Oct. 21, 1969 T. H. KEOGH 3,474,369

HERMETICALLY SEALED DISTRIBUTION TRANSFORMER

Filed Dec. 5, 1967 2 Sheets-Sheet 1

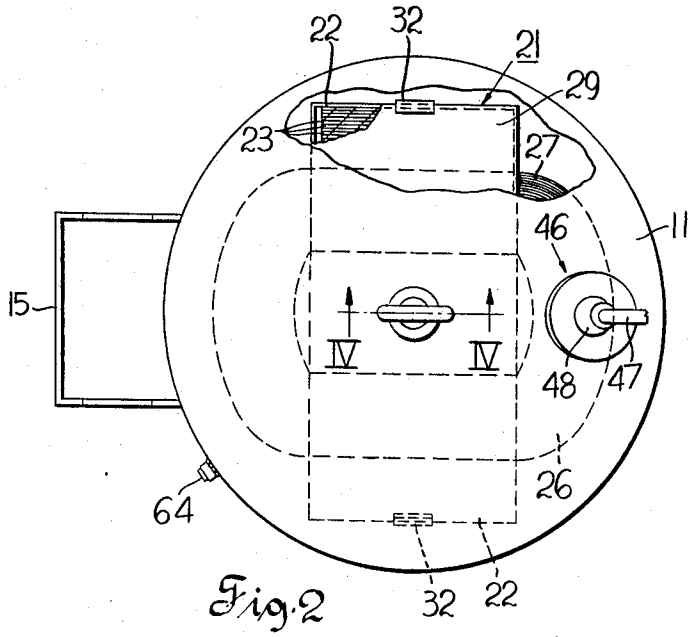


Fig. 2

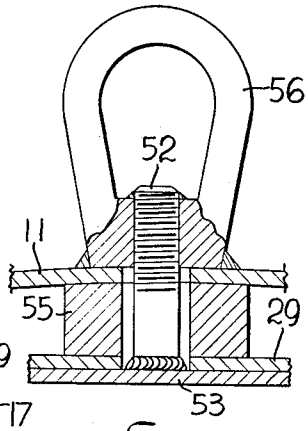


Fig. 4

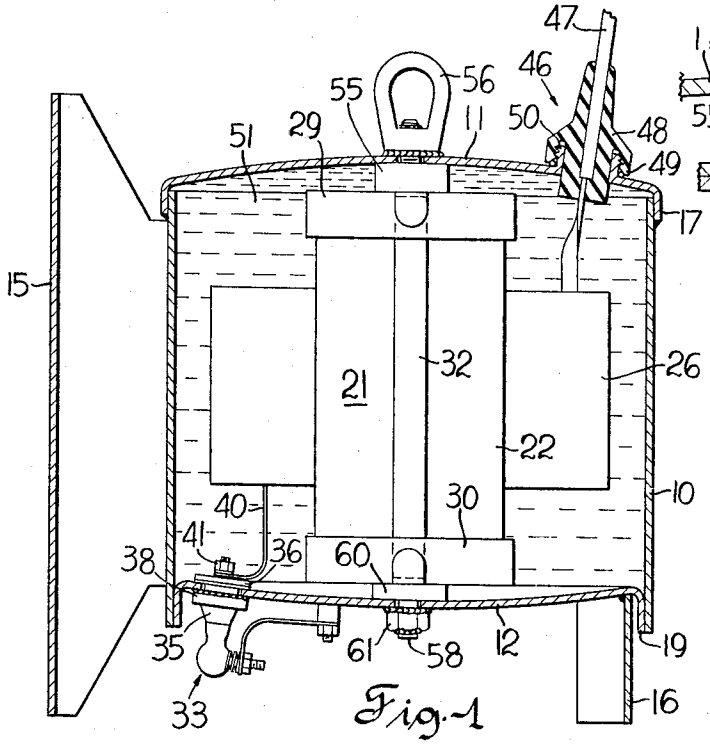


Fig. 1

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HERMETICALLY SEALED DISTRIBUTION TRANSFORMER

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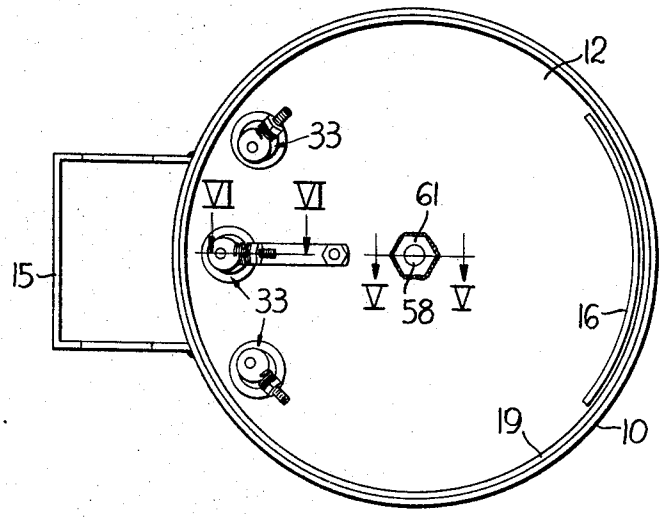


Fig. 3

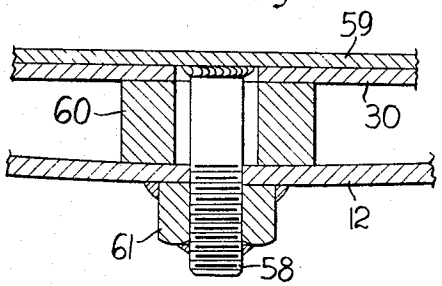


Fig. 5

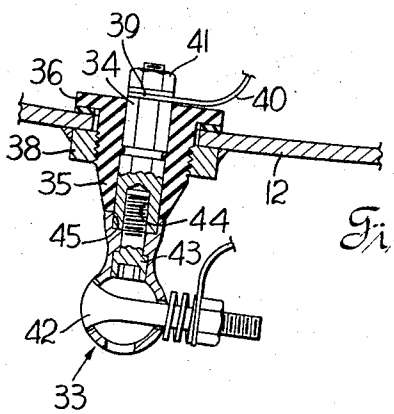


Fig. 6

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HERMETICALLY SEALED DISTRIBUTION TRANSFORMER

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U.S. Cl. 336—65
14 Claims

ABSTRACT OF THE DISCLOSURE

A hermetically sealed distribution transformer has a tank which exhibits maximum strength against deformation caused by internal pressure variations formed by a circuluar sidewall member **10** welded at its open upper and lower ends to outwardly domed cover and bottom members **11** and **12**. The tank encloses a transformer core and coil assembly **21** held together by a frame including upper and lower pans **29** and **30** locked by end straps **32**. The central portion of the cover and bottom members **11** and **12** are stayed and rigidly secured to the frame by threaded studs **52** and **58** integral with plates **53** and **59** disposed beneath the pans **29** and **30** and extending through apertures in spacers **55** and **60** and engaging nuts **56** and **61** on the cover and bottom members. The interior of the tank is filled with a dielectric liquid **51** and is under negative pressure when the transformer is out of service so that no positive internal pressure is exerted against the walls of the tank during operation, thereby minimizing flexure of the tank walls due to pressure changes and permitting the transformer to be handled in any position without danger of air being entrapped in the windings.

