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(71) Applicant: **ABB Technology Ltd**
8050 Zürich (CH)

(72) Inventors:
- **Stenestam, Bengt-Olof**
  SE-771 42 Ludvika (SE)
- **Andersson, Gunnar**
  SE-770 14 Nyhammar (SE)
- **Sundqvist, Pontus**
  SE-784 50 Borlänge (SE)
- **Larsson, Tommy**
  SE-771 90 Ludvika (SE)

(74) Representative: **Savela, Reino Aleksi**
ABB AB
Intellectual Property
Ingenjör Bååths Gata 11
721 83 Västerås (SE)

(54) Transformer tap changer

(57) The present disclosure relates to a tap changer (1) for an electrical power transformer, the tap changer comprising: a housing (2) enclosing the tap changer, said housing being configured to be filled with an electrically insulating fluid (6); an electrical switch (3) positioned at least partly inside the housing and configured for switching between different taps of a transformer winding; a particle trap (4), positioned inside the housing such that it will intercept a flow (5, 7) of the electrically insulating fluid caused by natural circulation of said electrically insulating fluid when the tap changer is in use.

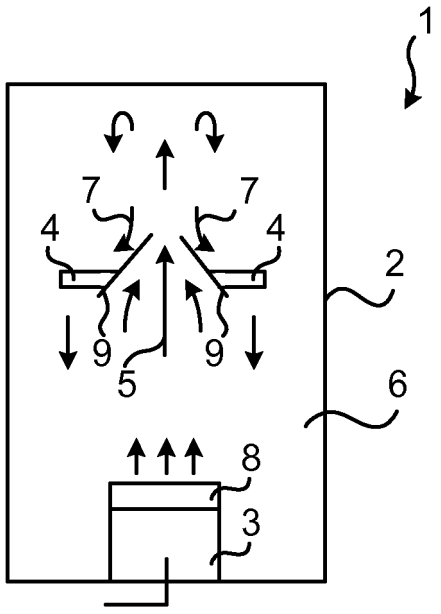

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to the removal of particles from an electrically insulating fluid in a fluid filled tap changer for an electrical power transformer.

BACKGROUND

[0002] Liquid or gaseous electrically insulating fluids are used in electrical apparatuses such as transformers, capacitors, switchgear, bushings, etc., and have a multitude of functions. Insulating, dielectric, fluids typically act as electrically insulating medium separating different voltages from each other and towards ground within the apparatus and function as a cooling medium to transfer the heat generated in various parts of the apparatus. Additionally, analysis of the fluids provides a means to monitoring the health of electrical equipment during operation.

[0003] In addition to the above mentioned basic functions, the insulating fluid should also comply with other necessary and desired requirements. The fluid when used in electrical equipment should contribute to a high efficiency, long operational life time, and minimal environmental impact. Further, the fluid has to be compatible with the materials used in the electrical equipment and it should not constitute a hazard for the health and safety of personnel. In practice, insulating fluids should exhibit various physical, electrical, and chemical properties. Most of these properties are regulated through standards and specifications that stipulate requirements for each one.

[0004] Traditionally, petroleum-based oils have been used as the insulating fluid in fluid-filled transformers mainly because of the advantageous properties relating to low viscosity, low pour point, high dielectric strength, easy availability and low cost. Lately, ester liquids are becoming an alternative to mineral oils. Esters are advantageous due to their high biodegradability and high fire/flash points (> 300°C).

[0005] Electrically insulating fluids are consequently also used in on- load tap changers (OLTC) in power transformers. A tap changer is used in an power transformer to choose the voltage by switching between different taps of the winding, thus changing the ratio between windings.

[0006] An OLTC will for different temperatures, expand and contract its oil volume. This is done via an oil expansion vessel, normally breathing through a silica gel breather to avoid moisture ingress in the oil volume. However, the OLTC can over time anyhow accumulate moisture in the oil, and thus drying or replacement of the oil is needed at regular intervals.

