WINDINGS FOR TRANSFORMERS OR CHOKE COILS

FIG. 1

FIG. 2

FIG. 3

EGBERTUS A. FROWEIN

INVENTOR

BY

ATTORNEYS
Transformer or choke coil winding wrapped in a torus-shaped envelope made from material which is adapted to be subjected to a tensile load in planes containing the axis of the winding, in which a pneumatically or hydraulically expandable bag is provided between one or each of both end faces of the winding and said envelope to exert axial pressure on the winding.

The invention relates to a winding for a leg portion of the magnetic core of a transformer or a choke coil, said winding being wrapped in a torus-shaped envelope. It has the object to provide a winding which can be easily mounted and easily put under axial pressure to take up the forces occurring at a short-circuit and which is adapted to be separately transported and mounted on a leg portion of the magnetic core of a transformer or a choke coil on the spot of assembly thereof. This makes it possible to transport transformers and choke coils in parts, so that the design has to make less allowance for the railway profile and transformers and choke coils of very much larger power and for higher voltages can be manufactured more easily.

According to the invention the object aimed at is obtained in that the said envelope consists of or contains material which is adapted to be subjected to a tensile load at least in planes containing the axis of the winding, and at least one pneumatically or hydraulically expandable bag to exert axial pressure on the winding is provided between at least one end face of the winding and the corresponding end face of the envelope. The envelope may consist of parallel wires, e.g. glass fibre wires, which are mostly used in bundles (rovings). Such an envelope can take up great tensile stresses, so that, when the bag is pneumatically or hydraulically put under pressure, the axial pressure required to keep, under all circumstances, the turns of the winding pressed against each other can be exerted on the winding. If moreover, the envelope is made impenetrable for moisture, for instance by means of synthetic material, the winding can be transported separately, that means without being mounted in the transformer tank.

Advantageously, the envelope may be formed as a torus-shaped body constituted by parallel glass fibre wires wound around the winding and pre-stressed by said bag and a coating of synthetic material provided on the outer surface of said body. In that case the torus-shaped body of glass fibre wires itself hardly contains synthetic material. It is avoided thereby that synthetic material is subjected to compressive stress between the stretched wires which would result in the occurrence of creeping phenomena in the synthetic material.

If at least one pressure ring is provided between at least one end face of the winding and the corresponding end face of the envelope, a construction may be used, in which the wall of the bag is locally formed as a curling diaphragm and the bag embraces said pressure ring with its wall part formed as a curling diaphragm. This construction has the advantage that in order to exert the required pressure on the winding, said pressure depending on the elongation of the envelope, the relevant end face of the envelope can be moved over a relatively great distance, so that a great elongation of the envelope can be taken up. Another advantage is, that the material of the bag need not be stretched at the enlargement of the volume thereof, so that it is less subjected to overload.

Consequently, the bag need not be made from highly resilient material, which means that in the wall thereof a reinforcement of fibre material increasing the strength of the bag considerably can be used.

The invention shape of the bag required for the curling diaphragm holds the bag well in place. This makes it possible to replace the single annular bag by a number of smaller bags. Then the enveloped winding is preferably constructed in such a manner, that two or more angularly spaced indented bell-shaped bags are provided between two pressure rings, each one of said bags lying in a cavity of one of both pressure rings and embracing an axially projecting portion of the other pressure ring with its wall part formed as a curling diaphragm. Such indented bell-shaped bags are much easier to manufacture than annular bags. The use of a number of smaller bags has the additional advantage, that the electrical connections of the winding can extend to the outside at the end face of the winding between two bags, so that they need not extend through a bag.

To manufacture an enveloped winding of the described constructions it is advantageous to take the following steps. First at least one pneumatically or hydraulically expandable bag is placed against one of the pressure rings covering the end faces of the winding. Thereupon bundles of parallel glass fibre wires are wound around said winding, the pressure rings and said bag. Thereafter the bag is pneumatically or hydraulically expanded and put under such a pressure as to subject the glass fibre wires to the desired tensile stress and the winding to the required axial compressive stress. Finally the pre-stressed torus-shaped body of glass fibre wires is coated with a gas- and liquid-tight layer of synthetic material. This coating of synthetic material hardly penetrates into the voids between the glass fibre wires, since the latter are firmly forced against each other by the pre-tensioning thereof. The coating of synthetic material itself is not stressed, so that therein creeping phenomena are entirely avoided.

The envelope constructed in accordance with the invention is relatively very light, which facilitates the transport of the winding. Moreover, it has the advantage that it is adapted to keep the winding under axial compression during the transport from the factory to the spot where the transformer or the choke coil is to be assembled, without the necessity to use a heavy frame with rods adapted to be subjected to tensile stress.

The invention also relates to a transformer or a choke coil provided with one or more windings which are enveloped in the described manner.

The invention will be further elucidated with the aid of the drawing. Therein is:

FIG. 1 an axial cross sectional view of an enveloped torus-shaped winding, e.g. one of the windings for a leg portion of the magnetic core of a transformer.

