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DISTRIBUTION TRANSFORMER

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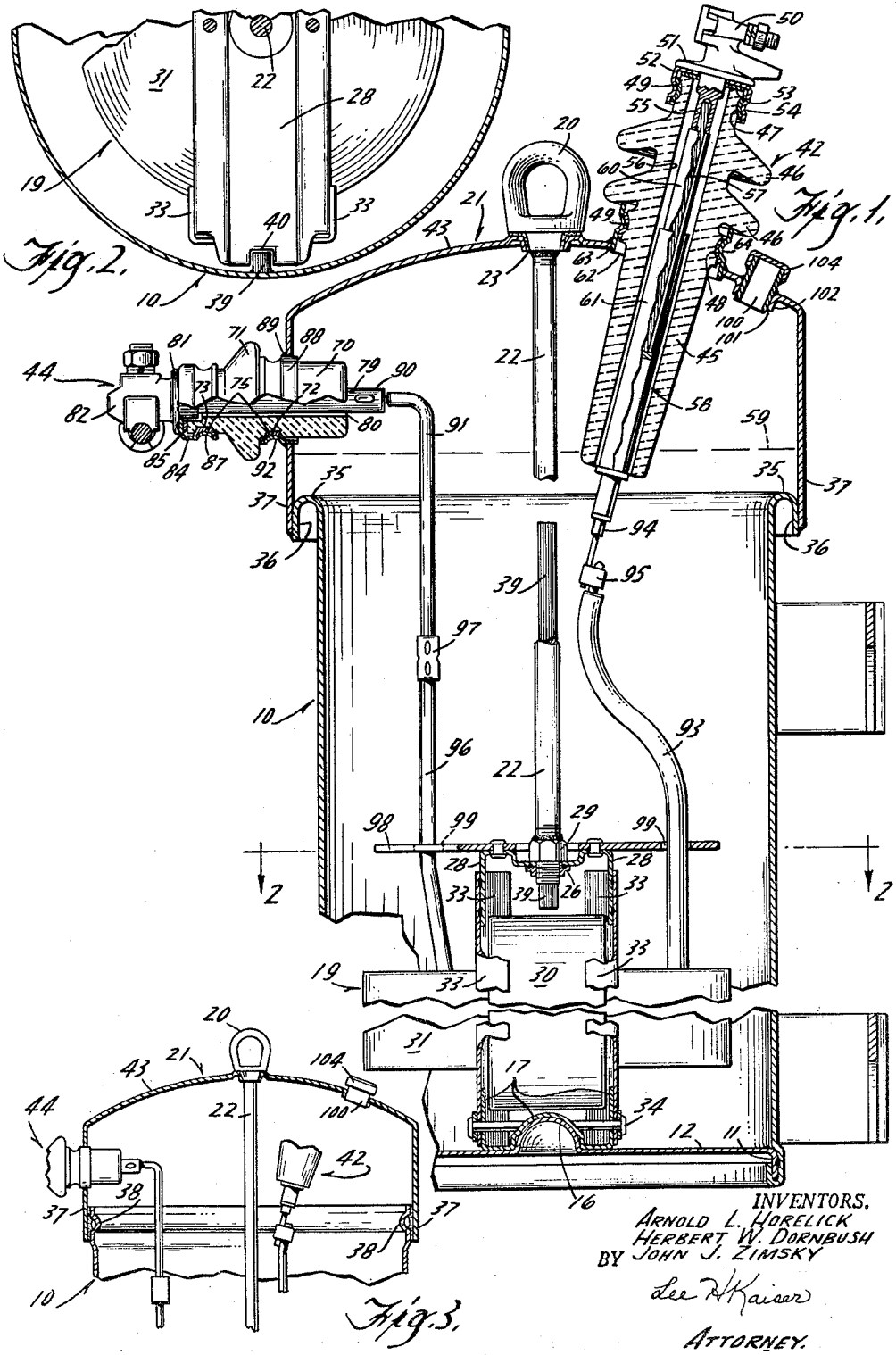


Fig. 2.

Fig. 1.

Fig. 3.

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DISTRIBUTION TRANSFORMER

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This invention relates to stationary induction apparatus and in particular to pole-mounted electrical distribution transformers.

