

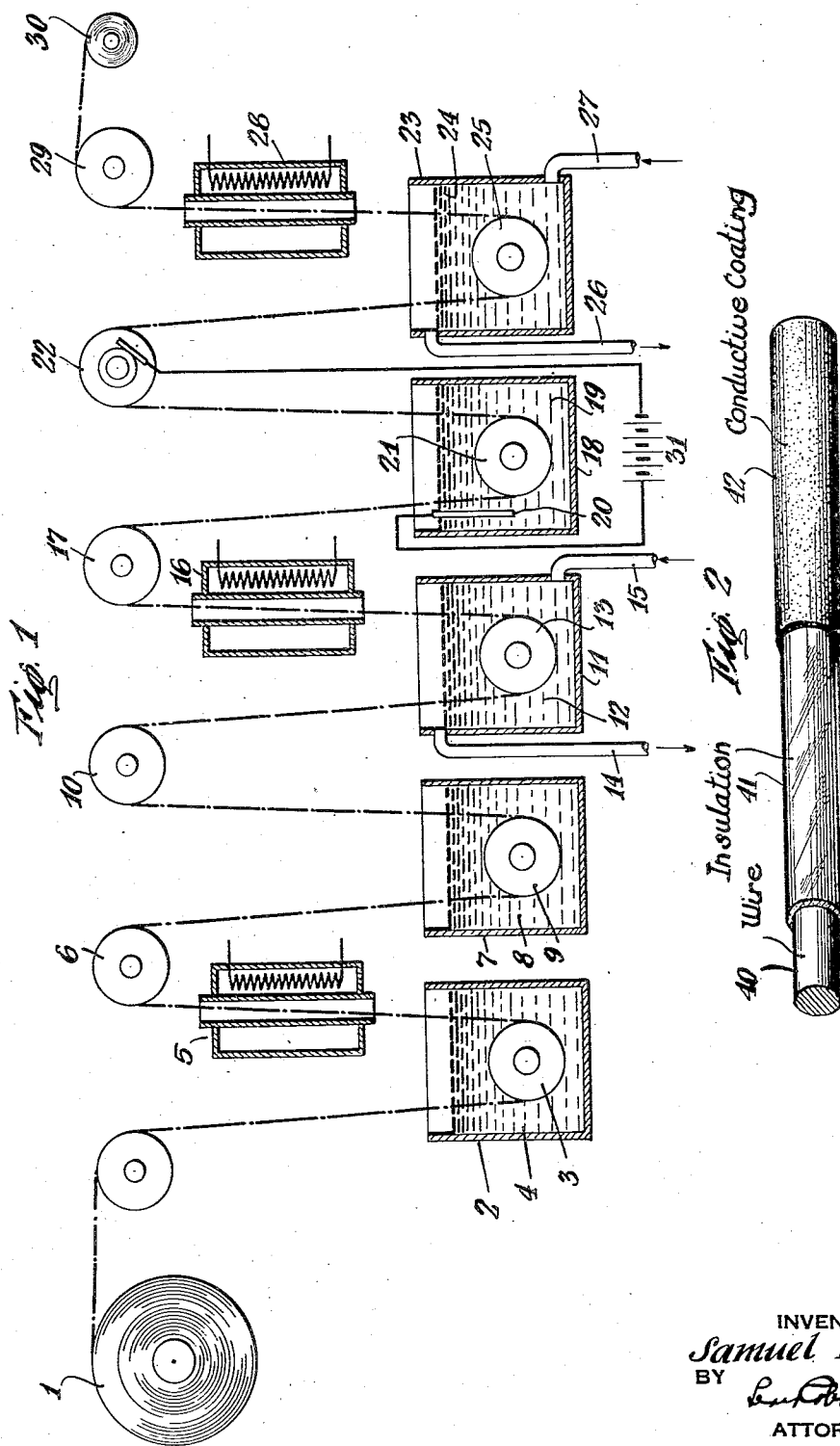
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COAXIAL ELECTRICAL CONDUCTOR

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COAXIAL ELECTRICAL CONDUCTOR

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9 Claims. (Cl. 174-102)

This invention relates to coaxial electrical conductors.

An object of the invention is to provide improved flexible coaxial conductors.

5 A further object is the provision of a unitary structure comprising an insulated conductor having a flexible conductive sheath over the insulating surface.

10 A further object is the provision of a coaxial cable having a central insulated conductor and a second conductor of finely divided metal bonded to the surface of the insulation.

15 Still another object is the provision of coaxial conductors in which one of the conductors comprises finely divided metal rendered conductive in place upon an insulated conductor.

Another object is the provision of a method for applying a conductive surface to an insulated wire.

20 Other objects will be apparent from the disclosure and from the drawing in which:

Fig. 1 illustrates a method and apparatus for providing a coaxial conductor on an insulated wire, and

25 Fig. 2 is a view in perspective, partially cut away, of a coaxial conductor showing the central conductor core, the insulation and a second conductor over the insulation.

