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(71) Applicant *(for all designated States except US)*: **ABB TECHNOLOGY AG** [CH/CH]; Affolternstrasse 44, CH-8050 Zurich (CH).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ROY MARTÍN, Carlos** [ES/ES]; C. Santa Teresa de Jesús, 9, 3º B, E-50006 Zaragoza (ES). **NOGUÉS BARRIERAS, Antonio** [ES/ES]; Plaza de España, 14, E-22200 Sariñena (ES).

(74) Agent: **ZBM PATENTS- ZEA, BARLOCCI & MARKVARDSEN**; Pl. Catalunya, 1, E-08002 Barcelona (ES).

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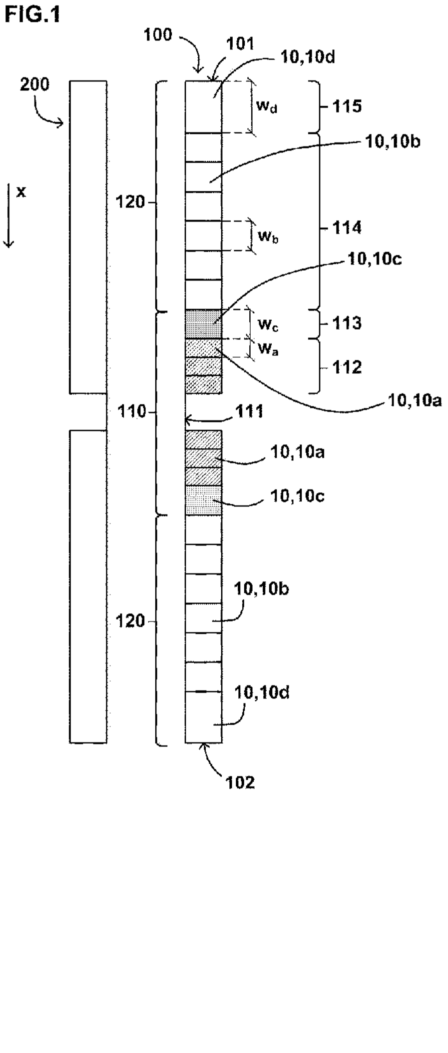
(54) Title: DRY-TYPE TRANSFORMER

FIG.1



(57) Abstract: The invention relates to a dry-type transformer comprising a winding (101) with a tapping zone (110), the tapping zone (110) being the zone wherein at least two connections can be made, allowing to change the number of turns of the winding (100) and thus change the turn ratio of the transformer, and with at least a first non-tapping zone (120), wherein the winding (100) comprises a conductor having, in at least part of the tapping zone (110), a first width (w_a) in the axial direction (x) of the winding (100), and having, in at least part of the first non-tapping zone (120), a second width (w_b) in the axial direction (x) of the winding, the first width (w_a) being smaller than the second width (w_b).

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Dry-type transformer

The present invention relates to a dry-type transformer comprising a winding with a tapping zone, with reduced losses in said winding.

BACKGROUND ART

Dry-type transformers for high voltage classes have been widely used in recent years in a number of utility and industrial installations because of their high reliability. Some of these dry-type transformers require the use of high voltages, high rated powers and a high regulating range, which lead to heating and hot-spot problems related to eddy and DC (or ohmic) losses in the windings of the transformer,

These eddy currents are induced by the magnetic flux generated by the current flowing through the winding, and they depend mainly on the module and direction of the magnetic flux: generally, it can be said that the more radial the magnetic flux, the higher the losses.

Also, in dry-type transformers requiring a high tapping range, when working in the lowest position of the transformer's tap-changer, high losses appear in the parts of the winding near to the connection points of the tap-changer, leading to a high hot-spot temperature within the zones surrounding said connection points.

In oil-type transformers, a regulation winding is employed to decrease hot spots created by the eddy currents along the winding; however, such a regulation winding may not be a suitable or appropiate solution for a dry-type transformer, since, because of its air-cooling system, it would require adding a very large and expensive regulation coil to the dry-type transformer.