Although a substantial percentage of distribution transformer failures result from "faults" on the power system external of the transformer casing such as direct lightning strokes, line faults, short circuits, overloads, surges, and transients, we have found that approximately eighty-five percent of distribution transformer failure is due to the entrance of moisture and air into the casing. Conventional means for bolting and clamping casing covers, handhole covers, and bushings can produce effective seals at the factory against leakage of air and moisture into the distribution transformer casing, but when the transformer casing is opened by the user there is no way of accurately determining if the transformer casing is again sealed against entrance of moisture and air. Moisture often enters after the customer removes a cover to make an adjustment and fails to properly gasket the cover or properly tighten the clamping bolts thereon. A half-turn of a nut or srew on a cover clamp can destroy an effective seal and allow restricted breathing. This permits moisture to be drawn into the distribution transformer tank where it becomes condensed and causes sludging of the transformer oil and deterioration of the dielectric strength of the windings and oil. Continued restricted breathing means a progressive increase in the amount of moisture in the transformer casing. This weakens the dielectric strength of the winding so that failure usually occurs when the transformer is subjected to the voltage permitted by lightning protective equipment.

It is an object of the invention to provide an improved electrical distribution transformer which eliminates breathing and has a considerably lower percentage of failures due to entrance of moisture and air into the casing than prior art construction.

It is a further object of the invention to provide an improved electrical distribution transformer which eliminates all seals made by resilient gaskets compressed by external, manually-actuated, releasable clamping means and thus obviates the danger of transformer failure due to entrance of air and moisture resulting from improper clamping pressure by the user.

Another object of the invention is to provide such an improved electrical distribution transformer wherein all external casing joints are positively sealed against entry of moisture, wherein all electrical connections internal of the casing are permanent, and wherein all bolts and nuts internal of the casing capable of becoming loose are eliminated.

It is a still further object of the invention to provide an electrical distribution transformer wherein both primary and secondary bushings are mounted on the casing cover and the core and coil assembly is integrally suspended from the cover, thus permitting electrical leads between the

coil and bushings to be permanent and eliminating internal bolts and nuts.

These and other objects and advantages of the invention will be more readily apparent from the following detailed description when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a vertical section view through a preferred embodiment of the invention;

FIG. 2 is a partial view taken along line 2—2 of FIG. 1; and

FIG. 3 is a partial vertical sectional view through an alternative embodiment having a solder seal between cover and transformer casing.

The words "integral" and "integrally" are used in the description and the appended claims to connote a unitary construction wherein components are permanently united and in contrast to a releasable juncture such as between screw-threaded parts.

Referring to the drawing, the tubular, steel, tank shell **10** of the improved distribution transformer of the invention is resistance welded at its lower end to a depending circumferential flange **11** on the tank bottom plate **12** before the lower edge of the shell **10** is curled over the flange **11** to provide an oil-tight seal. An upwardly extending central embossment **16** in the bottom plate **12** fits within a mating dimple in the channel cross-section, bottom core frame member **17** of the transformer core and coil assembly **19** to position the core and coil assembly **19** within tank **10**.

A center lifting eyenut **20** on the casing cover **21** permits lifting the entire transformer and the tanking of the complete core and coil assembly **19** as a unit. The core and coil assembly **19** is integrally suspended from the casing cover **21** by a lifting rod **22** which is threaded on both ends and extends through a conically outwardly flaring central opening **23** in cover **21**. Lifting eyenut **20** has a conical lower portion mating with opening **23** and is threaded onto the upper end of lifting rod **22** and integrally locked thereto by suitable means such as silver brazing. Eyenut **20** is also integrally secured to casing cover **21** by suitable means such as silver brazing. The threaded lower end of lifting rod **22** extends through an aperture in channel cross section upper core frame member **28** and engages a nut **26** disposed beneath and welded to upper core frame member **28**. A locknut **29** engaging the threaded lower end of bolt **22** above the upper core frame member **28** and locked thereto by suitable means such as solder assures that lifting rod **22** cannot become disengaged from the core and coil assembly **19**. The eyenut **20** permits lifting the complete transformer and also permits untanking the core and coil assembly **19** from the tank **10**. The full weight of the heaviest part of the transformer, i.e., core and coil assembly **19**, is directly connected by lifting rod **22** to eye **20**.

