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(54) On-load tap-changer for dry transformers and dry transformer

(57) The invention is related to an on-load tap-changer (10, 40, 60, 80) for dry transformers, comprising an electric insulating hollow casing (12, 62) extending around a virtual axis (14, 70), wherein several electric contact sections (16, 18, 20, 22) are foreseen along the inner surface of the hollow casing (12, 62), which are electrically joined through the wall of the hollow casing (12, 62) and a selector contact in the inner of the casing which is rotatable around the virtual axis and that's radial outer end is selectively connectable with one of the contact sections by a respective rotation. The inner space (30) of the hollow casing (12, 62) is hermetically sealed and filled with a preferably pressured insulating gas. The invention is also related to a transformer with an on-load tap-changer (10, 40, 60, 80).

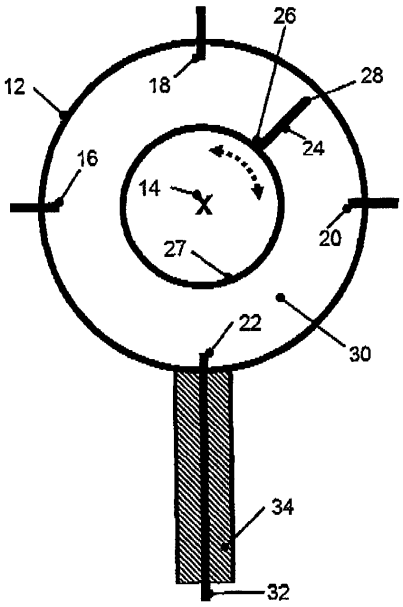

Fig. 1

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Description

[0001] The invention is related to an on-load tap-changer for dry transformers, comprising an electric insulating hollow casing extending around a virtual axis, wherein several electric contact sections are foreseen along the inner surface of the hollow cylinder, which are electrically joined through the wall of the hollow casing and a selector contact in the inner of the casing which is rotatable around the virtual axis and that's radial outer end is selectively connectable with one of the contact sections by a respective rotation. The invention is also related to a transformer with an on-load tap-changer.

[0002] A tap-changer is a selector switch which enables the selective electrical connection of one output with one of several contact sections. An on-load tap-changer has the ability to switch under load current. Typically the contact sections are arranged along a circular path wherein the selector contact is rotatable around a virtual axis in the center of the circular path. But also a selector contact which is moveable in axial direction along axially arranged contact sections is a suitable embodiment of an on-load tap-changer. On-load tap-changers are used to adapt the transmission ratio of a power transformer in distribution networks within certain limits.

[0003] In this case taps of the transformer winding are electrically connected with respective contact sections of a tap-changer, wherein a certain voltage difference inbetween the respective connector sections is present, which might be at around +/- 10% of the rated voltage of the transformer over all taps. In case of a circular arrangement the connector sections are typically foreseen on the inner surface of an electric insulating hollow cylinder. The electrical insulation inbetween adjacent connector sections has to be foreseen to withstand a respective voltage difference. The highest voltage difference will rise inbetween first and last tap, which are adjacent due to the circular arrangement.

[0004] Oil transformers are known for voltages of 380kV and higher and for a rated power of some 100MVA for example. As an oil transformer itself also a tap changer for an oil transformer is flooded with the insulation medium oil, which enables a compactor design due to the reduced required insulation distance inbetween adjacent connector sections.

[0005] Dry transformers avoid the insulation medium oil due to reasons of improved security or easier handling. Dry transformers are typically known for voltages up to 36kV or 72,5kV with a rated power of for example some MVA. Due to this - at least in relation - not as high voltage the required insulation distances inbetween the different selector contacts within the tap-changer are not as high so that the size of a respective oil-free on-load tap-changer is still within acceptable limits. Anyhow, the rated voltage for dry transformers is expected to increase in the future, for example to 110kV.

[0006] Disadvantageously within this state of the art is that the size of an oil-free tap-changer for dry transformers is exceeding an acceptable limit with increase of the rated voltage.

[0007] Objective of the invention is to provide an on-load tap-changer for dry transformers with a reduced size, especially with respect to an increased rated voltage.

[0008] The problem is solved by an on-load tap-changer for dry transformers of the aforementioned kind. This is characterized in that the inner space of the hollow casing is hermetically sealed and filled with a preferably pressured insulating gas. Preferably the casing is hollow cylinder like.