[0007] Another problem is the presence of and accumulation of particles in the OLTC. These particles can be formed from wear of moving parts in the OLTC, or they can enter the OLTC during assembly or with the oil from the expansion vessel. In oil breaking type of OLTC: s wills the breaking in addition also create oil break down products such as coal particles. Large particles fall after some time to the bottom of the tap changer and small particles stay moving around in the oil until they finally, due to dielectric, thermal and in some cases magnetic forces come to rest on insulating material or metallic surfaces in the OLTC. Some small particles may also agglomerate to larger particles and fall to the bottom. During the time when the small particles stay suspended in the oil, dielectric forces can get hold of them and move them to highly stressed areas on the insulating material. The dielectric field together with the insulating material works similar as an electrostatic filter. This is an unwanted effect since the dielectric strength will be largely reduced when particles are trapped on e.g. the insulating material in the OLTC. Today, a filter unit can be attached to the OLTC to remove particles by pumping the transformer oil through the filter.

[0008] EP 0 481 239 discloses an oil filter, especially for tap changers of tapped transformers, as a component of a separate filter circuit, the oil filter having two concentrically arranged filter chambers. In this case, the outer filter chamber is used for filtering out solid impurities and the inner filter chamber, in which, if required, guide elements are arranged in the form of a labyrinth, is filled with moisture-absorbing material and is used for extraction of the water that is in the oil. Thus a separate, external circuit through which the oil is pumped is needed.

SUMMARY

[0009] It is an objective of the present disclosure to solve a problem with external particle separation circuits for removal of particles from a tap changer fluid in the prior art.

[0010] According to an aspect of the present disclosure, there is provided a tap changer for an electrical power transformer, the tap changer comprising: a housing enclosing the tap changer, said housing being configured to be filled with an electrically insulating fluid; an electrical switch positioned at least partly inside the housing and configured for switching between different taps of a transformer winding; a particle trap, positioned inside the housing such that it will intercept a flow of the electrically insulating fluid caused by natural circulation of said electrically insulating fluid when the tap changer is in use.

[0011] According to an aspect of the present disclosure, there is provided a method of removing particles from an electrically insulating fluid in a tap changer for an electrical power transformer, the method comprising: heating a part of the electrically insulating fluid with heat generated by an electrical switch in the tap changer, whereby an upward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; cooling the upward flow, whereby a downward flow of the electrically insu-

lating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; and trapping at least some particles carried by the upward flow and/or the downward flow in a particle trap in the tap changer, through which particle trap at least a part of the flow passes as a result of the natural circulation, thereby removing said particles from the electrically insulating fluid.

[0012] It is an advantage to be able to remove particles from the electrically insulating fluid (typically a liquid such as mineral oil or an ester oil) by using a natural circulation of the fluid within the tap changer. Thereby, no pump is needed for circulating the fluid through e.g. a particle filter, and neither is any circulation loop needed. Instead, in accordance with the present disclosure, the natural circulation creates a flow within the tap changer, which flow can be intercepted by, and pass though a particle trap e.g. a filter or a labyrinth comprising a particle trapping (e.g. adsorbing) material. Natural circulation implies that the circulation is achieved without pumping. Rather, the natural circulation is caused by temperature gradients in the fluid in combination with the act of gravity. As the fluid is heated, e.g. by heat loss from electrical components in the tap changer such as the transition resistors, the density of the fluid is reduced and the heated fluid will rise, thereby also allowing cooler fluid to descend within the tap changer. A fluid flow caused by the natural circulation can then be intercepted by and pass through the particle trap in accordance with the present disclosure, and no extra pump and circulation loop is needed.

[0013] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated. The use of "first", "second" etc. for different features/components of the present disclosure are only intended to distinguish the features/components from other similar features/components and not to impart any order or hierarchy to the features/components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Embodiments will be described, by way of example, with reference to the accompanying drawings, in which:

Fig 1 is a schematic view in longitudinal section of an embodiment of a tap changer of a tap changer of the present disclosure.

Fig 2 is a schematic sectional view of an embodiment of a particle trap in accordance with the present disclosure.

