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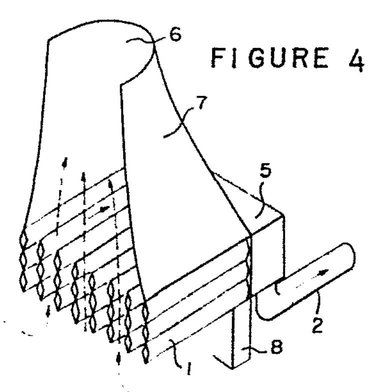
(54) Cooling device for electric transformer.

(57) A cooling device for an electric transformer comprises cooling means (1) disposed in the horizontal direction and through which cooling medium passes, first and second headers (5) provided at an inlet side and an outlet side of said cooling means (1), first tubing (2) to lead the cooling medium which has cooled the transformer to said first header (5), second tubing (2) to lead the cooling medium in said cooling means into said transformer through said second header (5), and a duct (7) to lead air to a region above said said cooling means (1) after completion of the heat-exchange between said cooling medium in said cooling means (1) and air.

FIGURE 4



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COOLING DEVICE FOR ELECTRIC TRANSFORMER

This invention relates to a cooling device for an electric transformer, and, more particularly, it is concerned with a cooling device for an electric transformer which performs cooling of such transformer by natural convection of air.

Heretofore, this type of the cooling device for the electric transformer is so constructed, as shown in Figure 1, that both ends of each of a multitude of cooling tubes 1, 1, ... juxtaposed in parallel at predetermined space intervals among them are connected with two tubes 2, 2 disposed in the direction perpendicular to these cooling tubes, one end of these tubes 2, 2 being closed and the other end thereof being connected with the main body 3 of the transformer. A forced circulation device 4 for a cooling medium is further connected to the base part of one of the tubes 2, 2 to cause the cooling medium to flow through the tubes as shown by arrow marks in solid line, while air flows in natural convection outside the cooling tubes 1, 1 ..... in the direction of arrow marks in dotted line.

However, according to the cooling device of the above-described construction, since the heat transfer rate between air and the cooling tubes 1, 1, ... is very small in comparison with the heat transfer rate between the cooling medium and the cooling tubes, the dimension of the cooling device is governed by a heat transfer area for obtaining a required quantity of heat passage between air and the cooling tubes 1, 1, ... Accordingly, in the above-described conventional construction of the cooling device, a broader heat transfer area had to be secured for passage of heat between air and the cooling tubes.

Therefore, while it may be contemplated, on the one hand, that the height of the cooling tube is increased to secure the required heat transfer area, it is not possible, on the other hand, to increase the height of the cooling tubes to a considerable degree due to mechanical strength thereof and economical restriction. As the result of this, acquisition of the required heat transfer area has been done mainly by increasing the number of cooling tubes with the consequent problem of a larger installation area having been required.

The present invention, taking note of the above-described points of problem in the conventional cooling device, has been made with a view to improving such disadvantage inherent in the known device.

It is therefore an object of the present invention to provide a cooling device for an electric transformer, in which a cooling medium is caused to flow through cooling tubes disposed in the horizontal direction, while air is caused to flow from lower side to upper side in the natural convection through a space gap between the adjacent cooling tubes, and in which a gas discharging duct is provided on the upper outlet port of air to thereby make it possible to reduce the area for installing the cooling tubes.

According to the present invention, in general aspect thereof, there is provided a cooling device for an electric transformer, which comprises: a) a cooling means disposed in the horizontal direction and through which cooling medium passes; b) first and second headers provided at an inlet side and an outlet side of said cooling means; c) first tubing to lead the cooling medium which has cooled the transformer to said first header; d) second tubing to lead the cooling medium in said cooling means into said transformer through said second header; and e) a duct to lead air to the upper part of said cooling means after completion of the heat-exchange between said cooling medium in said cooling means and air.

The foregoing objects, other objects as well as the specific construction and function of the cooling device according to the present invention will become more apparent and understandable from the following detailed description of the invention, when read in connection with the accompanying drawing.

