April 17, 1934. L. E. SAUER 1,955,313

VENTILATING MEANS FOR REACTANCE COILS

Filed Jan. 14, 1933

Fig. 1.

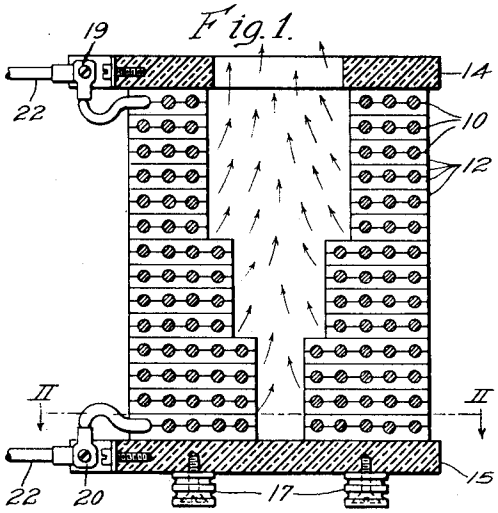


Fig. 2.

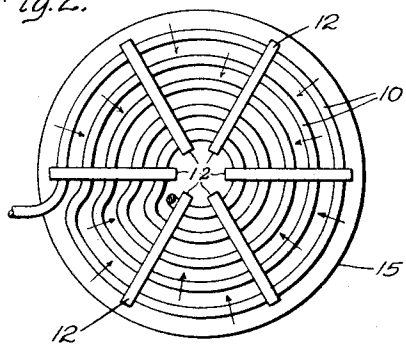


Fig. 3.

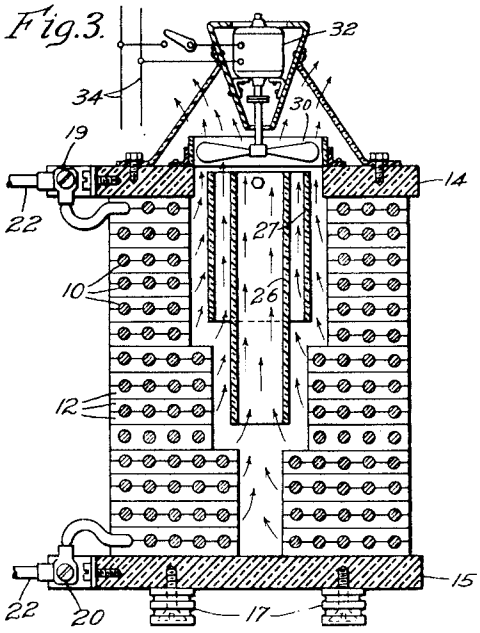


Fig. 4.

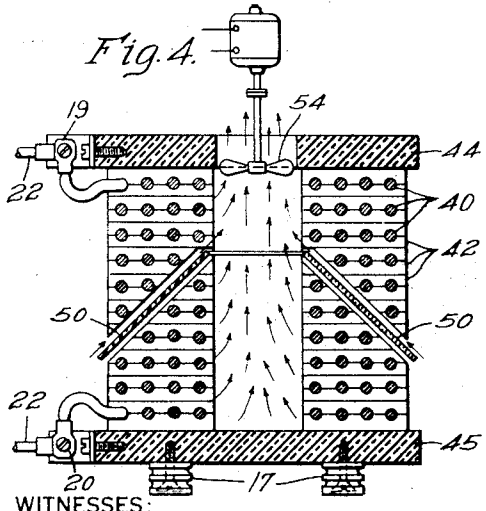
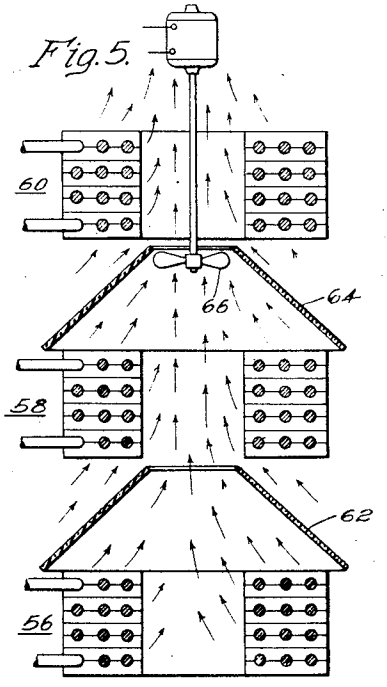


Fig. 5.



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UNITED STATES PATENT OFFICE

1,955,313

VENTILATING MEANS FOR REACTANCE COILS

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Application January 14, 1933, Serial No. 651,726

15 Claims. (Cl. 175—359)

My invention relates to the ventilation of electrical windings and it has particular relation to means for cooling current limiting reactance coils of the dry or air insulated type.

