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ELECTRICAL WINDING

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Fig. 1.

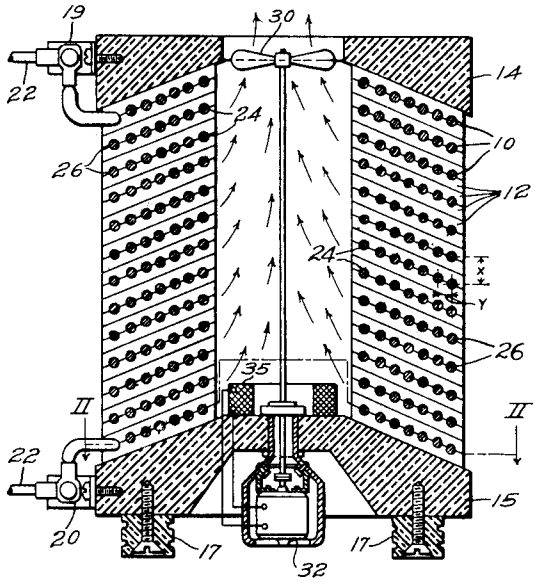
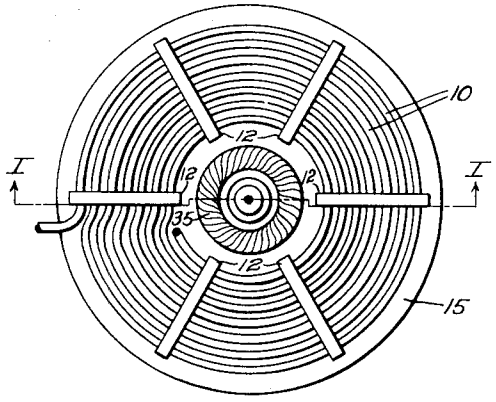


Fig. 2.



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ELECTRICAL WINDING

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5 Claims. (Cl. 175—359)

Our invention relates to electrical windings and it has particular relation to winding constructions possessing improved self-cooling or ventilating characteristics which are especially applicable to current-limiting reactance coils and other windings of the multi-layer cylindrical 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 limits the current capacity of the coil. In the past, ventilating characteristics of coils adapted for current-limiting service have been relatively inefficient, certain turns in the structure tending to become much hotter than do others. Since the current capacity is limited by the allowable coil temperature rise, such inherently poor ventilation has in the past made it necessary to increase the size of and amount of material in the coil structures, and the cost of manufacture has been correspondingly raised.

One object of our invention is to reduce the cost and size of current-limiting reactance coils and other comparable electrical windings.

Another object of our invention is to improve the 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 our invention is to modify the design of conventional current-limiting reactance coils of the spaced conductor multi-layer 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 winding having a central opening extending therethrough, to which type of winding our invention is especially applicable, ventilating fluid flows inwardly from the outside between the winding turns and upwardly through the central opening. When the axially disposed disc-like layers of winding turns are made substantially flat, the spaces between the layers, through which the ventilating fluid must flow to reach the central ventilating opening of the winding, fail to permit the greatest freedom of cooling-medum circulation, which, in a natural-ventilating system tends to take an upward direction as the inside of the winding is approached.

To overcome this difficulty, it has been proposed to dispose the conductor turns in each of the axially-spaced turn layers in the form of sections of cones which slope upwardly towards the central opening of the winding. By thus causing the inter-layer ventilating spaces, which communicate from the outside of the winding to the common central opening, to slope upwardly toward the inside, the freedom of flow of ventilating air therethrough is materially increased. However, when, as in the past, the turns in each of these conical layers are positioned close together with no space therebetween, the area of conductor surface which the ventilating fluid is enabled to actively contact is seriously limited, and the increase in cooling effectiveness attained by the accelerated flow of ventilating fluid is for this reason considerably reduced.

In accordance with our invention we provide a spacing between the turns in each of the conical layers, which spacing, by permitting a certain amount of ventilating fluid to rise vertically between the turns, allows these turns to be actively contacted by cooling medium on all sides intsead of restricting this contact to the top and bottom thereof only, as in case when no radial spacing is provided. Because of such increased contact the effectiveness of the cooling medium is materially raised, as may be conclusively demonstrated by temperature-rise tests.

As will become more apparent, in the type of winding construction contemplated by our invention, not only is the exposed surface of the conductor per unit volume of material made a maximum, but because of the upwardly sloping interlayer spaces afforded by the conical construction, the cooling medium will flow only a short distance vertically before it discharges into the central opening. This last-mentioned feature will be seen to be of substantial value in improving the uniformity of winding cooling in that it tends to direct the ventilating fluid heated by contact with the turns in the lower portions of the winding directly into the central opening through which it discharges upwardly without substantial contact with the upper portions of the winding.