FIG. 2 on a larger scale an axial cross sectional view of a portion of the winding shown in FIG. 1.

FIG. 3 an axial cross sectional view of a portion of two concentrical transformer windings which are enclosed by a common envelope.

FIG. 4 partly an elevational view, partly an axial cross sectional view of the upper end of an other embodiment of the invention,
FIG. 5 an axial cross sectional view of a portion of a variant of the enveloped winding shown in FIG. 4 and FIG. 6 a plan view of the portion shown in FIG. 5 of said variant.

In FIG. 4 and 5 one of the windings of a transformer is designated by 1. A pressure ring 2 having a half-round cross sectional area is positioned against the lower end face of said winding and a flat pressure ring 3 is placed against the upper end face thereof. Mounted on the pressure ring 3 is a hydraulically expandable annular bag 4. A cap made of paper layers embraces the bag 4 and the pressure ring 3 and the assembly consisting of the winding 1, the pressure rings 2, 3, the bag 4 and the top 5 is wrapped in a torus-shaped envelope of parallel glass fibre wires 6 and a coating 7 of synthetic material. The bag 4 is connected through a conduit 8 provided with a manometer 9 to a liquid supply conduit 10 provided with a check valve 11 and an expansion chamber 12, a wall of the latter being formed by a curling diaphragm 13 loaded by a spring 14.

After the pressure rings 2, 3 the bag 4 and the cap 5 have been mounted at the ends of the winding 1 and this assembly, in parts to the tapered assembly. An other variant, comprises an axial compressive stress is then exerted on the winding 1. The force, by which the winding 1 is compressed, is defined by the spring 14. This force can be indicated directly by the manometer 9. If an adjustable spring 14 is used this force can be adapted to the requirements.

The envelope of glass fibre wires has been subjected to tension, in the described manner, it is covered by a coating of hardening synthetic material 7 which seals the envelope liquid-tight. In that case the glass fibre wires 6 are pre-stressed and the coating of synthetic material 7 is not stressed. Furthermore there is no synthetic material between said wires. Owing thereto it is avoided that the glass fibre wires exert pressure on the synthetic material and creeping phenomena occurring in the synthetic material. The space 15 inside the envelope 6, 7 is filled with transformer oil which is free of air and moisture.

It will be understood, that the torus-shaped envelope of the winding must have means for passing the ends of the winding through the envelope and for being adapted to said envelope in an air- and moisture-tight manner and that a closable opening for the supply of transformer oil to the space 15 must be provided.

The thus enveloped winding can be transported as such and positioned on a leg portion of the magnetic circuit of a transformer or a choke coil on the spot where said transformer or choke coil has to be assembled and used. The winding is protected, during the transport, against air and moisture. This makes it easy possible to transport transformers and choke coils, of which the dimensions are greater than that of transportable transformers and choke coils, has been wrapped in bundles or bands of parallel glass fibre wires (rovings), liquid under pressure is supplied through the conduits 10 and 8 to the bag 4 and the expansion chamber 12. Due thereto the bag expands and the envelope of glass fibre wires is subjected to tensile stress in planes containing the axis of the winding. The required axial compressive stress is then exerted on the winding 1. The force, by which the winding 1 is compressed, is defined by the spring 14. This force can be indicated directly by the manometer 9. If an adjustable spring 14 is used this force can be adapted to the requirements.

The thus enveloped wire may be separately wrapped in the manner according to the invention. However, it is also possible, as is shown in FIG. 3, to place a number of concentrical windings, e.g. the windings 16, 17, the winding envelope and the inside of this embodiment illustrated in FIG. 3 the windings 16, 17 are separated from one another by a tube 19 of insulating material and each winding is provided with individual pressure rings 20, 21 and an individual pneumatically or hydraulically expandable annular bag 22, 23. In the embodiment shown in FIG. 4, the pressure ring 25 is mounted on the upper end of the winding 24. The lower part 25a of said pressure ring 25 has a radial dimensions equal to those of the winding and the upper part 25b thereof has an outer diameter which is smaller and an inner diameter which is greater than that of the winding. An indented annular bag 26 embraces the upper part 25b of the pressure ring and is connected by a conduit 27 to a gas- or liquid-supply device (not shown). Mounted over the bag 26 and the pressure ring 25 is a cap 28 of paper layers and the winding is wrapped together with its pressure rings, the bag 26 and the cap 28 in a torus-shaped envelope of bundles or bands of parallel glass fibre wires 29 (rovings) adapted to be subjected to tensile stress and a coating 30 of synthetic material. The portion 26a of the wall of the bag 26 which embraces the part 25b of the pressure ring operates as a curling diaphragm.

