# United States Patent [19]

**Staub et al.**

[11] **3,887,759**

[45] **June 3, 1975**

[54] **EVAPORATIVE COOLING SYSTEM EMPLOYING LIQUID FILM EVAPORATION FROM GROOVED EVAPORATOR SURFACE AND VAPOR PUSH PUMP FOR CIRCULATING LIQUID**


[75] Inventors: **Fred W. Staub; Philip G. Kosky,** both of Scotia, N.Y.

[73] Assignee: **General Electric Company,** Schenectady, N.Y.



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[21] Appl. No.: **452,945**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 310,323, Nov. 29, 1972, abandoned.

[52] **U.S. Cl.** .............................. **174/15 R;** 165/105

[51] **Int. Cl.** .......................................... **H01f 27/18**

[58] **Field of Search**.. 174/15 R, 15 C, 16 R, 16 BH; 165/105; 417/134, 135, 136, 138, 208, 209; 336/55, 57, 58, 61


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*Primary Examiner*—Arthur T. Grimley
*Attorney, Agent, or Firm*—Paul R. Webb, II; Joseph T. Cohen; Jerome C. Squillaro


[57] **ABSTRACT**


Within a vaporization chamber which houses apparatus to be cooled (e.g., a transformer) a film of liquid flowing over a heated surface of said apparatus is evaporated thereby cooling the apparatus. The surface includes grooves which stabilize the distribution of a flowing liquid film so that all sections of the surface are maintained in a wetted condition by the flowing film thereby eliminating, or significantly reducing, the occurrence of dry, and therefore hot, spots on the surface. A vapor push pump within the vaporization chamber recirculates liquid so that the liquid can be redistributed as a flowing film over the aforesaid grooved surfaces. The use of a vapor push pump in combination with grooved evaporator surfaces, inter alia, enables significant efficiencies and economies respecting, among other things, the circulation rate of liquid coolant required.


**3 Claims, 4 Drawing Figures**

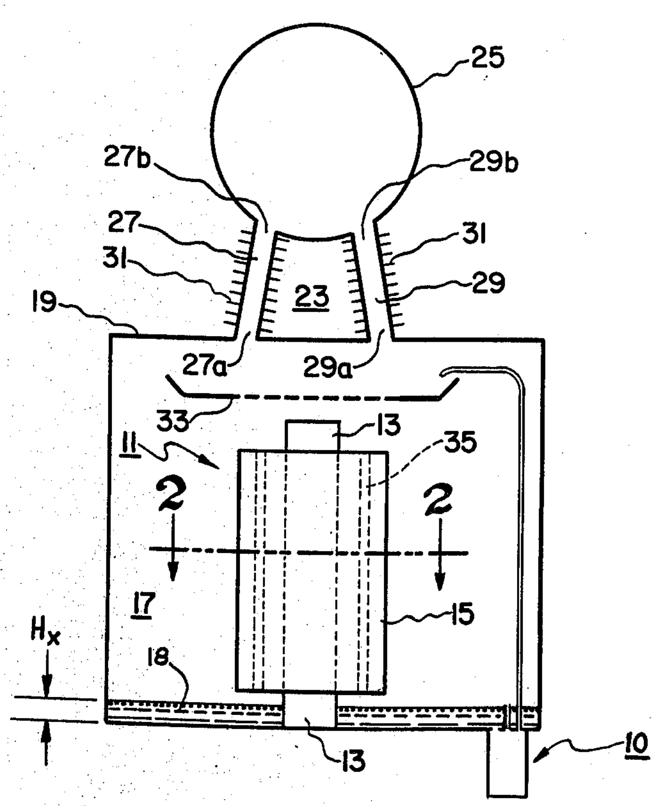
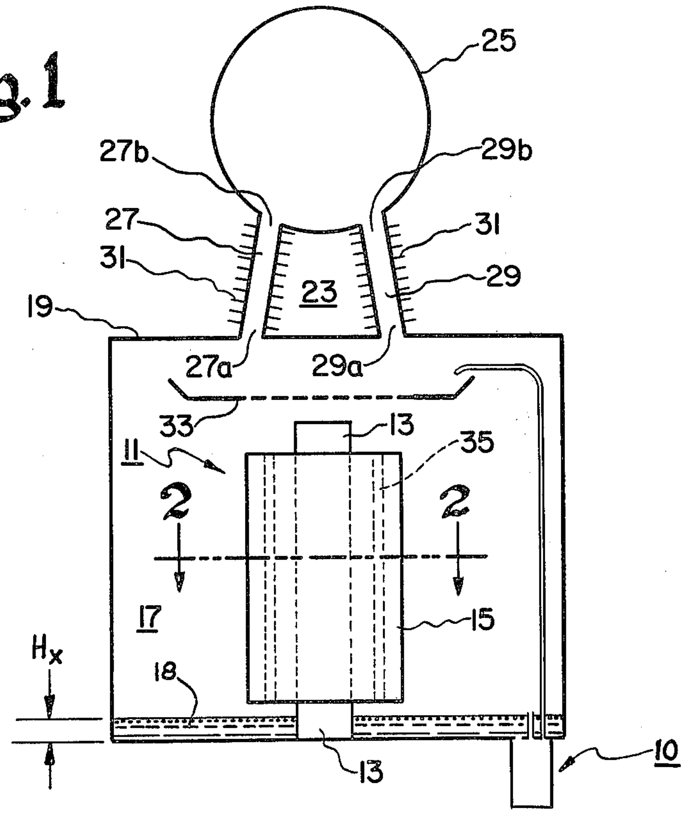


