

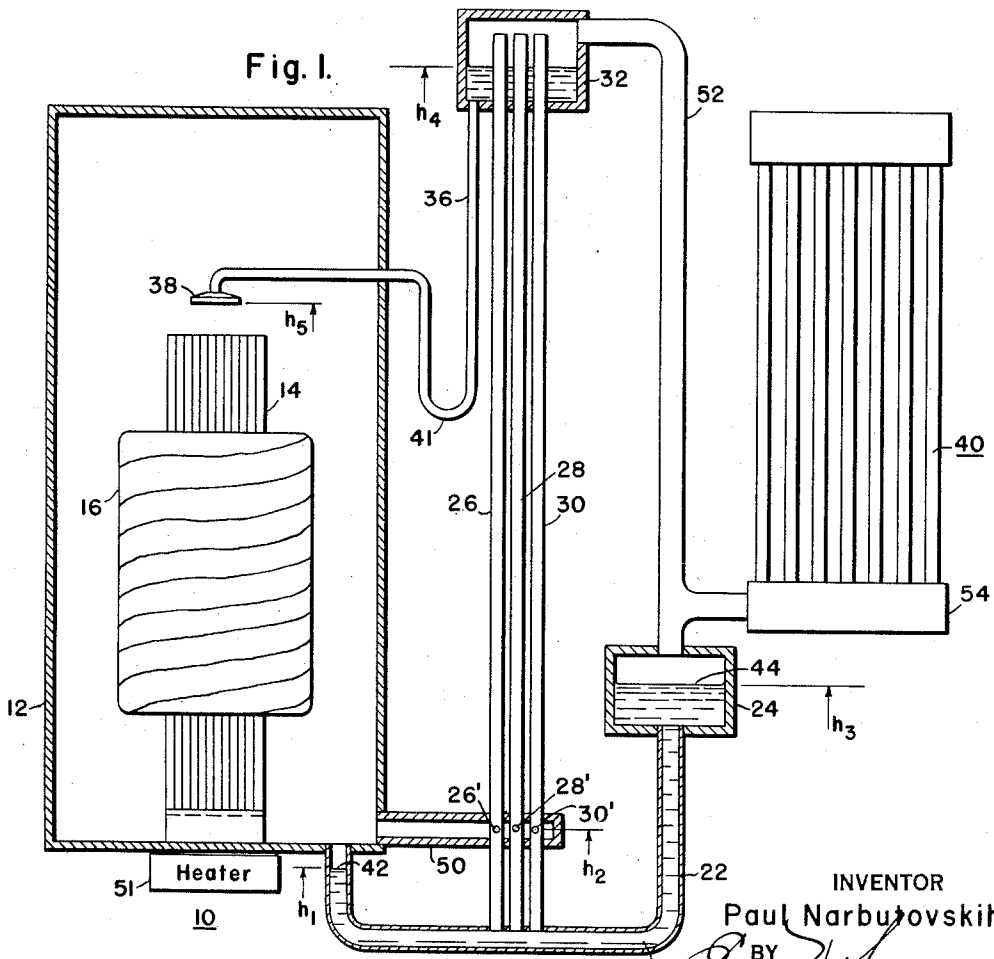
July 29, 1958

PAUL NARBUTOVSKI
NOW BY JUDICIAL CHANGE OF NAME
PAUL NARBUT
TRANSFORMER COOLING APPARATUS

2,845,472

Filed Aug. 28, 1953

2 Sheets-Sheet 1



INVENTOR
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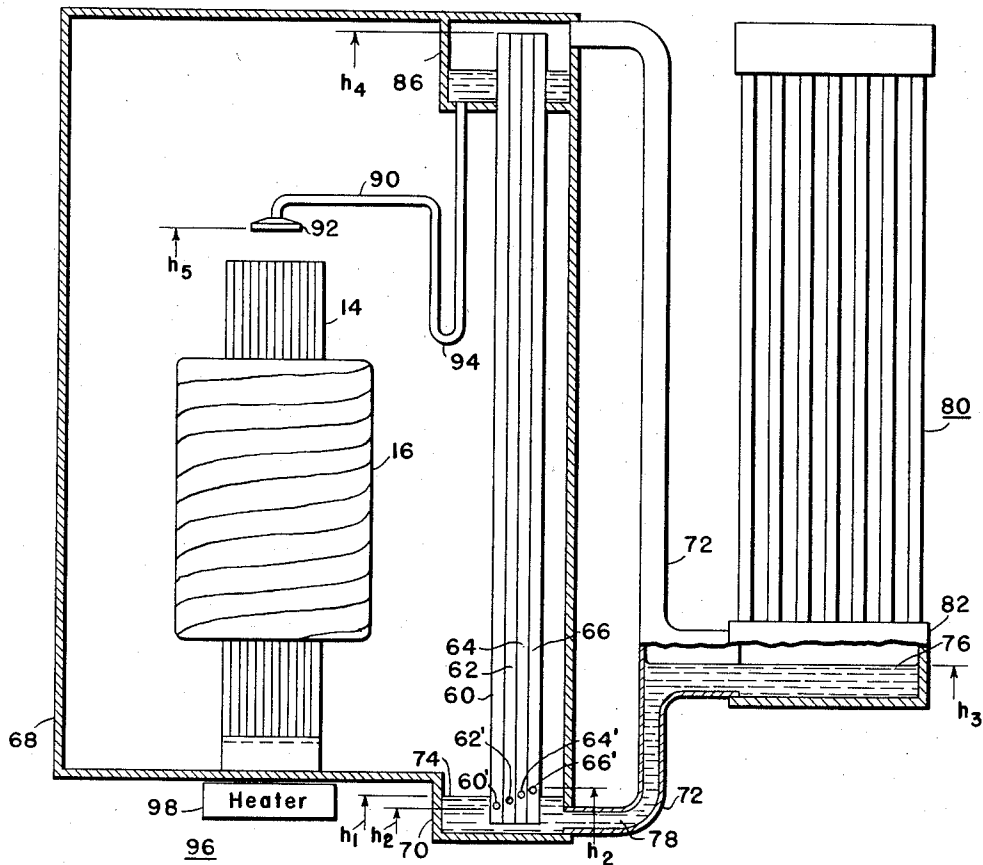


Fig. 2.

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2,845,472

TRANSFORMER COOLING APPARATUS

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Application August 28, 1953, Serial No. 377,049

8 Claims. (Cl. 174—15)

This invention relates to electrical apparatus in which a liquid coolant is vaporized so as to establish insulating medium for the apparatus and dissipate heat therefrom during its operation, and more particularly to means for recirculating the liquid coolant during the operation of the apparatus.

In electrical apparatus such as a transformer in which cooling of a member is accomplished by applying a liquid coolant over the member to be cooled, whereby cooling of the member is effected mainly by the vaporization of the applied liquid coolant, certain problems are present. For instance, it was found necessary to provide means for recirculating the liquid coolant so as to maintain a continuous supply of the liquid coolant to the member to be cooled. In the past, such means comprised a continuously running rotating pump. However, since the liquid coolant has very poor lubricating properties, the problem of lubrication and maintenance of the pump as well as the hermetic sealing required, presented some undesirable aspects.

An object of this invention is to provide, in a cooling system for transformers which effects the cooling by vaporizing and condensing a liquid coolant, for utilizing the heat energy of the transformer to operate a vapor lift which effects a recirculation of the condensed liquid coolant.

A more specific object of this invention is to provide for recirculating a fluorinated organic liquid coolant, so that the liquid coolant comes in contact with a hot portion of a transformer and is vaporized, by applying the vapor pressure of the vaporized liquid coolant within the transformer case to one end of a confined volume of the liquid coolant and applying a lesser pressure to the other end of the confined volume, and by associating one end of a tubular member having an orifice therein with the volume of liquid coolant so as to obtain an adequate submergence for the orifice, whereby the difference between the level of the orifice in the tubular member and the level of liquid coolant at the end of the confined volume that has the vapor pressure applied thereto determines the pressure drop across the orifice and thus the rate of upward flow of the liquid coolant through the tubular member whence it is applied to the hot portion of the transformer.

Other objects of this invention will become apparent from the following description when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a schematic diagram of apparatus embodying a teaching of this invention; and

Fig. 2 is a schematic diagram of another embodiment of this invention.

