

Feb. 9, 1932.

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1,844,114

MANUFACTURE OF CONTINUOUSLY LOADED CONDUCTORS

Filed May 20, 1931

2 Sheets-Sheet 1

FIG. 1.

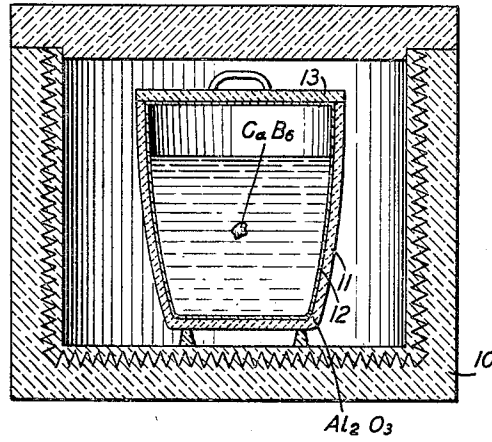


FIG. 2.

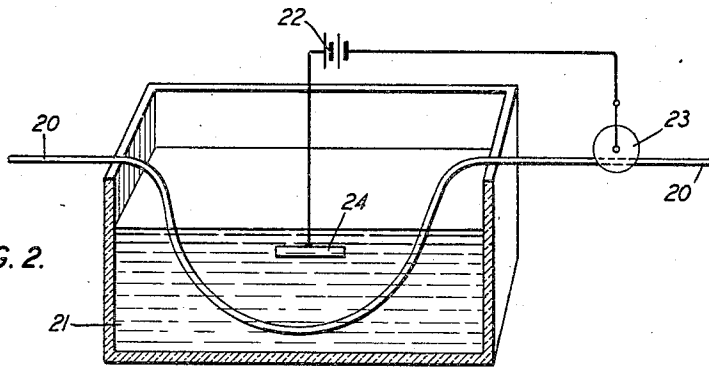
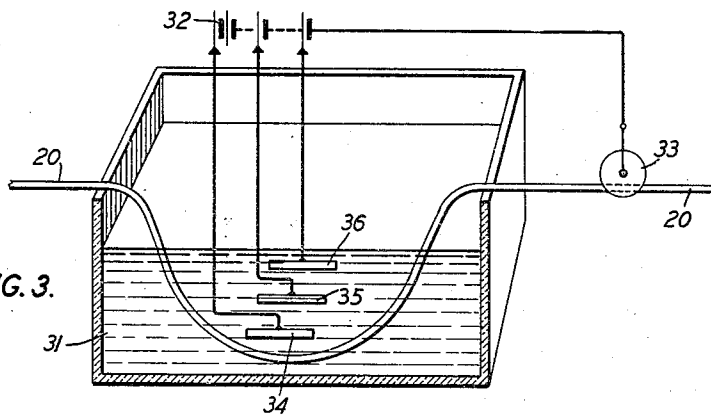


FIG. 3.



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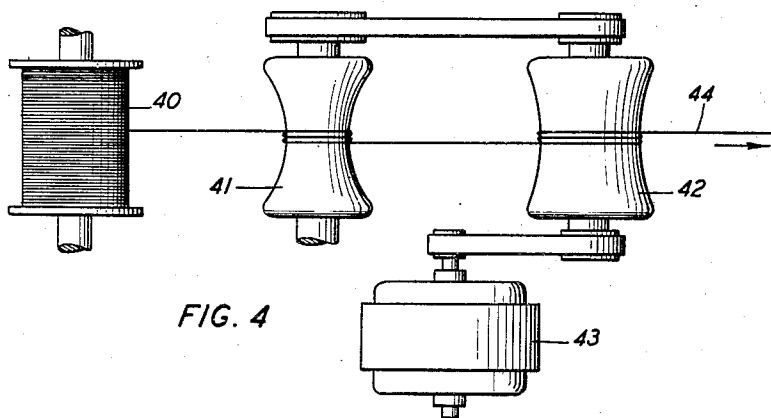