Fig 3 is a schematic flow chart of an embodiment of a method of the present disclosure.

DETAILED DESCRIPTION

[0015] Embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments are shown. However, other embodiments in many different forms are possible within the scope of the present disclosure. Rather, the following embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Like numbers refer to like elements throughout the description.

[0016] Figure 1 schematically illustrates an embodiment of a tap changer 1 of the present disclosure. The tap changer is configured for use in an electrical power transformer for switching between different taps in the winding of the transformer. The tap changer 1 comprises a housing 2 enclosing the tap changer, however still allowing parts of the tap changer e.g. parts of a switch 3 to extend outside of the housing 2. The housing 2 of the tap changer 1 is filled with an electrically insulating liquid fluid 6 e.g. a mineral or ester oil. The tap changer is configured to be positioned in the transformer such that a switch 3 of the tap changer 1 is arranged at the bottom region of the tap changer 1, at least partly within the housing 2, whereby insulation fluid 6 can be heated by the electrical components of e.g. the switch and rise upwards within the housing 2. By the fluid 6 being heated and thus rising within the housing 2, a natural circulation of the fluid is achieved within the housing of the tap changer. This natural circulation gives rise to an upward flow 5 of the fluid 6, as well as an adjacent downward flow 7. In the embodiment of figure 1, the upward flow 5 is created at the centre along a central longitudinal axis of the housing 2, while the downward flow 7 is more peripherally located within the housing 2, if the housing approximates a cylinder in shape. A particle trap 4 is positioned inside the housing 2 such that it intercepts a flow of the fluid 6, allows at least a part of the flow to pass through the particle trap 4. The particle trap may intercept an upward flow 5 and/or a downward flow 7 of the fluid. The particle trap 4 does not have to intercept the whole flow 5 or 7, although it may be desirable to intercept as much as possible in order to achieve efficient particle removal. Even if only a part, possibly a minor part, of the upward or downward fluid flows pass through the particle trap 4, that may be enough to sufficiently remove particles from the fluid 6 since the natural circulation and thus the flowing through the particle trap is continuous or reoccurs with every tap change. The particle trap may be a passive particle trap which allows the fluid flow to pass through it whereby particles are trapped/deposited within the particle trap. The particle trap may e.g. comprise a filter

which mechanically traps the particles and/or which electrostatically or otherwise binds or adsorbs the particles, depending on the material(s) used for the filter. Additionally or alternatively, the particle trap 4 may comprise a labyrinth comprising a material which traps the particles e.g. electrostatically or otherwise binds adsorbs the particles. Since no pumps are used and the circulation is only, or at least predominantly, through natural circulation, larger particles may be allowed to sediment within the tap changer, where they may do no harm since they are not circulating with the fluid and are not deposited on the solid insulation material within the tap changer. Thus, the particle trap 4 may mainly be arranged to trap smaller particles which do not sediment. This also prolongs the life time of the particle trap since it takes longer for it to be clogged by the trapped particles if fewer large particles are trapped. A suitable material which can be used in the particle trap 4 for trapping the particles is cellulose. Cellulose may also be beneficial since it can also take up moisture from the fluid 6, thereby drying the fluid 6 and extending the time period before the fluid needs to be exchanged.

[0017] In the embodiment shown in figure 8, the fluid is mainly heated by at least one transition resistor 8 during switching of the switch 3, causing the central upward flow 5 of the fluid. As the upward flow 5 travels upwards, the fluid therein is cooled down, creating the peripheral downward flow 7. Optionally, a heat exchanger (not shown) at the top of the tap changer can be used to additionally cool the fluid 6.

