June 27, 1961 J. J. ZIMSKY ET AL 2,990,528

LIGHTWEIGHT DISTRIBUTION TRANSFORMER

Original Filed May 26, 1954 3 Sheets-Sheet 1

Fig. 1

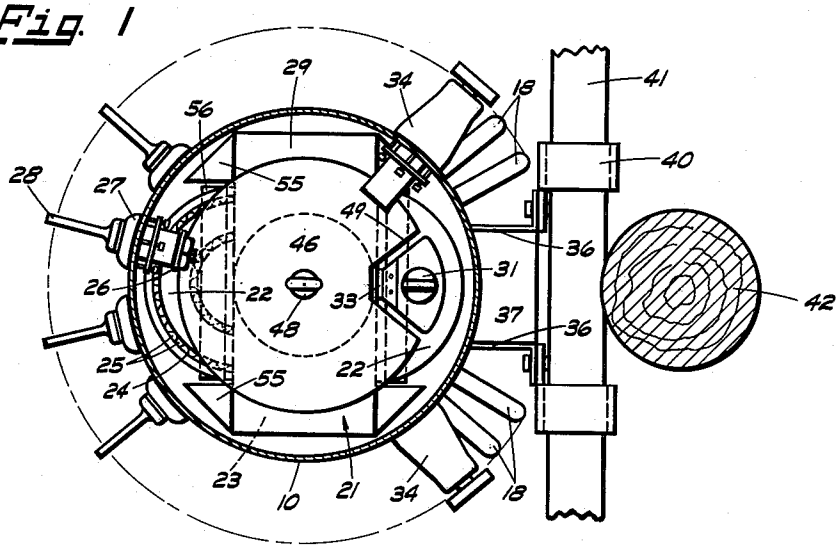
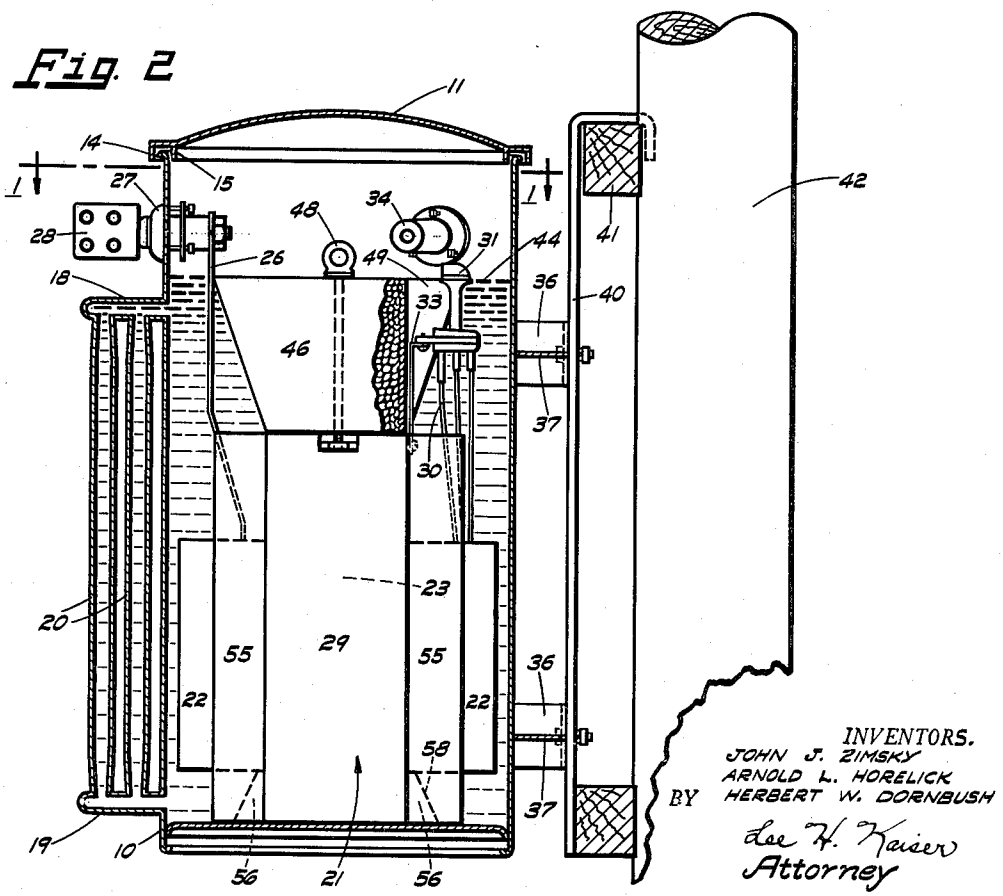


