June 2, 1931. D. R. BROBST 1,808,520

INSULATED CONDUCTOR

Filed Nov. 10, 1925

Fig. 1.

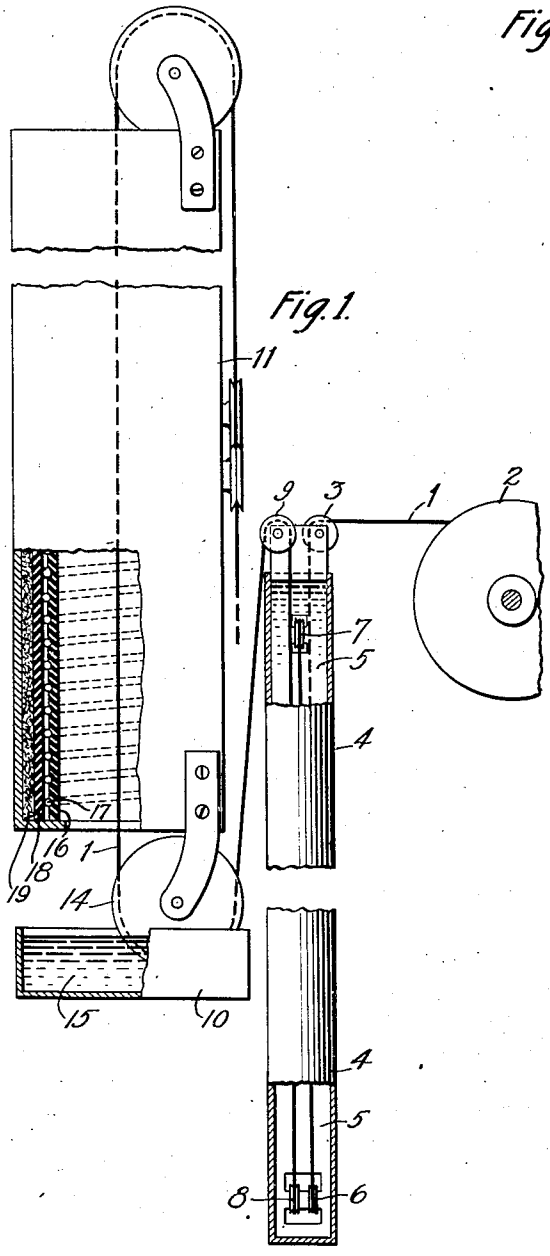
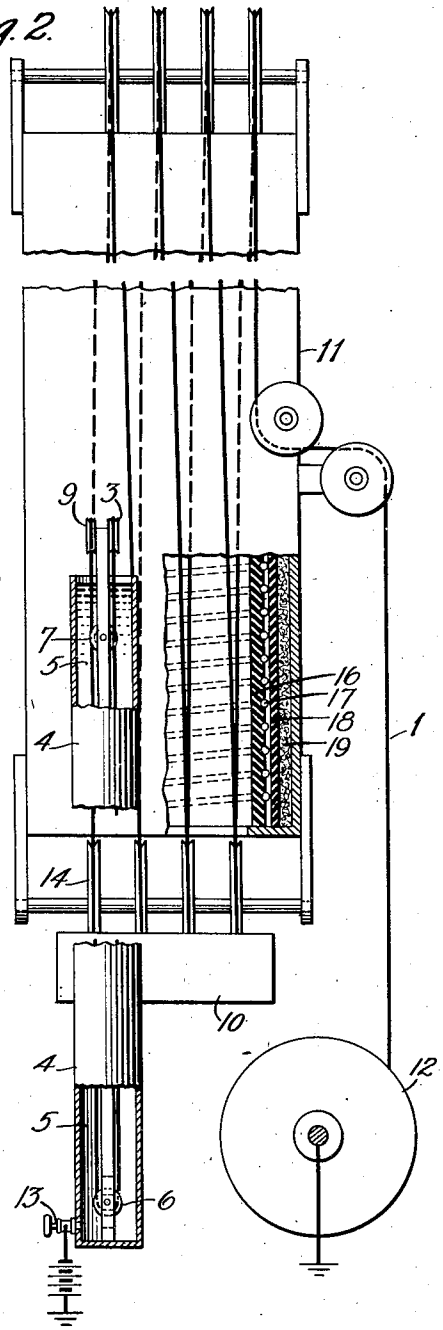


Fig. 2.