[0009] Basic idea of the invention is to reduce the size and the insulation distances within the electric insulating hollow casing by sealing it hermetically and filling it with a preferably pressurized insulating gas that's electrical insulation ability is better than the insulation ability of air. Thus the advantages of a dry transformer are still present, wherein the size of the tap-changer is reduced in an advantageous way respectively the tap-changer is enabled to withstand a higher rated voltage.

[0010] According to a further embodiment of the invention the insulation gas is SF6. This type of insulation gas is known for insulating switchgear-substations within an energy distribution system and is proven technology.

[0011] Following another embodiment of the invention a barrier-shield is foreseen in the radial space inbetween radial inner and radial outer end of the selector contact, which is rotatable together with the selector contact. Barriers are known means to improve the insulation ability within or around an electrical high voltage device. On the other side a fixed standard barrier is subject to collisions with the rotatable selector contact. Thus the idea of this embodiment consists in making a barrier rotatable together with the selector switch to exclude any collision. Of course, a rotatable barrier-shield is also suitable for a tap-changer, which is not hermetically sealed and which is not filled with a pressured insulating gas.

[0012] According to a further embodiment of the invention respective cables are foreseen to electrically connect the contact sections from the radial outer side of the hollow cylinder, wherein at least some of the cables comprise a respective surrounding outer insulation at least at their respective connected end. Concerning the electrical insulation ability of a tap-changer it has to be distinguished inbetween insulation within the electric insulating hollow casing and the outer insulation. As well the pressured insulation gases as the inner rotatable barrier increase the inner insulation behavior of the tap-changer. To successfully reduce the size of a tap changer also the insulation on the outer side of the electric insulating hollow casing has to be foreseen to withstand the increased requirements concerning insulation.

[0013] A cable is foreseen as electrical conductor leading for example from the taps of a transformer to the connector sections of the tap-changer. The creeping distance inbetween adjacent cables has significant influence on the insulation ability inbetween them. A respec-

tive surrounding outer insulation at the respective connected end on the tap-changer side of a cable increases the insulation ability inbetween adjacent cables in an advantageous way. Further increase could be gained by insulation rips or the like.

[0014] According to a further embodiment of the invention a front end of the surrounding insulation is hermetically connected with the outer surface of the hollow cylinder. This might be done for example by use of suitable glue or an epoxy resin. Thus it is excluded in an advantageous way that an air gap inbetween outer surface of the hollow casing respectively hollow cylinder and surrounding insulation is present, which could be reason for an electrical breakthrough.

[0015] According to a further embodiment of the invention the at least one cable comprises at least in sections a screen around its surrounding insulation. Thus the electrical potential on the outer surface of the cable insulation can be set to a defined value by connecting it with a defined voltage potential. Hence the insulation behavior is more reproducible and reliable therewith.

[0016] In a further variant of the on-load tap-changer the screen of the cable is electrically connected with one of those contact sections which are not connected with the respective cable. Thus the electrical potential of the screen of the cable is different than the electrical potential of the respective cable itself in case that the tap-changer is in the operating state. This is useful to reduce the potential of the screen compared to the potential of the inner cable, thus the insulation requirements on the outer surface of the hollow casing are reduced due to reduced voltage differences inbetween the respective screens of the respective cables. A part of the voltage is insulated by the surrounding insulation of the cable in such a case.

[0017] The problem of the invention is also solved by a dry transformer, comprising

- a winding with a first, a last and at least one medium tap,
- an on-load tap-changer as described before,
- wherein the respective taps of the winding are electrically connected with respective contact sections of the tap-changer and
- wherein the screen of the cable for the first and/or last tap is electrically connected to one of the at least one medium taps.

[0018] The first tab is assumed to have the lowest output voltage and the last tap to have the highest output voltage. Assuming further a sequential and circular arrangement of the contact sections within the hollow cylinder, the contact sections for first and last tap will be adjacent each to each other and the insulation inbetween the respective cables will be stressed by the maximum voltage difference inbetween first and last tap. Since the at least one medium tap will have a voltage-level inbetween the voltage of the first and the last tap, a connection of at least one of the screens of the cables for first or last tab with one of the at least one medium taps will reduce the voltage stress on the outer side of the hollow casing in an advantageous way. In case of several medium taps preferably this tap which is electrically exactly inbetween the first and last tap should be connected.

[0019] Further advantageous embodiments of the invention are mentioned in the dependent claims.

[0020] The invention will now be further explained by means of an exemplary embodiment and with reference to the accompanying drawings, in which:

Figure 1 shows a first exemplary on-load tap-changer,
Figure 2 shows a second exemplary on-load tap-changer,
Figure 3 shows third exemplary on-load tap-changer and
Figure 4 shows a fourth exemplary on-load tap-changer.

