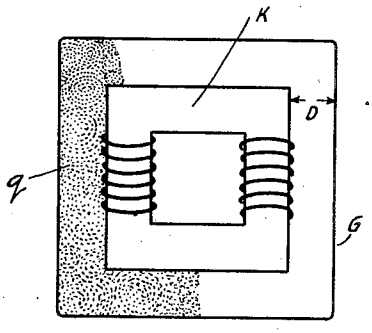
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ELECTRICAL APPARATUS

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## ELECTRICAL APPARATUS

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1 Claim. (Cl. 175—361)

This invention relates to electrical apparatus in which the parts subject to heating are embedded in insulation material, and are also subject to a tendency to move relative to each other during operation.

The present invention discloses novel ways and means for the construction of electrical apparatus of the kind which, on the one hand, must be properly insulated from the surroundings, while, on the other hand, such heat as is interiorly dissipated must be abducted as fast as feasible and yet the elements of which must not move relative to each other during operation. The invention originated from researches that were made on quartz. The result of these was that quartz represents one of our best technical insulators, and furthermore that crystalline quartz is an insulator possessing a very high thermal conduction power, indeed, that it possesses heat conducting powers amounting to one third or one fourth that of iron. If quartz is to be used, for example, for insulating transformers from the outside, at the present state of the art no suitable quartz bodies are available to suit the industrial or technical apparatus as to shape. Hence, it is necessary to utilize comminuted quartz, quartz grains or quartz sand. To be sure, the heat conducting power is then considerably diminished on the ground that on flowing from one grain to the next the heat is compelled to cross a film of air adhering to the surface of the granules, and this means a correspondingly larger resistance. Hence, if quartz in granulated condition is to be used these air skins or air-filled interstices must be eliminated to facilitate abduction and dissipation of the heat.

This is attained by enclosing the mass of quartz that is to be employed in an asphalt base, or in oil, ceresin, asphalt, resin, or some other binding agent. Enclosing the mass of quartz in a suitable base may be effected by boiling or heat application, or by pressure, or by the combined effect of these methods. If, then, this mass possessing a maximum thermal conduction power is filled into the tank of a standard oil transformer it is discovered that, although the mass possesses far greater heat conducting power than oil, the heat abduction is substantially lower than for the oil itself. The reason underlying this fact is that the container of the oil transformer is so designed that in operation, that is, when the transformer becomes heated, there is produced an intense circulation of oil; and this circulation of the oil results in a far more effective cooling of the windings than could be possibly realized by virtue of the heat conduction power of the oil.

In the light of the discoveries underlying the present invention, however, it is possible to build a transformer provided with a quartz filling in such a way that it becomes more efficient in performance than an oil transformer involving oil circulation. This is accomplished by adapting the entire construction of the transformer to this novel cooling means or material and its different properties. This at the same time insures a higher puncture strength as compared with oil. By exhaustive investigations it has been found that when the thickness of the outer quartz layer or sand layer of insulation is made less than, say, from 15–20 mm, the mass of quartz insures a more expeditious abduction of the heat than could be assured by circulating oil. If the insulation layer is made heavier or thicker, this novel type of quartz-insulated transformer is found to be inferior to a transformer having an efficient oil cooling system. But when the insulation layer is chosen less than 20 mm the chilling effect is essentially better than in an oil-insulated transformer.

Hence, by building the cooling vessel around a transformer just large enough so that it will be about 20 mm larger than the windings, and if this outer container is then filled with comminuted quartz or sand mass, this results in a transformer which, as regards cooling conditions is unsurpassed by any other type of transformer construction, while yet insuring an excellent insulation from the outside; for a layer of 20 mm of sand or quartz has a breakdown strength three fifth times higher than oil, in other words, a breakdown strength of several 100,000 volts. A transformer of this kind, from a technical and practical viewpoint, is substantially better than an oil-insulated transformer, particularly for the reason that should a puncture occur, there is no danger from fire.

