



(12)

EUROPEAN PATENT APPLICATION

- (43)

Date of publication:
05.06.2024 Bulletin 2024/23
- (21)

Application number: 22210860.7
- (22)

Date of filing: 01.12.2022
- (51)

International Patent Classification (IPC):
H01F 27/00 (2006.01) H01F 27/02 (2006.01)
H01F 27/06 (2006.01) H01F 30/10 (2006.01)
- (52)

Cooperative Patent Classification (CPC):
H01F 27/002; H01F 27/02; H01F 27/06;
H01F 30/10

- (84)

Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(71)

Applicant: Hitachi Energy Ltd
8050 Zürich (CH)
- (72)

Inventors:
 - WEDIN, Erik Carl
656 38 Karlstad (SE)
 - ASTRAND, Peter
743 82 Bälinge (SE)
 - VIKSTEN, Mattias
824 56 Hudiksvall (SE)
 - LYSELL, Erik
771 35 Ludvika (SE)

(74)

Representative: Valea AB
Box 7086
103 87 Stockholm (SE)

- (54)

METHOD AND TRANSFORMER ARRANGEMENT FOR HANDLING TRANSPORTATION AND ASSEMBLING OF A SINGLE PHASE TRANSFORMER
- (57)

A method for handling transportation and assembling of a single phase transformer. The single phase transformer is divided into two or more active parts (14). The two or more active parts (14) are transported to a site in at least two separate tanks (10). The single phase transformer is than assembled by connecting the tanks (10) together electrically at the site, wherein the tanks (10) are connected electrically by one or more leads.

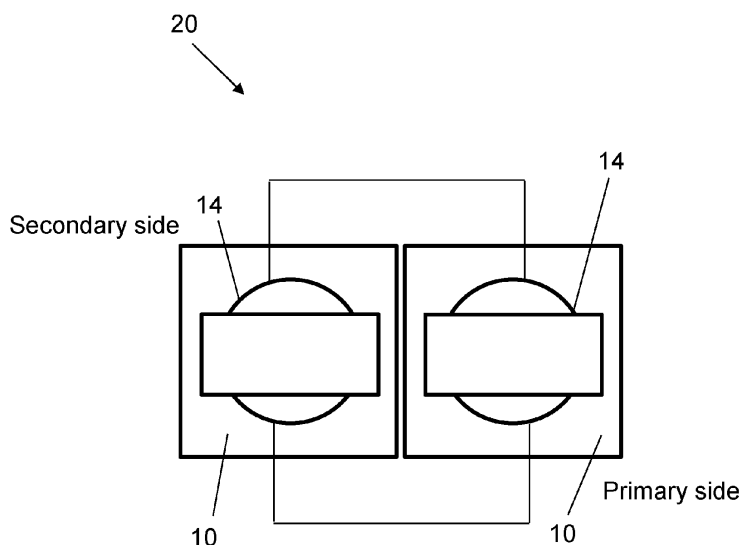


Fig. 1

Description

FIELD OF THE INVENTION

[0001] Embodiments herein relate to the field of transformers. In particular, the embodiments herein relate to handling transportation and assembling of a single phase transformer.

BACKGROUND

[0002] A power transformer is equipment used in an electric grid of a power system. Power transformers transform voltage and current in order to transport and distribute electric energy. Power transformers are in some cases very large and may not be possible to transport to some locations. Because of this, it is useful if the size of the largest transportable part of the transformer is reduced.

[0003] One way of solving this problem is that the transformer is disassembled at a factory and transported to a site in pieces. The transformer is then assembled at the site. This has the disadvantage that it needs, e.g. requires, facilities and resources on site to carry out the assembly. It is also challenging to ensure the quality as it is difficult to perform high voltage testing on site. High voltage testing after assembly on site is normally not carried out with this technology.

[0004] Another way of solving the problem is to use parallel units. The power rating required is divided in several smaller units and each unit is shipped to the site. One disadvantage of this is that each transformer requires its own installation on site, including e.g. foundation, fire walls, and electrical connections, including bushings on the transformers. This will drive both cost and footprint for transformers and for the site.

[0005] Yet another approach to solve the problem for three-phase transformers is by using a special three phase arrangement. A three phase unit is divided into three single phase active parts, each transported to site in a separate tank. The three tanks are located together on the same foundation at site and are normally connected together with leads in oil ducts. The disadvantage of this solution is that it does not sufficiently reduce the transport size of the single phase tank, which may be too large to transport. Also, if spare units are required, the full three phase transformer, i.e., three single phase tanks, are normally needed for the spare units.

[0006] The present disclosure presents an improved viable solution of a method and transformer arrangement.