Fig. 1



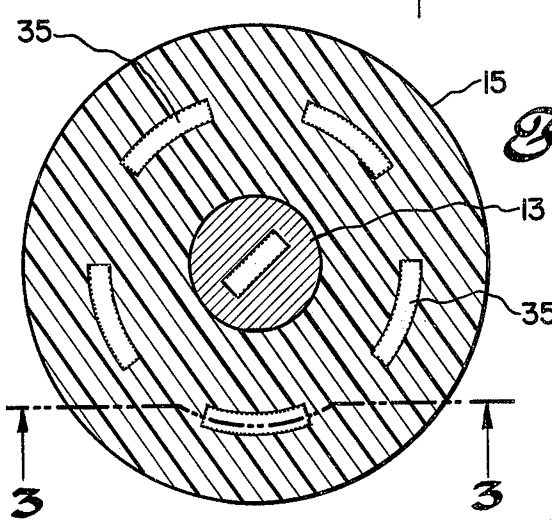




Fig. 2

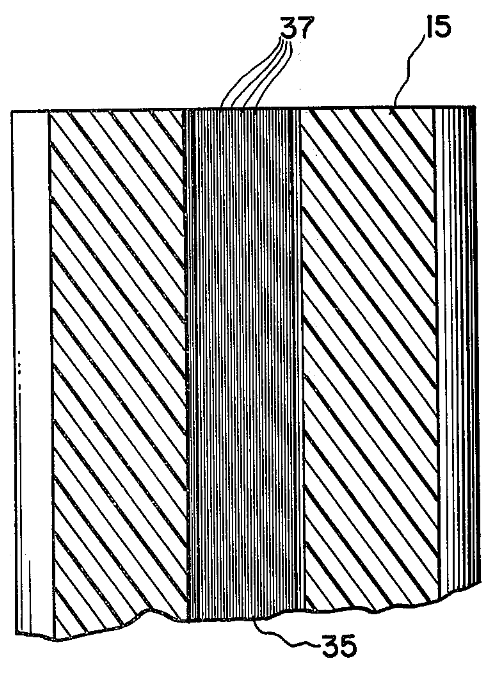
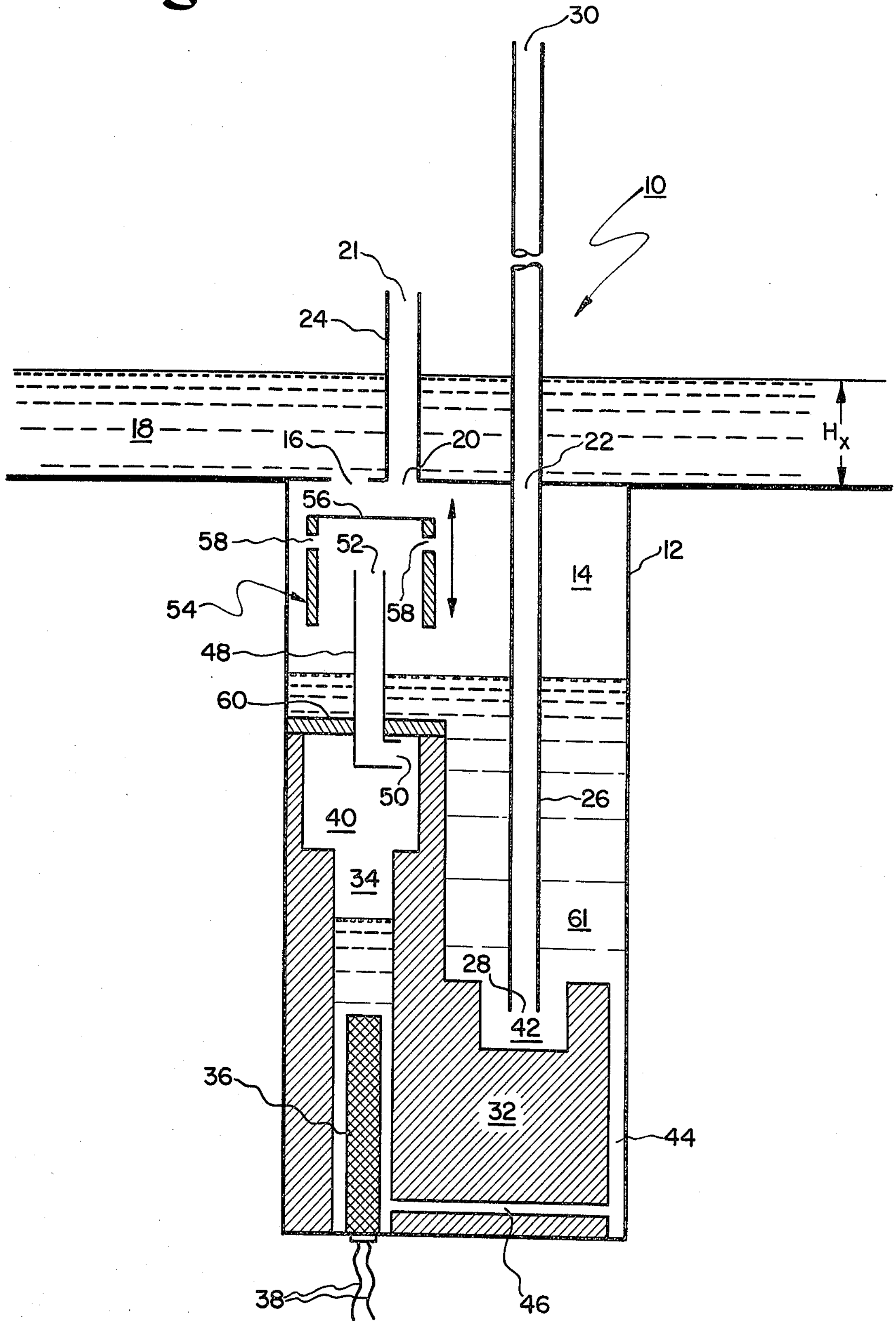



Fig. 3

Fig. 4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# EVAPORATIVE COOLING SYSTEM EMPLOYING LIQUID FILM EVAPORATION FROM GROOVED EVAPORATOR SURFACE AND VAPOR PUSH PUMP FOR CIRCULATING LIQUID

This is a continuation of application Ser. No. 310,323, filed Nov. 29, 1972, now abandoned.

## CROSS-REFERENCES TO RELATED APPLICATIONS

Hereinafter disclosed, but not claimed herein, is a vapor push pump which may, advantageously, be employed as the liquid recirculation pump in the combination forming the liquid film evaporative cooling system of the subject invention; said vapor push pump being both disclosed and claimed in the U.S. patent application, Ser. No. 310,662, filed Nov. 29, 1972, on even date herewith, now U.S. Pat. No. 3,819,301 in behalf of the inventors H. Jaster and P. G. Kosky, titled SINGLE VALVE VAPOR PUSH PUMP.

A related novel vapor push pump is also disclosed in the U.S. patent application Ser. No. 310,437, filed Nov. 29, 1972, on even date herewith, now U.S. Pat. No. 3,834,835 in behalf of the inventors H. Jaster, P. G. Kosky and F. W. Staub, titled DOUBLE VALVE VAPOR PUSH PUMP.

Also, an example of a liquid film evaporative cooling system, with which the subject invention is concerned, as well as some sophistications which may be included therein is to be had by referring to the earlier-filed U.S. patent application, Ser. No. 266,065, filed June 26, 1972, now abandoned in behalf of F. W. Staub titled VAPORIZATION COOLING SYSTEM USING A SEGREGATED NON-CONDENSIBLE DIELECTRIC GAS FOR PRESSURIZING A VAPOR COOLANT AND MAINTAINING DIELECTRIC STRENGTH WITHOUT SIGNIFICANTLY INTERFERING WITH CONDENSATION OF THE VAPOR.