Fig. 2



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Fig. 3

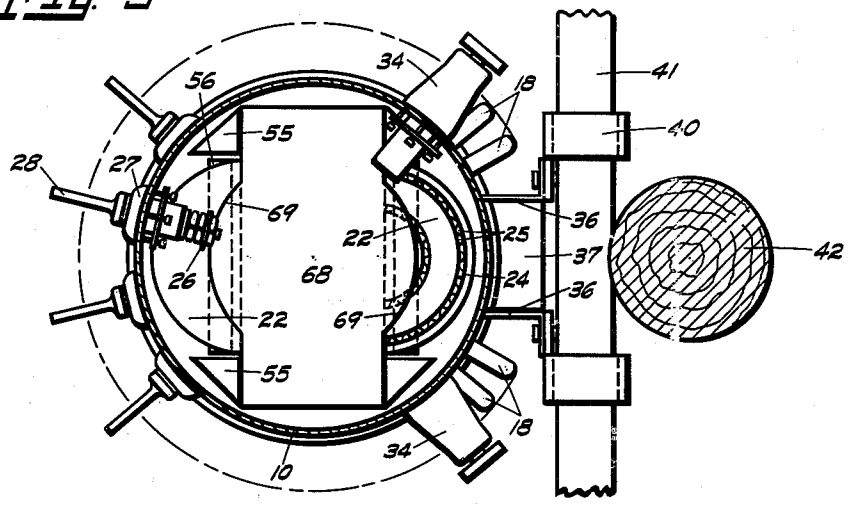
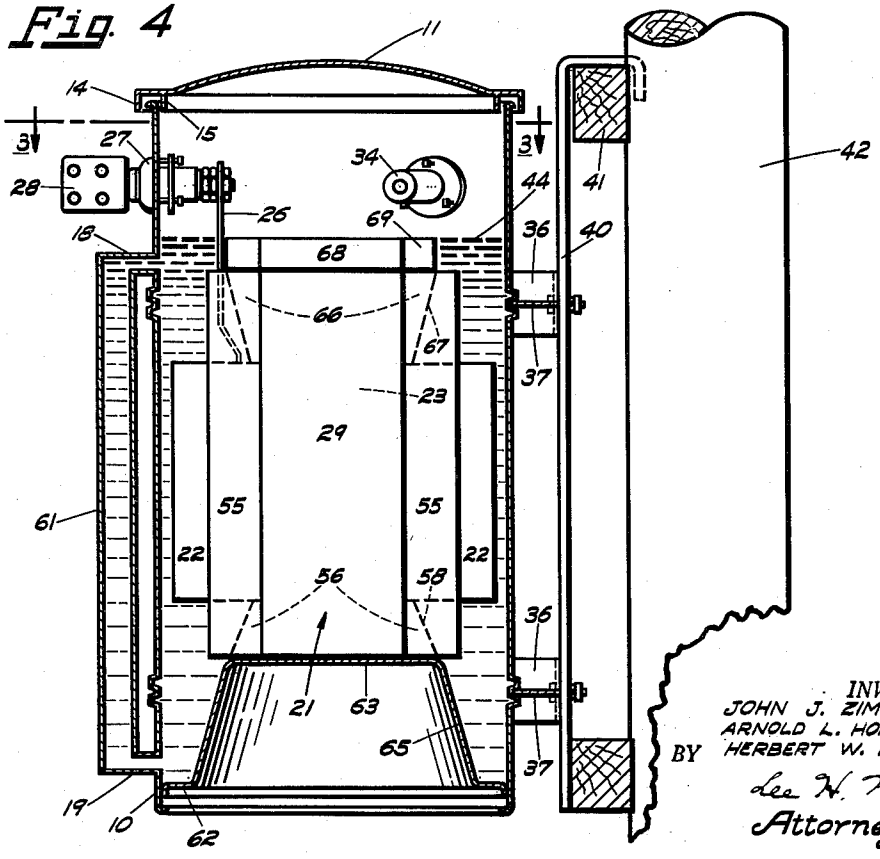


Fig. 4



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Fig. 5

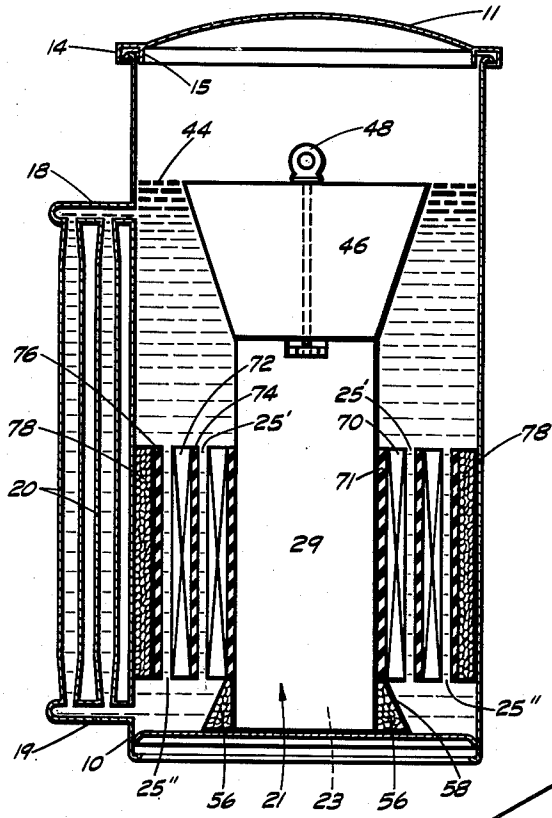


Fig. 6

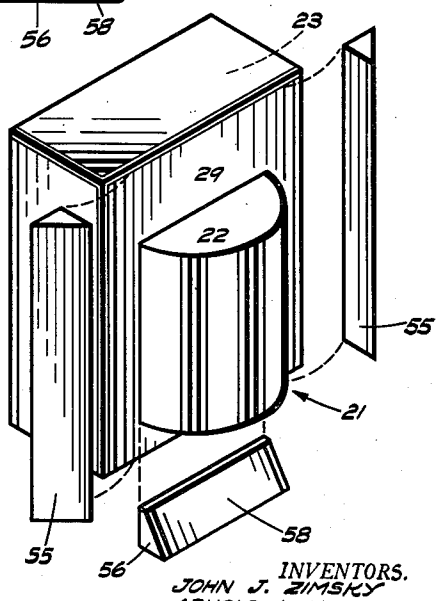
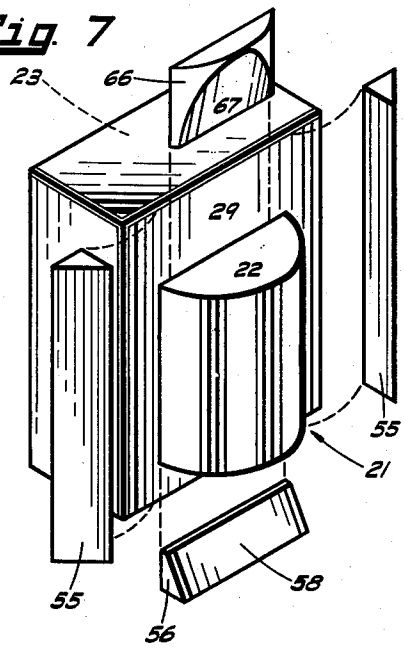