SUMMARY

[0007] It is an object of embodiments herein to enhance transportation and assembling of a single phase transformer.

[0008] According to an aspect the above-mentioned

object is achieved by providing a method performed by a transformer arrangement for handling transportation and assembling of a single phase transformer. The single phase transformer is divided into two or more active parts.

The two or more active parts are transported to a site in at least two separate tanks. The single phase transformer is then assembled by connecting the tanks together electrically at the site, wherein the tanks are connected electrically by one or more leads.

[0009] According to some embodiments, the tanks may be located on a same foundation at the site.

[0010] According to some embodiments, at least two of the tanks may not be separated by fire walls.

[0011] According to some embodiments, at least two of the tanks may have different electrical properties.

[0012] According to some embodiments, at least one of the tanks may comprise a regulating winding to regulate a voltage and at least one of the tanks does not comprise a regulating winding.

[0013] According to some embodiments, at least two of the tanks may be connected in series.

[0014] According to some embodiments, at least two of the tanks may be connected in parallel.

[0015] According to some embodiments, the tanks may be connected on a primary side of the single phase transformer and/or on secondary sides of the single phase transformer.

[0016] According to some embodiments, the tanks may share a same common cooling equipment.

[0017] According to some embodiments, at least two of the tanks may be mechanically connected. According to some embodiments, the mechanical connection may be performed in such a way that allows the at least two tanks to be transported in connected state at the site.

[0018] According to some embodiments, at least one of the tanks may comprise a tertiary winding and at least one of the tanks may not comprise a tertiary winding.

[0019] According to another aspect the object is also achieved by providing a transformer arrangement. The transformer arrangement comprises a single phase transformer and two or more tanks. The transformer arrangement is configured to divide the single phase transformer into two or more active parts and transport the two or more active parts to a site in at least two separate tanks. The transformer arrangement is further configured to assemble the single phase transformer by connecting the tanks together electrically at the site, wherein the tanks are connected electrically by one or more leads.

[0020] According to yet another aspect the object is also achieved by providing a single phase transformer. The single phase transformer is configured to be divided into two or more active parts, wherein the two or more active parts are transported to a site in at least two separate tanks. The single phase transformer is further configured to be assembled by connecting the tanks together at the site, and wherein the tanks are connected electrically by one or more leads.

[0021] Embodiments herein are based on the realisa-

tion that by dividing the single phase transformer into at least two active parts which are transported to the site in at least two separate tanks, the transportation size of the single phase transformer is significantly reduced. Furthermore, as the single phase transformer then can be assembled by connecting the tanks together electrically at the site the assembly is handled in a more efficient manner. Thereby the transportation and assembling of a single phase transformer is enhanced.

BRIEF DESCRIPTION OF THE FIGURES

[0022] Further technical features of the invention will become apparent through the following description of one or several exemplary embodiments given with reference to the appended figures, where:

- Fig. 1 is a schematic overview depicting a transformer arrangement, according to embodiments herein;
- Fig. 2 is a flowchart depicting a method according to embodiments herein;
- Fig. 3 is a schematic overview depicting a transformer arrangement, according to some embodiments herein; and
- Fig. 4 is a schematic overview according to some embodiments.

[0023] It should be noted that the drawings have not necessarily been drawn to scale and that the dimensions of certain elements may have been exaggerated for the sake of clarity.

DETAILED DESCRIPTION

[0024] A transformer arrangement 20 according to embodiments herein is illustrated in **Fig. 1**. The transformer arrangement 20 is configured to divide, e.g. separate, a single phase transformer into two or more active parts 14. The active part 14 of the single phase transformer when used herein is the core, the windings, and the electrical insulation between the windings of the single phase transformer. The two active parts 14 may be placed in at least two separate tanks 10, e.g. transformer tanks. The at least two separate tanks 10 are connected electrically by one or more leads and may be mechanically attached together. The two or more active parts 14 are then transported to a site in the at least two separate tanks 10. When at the site, the single phase transformer is assembled by connecting the tanks 10 together electrically. If a voltage regulating system is used in the transformer arrangement it may be possible to enable it by using a common On-Load Tap Changer (OLTC) or a common OLTC drive unit. This means that at least some tanks 10, may be reduced in size and that the number of components can be reduced. According to some embodiments, a fully assembled spare single phase unit comprising the at least two separate tanks 10 with the active parts 14,

installed at the site, may be provided at the site as a backup. Access to a fully assembled spare unit reduces the replacement time in case of a failure in one of the single phase transformers that are in operation.

