MANUFACTURE OF LOADED ELECTRIC SIGNALING CONDUCTORS

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This Invention relates to improvements in the manufacture of loaded electric signaling conductors, and more particularly to conductors in which the loading is in the form of a wire or tape of magnetic material wound upon the conductor.

Such signaling conductors are subjected to an annealing treatment in order to develop magnetic permeability in the loading, and in order to eliminate strain in the loading material it is desirable to employ what is commonly termed a spacer between the conductor and the loading material.

This spacer may consist of a layer of combustible or other material which is subsequently removed or modified in order to provide the necessary space between the conductor and its loading. Alternatively the spacer may consist of a wire or the like, fusible at a temperature not exceeding the temperature of annealing so that during the anneal, the wire will fuse and thus relieve the tension in the loading material. This manufacture is the subject of our prior Patent No. 322,504, and the present invention concerns an improvement or modification.

According to one feature of the present invention we employ a non-metallic spacer of thermoplastic material which fuses during the annealing operation, to which the loaded conductor is subjected.

While the thermoplastic spacing material may be applied in the form of a wrapping surrounding the conductor it is preferred to employ it in linear form since the latter is less expensive and can be applied in the same operation as that of applying the loading material.

A thread or ribbon of gutta percha and/or balata or rubber or mixtures of rubber and gutta percha has been found to give satisfactory results.

In practice, the annealing process is carried out in an atmosphere of nitrogen, so as to exclude oxygen, the presence of which is harmful for various reasons. The gutta percha spacer will therefore fuse at about 150° C. and then flow out as a liquid between the interstices of the loading material, after which it will be converted into vapour in the hotter regions of the furnace, and then will be carried away by the nitrogen.

For a cable having a core whose diameter is 0.17" a tape measuring about 0.08"×0.06" wide will provide the necessary space. The size of the spacer, however, is variable to meet required conditions.

The spacing thread or ribbon may be laid in a straight line, or it may be given a slight helical lay.

The annealing operation or other heat treatment necessary to fuse the spacer is generally carried out by drawing the loaded conductor through a tubular furnace through which an inert gas, e.g. nitrogen is passed. Under these conditions the thermoplastic spacing material first melts and flows between the interstices of the loading material and is then vapourized in the hotter regions of the furnace. The vapours derived from the thermoplastic spacing material suffer a certain amount of decomposition in the hotter regions of the furnace, as a result of which a certain amount of finely divided carbon is formed in the furnace tube.

As is well known the heat treatment is worked as a continuous process, for which reason it is desirable to remove continuously or to prevent the carbon formation. For this purpose oxygen in controlled proportions has been tried, which oxygen is admitted with the nitrogen or other inert gas with the object of reacting with the carbon, hydrocarbons, hydrogen and other reducing substances to form carbon dioxide and water. It is extremely difficult, however, to adjust the inlet of oxygen so that the reducing bodies are fully oxidized while at the same time the conductor is unattacked by the oxygen.

According to a further feature of the present invention, we employ an atmosphere consisting of an inert gas containing a gas in which there is combined oxygen capable of reaction at the temperature of the annealing operation in such a way as to oxidize the carbon present. A gas such as water vapour which is not harmful to the conductor should be employed.

At the high temperature the water vapour probably oxidizes the carbon in accordance with the equation

\[ \text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2 \]

and indeed carbon monoxide has been detected in the gases issuing from the tube at the end where the conductor leaves the furnace.

The proportion of water vapour admixed with e.g. the nitrogen does not need to be at all critical provided sufficient water is present to oxidize the carbon formed from the thermoplastic material to carbon monoxide. Loaded conductors have been successfully heat-treated in an atmosphere consisting almost entirely of water-vapour. The nickel alloy loading material of the conductor is substantially unaffected when it has been heat-treated in an atmosphere containing only a relatively small or moderate proportion of water-vapour, but is covered with a very thin film, probably of oxide, when high proportions of water
vapour are used in the gaseous mixture. Although the presence of this thin film is harmless in the case of conductors loaded with comparatively thick tape, e. g. .006 inch thick, it is preferable when very thin tape e. g. only .001 inch thick is used, to employ such a proportion of water vapour that no oxidation of the metal surface occurs.