The present invention aims to provide a dry-type transformer which solves at least partly the above drawbacks, by reducing the losses due to eddy currents, at least in the more problematic operating positions of the tap changer.

SUMMARY OF THE INVENTION

In a first aspect, the invention provides a dry-type transformer comprising a winding with a tapping zone, the tapping zone being the zone wherein at least two connections can be made, allowing to change the number of turns of the winding and thus change the turn ratio of the transformer, and with at least a first non-tapping zone, wherein the winding comprises a conductor having, in at least part of the tapping zone, a first width in the axial direction of the winding, and having, in at least part of the first non-tapping zone, a second width in the axial direction of the winding, the first width being smaller than the second width.

The use of a conductor having such a smaller width in the tapping zone reduces the axial length of this zone, and in particular reduces the gap of unused turns in the lower position of the tap changer of the transformer, i.e. the position in which the winding has a smaller number of turns. This reduction in the gap brings about a more axial magnetic flux, reducing the radial component thereof; as a consequence of this change in the magnetic flux, the eddy currents and corresponding losses caused by the radial magnetic flux in those non-tapping zones of the windings that are adjacent to the tapping zone are reduced.

Additional objects, advantages and features of embodiments of the invention will become apparent to those skilled in the art upon examination of the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Particular embodiments of the present invention will be described in the following by way of non-limiting examples, with reference to the appended drawings, in which:

Figure 1 depicts schematically a dry-type transformer comprising a high voltage winding and a low voltage winding, according to an embodiment of the present invention;

Figure 2 depicts schematically the conductors of a high voltage winding of a dry-type transformer, according to an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Figure 1 shows schematically a dry-type transformer according to an embodiment of the present invention. More particularly, it shows schematically the arrangement of the windings of a transformer, according to a partial section taken along a plane that contains the axis of the windings.

Dry type transformers according to embodiments of the present invention may be of the type wherein the transformer is designed to operate with a certain rated current flowing through the high voltage (HV) winding. Therefore, substantially the same current flows through all the conductors forming the winding, even if the winding may comprise several conductors in series with different physical features.

The transformer may comprise an HV winding 100 and a low voltage (LV) winding 200 inductively coupled with the HV winding, each winding comprising a conductor, and both windings being displayed in the figure in a usual arrangement wherein the LV winding is mounted coaxially inside the HV winding; the HV winding 100 may comprise a tapping zone 110, two non-tapping zones 120, and a tap-changer (not shown) which allows changing the turn ratio of the windings, in order to change the transforming relation of the dry type transformer. The tap-changer may comprise two connectors (not shown) which are connectable at different points of the conductor along the tapping zone 110 of the HV winding 100, so as to exclude a plurality of turns of the HV winding, thus enabling a change in the turn ratio of the transformer.

It has to be noted that the conductor forming the HV winding may be formed by, for example, a plurality of conducting parts connected to each other by welding or using a connecting part, such as, for example, a non-conducting part engaging both conducting parts together to allow a suitable current flow through them.

By way of example, in figure 1, according to this specific embodiment, the HV winding 100 may be formed by two sub-winding structures 101, 102, connected to each other at an intermediate point 111 of the tapping zone 110. However, other embodiments may comprise a HV winding in a single structure, or more than two sub-winding structures, depending on the physical structure of the windings used to configure the transformer.

Figure 2 shows schematically a portion of the HV winding of a transformer, according to a section taken along a plane that contains the axis (A) of the windings.

According to figure 2, the conductor forming the HV winding 100 may be shaped as a strip 300 having a width w, which may be arranged forming a plurality of spiral-shaped “disks” 10, the strip-shaped conductor having within each disk a uniform width in the axial direction of the winding. Furthermore, the disks may be interconnected with each other, and the spiral in each disk may have an inner strip end 301 and an outer strip end 302. Each spiral-shaped disk 10 may be connected with the adjacent ones by means of a suitable electric coupling 303 connecting the outer strip end 302 of each disk to the inner strip end 301 of the following disk in such a way that the disks are connected in series forming the winding 100. Figure 2 shows four of such disks 10 connected to each other.

