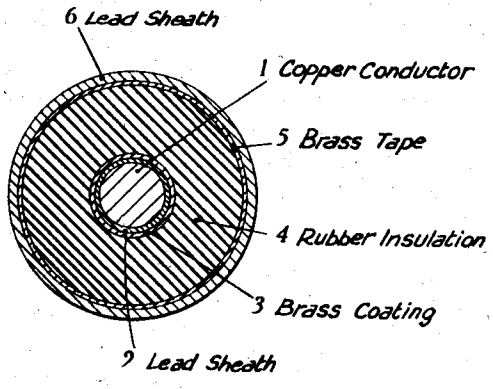
April 13, 1943. T. R. SCOTT 2,316,293

ELECTRIC POWER CABLE

Filed March 26, 1940

FIG. 1



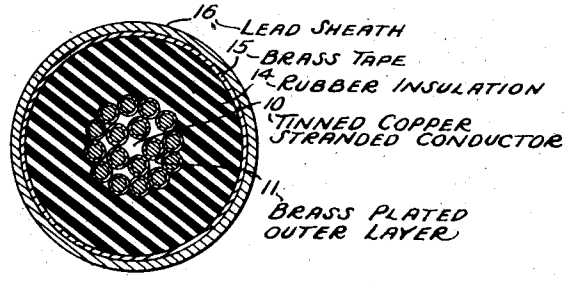


FIG. 2

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ELECTRIC POWER CABLE

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In Great Britain June 20, 1939

3 Claims. (Cl. 174—102)

This invention relates to electric power cables the chief object being to improve the electrical characteristics of the insulation thereof. It is well known that in power cables harmful ionisation can occur at the interior and exterior surfaces of the insulation, i. e. between the inner surface of the insulation and the conductor, and between the outer surface of the insulation and the outer cable sheath. Particularly is this true when the cable is bent or when heat cycles are applied, for example by the intermittent loading of the cable by current. More specifically, therefore, the chief object of the invention is to improve the electrical characteristics of the insulation by taking steps to minimise ionisation at one or both boundary surfaces of the insulation.

It will be appreciated that the problem is most acute at the inner surface of the insulation in view of the fact that the electrical stress is at a maximum in the region adjacent to the conductor and in view of the fact that in most cases the conductor is stranded, in which case there is a finite film of gas between the conductor and the insulation. Moreover, the periphery of the stranded conductor gives rise to electrical stresses which may be as high as 30% in excess of that calculated for a smooth conductor surface. In accordance with a feature of the invention, therefore, it is proposed to prepare the outer surface of the conductor to adhere to the surrounding insulation.

In one arrangement according to this invention, the conductor may be surrounded with a layer of insulating material comprising rubber, the outer surface of the conductor being prepared for vulcanisation to the layer of insulating material in order to eliminate the film of gas between the insulation and the conductor. In order to prepare the conductor for vulcanisation to the layer of insulating material, the conductor which is preferably of copper (protected against sulphiding e. g. by the well known tinning or lead tinning process), may be provided with an outer surface layer of brass which we have found readily adheres to the layer of insulating material upon vulcanisation thereof. The conductor may be made up from stranded copper wires, an outer layer of brass coated copper tapes, preferably tinned prior to brass coating, or simply brass tapes being applied around the wires over which the layer of insulating material may be provided. Alternatively lead tapes which have been brass coated or flashed may be used in place of the aforesaid copper or brass tapes. Alternatively, the conductor may be provided with a surrounding sheath of lead in close contact therewith which may be directly surrounded by the layer of insulating material which is vulcanised thereto or may be provided with a brass or like coating in order to improve the adherence of the conductor to the insulating material applied over the coated lead sheath.

