Feb. 17, 1948. J. S. JOHNSON **2,436,306**

CORONA-ELIMINATION IN GENERATOR END-WINDING

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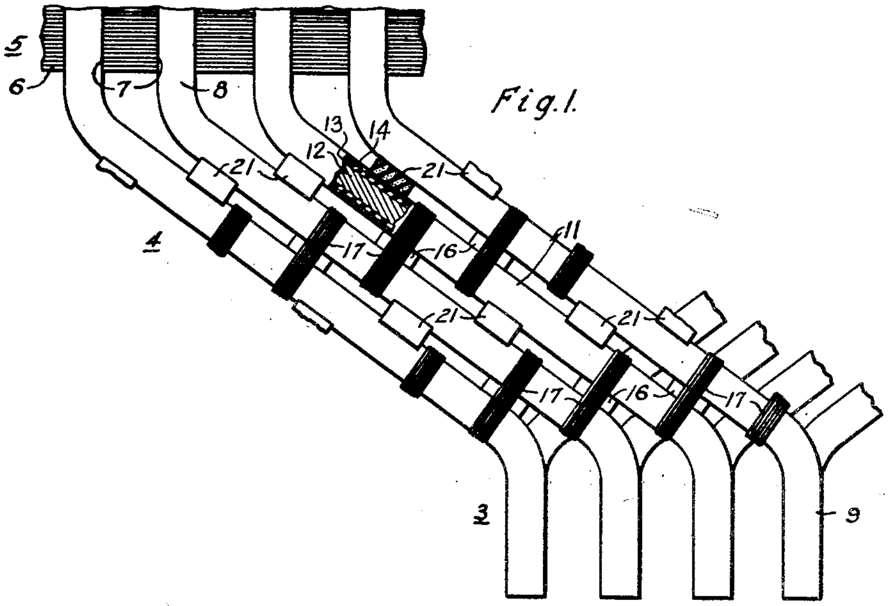


Fig. 1.

Fig. 2.

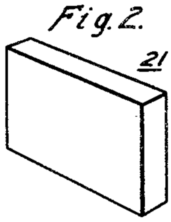
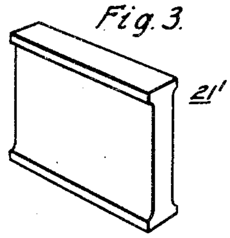


Fig. 3.



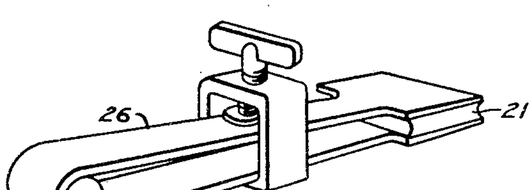


Fig. 4.

WITNESSES:

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CORONA ELIMINATION IN GENERATOR END WINDINGS

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4 Claims. (Cl. 174—73)

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My invention relates to a high-voltage apparatus which comprises a plurality of closely spaced insulated conductors which are subject, at times, to such high voltage-differences between them, that corona-preventive measures are necessary. While my invention is of more generic applicability, it was specifically designed for cross-connecting the semiconducting corona-preventive surfaces of certain insulated conductors of the end-windings of high-voltage dynamo-electric machines such as synchronous generators. Although it is generally applicable to all of the spaced conductors of the end-windings of such a machine, my invention finds its greatest applicability, at present, to the provision of semi-conducting cross-connections at the junction of different phase-groups, or between layers of conductors which have unusually high voltage-differences between them, as compared to other pairs of conductors of the end-windings.

In high-voltage machines of the type to which my invention applies, the several conductors have each been covered by insulating inner layers, and at least the outer exposed portions of said insulating layers have been covered by semiconducting outer layers, usually provided by a semiconducting paint or compound. In the past, semiconducting spacing-blocks have been utilized between the treated conductors which are subject, at times, to such high-voltage differences between them that corona-preventive measures are necessary. In the past, these semiconducting spacing-blocks have been substantially non-resilient, and they have necessitated roping in place, with a semiconducting glass twine, to hold them in place in the event that they should loosen in service.

The twine has not always maintained a sufficiently firm contact between the spacer-blocks and the treated surfaces of the conductors between which the blocks were placed, sometimes resulting in visible corona appearing at these points of contact, thus not only defeating the purpose of the corona-preventive treatment, but also being destructive to the semiconducting materials. Furthermore, the semiconducting twine has caused difficulty, because it, in effect, shortens the air gap between adjacent coils or spaced conductors, because the semiconducting twine takes up some of the space, and thus the twine sometimes results in the formation of visible corona at the points where the twine comes closest to the next adjacent spaced conductor, in spite of the corona-preventive treatment. This condition is aggravated, because of the fibrous nature of the twine, which results in a rough surface, with many fine protruding filaments, each one of which becomes a point of high voltage-stress concentration.

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An object of the present invention is to overcome the foregoing and other difficulties by utilizing, at least for the places where the highest voltage-stresses are encountered, compressible resilient semiconducting blocks, which are held in compression between the treated surfaces of the conductors in question, and which hold themselves in place, by their own resilience, without requiring any roping.

With the foregoing and other objects in view, my invention consists in the combinations, parts, apparatus, and methods hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a perspective view of a portion of the end-windings of the stator member of a high-voltage synchronous generator to which my invention is applied, parts being broken away in section, to show the construction;

Figs. 2 and 3 are perspective views of two of the forms which my resilient spacer-blocks may take; and

Fig. 4 is a perspective view of a clamping-tool which may be used to insert my resilient blocks.