Fig. 7



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LIGHTWEIGHT DISTRIBUTION TRANSFORMER

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Continuation of application Ser. No. 432,368, May 26, 1954. This application Feb. 25, 1960, Ser. No. 11,101

15 Claims. (Cl. 336—58)

This invention relates to encased electrical apparatus and in particular to encased, liquid insulated, stationary electromagnetic induction apparatus.

This application is a continuation of our application Serial No. 432,368, filed May 26, 1954, now abandoned.

It is standard practice among electric utilities to limit the rating of single phase distribution transformers for direct pole mounting to 100 kva. or lower, and both the Edison Electrical Institute and the National Electrical Manufacturers Association standards for distribution transformers contain such limitation. This restriction has heretofore been necessary because the weight of conventional 167 kva. distribution transformers, which is the next standard rating above 100 kva., is beyond the capacity of the wood poles conventionally used by electric utilities for mounting of distribution transformers. For example, it is common practice among electric utilities to use a forty foot, class 5 wood pole having a maximum weight capacity of approximately 1500 pounds for mounting electrical distribution transformers. A conventional 100 kva. transformer weighs approximately 1450 pounds and in the past has been the highest rating which this class of pole could accommodate. As a matter of economics, electric utilities do not desire to use heavier and more expensive poles or to utilize more than one pole to provide a platform mounting for transformers of higher than 100 kva. rating.

It is an object of the invention herein disclosed to provide an electrical distribution transformer which is considerably lighter in weight than transformers of the same kva. rating heretofore manufactured and which still meets all the requirements of the national standards for distribution transformers.

A specific object of the invention is to provide an electrical distribution transformer of 167 kva. rating which weighs less than the load capacity of wood poles conventionally used for mounting of transformers of lower kva. rating and which thus can be directly pole mounted without overloading such a pole.

The weight of the liquid dielectric accounts for a large percentage of the overall weight of a distribution transformer. In the past it has not been considered practicable to reduce the amount of liquid dielectric and still provide adequate cooling for the core and coil. The application of external radiators, or coolers, to insulating liquid filled transformers as a means of dissipating heat in the transformers is well known. In a liquid cooled transformer having a radiator-type cooling system, the heat is conveyed from the winding and core to the dielectric, and then as the liquid dielectric circulates through the system, from the liquid through the walls of the transformer tank and the radiator tubes to the air. It has been found that in a transformer cooled by natural convection, the capacity of the cooling system for dissipating heat generated by the flow of current through the transformer winding varies as a function of the length of the cooling tubes. Inasmuch as the depth of the liquid dielectric in the transformer casing must be at least as great as the length of the cooling tubes, it has heretofore been considered impracticable to eliminate any of the liquid dielectric and still operate the copper of the transformer winding at or below a certain predetermined temperature.

It is a further object of the invention to provide an electrical distribution transformer which, without reduction in length of cooling tubes or in heat dissipating capacity of the cooling system, requires considerably less cooling dielectric than transformers heretofore constructed.

Our invention contemplates an improved and more efficient cooling system which will permit a considerable reduction in volume of cooling dielectric without a corresponding decrease in heat dissipating capacity. Our invention further contemplates positioning the core and coil in the coolest dielectric at the bottom of the casing and displacing the hottest oil and directing it toward the upper end of the cooling radiators.

It is a further object of the invention to displace those portions of the dielectric fluid which are inefficient in effecting heat transfer from the heat evolving apparatus to the liquid dielectric by conduction and from the dielectric to the tank wall and to the external cooling tubes, with inert, lightweight liquid displacing members which direct the flow of dielectric through the vertical ducts in the coil and through the external cooling tubes.

The pressure difference which maintains the continuous circulation of the oil in conventional transformers is dependent (in addition to oil density and thermal coefficient of expansion) upon two factors, namely, (1) the height of the center of cooling surface above the center of gravity of the generated loss and (2) the cyclical temperature range of the oil. On short time overload of a conventional transformer, the rising streams of oil become dispersed and cause turbulence and slow increase of temperature in the mass of oil between the core and the tank cover. Our invention contemplates a configuration of transformer components wherein the first of the above factors which determine rate of oil circulation, is inherently a maximum and the second factor is maintained at a desirable value. In addition, our invention contemplates displacing the mass of oil in which turbulence and consequent undesirable temperature rise occurred in prior art constructions, and further in directing the flow of liquid dielectric to provide maximum rate of oil circulation.

A still further object of the invention is to provide lightweight fluid displacement members of nonhygroscopic material which are unaffected by changes of pressure within the casing.

An object of one embodiment of the invention is to provide such a lightweight liquid displacement member which acts as a baffle for preventing circulation of dielectric fluid upwardly about the heat evolving apparatus without passing through the cooling ducts in the coil.

Still another object of the invention is the provision of cellular liquid displacement members which considerably reduce the noise level of the transformer of our invention in comparison to conventional transformers.