[0025] The method actions for handling transportation and assembling of a single phase transformer, according to embodiments herein, will now be described with reference to a flowchart depicted in Fig. 2. The actions do not have to be taken in the order stated below but may be taken in any suitable order.

Action 201.

[0026] To significantly reduce the transportation size of the single phase transformer, the single phase transformer is first divided into two or more active parts 14. Thereby, certain transportation modes may be enabled. Accordingly, transportation of the single phase transformer can be significantly simplified, leading to reduced costs. Furthermore, in some cases, transport of a full size single phase unit may not be possible at all and measure to reduce the size is necessary.

Action 202.

[0027] The two or more active parts 14 are then transported to a site in at least two separate tanks 10. The at least two tanks 10 with the active parts 14 may be seen as a unit such as a transportation unit and may be referred to as a single phase unit. The tanks 10 may be transported by one or more vehicles, such as lorries.

[0028] According to some embodiments, at least two of the tanks 10 may have different electrical properties. This is advantageous/useful because it may, under certain conditions, allow for a decrease in size of the largest transportable part or it may, under certain conditions, allow for a decrease in total number of active parts and tanks. In some conditions, it may also reduce the cost of the single phase transformers as the active parts 14 can be more specialised. Furthermore, the reliability of the single phase units may be improved because fewer components, for example regulating windings, tertiary windings and/or tap changers, may be required with less overall risk for failures as a consequence.

[0029] At least two of the tanks 10 may be mechanically connected. The mechanical connection may be performed in such a way that allows the at least two tanks 10 to be transported in connected state at the site, i.e. inside the site. Thus, the at least two of the tanks 10 may not be connected during transport to the site, but they may be moved connected within the site. This is a great advantage if needing to replace a unit in operation with a fully assembled spare unit in short time. This is a great advantage if needing to replace a unit in operation with a spare unit. The spare unit can in such case be fully assembled prior to the replacement procedure which will reduce the time to put the spare unit into operation.

[0030] According to some embodiments, at least one

of the tanks 10 may comprise a regulating winding to regulate a voltage and at least one of the tanks 10 does not comprise a regulating winding. This is advantageous/useful because it may, under certain conditions, allow for a decrease in size of the largest transportable part or it may, under certain conditions, allow for a decrease in total number of active parts and tanks. Furthermore, the reliability of the single phase units may be improved because fewer components, such as tap changers and regulating windings, are required. According to some embodiments, the at least one of the tanks 10 that comprises the regulating winding may not be connected to a primary side or secondary side of the transformer.

[0031] According to some embodiments, the at least one of the tanks 10 that comprises the regulating winding may be connected to one of the primary side and the secondary side, but not connected to both. According to some embodiments, the at least one of the tanks 10 that comprises the regulating winding may be connected to both the primary side and the secondary side.

[0032] According to some embodiments, at least two of the tanks 10 may be connected in series. This is advantageous because it may, under certain conditions, allow for a decrease in size of the largest transportable part or it may, under certain conditions, allow for a decrease in total number of active parts and tanks. Furthermore, the reliability of the single phase units may be improved, and cost may be reduced because some parts may be exposed to a lower voltage level.

[0033] According to some embodiments, at least two of the tanks 10 may be connected in parallel. This is advantageous because it allows for less complex design as each part can be made with the same or similar design. Furthermore, in some implementations the reliability can be increased as some of the parallel parts may be operated even with failures on other parallel parts. The at least two of the tanks 10 may be connected both in parallel and in series.

[0034] According to some embodiments, the tanks 10 may be connected on a primary side, of the transformer. This is advantageous because it allows for a single connection towards the external primary voltage system, which may reduce overall size and cost of the transformer arrangement 20, including size of transformer tanks 10, transformer foundation and transformer booth. Furthermore it may improve the reliability of the single phase transformer because fewer components, for example bushings, may be required.

[0035] According to some embodiments, the tanks 10 may be connected on secondary sides of the transformer. This is advantageous because it allows for a single connection towards the external secondary voltage system, which may reduce overall size and cost of the transformer arrangement 20, including size of transformer tanks 10 and transformer booth. Furthermore it may improve the reliability of the transformer because fewer components, for example bushings, may be required.

[0036] According to some embodiments, the tanks 10

may be connected on the primary side and the secondary sides of the transformer. This is advantageous because it allows for a single connection towards the external primary and secondary voltage system, which may reduce overall size and cost of the transformer arrangement, including size of transformer tanks 10 and transformer booth. Furthermore it may improve the reliability of the transformer because few components, for example bushings, is required.

[0037] Thus, the tanks 10 may be connected on the primary side of the single phase transformer and/or on secondary sides of the single phase transformer.

