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CORONA PROTECTION SCREEN FOR INDUCTOR COILS IN VACUUM FURNACES

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Fig.1

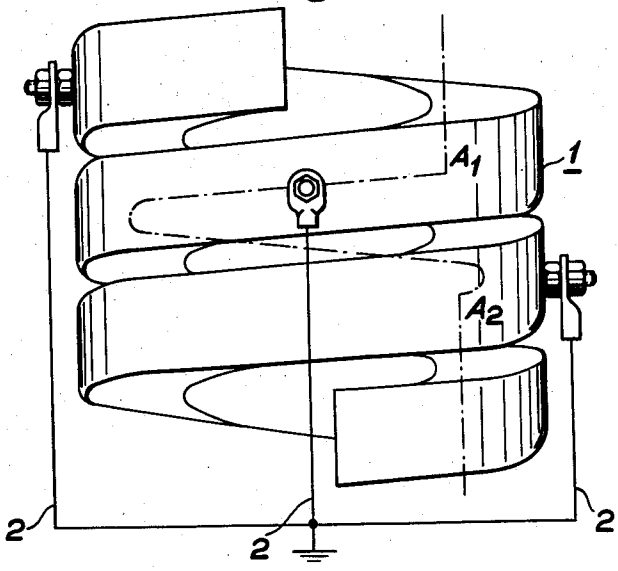


Fig.2

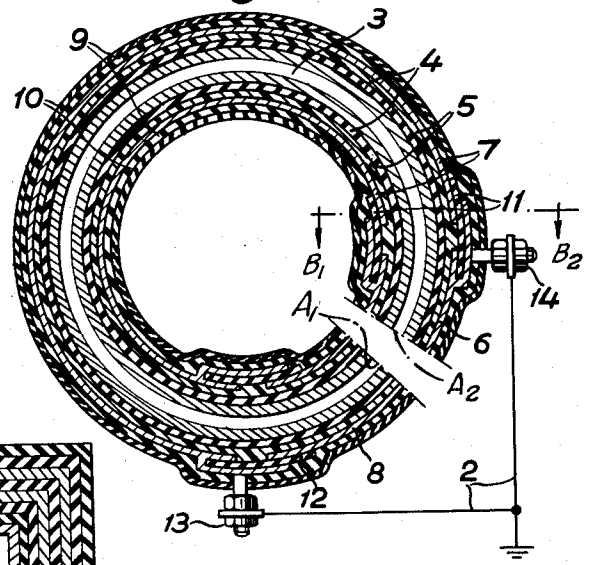
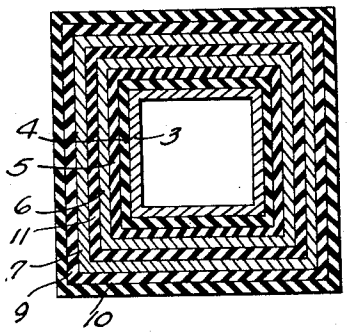


Fig.3



INVENTORS
Ivar Beckius
Mats Rydinger
BY
Bailey, Stephens & Huettig
ATTORNEYS

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CORONA PROTECTION SCREEN FOR INDUCTOR COILS IN VACUUM FURNACES

Ivar Beckius and Mats Rydinger, Vasteras, Sweden, assignors to Allmänna Svenska Elektriska Aktiebolaget, Vasteras, Sweden, a Swedish corporation

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In vacuum furnaces in which the heating is brought about by means of an inductor coil, it is extremely difficult to prevent flashover between different coil parts and between the coil and surrounding parts of the furnace. The reason that particular problems regarding occurring flashover are present in vacuum furnaces is that the rarified atmosphere has poor insulation properties, and therefore the corona, i.e., electrical gas discharges which can develop into flashover, easily occurs.

In order to prevent corona on the part subjected to an electrical tension, namely the furnace coil and connection leads in the vacuum chamber, these parts are usually first insulated and subsequently provided with a corona protection screen which may consist of a number of conducting layers insulated from each other within the coil, but which are connected together outside the coil and are usually connected to earth or a potential lower than the critical electrical tension at which corona appears.

If rupture arises in the connection between the layers or between a layer and earth potential or other potential under the critical tension where corona appears, for example because of mechanical damage or thermal strain, the layer receives approximately the same potential as that part of the copper conductor which the screen encloses. If rupture arises within a layer, in a similar manner, that part of the layer which after the rupture is not in connection with the other layers or with earth or another potential under the corona limit tension, receives approximately the same potential as the copper conductors situated within this part. Such ruptures result immediately in flashover phenomena so that the furnace can become unusable and the processes which the furnace is intended to carry out must be uncontrollably cut off. Apart from the necessity of re-insulating the furnace coils and possibly replacing or repairing other damaged parts, sometimes the material which is being processed in the furnace may have to be discarded, with the considerable economic losses which this entails.