[0021] Figure 1 shows a first exemplary on-load tap-changer 10 in a cross-sectional view. An electric insulating hollow casing 12, in this case a hollow cylinder for example made from glass fiber epoxy, is extending around and along a virtual axis 14. Several exemplary contact sections 16, 18, 20, 22 are arranged along a circular path on the inner surface of the electric insulating hollow casing 12. An inner pole 27 with a radial oriented selector contact 24 with radial inner end 26 and radial outer end 28 is rotatable around the virtual axis 14. By rotation of the inner pole 27 the radial outer end 28 of the selector contact 26 is selectively connectable with one of the contact sections 16, 18, 20, 22.

[0022] The contact section 22 is electrically connected with a cable 32 that is surrounded by an outer insulation 34. The insulation 34 increases the insulation ability inbetween adjacent cables 32 on the outer side of the electric insulating hollow casing 12. The cable 32 is leading to a tap of a non-shown transformer winding and also the other contact sections 16, 18, 20 are supposed to be connected with further taps of the non-shown transformer winding.

[0023] By sealing hermetically the inner space 30 of the electric insulating hollow casing 12 and filling it with a pressured gas such as SF6 the insulation ability inbetween the contact sections 16, 18, 20, 22 in the inner space of the electric insulating hollow casing 12 is increased advantageously.

[0024] Figure 2 shows a second exemplary on-load tap-changer 40 in a cross-sectional view. A cable 42 is leading to the outer surface of an electric insulating hollow casing 50. The cable 42 is surrounded by an outer insulation 44, which itself is surrounded by an electrical screen 46, wherein on the outer surface of the screen 46 a further insulation layer 48 is foreseen. The screen 46 is electrically connected 54 with a further cable leading to another contact section. Thus the electrical potential of the shield corresponds to the potential of the further

cable 56. To avoid any air gap inbetween the axial front end of the surrounding insulation 44 and the electric insulating hollow casing 50 both components 44, 50 are hermetically connected as indicated with the dotted ellipse 52. This can be done for example by use of suitable glue or an epoxy resin or the like.

[0025] Figure 3 shows a third exemplary on-load tap-changer 60 in a 3D view. An electric insulating hollow casing 62 is arranged around a virtual axis 64 and shown in a three dimensional view. Front end covers 66 are foreseen at both axial ends to ensure, that the inner space of the electric insulating hollow casing 62 is hermetically sealed, so that pressured insulating gas, which is filled therein, can't leak therefrom. The pressured insulating gas enables a smaller design of the on-load tap-changer 60. A cable 68 indicates an electrical connection to a not shown tap of a transformer, wherein several cables of this kind are supposed to be foreseen. A rotation shaft 70 around the virtual axis 64 is foreseen to rotate a selector contact in the inner of the electric insulating hollow cylinder.

[0026] Figure 4 shows a fourth exemplary on-load tap-changer 80 in a cross-sectional view. Here a selector contact 86 is rotatable together with a barrier shield 82 around a virtual axis, so that the selector contact is selectively connectable with one of several contact sections. Rips 84 increase the creeping distance along the surface of the barrier shield 82.The barrier improves the insulation behavior in the inner of the hollow cylinder, so that either the tap-changer 80 can be operated with a higher voltage or its size can be reduced in an advantageous way.

List of reference signs

[0027]

10 first exemplary on-load tap-changer
12 electric insulating hollow cylinder
14 virtual axis
16 first electric contact section
18 second electric contact section
20 third electric contact section
22 fourth electric contact section
24 selector contact
26 radial inner end of selector contact
27 inner pole
28 radial outer end of selector contact
30 inner space of electric insulating hollow cylinder
32 cable
34 surrounding outer insulation of cable
40 second exemplary on-load tap-changer
42 cable
44 surrounding outer insulation of cable
46 screen
48 further insulation layer
50 electric insulating hollow cylinder
52 hermetic connection
54 electrical connection
56 further cable
60 third exemplary on-load tap-changer
62 electric insulating hollow cylinder
64 virtual axis
66 front end cover of cylinder
68 cable
70 rotation shaft
80 fourth exemplary on-load tap-changer
82 barrier shield
84 rib on barrier shield
86 selector contact

Claims

1. On-load tap-changer (10, 40, 60, 80) for dry transformers, comprising

   • an electric insulating hollow casing (12, 62) extending around a virtual axis (14, 70), wherein several electric contact sections (16, 18, 20, 22) are foreseen along the inner surface of the hollow casing (12, 62), which are electrically joined through the wall of the hollow casing (12, 62),
   • a selector contact in the inner of the casing which is rotatable around the virtual axis and that's radial outer end is selectively connectable with one of the contact sections by a respective rotation,

   characterized in that

   the inner space (30) of the hollow casing (12, 62) is hermetically sealed and filled with a preferably pressured insulating gas.