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UNITED STATES PATENT OFFICE

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INSULATED CONDUCTOR

Application filed November 10, 1925. Serial No. 68,058.

This invention relates to electric conductors and particularly to flexible conductors and cables.

An object of the invention is to improve the insulation characteristics of conductors insulated with cellulose acetate.

Another object of the invention is to improve the skinning characteristics of fibrous covered conductors impregnated with cellulose acetate.

Another object of the invention is to eliminate air-gaps and interstices in the insulation of a conductor.

Another object of the invention is to improve the quality and reduce the cost of switchboard cables.

Another object of the invention is to improve methods of impregnating fibrous covered conductors with cellulose acetate.

Heretofore, it has been proposed to enamel bare conductors with cellulose acetate lacquers as well as to treat fabrics with cellulose acetate in order to produce a glossy finish. It has also been suggested to impregnate fibrous covered conductors with cellulose acetate in order to improve the insulation characteristics of such conductors. An example of such a method is that disclosed in a copending application of John H. White, Serial No. 750,718, filed November 19, 1924.

According to the method disclosed in Whites' applicaiton the fibrous insulation upon a conductor is impregnated with a solution of cellulose acetate and dried preferably without allowing moisture to come in contact with the impregnated conductor during the drying operation. The result of this process is to produce a conductor provided with a glossy tube-like cover in which the cotton fibres are enclosed in a solid matrix of cellulose acetate. Such an insulating cover has been found to maintain its insulation characteristics under substantially all humidity conditions up to the dew point.

The present invention is concerned particularly with obtaining a thorough penetration of the cellulose acetate solution into the inner pores and interstices of the material. Fibrous materials are naturally repellent to the rather thick cellulose acetate solution and also it has been found that the cellulose acetate solution does not readily replace the air in the lower layers of the fibrous material unless special precautions are taken. Various methods of treating the fibrous material to overcome this difficulty have been developed but these have the objection of adding an extra step to the process.

A thorough penetration of cellulose acetate is particularly desirable in those cases where the impregnated conductor is to be subsequently skinned. When a thorough impregnation is not obtained the fibrous covering shows a tendency to fray when put through a skinning operation. This trouble may be overcome by impregnating the covering to such a depth with cellulose acetate that the various component elements of the covering will adhere to each other; in some cases it may also be desirable that the covering be made to adhere to the material upon which it is applied.

In accordance with one of its features, the invention provides a new and improved method of treating the individual conductors of a cable such as a telephone switchboard cable with cellulose acetate in which the impregnation is carried out so that the cellulose acetate permeates the complete structure being treated. In this manner, all the individual fibres of the covering receive a thorough coating of cellulose acetate, and all the elements of the covering will adhere together. Such a structure has been found to materially enhance the electrical insulating characteristics and the skinning characteristics of the impregnated conductor.

Briefly, this is accomplished by impregnating the fibrous covered conductor with a solution of cellulose acetate, applying a potential between the conductor and the container holding the solution during the impregnation, and drying.

The result of this process is to produce a conductor provided with a glossy tube-like cover in which the cotton fibres are enclosed in a solid matrix of cellulose acetate, and in which air-gaps are substantially eliminated.

The various features and advantages of the invention are described in detail with

reference to the accompanying drawings in which: Fig. 1 is a sectional side view illustrating the method of treating an insulated conductor in accordance with the invention.

Fig. 2 is a front view in section of the apparatus shown in Fig. 1.

As shown in the figures, a conductor 1 insulated with cotton or other suitable insulating material is drawn from a supply reel 2 over a suitable pulley or other guiding means 3 to an impregnating tank 4 containing a cellulose acetate bath 5. The impregnating tank 4 is preferably composed of a suitable electrically conducting cellulose acetate-inert material, such as brass, for example.

From the pulley 3 the conductor passes under the pulley 6, up and over the pulley 7, down and under the pulley 8, up and out of the bath and tank and over the pulley 9. From the tank 4 the conductor passes to an impregnating tank 10, and drying chamber 11 to a suitable take-up reel 12.

