

Sept. 21, 1965

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3,208,019

TRANSFORMER WITH SEALED WINDING ENCLOSURE

Filed Nov. 27, 1962

5 Sheets-Sheet 1

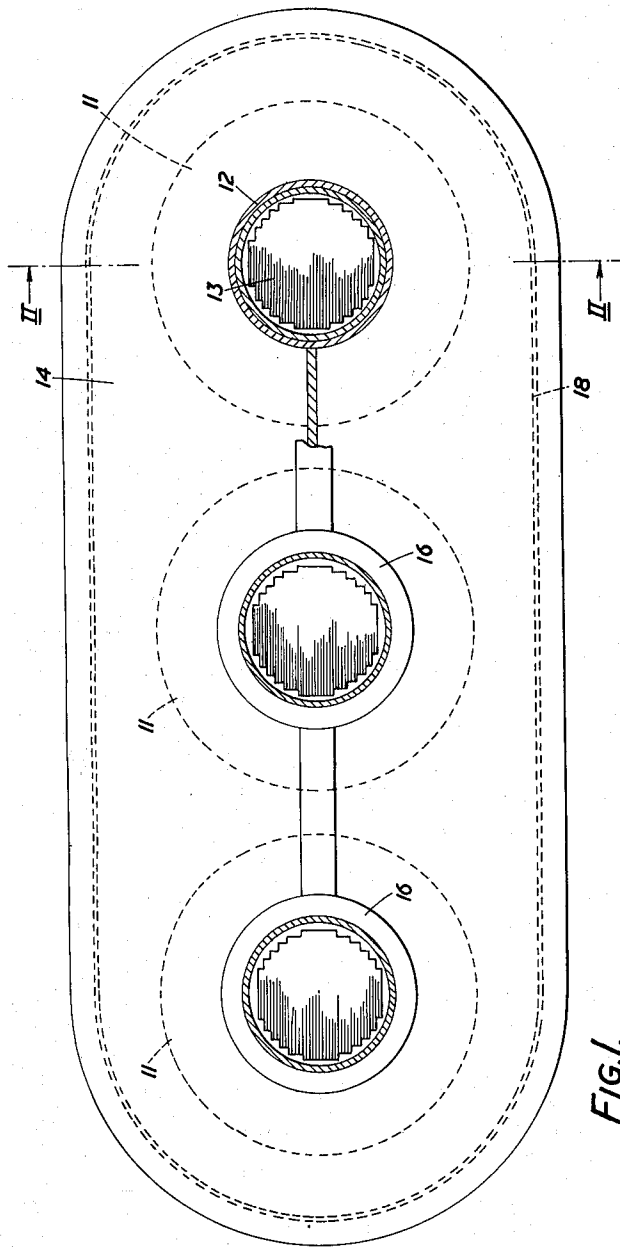


FIG. 1.

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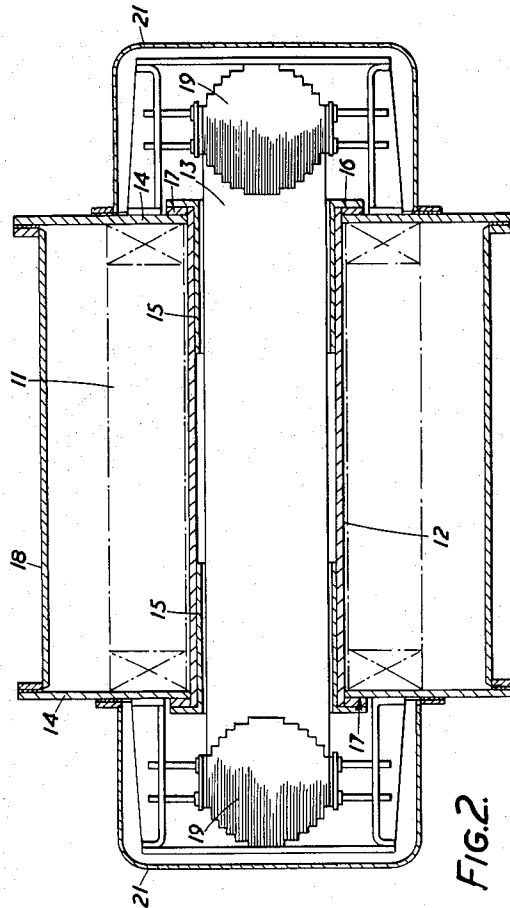


FIG. 2.