Furthermore, as seen in figure 1, at least a portion 112 of the disks 10a in the tapping zone 110 may be configured in such a way that they comprise a strip-shaped conductor having a smaller width w_a, in the axial direction of the winding (direction x), than the width w_b of the strip-shaped conductor of the disks 10b of the non-tapping zone 120. The portion of the disks 10a having a conductor with such a width w_a is shown with reference 112 in figure 1, and the portion of the disks 10b having a conductor with such a width w_b are shown with reference 114 in figure 1.

In this way the axial length of the tapping zone is reduced, thus reducing the gap of unused turns when the tap-changer works at a low range, i.e. the position in which the winding has a lower number of turns. This reduction allows to reduce the losses related to the eddy currents caused by the radial magnetic flux in those non-tapping zones 120 of the windings adjacent to the tapping zone 110.

According to an embodiment, the disks 10a of the tapping zone 110 may have a conductor with a width w_a in the axial direction of the HV winding 100 which may be between 40% and 80% of the width w_b of the disks of the non-tapping zone 120, and may preferably be approximately 60% of the width of the disks of the non-tapping zone 120.

Also, according to an embodiment, the conductors of the disks 10a, 10c of the tapping zone 110 are made of a material with a higher conductivity than the materials used on the disks 10b, 10d of the non-tapping zones 120.

This improves the efficency of the transformer when it is working with a high range in the tap changer, i.e. the position in which the winding has a higher number of turns: in this position, ohmic losses appear in the disks 10a, 10c of the tapping zone 110, and this losses may be relevant in disks having a relatively small width, since ohmic losses will depend proportionally on the size of the conductor. Such losses can be reduced by using disks 10a, 10c with higher conductivity in the tapping zone 110.

According to some embodiments, the disks 10a, 10c of the tapping zone 110 may be made of copper, and the disks 10b, 10d of the non-tapping zones 120 may be made of Aluminum.

Using smaller disks in the tapping zone leads to a reduction of the losses when the tap changer works at a lower range, and making these disks of copper reduces the losses due to said reduction of the size of the disks, when the tap changer works at a higher range.

Furthermore, the conductor of a portion of the disks 10c at the ends of the tapping zone 110 adjacent to the non-tapping zones 120 may have a width w_c higher than w_a. This relatively higher width allows to reduce the DC or ohmic losses in the disks 10c, in order to compensate the overall losses, which also comprise eddy losses, in the disks 10c, when the transformer is working at a high range in the tap changer. The portion of the disks 10c having a conductor with such a width w_c is shown with reference 113 in figure 1 (in the example, only one disk 10c in each winding structure is shown).

Also, according to an embodiment, the conductor of a portion of the disks 10d at the ends of the non-tapping zones 120 remote from the tapping zone 110, may also have a width w_d bigger than w_b. In this way, a reduction of DC or ohmic losses is achieved in said disks 10d, in order to compensate the eddy losses caused by the radial magnetic flux in the ends of the non-tapping zones remote from the tapping zone. The portion of the disks 10d having such a width w_d is shown with reference 115 in figure 1 (in the example, only one disk 10d in each winding structure is shown).

It will be noted that each of the above features regarding the width and material of the conductor may be implemented in a dry-type transformer independently from each other, since each provides an effect that is not dependent on the others, although the combined effects may be advantageous.

According to experimental results, in a HV coil of a 25MVA 66kV transformer with a tapping range of +-18%, a reduction of approximately 40% of the losses caused by eddy currents has been achived when the transformer is working at the lower position of the tap changer, and the relation of the widths are: w_a being 60% of w_b, w_c being the same as w_b, and w_d being 120% of w_b. Most of said reduction is found in the disks of the non-tapping zone (120) adjacent to the tapping zone (110), where a reduction of the hot spot temperature has been achieved from 210ºC to 116º.