The core and coil assembly **19** is preferably similar to the construction disclosed in U.S. Patent No. 2,931,993 to H. W. Dornbush, having the same assignee as the subject application. Two closed, generally rectangular, magnetic cores **30** of flatwise wound magnetic strip laminations are assembled through the axial window of a preformed winding **31** so that winding legs thereof are in abutting relation, and the laminations (not shown) have their respective ends overlapped so that each lamination constitutes a closed magnetic circuit. The channel upper

and lower core frame members 17 and 28 enclose the upper and lower yokes respectively of the rectangular cores 30. Side frame members 33 of L-shape cross section are secured to the depending legs of the channel upper core frame 28, preferably by spot welding. After the core and coil assembly 19 is placed within the assembled channel upper frame member 28 and side frame members 33, rivets 34 are inserted through registering holes in the lower end of the side frame members 33 and in the legs of the lower core frame channel member 17 to unite the core frame members 17 and 33 and permit the core and coil assembly 19 to be lifted by the eye 20.

The upper edge of casing shell 10 at its open end is rolled over to form a circumferential flange 35 having a depending portion 36 approximately parallel to the axis of casing shell 10. Tank cover 21 is generally cup-shaped and has a depending circumferential flange 37 adapted to telescope snugly over the depending portion 36 of casing flange 35. After the unitary assembly of cover 21 and core and coil assembly 19 are assembled to tank 10 by lifting at eye 20, the cover flange 37 is welded to the depending portion 36 of casing flange 35 to make casing 10 and cover 21 integral with a positive seal therebetween which eliminates gaskets and thus assures that the transformer cannot breathe due to improper clamping pressure by the user as frequently occurred with prior art construction. The cover 21, being permanently sealed to casing 10, exerts a restraining force through the lifting rod 22 to hold the embossment 16 in bottom plate 12 in engagement with the mating dimple in the lower channel core frame member 17 and thus positively holds the core and coil assembly 19 in position.

In the alternative embodiment illustrated in FIG. 3 a circumferential groove 38 is provided in casing shell adjacent the upper edge thereof. Circumferential flange 37 on cover 21 is adapted to telescope snugly over the upper end of the casing 10 so as to overlap groove 38. A ring of alloy solder is placed in groove 38 before the unitary assembly of cover 21 and core and coil assembly 19 are assembled to tank 10 by lifting at eye 20. Heat is then applied to the depending flange 37 on tank cover 21 as tank shell 10 and cover 21 are rotated as a unit. The heating causes the sealing alloy ring to flow upwardly and downwardly between the closely fitting telescoped surfaces of cover 21 and casing 10, thus making casing 10 and cover 21 integral with a positive metal-to-metal seal therebetween.

Elongated guide bars 39 extending parallel to the axis of casing 10 are secured by suitable means such as welding at diametrically opposed positions to the inner periphery of casing 10. Indentations 40 provided in the ends of the web portion of upper core frame channel member 28 slidably receive the guide bars 39 to prevent rotation of core and coil assembly 19 within casing 10.

Both primary and secondary insulating bushings are mounted on tank cover 21, and in the illustrated embodiment two primary bushings 42 are mounted on the upper wall 43 of the cover 21 and three secondary bushings 44 are mounted on the depending sidewall 37. Each primary bushing 42 includes a tubular body portion 45 having a plurality of petticoats 46 and circumferential grooves 47 and 48 on opposite sides of the petticoats 46. Continuous gaskets 49 of suitable resilient material such as rubber are disposed in the grooves 47 and 48. A metallic terminal connector 50 adapted to clamp a power line conductor is substantially integrally secured to the upper end of porcelain body 45 to provide an air-tight and moisture-tight seal for the outer end of each primary bushing 42. Terminal connector 50 has a circumferential flange 51 secured by suitable means such as brazing to a thin, copper, cup-shaped member 52 telescoped over the outer end of porcelain body 45 so that it overlies resilient gasket 49 in groove 47. A ring-shaped gasket 53 of suitable material such as asbestos is disposed between the outer end of porcelain body 45 and the cup-shaped member 52. A circumferential depression 54 is spun, or rolled, into cup-shaped copper member 52 so that depression 54 overlies groove 47 and the metal of cup-shaped member is pushed into groove 47 with resilient gasket 49 compressed therebetween, thereby interlocking terminal connector 50 to porcelain body 45 and producing a substantially rigid and fluid-tight joint therebetween.