It is usual to insert current limiting reactance coils in the conductors comprised by an alternating current power system to prevent the current therein from rising to unsafe values upon the occurrence of short circuits or during other abnormal conditions. Reactance coils, as commonly used, are devoid of iron core members and comprise copper conductors or strands which are preferably spaced from one another in order to provide an open structure for ventilating purposes.

The allowable temperature to which the coil may rise without damage to the insulation, limits the current values which the coil is capable of handling. In the past, the ventilating characteristics of coils adapted for current limiting service have been relatively inefficient and the upper turns in the structure have tended to become much hotter than the others. This non-uniform temperature rise has made it necessary to design the coils with such generous proportions that they have occupied an excessive amount of space and have been expensive to manufacture.

One object of my invention is to reduce the cost and size of current limiting reactance coils required for a given service.

Another object of my invention is to improve the uniformity of cooling effectiveness of the ventilating fluid which flows past the conductor turns of electrical windings of the vertically-mounted cylindrical or discoidal layer type.

A further object of my invention is to provide an improved form of construction for windings of the above-mentioned type which permits the axial height of such windings to be materially increased.

A still further object of my invention is to modify the design of conventional current-limiting reactance coils of the spaced conductor multilayer cylindrical type disposed for vertical mounting in such manner that the natural ventilation characteristics will be materially improved.

In the case of a vertically mounted cylindrical or discoidal layer winding having a central opening extending axially therethrough, to which type of winding my invention is primarily applicable, the ventilating air flows inwardly from the outside between the winding turns and upwardly through the central opening. In passing by the turns at the lower portion of the winding, the air becomes heated and in rising in contact with the turns near the upper portions allows these upper turns to reach a higher temperature than would result were the air contacting them to be of a coolness comparable to that entering the winding near the bottom. Tests indicate that the inside turns near the top of the winding become hottest, the reason being that the air flowing past them is of the highest temperature. Because of this tendency for the upper portions of the winding to overheat, there has in the past been a definite limit to the axial height which it is permissible that a cylindrical or discoidal winding have.

In practicing my invention, I overcome the difficulty above pointed out by providing means for modifying the circulation of ventilating air or other fluid which flows inwardly between the winding turns and upwardly through the central opening of the winding in a manner that the fluid heated by contact with the turns in the lower portions of the winding will be discharged directly through the central opening without substantial contact with the turns in the upper portions of the winding.

My invention, together with additional objects and advantages thereof, will best be understood through the following description of specific embodiments when taken in conjunction with the accompanying drawing, in which

Figure 1 is a view in vertical section of an electrical winding constructed in accordance with one embodiment of my invention which provides that the internal diameter be progressively increased as the top of the winding is approached,

Fig. 2 is a sectional view taken on line II—II of Fig. 1 illustrating the arrangement of conductor turns and supports therefor utilized by one of the layers of turns of the winding of Fig. 1,

Fig. 3 is a view of a reactor employing the winding of Fig. 1 together with draft equalizing tubes and a motor-driven ventilating fan,

Fig. 4 is a view in vertical section of an electrical winding constructed in accordance with another embodiment of my invention employing an air baffle, and

Fig. 5 illustrates an arrangement of baffles applied to three single-phase coil units mounted one above the other.

Referring to the drawing, Figs. 1 and 2 illustrate a current-limiting reactance coil comprising a plurality of discoidal layers of conductor turns 10 stacked on top of each other and supported in position by apertured horizontal spacing members 12 arranged in stacks or groups, all of which extend radially from the center line

of the structure. Top and bottom end plates 14 and 15 are formed of suitable insulating material and are provided to complete the structure in the manner shown, which structure may be supported by feet 17 of insulating material. The reactor is connected to the alternating current power circuit the current of which is to be limited by means of terminals 19 and 20 attached to the top and bottom end plates, respectively, the power circuit conductors connected thereto being designated at 22. The cooling of the winding is effected by the passage of air from the outside of the coil between the spaced winding turns and upwardly through the central opening, as indicated by the arrows.

To improve the natural ventilation of the winding in a manner to prevent overheating of the inside turns near the top of the structure, I step the winding outwardly as it approaches the top and close the bottom end plate 15 entirely as shown in Fig. 1. It will be recognized that this represents a marked departure from previously known designs which have utilized a central opening of constant diameter throughout the entire length of the winding and which have used a bottom end plate having an opening in the center thereof. In such previous designs, as has been pointed out, air is allowed to leak directly into the center through the bottom disk opening without directly contacting the winding turns and because of the uniform internal diameter of the winding those turns located at the top have been subjected to ventilating air having a much higher temperature than those at the bottom.