In the application of my invention which is illustrated in Figure 1, the primary winding 3 of a high-voltage polyphase synchronous generator 4 is mounted on the stator member 5 of the generator. For clearness in illustration, the rotor member is not shown. The stator member 5 comprises a stator core 6 of a type having a smooth cylindrical bore, and having conductor-receiving slots 7 for receiving the high-voltage polyphase winding 3. This winding has coil-sides 8, lying in the slots 7, and it has an end-winding portion 9 which consists of spaced insulated conductors 11, which have gaseous spaces between them, and which are subject, at least at times, to such high voltage-differences between them, that corona-preventive measures are necessary. Each conductor 11, as exaggeratedly indicated in Fig. 1, comprises a strap-conductor 12, which is covered by an insulating inner layer 13, which is in turn covered by a semi-conducting outer layer 14 which may be provided by a semi-conducting compound, or by other means, as is well known in previously used corona-preventing means for such machines.

These spaced end-winding conductors 11, or at least the pairs of conductors between which the voltage-difference is not too excessive, may be braced, in a known way, by substantially non-yielding spacers 16 which are roped in place by twine 17. The non-yielding spacers 16 and the twine 17 may, or may not, be impregnated with semiconducting material, but preferably, in either event, they are coated with a semiconducting painted coating.

Between the spaced conductors of different coil-groups, or between different phases, or between any other two spaced conductors where the voltage-gradient is exceptionally large, endangering the formation of corona, I prefer to apply my new compressible resilient semiconducting spacer-blocks 21, the use of which may be confined to these places of exceptional voltage-stress, as indicated in Fig. 1, or the semiconducting resilient spacer-blocks 21 may be utilized throughout, to the exclusion of the rigid or non-yielding spacers 16, if desired. The resilient blocks 21 are composed of a rubber-like material, which is preferably one of the new synthetic materials, such as the silicon rubbers, having a far greater heat-resistivity than natural rubber. This rubber-like material is preferably loaded with a semiconducting material such as carbon or reduced titanium oxide, or its semiconducting quality may be given to it by means of an externally applied semiconducting coating or layer. The thickness of the rubber-like spacer-blocks 21 is such that each resilient block is compressed when it is in place between the two spaced conductors 11 with which it is associated.

The use of this type of spacer 21 results in an intimate contact between the spacer and the treated surfaces of the conductors, thereby eliminating the possibility of corona forming as a result of imperfect spacer-contact. Also, because of the rubber-like nature of the material, and because it is under compression, my new spacer 21 will stay in place without roping. By this, I mean that the many turns of strong twine, which have heretofore been utilized with non-resilient spacers such as 16, are not needed.

The shape of the resilient spacer 21 may be either flat, as shown in Fig. 2, or of a shaped or molded section, preferably of such configuration that the uncompressed spacer-block 21 approximately fits partially around the surfaces between which said block is compressed. One of the configurations which the spacer-block 21 may assume is shown at 21' in Fig. 3. In this way, the shape of the spacer causes it to have a sort of interlocking action which helps to hold it in place.

The use of a rubber-like material for the spacer 21 makes the application of the spacers a more economical manufacturing operation, saving the labor-cost which is involved in roping the non-resilient spacers of the previous practice. The resilient spacers 21 can be applied, after the stiff end-winding conductors 11 are in place in the machine, by first compressing each spacer 21, as indicated by the clamping-blades 26 in Fig. 4, then inserting the spacer between the conductor-pair in question, and finally removing the clamping-tool by withdrawing the blades 26, leaving the spacer in place, where its own resilience holds it in place.

Because of the complex nature of the end-windings 9, it is not always possible to completely anticipate the number and the location of all

points requiring cross-connection. With the use of a resilient material for a cross-tying spacer, the insertion or removal of such spacers, after the machine is wound, becomes a simple operation.

The flexibility of choice and application of my new resilient semiconducting spacers 21 provides greater freedom of choice or selection of the cross-tie resistances of the semiconducting cross-ties, because it is possible to insert any one of a plurality of different available spacers which have been manufactured with an assortment of different resistivities, shapes, and sizes, so that the most complex end-winding problems may be readily solved.

I claim as my invention:

1. A high-voltage electric apparatus comprising a plurality of closely spaced insulated conductors, said conductors having gaseous spaces between them, and being subject, at times, to such high voltage-differences between them that corona-preventive measures are necessary, said conductors being covered by insulating inner layers, and at least the outer exposed portions of said insulating layers being covered by semiconducting outer layers, in combination with one or more compressible resilient semiconducting blocks held in compression between the semiconducting outer layers of one or more pairs of such conductors and held in place by their own resilience.

2. The invention as defined in claim 1, characterized by said block or blocks having an initial uncompressed configuration adapted to approximately fit partially around the semiconducting surfaces between which said block or blocks are compressed.

3. The invention as defined in claim 1, characterized by said block or blocks being composed of a rubber-like material loaded with a semiconducting material.

4. A high-voltage electric apparatus comprising a plurality of closely spaced insulated conductors, said conductors having gaseous spaces between them, and being subject, at times, to such high voltage-differences between them that corona-preventive measures are necessary, said conductors being covered by insulating inner layers, and at least the outer exposed portions of said insulating layers being covered by semiconducting outer layers, in combination with a semiconducting connecting-block, between the semiconducting outer layers of one or more pairs of such conductors, the opposite faces of said semiconducting connecting-block comprising resilient semiconducting material held in compression against, and making an intimate electrical contact with, the semiconducting outer layer of one of said conductors.

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