This invention relates to stationary induction apparatus and in particular to hermetically sealed distribution transformers.

Distribution transformers often fail electrically due to deterioration of the transformer oil caused by entrance of moisture and other contaminants into the interior of the tank at the gasketed joint for the cover or the hand hole cover. Further, distribution transformers are larger and heavier than necessary because the tank is considerably taller and wider than the core and coil assembly and is filled with oil to a level above the core and coil assembly and has a cushion of air above the oil to compensate for expansion and contraction of the oil with temperature changes during operation. The cushion of air requires that transformer tank always be maintained in an upright position to prevent air from being trapped in the windings wherein it may cause failure during service. Hermetically sealed distribution transformers are known wherein the tank is permanently welded closed to prevent entrance of moisture and other contaminants, but such transformers are not entirely satisfactory in that the tank walls continuously flex due to expansion and contraction of the oil with temperature, and such continuous flexing can result in fatigue of the metal of the tank. Known hermetically sealed distribution transformers necessitate a pallet for fork truck handling and have spaced vertical cooling flanges with a flat surface therebetween which form a collecting place for dirt and corrosive material and a possible location for bird nests. Further, the low voltage bushings of such known hermetically sealed transformers are located between the vertical flanges at three different distances from the pole in a location which makes connection thereto awkward and results in an unsightly drop arrangement.

