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TRANSFORMER POCKETS FOR VAPORIZED COOLING

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Fig. 1.

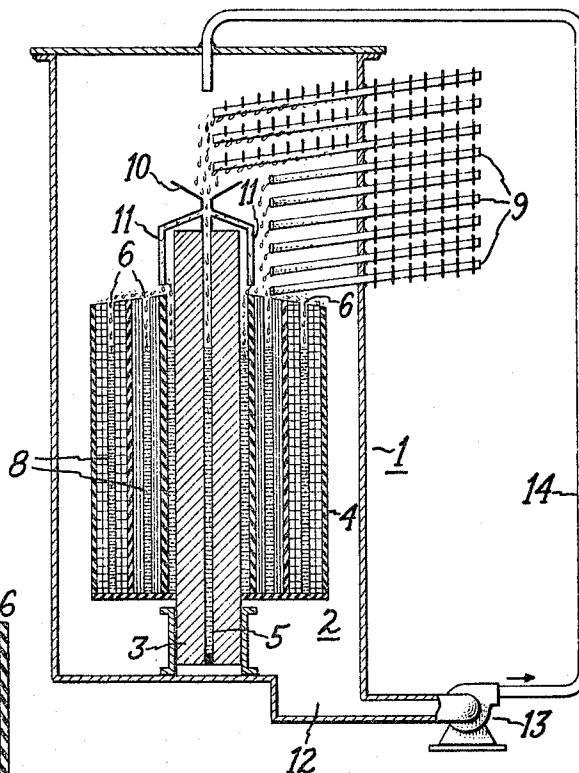


Fig. 2.

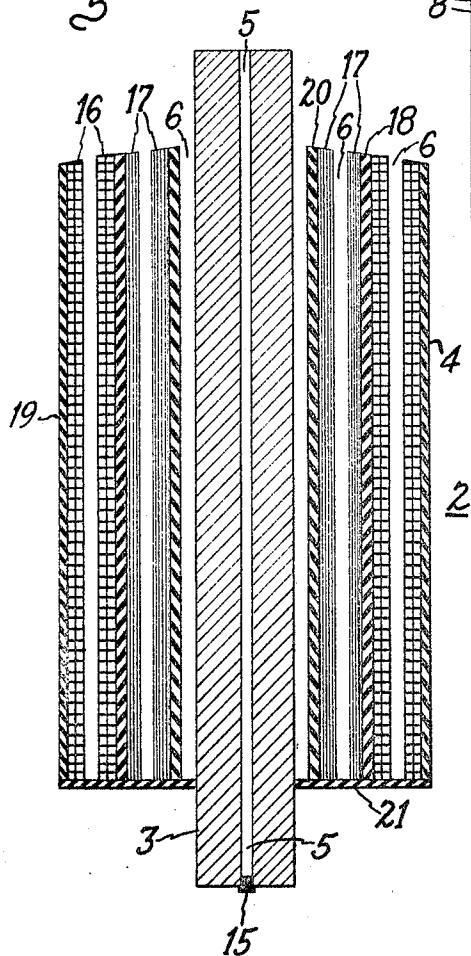
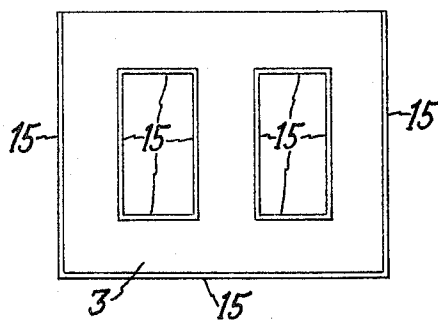


Fig. 3.



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TRANSFORMER POCKETS FOR VAPORIZED COOLING

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8 Claims. (Cl. 336-57)

This invention relates to vaporization cooling and more particularly to improvements in vaporization cooling of electrical apparatus such as transformers.