Referring to Fig. 1, this invention is illustrated by reference to a transformer 10 comprising a sealed case 12 within which is disposed a magnetic core member 14 and electrical windings 16 associated therewith, the core member 14 being disposed to seat on the base of the sealed case 12. For the purpose of simplifying the drawings, the leads to the windings 16 and the bushings nor-

mally carried by the top or cover of the sealed case 12 are not shown.

As hereinbefore mentioned, cooling of electrical apparatus such as the transformer 10 is accomplished by applying a liquid coolant over a hot portion of the transformer, such as the windings 16. Different vaporizable liquid coolants are known to those skilled in the art and can be employed in practicing this invention. The vaporizable liquid coolant may comprise the liquid fluorinated organic compounds selected from the group consisting of hydrocarbons, hydrocarbon ethers and tertiary hydrocarbon amines in which at least half the hydrogen atoms have been substituted by at least one halogen selected from the group consisting of chlorine and fluorine, and of which at least half of the halogens is fluorine. The hydrocarbons and the hydrocarbon groups attached to oxygen or nitrogen atoms may be aliphatic, aromatic, cycloaliphatic and alkaryl. Liquid perfluorocarbons, perfluorocarbon ethers and perfluorocarbon tertiary amines boiling between 50° C. and 225° C. have outstanding properties. Perhalocarbon compounds composed of only carbon and a halogen selected from at least one of the group consisting of chlorine and fluorine, of which fluorine comprises at least half the halogen atoms, have proven to be highly useful.

The vapors of the fluorinated organic compound referred to hereinbefore have outstanding electrical insulating properties. They are superior to practically all other gases in such electrical insulating characteristics as breakdown strength, dielectric strength, power factor and resistance to formation of corona under similar conditions of pressure. These compounds are outstanding in their stability to chemical and thermal breakdown being surpassed only by the permanent gases. The fluorinated compounds in the liquid state exert negligible, if any, solvent or deteriorating action on ordinary insulating materials and varnishes employed in the preparation of conventional electrical elements such as windings, cores and coils.

As examples of specific fluorinated organic compounds having an effective dielectric strength and which may be utilized in practicing this invention either alone or in mixtures, reference may be had to the following list of fluorinated organic compounds:

	Boiling point, ° C.
Perfluorophenanthrene	205
Perfluorodibutyl ether	100
Perfluorotriethyl amine	71
Perfluorotributyl amine	178
Perfluorodimethylcyclohexane	101
Perfluoromethylcyclohexane	76
Perfluoro-n-heptane	82
Perfluorotoluene	102
Perfluorocyclic ether (C ₈ F ₁₈ O)	101
Perfluorocyclic ether (C ₈ F ₁₂ O)	52
Monochlorotetrafluoro-(trifluoromethyl) benzene	137
Dichlorotrifluoro-(trifluoromethyl) benzene	170
Trichlorodifluoro-(trifluoromethyl) benzene	207
Monochloropentadecafluoroheptane	96
2-chloro-1,4-bis(trifluoromethyl) benzene	148
2-chlorotrifluoromethylbenzene	150
Perfluorodimethylcyclohexane	148
Perfluoroethylcyclohexane	101
Perfluoropropylcyclohexane	123
Chlorononafluorobis(trifluoromethyl)cyclohexane	129
Perfluoronaphthalene	140
Perfluoro-1-methylnaphthalene	161
Perfluorodimethylnaphthalenes	177 to 179
Perfluorindane	116 to 117
Perfluorofluorane	190
Perfluorobicyclo-(2.2.1)heptane (746 mm.)	70

The amines, and ethers may have dissimilar halogen substituted hydrocarbon groups present as, for example, 2,2 - dichloro - 1,1,1, - trifluoroethyl - perfluorobutylether and perfluorodibutylethyl-amine. The freezing points of the above listed liquid compounds are below zero degrees centigrade, many being below -50° C., so that they can be safely employed, individually or in mixtures, under nearly all ambient conditions to be expected in service.

In accordance with the teachings of this invention, a volume of liquid coolant 20, comprising at least a portion of the liquid coolant provided for the transformer 10, is confined within a conduit 22 and a reservoir 24, the reservoir 24 actually being an extension of the conduit 22. Further, in accordance with the teachings of this invention, as will be explained more fully hereinafter, the liquid coolant disposed within the conduit 22 flows in operation through a plurality of tubular members 26, 28 and 30, having orifices 26', 28' and 30', respectively, to a sealed separator 32. The function of the separator 32 is to separate the liquid from the vapor phase, as they flow from the tubular members 26, 28 and 30 into the separator 32.