2. On-load tap-changer according to claim 1, **characterized in that** the pressured insulating gas is SF6.

3. On-load tap-changer according to claim 1 or 2, **characterized in that** a barrier shield (82) is foreseen in the radial space inbetween radial inner (26) and radial outer (28) end of the selector contact (24), which is rotatable together with the selector contact (24).

4. On-load tap-changer according to any of the previous claims, **characterized in that** respective cables (32, 42, 68) are foreseen to electrically connect the contact sections (16, 18, 20, 22) from the radial outer side of the hollow casing (12, 62), wherein at least some of the cables (32, 42, 68) comprise a respective surrounding outer insulation (34, 44) at least at their respective connected end.

5. On-load tap-changer according to claim 4, **characterized in that** a front end of the surrounding insulation (34, 44) is hermetically connected (52) with the outer surface of the hollow casing (12, 62).

6. On-load tap-changer according to claim 5, **characterized in that** at least one cable (32, 42, 68) comprises a screen (46) around its surrounding insulation (34, 44).

7. On-load tap-changer according to claim 6, **characterized in that** the screen (46) of the cable (32, 42, 68) is electrically connected with one of those contact sections (16, 18, 20, 22), which are not connected with the respective cable (32, 42, 68).

8. Dry transformer, comprising

- a winding with a first, a last and at least one medium tap,
- an on-load tap-changer (10, 40, 60, 80) according to claim 7,
- wherein the respective taps of the winding are electrically connected with respective contact sections of the tap-changer (10, 40, 60, 80),
- wherein the screen (46) of the cable (32, 42, 68) for the first and/or last tap is electrically connected (54) to one of the at least one medium taps.

