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(54) **AN ON-LOAD TAP CHANGER INCLUDING AN INSULATION BARRIER**

(57) The present invention relates to an on-load tap changer including a tap changer tank (3) filled with a dielectric fluid and an insulation barrier comprising an insulating sheet (12) made of an electrically insulating material. The insulation barrier comprises a frame (14) at least partly surrounding the insulating sheet, and a plu-

rality of spring-loaded fastening members (35) for fastening the frame (14) to the tap changer tank (3). The fastening members (35) are pivotably arranged relative the frame and the tap changer tank to allow relative movements between the frame and the tap changer tank.

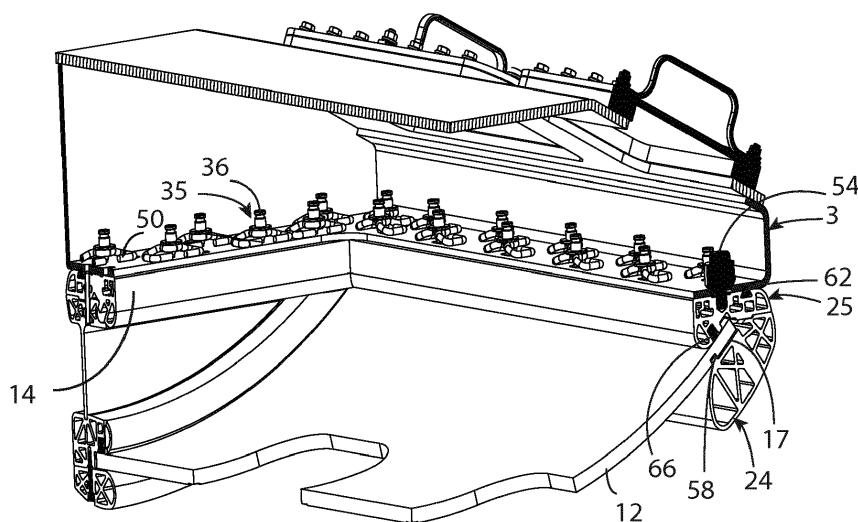


Fig 9

Description

Technical field

[0001] The present invention relates to an on-load tap changer including a tap changer tank filled with a dielectric fluid and an insulation barrier comprising an insulating sheet made of an electrically insulating material.

Background

[0002] Electromagnetic induction devices, such as power transformers and reactors, may be provided with On-Load Tap Changers (OLTC) for enabling stepped voltage regulation of the electromagnetic induction device as a means for voltage compensation when the electromagnetic induction device is On-Load, i.e. connected to a transmission or distribution network. Tap changers are used for regulation of the voltage levels by altering the number of turns in a winding of the transformer. On load tap changers have a tap changer mechanism comprising a diverter switch and a tap selector operating as a unit to effect transfer of current from one voltage tap to the next. The diverter switch is placed in a tap changer tank and submerged in oil. The oil in the tap changer tank acts as electric insulator and as a coolant to remove heat generated in the OLTC.

[0003] An OLTC unit can either be of in-tank type or on-tank type. If the OLTC unit is arranged inside the electromagnetic core housing, i.e. the transformer tank or reactor tank, it is of in-tank type. If the OLTC unit is mounted to the electromagnetic core housing, it is of on-tank type. For the latter type of OLTC unit, the tap changer mechanism is separated from the interior of the electromagnetic core housing by means of an insulation barrier. The insulation barrier acts as an interface between windings inside the electromagnetic core housing and the tap changer mechanism in the OLTC unit. Moreover, the insulation barrier separates dielectric fluid in the electromagnetic core housing from dielectric fluid in the OLTC unit, preventing mixing of the dielectric fluids and thus reducing the risk of one dielectric fluid contaminating the other. The insulation barrier comprising an insulating sheet made of an electrically insulating material. For example, the insulating sheet is made of a composite material, such as reinforced glass fibers. The insulating sheet is provided with electrical connections for connecting between the tap changer mechanism and the transformer.

[0004] The insulation barrier is often cylindrical or can be flat and rectangular. The tap changer tank and the transformer tank are normally made of steel. Today are tap changer barrier systems included in "on-tank tap changers" made by directly clamping the insulating sheet made of composite material towards a steel surface, either on the transformer tank or on the tap changer tank. In-between the insulating sheet and the steel tank are some sealing members put that structurally need to de-

form to handle differences in thermal behavior between the two materials.

[0005] Today do tap changer barrier systems included in "on-tank tap changers" require significant skill from the transformer manufacturer. For example, the transformer manufacturer often needs to perform a gluing process for the tap changer sealing to secure final tightness and/or weld the tap changer to the transformer during assembly as the final step during transformer production. Further, it is necessary to handle the different thermal behavior in the insulating sheet and the surrounding metallic materials. Thus, a problem with the insulation barrier is that time tightness due to material aging and settling of the sealing function, combined with structural and thermal movements, can be an issue. Further, materials used in the barrier and sealing system are normally not suitable for passing a transformer drying process, so final drying of the transformer including the tap changer can normally not be made.

Summary

[0006] It is an aim of the present invention to at least partly overcome some of the above problems, and to provide an on-load tap changer with an improved insulation barrier that can handle both thermal and structural movements between the insulation barrier and the tap changer tank.

[0007] This aim is achieved by an on-load tap changer as defined in claim 1.

[0008] The on-load tap changer includes a tap changer tank filled with a dielectric fluid and an insulation barrier comprising an insulating sheet made of an electrically insulating material. The insulation barrier comprises a frame at least partly surrounding the insulating sheet, a sealing member for sealing between the frame and the tap changer tank, and a plurality of spring-loaded fastening members for fastening the frame to the tap changer tank, and the fastening members are pivotably arranged relative the frame and the tap changer tank to allow relative movements between the frame and the tap changer tank.

[0009] This invention suggests an insulation barrier that works well together with a tap changer tank by using a frame in-between made such as it will stress release the insulation barrier by partly decoupling of the thermal and structural movement in-between the tap changer tank and the insulation barrier. At the same time life time and security of the insulation barrier and the tightness system is improved.

[0010] A frame is put in-between the insulation barrier and the tap changer tank. In one aspect, the frame is made of metal. The frame makes it possible for the insulation barrier to move more freely to stress release it by significant decoupling of the thermal and structural movement in-between the tap changer tank and the insulation barrier.

[0011] With the term "tap changer tank" is meant all

parts facing the dielectric fluid of the tap changer. For example, there may exist one or more parts attached to both the transformer and the tap changer and shared between them. Thus, such parts are defined to belong to the tap changer tank if they face the dielectric fluid inside the tap changer tank.

[0012] In one aspect, the fastening members are pivotably arranged relative a fixation plane (x-y plane) extending between the tap changer tank and the frame. The fixation plane is defined by a contact surface between the frame and the tap changer tank.

[0013] Due to the fact that the fastening members are spring-loaded, relative movements between the frame and the tap changer tank are allowed in a direction (z-direction) perpendicular to the fixation plane. However, the tension of the spring restricts the size of the movements, so they will not become too large. Further, due to the fact that the fastening members are pivotably arranged relative the frame and the tank, minor relative movements between the frame and the tap changer tank are also allowed in directions parallel to the fixation plane (x-direction and y-direction). Thus, minor relative movements between the frame and the tank is allowed in three degrees of freedom. This leads to reduced stress in the tank as well as the frame.

[0014] In one aspect, the frame is made of a material having a coefficient of thermal expansion that is between the coefficient of thermal expansion of the material in the tap changer tank and the coefficient of thermal expansion of the electrically insulating material in the insulating sheet. This will reduce the sliding between the insulating sheet and the frame, and between the insulating sheet and the tap changer tank. The coefficient of thermal expansion describes how the size of an object changes with a change in temperature. Thus, the thermal elongation of the frame is between the thermal elongation of the tap changer tank and the insulating sheet.