After the winding 24 has been provided with its pressure rings, the bag 26 and the cap 28 have been brought into place and the assembly has been wrapped in bundles or bands of parallel glass fibre wires 29, gas of liquid under pressure is fed into the bag 26 through the conduit 27. Due thereto the bag expands and the glass fibre wires are subjected to tensile stress. During the expansion of the bag 26 the wall portion 26a thereof curls along the outer periphery and the inner periphery of the part 25b of the pressure ring. As the change of volume of the bag 26 only effects the curling of the wall part 26a thereof, the material of the wall of the bag will not be stretched. This means that the wall of the bag can be made of flexible material adapted to be subjected to tensile stress, e.g. of rubber or synthetic material which is reinforced by fibrous substances. After the tensioning of the glass fibre wires 29 the gas- and liquid-tight coating of synthetic material 30 is applied.

In the variant shown in FIGS. 5 and 6 the annular bag 26 shown in FIG. 4 is replaced by six bell-shaped indented bags 31 which are each filled with gas or liquid under pressure. The ends of the bags 31 and the said envelope is placed in cavities of a pressure ring 33 and they embrace with their portions 31a operating as curling diaphragms axially projecting disc-shaped parts 34 of a pressure ring 34, the base 34a of which rests on the end of the winding 24. The envelope of the winding, its pressure rings 33, 34 and the bags 31 consist again of bundles or bands of parallel glass fibre wires 29 and a coating 30. Mounted in the cavities of the pressure ring 33 are rings 35 adapted to be subjected to tensile stress. These rings prevent that the pressure ring 33, which is mostly made of wood, is pressed to pieces by the pressure of the bags 31. This embodiment has the advantage that the electrical connections of the winding can be led to the outside through the end faces of the enveloped winding in places between two bags. Due to the fact that the bags 31 embrace the parts 34 of the pressure ring 34 they are kept in place.

If a material is used for the envelope to be subjected to tensile stress which elongates more than glass fibres it may be necessary to provide at each end face of the winding a pneumatically or hydraulically expandable bag in order to take up said greater elongation of the envelope. Instead of one or more bags of elastic material one or more bellows of metal may be used. Such bellows may then also be used as potential controlling rings. It is finally observed that, when the transport of the transformer or the choke coil is possible in its own tank filled with oil,
the envelope of the winding adapted to be subjected to tensile stress need not be liquid-tight.

What I claim is:

1. A winding for a leg portion of the magnetic core of a transformer or a choke coil, an envelope enclosing said winding, said envelope consisting of or containing material which is adapted to be subjected to a tensile load at least in planes containing the axis of said winding, at least one pneumatically or hydraulically expandable bag provided between at least one end face of the winding and the corresponding end face of the envelope, said envelope comprising a torus-shaped body constituted by parallel glass fibre wires wound around said winding and prestressed by said bag, and a coating of synthetic material provided on the other surface of said body.

2. A winding for a leg portion of the magnetic core of a transformer or a choke coil, an envelope enclosing said winding, said envelope consisting of or containing material which is adapted to be subjected to a tensile load at least in planes containing the axis of said winding, at least one pneumatically or hydraulically expandable bag provided between at least one end face of the winding and the corresponding end face of the envelope, said envelope comprising a torus-shaped body constituted by parallel glass fibre wires wound around said winding and prestressed by said bag, and a coating of synthetic material provided on the other surface of said body.

7. A winding-assembly as claimed in claim 5, in which at least one end face of said winding is covered by a pressure ring and at least one bag partly embraces said pressure ring with its wall facing said ring and formed as a curling diaphragm.

8. A winding-assembly as claimed in claim 7, in which two pressure rings are provided within the envelope beyond one and the same end face of the winding, one of said pressure rings having a plurality of angularly spaced axially projecting cylindrical portions and the other pressure ring having a plurality of angularly spaced cylindrical cavities, and in which a plurality of bags is provided between said pressure rings, each one of said bags lying in such a cavity of one ring and embracing partly as a curling diaphragm such a projecting portion of the other ring.

9. In a transformer or like assembly adapted to be manufactured as separate units ultimately to be assembled at remote site, a self-contained winding assembly comprising:

an annular winding presently axially spaced opposite end faces, moisture impermeable, flexible toroidal envelope means completely surrounding said winding and presenting a space between one end face of said winding and said envelope means, and inflatable means within said space reacting only between said envelope means and said one end face of said winding for imparting and maintaining axial compression on said windings, said envelope means providing the sole reaction member between said winding and said inflatable means whereby axially to compress said winding through said envelope means.

10. In the assembly as defined in claim 9 wherein said envelope means includes tension-resistant filaments extending in planes containing the axis of said winding.

11. In the assembly as defined in claim 10 including a non-stressed coating of synthetic material on said filaments and forming an impermeable envelope therewith.

12. The method of manufacturing a winding assembly for transformers and the like devices, comprising the steps of:

placing inflatable, compression-producing means against one end face of an annular winding, winding tension-resistant means toroidally around said winding and said compression-producing means to provide a completely enclosing permeable envelope therefor, subjecting said compression-producing means to fluid pressure sufficient to react against said tension-resistant means and produce predetermined axial compression of said winding, and then coating said tension-resistant means while said envelope is under tension to render the envelope impermeable.

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