Terminal connector 50 has a socket 55 within the axial bore 56 in porcelain body portion 45 adapted to receive the lead 57 of a temperature sensitive device 58 disposed within the axial bore 56 in porcelain body portion 45 and immersed in an insulating and cooling fluid 59 such as transformer oil within casing 10. Preferably the lead 57 is dipped in solder and securely crimped within socket 55 before the terminal connector 50 is secured to the outer end of porcelain body 45. A tube 60 of suitable insulating material surrounds lead 57 within axial bore 56 between the temperature sensitive device 58 and socket 55. A second, larger tube 61 of suitable insulating material is telescoped over the end of the insulating tube 60 and surrounds the portion of temperature sensitive device 58 within axial bore 56. Temperature sensitive device 58 prevents excessive buildup of pressure within casing 10 resulting from an incipient fault within the casing and is somewhat analogous to a primary fuse link. However, temperature sensitive device 58 differs from a conventional primary fuse link in that it is not intended to operate directly in response to the flow of overcurrent therethrough even in the event of a short circuit on the transformer. Rather temperature sensitive device 58 melts in response to excessive temperature within the casing 10 incident to an incipient fault and thus prevents excessive buildup of pressure within casing 10, and temperature sensitive device 58 may be a commercially available low temperature fuse such as the Bussman type JPH fuse.

A thin copper support sleeve 62 for primary bushing 42 is positioned within an aperture 63 in the tank cover upper wall 43, and the lower end of the support sleeve 62 is welded to cover 21 around the entire margin of aperture 63. After the primary bushing 42 is pressure tested independently of the cover, bushing 42 is inserted within support sleeve 62 so that support sleeve 62 is telescoped over resilient gasket 49 within circumferential groove 48 in porcelain body 45. A portable hand tool is placed around body portion 45 and operated to roll a circumferential depression 64 in support sleeve 62 in overlying relation to groove 48 so that the metal of support sleeve 62 is pushed into groove 48 in porcelain body 45 and the resilient gasket 49 is compressed tightly between porcelain body 45 and support sleeve 62. In this manner a substantially rigid connection is established between insulating bushing 42 and support sleeve 62, the porcelain body 45 is held against removal from support sleeve 62, and primary bushing 42 is integrally mounted on cover 21. However, since the gasket 49 is of resilient material, the copper support sleeve 62 and porcelain body 45 may individually respond to temperature changes without destroying the joint therebetween. This construction is also advantageous in that a broken primary insulating bushing 42 can be removed and replaced in the factory, and, further, the insulating bushing 42 is affixed to the cover 21 without the application of heat after the resilient gasket 49 is in place, thus permitting use of a conventional Buna-N rubber gasket rather than a more expensive silicone gasket which would be required if the last operation involved welding the support sleeve 62 to the cover 21.

Insulating and cooling fluid 59 fills the interior of the casing 10 above the core and coil assembly 19 and the lower portions of the primary bushings 42. The shanks of the porcelain high voltage bushings 42 extending into the transformer oil 59 permit coordination of breakdown strength so that lightning arresters (not shown) external of the transformer will always flashover before breakdown can occur at either high voltage lead.

Each secondary bushing 44 includes a tubular porcelain

body 70 having a petticoat 71 and circumferential grooves 72 and 73 on opposite sides of petticoat 71. Continuous resilient gaskets 75 of suitable resilient material such as rubber are disposed in grooves 72 and 73. A central conductor stud 79 extending through the axial bore 80 in tubular procelain body 70 terminates in a circumferential flange 81 and a terminal connector 82 for clamping a power line lead. A thin, cup-shaped, copper member 84 having a central aperture surrounding stud 79 is disposed against and affixed to circumferential flange 81 by suitable means such as brazing so that it overlies gasket 75 within circumferential groove 73 in porcelain body 70. A gasket 85 of suitable material such as asbestos is disposed between cup-shaped member 84 and the outer end of porcelain insulator body 70. A circumferential depression 87 is spun or rolled into cup-shaped copper member 84 in a manner similar to that described hereinbefore for primary bushing 42 to cause gasket 75 and the metal of cup-shaped member 84 to substantially conform to the contour of porcelain body 70 and to push the metal of member 84 into the groove 73 and compress gasket 75 within circumferential groove 73 and between porcelain insulator 70 and cup-shaped member 84 to provide a fluid-tight seal therebetween.