[0015] In one aspect, the frame is made of a material having a thermal expansion coefficient that is larger than the thermal expansion coefficient of the material in the tap changer tank and less than the thermal expansion coefficient of the electrically insulating material in the insulating sheet. For example, the electrically insulating material in the insulating sheet is composite, such as glass fibers, and the tap changer tank is made of steel. Thus, the coefficient of thermal expansion of the insulating sheet is larger than for the tap changer tank, and the coefficient of thermal expansion of the frame is between them.

[0016] In one aspect, the frame is made by a material with a coefficient of thermal expansion that is closer to the coefficient of thermal expansion for the electrically insulating material of insulating sheet than the material in the tap changer tank. This to reduce the necessary sliding needed in between the insulating sheet and the frame.

[0017] In one aspect, the frame is made of aluminum. The coefficient of thermal expansion for aluminum is less

than the coefficient of thermal expansion of glass-fiber and larger than coefficient of thermal expansion for steel. Thus, aluminum is a suitable material for the frame. A further advantage with aluminum is that it has a low weight. However, the frame can be made of other materials, for example, of other metals.

[0018] In one aspect, the electrically insulating material in the insulating sheet is composite, and the tap changer tank is made of steel.

[0019] In one aspect, the frame is arranged such that the insulating sheet is allowed to slide in relation to the frame in at least one direction. Preferably, the insulating sheet is allowed to slide in relation to the frame in a direction in parallel with a fixation plane between the frame and the tap changer tank. Thus, the thermal elongation of the insulating sheet can be handled. This leads to reduced stress in the insulating sheet. Thus, all three parts, i.e. the tank, the frame and the insulating sheet, do not need to strictly follow each other during any load situation, which leads to reduced stress in all three parts.

[0020] In one aspect, the frame comprises at least one elongated slot for receiving at least one edge of the insulating sheet, and the at least one elongated slot is arranged so that the at least one edge of the insulating sheet is allowed to slide in the elongated slot. Thus, the insulating sheet can move with respect to the frame and the thermal elongation of the insulating sheet can be handled.

[0021] In one aspect, the frame comprises at least two elongated first slots for receiving a pair of first edges of the insulating sheet, and the first slots are arranged so that the pair of first edges is allowed to slide in the first slots. Preferably, the pair of first edges belongs to opposite sides of the insulating sheet.

[0022] In one aspect, the frame comprises at least one elongated second slot for receiving a second edge of the insulating sheet, wherein the second slot is arranged transverse the first slot, and there is a space between second edge and a bottom of the second slot to allow the insulating sheet to move with respect to the frame.

[0023] In one aspect, the frame comprises two second elongated slots for receiving a pair of second edges of the insulating sheet, and there is a space defined between the edges of the insulating sheet and a bottom of the second slots to allow the insulating sheet to move with respect to the frame. Suitably, the second slots are arranged at a distance from each other and in parallel. The second slots are transverse the first slots. Thus, the thermal elongation of the insulating sheet can be handled. Further, the insulating sheet can flex and changing its radius or bending without risking high stress in the fixation area between the frame and the insulating sheet.

[0024] In one aspect, the frame comprises two elongated rails arranged on opposite sides of the insulating sheet and provided with said first slots. Suitably, the elongated rails are arranged in parallel and at a distance from each other.

[0025] In one aspect, each of the rails comprises a first

rail part and a second rail part arranged so that said at least one elongated slot is formed between the first and second rail parts. This simplifies mounting of the frame and the insulating sheet.

[0026] In one aspect, the insulating sheet is clamped between the first and second rail parts. Suitably, the second rail part is attached to first rail part, and the first rail part is connected to the tap changer tank by means of said spring-loaded fastening members.

[0027] In one aspect, the frame comprises two elongated side elements arranged perpendicular to the rails on opposite sides of the insulating sheet, and each of the side elements is provided with one of the elongated second slots. Suitably, the elongated side elements are arranged in parallel and at a distance from each other.

[0028] In one aspect, the insulation barrier comprises a fixation arrangement configured to fixate a part of the insulating sheet relative the frame, and the fixation arrangement is disposed closer to the middle than to the ends of the rails so that the second edges of the insulating sheet are allowed to move relative the frame. Thus, the second pair of edges of the frame is allowed to move relative the frame, at the same time as the middle part of the insulating sheet is fixed to the frame and is not allowed to move. In this way the thermal movements of the insulating sheet are distributed over the insulating sheet and consequently the size of the thermal movements is reduced.

[0029] In one aspect, each of said fastening members comprises a fastening element, and the frame is provided with a plurality of recesses and the tap changer tank is provided with a plurality of through holes arranged to cooperate with the recesses of the frame to receive the fastening members. Preferably, each of the through holes are aligned with one of the recesses so that the fastening member can penetrate through the through hole and extend into the recess.

[0030] In one aspect, each of the fastening members includes an elongated leg extending through the through hole, and the width of said through holes is larger than the width of the legs of the fastening members. Thus, the fastening members can pivot relative the tank. Suitably, the through hole is elongated in a direction in parallel with the fixation plane.

[0031] In one aspect, the width of the recesses is larger than the width of the elongated legs of the fastening elements. Thus, the fastening members can pivot relative the frame and consequently, the frame can move relative the tank.

[0032] The elongated leg extends from the inside of the tap changer tank, via the through hole to the recess of the frame. In one aspect, a lower part of each of said fastening elements is adapted to fit in the recess, and the recess and the lower part of the fastening member are designed so that the fastening member can pivot relative the recess.

[0033] In one aspect, a lower part of each of said fastening elements is provided with a second protruding part

adapted to fit in the recesses, and a width of the recesses is larger than the width of the second protruding part of the fastening elements so that the fastening elements can pivot relative the frame and consequently, the frame can move relative the tank.

[0034] In one aspect, each of the recesses has an opening for receiving the lower end of the fastening member, and the width of the openings of the recesses is larger than the width of the legs of the fastening members. Thus, the fastening members can pivot relative the frame.

[0035] In one aspect, the fastening members are bolts.

[0036] In one aspect, the fastening members are T-bolts.

[0037] In one aspect, an upper part of each of said fastening members is provided with a protruding part and each of said fastening members comprises a spring arranged between said protruding part and the tap changer tank so that the spring is compressed in a direction in parallel with the leg. Thus, the spring is compressed in a direction substantially perpendicular to the fixation plane. With "substantially perpendicular" is meant that the angle may vary within (+/-) 10% from 90°. Consequently, the frame and the tap changer tank can move relative each other within a defined distance that depends on the compression force on the spring. The higher compression force on the spring, the smaller relative movements are needed to be handled. A higher compression force reduces the relative movement between the tap changer tank and the frame.

[0038] In one aspect, each of said bolts is provided with a locking mechanism arranged to lock the compression force on the spring. Thus, the compression force can be adjusted and locked when a suitable compression force has been achieved.

[0039] In one aspect, the frame comprises two elongated rails arranged on opposite sides of the insulating sheet, and the insulation barrier comprises two guiding devices for positioning the frame relative the tap changer tank in a fixation plane extending between the tap changer tank and the frame, and the guiding devices are arranged between the tank and the elongated rails respectively, so that the guiding devices are closer to the middle than to the ends of the rails. For securing the position of the insulating sheet in relation to the tap changer tank, in the fixation plane, is the position secured by guiding devices in-between the frame and the tap changer tank. The guiding devices can as an example be two guiding pins. The guiding devices are preferable put close to the middle of the rails of the frame, to minimize the maximum thermal and structural movement in the fixation plane. The distance that the frame and the tap changer tank can move relative each other depends on the two guiding devices, which are keeping the frame in a specific position relative the tap changer tank, as well as the compression force on the spring.

[0040] In one aspect, the insulation barrier comprises a sealing member for sealing between the frame and the tap changer tank, and the frame comprises a first grooves

for housing the sealing member. In one aspect, the sealing member is a resilient O-ring, and the frame comprises elongated grooves for housing the O-ring. The sealing in-between the frame and the tap changer tank is made with an O-ring groove that allow the O-ring to stay put in the groove even if the insulating sheet during assembly onto the transformer is handle in a vertical direction or slightly tilted. Since this O-ring don't need to pass the transformer drying process or at least never will be compressed during such process can beside FKM material also less expensive but special quality NBR rubber also be used in this sealing. Further, the insulation barrier that doesn't need retightening or gluing in the production.