[0038] According to some embodiments, at least two of the tanks 10 may comprise a separate cooling equipment and/or at least two of the tanks 10 may comprise a common cooling equipment. According to some embodiments, the tanks 10 may share a same common cooling equipment. This is advantageous because the overall size, cost and complexity of the transformer arrangement, including cooling control and size of the transformer booth may be reduced.

[0039] According to some embodiments, at least one of the tanks 10 may comprise a tertiary winding and at least one of the tanks 10 may not comprise a tertiary winding.

[0040] According to some embodiments, the tanks 10 may be aligned in a row and a three phase bank may be constructed by aligning the single phase side by side such that the rows are parallel to each other.

[0041] According to some embodiments, the tanks 10 are aligned side by side with the long side of the tanks facing each other.

[0042] According to some embodiments, at least one of the tanks 10 may comprise a tertiary winding and at least one of the tanks 10 may not comprise the tertiary winding.

Action 203.

[0043] The single phase transformer is then assembled by connecting the tanks 10 together electrically at the site, wherein the tanks 10 are connected electrically by one or more leads, e.g. in oil or fluid.

[0044] According to some embodiments, the tanks 10 may be located, e.g. connected together electrically, on a same foundation at the site. This is advantageous because it reduces the required footprint and cost of civil construction at site. At least two of the tanks 10 may not be separated by fire walls

[0045] By adopting the embodiments herein as described above, the size and weight of the single phase transformer to be transported, e.g. each transport unit, can be significantly reduced.

[0046] Embodiments herein such as mentioned above will now be further described and exemplified. The text below is applicable to and may be combined with any suitable embodiment described above.

[0047] A transformer arrangement 20 according to

some embodiments is illustrated in **Fig. 3**. At least two tanks 10 may be mechanically attached together, are connected electrically in oil by one or more leads, e.g. in oil or fluid ducts, and are transported to the site. At least one of the tanks 10 may comprise a regulating winding to regulate a voltage and at least one of the tanks 10 may not comprise a regulating winding. The at least one of the tanks 10 may comprise the regulating winding to regulate the voltage is marked with an X in Fig. 3. Accordingly, at least one tank 10 may contain regulation. At least one of the tanks 10 may comprise a tertiary winding to supply power to a separate voltage system and at least one of the tanks 10 may not comprise a tertiary winding. Providing tertiary windings in less than all tanks may reduce the cost because less total number of tertiary windings are required, which may also improve the reliability of the single phase transformer. Fig. 3 shows four tanks 10 connected in parallel, wherein three of the tanks 10 may be connected in parallel as main single phase transformer, and wherein all four tanks 10 may be referred to as a single phase unit.

[0048] A transformer arrangement 20 according to some embodiments is illustrated in **Fig. 4**. The figure shows an example with three series connected units, e.g. three series connected tanks 10 comprising the active parts 14 of the single phase transformer. However, it does not necessarily have to be three unit in series, it may be any number from two and above. The three tanks 10 may be connected mechanically and have electrical connection in oil. In some implementations, for example a Y connected transformer, the series connected units have advancingly lower voltage. According to one implementation, the tap changer is located in the unit with the lowest voltage.

[0049] It is to be noted that any feature of any of the aspects may be applied to any other aspect, wherever appropriate. Likewise, any advantage of any of the aspects may apply to any of the other aspects.

[0050] 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.

[0051] It will be appreciated that the foregoing description and the accompanying drawings represent non-limiting examples of the method taught herein. As such, techniques taught herein are not limited by the foregoing description and accompanying drawings. Instead, the

embodiments herein are limited only by the following claims and their legal equivalents.

5 Claims

1. Method for handling transportation and assembling of a single phase transformer, wherein the method comprises:

dividing (201) the single phase transformer into two or more active parts (14);

transporting (202) the two or more active parts (14) to a site in at least two separate tanks (10); and

assembling (203) the single phase transformer by connecting the tanks (10) together electrically at the site, wherein the tanks (10) are connected electrically by one or more leads

2. The method according to claim 1, wherein the tanks (10) are located on a same foundation at the site.

3. The method according to claim 1 or 2, wherein at least two of the tanks (10) are not separated by fire walls.

4. The method according to any one of claims 1-3, wherein at least two of the tanks (10) have different electrical properties.

5. The method according to any one of claims 1-4, wherein at least one of the tanks (10) comprises a regulating winding to regulate a voltage and at least one of the tanks (10) does not comprise a regulating winding.

6. The method according to any one of claims 1-5, wherein at least two of the tanks (10) are connected in series.

7. The method according to any one of claims 1-5, wherein at least two of the tanks (10) are connected in parallel.

8. The method according to any one of claims 1-7, wherein the tanks (10) are connected on a primary side of the single phase transformer and/or on secondary sides of the single phase transformer.