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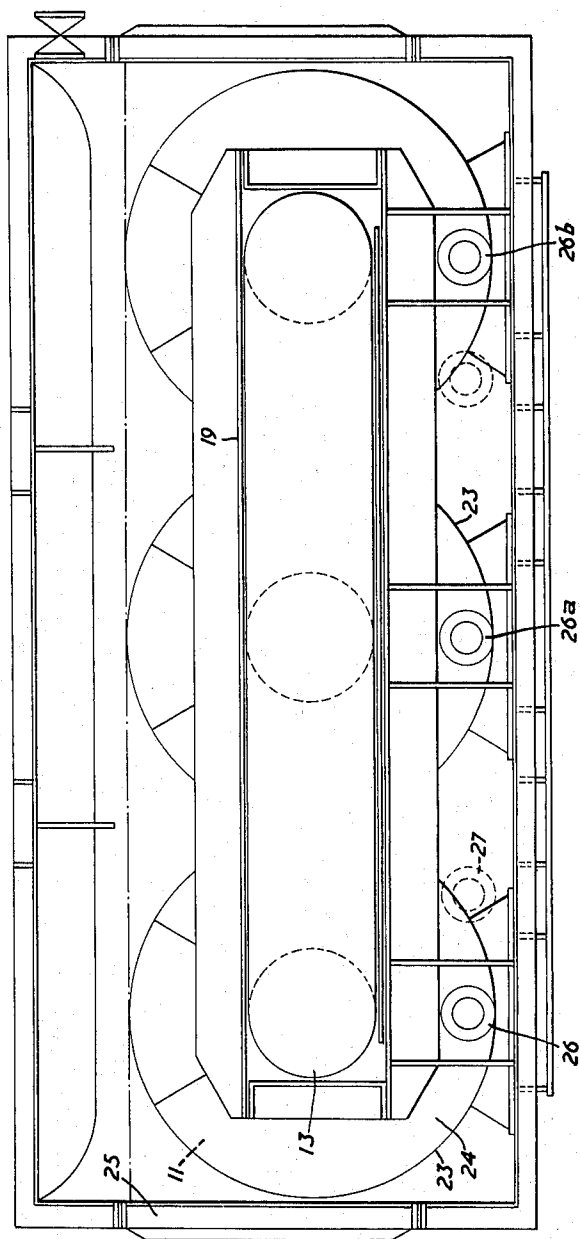


FIG. 3.