[0041] In one aspect, the insulation barrier comprises a resilient sealing element for sealing between the insulating sheet and the frame and the frame comprises a second grooves for housing the sealing element. Suitably, the resilient sealing element is made of rubber. Thus, the insulation barrier that doesn't need gluing in the production.

[0042] In one aspect, the sealing element is made of a resilient material and has an upper part that has a convex shape, and the upper part is adapted to be in contact with the insulating sheet and to be deformed when the backboard is moving relative the frame. The resilient sealing element has an upper rounded part adapted to be in contact with the insulating sheet. This geometry of the sealing makes it possible to take care of large structural and thermal movements, that easily can be in the range of 1-5mm in the sealing, due to a geometry able to partly roll instead of glide. The sealing element has a shape designed for taking care of the relatively large thermal and structural movement in-between the frame and the insulation material of the insulating sheet without leakage. The sealing material preferable used is a material suitable for withstanding the transformer drying process. One example of such material is Fluor elastomer (FKM) material.

Brief description of the drawings

[0043] The invention will now be explained more closely by the description of different embodiments of the invention and with reference to the appended figures.

Fig. 1 shows an example of an on-load tap changer including a tap changer tank, an insulation barrier comprising an insulating sheet and a frame for fixating the sheet.

Fig. 2 shows the insulation barrier in a perspective view from below.

Fig. 3 shows the insulation barrier in a perspective view from above.

Fig. 4a shows a cross-section A-A through the insulation barrier shown in figure 3.

Fig. 4b shows an enlargement of a left part of the insulation barrier shown in figure 4a.

Fig. 5a shows a cross-section B-B through the insu-

lation barrier shown in figure 3.

Fig. 5b shows an enlargement of a left part of the insulation barrier shown in figure 5a.

Fig. 6 illustrates how the insulating sheet can be engaged to a central part of the frame.

Fig. 7 shows an enlargement of the central part of the frame and the insulation barrier shown in figure 6.

Fig. 8 shows how the frame can be fasten to the tap changer tank by means of spring-loaded fastening members.

Fig. 9 shows the frame connected to the tap changer tank and the insulating sheet clamped between a first part and a second part of the frame.

Fig. 10 shows an example of the spring-loaded fastening members connecting the frame to the tap changer tank.

Fig. 11 shows an example of a sealing element for sealing between the insulating sheet and the frame.

Fig. 12 shows an example of a transformer and how the insulation barrier is mounted on the transformer.

Detailed description

[0044] Figure 1 shows an example of an on-load tap changer 1 including a tap changer tank 3 filled with a dielectric fluid, such as oil. The tap changer has a tap changer mechanism 5 normally comprises a diverter switch and a tap selector to effect transfer of current between voltage taps of an electromagnetic induction device, and a motor drive 9 for actuate movement of the switches. The tap changer mechanism 5 is mainly placed in the tap changer tank 3 and submerged in oil. At least the diverter switch is placed in the tap changer tank 3. The oil in the tap changer tank acts as electric insulator and as a coolant to remove heat generated in the tap changer. The tap changer 1 further comprises an insulation barrier 10 including an insulating sheet 12 and a frame 14 for fixating the sheet. The insulating sheet 12 is mechanically connected to the frame 14 and the frame 14 is mechanically connected to the tap changer tank 13. The insulation barrier 10 is mechanically connected to the electromagnetic induction device, for example, a transformer, as shown in figure 12. The insulation barrier 10 separates dielectric fluid in a housing of the electromagnetic induction device from the dielectric fluid in the tap changer tank, thus preventing mixing of the dielectric fluids and reducing the risk of one dielectric fluid contaminating the other.

[0045] In the following, an example of an insulation barrier 10 will be described in more details with reference to figures 2 - 6. Figure 2 shows the insulation barrier 10 in a perspective view from below, and figure 3 shows the insulation barrier 10 in a perspective view from above. Figure 4a shows a cross-section A-A through the insulation barrier 10 and figure 4b shows an enlargement of a left part of the insulation barrier shown in figure 4a. Figure 5a shows a cross-section B-B through the insulation barrier 10, and figure 5b shows an enlargement of

a left part of the insulation barrier show in in figure 5a.

[0046] The insulating sheet 12 is made of an electrically insulating material. For example, the insulating sheet 12 is made of a composite material, such as reinforced glass fibers. The insulating sheet 12 is provided with openings 13 for electrical and mechanical connections for connection between different parts of the tap changer mechanism and the electromagnetic induction device. Preferably the insulating sheet 12 is rectangular and has four edges. The insulating sheet 12 has two first edges 19a-b arranged in parallel, and two second edges 20a-b extending perpendicular to the first edges 19a-b. The insulating sheet 12 can be flat or bent. In this example, the insulating sheet 12 is bent, and the second edges 20a-b are bent.

[0047] The insulation barrier 10 comprises a frame 14 surrounding the insulating sheet 12. Suitably, the frame is a metallic frame. The frame 10 is typically about 1x2m, but smaller and larger are possible. In this example, the frame is rectangular and defines a x-y plane. Suitably, the frame is made of a material having a coefficient of thermal expansion that is between the coefficient of thermal expansion of the material in the tap changer tank and the coefficient of thermal expansion of the electrically insulating material in the sheet. The coefficient of thermal expansion describes how the size of an object changes with a change in temperature. It is advantageous if the frame is made by a material with a coefficient of thermal expansion that is closer to the coefficient of thermal expansion of the electrically insulating material of insulating sheet than the coefficient of thermal expansion of the material in the tap changer tank. For example, the electrically insulating material in the insulating sheet is composite, such as glass fibers, and the tap changer tank is made of steel. Thus, the coefficient of thermal expansion of the insulating sheet is larger than the coefficient of thermal expansion of the tap changer tank. In this case, aluminum is a suitable material for the frame since the coefficient of thermal expansion for aluminum is less than the coefficient of thermal expansion of glass-fiber and larger than the coefficient of thermal expansion for steel.

[0048] In one aspect, the frame comprise a pair of elongated rails 15a-b arranged on opposite sides of the insulating sheet 12, as shown in figures 2 and 3. The elongated rails 15a-b are arranged in parallel and at a distance from each other. Each of the rails 15a-b is provided with an elongated first slot 17 for receiving one of the first edges 19a-b of the insulating sheet, as shown in figure 4b. The insulating sheet 12 extends between the rails 15a-b. The slots 15a-b make it possible for the insulating sheet 12 to slide relative the frame in a direction parallel with the longitudinal axes of the rails, in the following called an x-direction. A direction perpendicular to the longitudinal axes of the rails is in the following called a y-direction. The longitudinal axes of the rails 15a-b define a plane, in the following called a fixation plane. The fixation plane lies in the x-y plane. An axis perpendicular to the fixation plane is in the following called a z-direction.

[0049] In one aspect, the frame also comprises two elongated side elements 21a-b arranged at a distance from each other on opposite sides of the insulating sheet 12, as shown in figure 3. The side elements 21a-b extends between the ends of the rails 15a-b. In this example, the side elements 21a-b are bent to correspond to the shape of the bent insulating sheet. However, if the insulating sheet is flat, the side elements 21a-b are straight and are arranged perpendicular to the rails 15a-b. The side elements 21a-b are arranged in parallel and at a distance from each other. Each of the side elements 21a-b is provided with an elongated second slot 22 for receiving one of the second edges 20a-b of the insulating sheet 12, as shown in figure 5b. In this example, the second slot 22 is bent to fit with the bent edges of the insulating sheet. Thus, the insulating sheet 12 extends between the first slots 17 of the rails 15a-b in the x-direction and between the second slots 22 of the side elements 21a-b in the y-direction. In one aspect, the second slots 22 of the side elements 21a-b are designed so that there is a free space 23 between the second edges 20a-b of the insulating sheet 12 and a bottom of the second slot 22 to allow the insulating sheet 12 to change its length in the x-direction. Due to the first and second slots 17, 22, thermal elongation of the insulating sheet 12 in the x-direction can be handled. Further, thermal elongation of the insulating sheet 12 in other direction can also be handled since the insulating sheet 12 can flex and change its radius of bending. This leads to reduced stress in the insulating sheet 12.