It is an object of the invention to provide an improved hermetically sealed distribution transformer which is approximately 35 percent smaller and 25 percent lighter in weight than conventional distribution transformers of equal rating and which can be stored and shipped in any convenient position and handled without danger of air being entrapped in the windings. Another object is to provide such an improved transformer which does not require a pallet for fork truck handling.

It is a further object of the invention to provide improved distribution transformer which permits mounting on horizontal poles while at a central location without danger of air being trapped in the windings, then trucked to the field and raised quickly to the vertical, thereby allowing quick and easy installation.

Another object of the invention is to provide an improved hermetically sealed distribution transformer having an arrangement of secondary bushings equally spaced from the pole which speeds installation, adds to pole-hugging compactness, results in a symmetrical drop arrangement, and permits the pole to be shorter than those utilized with conventional transformers.

Still another object is to provide an improved distribution transformer wherein the bushing height is considerably reduced in comparison to prior art transformers.

A still further object of the invention is to provide a hermetically sealed distribution transformer which minimizes flexing due to pressure changes within the tank and eliminates the danger of fatigue of the metal of the tank walls due to continuous flexing as a result of expansion and contraction of the oil.

Another object of the invention is to provide an improved permanently sealed distribution transformer wherein the maximum internal tank pressure caused by thermal expansion of the oil is limited.

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

FIG. 1 is a cross section view through a distribution transformer embodying the invention;

FIG. 2 is a plan view of the transformer of FIG. 1 with a portion of the cover and a portion of the top pan of the frame broken away to illustrate the internal construction;

FIG. 3 is a bottom view of the transformer of FIG. 1;

FIG. 4 is an enlarged view taken along line IV—IV of FIG. 2;

FIG. 5 is an enlarged view taken along line V—V of FIG. 3; and

FIG. 6 is an enlarged cross section view through one of the low voltage bushings taken along line VI—VI of FIG. 3.

Referring to the drawing, the hermetically sealed pole type distribution transformer of the invention has an aesthetically appealing round tank including a cylindrical shell **10** defining the tank sidewall jointed by welding at its upper open end to a circular cover **11** and at its open lower end to a circular tank bottom member **12**. A U-shaped hanger bracket **15** for mounting the transformer on a pole is welded to shell **10** and extends below the tank bottom member **12** where it acts as a foot which cooperates with a depending foot **16** welded to tank bottom member **12** at a diametrically opposite position from bracket **15** to provide means for supporting the transformer which permit fork truck handling without a pallet. Circular cover **11** is outwardly domed, i.e., convex, and has a depending circumferential flange **17** surrounding the upper end of, and welded to, cylindrical shell **10**. Bottom tank member **12** is also outwardly domed, i.e., convex, and has a depending peripheral flange **19** which

fits within the open lower end of, and is welded to, cylindrical shell **10**.

The transformer core and coil assembly **21** is of conventional construction and may include a pair of back-to-back, closed, generally rectangular magnetic cores **22** having laminations **23** (see FIG. 2) of grain oriented magnetic steel linked with a transformer coil **26** having radially inner and radially outer low voltage winding sections **27** (only the latter being shown in FIG. 2) of aluminum strip conductor having a width equal to the axial length of the coil with a high voltage winding section wound from enamel insulated wire disposed between the inner and outer low voltage sections **27**. The frame for the core and coil assembly **21** includes hollow upper and lower pans **29** and **30** respectively which embrace the back-to-back magnetic cores **22** at the upper and lower ends thereof and are locked together by heavy metallic end straps **32**. The lower portions of the end straps **32** are secured to the lower pan **30**, and the end straps **32** protrude through openings in the upper pan **29** and are bent over, while the pans **29** and **30** are pressed together, to lock the assembly together. Three low voltage insulating bushings **33** are secured in spaced apart relation to bottom tank member **12**. Each bushing **33** may include a threaded hexagonal conductor stud **34** molded axially of a cylindrical body member **35** of suitable insulating material such as epoxy resin. Body member **35** may have a circumferential flange **36** internal of the tank and may also have external threads engaged within an internally threaded metallic ring **38** welded to tank bottom member **12**, and body member **35** may be secured to ring **38** by suitable means such as cement. An eye terminal **39** crimped to a secondary lead **40** from low voltage winding **27** may fit over the threaded end of conductor stud **34** internal of the tank and be secured thereto by a nut **41** engaging the threads on stud **34**. An eyebolt terminal **42** is bolted to conductor stud **34** by a socket head screw **43** engaged within a tapped hole **44** in the end of conductor stud **34** external of the tank. The base of eyebolt terminal **42** has a twelve point socket which fits over hexagonal conductor sutd **34** and permits indexing within seven and one-half degrees of any desired position. The secondary bushings **33** are equidistant from the pole and exit from the bottom of the tank immediately adjacent the pole where they shorten and facilitate installation of a symmetrical arrangement of secondary distribution leads (not shown) and permit use of poles which are considerably shorter than those on which conventional pole type distribution transformers are mounted.