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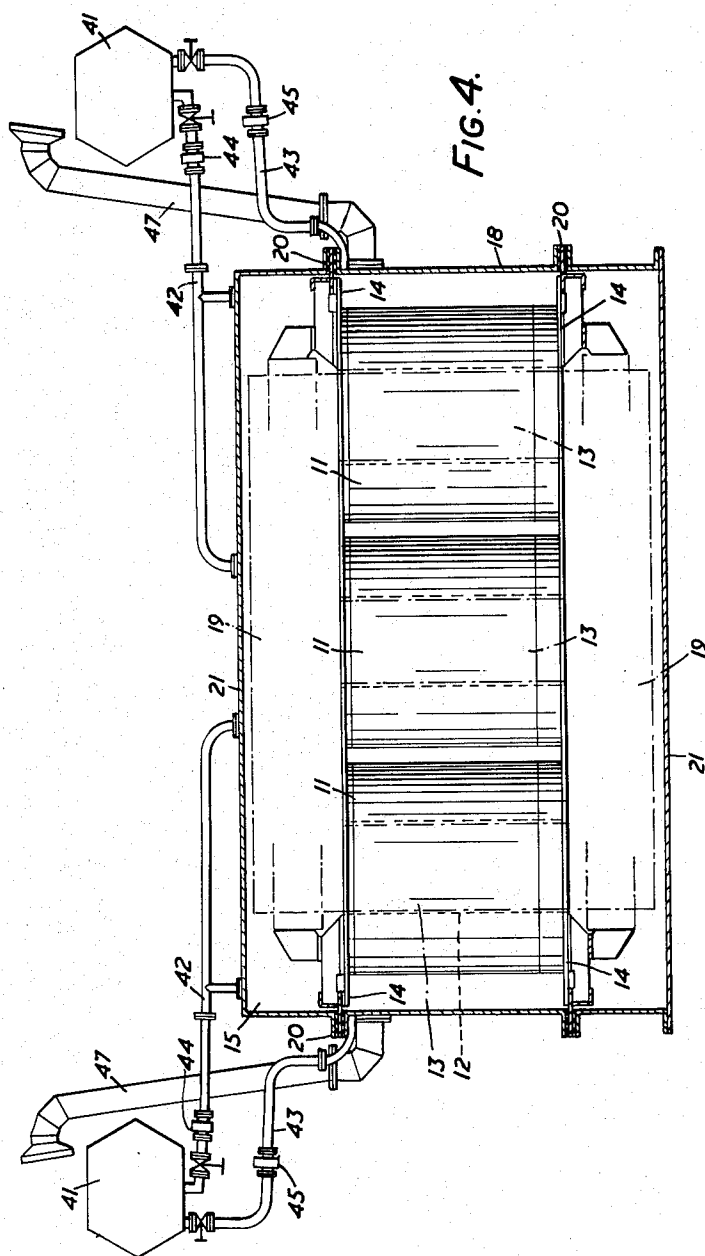


FIG. 4.

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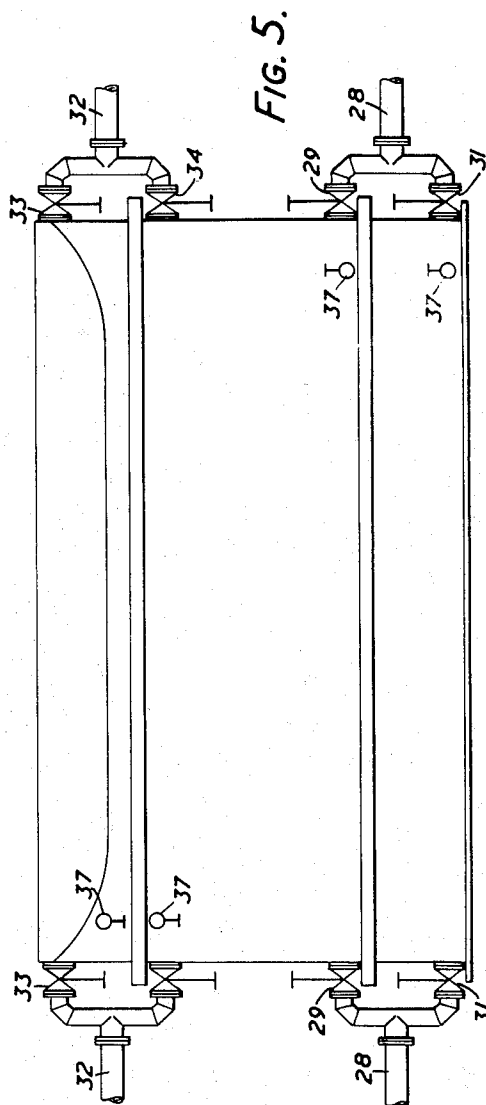
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5 Sheets-Sheet 5



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3,208,019
TRANSFORMER WITH SEALED WINDING
ENCLOSURE

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Claims priority, application Great Britain, Nov. 29, 1961, 42,746/61

7 Claims. (Cl. 336—58)

This invention relates to electrical reactors and transformers and one object is to provide a construction which facilitates the shipping of a larger transformer or reactor in individual components in separate cases and subsequent re-erection on site.