Other objects and advantages of our invention will be apparent from the following description of the preferred embodiments of the invention taken in connection with the accompanying drawing in which:

FIG. 1 is a horizontal sectional view through the preferred embodiment of our invention taken on line 1—1 of FIG. 2;

FIG. 2 is a vertical sectional view of the preferred embodiment taken on the vertical axis of the transformer casing and showing the apparatus disposed therein;

FIG. 3 is a horizontal sectional view through another embodiment of the invention taken on line 3—3 of FIG. 4;

FIG. 4 is a vertical sectional view taken on the vertical

axis of the embodiment of FIG. 3 and showing the apparatus therein;

FIG. 5 is a vertical sectional view taken on the vertical axis of the transformer casing and illustrating an alternative embodiment of the invention wherein a liquid displacing member acts as a baffle to direct the dielectric fluid through vertical cooling ducts in the coil and also reduces the intensity of the vibrations generated in the core and coil and transmitted to the casing by the dielectric, parts of the assembly being removed for clarity;

FIG. 6 is an exploded isometric view of certain of the liquid displacing members which surround the core and coil assembly of the embodiment of FIGS. 1 and 2; and

FIG. 7 is an exploded isometric view of certain of the liquid displacing members which surround the core and coil assembly of the embodiment of FIGS. 3 and 4.

Referring now to the drawing and in particular to FIGS. 1 and 2 which illustrate the preferred embodiment of the invention, an electrical distribution transformer is shown having a tank, or casing, **10** and a cover **11**. The outer edge of the cover **11** is flanged downwardly to provide an annular skirt **14** cooperating with a downwardly extending circumferential flange **15** of slightly smaller diameter to retain a sealing gasket (not shown) for effecting a hermetic seal between casing **10** and cover **11**. The casing **10** is provided externally thereof with a plurality of radially extending, circumferentially spaced, upper headers **18** and lower headers **19** which communicate with the interior of the casing and are attached thereto at the upper and lower ends respectively. In the preferred embodiment, two external, vertically extending, heat radiating tubes, or cooling ducts **20**, connect each upper header **18** with a lower header **19**. Although only a few of the upper headers **18** are shown in FIG. 1, it will be understood that the radiating tubes **20** are circumferentially spaced apart at equal angles around the outer periphery of the casing **10**. The tank **10**, the cover **11**, the headers **18** and **19**, and the radiating tubes **20** are preferably constructed of aluminum to provide minimum weight. In order to attain greater cooling tube area and greater heat dissipating capacity, the radiating tubes **20** are made smaller in cross section than the comparatively large cooling ducts of conventional transformers and are arranged in a double row.

A unitary transformer core and coil assembly **21** within the casing **10** comprises concentric primary and secondary windings **22** surrounding the central winding leg of a magnetic core **23** which rests on the bottom wall of the casing **10**. The core **23** may comprise two closed, rectangular core loops (not shown) having adjacent sides abutting and jointly forming a winding leg which passes through the window of the primary and secondary windings **22**. A metallic core frame **29**, preferably aluminum, embracing the yokes and outer legs of the core **23** adds mechanical strength and rigidity to the unitary core and coil assembly **21**. Vertically extending corrugated spacers **24** (see FIG. 1) spacing the electrical windings **22** radially form vertical cooling ducts **25** which permit upward circulation of the cooling dielectric through the winding structure. Although a plurality of corrugated spacers **24** are provided in radially separated positions to provide the required number of vertical cooling ducts **25**, in order to clarify the drawing only two such spacers **24** are shown on only one half of the winding in the views of FIGS. 1 and 3, and the vertical ducts and spacers are not shown in FIGS. 2, 4, 6 and 7.

Copper conductors **26** from the secondary windings are secured to low voltage bushings **27** which extend through the sidewall of the casing **10** above the upper headers **18** and terminate externally of the casing in terminal pads **28**. Leads **30** from the primary winding are connected to the contacts of a tap changer **31** which is mounted upon a bracket **33** secured to the core frame **29**. Electrical leads (not shown) connect the tap changer **31** to high voltage bushings **34** which extend through the sidewall of the tank **10**.

L-shaped support lugs **36** arranged in pairs and circumferentially spaced from each other are welded or otherwise secured to the exterior of the casing **10** near the top and bottom thereof. A horizontal cross piece **37** joins and is integral with the spaced support lugs **36** of each pair. The support lugs **36** are bolted to hangers **40** for suspension of the transformer of our invention from the cross arms **41** of a wood pole **42**.

The casing **10** is filled with insulating liquid dielectric **44** to a horizontal plane disposed above the upper headers **18**. The dielectric fluid above the core and coil assembly adds little to the heat dissipating capacity of the transformer. The preferred embodiment of our invention contemplates displacement of the major portion of this dielectric above the core and coil assembly with comparatively lightweight fluid displacing members without affecting the heat dissipating capacity of the fluid. The length of the cooling tubes of the preferred embodiment of the invention is maintained at least as great as those of conventional transformers of similar kva. rating. The height of the magnetic core **23** is considerably less than the vertical length of the radiator tubes **20**, and the unitary core and coil assembly **21** is in the coolest dielectric fluid **44** at the bottom of the casing **10**.

A liquid displacing and liquid directing member **46** of inverted frusto-conical shape and having a specific gravity considerably less than the liquid dielectric **44** is immersed in the dielectric in a central position in the casing **10** in vertical alignment with the core and coil assembly **21**. A vertical eyebolt **48** extending axially through the liquid displacing member **46** is secured at its lower end to the core frame **29**. The liquid displacing member **46** is thus rigid with the core and coil assembly **21**, and the eye of the bolt **48** permits lifting of these integral members as a unitary assembly.

The liquid displacing members utilized in the transformer of our invention must be light in weight in comparison to the dielectric displaced and relatively inert to both refined petroleums which are conventionally used for insulating and cooling dielectrics and to halogenated cyclic organic compounds added thereto for oxidation inhibition. The liquid displacing members should be nonhygroscopic and noncapillary in that they should not absorb the fluid dielectric or other liquids, and further should be durable, strong, and readily workable. In addition, the material of the liquid displacing members should not be affected by variations in pressure within the casing.