A thin, copper support sleeve 88 is inserted into an aperture 89 in the depending circumferential cover flange 37, and the support sleeve 88 is welded to cover flange 37 around the margin of aperture 89. Conductor stud 79 is provided with a socket 90, and a wire lead 91 is preferably crimped within socket 90 before secondary bushing 44 is assembled to cover 21. Porcelain insulator body 70 of each secondary bushing 44 is positioned within a support sleeve 88 so that the support sleeve 88 overlies gasket 75 in groove 72, and a portable tool is placed around the bushing 44 and operated to roll, or spin, a circumferential depression 92 in support sleeve 88 to cause the gasket 75 and the metal of support sleeve 88 to be pushed into the groove 72 and substantially conform to the surface of porcelain body 70 with the resilient gasket 75 compressed between porcelain body 70 and support sleeve 88, thus establishing a substantially rigid and fluid-tight joint therebetween and integrally mounting secondary bushing 44 on cover 21. However, since gasket 75 is of resilient material, porcelain body 70 and support sleeve 88 may individually respond to temperature changes without impairing the joint therebetween. This construction permits replacement of a broken secondary bushing 44 in the factory in the same manner as described for the primary bushings 42 and also has the advantage that bushing 44 can be affixed to cover 21 without the application of heat after the gasket 75 is in place, thus permitting use of gaskets of the Buna-N rubber type rather than more expensive silicone rubber gaskets.

Inasmuch as core and coil assembly 19 is integral with tank cover 21, the primary leads 93 emanating from the coil one one side of magnetic core 30 can be permanently and integrally connected to the lead 94 from the temperature sensitive device 58 by suitable means such as a parallel connector 95 crimped to the leads 93 and 94. Similarly the secondary leads 96 emanating from the coil on the opposite side of the magnetic core 30 from the primary leads 93 can be permanently and integrally connected to the wire leads 91 from the secondary bushings 44 by suitable means such as a butt connector 97 crimped to the leads 91 and 96. A support plate 98 of suitable insulating material permanently affixed to upper core frame 28 by suitable means such as rivets, has spaced apart apentures 99 for receiving the primary leads 93 and secondary leads 96 to hold them in proper position.

A tubular oil-filling and pressure-testing stem 100 fits snugly within an aperture 101 defined by a turned-over annular lip 102 in cover 21 and is affixed to cover 21 by suitable means such as brazing. The turned-over lip 102 provides increased surface area for brazing between cover 21 and stem 100. After a pressure test on the transformer casing is made in the factory, a cup-shaped metallic plug 104 fitting over stem 100 is integrally secured thereto by suitable means such as a metal alloy solder joint.

It will be appreciated that all external joints of the disclosed distribution transformer construction are permanently sealed in the factory and that sealing gaskets compressed by manually operable clamping means are eliminated. There are no clamps which must be tightened by the user in the field to seal the transformer. The electric utility employee in the field has no way of determining if a transformer is accurately sealed, whereas the permanently sealed joints of the disclosed construction are produced in the factory where even minute leaks can be easily detected. The permanently sealed joints eliminate the danger of restricted breathing due to a customer exerting too little or too great torque on a gasket clamping bolt as frequently occurred in prior art distribution transformers. The permanent seal of all joints positively prevents entrance of air and moisture into the casing, and deterioration of the oil and weakening of its dielectric strength due to moisture within the casing is thus prevented. There are no bolts or nuts to come loose within the tank, and all electrical connections are permanently made by brazing or crimping. Consequently there is no need for the transformer to be opened by the customer before it is put into service. All cover clamps, bushing clamps, and lift lugs are eliminated from the transformer casing which is lifted by an eye in the center of the cover. Should the user desire to do so, electrical continuity tests can be easily made, but it is unnecessary for the user to make elaborate tests in his shop before installing the transformer.