According to the present invention each winding is enclosed in an individual container but the core is not within the enclosure. In this specification the expression "enclosure" is used to mean the total space within the container, or all the containers if there are more than one.

Where, on a transformer, cylindrical high and low voltage windings are arranged concentrically, they may be included in a single container, but in any case a winding or winding assembly in the form of a cylindrical shell may be in axially separated parts each in a separate container. Of course, with a multiphase reactor or transformer, or other reactor or transformer having windings on two or more cores it may be convenient to enclose the windings on each core in different containers.

In general it is preferred that the containers can be sealed and that the core can be assembled and removed with the windings inside the container and without breaking the seal of the container.

Thus after manufacture a transformer can be tested with the windings in oil in the enclosure and can be shipped and re-assembled on site without disturbing the inside of the container. This means that it will not be necessary to remove the windings from the oil for shipping so that they will not become wet and will not have to be dried out again and tested again on site. It is expected that this will make a substantial reduction in the testing plant and erecting apparatus which is necessary on site.

Sometimes, at present, the re-erected transformer is not satisfactorily tested on site because of the absence of the test plant, and this is a serious drawback where the windings have been exposed to air after factory test.

If, in order to reduce the weight of the individual containers during shipping it is desired to remove the oil, it may be replaced by a suitable fluid such as dry air or inert gas. Degassed, dry transformer oil would be re-introduced on site.

Moreover, a transformer can be shipped in a large number of units, for if necessary each winding would be in a different container or in several parts each in a different container, while the limbs and yokes of the core could each be shipped as a separate unit, or even the laminations could be shipped in separate packages so that the whole core is assembled on site.

In a convenient form of container for the windings on one core limb there is an inner and a surrounding outer wall and the space within the inner wall is outside the enclosure and then the core can extend through this space within the inner wall.

The outer wall may surround a number of inner walls, one for each limb of a multi-limb core so that all windings are in a single container and the core limbs can be assembled and withdrawn without opening the container.

The invention includes a reactor or transformer winding or part of such a winding in a sealed container having a space for the core limb within the inner wall and outside the enclosure.

The core itself may be in a separate casing or separate casings while there may be instead or in addition a complete casing enclosing the core and the windings in their individual containers.

The core casing will conveniently have a liquid cooling system which is independent of the liquid cooling system for the winding containers and indeed different parts of a winding or the windings in different phases of a multi-phase winding, where they are in separate containers, may each have their individual liquid cooling system.

The idea of having individual windings in individual containers which are thermally separated leads to the suggestion that each phase of a multi-phase transformer may have its load test carried out independently in order to reduce the capacity of the test plant required in the factory, and according to another aspect of the invention in a method of testing a multi-phase reactor or transformer tests are carried out on the windings of each phase separately. Thus with a three-phase transformer the MVA which the test equipment must be capable of providing to pass full load current through one phase on short circuit may be one-third of that which would be necessary to pass this current through all windings on short circuit together and since the cost of test plant is roughly proportional to its capacity a substantial saving can be achieved and moreover larger transformers can be manufactured without having to install additional test plant.

Thus the invention makes it possible to build much larger transformers than have been built before because the same test plant can be used and because with the novel construction the transformers can be shipped in more separate parts, each of which can be as large as the maximum size it is practicable to ship.

Moreover, the invention enables a simple form of fault-detector to be used, which indicates whether a fault is in the winding or the core.

Thus, the winding or windings on the one hand and the core on the other hand are in separate enclosures for containing oil, which enclosures are sealed from each other and the transformer includes separate gas-operated devices for indicating the presence of gas pressure in the respective separate oil enclosures.

A fault in core or winding will be accompanied by a generation of gas which can cause the gas-operated devices to indicate that a fault has occurred. The source of the fault whether in core or winding can be determined by discovering which of the gas-operated devices has given the indication.

Conveniently there is a common oil conservator for both enclosures and then there may be two oil lines, one from each enclosure to the conservator and each line containing one of the gas-operated devices.

The invention may be carried into practice in various ways and one embodiment together with a modification will be briefly described by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a plan view partly in section of a three-phase power transformer embodying the invention, taken parallel with the core limb axes, with the yoke and a core cover removed.