30 The invention comprises the use of a conductive base, such as a copper wire, an insulation on said wire, such as enamel, rubber, etc., and a coating of finely divided metal held on said insulation by a binder, the metal particles being normally non-conductive, due to inter-particle contact resistance, and a method for eliminating the inter-particle resistance and rendering the finely divided metal conductive over the entire surface. The metallic conductive coating produced thereby may be further improved by electro-plating or electro-depositing of additional metal thereon.

40 Heretofore several methods have been used to provide electrically conductive coatings on insulating or high resistance bases. By one method atomized metal is sprayed onto the insulator surface by a "Schoop" gun. By another method vaporized metal is sputtered upon the insulator surface. Such methods are expensive inasmuch as they require the use of hydrogen, vacuum or inert atmospheres and the coatings produced are in a great many cases unsatisfactory due to rigidity and lack of uniformity. Another method, much used, is to graphitize the non-conductive surface and electroplate a metal over the graphite. While for a number of uses this method is

55 satisfactory, the specific resistance of the carbon

or graphite is so high as to preclude the initial use of high current densities in the electro-plating process. In addition, as the graphite is not bonded to the insulator, peeling sometimes results with consequent dislodging of the plated metal film.

The coating produced by my present method results in a low resistance surface, the conductivity of which closely approximates that of metal foil.

10 In an endeavor to produce a coaxial cable utilizing an insulated wire and an auxiliary or second conductor over the insulation which would be free of the limitations heretofore encountered in the art, I have found the following:

15 If the insulated wire is coated with a thin layer of metal powder, such as copper bronze powder, even though a very small amount of binder is used, insufficient to completely surround the particle surfaces, the coating is practically non-conductive, the resistance being of an unusably high value. This high resistance I have discovered is due to the additive effect or sum of the high contact resistance which exists between the particles. Further, I have discovered that the non-conductivity or high resistance of these coatings of copper or copper alloys, such as bronze powder, is apparently due to a superficial layer of cuprous and other oxides on the surfaces of the particles and that if this oxide layer is removed as by reducing and dissolving the cuprous oxide, the inter-particle contact resistance is eliminated and a highly conductive surface is obtained.

20 One method is to coat the insulated wire with copper bronze powder to a thickness of about 1/2 mil, using a quick drying binder, such as a solution of 2 ounces of nitro cellulose in one gallon of amylacetate. This solution forms a porous skin between the particles and allows them to be treated. After the coated film is dried it is exposed to a strong solution of hydrochloric acid, then washed in hot water to remove excess acid or by-products and thereafter dried and heated to eliminate any absorbed moisture or acid. The hydrochloric acid reduces and dissolves the cuprous and other oxides on the surface of the particles and also has a slight dissolving action on other metals such as zinc, which may be present in the bronze. If a section of the coating is tested before the hydrochloric acid treatment, it will be found to have a very high insulation resistance. When tested after the final drying treatment, however, the bronze layer will be found highly conductive, the resistance being of a very low order. In place of hydrochloric

25 30 35 40 45 50 55

acid, other solutions may be used, for instance, mercurous chloride, mercurous nitrate, hydrofluoric acid or lactic acid. However, the hydrochloric acid gives the best results and is preferred.

Where mercurous chloride or mercurous nitrate are used, a slight amalgamation takes place between the bronze and the mercury, in addition to the reducing or dissolving action effected.

I have also found it possible to eliminate the metal powder interparticle resistance by exposing the coated wire to the vapors given off by warm hydrochloric acid. This is readily accomplished by passing the wire through a closed chamber above a vessel containing heated hydrochloric acid, the reducing or dissolving action being due to the hydrogen chloride gas derived from the acid. After the exposure which may be from one to five minutes, depending upon the temperature of the acid, the wire is heated to bring about a further reduction in resistance and drive off any surface absorbed gas or vapors.

The co-axial conductors thus produced are suitable for many uses. However, in order to minimize abrasion effects, facilitate soldering and reduce the possibility of corrosion I prefer to electroplate a film of metal over the coated bronze surface. This may be readily accomplished at a higher current density than is possible in the electroplating of metals upon graphitized or carbonized surfaces, the low resistance of the sprayed surface making the immediate use of high currents practicable. In part, this superiority to the usual carbon or graphite surfaces heretofore used is due to the more intimate binding of the conductive particles to the insulation, the water-proof character of the bronze coating and its lower resistance. Any of the commonly used plating metals may be employed, for instance, copper, chromium, tin, cadmium, lead, etc.

While I have found a solution of 2 ounces of nitro cellulose to one gallon of amylacetate to be a very satisfactory binder, other materials may be used, such as shellac, glyptal, methyl methacrylate, etc. The amount of binder used should be limited so as not to form a complete physical insulating layer around the particles, but sufficient to firmly hold the metal particles upon the insulation. In practice, I have used a mixture consisting of 2 ounces of nitro cellulose to one gallon of amylacetate to which I add 20% by weight of finely divided bronze powder. When this mixture is coated upon the insulated wire, the cellulose film formed around the bronze is porous and allows contact between the particles. While the bronze powders are preferred because of their low cost, flakelike structure and less oxidizable nature, other suitable metal powders may be used such as copper or copper alloys.