The filling material for the transformer may consist either of sand or better of comminuted quartz in crystalline condition. The heat conduction power and also the insulation power become so much greater the larger the pieces of quartz. It is a good plan also in this case to utilize relatively large pieces of quartz, at least for the layer near the outside of the cooling jacket or tank, care, of course, having to be taken so that such air interstices as may be present between the quartz pieces will be avoided.

A transformer as hereinbefore disclosed is illustrated by way of example in the accompanying

drawing. Referring to the latter, K denotes the iron core upon which the two transformer coils are wrapped, while G is the transformer tank preferably provided with cooling ribs. Electric insulation between the coils and the wall of the vessel consists of quartz grains, the latter being embedded in oil. The distance D between the insulated coils and the wall of the vessel, according to the present invention, is smaller than 20 mm.

Another important problem in modern power and high-potential engineering is to properly embed or enclose electrical apparatus or parts thereof, windings, etc., in an insulation material.

To overcome difficulties which often arise on account of the fact that, for instance, by short-circuits powerful forces are set up between winding elements with the result that the latter are subject to movement, torsions and destruction, attempts have been made to preclude such movements of the windings by embedding them in cement or mortar, sand cemented or bound by lime, etc. Such a binding material sets or solidifies after a short while so that the whole mass results in a solid block. Now, such a block about the winding involves great technical drawbacks insofar as, if the winding is damaged, say, by a short-circuit, it is difficult to take the winding apart without destroying it incidentally. One way of overcoming this difficulty has been to embed the windings in pulverulent insulators such as porcelain powder, kaolin, or sand alone. However, in these arrangements the turns could by no means be rendered rigid and firm enough to prevent shifts or movements thereof whenever powerful forces happen to act on them, so that also in this scheme movements of the windings resulting in destruction and damage were caused.

By the present invention all of the said difficulties are obviated. The fundamental idea is that the windings must be embedded inside a rigid insulating block capable of withstanding powerful actions. However, in accordance with the present invention, instead of lime or cement as a binding agent for the insulation material, for embedding the insulating material, I use a mass which is rigid under normal working conditions so that the whole embedding around the turns consists of a rigid and solid block, while upon an increase of temperature of the whole electrical apparatus the binder becomes soft and fluid so that the winding body can be dismantled quite readily and without an incidental destruction. What is particularly suited to be used as a binder of the said sort are materials with an asphalt base, ceresin, resin, and many grades of bakelite.

As an embedding material, which in general insures insulation against a breakdown, and which may be maintained by the binder in mechanical solid form, I have found that quartz sand, quartz grains or larger pieces of the crystal, are well suited.

This insulation method provides an excellent technical means for the embedding and sheathing of transformer windings, windings of choke-coils and also air-cored reactor coils. The same method is also greatly suited for filling cable joints (compounding). For insuring a satisfactory operation of the arrangement it is convenient, however, to fill or introduce the insulation material consisting of pieces of quartz or grains and the binding material into the transformer tank with the application of pressure.

The transformer hereinbefore disclosed overcomes this difficulty. Referring again to the drawing, K is the iron-core upon which are wrapped the two transformer coils. G denotes the transformer tank which is suitably provided with radiator or cooling ribs or corrugations not shown. Electrical insulation between the coils and the tank wall is insured by means of a layer Q comprising pieces of granules of quartz to which suitable binding material such as ceresin is added.

In order that the arrangement may operate satisfactorily it is convenient to fill the quartz granules possessing electrical insulation power together with the binding agent into the transformer tank under pressure.

Having thus described my invention and the operation thereof, what I claim is:

In electrical apparatus such as transformers, in which the parts are subjected to an electrical field during operation, said field tending to heat and cause movements of the transformer winding, an insulating and heat conducting layer of quartz granules held together with a binding agent having an asphalt base, said layer having a breakdown strength of substantially 100,000 volts, the thickness of said layer being substantially 15 to 20 milliammeters thick to insure rapid abduction of heat from the transformer winding.

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