9. The method according to any one of claims 1-8, wherein at least two of the tanks (10) comprise a separate cooling equipment and/or at least two of the tanks (10) comprise a common cooling equipment.

10. The method according to any one of claims 1-9, wherein at least two of the tanks (10) are mechani-

cally connected.

11. The method according to claim 10, wherein the mechanical connection is performed in such a way that allows the at least two tanks (10) to be transported in connected state at the site. 5

12. The method according to any one of claims 1-11, wherein at least one of the tanks (10) comprises a tertiary winding and at least one of the tanks (10) does not comprise a tertiary winding. 10

13. A transformer arrangement comprising a single phase transformer and two or more tanks (10), wherein the transformer arrangement is configured to: 15

divide the single phase transformer into two or more active parts (14);

transport the two or more active parts (14) to a site in at least two separate tanks (10); and 20

assemble the single phase transformer by connecting the tanks (10) together electrically at the site, wherein the tanks (10) are connected electrically by one or more leads. 25

14. The transformer arrangement according to claim 13, wherein the transformer arrangement is configured to perform the method according to any one of claims 2-12. 30

15. A single phase transformer, configured to be divided into two or more active parts (14), wherein the two or more active parts (14) are transported to a site in at least two separate tanks (10), and wherein the single phase transformer is assembled by connecting the tanks (10) together at the site, and wherein the tanks (10) are connected electrically by one or more leads. 35