The water may be introduced either in the form of steam or as drops of liquid water through a special entrance tube into the furnace or it may be sprayed in with the nitrogen. Or alternatively the conductor, prior to entering the furnace, may be wetted either with drops of water or by passage through a water-shower. It is also adventageous if the spacing thread or strip of thermoplastic material has, prior to the heat-treatment, been allowed to take up water, in most cases to the saturation point.

As stated above the gases issuing from the end of the furnace tube contain carbon monoxide, the highly poisonous nature of which is well known.

In order to prevent escape of this carbon monoxide into the surrounding atmosphere it is necessary to employ a modified form of furnace such as described in our copending application No. 4,726/31 or the issuing gases may be ignited in the air as they leave the furnace tube.

The invention is illustrated in the accompanying drawing in which Figure 1 is a perspective view of a loaded signaling conductor prior to the annealing operation and provided with a spacer in the form of a thread.

Figure 2 is a transverse section of the conductor shown in Figure 1, while Figure 3 is a view of the conductor after annealing.

Figure 4 is a transverse section of a signaling conductor with a spacer in the form of a tape and prior to annealing.

Prior to the winding on of the loading material there is laid along the surface of the conductor a Spacer which may conveniently consist of a thread 4 (see Figures 1 and 2) or a tape 5 (see Figure 4).

After the application of the loading material the whole is subjected to an annealing operation or other suitable form of heat treatment which causes the spacer to fuse and run out between the interstices of the loading material, thereby providing for the necessary space between the conductor and the loading material.

The chief advantages of a spacing wire or tape of thermoplastic material are:

1. The thread or tape of thermoplastic material can be produced much more cheaply than the fine metal wire. It is not necessary to use a high grade gutta percha for the spacing thread or tape; quite low grade gutta percha will do.

2. As the thermoplastic material melts at a relatively low temperature, the space is produced early in the annealing operations, whereby absence of strain in the loading material is made quite certain.

3. A thermoplastic thread or tape can be used in those cases when it is not desired to heat the loaded conductor to such a high temperature as would cause, e. g. a silver copper alloy, which has also been found to be particularly suitable in some cases, to melt.

4. The thermoplastic spacer is specially useful when the conductor is loaded with very thin loading material, e. g. with tape having a thickness of the order of .001".

In the first place the danger of diffusion at the high temperature of the material of the spacing wire into the loading material is avoided. When a thicker tape having a thickness of e. g. .0001" is used, the effect of slight diffusion on the magnetic properties will be negligible but with a much thinner loading tape, the same diffusion may have a deleterious effect upon the magnetic properties. Again, although a suitable metal wire spacer for the greater part melts and alloys with the copper conductor to form a smooth film on the surface of the latter, it may happen that isolated small sharp asperities are produced, which may be a source of danger to extremely thin loading tape.

5. In the manufacture of Khrup cables, in those cases where two or more layers of magnetic loading material, requiring heat-treatment are applied to the conductor, the layers being separated by a straight wire tension of the liquid metal will hinder its passage through the interstices of the several layers of the loading wire or tape. On the other hand it is also very undesirable that the metals of the spacing wire should alloy themselves with those of the loading material, since the magnetic properties of the latter would probably be deteriorated thereby.

Liquid gutta percha is mobile and has a comparatively low surface tension. It therefore readily flows out between the interstices in the loading wire. A gutta percha thread is thus of particular value as a spacer in the manufacture of Khrup conductors having a plurality of layers of loading material.