One or more high voltage bushings **46** are mounted on cover **11** and may comprise a short length of unshielded high voltage cable **47** having insulation of suitable voltage rating molded axially within a bushing body member **48** cast of suitable insulation such as epoxy resin. Body member **48** may be generally of inverted conical shape and have a depending circumferential flange **49** spaced radially from its axial portion and having internal threads which engage external threads on a metallic pipe fitting **50** welded on cover **11**. The conductor of cable length **47** is connected internally of the tank to a lead from the high voltage winding. The lower end of bushing body member **48** extends into the transformer oil **51** filling the tank, and the depending flange **49** extends creep distance downwardly externally of the tank and upwardly internally thereof, and both features contribute toward reduction of the external height of the high voltage bushing **46**.

Both cover **11** and tank bottom member **12** are outwardly domed and stayed by the core and coil assembly **21** so that the tank walls exhibit virtually no deformation or flexing due to internal pressure changes within the tank. A threaded stud **52** (see FIG. 4) welded to a plate **53** disposed beneath upper pan **29** extends upwardly through the axial opening in an annular metallic spacer **55**, positioned between cover **11** and upper pan **29**. Stud **52** is welded to eyenut **56** after assembly to prevent leakage of oil from the tank. Stud **52** transmits the lifting force exerted on eyenut **56** directly to the core and coil assembly **21** and further rigidly connects cover **11** to the upper pan **29** of the core and coil assembly with spacer **55** therebetween.

The domed tank bottom member **12** is similar rigidly connected to the core and coil assembly **21** by a threaded stud **58** (see FIG. 5) welded to a plate **59** disposed above lower pan **30** and protruding through the axial opening in an annular metallic spacer **60** positioned between lower pan **30** and bottom member **12** and engaged within the internal threads in a nut **61** welded to the exterior of tank bottom member **12**. Stud **58** is welded to nut **61** after assembly to prevent leakage of oil from the tank. The round shell **10** and domed cover **11** and tank bottom member **12** provide maximum mechanical strength against deformation of the tank, and inasmuch as domed cover **11** and tank bottom member **12** are rigidly affixed to the core and coil assembly **21**, minimum flexing and deformation of the transformer walls occurs due to internal pressure variations resulting from thermal changes of the transformer oil.

During manufacture the secondary bushings **33** are first assembled to the tank bottom member **12** having the foot **16** secured thereto. After the laminations **23** of the two magnetic cores **22** are linked with the coil **26**, the back-to-back cores **22** are framed in the lower and upper pans **30** and **29**. The stud **58** on plate **59** is then inserted through the axial opening in spacer **60** and bottom member **12**, nut **61** is threaded on stud **58**, and the eye terminals **39** on secondary leads **40** are secured by nuts **41** to the conductor stud **34** of the secondary bushings **33**. The core and coil assembly so assembled to tank bottom member **12** is subjected to vacuum and heat to remove moisture from the core and coil assembly. In a separate assembly operation cover **11** is welded to cylindrical shell **10** and one high voltage bushing **46** is secured to cover **11**. The assembly of shell **10** and cover **11** is then positioned above the core and coil assembly **21** and the conductor of primary cable **47** extending from high voltage bushing **46** connected to a high voltage lead from the primary winding. Shell **10** having cover **11** welded thereto is then assembled over the core and coil assembly **21** and welded to the depending flange **19** on tank bottom member **12**. Lifting eyenut **56** is then threaded on stud **52**, tightened and welded to cover **11** and stud **52**.