FIGURE 2 is a section on the line II—II in FIGURE 1 rotated counterclockwise 90° with the yoke and core cover in position.

FIGURE 3 is an elevation of a modification in which the three phase windings are in three separate containers.

FIGURE 4 is a side elevation of a modification of the transformer of FIGURES 1 and 2 showing how the construction enables faults to be readily indicated, and

FIGURE 5 is an outline diagram corresponding to FIGURE 4 showing the oil circulation arrangements.

In the first embodiment (FIGURES 1 and 2) each wind-

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ing 11 of a three-phase power transformer is wound on an insulating cylinder 12 within which the core limb 13 can extend. The three windings of the three phases are arranged side by side as is conventional and steel closure plates 14 fit over the windings at top and bottom having for this purpose three holes 20 which closely fit around the insulating cylinders 12. A steel cylindrical sealing tube 15 with an outward annular flange 16 fits within each end of each of the insulating cylinders 12 to effect a seal with the closure plates 14 by means of flexible rings 17 between the outer surfaces of the closure plates and the co-operating surfaces of the annular flanges 16. An outer wall 18 of steel with flat sides and semi-cylindrical ends surrounds all three windings 11 and is sealed at its edges to the outer edges of the closure plates 14. This forms a sealed container enclosing all the windings 11 and their insulation. Suitable apertures are left for bushings, tap-changing gear and so on.

Steel has been referred to as the material for the components of the container in this example, but in some cases a glass fibre laminate or other material may be used.

The three core limbs 13 extend through the three insulating cylinders 12 and protrude at either end and are interleaved with the yokes 19.

A core cover 21 is placed over and sealed to each closure plate 14 of the winding container to provide a casing for the iron of the core at each end.

It will be seen that the windings and the core are in separate enclosures and in particular that one can remove both core covers 21, both yokes 19, and each of the three limbs 13, while the winding container 12, 14, 15, 18 remains intact and fully sealed. This means that once the windings 11 have been dried out and the container has been filled with oil and the windings tested they can be shipped in the container and reassembled on site without the windings again coming into contact with the atmosphere. High voltage tests do not therefore have to be carried out again on site.

Conveniently both the winding enclosure and the core enclosure will have their individual liquid cooling systems.

For shipping, the core limbs 13 would be removed from the winding container 12, 14, 15, 18 and packaged separately. The core can be broken down into three limbs and two yokes, or even into separate sets of limb and yoke laminations which can be built up again on site. In, for example, the case where the limbs are not broken down on site, these would be threaded into the winding container and the yoke interleaved in normal fashion. There will then be a fully interleaved core.

Where the winding container is too heavy for shipping the oil may be removed and replaced by dry air or inert gas and transformer oil can be re-introduced on site.

It will usually be necessary to insert a non-conducting fillet (not shown) in any metal member which surrounds an individual limb, to avoid the effect of a short-circuited turn.

In the modification shown in FIGURE 3 (where similar components have the same numerals as in FIGURES 1 and 2) the windings 11 on each core limb 13 are in separate cylindrical casings 23 each surrounding an insulating cylinder (not shown) on one of the limbs and each having its own closure plates 24 at either end. The three winding containers 23, 24 together with the core 13, 19 may be included in a single external casing 25. Once again the winding containers 23, 24 with their surroundings can be shipped as tested after removal from the core 13 but in this case the containers will each contain one winding phase, or looking at it another way a larger transformer can be shipped in discrete packages of the same size. The outside casing 25 if used, can be broken down into individual plates for shipping.

In this embodiment separate cooling systems 26, 26a, 26b, may be used for the winding containers on each limb and also 27 for the core casing inside the outer enclosure 25 and outside the winding containers 23.

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If it is desired to ship still larger transformers each winding on each core limb may be in a number of axially-spaced sections each of which can be in its own container.