40

45

50

55

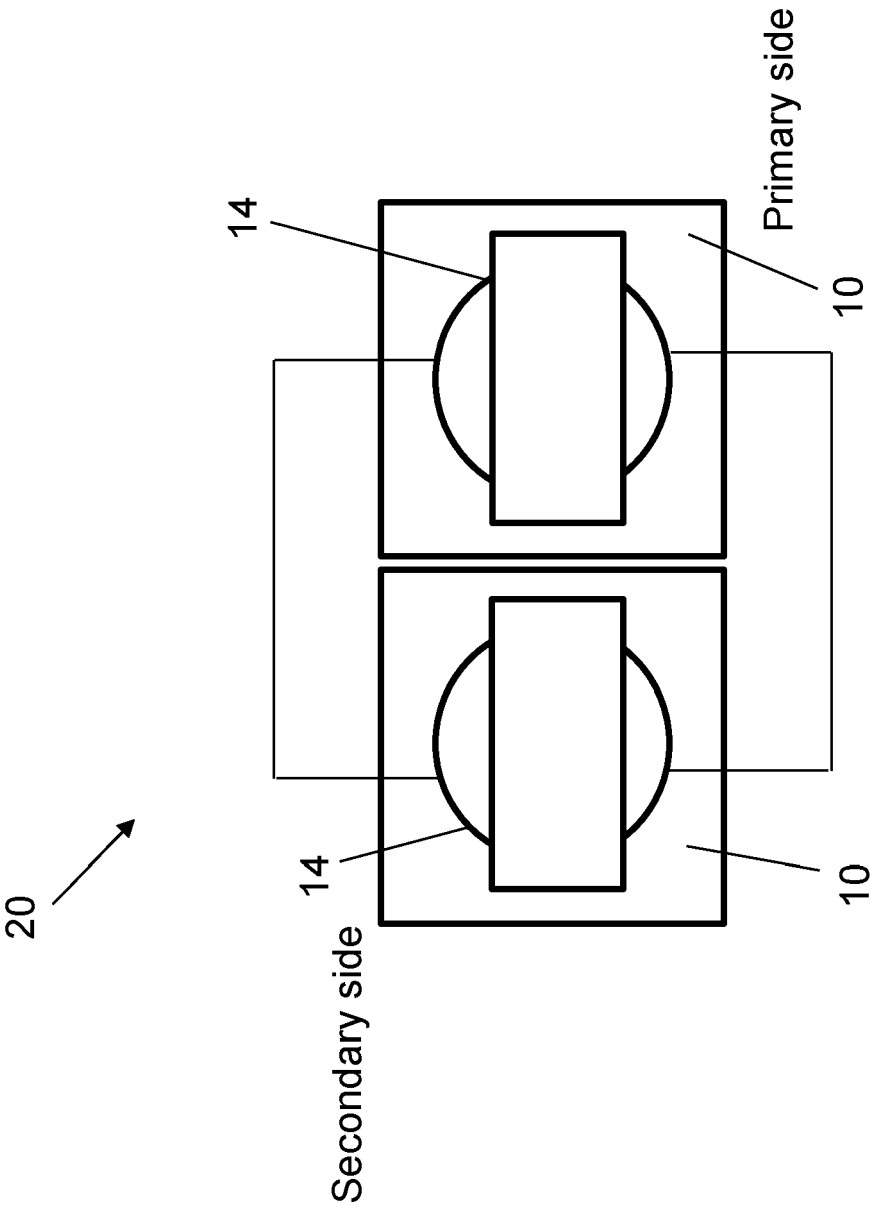


Fig. 1

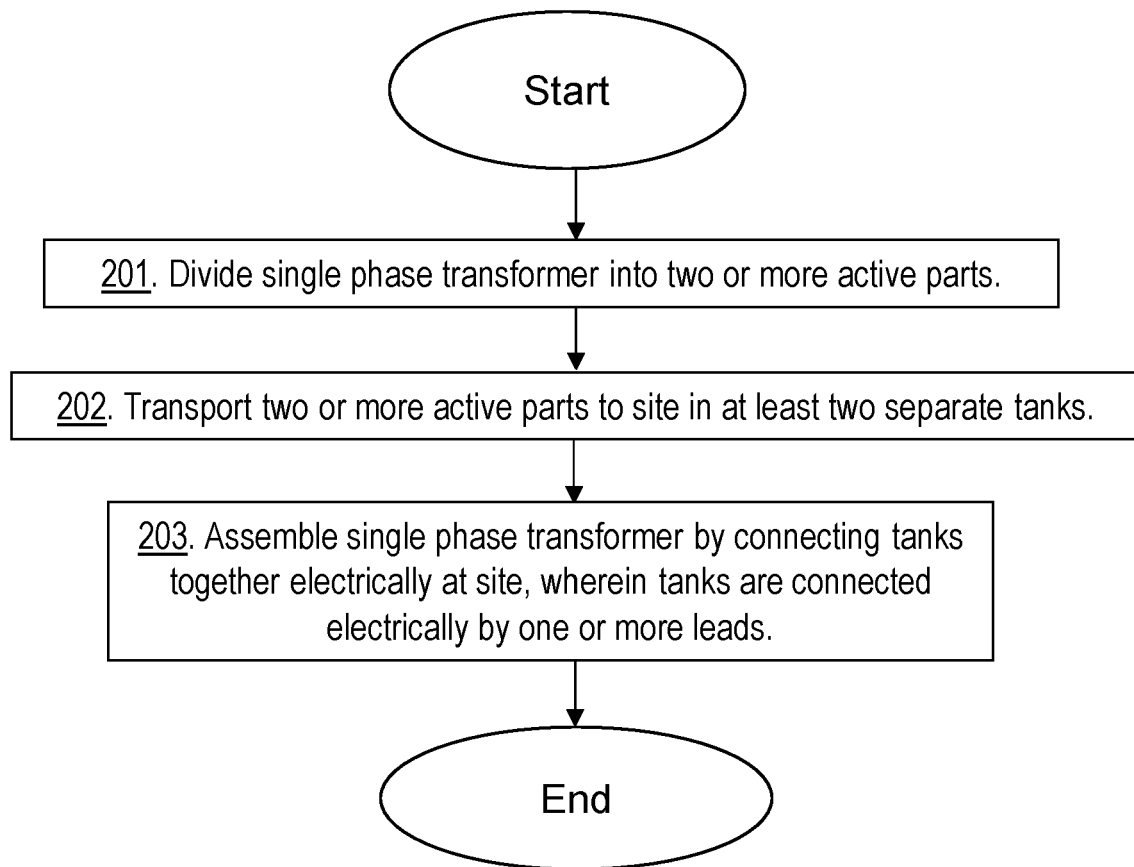


Fig. 2

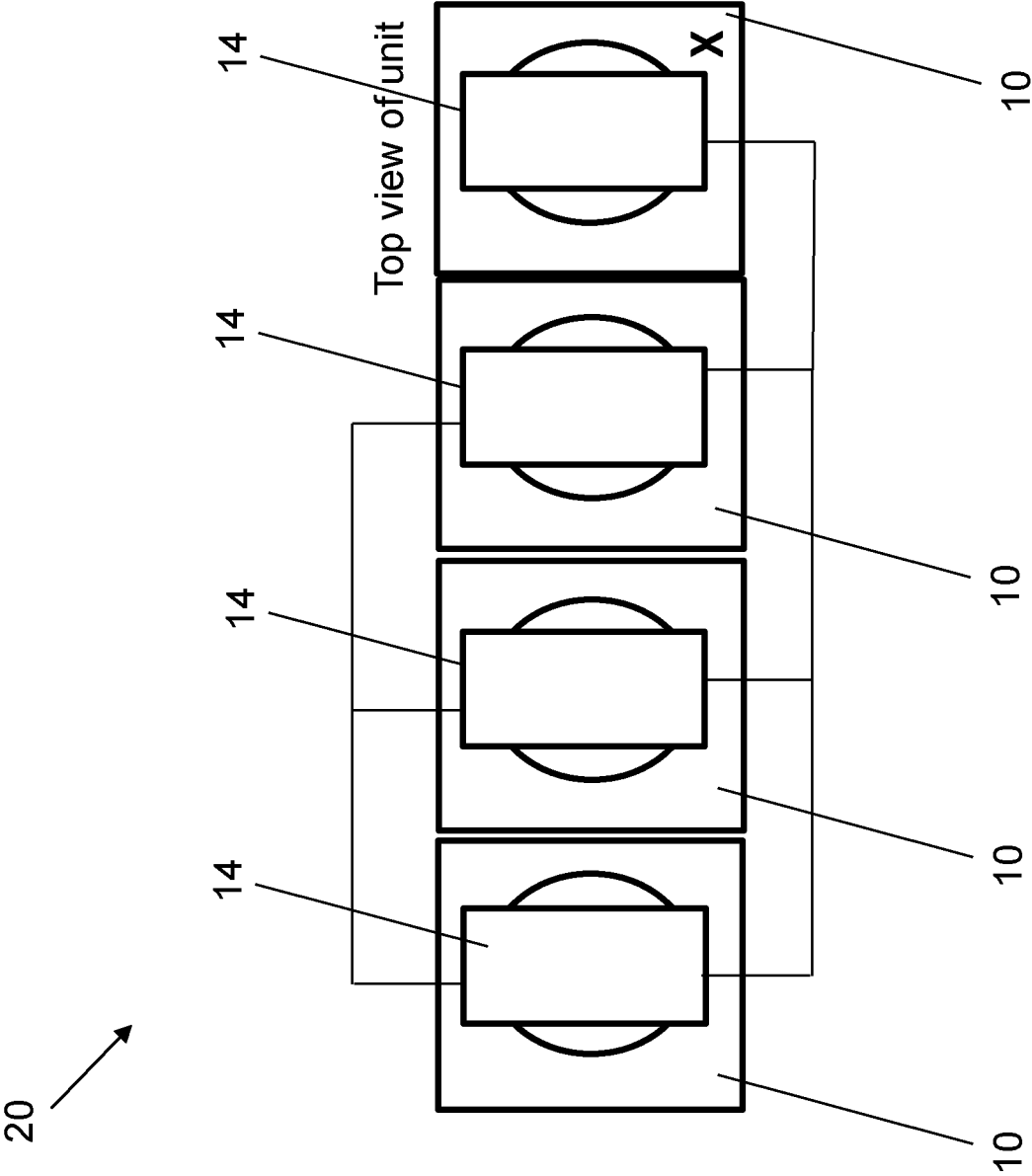


Fig. 3

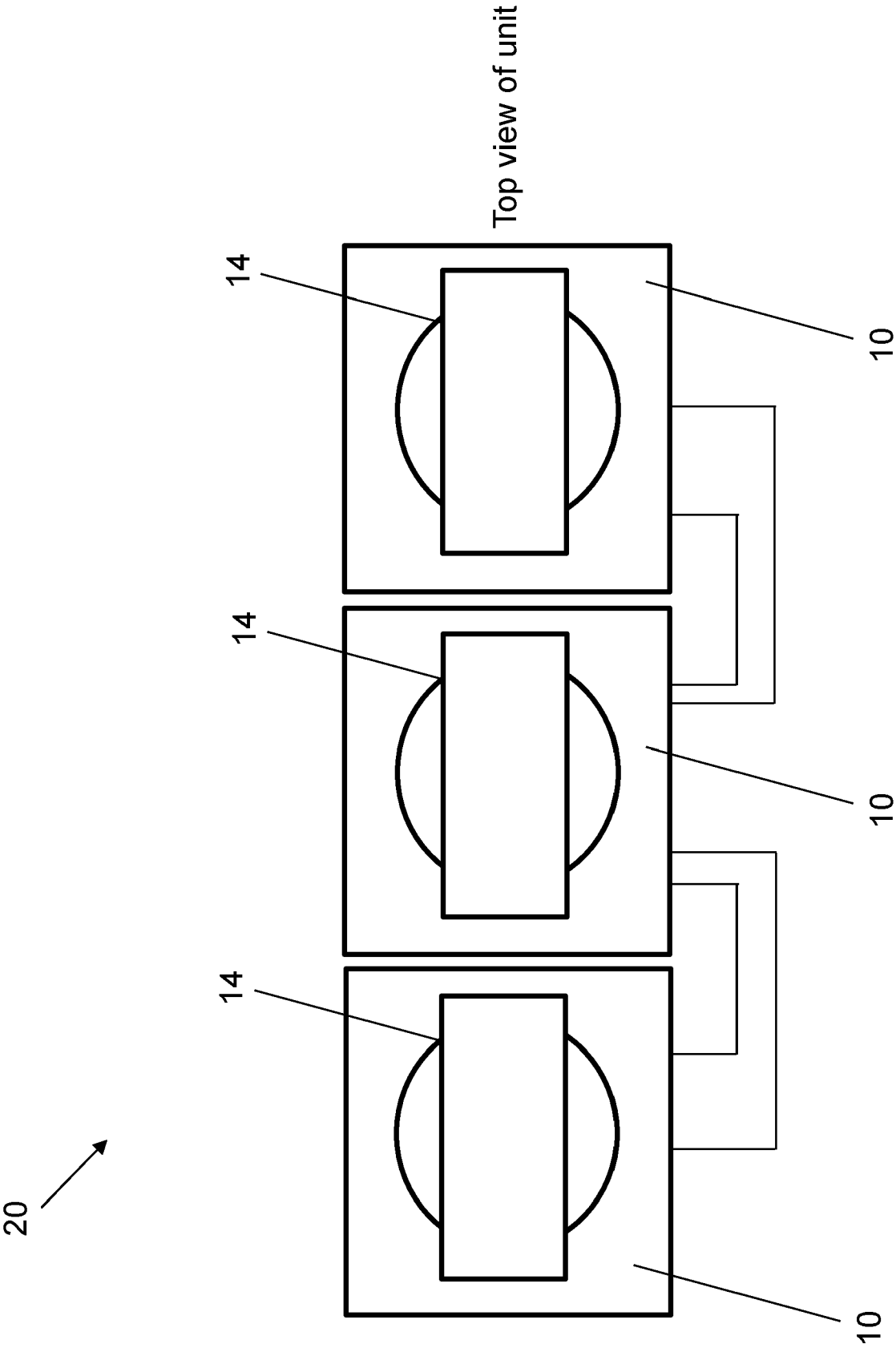


Fig. 4



EUROPEAN SEARCH REPORT

Application Number

EP 22 21 0860

5

10

15

20

25

30

35

40

45

50

55

2

EPO FORM 1503 03.82 (P04C01)

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	JP H06 101410 B2 (HITACHI LTD) 12 December 1994 (1994-12-12) * figures 1-4 * * corresponding description * -----	1-15	INV. H01F27/00 H01F27/02 H01F27/06 H01F30/10
X	JP H06 251951 A (TOSHIBA CORP) 9 September 1994 (1994-09-09) * figures 1-7 * * corresponding description * -----	1-15	