6. A gutta percha or other thermoplastic spacer has an advantage over a cotton thread spacer. The cotton thread spacer is decomposed in situ in the furnace and there is a danger that carbon may be formed in the interstices of the loaded conductor. The gutta percha melts and flows out before being vapoured and decomposed in the furnace, and therefore any carbon that may be formed will not be deposited in the interstices of the conductor.

In an experiment, three samples of conductor (diameter 5.4 mm.) each loaded with four layers of a magnetic tape, were prepared (diameter of loaded conductor 5.0 mm.). The samples were identical, except that in (1) a cotton thread was used as a spacer between each of the layers of magnetic tape and between the magnetic tape and the copper conductor; in (2) a tape of gutta percha was used in the place of the cotton thread, and in (3) a thread of gutta percha was used, the space factor being as nearly as possible the same in each case. The three conductors were surface-treated in exactly the same way and tested, when the following results were obtained:

<table>
<thead>
<tr>
<th>Cotten thread</th>
<th>Gutta percha tape</th>
<th>Gutta percha thread</th>
</tr>
</thead>
<tbody>
<tr>
<td>279</td>
<td>660</td>
<td>610</td>
</tr>
<tr>
<td>239</td>
<td>669</td>
<td>669</td>
</tr>
</tbody>
</table>

The experiment was repeated a number of times with concordant results, as shown by the above table.

What we claim is:

1. In the manufacture of a loaded signaling conductor, applying to a conductor a spacer consisting of fusible thermoplastic material, placing loading material around the conductor and
spacers, and heat treating the loaded conductor thus formed to anneal the loading material and at a temperature not less than the fusion temperature of said thermoplastic material.

5. In the manufacture of a loaded signaling conductor, applying to a conductor a spacer consisting of fusible thermoplastic material, winding loading material around the conductor and spacer in a manner to provide interstices between adjacent convolutions of the loading material, and annealing the loading material, at a temperature not less than the fusion temperature of said thermoplastic material whereby said material will be fused and will flow out through said interstices.

3. In the manufacture of loaded electric signaling conductors, applying a space forming material consisting of a fusible thermoplastic material to the conductor, winding a loading wire or tape over the conductor thus formed and then subjecting the loaded conductor to an annealing operation during which the spacing material is removed by fusion.

4. In the manufacture of loaded electric signaling conductors, applying to a conductor a spacer of thermoplastic material comprising gutta percha fusible at the temperature of annealing of the loading material, and winding a loading wire or tape around the conductor and spacer, and then subjecting the loaded conductor to an annealing operation during which the spacing material is removed by fusion.

5. In the manufacture of loaded electric signaling conductors, applying to a conductor a spacing thread or ribbon of thermoplastic material comprising gutta percha fusible at the temperature of annealing of the loading material, winding a loading wire or tape around the conductor and spacer, and then subjecting the loaded conductor to an annealing operation during which the spacing material is removed by fusion.

6. In the manufacture of loaded electric signaling conductors, applying helically to a conductor a spacing thread or ribbon of thermoplastic material comprising gutta percha fusible at the temperature of annealing of the loading material, winding a loading wire or tape around the conductor and spacer, and then subjecting the loaded conductor to an annealing operation during which the spacing material is removed by fusion.

7. In a method as claimed in claim 1 in which the loaded conductor is subjected to a heat treatment in order to fuse the space forming material, the use of an atmosphere consisting of an inert gas containing a gas, in which there is combined oxygen capable of reaction with said thermoplastic material at the temperature of the heat treating operation.

8. In a method as claimed in claim 1 in which the loaded conductor is subjected to a heat treatment in order to fuse the space forming material, the use of an atmosphere consisting of an inert gas containing water vapour containing oxygen capable of reaction with said thermoplastic material at the temperature of the heat treating operation.

9. In a method as claimed in claim 1 in which the loaded conductor is subjected to a heat treatment in order to fuse the space forming material, the use of an atmosphere consisting of a mixture of nitrogen and water vapour containing oxygen capable of reaction with said thermoplastic material at the temperature of the heat treating operation.

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