As the size of a transformer increases the capacity of the test plant at the factory for supplying load current on test must also be increased, and since the cost goes up with the capacity it will be economical to test individual windings separately. This can be done if the individual phases are thermally separated with the individual cooling system referred to. In the case of a three-phase transformer the test plant capacity can be one-third of that which would be needed if all three windings were tested on load at once.

The arrangement also enables a fault to be readily detected, by using the cooling oil arrangement of FIGURES 4 and 5. Again the same reference numerals are used for similar parts.

The plates 14 divide the casing into a winding enclosure between the upper and lower plates 14, around the cylinders 12 and within the portion 18 of the transformer casing which is between upper and lower seals 20 with the core covers 21 and a core enclosure.

The core enclosure consists of upper and lower chambers within the upper and lower core covers 21 which are sealed to the plates 14 at 20, and of the interconnecting spaces within the cylinders 12. The core legs 13 are within the cylinders 12 and the yokes 19 are within the chambers provided by the covers 21.

As can be seen from FIGURE 5, oil is supplied separately to the winding and core enclosures from a delivery passage 28 through a pair of controllable delivery valves 29 and 31. Similarly, circulating oil is removed through a suction line 32 communicating by way of two suction valves 33 and 34 with the tops of the two enclosures. The enclosures also have filter and drain valves 37 at both their low and high points.

As can be seen from FIGURE 4, an oil conservator 41 is connected individually to the tops of the two enclosures through pipes 42 and 43, each including a gas-operated relay 44 or 45.

It is known that if a fault occurs, it is accompanied by the generation of gas in the cooling oil; such gas can be arranged to operate one of the gas-controlled relays. It is clear that since the core cooling oil is separated from the winding cooling oil, core faults can be distinguished from winding faults accordingly as it is the relay 44 or the relay 45 which indicates the presence of gas pressure.

A similar conservator and gas-operated relay arrangement is provided at each end of the transformer tank in case the foundations of the transformer are not level.

Finally it may be remarked that pressure relief vents 47 (FIGURE 4) are provided at each end of the tank to relieve pressures due to possible internal explosions. Since such explosions will only occur in the winding enclosure the relief vents are connected near the top of that enclosure.

It is possible to remove the covers 21, disassemble and take out the core and leave the windings in the sealed winding enclosure, for example for shipping after test.

A similar fault detector can be used with the embodiment of FIGURE 3.

What we claim as our invention and desire to secure by Letters Patent is:

1. A transformer comprising a container having walls defining an enclosure, a winding within the container, the container being adapted to receive a cooling fluid to immerse the winding and to be hermetically sealed about the winding and the received fluid, said walls including an inner wall which surrounds a space for a core leg and an outer wall defining an external surface of the complete transformer for direct cooling of said fluid by heat conduction through said outer wall from the fluid to the surroundings, and a core assembled with the container and the winding, said core including a leg extending through said core space and being adapted to be readily disassembled from and reassembled with the container and the winding

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while the container remains in hermetically sealed condition.

2. A transformer as defined in claim 1 in which the insulating inner wall has opposite end openings, cover means disposed across and sealing said end openings and defining core chambers continuous with the core space, the core including portions projecting through said end openings and into the core chambers, the cover means being adapted to receive a cooling fluid in hermetically sealed condition within the core space and core chambers to immerse the core, and the cover means being exposed to the atmosphere for direct cooling of the fluid in the core space and core chambers by heat conduction through said cover means.

3. A transformer as claimed in claim 1 including means for restricting the circulation of the cooling fluid for the winding to be confined in the enclosure of the container.

4. A transformer as claimed in claim 2 including means for restricting the circulation of the cooling fluid for the winding to be confined in the enclosure of the container.

5. A transformer according to claim 1 further including

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a separate enclosure for said core, said core enclosure and said winding container being sealed from each other and further including separate gas pressure indicating devices coupled to said enclosure and said container.

6. A transformer as claimed in claim 1 in which the core has more than one leg, each carrying a winding, and different containers for the windings on the different core legs.

7. A transformer as claimed in claim 1, in which the core has more than one leg, each surrounded by an inner wall, and the outer wall surrounds all the inner walls.

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