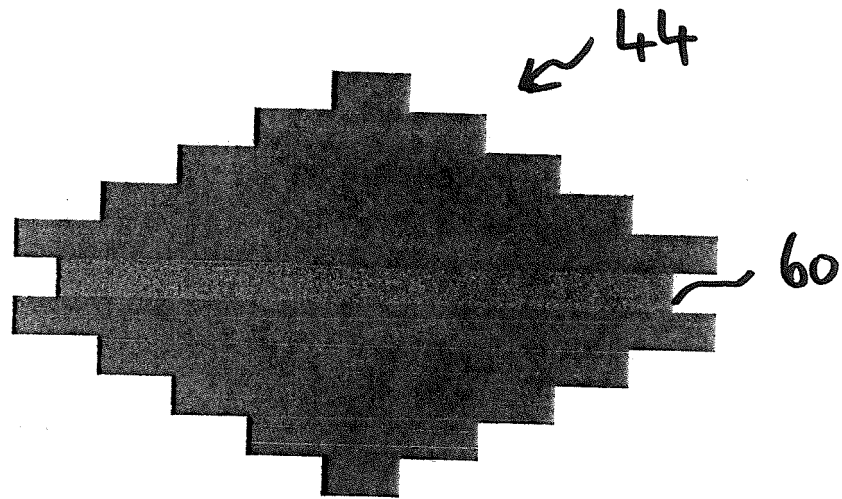


Fig. 16

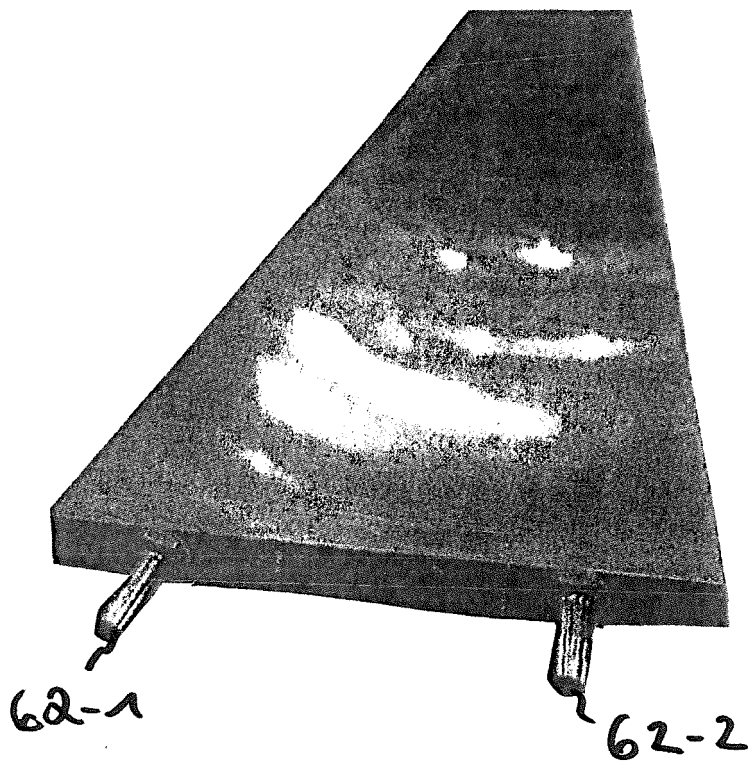


Fig. 17

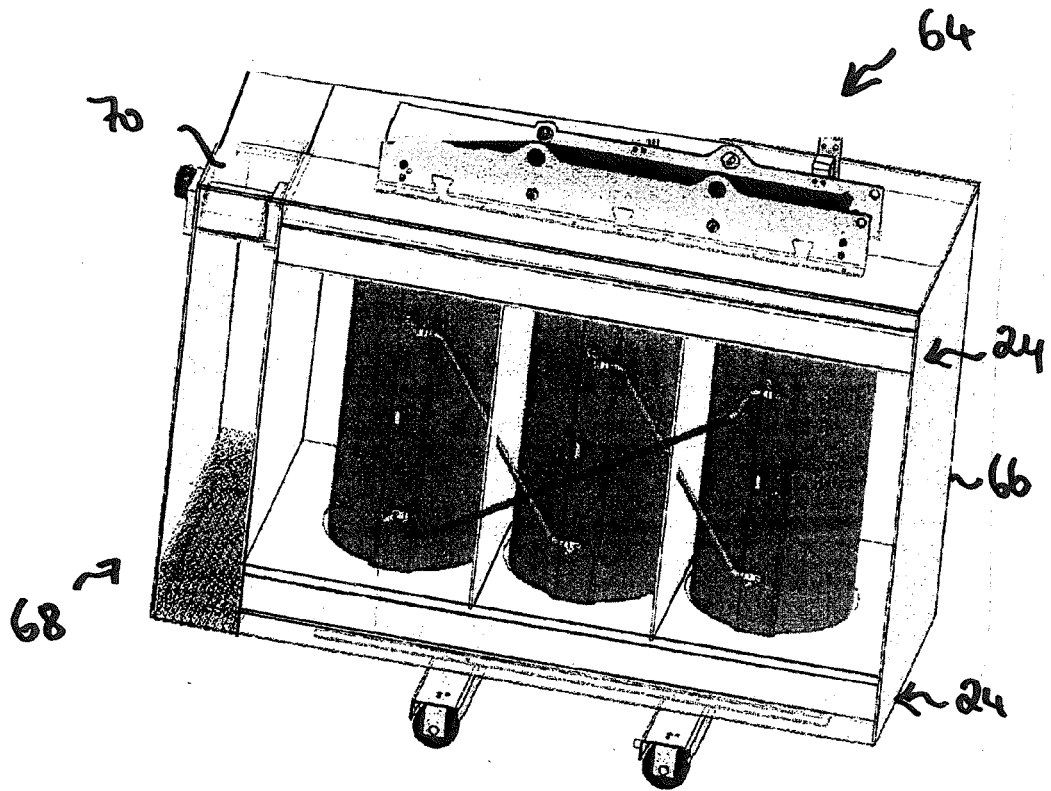


Fig. 18

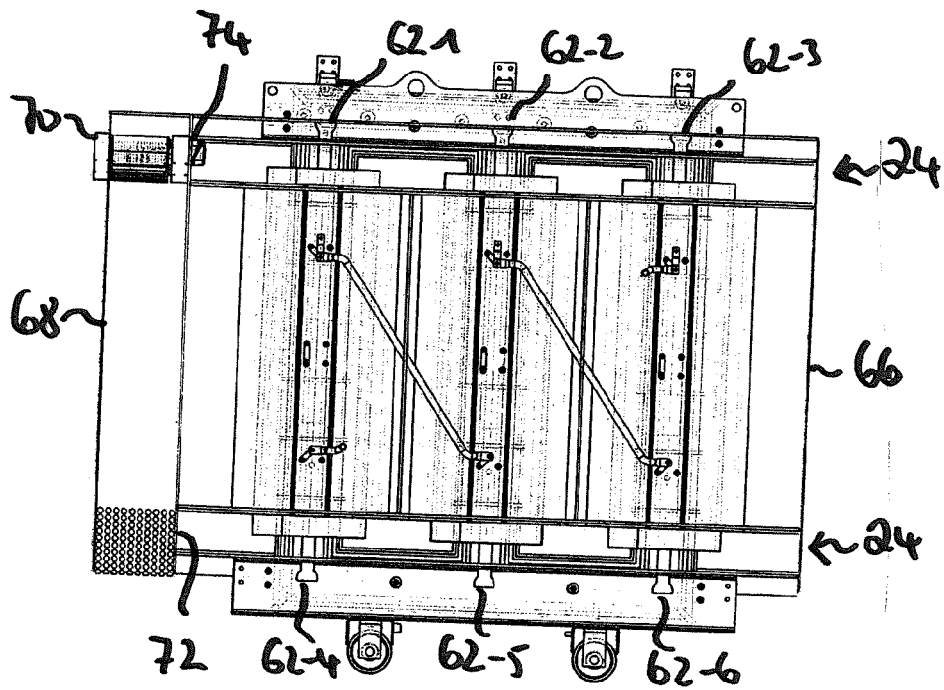


Fig. 19



EUROPEAN SEARCH REPORT

Application Number
EP 16 19 4557

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A		2-9,12, 15,16	H01F27/08
X	----- US 2015/213940 A1 (MIYAMOTO NAOYA [JP] ET AL) 30 July 2015 (2015-07-30)	1,10	
Y	* abstract *	11,13,14	
	* page 1, paragraph 3 *		
	* page 2, paragraph 24-30 *		
	* page 3, paragraph 42-45 *		
	* figures 1-9 *		
Y	----- JP S62 49216 U (HITACHI, LTD.) 26 March 1987 (1987-03-26)	11,13,14	
	* figures 3,4 *		
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	* figures 1-4 *		
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	* column 7, line 20 - column 10, line 29; figures 9-16 *		

The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 31 March 2017	Examiner Kardinal, Ingrid
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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