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COOLING SYSTEM

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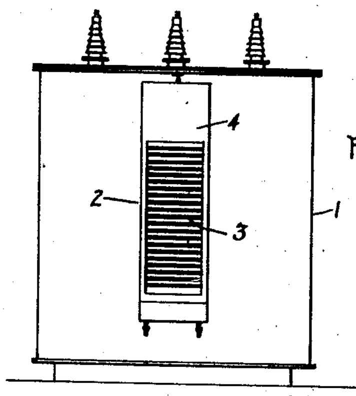

Fig. 1.

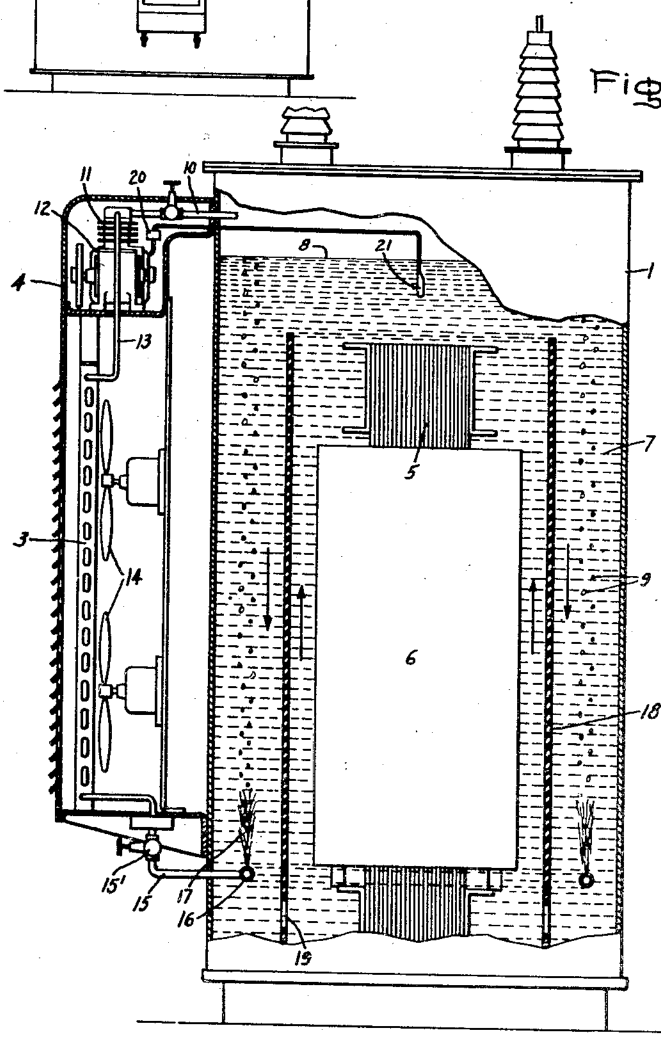

Fig. 2.

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COOLING SYSTEM

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6 Claims. (Cl. 62—115)

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This invention relates to cooling systems and more particularly to improvements in cooling systems for encased liquid insulated stationary electromagnetic induction apparatus.

Typical examples of such apparatus are power transformers and not infrequently such power transformers must be placed in locations where space is at a premium. Examples of such locations are locomotives and congested industrial load center areas. It is customary to cool such transformers by means of a radiator or radiators mounted outside the tank and through which the dielectric liquid circulates. In this manner the dielectric liquid also acts as a cooling medium. Obviously, the size of the power transformer can be reduced by reducing the area of the radiator or heat exchanger, but if this is done, the temperature of the cooling liquid must increase in order to dissipate the same amount of heat which is generated in the transformer. Unfortunately, the most satisfactorily known dielectric liquids, such as mineral oils and askarels, do not have a high stable temperature so that heretofore there has been a definite limit on the minimum size of the cooling radiator.

In accordance with this invention a second liquid is employed for performing the refrigerating function so that the dielectric liquid will perform essentially only its prime function of acting as an insulator. By making the refrigerating liquid one which is stable at relatively high temperatures and which has a lower boiling point than the dielectric liquid it is possible by means of a mechanical refrigeration cycle to operate the radiator at greatly increased temperature rises above that of the ambient, which normally is air, and in this manner the same amount of heat can be dissipated in a much smaller radiator. It will be noted, however, that this high temperature is outside the transformer tank and therefore does not reduce the life of the transformer.