In order to more completely describe the invention, reference is made to the drawing.

In Fig. 1, enamel or rubber covered copper wire 1, is passed into vessel 2, containing finely divided bronze suspended in a solution of nitro cellulose amylacetate 4. The bronze coated wire passes via pulley 3, up through heated dryer 5, via pulley 6, into vessel 7, containing hydrochloric acid 8, which reduces the inter-particle resistance. The treated wire then passes via pulley 9, around pulley 10, into vessel 11, containing water 12, a fresh supply of water being continually maintained through inlet 14, and outlet 15. The washed wire then passes via pulley 13, up through heater and dryer 16, which drives out any residual water or acid and thereafter passes

via pulley 17, into plating tank 18, containing cadmium plating solution 19, and cadmium electrode 20. The plating potential is supplied by battery 31. The plated wire then passes via pulley 21 to metallic roller 22, which is connected to one side of battery 31, and thereafter passes into vessel 23, containing water wash 24, a fresh supply of water being maintained through inlet 26 and outlet 27. After this final wash the wire is passed up through heater and dryer 28, and over top roller 29, to be wound ready for use on mandrel 30.

In Fig. 2 copper wire 1, is shown with enamel varnish insulation 41, and top metal coating 42, corresponding to the condition of the wire as it is rolled on to mandrel 30.

It is apparent that rubber covered wires containing two or more insulating layers and two or more conductors in a single casing can also be produced by this method using the conductive sheath as a shield, ground or common return conductor for all of the enclosed wires.

The coating produced by the above method is highly conductive, flexible, adherent and well bonded to the insulation.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. Coaxial electrical conductors comprising a conductor core, an insulated coating thereover and a conductive coating thereon of copper bronze metal particles bonded to said insulation by an organic binder, said particles having initially high resistance surface layers of superficial thickness so that said coating is substantially non-conductive along its length, said high resistance layers being chemically reduced in situ on said base insulation to a highly conductive state.

2. Coaxial electrical conductors comprising a conductor core, an insulating coating thereon and an electrically conductive surface bonded thereto comprising copper base metal particles and a waterproof organic binder, said surface being initially characterized by high inter-particle contact resistance at the particle interfaces so as to make said surface non-conductive along its length, said high contact resistance being eliminated by chemical reduction at the particle interfaces in situ on said base insulating coating, and a metal layer electroplated upon said particles.

3. The method of adding a conductive surface to an insulated wire which comprises coating said insulated wire with copper-bronze particles and a carrier therefor adapted to permanently bond said copper-bronze particles to said insulated wire, said copper-bronze particles having normally a high resistance layer of superficial thickness at the surfaces thereof, subjecting said coated insulated wire to the action of a reducing acid capable of reacting with copper-bronze particles to convert said high resistance surfaces to a conductive state.

4. The method of adding a conductive surface to an insulated wire which comprises coating said insulated wire with copper-bronze particles suspended in a carrier adapted to permanently bond said copper-bronze particles to said insulated wire, subjecting said coated insulated wire to the action of an acid in vapor form capable of reacting with said bronze particles to convert the initial high resistance surfaces of said bronze particles to a conductive state, heating said treated coated insulated wire to drive off acid vapor and moisture and thereafter electroplating

another metal layer upon said coated insulated wire.

5. The method of adding a conductive surface to an insulated wire which comprises coating said insulated wire with finely divided copper base particles and a permanent organic binder, drying said coating upon said insulated wire, said coating being characterized by high contact resistance at the particle interfaces, reacting hydrochloric acid with said interfaces to bring about high inter-particle conductivity.

6. The method of producing a conductive surface upon an insulated wire which comprises applying to an insulated wire a coating of finely divided copper bronze powder and a permanent organic binder therefor, said coating being substantially non-conductive along its length due to high resistance between the bronze particles, subjecting said coating to the action of hydrochloric acid in vapor form to reduce said inter-particle resistance and causing said coating to become conductive along its length.

7. The method of producing a conductive surface upon an insulated wire which consists in applying a coating of powdered copper bronze and a permanent organic binder to an insulated wire, said coating at this stage being substan-

tially non-conductive along its length, and thereafter subjecting said coating to the action of hydrochloric acid to cause said coating to become conductive along its length.

8. The method of adding a conductive surface to an insulated wire which comprises coating said insulated wire with copper bronze particles suspended in a carrier adapted to permanently bond said bronze particles to said insulated wire, subjecting said coated insulated wire to the action of a reducing acid to convert initial high resistance surfaces of said bronze particles to a conductive state.

9. An electrical conductor comprising a highly conductive metal core, an insulating coating and an electrically conductive surface bonded thereto comprising copper-base metal particles and a water-proof organic binder, said surface being initially characterized by high inter-particle resistance at the particle interfaces so as to make said surface nonconductive along its length, said high contact resistance being eliminated by chemical reduction at the particle interfaces in situ on said base insulating coating and a metal layer electroplated on said particles.

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