Feb. 12 , 1924. 1,483,442

H. M. HOBART

MEANS FOR COOLING ELECTRICAL APPARATUS

Filed April 15, 1919

Fig.1.

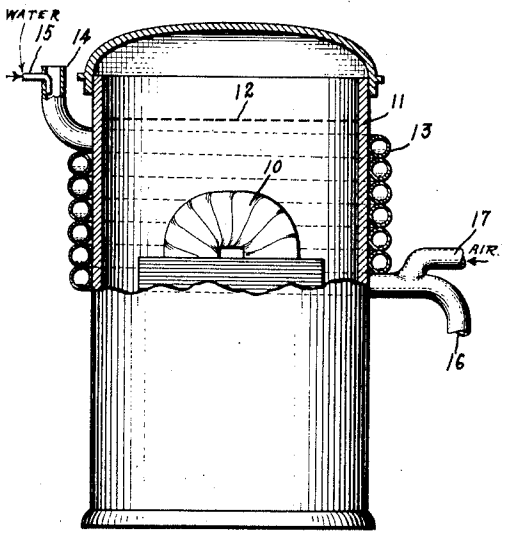


Fig.4.

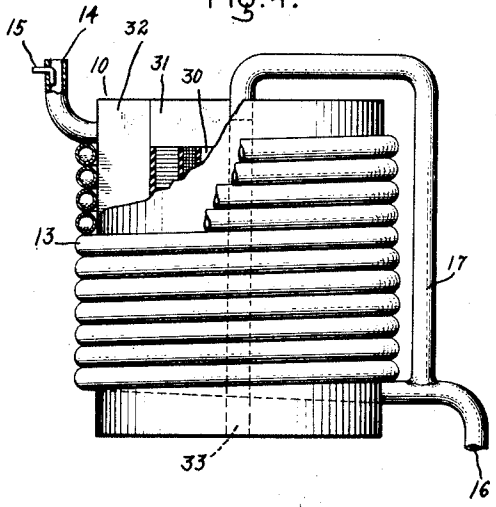


Fig.2.

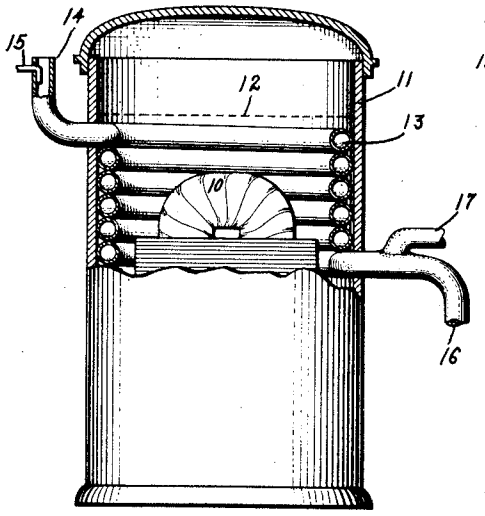
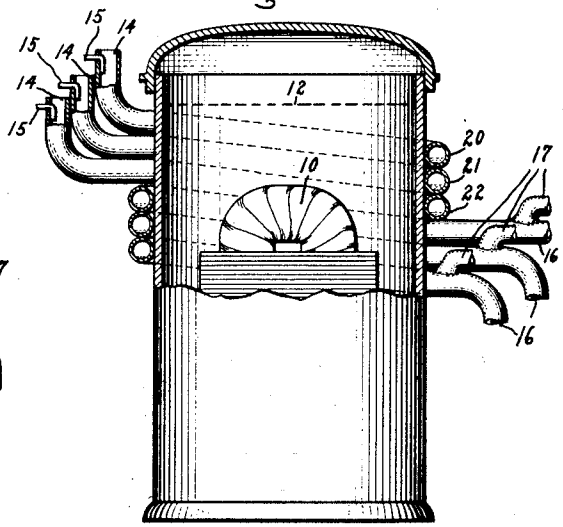


Fig.3



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Patented Feb. 12, 1924. 1,483,442

UNITED STATES PATENT OFFICE.

HENRY M. HOBART, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

MEANS FOR COOLING ELECTRICAL APPARATUS.

Application filed April 15, 1919. Serial No. 290,358.

To all whom it may concern:

Be it known that I, HENRY M. HOBART, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Means for Cooling Electrical Apparatus, of which the following is a specification.

Electrical apparatus develops heat continuously during operation, and the heat so developed must be withdrawn to prevent the destruction of the apparatus. In many instances this heat is dissipated by natural radiation to the surrounding atmosphere; in certain instances involving large devices, the heat passes first into a body of submerging oil and thence through the walls of the container or tank to the atmosphere. Devices cooled by natural radiation to the atmosphere are termed "self-cooled". In other instances, due to the size of the apparatus, its location, or otherwise, the heat produced cannot be dissipated sufficiently rapidly by "self-cooling", and some special means must be resorted to or are desirable to hasten the withdrawal of the heat from the electrical apparatus; examples of such special means are the natural flow of cool water, pumps for forcing the flow of cool water, pumps for passing cool oil or cool air over the apparatus, etc. Devices cooled by special means are termed "artificially cooled". Large transformers are examples of electrical apparatus often artificially cooled. My invention relates to the cooling of electrical devices which are of such sizes or are so located, or which have such other characteristics or must meet such other conditions, that artificial cooling is desirable or necessary.