The present invention relates to a corona protection screen in which flashover phenomena cannot arise as a direct result of a connection between any of its parts or between these parts and the earth potential or another potential lower than the critical electrical tension at which corona appears. The object of the invention is a corona protection screen consisting of layers of conducting or semiconducting material, which are covered on the outside by a tight and pore-free coating of an insulating material, for example silicone rubber. It is advantageous if this material has resistance against corona. The conducting or semiconducting layers are suitably attached to the insulation of the coil with a thermosetting resin. The expression "thermosetting resin" is intended not only to include resins which are cured by heating but also those resins which cure at room temperature such as completely polymerizable resins. These conducting or semiconducting layers, further, can suitably be made up of metal, sprayed on, or varnishes containing suspended metal particles, in which case the spraying on of the metal or application of the varnish takes place while the resin is still uncured, so that a close connection between the insulation and the said layers is obtained. The resin is then transferred to cured condition, preferably before the conducting of semiconducting layers are embedded in the insulating covering. If the connection between the layers or with the earth should be broken and corona arise, the furnace will not be incapable of function since the covering is capable of resisting the strain arising so that flashover does not occur. Consequently, it is possible under these circumstances to continue the process taking place under the planned conditions and thereby obtain the result aimed at with the treatment in the furnace. The furnace need not immediately afterwards be taken out of operation, but it may still be used in the normal way, so that repair of the corona protection screen may be made at a suitable time. Damage of such a nature that corona arises can further be established through the observable corona phenomenon on the coating, which makes it possible to stop the process under complete control, if it is considered suitable. This may be the case, for example, if certain parts of the furnace are made of materials which are easily damaged by corona, or if for special reasons it is suspected that the risk of flashover might be present with continued operation. Because a fault arising can be established before flashover takes place, damages resulting from such a phenomenon consequently can be avoided.

The invention will be described more closely with reference to the FIGURES 1 and 2.

FIGURE 1 shows a side view of a part of a helically wound, water-cooled coil for an induction furnace. The coil is insulated and provided with a corona protection screen according to the invention. In relation to the diameter of the coil, the diameters of the conductor sections are enlarged.

FIGURE 2 shows a section A_1–A_2 of a turn of the coil in FIGURE 1. The coil shown in the figures is only chosen as an example of a coil which may be provided with a corona protection screen according to the invention. The shown corona protection screen constitutes an embodiment of the invention chosen by way of example. FIGURE 3 is a cross-section on the line B_1–B_2 of FIGURE 2.

FIGURE 1 shows the shape of the coil, one turn of which can be seen in more detail in FIGURE 2, and also how the conducting or semi-conducting layers insulated from each other within the coil are connected together and to earth outside the coil by leads **2**. The conductor consists of a copper pipe **3** which is internally cooled by water. Outside the real insulation **4**, which consists for example of a silicone varnish, an epoxy resin, an alkyd varnish, a phenolic varnish, an unsaturated polyester resin, or silicone rubber, is applied a ground layer **5** for the conducting or semiconducting layers **6**, **7** and **8**, which together with the covering **9** of a tight, pore-free and corona-resistant material, form the corona protection screen. Outermost is applied an insulating material **10** for protection against mechanical damages. The insulation **4** may also consist, e.g., of a wrapping of glass fibre tape impregnated with the mentioned resins and varnishes or of a wrapping of silicone rubber tape reinforced with a glass fibre tape. The ground layer **5** consists in the exemplified case of a wrapping, e.g., with half-overlap of a woven glass fibre tape, e.g., with a width of 19 mm. and a thickness of 0.08 mm. After the glass tape has been applied to the insulation of the coil, an epoxy resin is supplied, for example the epoxy resin "Araldite XV" with "Curing Agent XV" from Ciba AG., which components are previously mixed in the proportion of 100 parts by weight of the first mentioned and 30 parts by weight of the last mentioned. The mentioned epoxy resin is of the bisphenol type and dissolved in a solvent, and the curing agent is of the anhydride type and also dissolved in a solvent. Heating-curing as well as room-temperature-curing resin may be used. Instead of the exemplified epoxy resin other