X	JP S59 210622 A (TOSHIBA KK) 29 November 1984 (1984-11-29) * figures 1-5 * * corresponding description * -----	1-15	
X	JP S57 133609 A (TOKYO SHIBAURA ELECTRIC CO) 18 August 1982 (1982-08-18) * figures 1-6 * * corresponding description * -----	1-15	
X	JP S58 124215 A (TOKYO SHIBAURA ELECTRIC CO) 23 July 1983 (1983-07-23) * figures 1-5 * * corresponding description * -----	1-5, 7-15	TECHNICAL FIELDS SEARCHED (IPC) H01F
X	JP S62 229909 A (TOSHIBA CORP) 8 October 1987 (1987-10-08) * figures 1-4 * * corresponding description * -----	1-5, 7-15	
X	JP H09 312216 A (TOSHIBA CORP) 2 December 1997 (1997-12-02) * figure 6 * * corresponding description * -----	1-15	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 11 May 2023	Examiner Weisser, Wolfgang
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	

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

EP 22 21 0860

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-05-2023

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H06101410 B2	12-12-1994	JP H06101410 B2	12-12-1994
		JP S56103407 A	18-08-1981

JP H06251951 A	09-09-1994	NONE	

JP S59210622 A	29-11-1984	NONE	

JP S57133609 A	18-08-1982	NONE	

JP S58124215 A	23-07-1983	JP H0544166 B2	05-07-1993
		JP S58124215 A	23-07-1983

JP S62229909 A	08-10-1987	NONE	

JP H09312216 A	02-12-1997	NONE	

15

20

25

30

35

40

45

50

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82