In my improved design exemplified by Fig. 1, however, all of the air which is discharged through the central opening in the upper end plate must flow inwardly from the outer circumference of the structure between the spaced winding turns by virtue of the fact that the bottom end plate 15 is closed. By progressively widening the central opening through the winding from the bottom toward the top of the winding the heated air from the lower winding turns does not contact with the upper turns. For a given amount of material, therefore, a winding constructed in accordance with the principles just described will have a much higher current carrying capacity than will a winding of the old design, and the permissible height of winding construction will be substantially increased.

To further improve the ventilation characteristics of the winding of Fig. 1, draft tubes may be disposed in the central opening extending from the top thereof to different points within the winding. Such tubes are illustrated in Fig. 3 at 26 and 27 as having lengths corresponding substantially to the distances of the steps in the internal diameters of the winding from the top of the winding. The effectiveness of these tubes may be greatly improved by the provision of a ventilating fan 30 disposed at the top of the central opening and driven by a motor 32. This motor may be energized from any suitable source such as an auxiliary circuit 34 which, if desired, may be arranged for automatic control in the manner disclosed and claimed in my copending application, Serial No. 651,727, filed January 14, 1933, and assigned to the same assignee as this invention. In accordance with the teachings of that application the fan-driving motor is energized in accordance with the current carried by the coil to be ventilated in order that the cooling force may at all times be commensurate with the coil heating.

When the ventilating fan 30 is used with the draft tubes 26 and 27, ventilating air will be drawn in from the outside of the winding between the spaced turns in the same manner as were the fan to be directly located at elevations corresponding to the lower ends of the tubes, in this manner, the uniformity of cooling is greatly increased and the permissible height of the winding construction is accordingly raised.

In cases in which it is desired to retain the uniform internal diameter throughout the entire winding length, the expedient illustrated in Fig. 4 may be utilized. The winding shown in Fig. 4 is similar to that already described in connection with Figs. 1 and 2, it comprising a plurality of discoidal layers of spaced conductor turns 40 held in position by apertured supporting members 42 with which end plates 44 and 45 are associated. At some intermediate position along the winding height, a deflecting baffle 50 is disposed in the manner shown, certain conductor turns being omitted from the winding to accommodate the baffle.

Because of the presence of the baffle, the ventilating air heated by contact with the lower turns in the winding is all directed into the central opening through which it rises and discharges out of the top without substantial contact with the turns at the upper end of the winding. These upper turns are thus ventilated by cool air which enters from the outside and flows therebetween into the central opening in the same manner as were the turns to be located near the bottom of the winding.

If forced cooling is desired, a motor-driven fan, indicated at 54, may be utilized to increase the volume of air which flows through the winding to thus further limit the temperature rise of the turns.

The expedient disclosed in Fig. 4 is not limited in its application to single phase windings but may also be applied to a plurality of vertically disposed coils in the manner indicated in Fig. 5. In Fig. 5 windings 56, 58 and 60, which may be respectively connected in the conductors of a three-phase power circuit, are indicated in simplified form as being mounted with their center lines along a common vertical axis. Intermediate the windings are disposed the deflecting baffles 62 and 64 which function in the manner already explained to direct the heated air from the lower coils into the common central opening through which it may discharge in an upward direction without contacting the upper coils. To adapt the scheme to forced ventilation, a motor-driven fan 66 may be disposed in some position such as shown.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many further modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the scope of the appended claims.

I claim as my invention:

1. In an air-cooled current-limiting reactor, a plurality of layers of spaced turns of conductor disposed about a common vertical axis, said coil structure having a central opening which extends axially therethrough, means for reducing the tendency of the turns at the upper portions of the coil to become hotter than those at the lower portions comprising means for directing the ven-

tilating air heated by contact with the said lower turns into the central opening through which it may pass upwardly without appreciable contact with the said upper turns.

2. An electrical winding comprising a plurality of layers of spaced turns of conductor disposed about a common vertical axis, the outer diameter of said winding being substantially uniform from top to bottom and the inner diameter being increased by progressively decreasing the number of turns per layer from the bottom toward the top of the winding.

3. An electrical winding comprising a plurality of layers of spaced turns of conductor disposed to form a central opening along a vertical axis, the outer diameter of said winding being substantially uniform from top to bottom and the inner diameter being stepped outwardly, by progressively decreasing the number of turns per layer from the bottom toward the top of the winding, and means for completely closing the central opening at the bottom of said winding.

4. A current-limiting reactance coil comprising a plurality of spaced turns of conductor wound in a plurality of layers disposed for mounting with the longitudinal axis thereof substantially vertical, the number of turns per layer being less at the upper end of the coil than at the lower end, and so positioned that the inside diameter of said upper end of the coil is greater than that of the said lower end of the coil.