Although only a number of particular embodiments and examples of the invention have been disclosed herein, it will be understood by those skilled in the art that other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof are possible. Furthermore, the present invention covers all possible combinations of the particular embodiments described. Reference signs related to drawings and placed in parentheses in a claim, are solely for attempting to increase the intelligibility of the claim, and shall not be construed as limiting the scope of the claim. Thus, the scope of the present invention should not be limited by particular embodiments, but should be determined only by a fair reading of the claims that follow.

CLAIMS

1. Dry-type transformer comprising a winding (101) with a tapping zone (110), the tapping zone (110) being the zone wherein at least two connections can be made, allowing to change the number of turns of the winding (100) and thus change the turn ratio of the transformer, and with at least a first non-tapping zone (120), wherein the winding (100) comprises a conductor having, in at least part of the tapping zone (110), a first width (w_a) in the axial direction (x) of the winding (100), and having, in at least part of the first non-tapping zone (120), a second width (w_b) in the axial direction (x) of the winding, the first width (w_a) being smaller than the second width (w_b).

2. Dry-type transformer according to claim 1, wherein the conductor of the winding (100) is made of at least two materials with different conductivity.

3. Dry-type transformer according to claim 2, wherein the conductor of the winding (100) in at least part of the tapping zone (110) is made of a first material and the conductor of at least part of the rest of the winding is made of a second material.

4. Dry-type transformer according to any of claims 2 or 3, wherein the two materials are Copper and Aluminum.

5. Dry-type transformer according to any of claims 3 or 4, wherein the conductor of the winding (100) in at least part of the tapping zone (110) is made of Copper, and the conductor of the winding (100) in at least part of the non-tapping zone (120) is made of Aluminum.

6. Dry-type transformer according to any of claims 1 to 5, wherein a length of the conductor in the tapping zone (110) adjacent to a non-tapping zone (120) has a third width (w_c), in the axial direction (x) of the winding, which is different with respect to the first width (w_a) of the conductor.

7. Dry-type transformer according to claim 6, wherein said third width (w_c) is higher than the first width (w_a) of the conductor.

8. Dry-type transformer according to any of claims 1 to 7, wherein the first width (w_a) is between 40% and 80% of the second width (w_b), preferably approximately 60% of the second width (w_b).

9. Dry-type transformer according to any of claims 6 to 8, wherein the third width (w_c) is approximately equal to the second width (w_b).

10. Dry-type transformer according to any of claims 1 to 9, wherein at least part of the conductor is shaped as a strip (300).

11. Dry-type transformer according to any of claims 1 to 10, wherein the conductor is arranged forming a plurality of spiral-shaped disks (10), the strip-shaped conductor (300) having within each disk (10) a uniform width in the axial direction (x) of the winding.