The entire right, title and interest in and to the inventions described in the aforementioned patent applications, as well as in and to the aforementioned patent applications, and the entire right, title and interest in and to the invention herein disclosed, as well as in and to the patent application of which this specification is a part, are assigned to the same assignee.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention pertains, in general, to the cooling of apparatus (e.g., transformers, etc.) by evaporating a film of liquid from the surface, or surfaces, of the apparatus; and, in particular, to a film evaporation cooling system including, inter alia, liquid pumping means for supplementing condensate coolant, film flow over said surfaces, said surfaces including grooves therein for stabilizing the distribution of the flowing film of liquid coolant.

Although the subject invention is hereinafter described, and illustrated in the accompanying drawing figure, in connection with the liquid film evaporation cooling of static heat producing electrical apparatus, such as a transformer, it is to be understood that the invention may be otherwise employed. For example, the heat producing apparatus need not be electrical and, if electrical, it need not be static. However, for purposes of illustration the subject invention is hereinafter disclosed as being incorporated in the hereinbefore identified vaporization cooling system disclosed in U.S. patent application Ser. No. 266,065, filed June 26, 1972, in behalf of F. W. Staub.



2. Description of Prior Art

Closed, or hermetically sealed, film evaporation cooling systems employing two-phase fluid coolants have been proposed. In such systems the fluid coolant is distributed while in its liquid phase as a liquid film over a surface, or surfaces, of the apparatus to be coded. Heat transfer from the heated surface of the apparatus to the liquid film evaporates the film thereby cooling the surface and the apparatus. Where the apparatus to be cooled is electrical in nature (e.g., a transformer, etc.) the two-phase fluid coolant is a dielectric and, sometimes, an inert non-condensible dielectric gas is used in addition to the aforesaid two-phase fluid; the inert non-condensible gas serving to maintain adequate system pressure and dielectric strength. In the aforementioned film evaporation cooling system the vapor produced subsequently condenses and is redistributed as a liquid film over the surfaces of the apparatus to be cooled. The evaporation-condensation cycle causes a natural recirculation of the coolant. However, it has been found that the flowing liquid coolant cannot normally be maintained intact on smooth surfaces unless substantial liquid coolant is caused to flow in addition to the aforementioned natural recirculation rate. If the aforesaid rupture of the liquid film occurs then large dry and therefore hot spots are formed on the surfaces to be cooled resulting in undesirably high temperatures. To reduce the said undesirable situation either excess liquid may be pumped to the cooling surfaces in addition to the condensate flow, or the apparatus to be cooled may be partially submerged in a pool of the liquid coolant.

## SUMMARY OF THE INVENTION

One object of the invention is to provide a cooling system wherein apparatus to be cooled by evaporation of a film of liquid coolant therefrom need not have substantial portions of the apparatus immersed in a pool, or reservoir, of the liquid coolant.

Another object of the invention is to provide a film evaporation cooling system wherein the quantity of the two-phase fluid coolant required is, under the circumstances, the minimum quantity.

Another object of the invention is to provide a film evaporation cooling system which can satisfactorily perform the required cooling of apparatus throughout a wide range embracing a relatively low heat flux condition of the apparatus to a design heat flux condition of the apparatus.

Another object of the invention is to provide a film evaporation cooling system wherein liquid film is maintained intact to insure intact liquid film flow in order to at least reduce to a minimum the formation of hot, or dry, spots on the surfaces of the apparatus to be cooled.

In accordance with the invention there is provided a film vaporization cooling system comprising: a vaporization chamber containing heat producing apparatus to be cooled and a two-phase fluid coolant comprising a liquid and a vapor, said liquid residing at a bottom portion of the chamber and having a liquid level above the bottom of the chamber, said liquid also being distributed as a film which coats said apparatus, said vapor being produced by vaporization of said liquid by the heat produced by said apparatus, said vapor occupying space in said chamber above said liquid level; a condenser coupled with said vaporization chamber for receiving vapor from said vaporization chamber, condensing the received vapor and enabling its return as a liquid to said chamber; means in said vaporization chamber for receiving the liquid from said condenser and enabling the distribution of said liquid as a film coating said apparatus; and, a vapor push pump for pumping liquid from said liquid residing at the bottom portion of said chamber to said means for enabling the distribution of liquid as a film.