Another feature of the invention is that the refrigerating liquid is preferably introduced directly into the dielectric liquid in what may be characterized as a spray. This produces turbulence in the dielectric liquid which not only facilitates the cooling of the dielectric liquid but at the same time prevents it from congealing or even freezing solid. This is important, for if the viscosity of the dielectric liquid increases materially, its circulation decreases so that heat will not be drawn away from the heat evolving electrical apparatus as rapidly as necessary and injurious hot spot temperatures will result.

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

Another object of the invention is to provide a new and improved cooling system for liquid insulated encased electrical apparatus.

A further object of the invention is to reduce materially the size of the external cooling area of a power transformer.

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 Fig. 1 is a front elevation of a power transformer embodying the invention and Fig. 2 is an enlarged cut-away side elevation of the transformer shown in Fig. 1.

Referring now to the drawing and more particularly to Fig. 1, there is shown therein a power transformer having a tank 1 and having an exterior cooling unit 2. The cooling unit 2 consists principally of a radiator or heat exchanger 3 and a housing 4 for auxiliary apparatus. It will be noted that the size of the radiator 3 in comparison with the size of the tank 1 is very much smaller than in conventional transformers.

Referring now to Fig. 2, the tank 1 contains the core 5 and the coils 6 of a transformer. These parts are completely immersed in any suitable dielectric liquid 7 which partially fills the tank up to the level 8. Examples of suitable dielectric liquids are mineral oil and askarel.

Mixed with the dielectric liquid 7 is a refrigerating liquid of any suitable type, such as dichloromonofluoromethane ($CHCl_2F$), which has a lower boiling point than that of the dielectric liquid 7 and which boiling point is, in fact, lower than the normal operating temperature of the dielectric liquid 7 so that the refrigerating liquid vaporizes into vapor bubbles 9 within the dielectric liquid 7 and which bubbles rise to the top of the dielectric liquid. This refrigerating liquid is also stable at very much higher temperatures than the dielectric liquid so that its vapor can be compressed to relatively high pressures and temperatures and then recondensed into a liquid without changing its chemical properties. The vaporization of the refrigerating liquid, of course, isothermally removes heat from the dielectric liquid 7.

Heat is removed from the vaporized refrigerating liquid by drawing it out of the space above the dielectric liquid level 8 through a conduit 10 by means of a compressor 11. This compressor may be driven in any suitable manner, such as by an electric motor 12. The compressor raises the pressure and consequently the temperature of the refrigerant gas to relatively high values; for example, the temperature can be raised to 200 degrees Centigrade above the temperature of the surrounding air. This high temperature gas is then discharged through a conduit 13 into the radiator 3. Preferably, motor-driven fans 14 are provided for forcing air through the radiator 3 so as to increase the heat dissipating capacity of the radiator. By reason of the high temperature of the refrigerant gas which enters the radiator 3 a relatively large amount of heat can be dissipated by a radiator of relatively small size for it is well known that the amount of heat exchanged in a radiator is a function of the temperature rise of the fluid to be cooled over the ambient temperature. The refrigerant is isothermally condensed at high temperature into a liquid in the radiator 3 and it then flows under pressure through a conduit 15 into the tank 1 near the bottom where it emerges through nozzles 16 in the form of the sprays indicated schematically at 17. An expansion device which, for example, may be in the form of a regulating valve 15' controls this flow.

The temperature of the vaporizing liquid sprays 17 is very much lower than the temperature of the dielectric liquid 7 but the sprays cause turbulence in the dielectric liquid 7 and thus not only increase the effective contact area between the two liquids and thus increase the heat exchange between them and the vaporization of the refrigerating liquid but this turbulence also effectively prevents congealing or freezing of the dielectric liquid.

For preventing the gas bubbles 9 from coming in contact with the transformer core and coils suitable barriers or baffles 18 are provided and, as shown, these have openings 19 near the bottom and they do not extend to the top of the dielectric liquid, with the result that there is a circulatory motion of the dielectric liquid, as shown by the arrows. Thus, the cooled dielectric liquid between the barriers and the walls of the tank 9 increases in density and descends, thus displacing the warmer dielectric liquid at the bottom which flows through the openings 19 between the barrier and upward between the barrier and core and coils, and this circulation further improves the heat conduction away from the core and coils.