heat resistant thermosetting resins may be used such as commercially available other epoxy silicone, saturated and unsaturated polyester and phenolic resins. After solvents in the mixture have evaporated, but before the resin is cured, the conducting layers **6**, **7** and **8** are applied, which layers may consist of lead and be applied by flame spray. They could also constitute, for example, varnishes containing suspended metals such as aluminum and silver in powder form. Each metal layer, for example layer **7** encloses in this example, as is clear from FIGURE 2, ¾ coil turns and is insulated from the metal layers **6** and **8** in the adjacent ¾ coil turns by insulations **11** and **12** of the same type as the insulation **4**. The metal layers are connected to each other outside the coil. From FIGURE 2 is seen particularly how the metal layers **6** and **7** via the connections **13** and **14** and the leads **2** are connected with each other outside the conductor. It is also seen that they are insulated from each other inside the coil. The conducting layer **6** is insulated from the conducting layer **7** in the radial direction by the insulation **11** applied between the overlapping parts of the conducting layers **6** and **7** and in the peripheral direction by the insulating material **5** present between the end parts of the conducting layers **6** and **7** in the same periphery of the coil. In the same way the conducting layer **7** is insulated from the conducting layer **8** in the radial direction by the insulation **12** applied between the overlapping parts of the conducting layers **7** and **8** and in the peripheral direction by the insulating material **5** present between the end parts of the conducting layers **7** and **8** in the same periphery of the coil. As is seen from FIGURE 2, the insulation **11** is present also between the two end parts of the conducting layer **6** at different radial distances from the center at the place where the layer is connected to the connection **14**. In the same way the insulation **12** is present between the two corresponding end parts of the layer at the connection **13**. The covering **9** may advantageously consist of an unreinforced silicone rubber tape or of a silicone rubber tape containing a reinforced glass tape, for example of Westinghouse Silastic Tape 9495–12 with a width of 19 mm. and a thickness of 0.25 mm. from Westinghouse Corp. The silicone rubber tape may, for example, be wound in two layers with half over-lap. The winding must be done with the greatest care so that each part is covered by at least one tape thickness, and the bandage obtained is completely tight and pore-free. The outer protection **10**, the main purpose of which is to protect the insulated coil, provided with the corona protection screen, from mechanical damage in connection with its transport, manipulation and mounting may for example consist of glass tape with an adhesive material, e.g., a silicone rubber tape reinforced with a woven glass fibre tape such as Tape No. 659 from Vernon Chemical and Mfg. Corp., having a width of 19 mm. and a thickness of 0.15 mm. This tape may, e.g., be applied with half overlap. If the covering **9** itself has sufficient resistance against mechanical damage, the protection **10** may be dispensed with. The resin used during the application of the metal layers is suitably cured after the layers have been sprayed on, but curing may also be deferred until the layers are covered with the tight and pore-free material.

We claim:

1. A vacuum furnace inductor coil adapted to be arranged in a vacuum chamber, said inductor coil comprising an electric conductor forming a coil for induction heating, a layer of electrical insulation applied around said conductor, a corona protection screen applied around said insulation along the entire length of the conductor and connected to a potential lower than the critical tension at which corona appears, said corona protection screen comprising at least two electrically conducting parts extending in the longitudinal direction of said conductor, arranged successively one after the other in the longitudinal direction of the conductor and insulated from and partially overlapping each other, and a tight, pore-free cover of silicone rubber enclosing said electrically conducting parts.

2. A vacuum furnace inductor coil as claimed in claim 1, in which said electrically conducting parts comprise metal layers.

3. A vacuum furnace inductor coil as claimed in claim 1, in which said electrically conducting parts comprise layers of solid resin containing metal powder.

4. In a coil as claimed in claim 1, means connecting said electrically conducting parts outside the screen.

5. In a coil as claimed in claim 1, said tight, pore-free cover of silicone rubber comprising a wrapping of silicone rubber tape.

6. A vacuum furnace inductor coil adapted to be arranged in a vacuum chamber, said inductor coil comprising an electric conductor forming a coil for induction heating, a layer of electrical insulation applied around said conductor, a layer of a thermo-setting resin applied on said insulation, a corona protection screen applied around said layer of resin along the entire length of the conductor and connected to a potential lower than the critical tension at which corona appears, said corona protection screen comprising electrically conducting parts extending in the longitudinal direction of said conductor, arranged successively one after the other in the longitudinal direction of the conductor and insulated from and partially overlapping each other; and a tight, pore-free cover of silicone rubber applied on said electrically conducting parts.

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