An additional feature of the invention is the inclusion of a number of grooves in the surfaces of the heat producing apparatus to be cooled. The grooves enable the liquid which is coating the apparatus to maintain an intact liquid film thereon thereby significantly reducing the occurrence of hot or dry spots on said surfaces for a minimum liquid coolant rate.

Other objects and features, as well as the many advantages of the invention, appear hereinafter whereat the invention is disclosed by means of an illustrative example with reference to accompanying drawing figures.

## THE DRAWINGS

FIG. 1 is a schematic diagram of the film vaporization cooling apparatus according to the invention showing a vaporization chamber, a condenser, and an inert gas-holding reservoir, a transformer to be cooled within the vaporization chamber and a vapor push pump.

FIG. 2 is a cross section view taken on section line 2—2 of FIG. 1.

FIG. 3 is another cross section view taken on section line 3—3 of FIG. 2.

FIG. 4 is a schematic diagram of one form of vapor push pump which may be employed in the combination shown in FIG. 1.

## DESCRIPTION OF PREFERRED EMBODIMENT

In the schematic diagram shown in FIG. 1 a transformer designated, generally, by the reference number **11** includes a core **13** of laminated magnetic steel on which a number of conductor windings embedded in a matrix **15** of insulating material are disposed. The transformer **11** may be mounted on a suitable pedestal (not shown) of dielectric material. As shown the transformer **11** is located within a vaporization chamber **17** of a transformer casing **19**. A surface condenser **23** is coupled in series between chamber **17** of casing **19** and a gas-holding reservoir **25**. The system including the vaporization chamber **17**, the condenser **23** and gas-holding reservoir **25** form a closed, or hermetically sealed, system. The system is charged with a mass of vaporizable dielectric liquid, such as an inert fluorocarbon liquid; e.g., perfluoro-2-butyltetrahydrofuran which is marketed under the designation FC–75 of the 3M Company. The system is also charged with an inert non-condensible dielectric gas such as sulfur hexafluoride ($SF_6$). The fluorocarbon liquid coolant has a high dielectric strength. However, the dielectric strength of its vapor varies directly with its density. Accordingly, at low system temperatures when the vapor density is low little dielectric protection is provided. Accordingly, the non-condensible inert dielectric gas is charged into the system to regulate the system pressure for the purpose of maintaining the dielectric strength in the vapor phase in the chamber **17** when the system temperature is low. It is to be understood that the aforementioned inert fluorocarbon liquid coolant and inert gas are specifically named herein as examples and that other liquid coolants and inert non-condensible gases may be employed. The operation of a film vaporization cooling system employing the combination of a non-condensible dielectric gas and a dielectric two phase fluid coolant is disclosed in the U.S. patent application Ser. No. 266,065 of F. W. Staub, hereinbefore more fully identified.

In FIG. 1 the condenser **23** is illustrated as an air-cooled surface condenser comprising a plurality of condenser tubes, such as the tubes **27** and **29**. Each of the tubes **27** and **29** may be provided with spaced cooling fins **31 . . . 31** which are connected to the outer wall surfaces of the tubes and, as is well known, such cooling fins promote heat transfer from the tubes. The tube **27** is open at both ends, **27***a* and **27***b;* the opening **27***a* serves as a vapor inlet as well as a condensate outlet port. As indicated the tube opening **27***a* is coupled to and communicates with the top of the vaporization chamber **17.** The tube opening **27***b* is coupled to and communicates with the gas-holding reservoir **25.** Similarly, the condenser tube **29** is open at both ends, **29***a* and **29***b*. The opening **29***a* serves as both a vapor inlet and condensate outlet port and is coupled to and communicates with the top of the vaporization chamber **17.** The tube opening **29***b* is coupled to and communicates with the gas reservoir **25.** Mounted within the vaporization chamber **17** near the top thereof and situated directly below the tube openings **27***a* and **29***a* is a perforated drip pan **33** which is arranged to receive condensate exiting from the openings **27***a* and **29***a* of the surface condenser **23.** Being perforated the pan **33** enables condensate collected therein to be distributed over the surfaces of the transformer **11.** The liquid collected in the pan **33** drips or falls on the core **13** which may contain one or more cooling ducts and on insulating matrix **15** where is formed a liquid film which coats the surfaces of the transformer **11.** FIGS. **2** and **3,** hereinafter discussed, illustrate grooved surfaces. The excess liquid collects in a pool **18** or body of liquid in the bottom of vaporization chamber **17.** The pool **18** of liquid coolant, having the liquid level $H_x$ measured from the bottom of the chamber **17** of casing **19** includes the bottom portion of the core **13** immersed therein.