[0050] In one aspect, each of the rails 15a-b comprises an elongated first rail part 24 and a second elongated rail part 25, as shown in figure 4b. Suitably, the second frame part 25 is attached to first frame part 24, for example, by means of bolts. The first and second rail parts 24, 25 are designed so that the first slots 17 are formed between them. This simplifies mounting of the frame 14 and the insulating sheet 12. The first and second rail parts 24, 25 can be arranged such that the insulating sheet 12 is mechanically clamped between them. The frame is designed so that that the insulating sheet 12 can slide in the x-direction, and the mechanical clamping is cambered, i.e. convex, by that avoiding that torque is transferred between the frame and the insulating sheet, meaning the insulation barrier can flex and changing its radius or bending without risking high stress in the fixation area.

[0051] In one aspect, the insulation barrier 10 comprises a fixation arrangement 27 configured to fixate a part of the insulating sheet 12 relative the frame 14, as shown in figures 6 and 7. The fixation arrangement 27 is arranged to fixate a central portion of the insulating sheet 12 relative the frame. The fixation arrangement 27 is disposed in a central area 30a-b of the insulation barrier and at a distance from the second edges 20a-b of the insulating sheet, as shown in figure 6. Figure 7 shows an enlargement of the central area 3b shown in figure 6. Preferably, the fixation arrangement 27 is disposed closer to the middle than to the ends of the rails 15a-b so that

the second edges 20a-b of the insulating sheet can to move relative the frame in the x-direction, at the same time as the middle part of the insulating sheet 12 is fixed to the frame and is not allowed to move. The fixation arrangement 27 is arranged at a distance from the outer ends of the rails 15a-b and at a distance from the elongated side elements 21a-b of the frame. For example, the fixation arrangement 27 comprises recesses and protrusions adapted to fit in the recesses. The recesses and protrusions are configured to cooperate to fixate the insulating sheet 12 relative the frame in the area 30a-b. For example, each of the first edges 19a-b of the insulating sheet 12 is provided with a protrusion and each of the rails 15 a-b are provided recesses adapted to receive the protrusions, as shown in figure 7.

[0052] In the following, an example of how the insulation barrier 10 can be connected to the tap changer tank 7 will be described in more details with reference to figures 8 - 10. Figure 8 shows an example of how the frame 14 can be fastened to the tap changer tank 3 by means of spring-loaded fastening members 35 in a view from above. Figure 9 shows the frame 14 connected to the tap changer tank 3 and the insulating sheet 12 clamped between the first and second rail parts 24,25 of the frame in a perspective view. Figure 10 shows an example of the spring-loaded fastening members 35 connecting the frame 14 to the tap changer tank 3.

[0053] The insulation barrier comprises a plurality of spring-loaded fastening members 35 for fastening the frame 14 to the tap changer tank 3. The fastening members 35 comprise elongated fastening elements 36 and springs 50, as shown in figure 10. The springs 50 are compressed in the z direction perpendicular to the fixation plane 56, as shown in figure 10. The frame 14 is clamped towards the tap changer tank 3 by means of the fastening members 35 and by using the springs 50. Thus, some small sliding, typically about 1-2mm, is allowed in-between the frame and the tap changer tank 3 in the fixation plane 56, caused by the deformation and any thermal expansion difference. Typical force of each such spring may be in the range of 4000N-15000N, but also higher and lower depending of number of fixation points.

[0054] The fastening elements 36 are pivotably arranged relative the frame 14 and the tap changer tank 3 to allow relative movements between the frame 14 and the tap changer tank 3. For example, the fastening elements 36 are bolts. In this example, the fastening elements are T-bolts. The tap changer tank 3 may comprise a fixation flange 37, as shown in in figure 10. The rails 15a-b of frame 14 are provided with a plurality of recesses 39 and the fixation flange 37 of the tap changer tank 3 is provided with a plurality of though holes 40 arranged to cooperate with the recesses 39 of the frame to receive the fastening elements 36, as shown in figure 10. The through holes 40 are, for example, elongated in a direction parallel with the fixation plane, as shown in figure 10, to allow the fastening elements 36 to pivot in that direction. In one aspect, the recesses 39 can also be

through holes. For example, each of the fastening elements 36 comprises an elongated leg 42 extending from the inside of the tap changer tank 3, via the through hole 40 to the recess 39 of the frame 14, as shown in figure 10. The width of the through holes 40 is larger than the width of the legs 42 of the fastening elements 36 to allow the fastening element 36 to pivot relative the tap changer tank 3. The width of the recesses 39 is larger than the width of the legs 42 of the fastening elements 36 to allow the fastening element to pivot relative the frame. In one aspect, the recess 39 comprises an upper part 44 and a lower part 45, and the width of the lower part 45 is larger than the width of the upper part 44. An upper part of the fastening element 36 is provided with a first protruding part 47. A lower part of the fastening element 36 is provided with a second protruding part 48 adapted to fit in the lower part 45 of recess.

[0055] The spring 50 of the fastening member 35 is arranged between the first protruding part 47 and the fixation flange 37 of the tap changer tank so that the spring 50 is compressed in a direction in parallel with the leg 42, i.e. in the z-direction. Thus, the spring 50 is compressed in a direction perpendicular to the fixation plane 56. Consequently, the frame and the tap changer tank can move relative each other within a defined distance that is determined by the compression force on the spring. The higher compression force on the spring, the smaller relative movements are allowed. In one aspect, each of the fastening members is provided with a locking mechanism 52 arranged to lock the compression force on the spring. Thus, the compression force can be adjusted and the compression force on the spring can be locked when a suitable compression force has been achieved. The spring 50 can be of different types known in the art. For example, the spring 50 can be a wire spring, for example a Pandrol® spring. However, other types of springs can be used.

[0056] For securing the position of the insulation barrier 10 in relation to tap changer tank 3, in the fixation plane, guiding devices 54 are arranged in-between the frame 14 and the tap changer tank 3, as shown in figure 9. The guiding devices 54 can, for example, be two guiding pins arranged on opposite sides of the frame. The guiding devices 54 are preferable disposed close to the middle of the rails 15a-b of the frame in the x-direction to minimize the maximum thermal and structural movement in the fixation plane, i.e. in the x-y plane. Suitably, the guiding devices 54 are disposed in the central area 30a-b, as shown in figure 2. The guiding devices 54 are arranged between the tank 3 and the rails 15a-b respectively, at a distance from the ends of the rails 15a-b so that the guiding devices 54 are closer to the middle of the rails than to the ends of the rails.

[0057] To prevent the insulating sheet from moving out of the first slots 17 due to large deformations of the insulating sheet 12, the frame can be provided with one or more fixation keys 58, as shown in figure 9. In this example, the fixation key 58 is a protrusion arranged to

protrude into an indentation of the insulating sheet and by that keeping the insulating sheet in place.

[0058] In the following, the sealing between the frame and the tap changer tank and the sealing between the frame and the insulating sheet will be discussed with reference to figures 9, 10 and 12. The insulation barrier comprises a sealing member 60 for sealing between the frame 14 and the tap changer tank 3. The sealing member 60 is resilient. The rails 15a-b of the frame comprises elongated first grooves 62 for housing sealing member 60, as shown in figures 9 and 10. For example, the first groove 62 has a dovetailed shape. Suitably, the first groove 62 extends along the entire length of the rail 15a-b. For example, the first sealing member is a resilient O-ring and the first groove 62 is an O-ring groove, as shown in figure 10. Thus, the sealing in-between the frame and the tap changer tank can be made with an O-ring groove that allow the O-ring to stay put in the first groove 62 even if the insulating sheet during assembly onto the transformer is handle in a vertical direction or slightly tilted. For example, the sealing member comprises flourocarbon elastomer, also called FKM material. Since the sealing member 60 don't need to pass the transformer drying process or at least never will be compressed during such process can, beside the FKM material, also less expensive but special quality NBR rubber be used in the sealing.