While only a single embodiment of the invention has been illustrated and described, many modifications and variations thereof will be apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such modifications and variations which fall within the true spirit and scope of the invention.

We claim:

1. An electrical distribution transformer comprising, in combination, a hollow cylindrical metallic casing open at the upper end, a cup-shaped metallic cover having a depending circumferential flange in telescoped relation with the open end of said casing and being integrally secured thereto with a metal-to-metal seal between said flange and said casing, an insulating and cooling dielectric fluid within said casing, a core and coil assembly including a magnetic core linked by an electrical coil immersed in said fluid within said casing, a lifting eye integral with said cover, a lifting member integrally secured at its upper end to said eye and to said cover and at its lower end to said core and coil assembly for integrally suspending said core and coil assembly from said cover, said eye permitting lifting of said transformer and also permitting untanking of said core and coil assembly from said casing prior to integrally securing said cover to said casing, primary insulating bushings each having an electrical conductor extending therethrough protruding in spaced apart relation through the upper wall of said cover and being integrally secured in fluid-tight relation to said cover, secondary insulating bushings each having an electrical conductor extending therethrough protruding in spaced apart relation through said circumferential cover flange and being integrally secured in fluid-tight relation thereto, and electrical leads from said coil each of which is integrally affixed to said electrical conductor of one of said bushings, whereby it is unnecessary to break the seal of said transformer in use and the danger of the transformer breathing is minimized.

2. An electrical distribution transformer comprising, in combination, a hollow cylindrical metallic casing open at the upper end, a metallic cover closing said open end and being integrally secured to said casing with a metal-to-metal, fluid-tight seal around the margin thereof, an insulating and cooling dielectric fluid within said casing, a

core and coil assembly including a magnetic core linked by an electrical coil immersed in said fluid within said casing and being integrally suspended from said cover, cooperating male and female means one of which is on the bottom wall of said casing and the other of which is on said core and coil assembly for holding said core and coil assembly in position within said casing, whereby prior to integrally securing said cover to said casing said core and coil assembly may be untanked from said casing by lifting said cover, primary cylindrical insulating bushings and secondary cylindrical insulating bushings each having central conductor means extending therethrough mounted in spaced apart relation on and extending through said cover and integrally secured thereto in fluid-tight relation, and primary and secondary electrical leads from said coil integrally secured to said central conductor means of said primary bushings and secondary bushings respectively, whereby it is unnecessary to open said transformer in use and the danger of air and moisture entering the casing is minimized.

3. A transformer in accordance with claim 2 wherein said cover has a plurality of spaced apart openings therein defined by tubular support sleeve portions integral with the cover, each of said bushings has a circumferential groove therein and is disposed in one of said openings so that said support sleeve portion overlies said groove, resilient gaskets are disposed in said grooves, and said support sleeve portions have circumferential depressions within said grooves compressing said gaskets against said bushings and integrally securing said bushings in fluid-tight relation to said cover.

4. An electrical distribution transformer comprising, in combination, a hollow cylindrical casing open at the upper end, a cup-shaped cover having a depending circumferential flange in telescoped relation with the open end of said casing and being integrally secured to said casing with a metal-to-metal seal around the periphery of said flange, an insulating and cooling dielectric fluid within said casing, a core and coil assembly immersed in said fluid within said casing and being integrally suspended from said cover, cooperating male and female means one of which is on the bottom wall of said casing and the other of which is on said core and coil assembly for holding said core and coil assembly in position within said casing, primary insulating bushings having central conductor means extending therethrough protruding in spaced apart relation through the upper wall of said cover and being integrally secured in fluid-tight relation to said cover, secondary insulating bushings having central conductor means extending therethrough and protruding in spaced apart relation through said circumferential cover flange and being integrally secured thereto, and electrical leads from said coil each of which is integrally affixed to said central conductor means of one of said bushings, whereby it is unnecessary to open said transformer in use and the danger of the transformer breathing is minimized.