Our invention, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when taken in conjunction with the accompanying drawing, in which:

Figure 1 is a view in section, taken on line I—I of Fig. 2, of an electrical winding constructed in accordance with a preferred embodiment of our invention, and

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

Referring to the drawing, the electrical winding there illustrated is in the form of a current-limiting reactance coil comprising a plurality of vertically disposed layers 10 of conductor turns stacked on top of each other and supported in position by apertured spacing members 12 arranged in stacks or groups, all of which are disposed radially from the center line of the structure. Top and bottom end plates 14 and 15 formed of suitable insulating material, such, for example, as concrete, are comprised by the structure in the manner shown, which structure may be supported by insulator feet 17. Connections with the alternating-current power circuit, the current in which is to be limited by the coil are made by terminals 19 and 20 attached to the top and bottom end plates respectively, the power circuit conductors received thereby being designated by the reference character 22. Cooling of the winding is effected by the passage of air or other ventilating fluid from the outside between the spaced winding turns and upwardly through the central opening, as indicated by the arrowheads.

To improve the natural ventilation of the winding, the conductors in each of the layers 10 are positioned in the form of truncated cones, the inner conductors 24 being at higher elevations than are the outer conductors 26, and the intermediate ones being at elevations in line with the inner and outer ones. The necessary sloping of the spacing-block members 12 required to hold the conductors in this desired position is maintained by an appropriate beveling of the top and bottom end members 14 and 15. Because of this vertical spacing, which in Fig. 1 is designated by the reference character X, the ventilating ducts between adjacent conical turn layers slope upwardly as the inside of the structure is approached, thereby tending to coincide with the paths taken by the natural flow of ventilating fluid, and hence increasing the volume of fluid which will flow between the turn layers. This increase is a substantial aid in making natural ventilation more effective.

To further improve the coil cooling, the individual turns in each of the several layers are, in accordance with our invention, also spaced apart from each other in order that a certain proportion of ventilating fluid may rise vertically therebetween, to thereby effect an active contact with the complete conductor surface. Preferably this turn spacing is of a magnitude, designed in Fig. 1 by the reference character Y, which is substantially less than the layer spacing X in order that the major portion of ventilating fluid will be directed into the common central opening of the winding through which it may discharge without appreciable contact with the turns in the winding portions above.

In practice, the provision of such turn spacing is found to effect substantial reductions in the temperature to which the winding turns will rise for a given loading, such improvement in ventilation effectiveness resulting, as has been pointed out, from an increase in the area of the conductor which is actively contacted by the ventilating fluid. Tests reveal that an important feature is a proper proportioning of the conductor spacing Y with respect to the layer spacing X, the most advantageous results being obtained when Y is but a fraction of X.

The advantages to be derived through our improved form of winding construction are in no way limited to the natural ventilation systems just described, but are likewise equally effective when forced-ventilation is utilized. Thus should it be desired to increase the flow of cooling fluid through the winding of Figs. 1 and 2, a fan 30 suitably mounted in the central opening of the winding and driven by a motor 32, which is shown as deriving its energization from an auxiliary pick-up winding 35 positioned in the path of the main coil flux, may be utilized. While the method of energizing the fan motor illustrated is the same as that disclosed and claimed in a co-pending application Serial No. 651,727 of L. E. Sauer, filed January 14, 1933, and assigned to the same assignee as this invention, it will be understood that any other type of fluid propelling means and driving equipment associated therewith may instead be utilized. When so employed, the advantages already pointed out in connection with natural ventilation are still retained, the magnitude of the cooling action merely being increased as a result of the forced circulation.

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

We claim as our invention:

1. An electrical winding, disposed to be mounted with the axis thereof substantially vertical, provided with a central ventilating space extending in the direction of said axis and comprising a plurality of axially disposed dished-disc layers of spaced conductor turns, said layers being spaced apart from each other to provide ventilating ducts communicating from the outside of the winding to the central ventilating space.

2. An electrical winding, disposed to be mounted with the axis thereof substantially vertical, provided with a central ventilating space extending in the direction of said axis and comprising a plurality of axially disposed dished-disc layers of spaced conductor turns, said layers being spaced apart from each other to provide ventilating spaces communicating from the outside of the winding to the central ventilating space, the axial spacing between adjacent layers being substantially greater than the spacing between the adjacent conductor turns in the said layers.

3. An electrical winding, disposed to be mounted with the axis thereof substantially vertical, provided with a central ventilating space extending in the direction of said axis and comprising a plurality of axially disposed layers of conductor turns, said layers being spaced apart to permit ventilating fluid to flow therebetween and each comprising a plurality of radially spaced turns, the inner turn of each layer being positioned at a higher elevation than is the outer turn and the intermediate turns being positioned at intermediate elevations in line with the said inner and outer turns.

4. An electrical winding disposed to be mount-

ed with the axis thereof substantially vertical, provided with a central ventilating space extending in the direction of said axis and comprising a plurality of axially disposed layers of conductor turns, said layers being spaced apart to permit ventilating fluid to flow therebetween and each comprising a plurality of radially spaced turns, the inner turn of each layer being positioned at a higher elevation than is the outer turn and the intermediate turns being positioned at intermediate elevations in line with the said inner and outer turns, the spacing between adjacent layers being greater than that between conductor turns in the said layers.

5. In combination, an electrical winding provided with a central ventilating space extending in the direction of the axis thereof and comprising a plurality of axially disposed dished-disc layers of spaced conductor turns, said layers being spaced apart from each other to provide ventilating ducts communicating from the outside of the winding to the central ventilating space, and means, comprising a motor-driven fluid propeller, for causing ventilating fluid to be drawn from the outside into the central opening of the winding and discharged from one end thereof.

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