FIG. 4

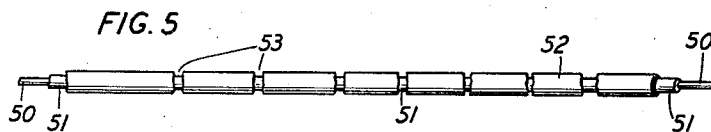


FIG. 5

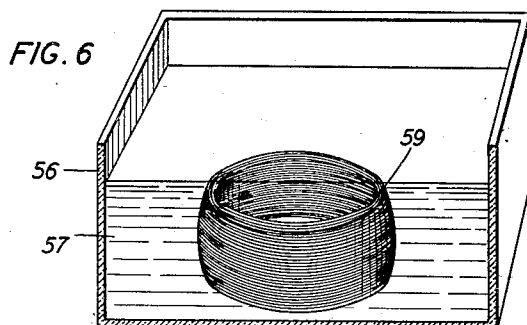


FIG. 6

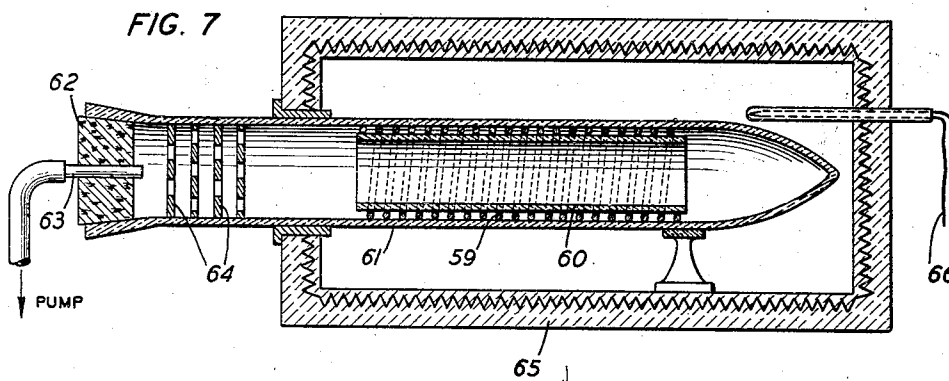


FIG. 7

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MANUFACTURE OF CONTINUOUSLY LOADED CONDUCTORS

Application filed May 20, 1931. Serial No. 538,664.

The present invention relates to loaded conductors and more particularly to conductors loaded continuously with magnetic materials which require a heat treatment after their application to the conductor.

An object of the present invention is to reduce the effective resistance of continuously loaded signaling conductors.

Another object of the invention is to secure constancy of inductance of continuously loaded signaling conductors under the action of large or disturbing magnetizing forces.

A further object of the invention is to apply magnetic loading material to a conductor in such a fashion that eddy current losses in said loading material are substantially decreased.

A still further object of the invention is to provide a method for continuously loading a conductor which must be subjected to heat treatment for obtaining the desired properties in the loaded conductor in which harmful effects during the heat treatment upon the loading material when in situ on the conductor are prevented.

It has been proposed heretofore in order to obtain the best magnetic and electrical properties attainable in continuously loaded conductors to prevent the formation of stresses and strains during and after the heat treatment thereof by the provision of spacing or separating materials between the loading material and the conductor proper. These spacing materials are destroyed or otherwise removed from the conductor before or during the heat treatment, such as by combustion, dissolving in acids, etc.

When electrical conductors are loaded by electrolytic deposition of the loading materials directly upon the conductor or by spraying the materials thereupon in molten form to obtain thin sheets, stresses and strains are introduced into the loading material during or after the heat treatment thereof owing to the difference in the coefficient of expansion between the two metals of the conductor and of the loading material; another disadvantage of such loading methods is due to the fact that at high frequencies the currents flow in the outer layers of the conductor, i. e., the loading material, consequently the effective

resistance to the flow of current is considerably increased since the electrical resistance of the loading material is much higher than that of the copper conductor proper.

It has been proposed heretofore to secure looseness of the loading material applied to copper conductors and at the same time to effect a decrease in the effective resistance of such conductors by causing frequent transverse breaks in the magnetic material, for instance, by stretching the conductor with the loading material applied thereupon; or by causing the electro-deposition of the magnetic loading material to take place in accordance with a pattern which provides for numerous discontinuities in the envelope constituted by the loading material; see, for instance, United States Patent 1,773,938, issued August 26, 1930, to W. M. Bishop and application Serial No. 272,881, filed April 26, 1928, by W. Fondiller.

In accordance with the present invention the above stated objects are obtained by depositing, either electrolytically or by any other suitable method, a metallic layer or film acting as a spacer upon a copper conductor consisting of deoxidized copper, depositing the loading material upon the spacing material, subjecting the conductor thus obtained to tension sufficient to cause the loading material to break up into numerous cylindrical rings separated by gaps, and removing the spacing material from under the loading material by attacking it by a suitable destructive agent such as any chemical solvent which does not attack copper to a material extent, or by subjecting it to a temperature sufficiently high to destroy the spacing film but insufficient to melt the copper conductor.