[0018] In the embodiment shown in figure 8, a guide 9 is used to additionally guide the upward and/or downward flows 5 and 7 to the particle trap 4 and to control the natural circulation. The guide 9 may e.g. be essentially rotation symmetrical to form a funnel facing downward. In figure 1, the natural circulation with the upward flow 5 and the downward flow 7 is illustrated with arrows. As can be seen, the flows 5 and 7 are essentially parallel and adjacent to each other, but in opposite directions. However, the guide 9 can guide the upward flow 5 and/or the downward flow 7 e.g. by concentrating the upward flow 5 when it passes through a funnel-shaped guide 9, as illustrated by the upward flow 5 arrows within the funnel 9 in figure 1. As the upward flow 5 reaches the top of the housing 2, the naturally circulating fluid 6 is cooled down, possibly also assisted by a cooling heat exchanger at the top of the housing, and forms part of the downward flow 7. The downward flow 7 is more peripheral than the concentrated upward flow 5 and is thus intercepted and guided by the outside of the funnel-shaped guide 9. The guide 9 guides the downward flow 7 to the particle trap 4 which in the embodiment of figure 1 is attached to the outside of guide 9. Possibly the particle trap 4 is also essentially rotation symmetrical and attached along the circumference of the funnel 9.

[0019] Figure 2 is a schematic sectional view of an embodiment of a particle trap 4 in accordance with the present disclosure. Possibly, figure 2 can be regarded as a detail of figure 4 showing an embodiment of the particle trap in figure 1. The particle trap 4 in figure 2 is attached to the guide 9 which guides the downward flow 7 of the naturally circulating fluid 6. In the embodiment of figure 2, the particle trap 4 is in the form of a labyrinth through which at least a part of the downward flow 7 passes, as indicated by the arrows in figure 2.

[0020] The labyrinth may comprise a material suitable for trapping particles, such as cellulose, especially small particles.

[0021] Figure 3 is a flow chart illustrating an embodiment of a method of the present disclosure. The method is performed in an embodiment of a tap changer of the present disclosure. A part of the electrically insulating fluid 6 is heated 101 by heat generated by a transition resistor 8 of an electrical switch 3 in the tap changer 1, whereby an upward flow 5 of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer. The upward flow 5 is intercepted and guided 102 by an inside of a funnel-shaped guide 9 arranged facing downwards in the tap changer 1, whereby the upward flow is concentrated by passing through the funnel-shaped guide. The upward flow 5 is cooled 103 above the funnel-shaped guide 9 in the tap changer 1, whereby a downward flow 7 of the electrically insulating fluid 6 is created through natural circulation of the electrically insulating fluid in the tap changer. The downward flow 7 is intercepted and guided 104 by an outside of the funnel-shaped guide 9, whereby said downward flow is guided by the guide such that at least a part of the downward flow passes through a particle trap 4 in the tap changer 1. At least some particles carried by the downward flow 7 in the particle trap 4 are trapped 105, thereby removing said particles from the electrically insulating fluid 6.

[0022] In some embodiments of the present disclosure, the electrical switch 3 comprises at least one transition resistor 8, wherein the natural circulation, when the tap changer is in use, is caused at least partly by heat generated by said at least one resistor. A resistance is used in the switch in order to not short circuit the step of the winding in the transformer when changing from one tap to another tap. This resistance is called the transition resistance and generates heat at each tap change, thus resulting in the natural circulation discussed herein. Additionally or alternatively, a more continuous resistance may be used to give more continuous heating and natural circulation, but this requires higher energy use. In accordance with the present disclosure, the transition resistance is enough to give sufficient circulation, although additional heating, e.g. by means of heating elements at the bottom region of the tap changer, is also possible and may be used in some embodiments of the present disclosure.

[0023] In some embodiments of the present disclosure, a guide 9 is positioned inside the housing 2 and arranged for guiding the flow 5, 7 of the electrically insulating fluid 6 caused by natural circulation to the particle

trap 4.

[0024] In some embodiments, the guide 9 is funnel-shaped. In some embodiments, the funnel-shaped guide 9 is arranged to collect and concentrate an upward flow 5 of the electrically insulating fluid which is then cooled and forms a downward flow 7 to the intercepting particle trap 4 positioned outside of the funnel-shaped guide. In some embodiments, the particle trap 4 is attached to the guide 9.