For the purpose of applying the liquid coolant to the core member 14 and the windings 16 a conduit 36 is connected in communication with the separator 32 so as to pass the liquid coolant disposed within the separator 32 to a spray device 38, which in turn sprays the liquid coolant over the core member 14 and the windings 16. The liquid coolant when thus delivered distributes itself over the core member 14 and the windings 16 and is caused to evaporate freely if these components are hot, thereby cooling the core member 14 and the electrical windings 16 and establishing a dielectric medium within the sealed case 12. However, in order to insure that a proper pressure difference can be built up between the sealed case 12 and a cooling device 40, a liquid trap 41 is provided in the conduit 36.

In order that the vapor pressure of the vaporized liquid coolant within the sealed case 12 is applied to the end 42 of the volume of liquid coolant 20 disposed within the conduit 22 and the reservoir 24, one end of the conduit 22 is connected to the sealed case 12 in a suitable manner. On the other hand, the reservoir 24, which is an extension of the conduit 22, is connected in communication with the cooling device 40, whereby a lesser pressure during operation is applied to the end 44 of the volume of liquid coolant 20 than is applied to the end 42.

Owing to this difference in pressures in the sealed case 12 and the cooling device 40 during operation of the apparatus, the end 42 of the volume of liquid coolant 20 is, for instance at a liquid level as represented at h_1 , and the other end 44 of the volume of liquid coolant 20, is, for instance at a liquid level as represented at h_3 .

In order to obtain liquid coolant in each of the tubular members 26, 28 and 30, these tubular members are connected to the conduit 22 so as to be disposed in communication with the volume of the liquid coolant 20 disposed within the conduit 22. In practice, the submergence h_3-h_2 (the level of the orifices 26', 28' and 30') should be slightly less than h_3-h_1 . Also in practice, the pressure drop across the orifices 26', 28' and 30' is determined by the difference between the levels h_2 and h_1 . With a pressure drop across the orifices 26', 28' and 30', the vaporized liquid coolant flows from within the sealed case 12 through a sealed conduit 50 and the orifices 26', 28' and 30', to thereby effect an upward flow of the liquid coolant through each of the tubular members 26, 28 and 30. The reason that the liquid coolant rises in the tubular members 26, 28 and 30 is that the vaporized liquid coolant flowing into the tubular members 26, 28 and 30 becomes intermixed with the liquid within the tubular members 26, 28 and 30, and hence it causes a decrease in the average density of the liquid-vapor within the tubular members 26, 28 and 30.

In order that the liquid coolant flowing up through the

tubular members 26, 28 and 30 can be applied to the core member 14 and the windings 16, the upper end of each of the tubular members 26, 28 and 30 is disposed in communication with the separator 32. In particular, the tubular members 26, 28 and 30 pass upwardly through the base of the separator 32, the tubular members 26, 28 and 30 being suitably secured to the separator 32.

Thus, in operation both the vaporized liquid coolant received from the case 12 and the liquid coolant pass upwardly through the tubular members 26, 28 and 30 and finally pass into the separator 32. The liquid coolant then passes through the conduit 36 to the spray device 38 which distributes the liquid coolant over the core member 14 and the electrical windings 16 in a customary manner. However, in order to insure the flow of the liquid coolant from the separator 32 to the spray device 38, it is necessary that $(h_4-h_5) > (h_3-h_1)$, h_1 , h_2 , h_3 , h_4 and h_5 all being taken from the same base line (not shown).

The vaporized liquid coolant that passes into separator 32 from the tubular members 26, 28 and 30 passes through a conduit 52 to the cooling device 40 where it is condensed. The vaporized liquid coolant condensed within the cooling device 40 flows back into the reservoir 24. In this instance, the conduit 52 is connected to the separator 32, to the reservoir 24 and to the lower header 54 of the cooling device 40, and thus connects the cooling device 40 in communication with the reservoir 24 and in communication with the separator 32.

