United States Patent

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[54] **METHOD OF MAKING ELECTRICALLY CONDUCTIVE PAPER**
4 Claims, No Drawings

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[50] **Field of Search** 117/62, 62.2, 213, 102, 217

[56] **References Cited**

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ABSTRACT: Means for and method of making paper electrically conductive, wherein the paper is first impregnated throughout with tiny metal particles which have been dispersed in a water-soluble adhesive, after which the impregnated paper is treated with a dilute acid and the exposed metal surfaces displaced by treating with a soluble salt of a more noble metal to provide bridges of noble metal between the metal particles and thus create an electrically conductive path. By applying the metal particles throughout the paper, the resulting product will be completely conductive; but, if the metal particles are applied throughout the paper and then cleaned from the paper surfaces prior to the displacement reaction, the product will have transverse conductivity only. Moreover, if the paper is first presoftened and the treatment applied to one surface thereof, the product will be transversely conductive as well as conductive upon the treated surface. Also, if the treatment is applied to dry paper at reduced temperatures, the product will have only surface conductivity.

METHOD OF MAKING ELECTRICALLY CONDUCTIVE PAPER

BACKGROUND OF THE INVENTION

This invention relates generally to the field of treating electrically nonconductive materials to make them conductive.

Heretofore, techniques have been available for preparing conductive paper. The most common of these involves the vapor deposition of a conductive metal or alloy. This can be an expensive technique, and there are limitations as to the rate at which the paper can be processed. Another known technique involves the electroless deposition of conductive metals on or within the paper structure. The relative cost of electroless deposition is less than that of vapor deposition, and in the electroless deposition process the paper can be treated on a continuous basis at high rates of speed.

The briefly described above techniques, however, do not meet the need for a process and means of preparing conductive paper that is less expensive than electroless plated paper, and one requiring a minimum of chemical and physical control during the processing.

SUMMARY OF THE INVENTION

The present invention relates generally to means and method for treating materials such as paper and the like for making them electrically conductive.

It is one object of the invention to provide improved means and method for economically making electrically conductive paper and similar materials.

A further object is to provide improved means for treating paper and similar materials to provide products having different types of electrical conductivity. For example, the product may have only one conductive surface, two conductive surfaces, no conductive surface, but conductivity transversely through the paper, or one conductive surface in combination with transverse conductivity through the paper.

Further objects and advantages of the present invention will be brought out in the following part of the specification, wherein detailed description is for the purpose of fully disclosing several embodiments of the invention without placing limitations thereon.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the basic concept of the present invention and the procedures generally in the treatment of paper and similar materials to make them electrically conductive, it may be noted generally in the case of paper that, at a temperature of approximately 80° C. the paper will soften and expand, and can be uniformly impregnated with a dilute solution of casein glue containing a suspension of powdered iron particles. Best results have been obtained by using between 1 and 10 percent of 2 to 5 micron diameter spherical carbonyl iron powder suspended in a 50 to 1 dilution of Bordon's casein glue obtainable under the trade name of "Cascorez 765." After the metal particles and glue have penetrated the paper, excess liquid can be squeegeed from the surfaces and the paper dried. The dry adhesive will hold the iron particles in the paper.

The above dried paper is not conductive, nor has it been darkened significantly by the addition of the tiny gray material particles. The paper can be made conductive by treating it with a dilute hydrochloric acid solution, followed by a solution of copper acetate. The dilute acid reacts with areas of exposed metal to provide fresh metal surfaces readily displaced by the more noble copper metal salt. Displacement will continue until about 8 to 10 microinches of copper has been deposited. The reaction rate then decreases. The reaction is complete in a very short time and additional time of immersion is not critical. The paper may be washed and dried.

More specifically, the preferred procedure comprises the steps of:

1. Treating the paper with a suspension of 2 to 5 micron diameter iron spheres in a 1 to 50 dilution of casein glue in water.
2. Drying the paper.

3. Treating the paper with a 1 percent solution of hydrochloric acid at 25° C. for 30 seconds.
4. Treating the paper with a saturated solution of copper acetate at 25° C. for 2 minutes.
5. Washing and drying the paper.

Using the above basic procedure, and by observing certain considerations in connection with the treating, the type of conductivity such as surface conductivity and transverse conductivity can be selectively controlled.

BOTH SURFACE AND TRANSVERSE CONDUCTIVITY

By fully impregnating the paper between its opposite surfaces and then treating in the manner explained above; it will be found that the copper has not only deposited upon exposed surfaces of the iron particles, but it has also deposited between the iron particles. A substantially continuous layer of honeycomb copper metal between 5 and 10 microinches in thickness will be found to exist both along the surface of the paper and throughout the paper thickness. On a square area basis, both the surface and the transverse resistance will be about 1 ohm.