In FIG. 1 two condenser tubes **27** and **29** of surface condenser **23** have been shown diagrammatically. However, it is to be understood that more than, or less than, two condenser tubes may be employed for connecting the vaporization chamber **17** with the gas holding reservoir **25,** depending on the heat transfer rate required for the specific purpose.

At, for example, median ambient design temperatures the vaporizable dielectric liquid coolant pool **18** fills the bottom portion of vaporization chamber **17** of casing **19** to the level $H_x$ as indicated. Heat produced by the transformer **11** vaporizes the liquid film thereby cooling the transformer. The vapor moves upwardly in the vaporization chamber **17** and enters the condenser **23** through the inlet openings **27***a* and **29***a*. The non-condensible dielectric gas is normally largely confined in the reservoir **25** if its vapor density is less than that of the dielectric vapor. The dielectric gas in effect, closes off the opposite ends **27***b* and **29***b* of the condenser tubes **27** and **29.** With the ends **27***b* and **29***b* closed by the gas, the vapor moves upwardly in the tubes **27** and **29** and condenses on the inner wall surfaces of these tubes. The condensate, thus formed, on the inner wall surfaces of the tubes **27** and **29** flows downwardly and ultimately exits as a liquid condensate from the openings **27***a* and **29***a* and collects in the perforated drop pan **33.** From the pan **33** the condensate is distributed over the surfaces of the transformer **11.** Thus, the condensate formed in the condenser tubes returns by gravity, in countercurrent flow relationship with the vapor in the tubes, to the pan **33** where, again, by means of gravity it is distributed within the core **13** and matrix **15** as a film. Subsequently, the heat producing transformer **11** again vaporizes the liquid film thereby rejecting its heat. This vaporization-condensation cycle is repeated and the temperature of the transformer **11** is maintained within safe operating limits.

Also located within the vaporization chamber **17** is a vapor push pump **10** for recirculating condensate from the pool **18** or body of liquid back to the drip pan **33.** The inclusion of a vapor push pump such as the vapor push pump **10** is advantageous. Without a pump **10** to recirculate the condensate from the pool **18** to the drip pan **33** the only liquid return is by the process of the vaporization and subsequent condensation cycle. In such a situation a large mass of the apparatus to be cooled (e.g., transformer **11**) must then be immersed in the liquid **18.** The details of the vapor push pump **10** are illustrated to the schematic cross section drawing of FIG. 4. As indicated, the pump **10** includes a housing **12** within which there is defined a chamber **14.** Housing **12** has a port **16** at the top thereof so that liquid from the external body **18** or pool of liquid may enter port **16** and at least partly fill the chamber **14.** The housing **12** is adapted to be submerged in the external body of coolant liquid **18** whose head $H_x$ is shown in FIGS. **1** and **4** as being the distance from the liquid level of the body of liquid **18** to the top of the housing **12.** Also, at the top of the housing **12** two additional openings **20** and **22** are provided. The opening **20** has one end of a conduit **24** coupled thereto. The conduit **24** has another opening **21** at an opposite end thereof. The opening **21** is above the level of the body of liquid **18.** The opening **20** with conduit **24** serves as a vapor vent, the action of which is hereinafter described. Another conduit **26** which is relatively long passes through the opening **22** in the housing **12.** The conduit **26** is sealed to the housing **12** where it passes through opening **22.** As indicated conduit **26** has an inlet opening **28** at the lower end thereof and an outlet opening **30** at the upper end thereof. The conduit **26** acts as a liquid delivery tube in that the liquid within housing **12** (in chamber **14**) is pushed through inlet opening **28** and flows upwardly in conduit **26** where it is discharged at the outlet opening **30** and into the drip pan **33** (of FIG. **1**) in vaporization chamber **17** (of FIG. **1**). The outlet opening **30** is above the external body **18** of liquid. Inlet opening **28** is submerged in liquid in chamber **14** in housing **12.** Situated in chamber **14** is a body **32** of low thermal conductivity and low thermal diffusivity. The body **32** includes a bore **34** within which an electric cartridge type heater **36** is located. A pair of electrical leads **38** having an end thereof electrically connected with the heater **36** extends in sealed relationship through the housing **12** to the outside thereof. If desired, the leads **38** may also extend through the transformer casing **19** so that electrical energization of the heater **36** may be initiated entirely from without the transformer housing **19.** The upper portion of the bore **34** communicates with a wider diameter cylindrical space **40** which is closed at its upper end by a seal **60,** or cover. Body **32** also includes a cylindrical well **42** within which the inlet opening **28** of conduit **26** is positioned. Between an outside wall surface of the body **32** and the inside wall surface of housing **12** there is provided the space **44** as shown. Body **32** also includes another bore **46** which communicates the aforesaid space **44** with the other bore **34** within which heater **36** is positioned.