It should be understood that the brass plating, flashing or coating applied to the aforesaid metals should preferably be kept clean and free from oxidation prior to the application of the conducting material. For this reason it is desirable to eliminate from the brass plating process or the like impurities which tend to cause oxidation or fouling of the surface. It may be desirable to apply a layer of the insulating material on emergence of the metal from the brass plating process or the like. When metal tapes are employed it is of course only necessary to prepare the outer surface of the tape to adhere to the insulating layer. Alternatively the wires constituting the outer layer of the conductor may be prepared for adhesion to the insulating material by the processes described above and may be individually supplied with a layer of insulating material extruded or otherwise applied thereabout and may collectively be covered by the main insulating layer as described above in the case of tapes, etc.

When the conductor has been prepared as described above the layer of insulating material may be applied thereto by extrusion or lapping, the preferable method being to extrude the layer around the conductor. The main body of the insulation should be applied before vulcanisation of the layer of insulating material, and should be capable of bonding thereto. For example, the main body of the insulation may also comprise rubber in which case the layer of insulating material and the main body of the insulation may be applied in one operation. Alternatively, the main body of the insulation may consist of a plastic composition similar to rubber, for example, the main body of the insulation, which is preferably extruded, may consist of a plastic material produced in accordance with U. S. Patent No. 2,282,002, assigned to the present assignee e. g. a mixture of polystyrene, polymerised paradivinylbenzene or other mononuclear vinyl-hydrocarbon compound and polyisobutylene, polyethylene or other aliphatic mono-olefine having less than six carbon atoms to which rubber may be added. The above mixture may be extruded around the layer of insulating material so that

the main body of the insulation and the layer of insulating material adhere to one another.

In another alternative arrangement the main body of the insulation may comprise lapped material, e. g. paper tapes, or fabric tapes which may be esterified, e. g. acetylated and/or impregnated with polymerised material, e. g. polystyrene or a polystyrene mixture. The lapped tapes may alternatively be polymerised tapes without a fibrous base or polymerised material rolled into an open mesh of fibrous material and so on; many variations are possible. It should, however, be remembered that the inner lapped layer should preferably be capable of adhering to the layer of insulating material. This effect may readily be obtained by impregnating or lacquering at least the inner layer of tape with suitable material of the nature described above or by using tape of suitable material. The fibrous or other tapes may be permeated by gas under pressure or by compound or the like.

In cases in which the layer of insulating material adhering to the conductor constitutes an impermeable sheath surrounding the conductor it is possible to apply gas under pressure within the conductor thereby pressing the said tube of insulating material against the main body of the insulation.

In a preferred process, a cable conductor of stranded copper wires is provided with an adherent thin lead sheath to which is subsequently applied a thin brass coating by passing the sheathed conductor through an electro-plating bath containing a mixture of copper compounds and zinc compounds in solution, the sheathed conductor itself forming the cathode. The conditions are so arranged that a thin layer of brass having a copper content of approximately 70% is deposited on the stranded conductor. It is found by experiment that the value of 70% copper content gives the best results as regards adhesion of rubber to the conductor. The plating current is adjusted to 9 amperes per square foot of sheathed conductor surface in the bath, and the conductor is slowly drawn through the bath at such a rate that each portion of its length is immersed in the bath for a period of approximately 15 seconds. The sheathed conductor is thereby given a brass coating amounting to .4 milligrams per square inch of sheathed conductor surface. The brass-plated sheathed conductor passes continuously forward and during its movement is washed and dried. After being washed and dried it continues to pass forward and insulation including, or consisting of rubber is extruded around it, the length of plated sheathed conductor coated with rubber per second being equal to the length of sheathed conductor plates with brass per second.

Considering now the prevention of ionisation of gas at the outer surface of the insulation, it will be appreciated that steps similar to the above may be taken, for example, the insulation may be provided with an outer coating of insulating material (lapped or extruded) over which may be applied a lapping of brass tape or of brass-plated tape, e. g. brass plated lead tape. In this way the brass tape adheres to the insulating coating and the coating to the main body of the insulation. According to a feature of the invention, therefore, steps are taken to ensure that a bonding effect is obtained between the inner surface of a conducting screen and the outer surface of the insulation, for example, by providing an outer layer of insulation and preparing the inner surface of the metallic screen to adhere thereto upon vulcanisation. The insulating layer or layers for adhering to the conductor or screen and which preferably contain rubber may comprise any suitable insulating material, for example, a mixture of polystyrene polymerised para-divinyl-benzene or other mononuclear vinyl-hydrocarbon compound and polyisobutylene, polyethylene or other aliphatic mono-olefine having less than six carbon atoms, such mixture being prepared according to U. S. Application, Serial #238,704, filed November 3, 1938, and assigned to the present assignee. A preferable material for forming the layer or layers is a mixture of polystyrene and rubber with or without a rubber plasticiser or a suitable plasticiser for the polystyrene e. g. mono-amyl-naphthalene.