[0025] In some embodiments of the present disclosure, the particle trap 4 is in the form of a filter and/or of a labyrinth.

[0026] In some embodiments of the present disclosure, the particle trap 4 comprises cellulose for trapping particles.

[0027] In some embodiments of the present disclosure, the particle trap 4 is configured to trap small particles, not settling, having a typical particle size of less than 100 μm but most particles will be smaller than 10 μm or even 1 μm. But the size of the particles not settling depends on the used fluid viscosity and the actual particle density.

[0028] In some embodiments of the present disclosure, the tap changer 1 is configured for being used in an electrical power transformer having a system voltage of at least 1 kilovolt. Higher voltages will increase the dielectrical forces and the need for clean surfaces, therefore is the removal of the particles of higher importance.

[0029] Below follow some other aspects of the present disclosure.

[0030] According to an aspect of the present disclosure, there is provided a method of removing particles from an electrically insulating fluid in a tap changer for an electrical power transformer, the method comprising: heating a part of the electrically insulating fluid with heat generated by a resistor of an electrical switch in the tap changer, whereby an upward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; allowing said upward flow to be intercepted by an inside of a funnel-shaped guide arranged facing downwards in the tap changer, whereby the upward flow is concentrated by passing through the funnel-shaped guide; cooling the upward flow above the funnel-shaped guide in the tap changer, whereby a downward flow of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; allowing said downward flow to be intercepted by an outside of the funnel-shaped guide, whereby said downward flow is guided by the guide such that at least a part of the downward flow passes through a particle trap in the tap changer; and trapping at least some particles carried by the downward flow in the particle trap, thereby removing said particles from the electrically insulating fluid.

[0031] According to an aspect of the present disclosure, there is provided a tap changer (1) for an electrical power transformer, the tap changer comprising: means for heating (101) a part of the electrically insulating fluid (6) with heat generated by an electrical switch (3) in the tap changer (1), whereby an upward flow (5) of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer; means for cooling (103) the upward flow (5), whereby a downward flow (7) of the electrically insulating fluid (6) is created through natural circulation of the electrically insulating fluid in the tap changer; and means for trapping (105) at least some particles carried by the upward flow (5) and/or the downward flow (7) in a particle trap (4) in the tap changer, through which particle trap at least a part of the flow (5) and/or (7) passes as a result of the natural circulation, thereby removing said particles from the electrically insulating fluid (6).

[0032] The present disclosure has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the present disclosure, as defined by the appended claims.

Claims

1. A tap changer (1) for an electrical power transformer, the tap changer comprising:

   a housing (2) enclosing the tap changer (1), said housing being configured to be filled with an electrically insulating fluid (6);
   an electrical switch (3) positioned inside the housing (2) and configured for switching between different taps of a transformer winding;
   a particle trap (4), positioned at least partly inside the housing (2) such that it will intercept a flow (7) of the electrically insulating fluid (6) caused by natural circulation of said electrically insulating fluid when the tap changer (1) is in use.

2. The tap changer of claim 1, wherein the electrical switch (3) comprises at least one transition resistor (8), wherein the natural circulation, when the tap changer is in use, is caused at least partly by heat generated by said at least one resistor.

3. The tap changer of any preceding claim, wherein a guide (9) is positioned inside the housing (2) and arranged for guiding the flow (5, 7) of the electrically insulating fluid (6) caused by natural circulation to the particle trap (4).

4. The tap changer of claim 3, wherein the guide (9) is funnel-shaped.

5. The tap changer of claim 4, wherein the funnel-shaped guide (9) is arranged to collect and concentrate an upward flow (5) of the electrically insulating

fluid which is then cooled and forms a downward flow (7) to the intercepting particle trap (4) positioned outside of the funnel-shaped guide.

6. The tap changer of any one of claims 3-5, wherein the particle trap (4) is attached to said guide (9).

7. The tap changer of any preceding claim, wherein the particle trap (4) is in the form of a filter and/or of a labyrinth.