Mounted by suitable means (not shown) at the upper portion of the cylindrical space **40** is a bent vapor outlet tube **48,** an inlet end **50** of which is within the cylindrical space **40** and an outlet end **52** of which extends above the uppermost part of the sealing cover **60.**

Mounted within chamber **14** is a valve body **54.** Valve body **54** is buoyant and may float upwardly or downwardly depending on the liquid level in chamber **14.** The upward and downward movement of the valve body **54** is indicated by the arrows in the drawing. Valve body **54** includes a number of openings **58** therein to allow for the passage of vapor therethrough.

Suitable stop members (not shown) limit the downward, as well as lateral movement of valve body **54.** In its uppermost position the valve body **54** seals and closes off the port **16** and opening **20.** Valve body **54** includes a flexible diaphragm **56** at the top thereof which facilitates closure of port **16** and opening **20.** The diaphragm **56** flexes and thereby enters a short distance into the port **16** and into opening **20** for closing these apertures. One suitable material, among others, for fabricating the diaphragm **56** is a thin sheeting of silicone rubber.

Heat generated by heater **36** efficiently raises the temperature of the liquid surrounding the heater and is not wastefully employed in heating body **32** which is fashioned of thermal insulation material. Moreover, heat is not wastefully employed in heating the housing **12** or the body of liquid **61,** inter alia.

Operationally, the valve body **54** due to its own weight is situated more or less in the position shown in FIG. 4 and is retained by stop members. In such a position the port **16** and the opening **20** are open. As a result liquid from body **18** enters port **16.** The liquid thus admitted fills the chamber **14.** When the liquid level in chamber **14** reaches the valve body **54** the buoyancy of the valve body **54** causes it to float upwardly in the liquid thereby closing the port **16** and the opening **20.** Some of the liquid within chamber **14** enters space **44** and thereafter enters bore **46** from whence it passes to the other bore **34** to surround heater **36.** Heater **36** adds heat to the surrounding liquid and converts it to vapor which rises into the space **40.** Vapor from space **40** enters inlet opening **50** and passes therethrough to the outlet opening **52.** From outlet opening **52** the vapor exits through openings **58** in valve body **54.** Vapor exiting from openings **58** enters the main chamber **14** where it accumulates and exerts pressure on the liquid **61** therebelow. The vapor contained in the upper portion of chamber **14** also acts on the underside of diaphragm **56** to help maintain diaphragm **56** in a position closing port **16** and opening **20.** Also, vapor in the upper portion of chamber **14** exerts pressure on the liquid in the lower portion of the chamber **14** thereby pushing or forcing the liquid into riser conduit **26** and through the inlet opening **28** thereof. The liquid entering the inlet opening **28** passes outwardly through conduit 26 and is discharged at opening 30 into the drip pan 33. (See FIG. 1) When the liquid level within chamber 14 has fallen to a level a little below the lower periphery or rim of the conduit 26 within the well 42 the conduit 26 drains free of liquid and the vapor within chamber 14 and within conduit 26 is in effect vented through conduit 26 and discharged at outlet opening 30. Accordingly, the vapor pressure within the chamber 14 is relieved and the valve body 54 falls due to its own weight, thus opening the port 16 and the opening 20. Also included in combination with vapor push pump 10 is a vapor venting conduit 24. If such a conduit 24 were not provided then float valve body 54 when moved downwardly to open inlet port 16 would not permit vapor in chamber 14 to escape other than through the port 16 during the time that liquid from body 18 was also being admitted through the same port 16. By incorporating a vapor venting conduit 24 with its opening 20 the vapor finds a low impedance path through opening 20 in conduit 24 to escape from pump 10.

The vapor push pump 10 will operate even though dielectric gas is occluded in the liquid coolant 18 and is later on enabled to escape.