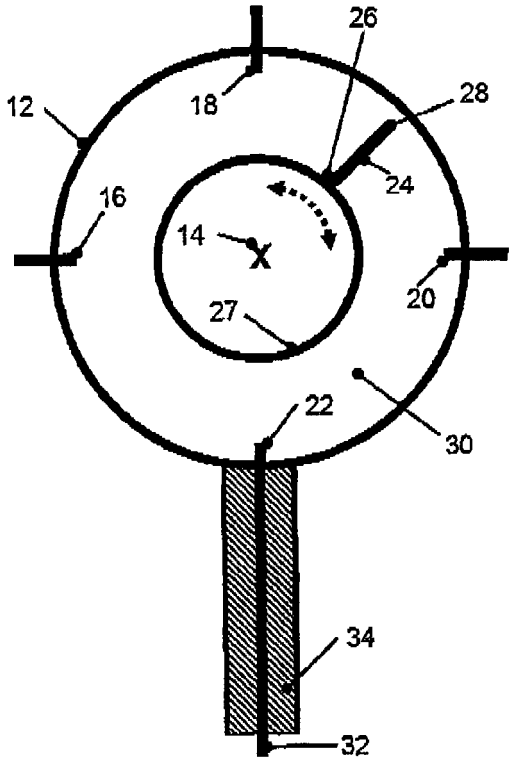

Fig. 1

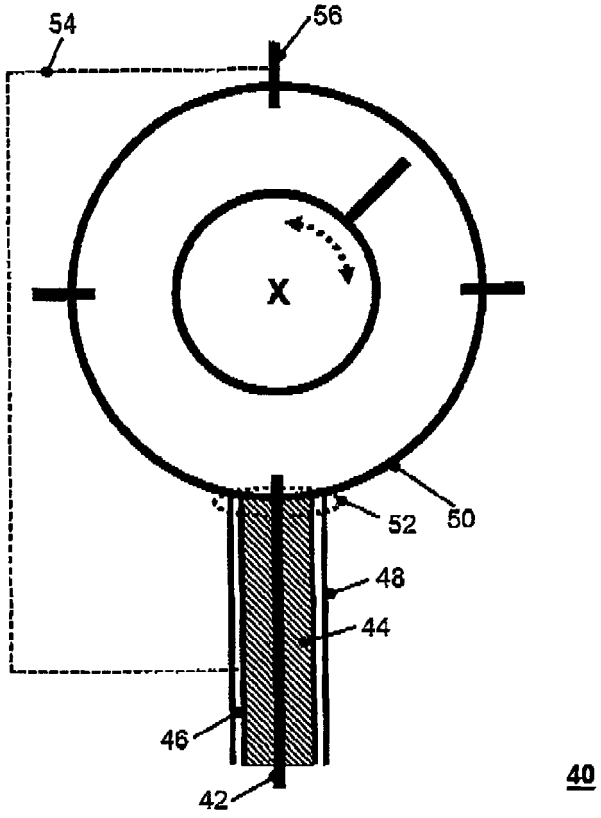

Fig. 2

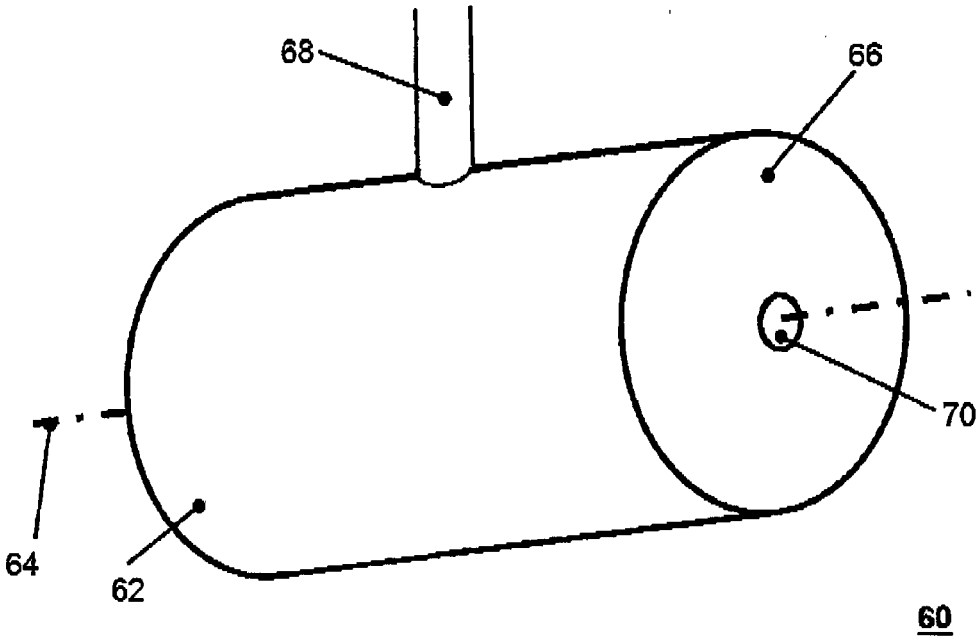

Fig. 3

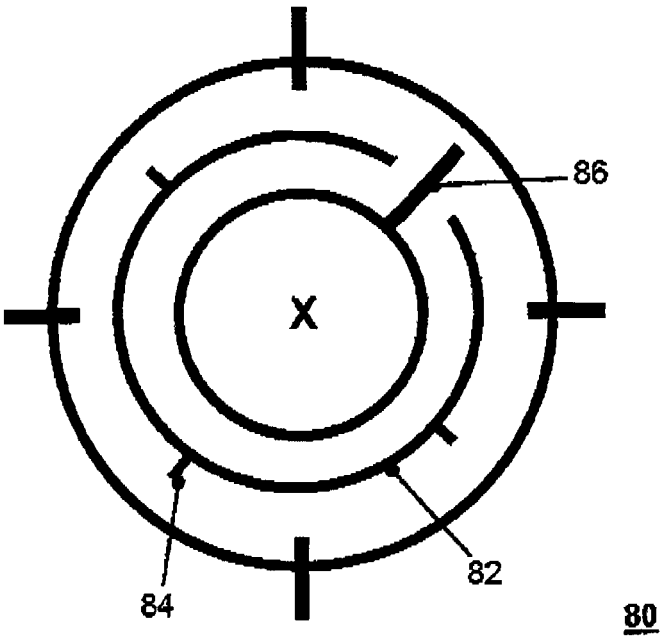

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 00 2816

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 2 637 186 A1 (ABB TECHNOLOGY LTD [CH]) 11 September 2013 (2013-09-11) * paragraphs [0020] - [0046]; figures *	1-8	INV. H01H9/00
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A	CN 202 307 477 U (SHAANXI HANZHONG TRANSFORMER CO LTD) 4 July 2012 (2012-07-04) * figures *	1	
A	EP 2 530 693 A1 (ABB TECHNOLOGY LTD [CH]) 5 December 2012 (2012-12-05) * paragraphs [0029], [0030]; figure 1a *	1	TECHNICAL FIELDS SEARCHED (IPC) H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	30 January 2015	Findeli, Luc

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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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30-01-2015

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