[0059] Figure 11 shows an example of a sealing element 64 for sealing between the insulating sheet 12 of the insulating sheet and the frame 14. The insulation barrier comprises the resilient sealing element 64. Suitably, the resilient sealing element 64 is made of rubber. The rails 15a-b of the frame comprises elongated second grooves 66 for housing the sealing element 64, as shown in figure 9. The shape of the groove 66 is, for example, U-shaped or rectangular in cross-section. In this example, the sealing element 64 has an upper part adapted to be in contact with the insulating sheet 12. The upper part 68 of the sealing element 64 is deformed when the insulating sheet is moving relative the frame. Preferably, the upper part 68 of the sealing element 64 is rounded or more specifically concave. Due to this geometry, the upper part 68 is able to partly roll instead of glide on the insulating sheet 12. This geometry of the upper part 68 of the sealing element 64 together with the shape of the groove 66 makes it possible to take care of large structural and thermal movements, that easily can be in the range of 1-5mm in the sealing. Thus, the sealing element 64 has a shape able to take care of the thermal and structural movement in-between the frame and the insulation material of the insulating sheet without leakage. The sealing material preferable used is a material suitable for withstanding the transformer drying process. One example of such material is Fluor elastomer (FKM) material.

[0060] Figure 12 shows an example of a transformer 70 and how the insulation barrier 10 can be mounted on the transformer. The transformer and the insulation barrier are enclosed by a transformer tank (not shown). The

transformer tank is filled with oil.

[0061] The present invention is not limited to the embodiments disclosed but may be varied and modified within the scope of the following claims. For example, the shape and size of the insulating sheet and the frame may vary. Further, the flange 37 can be a part of the transformer tank instead of a part of the tap changer tank. However, the flange 37 must be attached to the tap changer during mounting of the tap changer tank on the transformer tank and then form a part of the tap changer tank. The flange 37 is facing the dielectric fluid in the tap changer tank when the tap changer is in use. Thus, the flange is a part of the tap changer tank.

15 Reference list

[0062]

- 1 An on-load tap changer
- 3 Tap changer tank
- 5 Tap changer mechanism
- 9 Motor drive
- 10 Insulation barrier
- 12 Insulating sheet
- 13 Openings of the insulating sheet
- 14 Frame
- 15a-b Rails of the frame
- 17 First slot of the rails
- 19a-b First edges of the insulating sheet
- 20a-b Second edges of the insulating sheet
- 21a-b Side elements
- 22 Second slot of the side elements
- 23 Space
- 24 First rail part
- 25 Second rail part
- 27 Fixation arrangement
- 30a-b Central areas of the rails
- 35 Fastening member
- 36 Fastening element
- 37 Fixation flange of the tap changer tank
- 39 Recesses of the frame
- 40 Though holes of the tap changer tank
- 42 Leg of the fastening members
- 44 Upper part of the recess
- 45 Lower part of the recess
- 47 First protruding part of the fastening member
- 48 Second protruding part of the fastening member
- 50 Spring
- 52 locking mechanism
- 54 Guiding device
- 56 Fixation plane
- 58 Fixation key
- 60 Sealing member
- 62 First groove
- 64 Sealing element
- 66 Second groove
- 68 Upper part of the sealing element
- 70 Transformer

Claims

1. An on-load tap changer (1) including a tap changer tank (3) filled with a dielectric fluid and an insulation barrier (10) comprising an insulating sheet (12) made of an electrically insulating material, **characterized in that** the insulation barrier (10) comprises a frame (14) at least partly surrounding the sheet, and a plurality of spring-loaded fastening members (35) for fastening the frame (14) to the tap changer tank (3), and the fastening members (35) are pivotably arranged relative the frame and the tap changer tank to allow relative movements between the frame and the tap changer tank. 5
2. The on-load tap changer according to claim 1, wherein said frame (14) is made of a material having a thermal expansion coefficient that is larger than the thermal expansion coefficient of the material in the tap changer tank (3) and less than the thermal expansion coefficient of the electrically insulating material in the insulating sheet (12). 10
3. The on-load tap changer according to claim 1 or 2, wherein the frame (14) is made of metal. 15
4. The on-load tap changer according to any of the previous claims, wherein the frame (14) comprises two elongated first slots (17) for receiving a pair of first edges (19a-b) of said insulating sheet (12), and the first slots are arranged so that said first edges (19a-b) are allowed to slide in the first slots. 20
5. The on-load tap changer according to claim 4, wherein the frame comprises at least one elongated second slots (22) for receiving a second edge (20a-b) of the sheet, and there is a space (23) between second edge (20a-b) and a bottom of the second slot (22) to allow the insulating sheet (12) to move with respect to the frame (14). 25
6. The on-load tap changer according to any of the previous claims, wherein each of said fastening members (35) comprises a fastening element (36), the frame (14) is provided with a plurality of recesses (39) and the tap changer tank (3) is provided with a plurality of through holes (40) arranged to cooperate with the recesses (39) to receive the fastening elements (36). 30
7. The on-load tap changer according to claim 6, wherein a lower part (48) of each of said fastening elements (35) is adapted to fit in the recesses (39), and the lower parts (48) of the fastening elements and the recesses (39) are designed so that that the fastening elements can pivot relative the recesses. 35
8. The on-load tap changer according to claim 6 or 7, wherein each of the fastening elements (36) comprise an elongated leg (42) extending through said through holes (42), and the width of said through holes (40) is larger than the width of the legs of the fastening members. 40
9. The on-load tap changer according to any of the claims 6 - 8, wherein an upper part of each of said fastening elements (36) is provided with a protruding part (47) and each of said fastening members comprises a spring (50) arranged between said protruding part (47) and the tap changer tank (3), and the spring (50) is compressed in a direction substantially perpendicular to a fixation plane (56) extending between the tap changer tank and the frame. 45
10. The on-load tap changer according to any of the previous claims, wherein the frame (14) comprises two elongated rails (15a-b) arranged on opposite sides of the insulating sheet (12), the insulation barrier (10) comprises two guiding devices (54) for positioning the frame (14) relative the tap changer tank (3) in a fixation plane (56) extending between the tap changer tank and the frame, wherein the guiding devices (54) are arranged between the tap changer tank (3) and each of the rails (15a-b) so that the guiding devices (54) are positioned closer to the middle than to the ends of the rails (15a-b). 50
11. The on-load tap changer according to claim 1, wherein the frame (14) comprises two elongated rails (15a-b) arranged on opposite sides of the insulating sheet (12), the insulation barrier comprises a fixation arrangement (27) configured to fixate a part of the insulating sheet (12) relative the frame (12), and the fixation arrangement (27) is disposed closer to the middle than to the ends of the rails so that the second edges (20a-b) of the insulating sheet are allowed to move relative the frame. 55
12. The on-load tap changer according to any of the previous claims, wherein the insulation barrier (10) comprises a sealing member (60) for sealing between the frame (3) and the tap changer tank (3) and the frame (14) comprises an elongated first grooves (62) for housing the sealing member (60).
13. The on-load tap changer according to claim 12, wherein the sealing member (60) is a resilient O-ring.
14. The on-load tap changer according to any of the previous claims, wherein the insulation barrier (10) comprises a sealing element (64) for sealing between the insulating sheet (12) and the frame (14), and the frame comprises elongated second grooves (66) for housing the sealing element (64).
15. The on-load tap changer according to claim 14,

wherein the sealing element (64) is made of a resilient material and has an upper part (68) that has a convex shape and the upper part (68) is adapted to be in contact with the insulating sheet (12) and is deformed when the insulating sheet (12) is moving relative the frame (14). 5