We have discovered that a cellular glass material having a closed cell structure and commercially available under the trade name Foamglas is suitable for the liquid displacing members. This cellular glass material has a specific gravity of approximately 0.14, which is less than one sixth that of conventional fluid dielectrics, has excellent insulating properties, is incombustible, can easily be cut or molded in straight lines or odd shapes and easily shaped to curved surfaces, and has high compressive strength. The petroleum dielectric **44** and the oxidation inhibition additives are without deleterious effect on the cellular glass material regardless of the temperature of the dielectric **44**. The cellular glass material containst a multiplicity of separate, hermetically sealed cells. Such closed cell structure accounts for the noncapillary and nonhygroscopic properties which prevent absorption of dielectric or other liquid. The gas of the individual cells is above atmospheric pressure and the cellular glass material will withstand up to almost complete vacuum without expanding and disintegrating as might occur with sponge rubber. The cellular material with the multiplicity of individually sealed cells is decidedly superior to a hollow member of equivalent volume which would collapse under pressure, or if punc-

tured, would be rendered completely useless in that it would absorb the liquid dielectric.

The upwardly flaring sidewall of the liquid displacing member **46** aids in the circulation of coolant in optimum heat transfer from the liquid to the radiator type cooling system by directing the dielectric liquid **44** toward the upper headers **18**. The member **46** displaces that dielectric in vertical alignment with the core and coil assembly which in conventional construction is the hottest and which is useless in heat dissipation. The member **46** increases the rate of convection flow in comparison to conventional transformers by directing the hottest oil into the upper headers **18**.

The motion of the dielectric in natural convection is the result of differences in density resulting from temperature differences, and in conventional transformers the rate of flow through the radiating tubes **20** is dependent (in addition to oil density and thermal coefficient of expansion) upon and increases with both (1) the height of the center of cooling surface above the center of gravity of generated loss and with (2) the cyclical temperature range of the oil. On short time overload of conventional transformers, the rising streams of oil cause dispersion and turbulence in the region above the core and coil and thus serve to bring about a slow increase in the temperature of the mass of oil between the core and tank cover. Consequently, the temperature differential between entrance and exits from the cooling ducts is often accepted as a better basis for the calculation of the pressure difference which maintains the continuous circulation of the oil.

In the transformer of our invention, the first of the above factors upon which the circulating force depends is inherently maintained at a maximum value by providing a core and coil assembly whose height is considerably less than the length of the cooling tubes and positioning the core and coil assembly in the coolest oil at the bottom of the tank. The transformer of our invention is designed to maintain the second factor at a desirable value, while at the same time the displacement of the oil above the core prevents dispersion and turbulence of the oil with consequent undesirable increase in oil temperature as occurred in prior art devices. In addition, the liquid displacing members direct the flow of the coolant and thus further increase the circulation rate.

In the preferred embodiment of the invention, an inwardly extending depression **49** is provided in the outer periphery of the member **46** extending the height thereof to accommodate the tap changer **31** and its mounting bracket **33**.

The cellular glass material is abrasive, and in order to prevent particles from breaking off, for example from accidental blows during transformer repair, and falling into the dielectric, the liquid displacing member may, if desired, be wrapped with a flexible tape, preferably cotton, impregnated with shellac or other suitable material, and varnish applied thereto before the liquid displacing member is secured to the core and coil assembly **21**.

Additional liquid displacing members of cellular glass material having liquid directing surfaces to increase the circulation of the dielectric liquid through the vertical ducts **25** in the coil and through the radiating tubes **20**, are immersed in the liquid dielectric **44** surrounding the core and coil assembly **21** as illustrated in the exploded view of FIG. 6 which shows only the members on one side of the core and coil assembly **21** of the preferred embodiment of the invention. All of the liquid displacing members illustrated in FIG. 6 are positioned approximately at a juncture of the coils **22** with the core **23**. Four vertical liquid displacing members **55** of triangular horizontal cross section extending the height of the core **23** are positioned approximately in the corners formed between the outer legs of the core **23** and the portions of the coil windings **22** emerging from the windows in the core. Two horizontal liquid displacing members **56** approximately triangular in vertical cross section rest on on the bottom wall of the casing **10** and are disposed against the bottom yokes of the core **23**. The members **56** extend beneath the coil between members **55** and are each provided with a liquid directing wall **58** inclined at an angle to the vertical to direct the dielectric liquid returning through the lower headers **19** against the entire bottom surface of the coil assembly, from whence it circulates upward through the vertically extending cooling ducts **25** in the coil. Although any desired means may be utilized to secure the fluid displacing members **55** and **56** in position, in the preferred embodiment of the invention these members are affixed to the core frame **29** by bolt means (not shown).

In addition to the functions of displacing that dielectric fluid which is useless in effecting cooling and in directing the dielectric to increase the flow through the radiating tubes **20** and vertical cooling ducts **25**, the liquid displacing members perform the additional function of reducing the "A.C. hum" of the transformers. Tests prove that the noise level of transformers constructed with the cellular liquid displacement members included in our invention is considerably lower than that of conventional transformers of similar rating. Practically all of the noise of transformers originates in the magnetostriction of the core steel, and the cellular liquid displacement members interposed between the core and the coil are effective in interfering with the transmission by the dielectric **44** to the casing **10** of the vibrations generated by the magnetostriction of the steel. Although we do not care to be limited thereto, a theory which may be advanced to explain the reduction in noise level is that the walls of the individual cells at the surface of the cellular members are set in motion by the vibrations and absorb a portion of the energy.