The invention may be better understood from the following detailed description referring to the accompanying drawings in which:

Fig. 1 relates to a method for producing the deoxidized copper which is used for the copper conductor;

Fig. 2 represents a suitable method for depositing the spacing material upon the conductor;

Fig. 3 shows suitable apparatus for depos-

iting the loading material upon the spacing material;

Fig. 4 shows a suitable mechanism for causing discontinuities in the loading material;

Fig. 5 shows a loaded conductor produced in accordance with the invention;

Fig. 6 illustrates an arrangement suitable for removing the spacing film by attacking it by chemical corroding agents; and

Fig. 7 shows a furnace arrangement suitable for thermally removing the spacing material from the loaded conductor.

A method of producing copper free from oxygen has been described in copending application Serial No. 345,258, filed March 8, 1929, by J. E. Harris and J. H. White. For the purpose of describing the operation of this method, reference will be made to Fig. 1 in which the reference numeral 10 represents an electrical furnace of the resistance type containing the crucible 11 made of any suitable refractory material and lined with a layer 12 of aluminum oxide. The cover 13 is lined with the same material. Electrolytic cathode copper is placed in the crucible before its insertion in the furnace. The copper is then melted and just prior to its casting, a deoxidizing agent, such as calcium-boride, is added in the amount of about .1% of that of the copper and is well mixed by stirring. The melt is then cast into bars which are drawn into wire conductors and annealed. This process furnishes a copper which has both a high elongation and a high electrical conductivity and which is not embrittled by subsequent exposure to reducing atmospheres at relatively high temperatures.

In order to apply a suitable spacing sheath, in accordance with this invention, to the copper conductor thus produced, an electrolytic plating arrangement such as shown in Fig. 2 may be employed. The conductor 20 is slowly passed through an electrolytic bath 21 of which it forms the cathode. The conductor is connected to a source of current 22 by means of a roller contact 23. The anode 24 which is connected to the source of current 22 is constituted by the metal which it is desired to deposit upon the conductor. For instance, it may be zinc or magnesium or any other metal which is either easily dissolved in acid, or oxidized or volatilized by heat. While any desired thickness may be applied, the spacing layer need not be applied in thicknesses greater than about .0001" to .001" (.00254 mm. to .0254 mm.).

For applying loading material to the spacing material an electroplating method such as that described in application Serial No. 265,880, filed March 30, 1928, by R. M. Burns may be used. In accordance with this method which is illustrated in Fig. 3, the conductor 20, having the spacing film applied thereto, is slowly passed through an electro-

lytic plating bath 31 of which it forms the cathode. The conductor is connected to a source of current 32 by means of roller contact 33. The anodes 34, 35 and 36, respectively, may consist of any metals which are desired to be present as constituent elements in the loading material after its deposition upon the conductor. For instance, they may consist of nickel and iron only (in which case only two anodes would be used), or they may consist of nickel, iron and cobalt, respectively. The electrolytic bath 31 consists of a mixture of separate electrolytes varying in accordance with the relative percentages of the metals desired in the loading alloy. Each of the electrolytes contains a soluble sulphate and a soluble chloride of the metal to be deposited and a buffer mixture added for the purpose of regulating the acidity of the bath. Electric current is passed from the anodes to the cathode and the electrolytic bath is replenished in such a manner that its hydrogen ion concentration and the concentration of the ions of each metal remain substantially constant and that the current density—cathode potential characteristics of the metals used as anodes substantially coincide over the operating range of the current density used during the electroplating operation.

In Fig. 4 a supply of the conductor treated and loaded as heretofore described is taken from the reel 40 and run in succession over the friction capstans 41 and 42. Capstan 42 is rotated, by power device 43, about 5% faster than capstan 41. Thus the copper conductor 44 is permanently elongated about 3% to 5% which is sufficient to disrupt the magnetic loading material owing to its considerably lower coefficient of elongation as compared with that of the copper conductor proper. The conductor resulting from this treatment is shown in Fig. 5 in which 50 indicates the central copper conductor, 51 the film of spacing material, and 52 the loading material which is broken up into cylindrical rings separated by air gaps 53.