In the drawing:

Figure 1 is a cross-sectional view showing a conventional cooling device;

Figure 2 is a plan view showing one embodiment of the cooling device according to the present invention;

Figure 3 is a front view of the cooling device shown in Figure 2;

Figure 4 is a perspective view showing the cooling device of the present invention viewed along a plane cut by a line A-A' in Figure 2; and

Figures 5 to 8 are respectively explanatory diagrams comparing the effect of the conventional cooling device and the cooling device having a discharge duct according to the present invention.

In the following, a preferred embodiment of the cooling device according to the present invention will be explained in reference to Figures 2 to 8, wherein those parts common to those in Figure 1 are designated by the same reference numerals.

Figure 2 is a plan view illustrating one embodiment of the cooling device according to the present invention, Figure 3 shows a front view of the same, and Figure 4 shows a perspective view of the cooling device of Figure 2 as viewed along a line A-A' in Figure 2.

In the drawing, reference numeral 1, 1, ... designates cooling tubes, in the interior of which an insulated gas as a cooling medium flows, while air flows between adjacent tubes in the natural convection. Both ends of these cooling tubes 1, 1, ... are connected with headers 5, 5 for coupling the gas pipes 2, 2.

On the top part between the abovementioned headers 5, 5, there is provided a frusto-conical gas discharging duct 7 having an opening 6 at its top end, while, at the lower part of the headers 5, 5, there are provided legs 8, 8 which support the entire cooling device at a position floated from the floor surface so that air may flow thereinto from the bottom part thereof as shown by arrow marks in dotted lines, climb up inside the air discharging duct 7, and be discharged from the top end of the opening 6.

In the drawing, a reference numeral 3 designates a main body of the electric transformer, and 4 refers to a forced circulation device. In the cooling device constructed as mentioned above, air which has been heated at the portion of the cooling tubes 1, 1, ... passes through a space between the adjacent cooling tubes 1, 1, ... in the form of a rising current, and climbs upwards in the discharging duct 7, thereby inducing favorable natural convection to promote the heat-exchanging action.

In the next place, explanations will be given in reference to Figures 5 to 8 as to the effect to be resulted from providing the abovementioned gas discharging duct 7.

Figure 5 shows the cooling device not equipped with the gas discharging duct 7 and a passage route of air in its natural convection, and Figure 6 shows a temperature distribution of air in correspondence to height of the cooling device shown in Figure 5, the temperature changing in the direction of an arrow mark. A portion a in Figure 6 indicates that air climbs up through the space gap between adjacent cooling tubes 1, 1, ... and its temperature changes from Θ_1 to Θ_2. Portions b and c in the same drawing indicate a route, through which the heated air is diffused from the opening portion, cooled again to the temperature Θ_1, and reaches an inlet at the lower part of the cooling device.

Assume now that density of air at the temperature Θ_1 is r_1 and the same at the temperature Θ_2 is r_2.

A pressure to cause the air to flow into the space gap between the adjacent cooling tubes at the inlet part for the air at the lower part of the cooling device is developed by a difference in the density of air between the upper exit part of the device and the lower inlet part thereof, and is represented by the following equation.

$$\text{Pressure}=H_R r_1-\left(\frac{r_1+r_2}{2}\right)H_R=\left(\frac{r_1-r_2}{2}\right)H_R \;\ldots\ldots\; (1)$$

In the above equation (1), H_R represents a height of the cooling tube 1 as shown in Figure 5.

Figure 7 illustrates the cooling device provided with the gas discharging duct 7, and a passage route for air in its natural convection. Figure 8 shows a temperature distribution of air in correspondence to the height of the cooling device shown in Figure 7. In Figure 8, a portion a indicates that the air rises through the space gap between the adjacent cooling tubes 1, 1, ..., and the temperature changes from Θ_1 to Θ_2. A portion d indicates that the air at the temperature Θ_2 rises upwards in the gas discharging duct 7. The portions b and c illustrate the passage route, through which heated air is diffused from the opening portion 6 and cooled again to the temperature Θ_1 to reach the inlet port at the lower part of the cooling device.