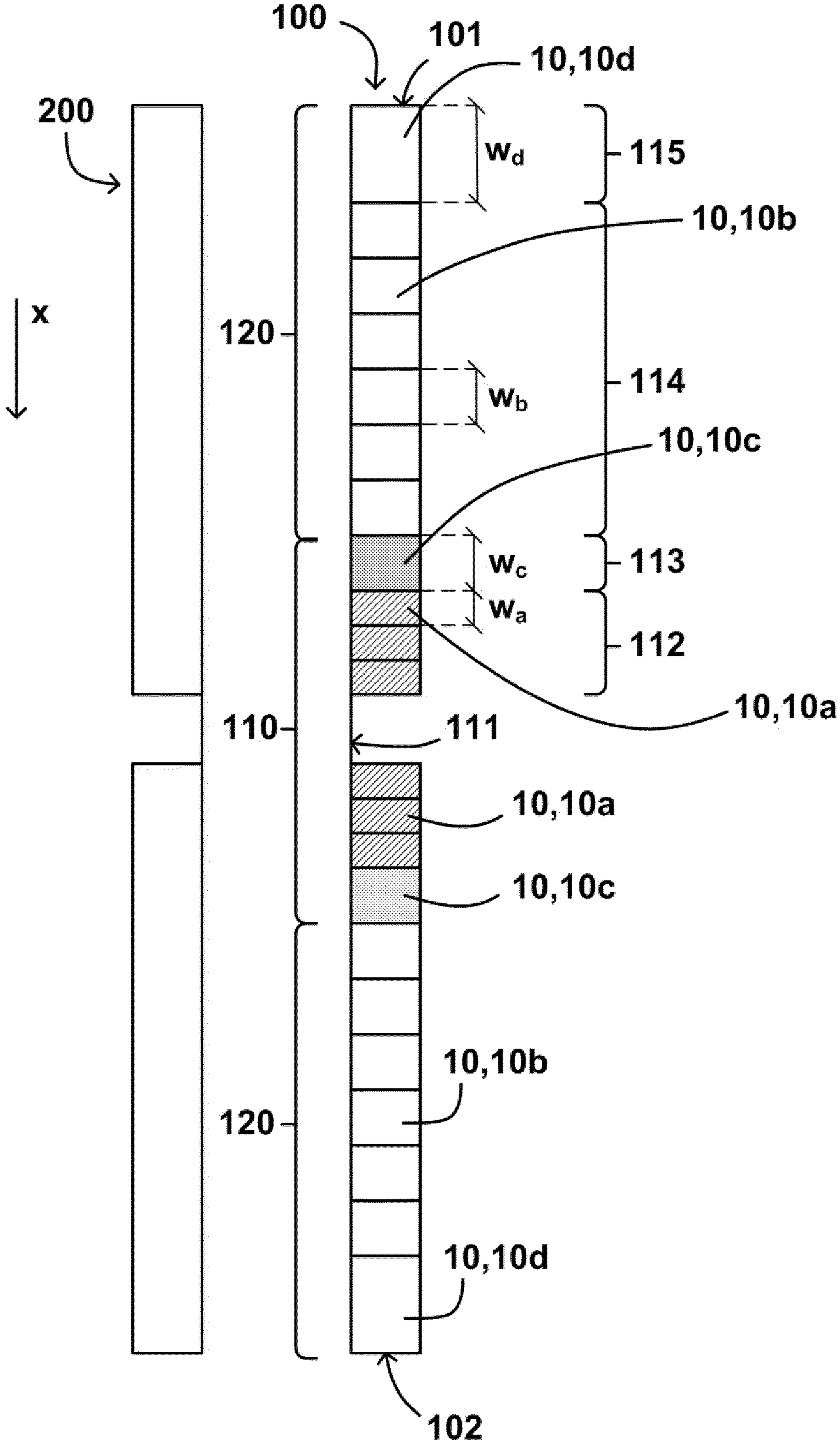
12. Dry-type transformer according to claim 11, wherein the strip-shaped conductor (300) is made of the same material within each disk (10).

13. Dry-type transformer according to any of claims 1 to 12, wherein a length of the conductor at the end of a non-tapping zone (120) remote from the tapping zone (110) has a fourth width (w_d) in the axial direction (x) of the winding, which is different with respect to the second width (w_b) of the conductor.

14. Dry-type transformer according to any of claims 1 to 12, wherein the fourth width (w_d) is higher than the second width (w_b) of the conductor.

15. Dry-type transformer according to any of claims 1 to 13, wherein the winding (100) is the high voltage winding of the transformer.