In summary, the apparatus illustrated in Fig. 1 operates as follows. Once the liquid levels h_1 and h_3 have been established, the vaporized liquid coolant in the sealed case 12 flows through the orifices 26', 28' and 30' of the tubular members 26, 28 and 30, respectively. The vaporized liquid coolant from the case 12 that passes through the orifices 26', 28' and 30' effects a flow of liquid coolant through the respective tubular members to the separator 32. The liquid coolant so transmitted to the separator 32 is then passed through the conduit 36 to the spray device 38 which applies the liquid coolant over the core member 14 and the windings 16, the heat of the core member 14 and the windings 16 effecting a vaporization of the liquid coolant whereby the core member 14 and the windings 16 are cooled and a dielectric medium, namely the vaporized liquid coolant, is established within the sealed case 12 to thereby insulate the core member 14 and the windings 16 from the sealed case 12.

The vaporized liquid coolant that passes upwardly through the tubular members 26, 28 and 30 to the separator 32 is simultaneously passed through the conduit 52 to the cooling device 40 where the vaporized liquid coolant is condensed. The condensed liquid coolant is then returned to the reservoir 24. This recirculating operation is continually taking place during the operation of the apparatus.

However, before the normal operation is established, it is necessary to provide some means for obtaining liquid levels h_3 and h_1 . That is, some means must be provided for building up the pressure within the sealed case 12. This can be accomplished by means of an auxiliary heater 51 which applies heat to the sealed case 12 to thereby increase the pressure therewithin and thus force the end 42 of the volume of liquid coolant 20 to a liquid level such as represented at h_1 . This establishes the necessary pressure difference between the case 12 and the cooling device 40, to thus effect a flow of the liquid coolant over the core member 14 and the windings 16. When the liquid coolant flows over the core member 14 and the windings 16, these members being hot, the pressure within the sealed case 12 will be maintained and the system will operate as hereinbefore explained without the need of the auxiliary heater 51. Of course, it is to be understood that the apparatus could be primed by means of an auxiliary pump (not shown) which would effect a flow of the liquid coolant

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over the core member 14 and the windings 16 to thereby increase the pressure within the sealed case 12. When the pressure within the case 12 reached a predetermined value, of course there would be no need for the further operation of the auxiliary pump (not shown).

Referring to Fig. 2 there is illustrated another embodiment of the teachings of this invention in which like components of Figs. 1 and 2 have been given the same reference characters. The main distinction between the apparatus illustrated in Figs. 1 and 2 is that in the apparatus illustrated in Fig. 2, tubular members 60, 62, 64 and 66, corresponding to the tubular members 26, 28 and 30, illustrated in Fig. 1, are disposed inside a sealed transformer case 68, rather than exteriorly of the transformer case, as illustrated in Fig. 1. As illustrated, the tubular members 60, 62, 64 and 66 are provided with orifices 60', 62', 64' and 66'.

In the embodiment shown in Fig. 2, the bottom of the case 68 is provided with a sump 70 for holding liquid coolant, the purpose of which will be explained more fully hereinafter. In this instance, one end of a conduit 72 is connected to the sealed case 68 adjacent the sump 70 and in communication therewith, the sump 70 and a portion of the conduit 72 containing at least a portion of the liquid coolant provided for the apparatus illustrated in Fig. 2. Thus, in operation the vapor pressure of the vaporized liquid coolant within the sealed case 68 is applied to the end 74 of the liquid coolant disposed within the sump 70. On the other hand, the end 76 of the volume of liquid coolant 78 disposed within the sump 70 and the conduit 72, has a lesser pressure applied thereto, as determined by the pressure within a cooling device 80, corresponding to the cooling device 40, illustrated in Fig. 1. In this instance, the cooling device 80 is provided with a lower header 82, which in combination with a portion of the conduit 72, functions as a reservoir.

As illustrated, the conduit 72 is connected in communication with the cooling device 80 and with a separator 86. More particularly, one end of the conduit 72 is suitably secured to the separator 86 so as to permit the passage of vapor from the separator 86 to the cooling device 80, the header 82 of the cooling device 80 being suitably secured to the conduit 72 intermediate its ends so as to permit the condensed liquid coolant to flow into the conduit 72 and to permit the passage of the vaporized liquid coolant from the conduit 72 to the cooling device 80.