A pressure to cause the air to flow into the inlet port at the lower part of the device is developed by a difference in the density of air between the upper part of the gas discharging duct 7 and the lower inlet part of the cooling device, and is represented by the following equation.

$$\text{Pressure}=(H_T+H_R)r_1-\left(\frac{r_1+r_2}{2}\right)H_R$$

$$=H_T r_1+\left(\frac{r_1-r_2}{2}\right)H_R \;\ldots\ldots\ldots\ldots\ldots\; (2)$$

In the above equation (2), H_T represents a height of the gas discharging duct 7 as shown in Figure 7. The other symbols are the same as in the equation (1).

Comparing the above equations (1) and (2), the inflow pressure of the air at the lower inlet part of the cooling device increases by $H_T r_1$, whereby flow rate of the air increases to augment the heat transfer rate between the air and the cooling tubes 1, 1, ... It therefore becomes possible to reduce the heat transfer area for the purpose of obtaining the same heat passing quantity. As the result of this, when the height of the inventive cooling device is made almost equal to that of the conventional device, the area for its installation can be reduced.

By the way, in the above illustrated embodiment, explanations have been given as to a case where the cooling medium is forced to circulate by use of the forced circulation device 4. However, this can also be circulated by the natural convection, by which the same effect as in the above-described embodiment can be obtained. Further, in the illustrated embodiment, explanations have been given as to a case wherein the cooling medium is an insulated gas, although the cooling medium may be other liquid such as insulated oil, etc..

As described in the foregoing, the present invention is able to improve the heat transfer rate between air and the cooling tubes by the provision of the gas discharging duct at the air exit port atop the arrangement of the cooling tubes, so that the area for installation of the cooling device can be effectively decreased for the improved heat transfer rate.

Although, in the foregoing, the present invention has been described with reference to a preferred embodiment thereof, it should be noted that the invention is not limited to this embodiment alone, but any modifications and changes may be made within the spirit and scope of the invention as set forth in the appended claims.

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Claims

1. A cooling device for an electric transformer, comprising cooling means (1) through which cooling medium passes and first and second tubing (2) through which cooling medium is lead to and from said cooling means respectively, c h a r a c t e r i z e d in that
   a) the cooling means (1) are disposed in the horizontal direction;
   b) first and second headers (5) are provided at an inlet side and an outlet side of said cooling means (1);
   c) said first tubing (2) is arranged to lead the cooling medium which has cooled the transformer to said first header (5);
   d) said second tubing (2) is arranged to lead the cooling medium in said cooling means into said transformer through said second header (5) and
   e) a duct (7) is provided to lead air to a region above said cooling means after completion of the heat-exchange between said cooling medium in said cooling means (1) and air.

2. Cooling device according to claim 1, c h a r a c t e r i z e d in that said cooling means is constructed with a plurality of cooling tubes (1).

3. Cooling device according to claim 1 or 2, c h a r a c t e r i z e d in that said first tubing (2) is positioned at a level higher than said second tubing (2).

4. Cooling device according to claim 1,2 or 3, c h a r a c t e r i z e d in that both said first and second tubings (2) are on the diagonal line.

5. Cooling device according to one of claims 1 to 4, c h a r a c t e r - i z e d in that said duct (7) reduces its cross-section as it goes upwards from the lower part thereof to the upper part.