In preparing a cable in accordance with the invention the constituent parts of the cable as described above may be assembled and the layers of insulation next to the sheath and the conductor may then be vulcanised in situ. For example, a cable in accordance with the invention may be prepared by stranding a conductor, lapping it with lead tapes coated with brass, extruding an insulating material containing rubber over the brass coated tapes, and providing an outer lapping of lead tape coated with brass and vulcanising the insulating material.

It is believed that it is during the vulcanisation of the insulating layers that the adherence between the layers and the prepared conductor or sheath takes place, possibly due to the formation of a metal sulphide; it is believed that several metals form a sulphide sufficiently readily for satisfactory adherence to be obtained, and therefore it will be understood that brass is only included as an example, although we believe that this gives the best results but other metals such as lead, and so on may possibly be used. Further, the fundamental idea may be to form a compound between a material in the insulation and a metal of the conductor; for this reason the invention is not necessarily limited to the provision of a layer or layers containing rubber, the limiting factor probably being a layer of plastic insulation containing a material selected in order to form a compound with a metal of the conductor and/or the sheath in order to cause adherence.

Two embodiments of the invention are shown by way of example in the accompanying drawing in which Figs. 1 and 2 show cross-sections of a cable according to the present invention. Reference character **1**, Fig. 1, represents a central copper conductor provided with a thin lead sheath **2** having a surface layer or coating **3** of brass applied thereto by a plating process. The brass coating **3** is surrounded by an extruded layer **4** of rubber or other insulation which adheres closely to the brass coating **3** upon vulcanisation. The insulation **4** is surrounded by a brass or brass-coated layer **5** which is preferably formed by a lapping of brass tape or of brass plated tape e. g. brass plated lead tape. The whole of this composite structure is then vulcanised and is finally enclosed in a lead sheath **6**. Fig. 2 shows an arrangement generally similar to Fig. 1 except that the central conductor **10** is stranded and the individual strands are coated with tin. The outer layer **11** is brass plated in addition and over the outer layer is rubber insulation **14** covered by a brass tape **15** vulcanized thereto and lastly over the brass tape is a lead sheath **16**.

Finally, it may be mentioned that while the

above description deals with single core cables, it will be understood that multi-core cables may also be constructed embodying the invention.

What is claimed is:

1. An electric power cable comprising an electric conductor, a coating of tin on said conductor to protect said conductor against sulphiding, a layer of metal to which rubber will vulcanize surrounding said conductor and said coating, said layer comprising brass coated lead tapes, a layer of insulating material comprising rubber surrounding said layer of metal and vulcanized thereto, whereby formation of any film of gas between said layer of insulating material and said metal is prevented, and a conductive sheath surrounding said layer of insulating material.

2. An electric power cable comprising an electric conductor comprising stranded copper wires, only the wires constituting the outer layer being provided individually with surface layers of brass, a layer of insulating material comprising rubber surrounding said wires and vulcanized to said outer layer, whereby formation of any film of gas between said layer of insulating material and said conductor is prevented, and a conductive sheath surrounding said layer of insulating material.

3. An electric power cable comprising a stranded electric conductor, a coating of tin on the strands of said conductor to protect said conductor against sulphiding, an additional brass coating for only the respective strands forming the outer surface of said conductor, a layer insulating material comprising rubber surrounding the outer surface of said conductor and vulcanized thereto whereby formation of any film of gas between said layer of insulating material and said conductor is prevented.

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