The artificial cooling practice which was almost if not entirely universal prior to my invention, prescribes that the heat of electrical apparatus be withdrawn by passing a cooler fluid, either a liquid or a gas, over or through or otherwise in thermal relation with the apparatus. Heat is extracted from the apparatus simply and solely by raising the temperature of the passing fluid without changing its state. Air is often used in following this prior practice, but water is the fluid used in perhaps the majority of the cases on account of its general availability and since water cooling so often otherwise satisfies the conditions to be met and water cooling is the only known form of artificial cooling which is practicable in certain instances. As distinguished from the prior artificial cooling practice, my invention utilizes the latent heat of a liquid; the latent heat of liquids is manifested when a liquid changes its state, as when it evaporates (that is, changes from a liquid to a gas or vapor), when all or a part of the solute is removed from a solution, etc. It has heretofore been proposed to use the evaporation of liquids to cool transformers, but such prior proposals require the use of expensive or uncommon liquids, because these proposals contemplate employing liquids which vaporize rapidly at temperatures considerably below 100° C. (100 degrees centigrade), for most electrical apparatus is destroyed when operated at a temperature much above 100° C. and the more common liquids do not evaporate fast enough under normal conditions to keep the temperature below safe values. Water is not a suitable liquid for such schemes for this reason; it evaporates so slowly at the external operating temperatures of common electrical apparatus (and under normal conditions) that it requires an impracticable extent of evaporating surface. On the other hand water as before indicated, is a desirable means for cooling electrical apparatus because of its general availability as well as for other reasons. My invention distinguishes from such prior suggestions in that I provide for hastening the change of the state of the liquid, namely by blowing air in contact with the liquid; the air may be somewhat heated if desirable in any case. Preferably in addition, I cause the liquid to flow, rather than stand stationary, where it is in thermal relation with the apparatus to be cooled and I blow the air over the flowing liquid. By thus hastening the change of state, it is possible to use water as the cooling liquid. Preferably also I flow the cooling liquid through pipes which the liquid only partly fills, and force air through the same pipes above the surface of the flowing liquid.

It may be noted, as emphasizing the advantage of my invention that a given weight of water when evaporating takes up some nine hundred and fifty times as much heat as is taken up by the same weight of water when its temperature is raised one degree.

Among the objects of my invention, as may be gathered from above, is to improve the cooling of electrical apparatus and to this end to provide an improved apparatus. Other objects and advantages of my invention will appear later.

The details of my invention will be most readily understood from the accompanying drawing and following description, in which I have illustrated and described in some detail the best embodiments of my invention in connection with transformers of which I am now aware. Fig. 1 is an elevation partly in section of a transformer submerged in oil embodying my invention. Figs. 2 and 3 are similar figures illustrating modifications of the structure of Fig. 1. Fig. 4 is an elevation, partly in section, of a transformer cooled more directly in accordance with my invention.

In the structure of Fig. 1 the transformer 10 is submerged in oil in a tank 11. The oil level is shown at 12. Around the outside of the tank 11, disposed spirally, is a pipe 13. Preferably this pipe is disposed about the upper part of the tank, below the oil level and adjacent the hottest oil. The pipe 13 is in close thermal relation with the surface of the tank and may be welded thereto to secure a better transfer of heat from the tank to the pipe. The upper end of the pipe is turned upwardly at 14 and is open. Passing into this pipe near the end 14 is a second pipe 15 through which water (or other liquid) is admitted. For simplicity I shall mostly hereinafter refer to the cooling liquid as water; it will be understood that by this term I intend to include also in the general case, any other liquid that may be suitable whether this other liquid evaporates in cooling the electrical device or in some other way changes its state to that end. At the lower end of the pipe 13 is provided an exit 16 for any water that may succeed in passing completely through the pipe. Entering this pipe through the upper wall thereof near the end 16 is a third pipe 17. Suitable connections are made to the pipe 15 for continuously supplying a suitable amount of water and connections are made to the pipe 17 for forcing air therefrom or therethrough into the pipe 13.