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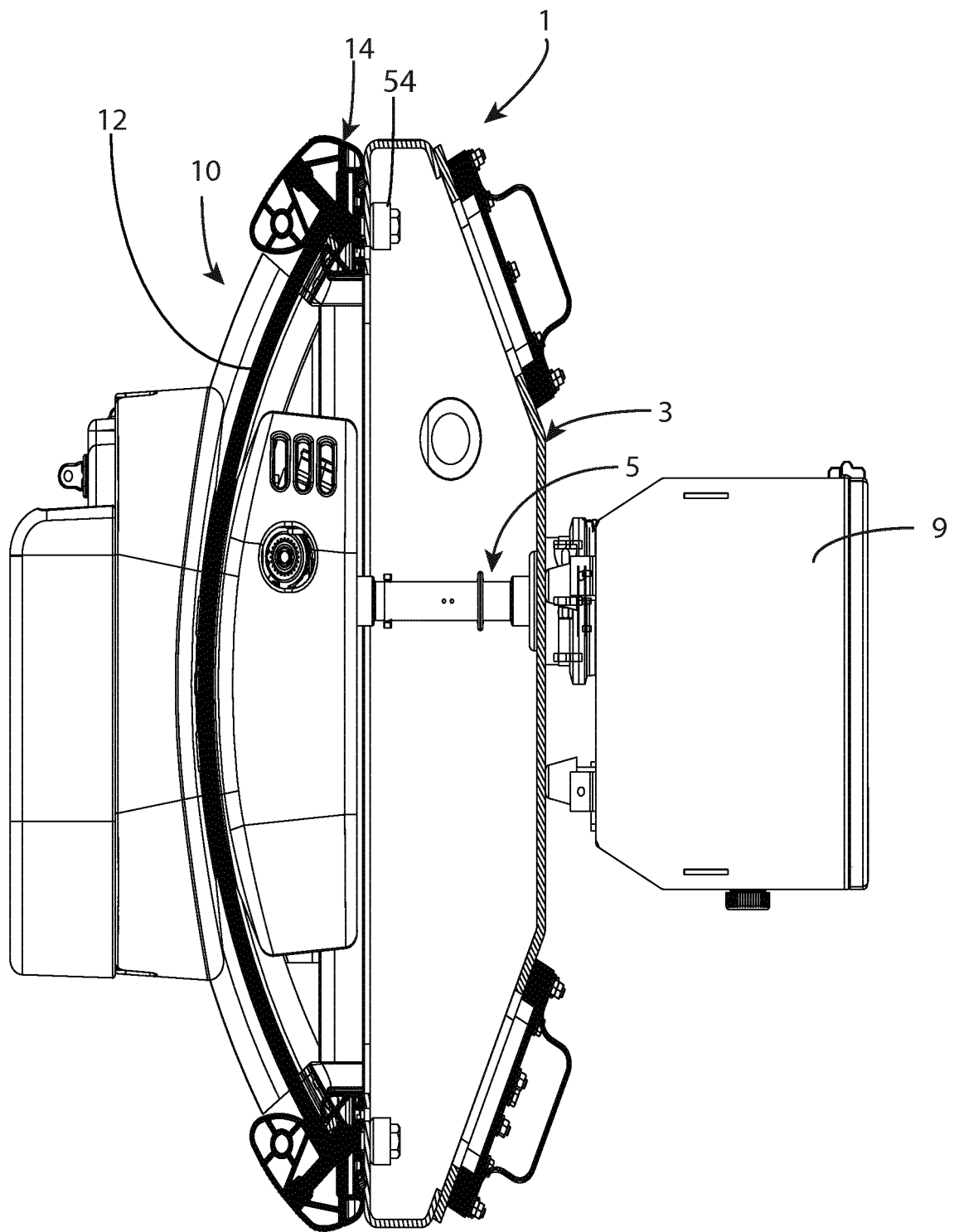