For removing the spacing material from underneath the loading material a variety of methods may be used. For instance, any suitable process which will not seriously affect either the copper conductor or the loading material will be satisfactory. Zinc dissolves in sulphuric acid and hydrochloric acid, which acids dissolve both copper and loading material slowly. Consequently the zinc may be removed by these reagents. Magnesium is soluble in hydrochloric acid and sulphuric acid and in ammonia salts and is slowly attacked and removed by hot water. Consequently these several reagents may be employed to remove the magnesium.

Fig. 6 shows a vat 56 containing hydrochloric acid 57 in which is submerged a section of a loaded and stretched conductor 59 such as shown on a larger scale in Fig. 5.

The acid corrodes the spacing layer (which may consist of zinc, for instance,) relatively easily, but does not seriously attack the copper conductor, nor the loading material which may consist of a composition containing about 78½% nickel and the balance iron.

Both zinc and magnesium oxidize rapidly at temperatures low compared to the annealing temperature of the loading material which is around 900° C.; this fact permits the applications of thermal methods for removing the spacing film. However, since some of the spacing material might alloy with the copper during the heat treatment, these treatments should preferably be used only when the ratio of the volume of the spacing material to the volume of copper is so small as not to affect the resistivity of the copper. If the quantity of spacing material is such as to affect the resistivity to an undesirable extent, and if the use of the solution methods is not desired, the spacing material may be removed by oxidation. For instance, maintenance of the loaded conductor at a temperature just below the alloying temperature of the spacing material with the copper will be sufficient.

Another method of removing the spacing material from between the copper and the loading material has been found to consist in heating the loaded conductor in a rarefied atmosphere. Fig. 7 shows suitable instrumentalities for practicing this latter method. A section of loaded and stretched conductor 59 such as illustrated on a larger scale in Fig. 5 is wound on a supporting quartz tube 60 open at both ends. The quartz tube 60 is enclosed in another quartz tube 61 which is open at one end and sealed at the other end. The open end of the quartz tube 61 is adapted to be sealed by an air-tight stopper such as shown at 62. The stopper 62 is perforated in its center and a suitable passage such as a pipe or glass tube 63 is inserted in the opening. The outer extremity of the pipe 63 is connected to an air pump (not shown). A baffle of heat resisting material 64 is provided between the stopper 62 and the inner quartz tube 60. The whole structure so far described is enclosed in a heat treating furnace 65 of the resistance type adapted to have its temperature regulated to any desired degree. The temperature within the furnace may be readily measured by means of pyrometer 66.

With the apparatus described, when zinc was used as a spacing material between the copper and the loading material, the spacing material was practically entirely removed after one hour of heating at about 600° C. The conductivity of the copper conductor after treatment was found to be only 1.5% below that of a conductor of the same diameter and material which had not been loaded and treated. The initial permeability devel-

oped in the loading material on the conductor, when a composition comprising 78½% nickel and the balance iron was used as a loading material, was 2700.

Initial permeabilities of over 2500 were obtained by heating another sample of zinc coated conductor loaded with the same composition for about one hour at about 950° C.

Although the heat treating method has been described herein as a specific process of eliminating the spacing material, and zinc as a particular spacing material, the scope of the invention is not limited to such removing process nor to such spacing material.

What is claimed is:

1. The method of loading a signaling conductor which comprises applying a metallic film or spacing sheath upon said conductor, applying the loading material thereupon in the form of a substantially continuous and uniform sheath, acting upon the loading sheath to produce circumferential discontinuities therein and subjecting the said spacing sheath to the action of a destructive agent.

2. Method in accordance with claim 1, characterized in this that the spacing sheath is removed by the application of heat thereto.

3. Method in accordance with claim 1, characterized in this that the spacing sheath is removed by being subjected to the action of a corrosive agent.

4. Method as defined in claim 1, characterized in this that at least one of said sheaths is applied electrolytically.

5. The method of obtaining looseness of the loading material to be applied continuously to a signaling conductor, which comprises applying a metallic spacing sheath upon said conductor, surrounding the sheath by the loading envelope, subjecting the loaded conductor to elongation until the continuity of the loading envelope is interrupted by frequent gaps, and attacking and removing the spacing sheath by a suitable destructive agent.

6. Method in accordance with claim 5, characterized in this that the spacing sheath is removed by subjecting the loaded conductor to a heat treatment within a rarefied atmosphere.

In witness whereof, I hereunto subscribe my name this 18th day of May, 1931.

WALTER M. BISHOP.