The volume of liquid dielectric required to provide the required heat dissipating capacity in an electrical distribution transformer of 167 kva. rating constructed in accordance with the preferred embodiment of the invention is reduced by more than 18% in comparison to conventional transformers. This reduction in volume of dielectric is accomplished without sacrifice in transformer efficiency. A transformer constructed in accordance with the invention has the proper thermal characteristics and meets all the national standards for distribution transformers. A transformer of 167 kva. rating constructed in accordance with the preferred embodiment weighs less than the 1500 pound maximum capacity of wood poles which are conventionally used by electric utilities for mounting distribution transformers of lower kva. rating.

In an alternative embodiment of the invention illustrated in FIGS. 3 and 4, the transformer casing is contoured to aid in circulation and displacement of the fluid dielectric. Parts similar to those of the preferred embodiment are given like reference numerals and their description is not repeated. Only a single circumferential row of external, vertically extending, heat radiating tubes **61** is illustrated, whereas a double row is utilized in the embodiment of FIGS. 1 and 2. A deep depression in a direction toward the interior of the casing **10** is provided in the bottom wall **62** of the casing **10** to form a platform **63** having an inverted-U cross section. The core and coil assembly **21** rests on the platform **63**. The sidewall **65** of the platform **63** flares outwardly toward the bottom of the casing **10** to direct the dielectric liquid returning through the lower end of the cooling tubes **61** upwardly against the bottom surface of the coil.

Certain of the liquid displacing members surrounding the core and coil assembly of the embodiment of FIGS. 3 and 4 are shown in the exploded isometric view of FIG. 7. The horizontal liquid displacing members **56** are positioned on the platform **63** against the lower yokes of the core **23** and aid in directing the coolant through the vertical ducts **25** in the coil **22** in a manner analogous to that described for the preferred embodiment. Vertical

liquid displacing members 55 of triangular cross section extending the height of the core 23 are disposed against the outer legs of the core 23 in a manner similar to the preferred embodiment. In addition, horizontal liquid displacing members 66 of approximately triangular vertical cross section disposed against the upper yokes of the core 23 have outwardly flaring, fluid directing surfaces 67 to direct the coolant toward the upper headers 18. A substantially rectangular, horizontal liquid displacing member 68 having arcuate portions 69 concentric with the casing 10 is immersed in the dielectric fluid 44. The member 68 is mounted on the top surface of the core frame 29 in a central position within the casing 10.

It will be noted that the length of the cooling tubes 61 is substantially greater than the height of coil and core assembly 21. This construction permits displacement by the platform 63 and the member 68 of a substantial volume of liquid dielectric in vertical alignment with the core and coil assembly 21 while retaining the same length of cooling tubes and the same heat dissipating capacity as in conventional transformers of similar kva. rating.

The embodiment of our invention illustrated in FIG. 5 includes a liquid displacing member which acts as a baffle for preventing circulation of dielectric upward about the heat evolving apparatus without passing through the cooling ducts and which is particularly effective in reducing the noise level. Parts similar to those of the embodiment of FIGS. 1 and 2 are given like reference numerals. In order to simplify the drawing, the high and low voltage bushings as well as the means for mounting the transformer have been omitted from the view. Of the liquid displacing members of the embodiment of FIGS. 1 and 2, only the frusto-conical member 46 and the members 56 which rest on the bottom of the casing 10 are utilized in the embodiment illustrated in FIG. 5.

The coil assembly is shown diagrammatically in cross section as having a low voltage winding 70 separated from the core by an insulating barrier 71. The low voltage winding 70 is schematically represented as spaced from a high voltage winding 72 by an insulating barrier 74 and suitable spacers (not shown) to provide a vertical cooling duct 25'. An insulating barrier 76 surrounds the high voltage winding 72 and is spaced therefrom by suitable spacers (not shown) to provide a vertical cooling duct 25".

A liquid displacing member 78 is interposed between the outer periphery of the core and coil asembly 21 and the sidewall of the casing 10. The member 78 surrounds the outer insulating barrier 76 and acts as a baffle to prevent dielectric from passing upward through the space between the core and coil assembly 21 and the sidewall of the casing 10, thus forcing the coolant to flow upward through the vertical cooling ducts 25' and 25" in the coil.

In transformer and similar alternating current oil immersed apparatus, the vibrations from the core and coil are transmited by the dielectric to the casing, causing it to vibrate and generate the hum characteristic of this type of apparatus. The member 78 is of the same closed cell, glass material as the other liquid displacing members, and being interposed between the casing and the core and coil around the entire periphery thereof, is particularly effective in interfering with the transmission of vibration by the liquid dielectric from the core and coil assembly to the casing.

Our invention results in considerable reduction in transformer weight without sacrifice in efficiency or impairment of thermal characteristics, and in certain transformer kva. ratings the invention permits construction of the next higher rating transformer at a weight equal to or less than that of conventional transformers of the lower rating. Displacement of fluid dielectric which is inefficient in effecting heat transfer is accomplished without obstruction of cooling ducts in the coil or of the surfaces of the core to be cooled. In addition, tests prove that the noise level of transformers constructed in accordance with the teaching of the invention is considerably lower than in conventional transformers.

Although the invention has been described with reference to an electrical distribution transformer, it will be appreciated that the teaching of the invention is applicable to reduce the weight of any dielectric liquid immersed, encased electrical apparatus. All sizes, types, and shapes of stationary induction apparatus, both single phase and multiphase, can be lighter in weight if made in accordance with the principles of construction embodied in the appended claims. While three particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that various changes and modifications can be made therefrom without departing from the invention and, therefore, it is intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entrance of fluid, heat evolving stationary induction apparatus including a core and coil assembly disposed within said casing, liquid dielectric within said casing surrounding said apparatus, a gaseous insulating medium within said casing above said liquid dielectric, and a closed, three-dimensional, rigid, liquid dielectric displacing member of substantial volume having a specific gravity of less than 0.2 immersed in said dielectric within said casing, said member being impervious to said liquid dielectric and having a surface inclined at an oblique angle to the direction of convection flow of liquid dielectric striking said surface for directing said liquid dielectric in direct heat transfer relation with said heat evolving apparatus.