5. An electrical distribution transformer comprising, in combination, a hollow cylindrical casing open at the upper end, a cup-shaped cover having a depending circumferential flange in telescoped relation with the open end of said casing and being integrally secured thereto with a metal-to-metal seal between said flange and said casing, a lifting eye integral with said cover, an insulating and cooling dielectric fluid within said casing, a core and coil assembly immersed in said fluid within said casing including a magnetic core, an electrical coil linked with a leg of said core, and a core frame having upper and lower channel members confining the yokes of said core and connected by side frame members integrally secured to said channel members; means including a lifting rod integrally secured at its upper end to said eye and to said cover and at its lower end to said lower channel member for integrally suspending said core and coil assembly from said cover, cooperating male and female means one of which is on the bottom wall of said casing and the other of which is on said lower channel member for retaining said core and coil in position within said casing, insulating bushings having central conductor means extending therethrough mounted in spaced apart relation on and extending through said cover and being integrally secured in fluid-tight relation to said cover, and a plurality of electrical leads from said coil each of which is integrally secured to said central conductor means of one of said bushings.

6. An electrical distribution transformer comprising, in combination, a hollow cylindrical casing open at the upper end, a cover closing said open end and being integrally secured to said casing with a metal-to-metal, fluid-tight seal around the margin thereof, an insulating and cooling dielectric fluid within said casing, a core and coil assembly immersed in said fluid within said casing and being integrally suspended from said cover, said cover having a plurality of spaced apart openings through the upper wall thereof and a plurality of spaced apart openings through said circumferential flange each of which is defined by a support sleeve portion integral with said cover, primary cylindrical insulating bushings each having a circumferential groove therein and an electrical conductor therethrough disposed within each said opening through the upper cover wall, secondary cylindrical insulating bushings each having a circumferential groove therein and an electrical conductor therethrough disposed within each said opening through said circumferential cover flange, a resilient gasket within the groove in each bushing, each support sleeve portion having a circumferential rolled-in depression within the groove in said bushing and compressing said gasket within said groove and integrally securing said bushing in fluid-tight relation to said support sleeve portion, and a plurality of electrical leads from said coil each of which is integrally affixed to said electrical conductor of one of said bushings.

7. An electrical distribution transformer comprising, in combination, a hollow cylindrical casing open at the upper end, a cover closing said open end and being integrally secured to said casing with a metal-to-metal, fluid-tight seal around the margin thereof, an insulating and cooling dielectric fluid within said casing, a core and coil assembly immersed in said fluid within said casing and being integrally suspended from said cover, said cover having a plurality of spaced apart openings therethrough, cylindrical insulating bushings each having an axial bore and a pair of axially spaced apart circumferential grooves and being disposed within one of said openings, resilient gaskets within said grooves, central conductor means within said axial bores each having a first tubular portion integral therewith overlying one of said grooves, metallic support sleeves disposed around said bushings and each having a second tubular portion overlying the other of said grooves and being integrally secured to said tank cover around the margin of one of said openings, circumferential depressions in said first and second tubular portions within said grooves compressing said gaskets within said grooves and against said bushings and integrally securing said bushings in fluid-tight relation to said support sleeves and to said central conductor means, and a plurality of electrical leads from said coil each of which is integrally affixed to said central conductor means of one of said bushings.

8. An electrical distribution transformer comprising, in combination, a hollow, cylindrical casing open at its upper end, a cover closing said open end and being integrally secured to said casing with a metal-to-metal seal around the margin thereof, an insulating and cooling dielectric fluid within said casing, a core and coil assembly immersed in said fluid within said casing, a frame having members confining said core and being integrally secured together, a lifting eye integral with said cover, a lifting rod integral at its upper end with said cover and said eye and at its lower end with said frame, said cover having

a plurality of openings therethrough, a cylindrical insulating bushing having a circumferential groove therein disposed within each said opening, resilient gaskets within sad grooves, an electrical conductor extending through each said bushing and supported thereby, a metallic support sleeve disposed around each insulating bushing and being integrally secured to said cover around the margin of one of said openings, said sleeve having a circumferential depression within said groove pressing said gasket against said bushing and integrally securing said sleeve in fluid-tight relation to said bushing, and a plurality of

electrical leads from said coil each of which is integrally affixed to said electrical conductor of one of said bushings.

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