Fig 1

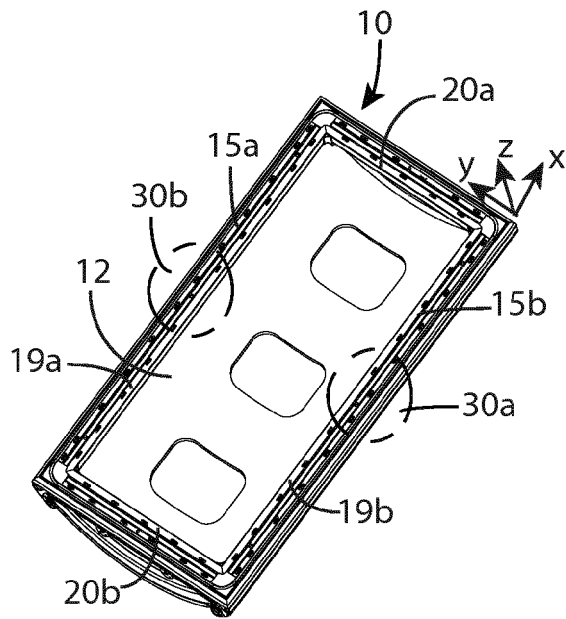


Fig 2

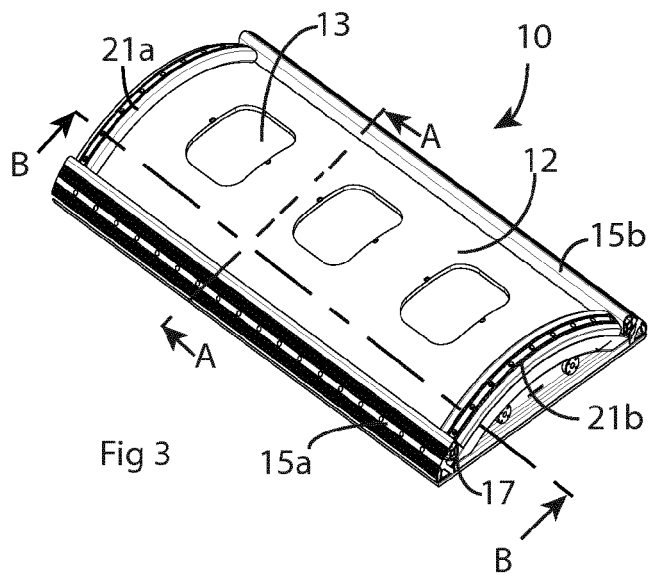


Fig 3

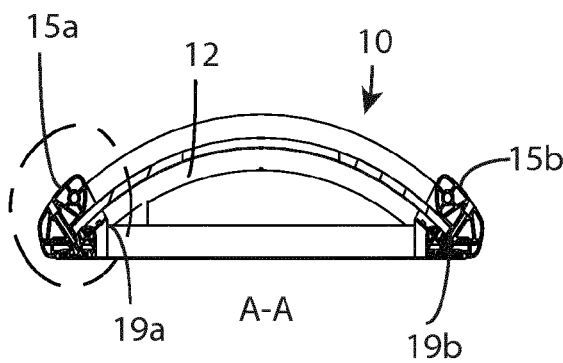


Fig 4a

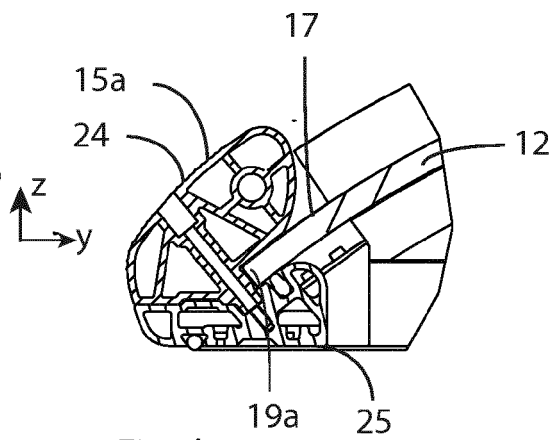


Fig 4b

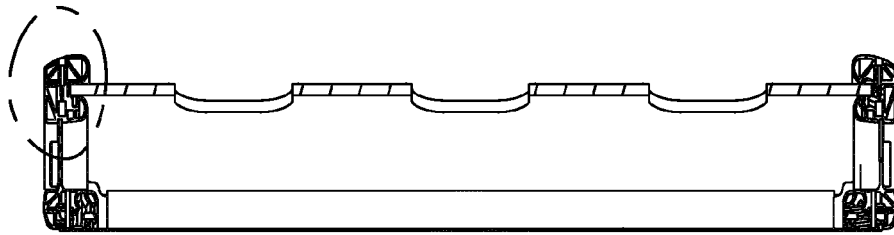


Fig 5a

B-B

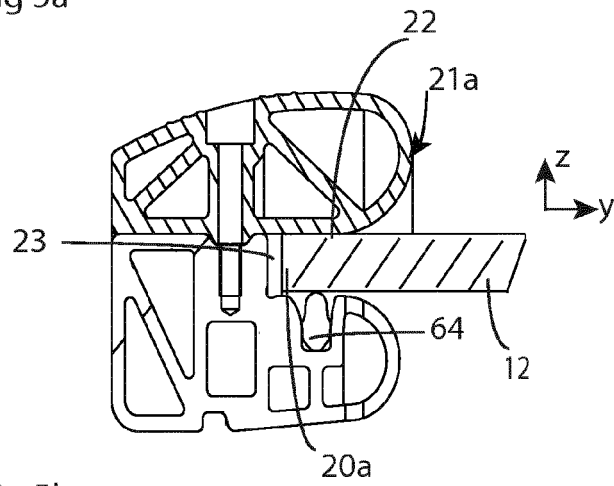


Fig 5b

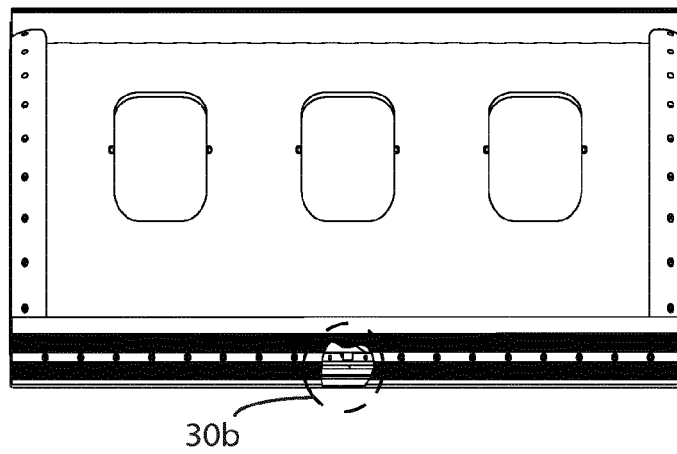


Fig 6

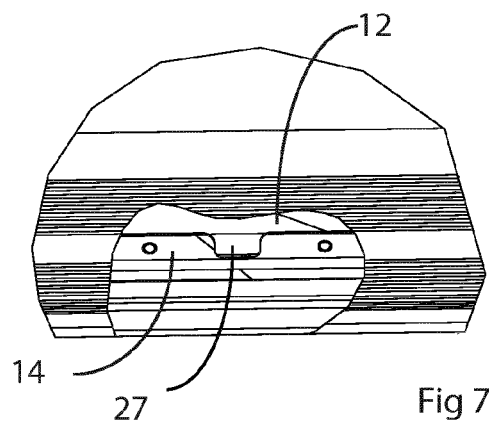


Fig 7

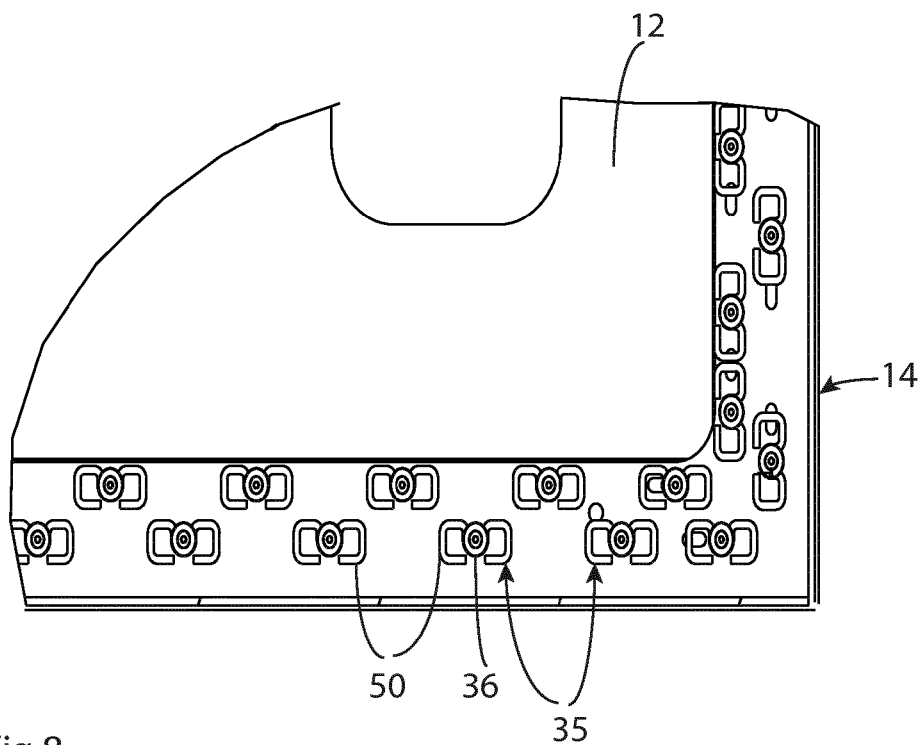


Fig 8

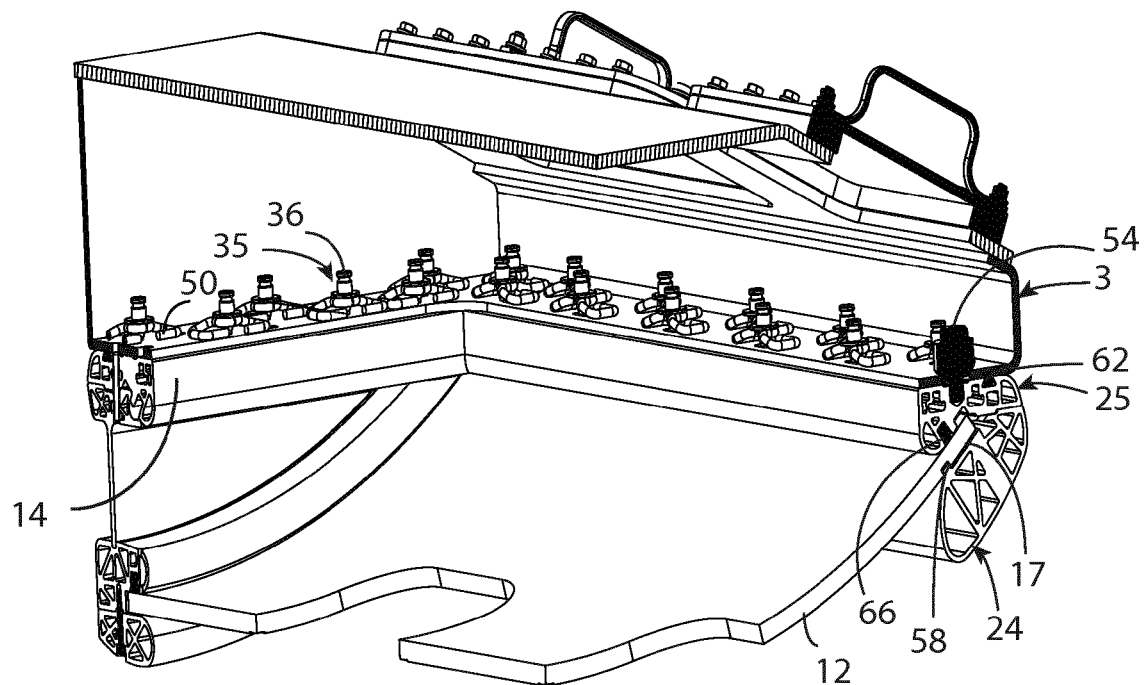


Fig 9

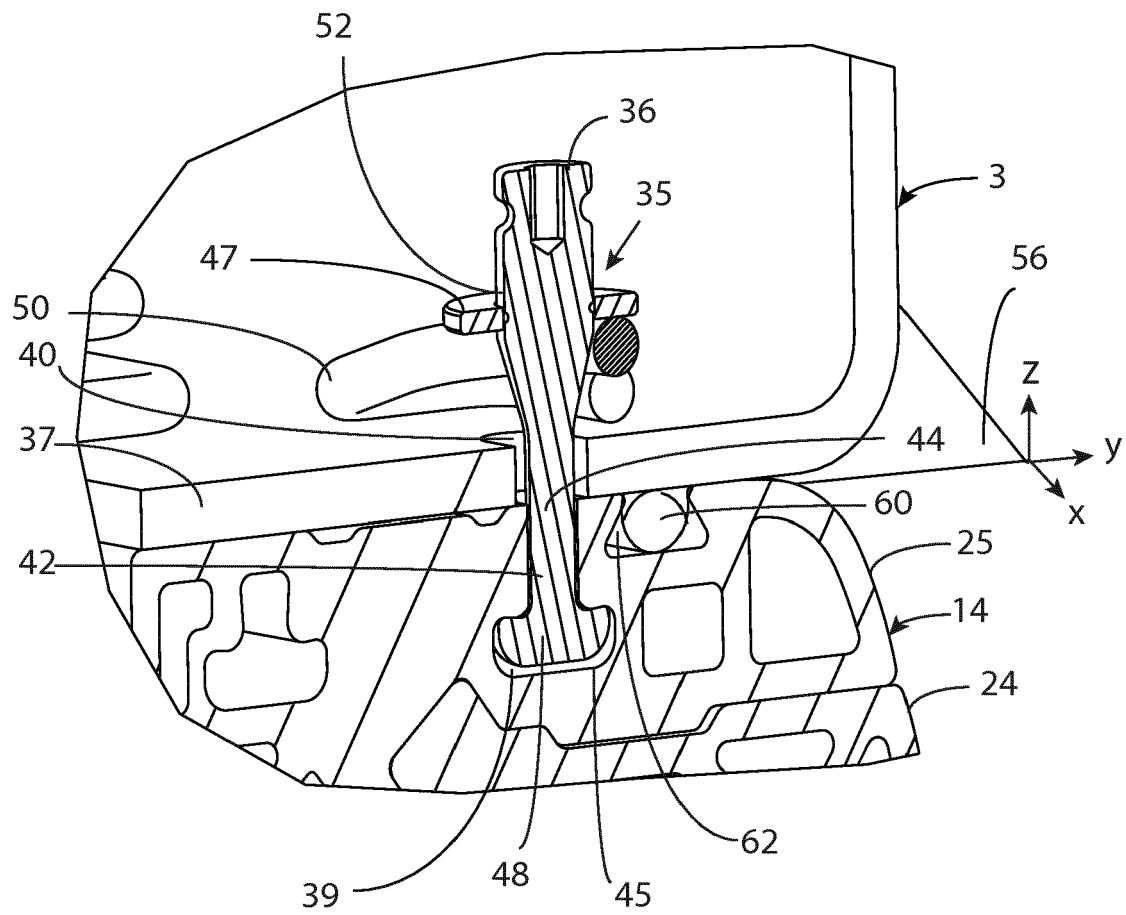


Fig 10

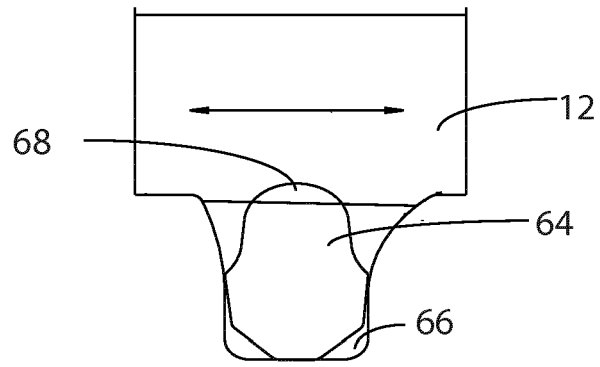


Fig 11

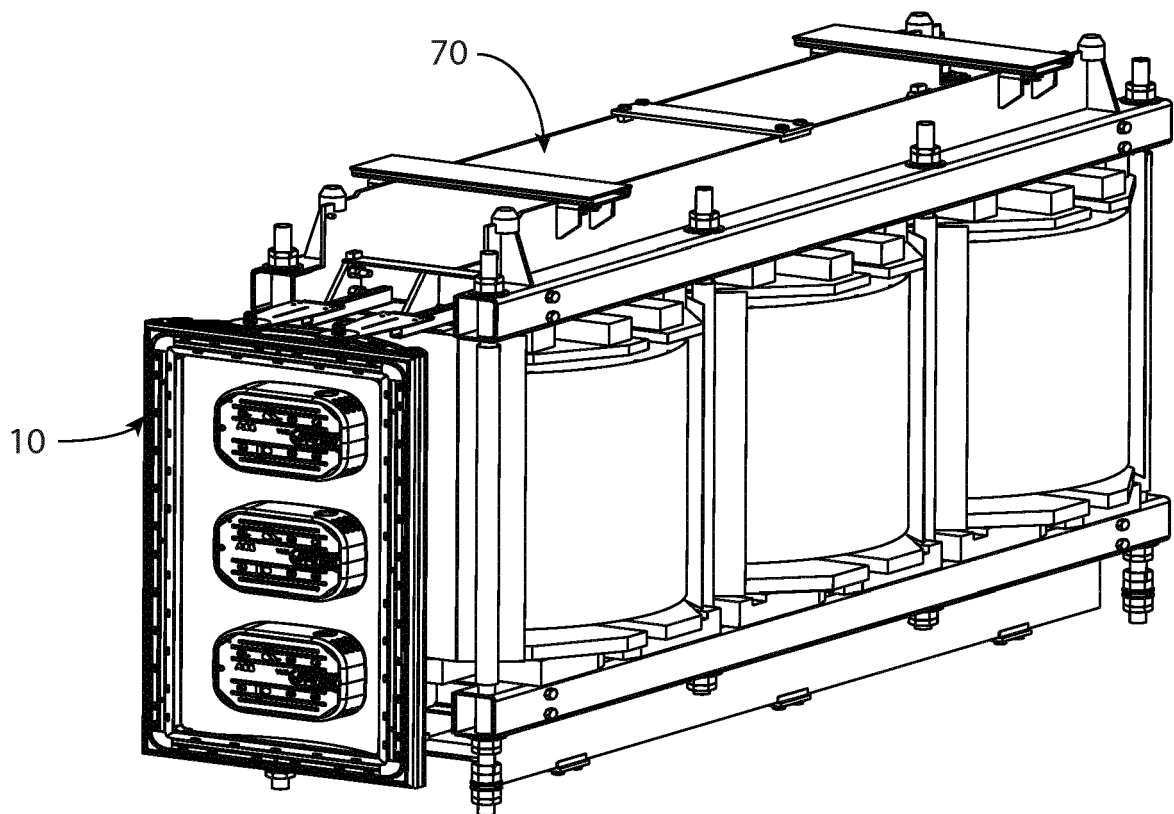


Fig 12



EUROPEAN SEARCH REPORT

Application Number
EP 19 18 3661

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 26 40 807 A1 (ELIN UNION AG) 7 April 1977 (1977-04-07) * figure 2 *	1-15	INV. H01H9/00 H01F27/02 H01H33/56
A	EP 1 032 003 A2 (ELIN OLTC STUFENSCHALTER FUER [AT]) 30 August 2000 (2000-08-30) * abstract; figure 1 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01H H01F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 December 2019	Examiner Socher, Günther
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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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.
The members are as contained in the European Patent Office EDP file on
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16-12-2019

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