Another feature of the invention is illustrated in FIGS. 2 and 3 where different sectional views of the insulation matrix 15 are shown. As shown in FIG. 2 the matrix 15 has a plurality of longitudinal ducts 35 extending therethrough vertically. The ducts 35 serve as cooling ducts. The liquid from the drip pan 33 falls onto the matrix 15 and enters the cooling ducts 35, forming therein on the side wall surfaces thereof liquid films which flow downwardly within the ducts 35 to the body of liquid 18. Although a specific number of cooling ducts 35 are indicated in FIG. 2 it is to be understood that more than or less than the specifically illustrated number of ducts 35 may be employed, depending on the maximum temperatures allowed. In the vertical cross section view shown in FIG. 3 a section of one such duct 35 is clearly illustrated. As indicated, the duct 35 has a plurality of grooves 37 formed, or otherwise provided, in its side wall. The longitudinally extending vertical grooves 37 serve to maintain the film of liquid intact so that film will not break into rivulets (as would be the case with a smooth surface) thereby preventing rupture of the film. The aforesaid rupture by the coolant film would allow dry and therefore hot spots to exist.

Although one more or less specific embodiment of the invention has been described and illustrated in the accompanying drawings, it is to be understood that this has been done for purposes of providing a working example of the invention and that many changes, not departing from the inventive principles involved, will occur to those skilled in the art. The scope of the invention is to be determined from the claims hereinafter set forth.

What is claimed is:

1. In combination: a vaporization chamber containing heat producing electrical apparatus to be cooled while dielectrically protected and a two phase dielectric fluid comprising a liquid and a vapor, said apparatus including at least one cooling duct extending vertically therethrough, said duct having a plurality of longitudinal extending vertical grooves in its side wall, said liquid residing at a bottom portion of the chamber and having a liquid level above the bottom of the chamber,



said liquid also being distributed as a film which coats said apparatus and coats the vertical grooves of said duct, said vapor being produced by vaporization of said liquid by said heat produced by said apparatus, said vapor occupying space in said chamber above said liquid level, a condenser having one end thereof connected to and communicating with an upper portion of said vaporization chamber occupied by said vapor, a reservoir containing a predetermined mass of noncondensable dielectric gas positioned above said condenser, said condenser having another end connected to and communicating with said reservoir and said gas therein, said gas forming an interfacial contact with said vapor in said condenser at a region therein between said ends of said condenser, said vapor condensing to form liquid condensate in the condenser on one side of said interfacial contact so that the effective condensation area of said condenser lies between said one end of said condenser and said interfacial contact; distribution means in said chamber positioned above said electrical apparatus for receiving liquid condensate from said condenser and distributing the liquid condensate as a film coating said apparatus and coating the vertical grooves of said duct, and a condensate make-up pump for pumping liquid from the bottom portion of the chamber to said distribution means.

2. A hermetically sealed system comprising a chamber including heat producing electrical apparatus therein, said apparatus having at least one surface which includes a plurality of grooves therein, said at least one surface and said plurality of grooves therein being inclined toward a vertical axis of said apparatus, a reservoir located above said chamber, a condenser connected between said chamber and said reservoir and establishing communication therebetween, a two phase fluid coolant comprising a dielectric liquid and its dielectric vapor confined in said system, a noncondensible dielectric gas, said gas being largely combined in said reservoir and making contact with said vapor in said condenser, said vapor being largely confined within said chamber and extending into said condenser to the region of contact with said gas, said vapor condensing to form liquid condensate, distribution means for receiving said liquid condensate from said condenser and distributing the liquid condensate as a film coating the grooves of said at least one internal surface and coating said apparatus, and a condensate make-up pump in said chamber for pumping liquid therein between a lower portion of said apparatus to said distribution means.

3. In combination: a vaporization chamber having upper and lower portions, heat-producing apparatus within said chamber, said apparatus having at least one surface which includes a plurality of grooves therein, said at least one surface and said plurality of grooves therein being inclined toward a vertical axis of said apparatus, a two-phase fluid coolant within said chamber, said fluid coolant having a liquid phase and a vapor phase, part of the liquid phase coolant residing at the lower portion of said chamber, the vapor phase coolant being produced by vaporization of the liquid phase coolant by said apparatus, a condenser coupled with the top portion of said chamber for receiving vapor phase coolant therefrom and returning liquid phase coolant thereto, means within said chamber at the top portion thereof for receiving liquid phase coolant from the condenser and distributing said coolant as a liquid

film on said at least one surface and in the grooves therein so that the liquid film stays intact, without forming rivulets, as the liquid film migrates downwardly in said grooves for collection at the lower portion of said chamber, and a condensate make-up pump for transporting liquid phase coolant from the lower portion of the chamber to said means within the chamber at the top portion thereof.

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