8. The tap changer of any preceding claim, wherein the particle trap (4) comprises cellulose for trapping particles.

9. The tap changer of any preceding claim, wherein the particle trap (4) is configured to trap small particles having a particle size of less than 100 μm, such as less than 10 μm or less than 1 μm.

10. The tap changer of any preceding claim, wherein the tap changer (1) is configured for being used in an electrical power transformer having a system voltage of at least 1 kilovolt.

11. The tap changer of any preceding claim, wherein the electrically insulating fluid (6) is or comprises an oil, such as a mineral oil or an ester oil.

12. A method of removing particles from an electrically insulating fluid (6) in a tap changer (1) for an electrical power transformer, the method comprising:

heating (101) a part of the electrically insulating fluid (6) with heat generated by an electrical switch (3) in the tap changer (1), whereby an upward flow (5) of the electrically insulating fluid is created through natural circulation of the electrically insulating fluid in the tap changer;
cooling (103) the upward flow (5), whereby a downward flow (7) of the electrically insulating fluid (6) is created through natural circulation of the electrically insulating fluid in the tap changer; and
trapping (105) at least some particles carried by the upward flow (5) and/or the downward flow (7) in a particle trap (4) in the tap changer, through which particle trap at least a part of the flow (5; 7) passes as a result of the natural circulation, thereby removing said particles from the electrically insulating fluid (6).

13. The method of claim 12, further comprising:

allowing said upward flow (5) to be intercepted by an inside of a funnel-shaped guide (9) arranged facing downwards in the tap changer (1), whereby the upward flow is concentrated (103) by passing through the funnel-shaped guide.

14. The method of claim 13, further comprising:

allowing said downward flow (7) to be intercepted by an outside of the funnel-shaped guide (9), whereby said downward flow is guided (104) by the guide such that at least a part of the downward flow passes through a particle trap (4) in the tap changer (1).

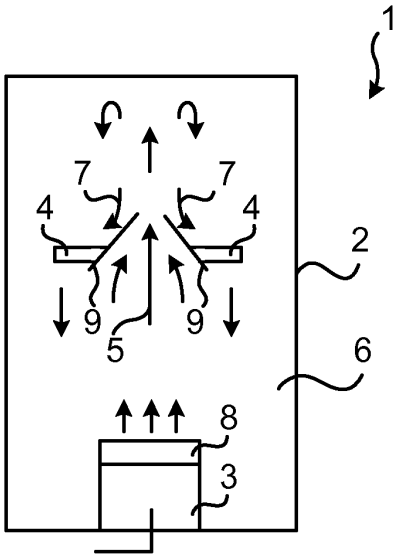

Fig. 1

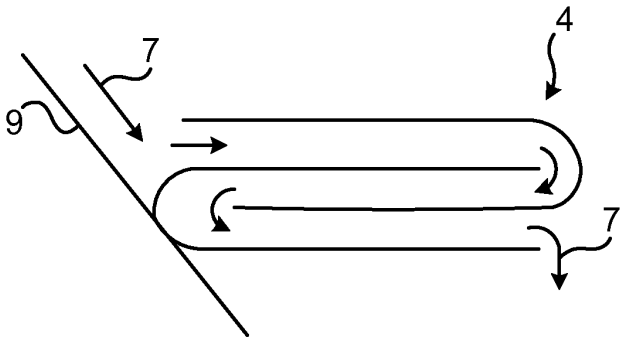

Fig. 2

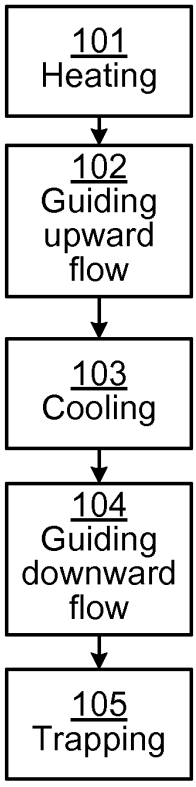

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 8798

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 September 2013	Gols, Jan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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