The transformer tank is then filled through filling plugs **64** (see FIG. 2) on cylindrical shell **10** with 100° C. transformer oil **51** under negative pressure and sealed off under vacuum. Preferably the core and coil assembly **21**, the tank, and the oil are preheated, the oil is de-gassed, and the tank is filled under vacuum and sealed while hot so that when the unit cools the tank is still under vacuum and is filled with transformer oil **51** and no air cushion exists within the tank. When the unit cools, the internal pressure within the tank decreases still further. When the transformer is in service at ambient temperature, heating of the oil during operation of the transformer expands the oil until its volume is substantially equal to that of the tank, and consequently no appreciable positive internal pressure is exerted against the walls of the tank during operation. Further, the circular shape of the shell **10** and the dome shape of cover **11** and tank bottom member **12** provide maximum mechanical strength against deformation of the tank.

In an alternative method of construction the transformer tank may be filled with cold oil and and then the entire oil-filled transformer heated to the desired temperature before the tank is sealed.

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

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A hermetically sealed distribution transformer comprising, in combination, a tank having a circular metallic sidewall member welded to and closed at its upper and lower ends by outwardly domed metallic cover and bottom members respectively, a liquid dielectric within said tank, a transformer core and coil assembly immersed in said dielectric within said tank including a magnetic core linked by transformer primary and secondary windings and a unitary frame within said tank embracing the upper and lower portions of said core and coil assembly, and means rigidly connecting said frame to the central portion of said outwardly domed cover and bottom members for staying and preventing deformation of said cover and bottom members in both the inward and outward directions as a result of internal pressure changes within said tank.

2. A transformer in accordance with claim 1 wherein the interior of said tank is under a negative pressure relative to atmospheric when said transformer is out of service and said liquid dielectric has substantially the same volume as and fills said tank when said liquid dielectric is heated during operation of said transformer.

3. A transformer in accordance with claim 2 and including a plurality of secondary insulating bushings mounted on said bottom member and having conductor means extending therethrough connected to the secondary winding of said core and coil assembly.

4. A transformer in accordance with claim 3 and including a hanger bracket affixed to said sidewall member and wherein said secondary bushings are positioned adjacent said hanger bracket and are approximately equidistant from said sidewall member.

5. A transformer in accordance with claim 4 wherein said hanger bracket depends below said bottom member and including a depending foot affixed to said bottom member in spaced relation to said hanger bracket and cooperating therewith to support said transformer in an upright position when said bracket and foot are rested on a horizontal surface.

6. A transformer in accordance with claim 5 wherein said cover member has an opening therein and including an upwardly extending suport ring affixed to said cover member in surrounding relation to said opening and a high voltage insulating bushing extending through said opening and including a central conductor and a cylindrical body of insulating material surrounding said central conductor and having a circumferential flange above said support ring provided with a depending portion radially outward from and surrounding and being affixed to said support ring, said central conductor being embedded axially within said cylindrical body.

7. A transformer in accordance with claim 6, wherein said cylindrical body is cast of insulating resin and said central conductor is a length of high voltage cable molded within said cylindrical body and said support ring has external threads and said depending portion of said cylindrical body has internal threads engaging said external threads on said support ring.

8. A hermetically sealed distribution transformer in accordance with claim 1 wherein each of said means rigidly connecting said frame to said cover and bottom members includes a pair of mating threaded members one of which is affixed to said frame and the other of which is affixed to said central portion of said member and including spacer means disposed between said frame and said central portion in surrounding relation to one of said threaded members.

9. A transformer in accordance with claim 1 wherein said frame includes upper and lower hollow pans fitting over the upper and lower portions of said core and coil asembly respectively and elongated members within said tank joining said upper and lower pans together, and said means rigidly connecting said frame to said cover and bottom members engage said upper and lower pans.

10. A transformer in accordance with claim 9 wherein said means for staying and preventing deformation of said cover and bottom members includes spacer means between said upper and lower pans and said central portion of said domed cover and bottom members.

11. A transformer in accordance with claim 9 and including a lifting eye member affixed to said means rigidly connecting said upper pan to said cover member.

12. A transformer in accordance with claim 10 wherein said means for staying and preventing deformation of said cover and bottom members includes threaded studs connected to said upper and lower pans extending through apertures in said spacer means and engaging female threaded means on said cover and bottom members.

13. A transformer in accordance with claim 12 wherein said means for staying and preventing deformation of said cover and bottom members includes a pair of plates integral with said threaded studs, one of said plates being disposed beneath said upper pan and the other being disposed above said lower pan.

14. A transformer in accordance with claim 13 and including a lifting eyenut on said cover member affixed to the threaded stud which is integral with the plate disposed beneath said upper pan.

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