In order to obtain liquid coolant in the tubular members 60, 62, 64 and 66, one end of each of the tubular members 60, 62, 64 and 66 is disposed in communication with the liquid coolant disposed within the sump 70. It is to be noted that the levels h_1 , h_2 and h_3 in the embodiment illustrated in Fig. 2, correspond to the levels h_1 , h_2 and h_3 illustrated in Fig. 1 and bear the same relationship as previously explained for the apparatus illustrated in Fig. 1.

For the purpose of passing the liquid coolant flowing through the tubular members 60, 62, 64 and 66 to the separator 86 so that the liquid coolant can be distributed over the core member 14 and the windings 16, the other end of each of the tubular members 60, 62, 64 and 66 is disposed in communication with the separator 86. In this instance, the means for applying the liquid coolant over the core member 14 and the windings 16 comprises a conduit 90 connected in communication with the separator 86 and a spray device 92. As illustrated, the conduit 90 is provided with a liquid trap 94 in order to insure that a proper pressure difference can be built up between the sealed case 68 and the cooling device 80 at the start of the operation. Also, as was the case for the apparatus illustrated in Fig. 1 ($h_4 - h_5 > (h_3 - h_1)$), in order to insure the flow of the liquid coolant from the separator 86 through the conduit 90 to the spray device 92.

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As can be seen from Fig. 2, the orifices 60', 62', 64' and 66' are vertically spaced from one another, at different levels h_2 , so that one or more of the tubular members 60, 62, 64 and 66 will be operating to supply liquid coolant to the separator 86, depending upon the load on the transformer 96. For instance, if the transformer 96 is operating at a low load, all but the orifice 66' will be submerged by the liquid coolant disposed within the sump 70. Thus, under such low load conditions, only the tubular member 66 is operating to supply liquid coolant to the separator 86. However, under heavy load condition on the transformer 96, none of the orifices 60', 62', 64' or 66' will be submerged by the liquid coolant disposed within the sump 70. Thus under such conditions, all of the tubular members 60, 62, 64 and 66 will be supplying liquid coolant to the separator 86. With the liquid coolant disposed within the sump 70 at the liquid level h_1 as shown in Fig. 2, only the tubular members 64 and 66 will function to supply liquid coolant to the separator 86. It is to be noted, however, that even though only one of these tubular members is operating to supply liquid coolant to the separator 86, the particular operating tubular member will deliver its full capacity at a normal efficiency. Also in operation the pressure drop across a particular orifice 60', 62', 64' or 66', that is not submerged by the liquid coolant within the sump 70, is proportional to the difference between the level h_2 of the particular orifice and the level h_1 . The pressure drop across the unsubmerged orifices determines the rate of flow of the liquid coolant up through the particular tubular member or members to the separator 86.

As was the case with the apparatus illustrated in Fig. 1, it is necessary to provide either an auxiliary heater 98 or an auxiliary pump (not shown) in order to prime the apparatus and thus increase the pressure within the sealed case 68 to such a value as to establish a pressure difference as represented by $(h_3 - h_1)$. Once such a pressure difference is established, the vaporized liquid coolant within the sealed case 68 flows through those orifices 60', 62', 64' and 66' that are not submerged by the liquid coolant disposed within the sump 70 to thereby effect a flow of the liquid coolant up through the tubular members whose orifices are not submerged to the separator 86. The liquid coolant disposed within the separator 86 is then passed through the conduit 90 to the spraying device 92 which applies the liquid coolant over the core member 14 and the windings 16. When the liquid coolant is applied to the hot core member 14 and the windings 16 it vaporizes to thereby establish a dielectric medium within the sealed case 68. The vaporized liquid coolant that flows upward through the particular tubular member or members to the separator 86 is simultaneously passed through the conduit 72 to the cooling device 80 where it is condensed. The condensed liquid coolant then returns to the volume 78 of liquid coolant. The above-described operation is continuously repeated during the operation of the apparatus illustrated in Fig. 2.

It is to be understood that although a single conduit 72 is illustrated in Fig. 2, two conduits (not shown) could be utilized, one of the conduits (not shown) could be connected between the sealed case 68 and the lower header 82 and the other conduit (not shown) could be connected between the separator 86 and the lower header 82 of the cooling device 80. Two such conduits (not shown) would be the full equivalent of the single conduit 72 illustrated in Fig. 2. Also, in Fig. 1, the conduit 22, the reservoir 24, and the conduit 52 could be formed from a single conduit (not shown) and such a single conduit (not shown) would be the full equivalent of the conduits 22 and 52 and the reservoir 24.