As water enters the pipe 13 from the pipe 15, it flows downwardly toward the end 16. Enough water is admitted to only partly fill the pipe 13, as indicated in Fig. 1, in order to allow for the passage of air above the water current. As this water flows downwardly, the air from the pipe 17 passes upwardly over the surface thereof, and hastens the evaporation of the water to which heat is conveyed from the transformer 10. For this reason, and as appears from Fig. 1, there is less water in the lower turns of the pipe 13 than in the upper turns thereof; indeed if a sufficiently small quantity of water is supplied through the pipe 15, no water at all will escape from the exit 16. The pipe 13 being in close thermal relation to the tank, preferably by being electrically welded to the tank, or more or less tightly disposed on the tank (preferably as tightly as possible), or both, the flowing water in the pipe 13 is in good thermal relation with the transformer 10 through the walls of tank 11 and the oil contained therein. The heat generated from the transformer 10 escapes therefore quite readily to the pipe 13, and from thence is dissipated by the evaporation of the water therein. The air entering pipe 13 from pipe 17 leaves pipe 13 at 14 together with the water vapor.

The structure of Fig. 2 is quite similar to that of Fig. 1 except that the pipe 13 is disposed within the tank 11 rather than external thereto, and the heat from the transformer 10 escapes more directly from the transformer to the pipe 13, viz, from the transformer to the oil and then directly to the pipe. Water is admitted to the pipe 13 through the pipe 15 and air is forced into the pipe 13 through the pipe 17, in exactly the same way as in the structure of Fig. 1. The operation of the device is similar to the operation of the device of Fig. 1.

In some instances it may be found that, due to the height of the tank or the number of turns required in passing the pipe from the top of the tank to a sufficiently low point along the tank wall, the water admitted through the pipe 15 is all evaporated before it reaches the lower turns of the spiral if sufficient room is left in the upper turns of the pipe for the passage of the air and water vapor. In such a case, or if for any other reason such a structure may be desirable, two or more pipes may be placed side by side, that is, arranged one below another turn by turn, for example as shown in Fig. 3. In the structure of this figure, three pipes 20, 21 and 22 are carried, one below another, turn by turn, from near the top of the tank to adjacent the middle thereof; these three pipes as a unit, side by side, pass around the tank something like a wide band. Air is admitted through the pipes 17, one for each of the pipes 20, 21 and 22; likewise as before, water is admitted to each of these three pipes by pipes 15 and exits are provided at 16 for each of the three pipes. The air and water vapor escape at 14 and the pipes 20, 21 and 22 are in good thermal relation with the transformer 10, as before described. The operation of this device being similar to the operation of the device of Fig. 1 need not be further described.

If desired, the submerging oil, or both the enclosing tank and submerging oil, may be eliminated; this is desirable when the device is to be installed in a locality where

the oil introduces a serious fire hazard, and under some other circumstances Fig. 4 illustrates such a modification. In this figure is shown a transformer 10 comprising a middle leg 30, yokes 31, and an outer leg 32. The inner leg 30 is substantially in the form of a cylinder. The yokes 31 are in the forms of discs, and the outer leg 32 is in the form of a hollow cylinder engaging at its ends with the yokes 31. Between the inner leg 30 and the outer leg 32 are disposed the windings, as illustrated. Tightly disposed on and outside of the leg 32, and preferably welded thereto, is a pipe 13. As before water is admitted through the pipe 15, air is forced in through the pipe 17, air and water vapor escape at 14, and any surplus water finds an exit at 16. However, in this instance, I have taken the opportunity to illustrate the use of heated air (rather than air at normal temperature) to assist in the evaporation of the water, and the heating of the air by the electrical device itself. The air is initially forced into one end of a passage 33 extending longitudinally through the transformer core leg 30, and in passing therethrough is somewhat heated by the heat generated in the transformer. From the other end of this passage 33, the air passes into the pipe 17 and thence through the pipe 13, as before. By thus heating the air, I not only directly assist the cooling of the transformer (by the extraction of heat in passage 33), but I also hasten the change of state of the liquid by forcing warm air rather than cool air into the pipe 13. Except as thus indicated, the operation of the structure of Fig. 4 is similar to the operation of the structure of Fig. 1, and need not be further described.

It will be understood that while I have illustrated and described above in some detail the best embodiments of my invention of which I am aware, these embodiments are merely illustrative of my invention, and that my invention is not limited thereto but is set forth in the following claims.

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

1. The combination with an electrical apparatus, of a cooling pipe in the form of a vertical spiral coil, disposed in thermally conducting relation with said apparatus, means for admitting a cooling liquid to said pipe to flow downwardly therein in a current only partially filling the pipe, and means for admitting a current of air to flow through said pipe in contact with said liquid.

2. The combination with an electrical apparatus, of a cooling pipe in the form of a vertical spiral coil, disposed in thermally conducting relation with said apparatus, means for admitting a cooling liquid to said pipe to flow downwardly therein in a current only partially filling the pipe, and means for admitting a current of air to flow upwardly through said pipe in contact with said liquid.

3. The combination with an electrical apparatus, of a cooling pipe in the form of a vertical spiral coil, disposed in thermally conducting relation with said apparatus, means for admitting a cooling liquid to said pipe near its upper end to flow downwardly therein in a current only partially filling the pipe, and means for admitting a current of air to said pipe near its lower end to flow upwardly therethrough in contact with said liquid.

In witness whereof, I have hereunto set my hand this 14th day of April, 1919.

HENRY M. HOBART.