Transverse Conductivity Only

If the paper is first softened for about 30 seconds in water at 80° C., and one side is then treated by the application of the hot dilute adhesive containing the suspended iron spheres; the particles will permeate the paper structure, but not penetrate through the opposite surface. If the treated surface is now squeegeed, then exposed to a fine water spray, and then squeegeed again; the number of particles remaining on the treated surface will be a minimum. Following dilute acid and copper salt treatment, washing and drying; the paper will have a transverse conductivity that can be measured from either side, but it will have negligible surface conductivity.

Both Surfaces Conductive, but no Transverse Conductivity

If the suspension of metal particles in glue is maintained at approximately 25° C., and the paper is processed without presoftening; the penetration of the particles will be limited. Following the dilute acid and copper salt treatment; the product will show conductivity on both surfaces, but no conductivity when measured transversely between the surfaces.

Higher resistances up through 10^8 ohms are available by reducing the concentration of metal particles in the initial suspension or by reducing the copper salt concentration or treating time. Reduced acid concentration or treating time will also result in less copper displacement and higher resistance. Reduction in temperature of the treating baths will also be effective in increasing resistance. In general, the resistance level of paper under ambient relative humidity conditions approximates 10^9 to 10^{11} ohms per square area. By means of the herein described technique, papers having square area resistance between a complete short and 10^8 ohms can be prepared.

The herein described method of treating paper to make it conductive is equally applicable if metal powder is added to the paper in the absence of an adhesive. However if the final product is to undergo extensive flexing, the metal particles can become mobile, rupture the copper honeycomb structure, and dust out of the paper fibers, thus causing a changing resistance. If desirable, the adhesive can be added as a second step after the impregnation with metal powder.

Although the above description has been limited to spherical iron particles, casein glue, dilute hydrochloric acid and copper acetate, it is to be understood that any metal or metal alloy particles of suitable size and shape can be employed as long as the electromotive potentials permit chemical displacement by a more noble conductive metal added in soluble salt form. Zinc or aluminum powder, for example, can be used in place of iron. Displacement by the much more noble metals such as silver, gold and platinum is equally possible as well as by metals less noble than copper. The acid can be selected from any number of mineral acids that will remove an oxide coating and expose the metal of the chosen particle composition. The glue or fixing agent can likewise be selected from a

wide range of adhesives. It is desirable that it be either water soluble or water dispersible for the technique described, however, resins of the polyvinyl or acryloid class can be used as long as the dilute acid treatment is preceded by a solvent to insure exposure of the metal surfaces.

High-resistance paper prepared by the herein described technique can be impregnated with dilute resins of, for example, the acryloid class to reduce the sensitivity of resistance to changes in relative humidity. The resin-treated paper can be dried against a polished metal drum so that a specular surface will result. At resin concentrations below about 3 percent the conductive metal is not masked and the glossy paper retains conductivity.

If it becomes desirable to provide a pigmented overcoating to the surfaces of the conductor paper the feature of transverse conductivity can be retained by loading the pigmented coating with tiny spheres of conductor metal. Copper spheres selected at a diameter equal to the thickness of the pigmented coating following solvent evaporation provide a very effective conductor. If the paper has been prepared to be conductive upon one or both surfaces, this surface conductivity can be made equally available upon a point-to-point basis as the conductive spheres in the pigmented coating make contact with the surface conductive materials. The visual properties of a white-pigmented overcoating are not noticeably influenced by the incorporation of copper metal spheres. Sphere loading can be selected to provide an additional means of controlling the resistance of the paper as measured by square area techniques.

From the foregoing description, the uses, advantages, and operation of the invention will be readily understood by those skilled in the art to which the invention appertains. While I have described the form of the invention which I consider to be the best embodiment thereof, I desire to have it understood that the form is merely illustrative and that the invention is not to be limited to the details disclosed herein, but is to be accorded the full scope of the appended claims.

I claim:

1. The method of preparing conductive paper which includes: impregnating the paper with metal particles suspended in an adhesive; and treating the impregnated paper with a dilute acid and a soluble salt of a metal more noble than the metal of the particles impregnated in the paper to cause chemical displacement and interlacing of deposited noble metal and provide an electrically conductive path therein.

2. The method according to claim 1, wherein the conductivity is substantially transverse, and including the step of removing excess metal particles and adhesive from a treated paper surface prior to chemical displacement with a more noble metal.

3. The method according to claim 1, wherein the conductivity is upon one surface thereof and transversely through the paper, and including pretreating the paper to soften and expand the fibers, and the impregnating of the paper is from one side only thereof.

4. The method according to claim 1, wherein there is substantially only surface conductivity, and which includes treating dry paper with the metal particles suspended in an adhesive.

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