Since certain changes may be made in the above apparatus and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above descrip-

tion or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature of between 50° C. and 225° C., means for confining a volume of the liquid coolant, one end of the volume of the liquid coolant being subjected to the vapor pressure of the vaporized liquid coolant within the sealed case, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a cooling device, the cooling device being connected in communication with the separator and with the means for confining a volume of the liquid coolant, whereby the other end of the volume of the liquid coolant is subjected to a lesser pressure within the cooling device, a tubular member having an orifice therein, one end of the tubular member being disposed in communication with the volume of the liquid coolant so as to obtain liquid coolant, the other end of the tubular member being disposed in communication with the separator, and the orifice in the tubular member being in communication with the vaporized liquid coolant within the sealed case, whereby the vaporized liquid coolant passes through the orifice to thereby effect an upward flow of the liquid coolant through the tubular member, and means for initially effecting the application of the liquid coolant to the member to be cooled.

2. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature of between 50° C. and 225° C., means for confining a volume of the liquid coolant, one end of the volume of the liquid coolant being subjected to the vapor pressure of the vaporized liquid coolant within the sealed case, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a cooling device, the cooling device being connected in communication with the separator and with the means for confining a volume of the liquid coolant, whereby the other end of the volume of the liquid coolant is subjected to a lesser pressure within the cooling device, a plurality of tubular members each having an orifice therein, one end of each of the tubular members being disposed in communication with the volume of the liquid coolant so as to obtain liquid coolant in each of the tubular members, the other end of each of the tubular members being disposed in communication with the separator, and the orifice in each of the tubular members being in communication with the vaporized liquid coolant within the sealed case, whereby the vaporized liquid coolant passes through the orifices to thereby effect an upward flow of the liquid coolant through the plurality of tubular members, and means for initially effecting the application of the liquid coolant to the member to be cooled.

3. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature between 50° C. and 225° C., a conduit containing at least a portion of said liquid coolant, one

end of the conduit being connected to the sealed case so that the vapor pressure of the vaporized liquid coolant within the sealed case is applied to one end of the liquid coolant disposed within the conduit, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a cooling device, the cooling device being connected in communication with the separator and with the other end of the conduit whereby a lesser pressure within the cooling device is applied to the other end of the liquid coolant disposed within the conduit, a tubular member having an orifice therein of predetermined size, one end of the tubular member being disposed in communication with the liquid coolant disposed within the conduit so as to obtain liquid coolant in the tubular member, the other end of the tubular member being disposed in communication with the separator, means for passing the vaporized liquid coolant from within the sealed case through the orifice in the tubular member to thereby effect an upward flow of the liquid coolant through the tubular member, and means for initially effecting the application of the liquid coolant to the member to be cooled.

4. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature between 50° C. and 225° C., a conduit containing at least a portion of said liquid coolant, one end of the conduit being connected to the sealed case so that the vapor pressure of the vaporized liquid coolant within the sealed case is applied to one end of the liquid coolant disposed within the conduit, a cooling device, the other end of the conduit being connected in communication with the cooling device, whereby a lesser pressure within the cooling device is applied to the other end of the liquid coolant disposed within the conduit, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a plurality of tubular members each having an orifice therein of predetermined size, one end of each of the tubular members being disposed in communication with the liquid coolant disposed within the conduit so as to obtain liquid coolant in each of the tubular members, the other end of each of the tubular members being disposed in communication with the separator, means for passing the vaporized liquid coolant from within the sealed case through each orifice in the tubular members to thereby effect an upward flow of the liquid coolant through the tubular members, another conduit connected between the cooling device and the separator, said another conduit functioning to pass the vaporized liquid coolant, that passes upwardly through the tubular members, to the cooling device, and means for initially effecting the application of the liquid coolant to the member to be cooled.