FIGURE 1

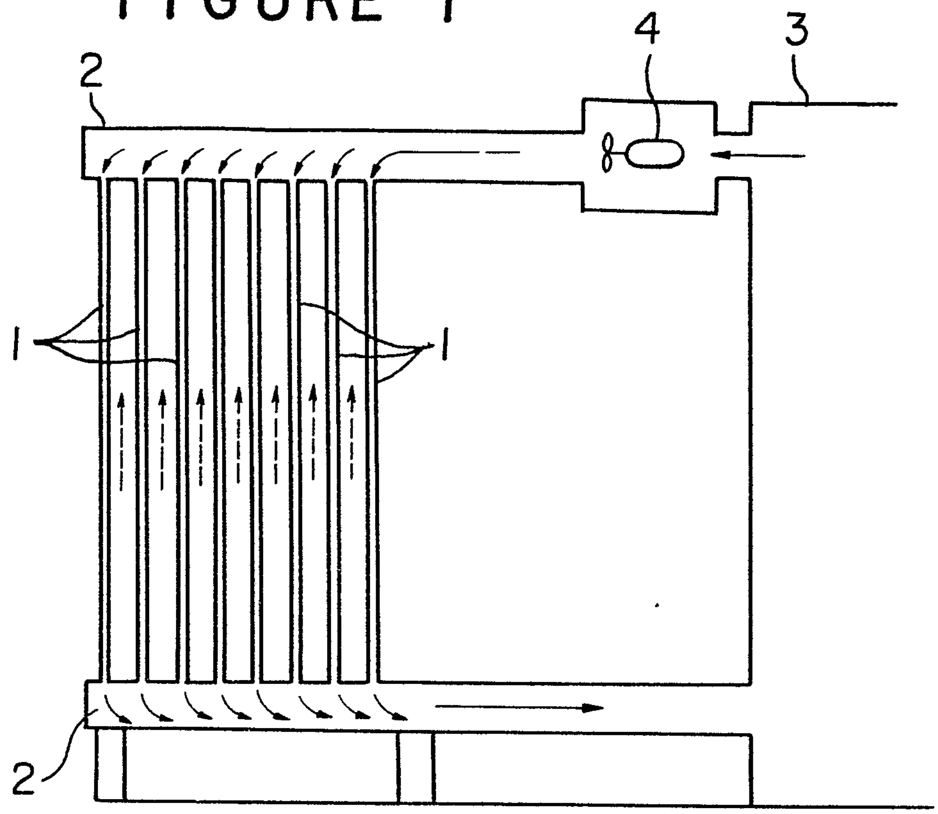


FIGURE 4

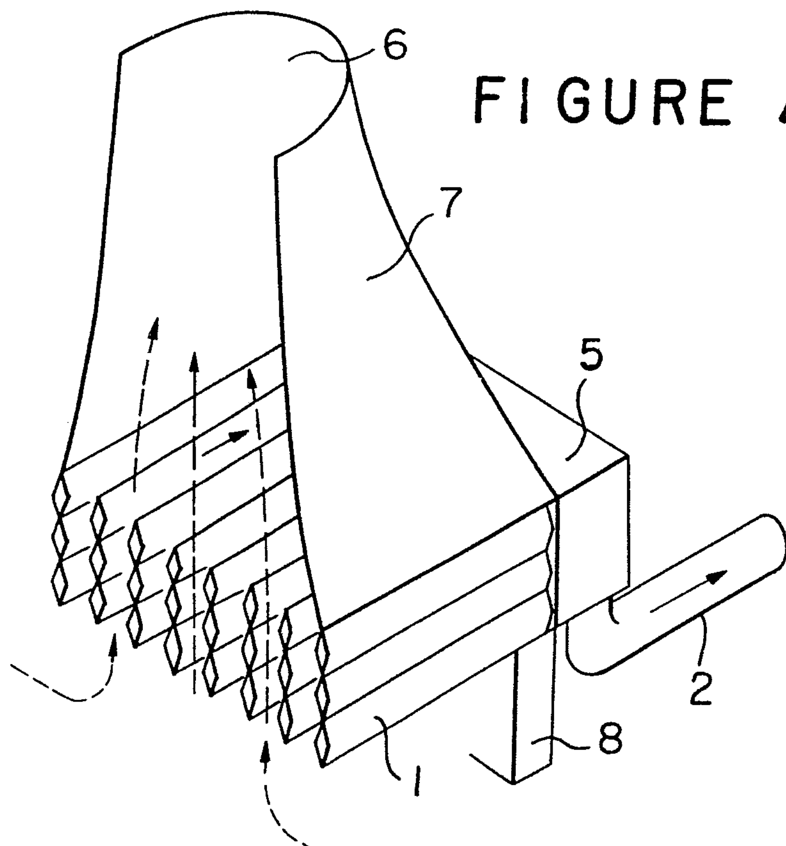


FIGURE 2

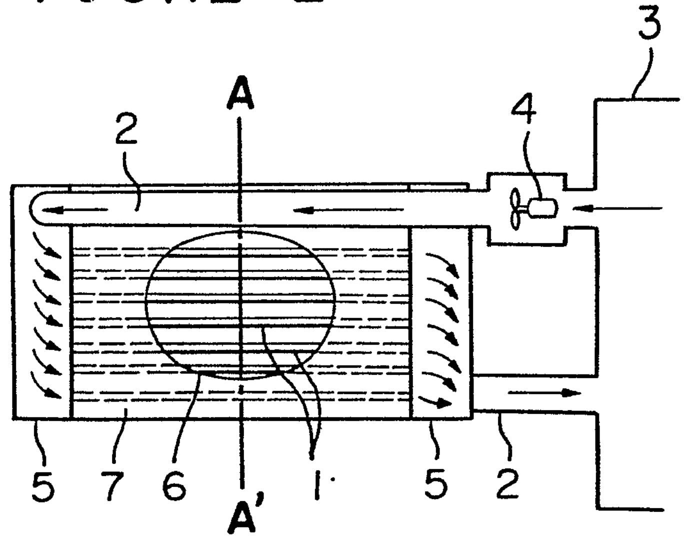


FIGURE 3

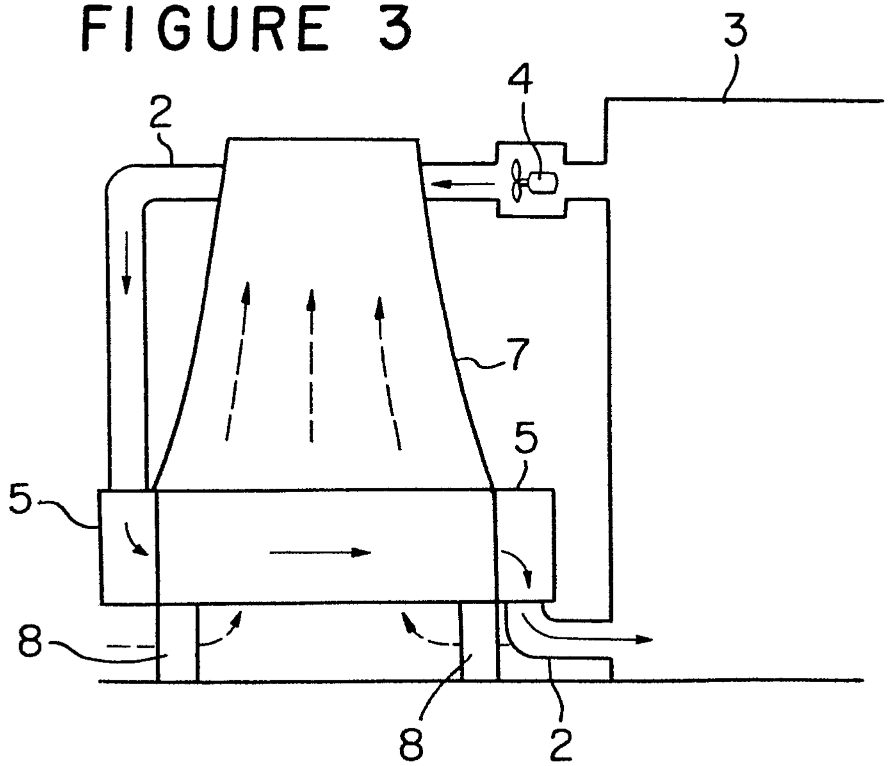


FIGURE 5

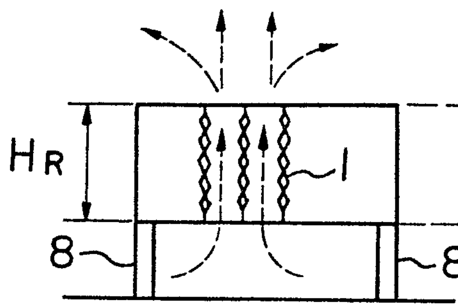


FIGURE 6

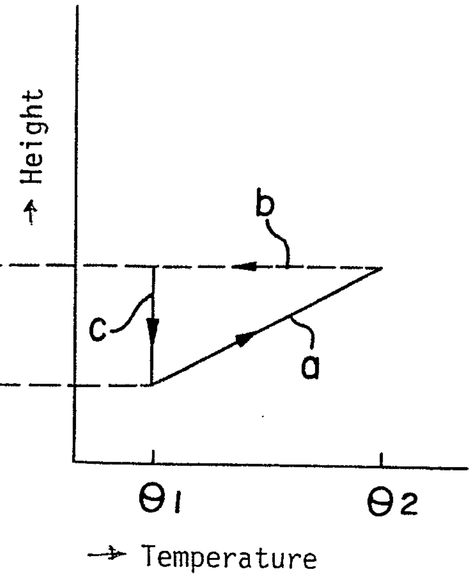


FIGURE 7

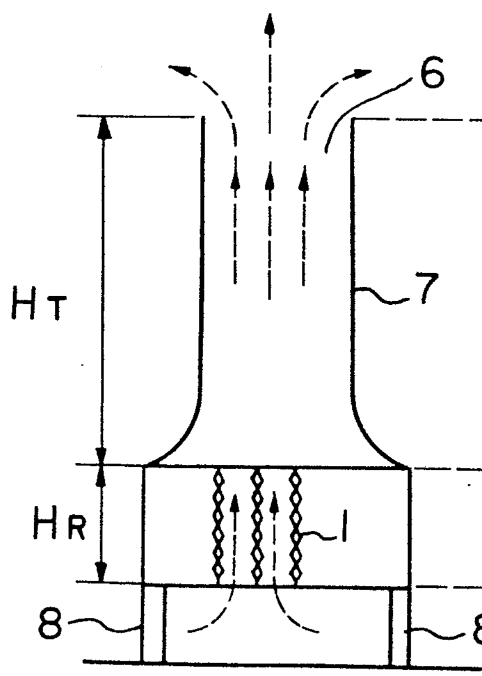
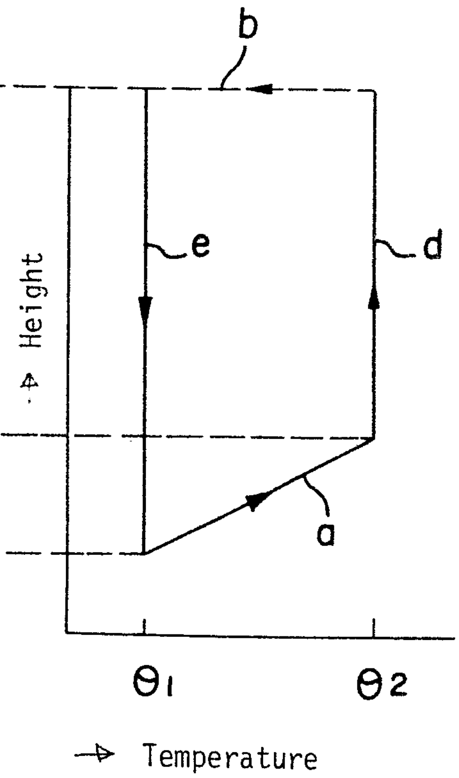


FIGURE 8



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EUROPEAN SEARCH REPORT

0082360
Application number

EP 82111078.0

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	CH - A5 - 607 261 (G.E.C. SOUTH ATRICA) * Column 3, lines 11-47; fig. 4-6 * --	1-4	H 01 F 27/20 H 01 F 27/12
A	AT - B - 101 584 (NORDON FRERES) * Page 1, line 17 - page 2, line 6: fig. 1-4 * --	1-4	
A	GB - A - 391 556 (SERCK RADIATORS LIMITED) * Page 3, lines 22-37; fig. 1 * --	1,2,3	
A	US - A - 1 711 364 (JAN ROOTHAAN) * Claim 1; fig. 4 * --	1	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	CH - A - 150 095 (SIEMENS) ----		H 01 F 27/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	17-03-1983	TSILIDIS

CATEGORY OF CITED DOCUMENTS

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