In accordance with a principal feature of this invention, pockets or ducts in the apparatus to be cooled are filled with vaporizable liquid for increasing the cooling capability of vaporization cooling and increasing the low temperature dielectric strength of the apparatus. Heretofore the vaporization cooling and insulating liquid was applied to the outside surface of the apparatus to be cooled, but as the heat flow in such apparatus is from the inside to the outside the cooling medium was relatively ineffective in eliminating internal hot spot temperatures particularly in the larger sizes of such apparatus. Furthermore, at low temperatures such as during starting of the apparatus all the vaporizable fluid was liquid and additional non-condensable insulating gas was needed to provide adequate internal insulation until sufficient liquid was vaporized to provide the needed electrical insulation.

An object of the invention is to provide a new and improved vaporization cooling system.

Another object of the invention is to increase the capability of vaporization cooling systems.

An additional object of the invention is to increase the low temperature dielectric strength of vaporization cooling systems.

A further object of the invention is to reduce the heretofore critical dependence on a fluid pump in vaporization cooling systems.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing,

FIGURE 1 is an elevational view partly in section of an embodiment of the invention,

FIGURE 2 is an enlarged sectional view of the transformer core and coil assembly shown in FIG. 1, and

FIGURE 3 is a side view of a magnetic core for use in the invention.

Referring now to the drawing and more particularly to FIG. 1, there is shown therein electrical induction apparatus comprising a sealed tank 1 enclosing a core and coil assembly 2. This assembly comprises a magnetic core 3 linked by a conductive coil 4 having any desired number of windings. The core 3 is provided with a central pocket or duct 5 and the coil 4 is shown as having two pockets or ducts 6. The pockets 5 and 6 extend vertically and are closed at the bottom and open at the top and are filled with any suitable cooling and insulating fluid 8 which is liquid at low temperatures but which has a boiling point at the approximate desired operating temperature considering all system parameters. A preferred composition of this vaporizable cooling and insulating liquid is perfluorocyclic ether ($C_6F_{10}O$).

A plurality of cooling tubes 9 extending through a wall or walls of the tank 1 are provided for condensing the vaporized liquid 8 and returning it by gravity to the pockets or ducts 6. To that end the tubes are all inclined upwardly from their inner ends to their outer ends and their inner ends are all vertically above the core and coil assembly. These cooling or condensing tubes may be of any suitable construction. For example, the top three are sealed at both ends and are provided with fins on the

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outside and may also be provided with specially shaped fins on the inside. This latter construction is per se the subject matter of U.S. Patent 3,174,540, issued to me on March 23, 1965. A volatile liquid of any suitable composition partially fills these three top tubes and serves as a medium for transfer of heat from inside the tank 1 to the atmosphere outside the tank 1. A preferred form of such volatile liquid is trichlorotrifluoroethane ($C_2Cl_3F_3$).

The lower set of cooling tubes 9 may be open at their inner ends so that vapor of the liquid 8 can enter them and rise in them until it is condensed by contact with the relatively cool walls of the finned portions thereof which are outside of the tank whereupon the liquid runs back by gravity and drips into the pockets or ducts 6.

To facilitate the return of the condensate to the pockets 6 a trough 10 is shown extending above the core and coil assembly and below the ends of at least some of the cooling tubes which trough is provided with depending conduits 11 for distributing the condensate to the pockets 5 and 6.

In the illustrated system, it is desirable to minimize condensation of the vaporized fluid on the inside walls of the tank 1, but in the event that some condensation takes place the condensate will be collected in a sump 12 and returned by a pump 13 and conduit 14 to a point above the core and coil assembly where it will be collected by the trough 10 and distributed to the pockets 5 and 6. However, the pump is used to a minimum extent and its presence is not essential to successful operation of the system for considerable periods of time.