5. An electrical winding comprising a plurality of spaced layers of turns positioned radially about a common vertical axis forming a central opening, extending longitudinally of the winding structure, the cross-sectional area of the opening being greater at the upper end of the winding than at the lower end, to thereby facilitate the natural circulation of ventilating air which flows inwardly between the winding turns and upwardly through said central opening.

6. In a current-limiting reactor, a coil comprising a plurality of turns of conductor spaced apart and wound in the form of a multi-layer cylinder, having a central opening, said reactor being disposed for mounting with the axis thereof substantially vertical, a bottom end member for said coil in the form of a solid disc, and a top end member therefor in the form of an annulus having an opening therein that substantially coincides with the central opening at the top of the coil.

7. An electrical winding comprising, in combination, a plurality of turns of conductor spaced apart and wound in the form of a cylinder having a central opening therein for mounting with the axis thereof vertical, a solid member attached to the bottom end of said winding structure, and an annular member attached to the top end of the structure, having an opening corresponding in size and position substantially with the central opening at the top of the winding, the inside diameter of the upper end of the winding being greater than that of the lower end to thereby facilitate the natural circulation of ventilating air which flows inwardly between the winding turns and upwardly through the central opening.

8. In combination, an electrical winding comprising a plurality of spaced turns of conductor disposed about a common vertical axis forming a central opening extending axially through the winding structure, means for equalizing the cooling effect of a ventilating fluid between the turns at the upper and lower portions of the winding which fluid flows inwardly between said turns and upwardly through the central opening comprising a hollow conduit disposed in said central opening extending from an intermediate point along the axial length of the winding to the top thereof to discharge from the top of the winding the fluid heated by contact with the lower turns thereof without allowing said fluid to contact the upper winding turns.

9. In combination, an air-cooled cylindrical electrical winding comprising a plurality of layers of spaced turns of conductor disposed about a common vertical axis in a manner that there is formed a central opening which extends axially through the winding structure, the inner diameter of said opening being stepped outwardly as the top of the winding is approached, a draft tube disposed in said central opening to extend from an intermediate point along the axial length of the winding to the top thereof to discharge from the top of the winding the ventilating air heated by contact with the lower turns thereof without allowing said heated air to contact the upper winding turns.

10. In combination, an air-cooled cylindrical electrical winding comprising a plurality of layers of spaced turns of conductor disposed about a common vertical axis in a manner that there is formed a central opening which extends axially through the winding structure, the inner diameter of said opening being stepped outwardly as the top of the winding is approached, means comprising a motor-driven fan for drawing upwardly through said central opening a draft of ventilating air, said air being caused to flow in from the outside of the winding between the spaced turns thereof.

11. In combination, an air-cooled cylindrical electrical winding comprising a plurality of layers of spaced turns of conductor disposed about a common vertical axis in a manner that there is formed a central opening which extends axially through the winding structure, the inner diameter of said opening being stepped outwardly as the top of the winding is approached, a hollow conduit disposed in said central opening to extend from an intermediate point along the axial length of the winding to the top thereof, and means comprising a motor-driven fan for drawing upwardly through said conduit a draft of ventilating air.

12. In combination with an air-cooled cylindrical electrical winding comprising a plurality of layers of spaced turns of conductor disposed about a common vertical axis in a manner that there is formed a central opening which extends axially through the winding structure, a baffle for directing the ventilating air heated by contact with the lower turns of the winding into the said central opening through which it may rise vertically to discharge from the top of the winding.

13. In combination, an air-cooled cylindrical electrical winding comprising a plurality of layers of spaced turns of conductor disposed about a common vertical axis in a manner that there is formed a central opening which extends axially through the winding structure, a baffle for directing the ventilating air heated by contact with the lower turns of the winding into the said central opening through which it may rise vertically to discharge from the top of the winding, and means for increasing the upward flow of ventilating air comprising a motor-driven fan disposed in said central opening.

14. In combination, a plurality of air-cooled

cylindrical electrical windings, having central openings therethrough, mounted one above the other with their axes substantially coinciding, a baffle for directing the ventilating air heated by contact with each of the lower windings into said central opening through which it may rise vertically to discharge from the top of the winding assembly.

15. In combination, a plurality of air-cooled cylindrical electrical windings, having central openings therethrough, mounted one above the other with their axes substantially coinciding along a common vertical axis, a baffle for directing the ventilating air heated by contact with each of the lower windings into said central opening of the windings above, through which it may rise vertically to discharge from the top of the winding assembly, and means for increasing the upward flow of ventilating air comprising a motor-driven fan disposed in said central opening.

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