2. In a pole mounted electrical distribution transformer, the combination of a hermetically sealed casing, heat evolving stationary induction apparatus disposed within said casing, liquid dielectric within said casing surrounding said apparatus, a gaseous insulating medium within said casing above said liquid dielectric, and means immersed in said dielectric for displacing a substantial volume of said dielectric, said means including a nonhygroscopic and noncapillary cellular member containing a multiplicity of individually sealed cells, the specific gravity of said member being considerably less than that of the dielectric displaced by it, said member being nondeformable and directing the convection flow of said dielectric in direct heat transfer relationship with said heat evolving stationary induction apparatus.

3. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entrance of fluid, heat evolving electrical apparatus disposed within said casing, a plurality of vertically extending, liquid conducting heat radiating tubes having their upper and lower ends connected to the casing near the top and bottom of the casing to provide a path for permitting the circulation of cooling liquid, the length of said tubes being substantially greater than the height of said apparatus, a dielectric liquid surrounding said apparatus and filling said casing above the upper end of said tubes, a gaseous insulating medium within said casing above said dielectric liquid, and a closed, three-dimensional, non-deformable, liquid-impervious member for displacing a substantial volume of liquid dielectric in vertical alignment with said apparatus and having a specific gravity considerably less than that of the dielectric displaced by it, said member abutting one end of said heat evolving apparatus and extending substantially to a horizontal surface of said dielectric liquid, said member also having a surface for directing said dielectric liquid in the circulation thereof through said heat radiating tubes and in direct heat transfer relationship with said heat evolving apparatus.

4. In a pole mounted electrical distribution transformer in accordance with claim 3 wherein said member is a cellular body of substantial volume having its interior filled with a multiplicity of individually sealed cells immersed in the hottest dielectric.

5. In a pole mounted electrical distribution transformer in accordance with claim 4 wherein said transformer includes a coil having a plurality of vertically extending cooling ducts therethrough and said member has a surface for directing the dielectric emerging from said ducts toward the upper end of said heat radiating tubes.

6. In a pole mounted electrical distribution transformer, the combination of a casing having external cooling means including a plurality of vertically extending heat radiating tubes communicating at their upper and lower ends with the interior of said casing, means including a cover for sealing said casing against entrance of fluid, heat evolving apparatus disposed within said casing including a coil having vertically extending cooling ducts therethrough, liquid dielectric within said casing surrounding said apparatus and filling said tubes and said ducts, and a solid cellular, three-dimensional, non-deformable, liquid displacing member of substantial volume containing a multiplicity of individually sealed cells immersed in said dielectric within said casing, the specific gravity of said member being a minor fraction of that of the dielectric displaced by it, said member having a liquid directing surface for increasing the flow of dielectric through said ducts and said heat radiating tubes.

7. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entry of fluid, liquid dielectric within said casing, a transformer core and coil assembly immersed in said dielectric, said coil having a plurality of ducts extending vertically therethrough, a gaseous medium within said casing above said liquid dielectric, and means including a closed, three-dimensional, non-deformable member containing a multiplicity of individually sealed cells immersed in said dielectric for displacing a substantial volume of said dielectric, said member being impervious to said liquid dielectric and the specific gravity of said member being considerably less than that of the dielectric displaced by it, said member having a surface inclined at an angle to the direction of convection flow of said dielectric for directing said dielectric through the ducts in said coil and in direct heat transfer relation with said core and coil assembly.

8. In a pole mounted electrical distribution transformer comprising a casing having exteriorly thereof a plurality of liquid cooling tubes extending from a horizontal plane adjacent the top of the casing to a horizontal plane adjacent the bottom of the casing and communicating with the interior thereof, means including a cover for sealing said casing against entrance of fluid, and a core and coil assembly supported on the bottom of said casing substantially below the first mentioned horizontal plane, said coil having a plurality of ducts extending vertically thereof, the combination with a liquid dielectric in said casing filling said cooling tubes and the ducts in said coil of a first liquid displacing member of substantial dimensions immersed in said dielectric above said core and coil assembly and a second liquid displacing member of substantial dimension provided with a surface for directing the liquid emerging from the lower end of said cooling tubes toward said ducts, a gaseous insulating medium within said casing between the top surface of said liquid dielectric and said top of the casing, each of said members being a three-dimensional, non-deformable body impervious to said liquid dielectric, the specific gravity of said liquid displacing members being a minor fraction of that of the liquid dielectric displaced, whereby the overall weight of the transformer is substantially reduced without impairment of its efficiency.

9. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entry of fluid, liquid dielectric within said casing, a transformer core and coil assembly immersed in said dielectric, said assembly including a coil having a plurality of ducts extending vertically therethrough, a gaseous medium within said casing above said liquid dielectric, and closed, three-dimensional, non-deformable means abutting one end of said core and coil assembly and extending substantially to a horizontal surface of said liquid dielectric for displacing a substantial volume of said liquid dielectric in vertical alignment with said core and coil assembly, said means having a surface for directing the liquid dielectric flowing by convection through said ducts, the specific gravity of said liquid displacing means being only a minor fraction of that of the liquid dielectric displaced.