The system may be automatically controlled in any suitable manner, such as by means of a thermal relay 20 having a temperature responsive control bulb 21 which is immersed in the top dielectric liquid. The thermal relay can be set to start the compressor motor 12 and the motors for the fans 14 whenever the temperature of the dielectric liquid reaches a predetermined maximum value and this relay will then shut off these units when the temperature is reduced sufficiently below this value.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention and, therefore, it is aimed 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. A cooling system for an enclosed space comprising, a first liquid partially filling said space, said first liquid having a relatively high boiling point and a relatively low maximum stable temperature, a second liquid mixed with said first liquid, said second liquid having a relatively low boiling point and a relatively high maximum stable temperature, the normal operating temperature of said first liquid being above the boiling point of said second liquid, a condenser outside said space, a compressor for drawing vapor of the second liquid out of the space above the level of the first liquid and discharging it at substantially increased pressure and temperature into said condenser, and means including an expansion device for discharging condensate of said second liquid directly into said first liquid.

2. A cooling system for an enclosed space comprising, a first liquid partially filling said space, said first liquid having a relatively high boiling point and a relatively low maximum stable temperature, a second liquid mixed with said first liquid, said second liquid having a relatively low boiling point, and a relatively high maximum stable temperature, the normal operating temperature of said first liquid being above the boiling point of said second liquid, a condenser outside said space, a compressor for drawing vapor of the second liquid out of the space above the level of the first liquid and discharging it at substantially increased pressure and temperature into said condenser, means including an expansion device for discharging condensate of said second liquid directly into said first liquid, and means responsive to the temperature of the first liquid for controlling the operation of said compressor so as automatically to maintain the temperature of said first liquid below a predetermined value.

3. A cooling system for electrical apparatus comprising, a casing, heat evolving electrical apparatus within said casing, a dielectric liquid partially filling said casing and surrounding said apparatus, a refrigerating liquid mixed with said dielectric liquid, the normal operating temperature of said dielectric liquid being above the boiling point of said refrigerating liquid, a condenser outside of said casing, a compressor for drawing vapor of the refrigerating liquid out of the space above the level of the dielectric liquid and discharging it at substantially increased temperature and pressure into said condenser, and means including an expansion device for discharging condensate of said refrigerating liquid directly into said dielectric liquid.

4. A cooling system for electrical apparatus comprising, a casing, heat evolving electrical apparatus within said casing, a dielectric liquid partially filling said casing and surrounding said apparatus, a refrigerating liquid mixed with said dielectric liquid, the normal operating temperature of said dielectric liquid being above the boiling point of said refrigerating liquid, a condenser outside of said casing, a compressor for drawing vapor of the refrigerating liquid out of the space above the level of the dielectric liquid and discharging it at substantially increased temperature and pressure into said condenser, means including an expansion device for discharging condensate of said refrigerating liquid directly into said dielectric liquid, and a baffle for preventing vapor bubbles of the refrigerating liquid from coming into contact with said electrical apparatus.

5. A small area cooling system for stationary electromagnetic induction apparatus comprising, a tank, stationary electromagnetic induction apparatus inside said tank, a dielectric liquid partially filling said tank and surrounding said electromagnetic induction apparatus, said dielectric

liquid having a relatively high boiling point and a relatively low stable temperature, a refrigerating liquid mixed with said dielectric liquid, said refrigerating liquid having a relatively low boiling point and a relatively high stable temperature, the normal operating temperature of said dielectric liquid being above the boiling point of said refrigerating liquid, a relatively small area condenser outside of said tank, a compressor for drawing liquid out of said tank above the level of the dielectric liquid and discharging it at substantially increased pressure and temperature into said condenser, and means including an expansion device for discharging condensate of said refrigerating liquid directly into said dielectric liquid.

6. A dielectric liquid immersed encased transformer, a radiator outside the transformer casing, said radiator having insufficient area for dissipating the heat of said transformer if said dielectric liquid is circulated therethrough at any stable temperature thereof, means for cooling said

transformer comprising a refrigerating liquid in heat exchanging relation with said dielectric liquid, a compressor for forcing vapor of said refrigerating liquid through said radiator at a temperature substantially in excess of the maximum stable operating temperature of said dielectric liquid and means including an expansion device for discharging condensate of said refrigerating liquid directly into said dielectrc liquid.

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