The take-up reel 12 is preferably formed of an electrically conducting material so that it may be employed as one of the electrodes for applying the potential between the conductor and the bath containing the conductor during the impregnation treatment. When used in this manner, the conducting core of the conductor being treated is attached to the metallic core of the take-up reel 12.

A suitable binding post is attached to the impregnating chamber 4 such as at 13.

The insulated conductor 1 may be preheated to remove moisture before the impregnating process though this step is not considered essential to the invention. Any number of layers of fibrous insulation may be employed. For example, the conductor may be insulated with a single layer of cotton yarn of sufficient coarseness to secure the desired separation between the conductors of the cable to keep down the capacity therebetween. It is also preferable to employ cotton yarn which is preferably not too highly hygroscopic avoiding the use of cotton which has been bleached or otherwise treated in such a way as to increase its hygroscopic properties. If desired, either before or after being spun into yarn, the cotton may be tested and if found to contain an undesirable quantity of soluble hygroscopic and saline materials, it may be put through a treatment of pure hot water to remove such materials.

During the passage of the conductor through the impregnating tank 4, a potential is applied in accordance with the invention between suitable electrodes, such as metallic reel 12 to which the conducting core of the conductor is attached and the binding post 13, the reel 12, that is, the conductor, being preferably made the anode or positive electrode. With the application of such a potential between the conductor and the container holding the conductor during the impregnating treatment, it has been found that the cellulose acetate solution penetrates the fibrous insulation substantially completely through to the conducting core. In this way, a substantially uniform structure is produced. The depth to which the cellulose acetate penetrates has been found to vary with the potential difference applied between the electrodes.

The composition of the cellulose acetate bath may be varied as desired. It will preferably have such a composition, however, that its viscosity will be such that with the rate of motion of the conductor, the temperature of the bath, and the potential employed a thorough penetration will be produced. For general use, however, it may be said that the proportion of cellulose acetate to solvent in the bath may be varied over wide limits. Solutions prepared for example, by dissolving about 150 grams to 300 grams of dry cellulose acetate pulp in a United States gallon of refined acetone having a specific gravity of 0.797 at 60° F. have been found suitable. This solution is preferably allowed to settle and the clear supernatant liquor drawn off for use in the impregnating tank 4 while the gray undissolved sludge, if such remains, is rejected.

The insulated conductor is passed through the tank 4, containing the cellulose acetate solution prepared in the manner described above, any number of times desired so as to become thoroughly penetrated with the solution. In the drawings the conductor is shown as being given four passes through the bath in the tank 4.

After passing through the tank 4 it has been found that the conductor covering is thoroughly impregnated with cellulose acetate. In order to produce a satisfactory finish, however, it has been found preferable to pass the initially impregnated conductor through a plurality of additional impregnation steps without the application of a potential. In order to carry out this object, the conductor after leaving the tank 4 is drawn under a suitable guide reel 14 through a cellulose acetate bath 15 contained in the tank 10. The distance between the outlet of tank 4 and the impregnating bath 15 and the speed of the conductor are preferably such as to prevent the deposition of moisture on the conductor before it reaches the bath 15. The conductor then passes through the drying chamber 11 which may be, for example, an electric furnace comprising a refractory core 16 wound with suitable resistance wire 17 and enclosed within a second refractory tube 18 over which suitable heat insulating material 19 is placed.

The passage of the conductor through the chamber 11 is preferably so regulated that

the insulation will be thoroughly dry after passing through the furnace. The degree of drying may be controlled in several ways such as by properly gauging the length of the core 16 or by regulating the temperature of the furnace and by regulating the speed at which the conductor is drawn through the chamber 11.

The subsequent impregnation treatments may be continued throughout any number of steps to produce the desired thickness of insulation and the desired smooth and polished appearance of the conductor. In the figure, the conductor is shown as being given four passes through the impregnating bath after the initial step employing the potential difference.

It has been found that when the insulated conductor is first passed through an impregnating process employing a potential difference between the conductor and the container holding the bath the insulated conductor is thoroughly impregnated down to the wire and the flaws heretofore encountered are obviated.