5. In a transformer provided with liquid coolant, the combination comprising a sealed case having a member to be cooled disposed therein, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature between 50° C. and 225° C., a conduit having a reservoir at one end thereof, the conduit and the reservoir containing at least a portion of said liquid coolant and the other end of the conduit being connected to the sealed case so that the vapor pressure of the vaporized liquid coolant within the sealed case is applied to one end of the liquid coolant disposed within the conduit and the reservoir, a cooling device, the reservoir being connected in communication with the cooling device whereby

a lesser pressure within the cooling device is applied to the other end of the liquid coolant disposed within the conduit and the reservoir, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a plurality of tubular members each having an orifice therein of predetermined size, one end of each of the tubular members being disposed in communication with the liquid coolant disposed within the conduit so as to obtain liquid coolant in each of the tubular members, the other end of each of the tubular members being disposed in communication with the separator, means for passing the vaporized liquid coolant from within the sealed case through each orifice in the tubular members to thereby effect an upward flow of the liquid coolant through the tubular members, another conduit connected between the cooling device and the separator, said another conduit functioning to pass the vaporized liquid coolant, that passes upwardly through the tubular members, to the cooling device, and means for initially effecting the application of the liquid coolant to the member to be cooled.

6. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, a portion of the sealed case comprising a sump, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature between 50° C. and 225° C., a conduit, one end of the conduit being connected to the sealed case adjacent the sump and in communication therewith, the sump and the conduit containing at least a portion of said liquid coolant whereby the vapor pressure of the vaporized liquid coolant with the sealed case is applied to the liquid coolant within the sump, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a cooling device, the conduit being connected in communication with the cooling device and with the separator, whereby a lesser pressure within the cooling device is applied to the end of the liquid coolant disposed within the conduit, a tubular member having an orifice therein of predetermined size, one end of the tubular member being disposed in communication with the liquid coolant disposed within the sump so as to obtain liquid coolant in the tubular member, the other end of the tubular member being disposed in communication with the separator so as to pass liquid coolant thereto as effected by the vaporized coolant that passes from within the sealed case through the orifice in the tubular member, and means for initially effecting the application of the liquid coolant to the member to be cooled.

7. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, a portion of the sealed case comprising a sump, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature between 50° and 225° C., a conduit, one end of the conduit being connected to the sealed case adjacent the sump and in communication there-

with, the sump and the conduit containing at least a portion of said liquid coolant whereby the vapor pressure of the vaporized liquid coolant within the sealed case is applied to the liquid coolant within the sump, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a cooling device, the conduit being connected in communication with the cooling device and with the separator, whereby a lesser pressure within the cooling device is applied to the end of the liquid coolant disposed within the conduit, a plurality of tubular members each having an orifice therein of predetermined size, one end of each of the tubular members being disposed in communication with the liquid coolant disposed within the sump so as to obtain liquid coolant in each of the tubular members, the other end of each of the tubular members being disposed in communication with the separator so as to pass liquid coolant thereto as effected by the vaporized coolant that passes from within the sealed case through the orifices in the tubular members, and means for initially effecting the application of the liquid coolant to the member to be cooled.

8. In a transformer provided with a liquid coolant, the combination comprising, a sealed case having a member to be cooled disposed therein, a portion of the sealed case comprising a sump, means for applying the liquid coolant over the member to be cooled whereby cooling of said member is effected mainly by the vaporization of the applied liquid coolant, the liquid coolant comprising a fluorinated organic liquid coolant boiling at a temperature between 50° C. and 225° C., a conduit, one end of the conduit being connected to the sealed case adjacent the sump and in communication therewith, the sump and the conduit containing at least a portion of said liquid coolant whereby the vapor pressure of the vaporized liquid coolant within the sealed case is applied to the liquid coolant within the sump, a separator, the separator being connected in communication with the means for applying the liquid coolant over the member to be cooled, a cooling device, the conduit being connected in communication with the cooling device and with the separator, whereby a lesser pressure within the cooling device is applied to the end of the liquid coolant disposed within the conduit, a plurality of tubular members each having an orifice therein of predetermined size, the orifices being vertically spaced from one another, one end of each of the tubular members being disposed in communication with the liquid coolant disposed within the sump so as to obtain liquid coolant in each of the tubular members, the other end of each of the tubular members being disposed in communication with the separator so as to pass liquid coolant thereto as effected by the vaporized coolant that passes from within the sealed case through the orifices in the tubular members, and means for initially effecting the application of the liquid coolant to the member to be cooled.

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