10. In a pole mounted electrical distribution transformer comprising a casing having externally thereof a plurality of liquid conducting cooling tubes extending from a horizontal plane adjacent the top of the casing to a horizontal plane adjacent the bottom of said casing and communicating with the interior thereof and a core and coil assembly within said casing, the distance between said planes being substantially greater than the height of said core and coil assembly, said coil having a plurality of ducts extending vertically thereof, and means including a cover for sealing said casing against entrance of fluid, the combination with a liquid dielectric in said casing fillng said cooling tubes and the ducts in said coil of a first liquid displacement member of substantial volume disposed above said core and coil assembly and extending to the top level of said dielectric and a plurality of other liquid displacement members immersed in said dielectric surrounding said core and coil assembly, the specific gravity of each of said members being a fraction of that of the liquid dielectric displaced by it, a gaseous insulating medium within said casing above said liquid dielectric, each of said liquid displacement members being three-dimensional and rigid and portions of said members acting as liquid directng surfaces for increasing the flow of dielectric through said tubes and through said ducts in said coil.

11. In a pole mounted electrical distribution transformer, the combination of a casing having a plurality of vertically extending, heat radiating tubes communicating at their upper and lower ends with the interior of said casing, means including a cover for sealing said casing against entry of fluid, heat evolving and vibration generating stationary induction apparatus disposed within said casing including a coil having vertically extending cooling ducts therethrough, liquid dielectric within said casing surrounding said apparatus and filling said tubes and said ducts, a gaseous insulating medium within said casing above said liquid dielectric, and a closed, three-dimensional, non-deformable, cellular, liquid displacing member containing a multiplicity of individually sealed cells immersed in said dielectric surrounding said apparatus between said apparatus and a portion of the wall of said casing intermediate the upper and lower ends of said tubes, the specific gravity of said member being only a minor fraction of that of the liquid dielectric displaced by it, said member preventing the liquid dielectric emerging from the lower end of said tubes from flowing upward between said apparatus and the wall of said casing, said member also reducing the intensity of the vibrations transmitted by said liquid dielectric to the wall of said casing.

12. In a pole mounted electrical distribution transformer, the combination of a casing having external cooling means including a plurality of vertically extending, heat radiating tubes registering at their upper and lower ends with the interior of said casing, means includ-

ing a cover for sealing said casing against entry of fluid, a transformer core and coil assembly immersed in said liquid dielectric within said casing, said coil having a plurality of ducts extending vertically therethrough, a gaseous medium within said casing above said liquid dielectric, and a plurality of closed, non-deformable, three-dimensional liquid-displacing and vibration-absorbing members immersed in said liquid dielectric, said members being impervious to said liquid dielectric and the specific gravity of said members being only a minor fraction of that of the liquid dielectric displaced, one of said members surrounding a substantial portion of the external periphery of said core and coil assembly between said assembly and the wall of said casing and obstructing the liquid emerging from the lower end of said tubes from flowing upward between said assembly and the wall of said casing, a second of said members being in vertical alignment with said core and coil assembly and directing the liquid dielectric emerging from said ducts toward the upper end of said radiator tubes.

13. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entry of fluid, liquid dielectric within said casing, a gaseous insulating medium within said casing above said liquid dielectric, a core and coil assembly immersed in said dielectric within said casing, a plurality of vertically extending cooling radiators connected at their upper and lower ends to said casing and communicating with the interior thereof, means for displacing a substantial volume of said liquid dielectric in vertical alignment with said core and coil assembly, said means including a platform of U-shaped cross section defined by the central portion of the bottom wall of said casing being indented toward the interior of said casing, the sidewall of said platform being spaced from the sidewall of said casing and said core and coil assembly resting on said platform, the upper end of said radiators registering with the interior of said casing above the top level of said core and coil assembly and the lower end thereof registering with the interior of said casing below the top surface of said platform, said platform directing the liquid dielectric emerging from said radiators in direct heat transfer relationship with said core and coil assembly.

14. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entry of fluid, liquid dielectric within said casing, a gaseous insulating medium within said casing above said liquid dielectric, the central portion of the bottom wall of said casing being indented toward the interior of said casing and forming a platform of inverted-U cross section having a sidewall spaced from the sidewall of said casing, heat evolving stationary induction apparatus including a coil having a plurality of ducts extending vertically therethrough supported on said platform, a plurality of vertically extending cooling radiators having their upper ends connected to said casing above the top level of said apparatus and having their lower end connected to said casing below the top surface of said platform, and a closed, three-dimensional, non-deformable liquid displacing member of substantial volume immersed in said liquid dielectric, the specific gravity of said member being only a minor fraction of that of the liquid dielectric displaced by it, said platform and said member directing the convection flow of said liquid dielectric through said ducts and said radiators.

15. In a pole mounted electrical distribution transformer, the combination of a casing, means including a cover for sealing said casing against entry of fluid, a plurality of liquid conducting cooling tubes connected to said casing and extending from a horizontal plane adjacent the top of said casing to a horizontal plane adjacent the bottom of said casing and communicating with the interior thereof, a core and coil assembly within said casing, said coil having a plurality of ducts extending vertically therethrogh, liquid dielectric in said casing filling said cooling tubes and the ducts in said coil, a gaseous insulating medium within said casing above said liquid dielectric closed, three-dimensional, non-deformable means disposed against one end of said core and coil assembly for displacing a substantial volume of liquid dielectric in vertical alignment therewith, and at least one closed, three-dimensional, non-deformable liquid displacing member of substantial volume immersed in said liquid dielectric, said member being impervious to said liquid dielectric and the specific gravity thereof being only a minor fraction of that of the liquid dielectric displaced by it, portions of said liquid displacing means and said liquid displacing member having liquid directing surfaces for increasing the flow of dielectric through said cooling tubes and said ducts in said coil.

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