The particular operating conditions employed in any given instance will vary, of course, with the working conditions of the plant. A set of conditions which has been found satisfactory for impregnating wire having a covering of two servings of cotton yarn, one being No. 50 cotton yarn and the other being No. 30 two-ply yarn, has been found to be the potential difference of 250 volts, and a rate of motion of a conductor of 10 feet per minute, the conductor being subject to the action of the potential difference while in contact with the cellulose acetate for approximately three minutes. The example given is one which has been found to produce satisfactory characteristics. However, this set of conditions cannot be said to be preferred for all purposes over others but conditions intermediate those given or differing widely from them and yet within the limits defined by the claim may be used to secure the advantages of the invention, the conditions employed depending upon the particular conditions present in each instance.

It will be obvious that the terminals for applying the potential difference may be other than those represented in the figure of the drawings. For example, the cathode might be an electrode in contact with the bath instead of the container holding the bath.

The temperature of the cellulose acetate bath which is employed, has not been found to substantially influnce the results obtained. The use of an initial temperature of the bath in the neighborhood of room temperature has been found satisfactory. As a general rule, it has been found that the temperature of the bath increases materially with time as a result of transfer of energy from such sources as friction due to passing of the conductor over the guide pulleys and the like, and the heating of the bath, due to its resistance to the flow of an electric current.

Tests over long periods of time have shown that the transmission characteristics are appreciably improved and the insulation resistance of the coating materially increased by treating an insulated conductor in accordance with the invention. It has been found, for example, that the AC mutual capacity and conductances between wires in a pair are both lowered and the DC insulation resistance and AC breakdown strength are materially increased. As an example of the increase in insulating characteristics which is produced by treating an insulating conductor in accordance with the invention, one insulated conductor was given 5 passes through cellulose acetate as show in the drawings without applying a potential difference and another conductor of the same type given the same treatment with the application of potential. The rate of motion of the conductor was approximately 17 feet per minute, applied potential difference between 230 and 250 volts and the length of time during which the conductor was subjected to the potential difference approximately 1½ minutes. The following table gives the results obtained:

Capacity in micro-micro farads in 50 feet

Temp.	85°	85°	85°	85°	85°	85°	85°
Humidity	65%	75%	85%	90%	93%	75%	65%
Conductor treated with applied potential	1,500	2,000	2,700	3,330	4,000	2,700	2,200
Conductor treated without applied potential	1,900	2,300	3,050	3,700	4,540	3,050	2,500
Percentage decrease	21%	13%	11½%	10%	12%	11½%	12%

Conductance in micro-mhos per 50 feet

Conductor treated with applied potential	2.2	2.2	2.3	8.3	6.0	2.4	2.2
Conductor treated without applied potential	2.2	2.2	2.3	14.0	10.1	2.6	2.3
Percentage decrease	0.0	0.0	0.0	40.6	40.6	8.0	5.0

Insulation resistance in megohms per 50 feet

Temp.	85°	85°	85°	85°	85°	85°	85°
Humidity	65%	75%	85%	90%	93%	75%	65%
Conductor treated with applied potential	63400	67200	6,600	1,520	540	1,600	7300
Conductor treated without applied potential	63200	26800	3,500	700	250	5,400	28,000
Percentage increase in insulating resistance due to application of potential	0	150%	88%	187%	115%	196%	160%

Breakdown voltage in volts per 50 feet

Conductor treated with applied potential	------	------	------	1,760	1,767	------	2,180
Conductor treated without applied potential	------	------	------	1,480	1,363	------	1,907
Percentage increase due to application of potential	------	------	------	20%	30%	------	14%

It will be noted that the insulating conductor prepared in accordance with the invention show superiority over one given a simple impregnation with cellulose acetate particularly at the higher humidities and also shows a greater tendency to recover rapidly from the effects of humidity. The varying humidity conditions to which the conductors were subjected throughout the test while severe, nevertheless indicate the conditions to which the switchboard cable may be subjected in actual operating conditions.

While the invention has been described with particular reference to cotton covered conductors, it is to be understood that it is equally applicable to conductors insulated with other materials.

The invention is also capable of other modifications and adaptations not specifically referred to but included within the scope of the appended claim.

What is claimed is:

The method of treating an insulated conductor which comprises immersing the conductor in a bath of cellulose acetate, causing a flow of electric current through the conductor and the bath, and subsequently in succession passing the conductor through a bath of cellulose acetate and through a drying chamber.

In witness whereof, I hereunto subscribe my name this 2nd day of November A. D., 1925.

DAVID R. BROBST.