FIGURE 2 is an enlarged view of the core and coil assembly 2 which shows a plug or seal 15 for closing the bottom of the pocket or duct 5 in the core 3. The coil 4 is shown as consisting of a two-section wire wound high voltage winding 16 with a cooling pocket or duct 6 between the two sections and a two-section foil wound low voltage winding 17 with an intermediate cooling pocket or duct 6 between the sections. The high and low voltage windings are separated by a solid insulating cylinder 18 entirely filling the space between them. This has the advantage of being a single uniformly stressed dielectric (with high dielectric strength) in the critically stressed region between high voltage and low voltage windings. This allows maximum working stress and minimum radial space between the high and low voltage windings with resulting reduction in transformer size. Surrounding the high voltage winding is a liquid tight insulating wrapping 19 and adjacent to the inner section 17 of the low voltage winding but spaced from the core 3 is another insulating cylinder 20. Thus an additional cooling duct or pocket 6 is provided between the coil and core. The bottom ends of all the elements of the coil are interconnected by solid insulation 21 so as to close the bottom ends of the pockets or ducts.

FIGURE 3 shows a side view of magnetic core 3 which may be considered as either a three phase core having three vertical windings legs or a single phase core having a single vertical center winding leg. In either case, the core laminations are divided into spaced packets for providing the cooling pockets 5 and sealing or plug means 15 is provided around the outside edges and bottom of the core and around all the sides of the windows of the core for closing the pockets at the sides and bottom while leaving them open at the top so that they can be filled with and retain the vaporizing and cooling liquid 8.

While there has been shown and described a particular embodiment of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention, and therefore it is intended by the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. In combination, a transformer core and coil assembly having vertically extending cooling pockets closed at the bottom and open at the top, a cooling and insulating liquid occupying said pockets, said liquid having a boiling temperature within the normal operating temperature range of said core and coil assembly in the region of said pockets, and means for condensing liquid vaporized in said pockets and returning it to said pockets.

2. In combination, a sealed tank containing a transformer core and coil assembly, said assembly including radially spaced-apart high voltage and low voltage windings and a barrier of solid insulation filling the space between said windings, each said winding having at least one vertically extending cooling pocket therein which is closed at the bottom and open at the top, a cooling and insulating liquid occupying said pockets, said liquid having a boiling temperature within the normal operating temperature range of said core and coil assembly in the region of said pockets, and means for condensing liquid vaporized in said pockets and returning it to said pockets.

3. The combination defined in claim 2 in which said condensing means is a plurality of cooling tubes inclined upwardly from ends in said tank which ends are vertically above said core and coil assembly and from which ends condensed vapor drips into said pockets.

4. The combination as defined in claim 2 in which said means for returning said condensed vapor to said pockets includes a trough above said core and coil assembly with depending conduits for directing liquid condensate by gravity into said pockets.

5. The combination defined in claim 2 in which said condensing means is a plurality of cooling tubes inclined upwardly from ends in said tank which ends are vertically above said core and coil assembly and from which ends condensed vapor drips into said pockets, said tubes being open at their inner ends and having finned portions extending outside said tank.

6. The combination defined in claim 2 in which said condensing means is a plurality of cooling tubes inclined

upwardly from ends in said tank which ends are vertically above said core and coil assembly, said tubes being sealed at both ends and being partially filled with a volatile liquid, said tubes being provided with cooling fins on portions thereof which are inside and outside said tank.

7. The combination as defined in claim 2 in which said means for returning said condensed vapor to said pockets includes a trough above said core and coil assembly with depending conduits for directing liquid condensate by gravity into said pockets, and a sump in the bottom of said tank for collecting liquid condensed on the walls of said tank, and a pump and conduit for delivering liquid from said sump and discharging it above said trough.

8. In combination, a transformer core and coil assembly having vertically extending cooling pockets closed at the bottom and open at the top, a cooling and insulating liquid occupying said pockets, said liquid having a boiling temperature within the normal operating temperature range of said core and coil assembly in the region of said pockets, and means for condensing liquid vaporized in said pockets and returning it to said pockets, said coil comprising spaced high and low voltage windings, and a barrier of solid insulation substantially filling the space between said windings.

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