FIG.1


100
101
10,10d
200
w_d
115
10,10b
x
120
114
w_b
10,10c
w_c
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w_a
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110
111
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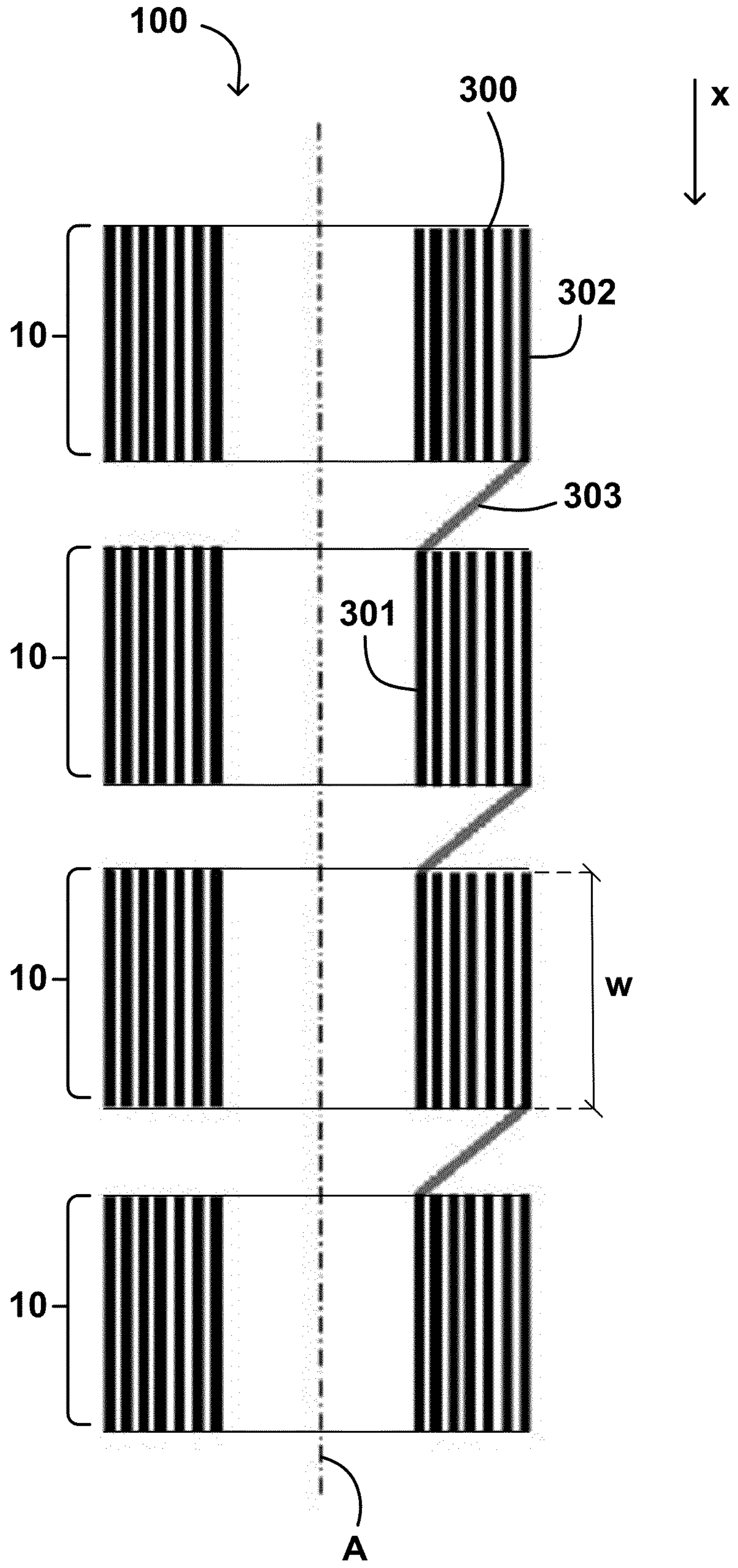
10,10c
10,10b
120
10,10d
102

FIG.2



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/066568

A. CLASSIFICATION OF SUBJECT MATTER
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ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 4 864 266 A (FEATHER LANDIS E [US] ET AL) 5 September 1989 (1989-09-05) abstract column 1, line 22 - column 2, line 19 column 2, line 66 - column 4, line 50 figures 2,3,5,6 -----	1,10-12, 15 6-9,13, 14 2-5
Y	DE 26 09 548 A1 (NAT IND AS) 16 December 1976 (1976-12-16) page 2, last paragraph - page 3, paragraph 2 page 4, last paragraph - page 5, paragraph 1 figures 2-4,8 ----- -/--	6-9,13, 14

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 December 2012	13/12/2012
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Kardinal, Ingrid

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 32 14 171 A1 (ASEA AB [SE]) 18 November 1982 (1982-11-18) abstract page 4, line 30 - page 5, line 12 page 8, line 23 - page 10, line 7 figures 1-6 -----	8

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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