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PRINTED BATTERY AND METHOD FOR MAKING

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1 This invention relates to printed batteries and to a method for making batteries by printing metallic inks on sheet material.

It is known to print electronic circuits on paper and to render the circuits electrically conducting by fusing to unite the individual metallic particles. This process is not feasible for the production of batteries however because fusion causes a breakdown of the boundaries between the anode and cathode of the battery, and the consequent short circuit renders the battery ineffective.

It is an object of this invention to provide a battery by the application of printing techniques.

Another object of the invention is to provide a printed battery in which alternate, separate layers of inks containing different metallic particles are effectively kept from intermingling.

A further object of the invention is to provide a novel method and means for orienting metallic particles in a printed ink.

Still another object of the invention is to provide a new method of making a light weight, high voltage, thin printed battery on a thin sheet material.

These and other objects and advantages of the invention will become more apparent upon consideration of the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is an enlarged sectional view of the primary cell of the invention showing the relationship of sheet and layers of metallic inks and

Fig. 2 is a perspective view showing a simple form of apparatus for practicing the invention.

In the accomplishment of the foregoing objects and in the practice of the invention there is now provided a printed battery comprised of alternate, separate layers of different metallic inks on a sheet material, the metallic substances of each layer being of different magnetic metals and aligned to touch only particles in the same layer and form an electrical conductor.

In one embodiment of the invention the printed battery previously described is prepared by printing a layer of an ink containing one magnetic metal powder suspended therein on a base plate of a smooth, electrically non-conducting sheet material, such as paper or plastic film. The vehicle for the printed ink is adjusted to dry within a certain predetermined interval of time but will remain liquid long enough to allow a magnetic orientation procedure to be completed. This procedure consists of passing the printed base sheet over a strong electromagnetic field in such a manner that will cause the magnetic metal powders to become oriented and magnetically aligned to touch one another and thereby to form an electrical conductor. The ink is then allowed to set whereby the particles in position so that they remain in contact with each other. It will be understood that the ink must also contain an electrolyte and a humectant in order that it will have the necessary electrical conducting properties in the battery.

After the first layer of ink is set, the printed sheet is thereafter passed through another printing operation in which an ink having a different magnetic powder suspended therein is impressed on the sheet over the first layer. The orienting and drying steps are repeated with the result that a second layer of ink is printed over the first layer, but without any contact between the metallic particles in the two layers. A two layer article of this type is known as a dry primary cell. The printing process may be repeated any desired number of times in the building of alternate layers of the two respective metallic inks, care being taken at all times to prevent any cross linking between individual layers or intermingling of the different metallic powders between the layers.

The resultant product is a thin, light-weight, high voltage battery which is suitable for many special purposes.

Referring to the drawings in detail there is shown in Fig. 1 a sheet of plastic material 18 which has had printed thereon by transfer printing technique a layer of metallic ink in which the particles of metal 12 are in contact with one another. A second layer of metallic ink overlies the first layer and likewise has particles of metal 14 in electrical conducting relationship with one another but not with the particles 12 of the other layer. The particles are surrounded by vehicle 15 which has the properties of an electrolyte or contains an electrolyte.

In Fig. 2 the plastic sheet 10 is passing rapidly beneath the printing roll 16 in contact therewith so that ink on the design 18 of the roll is transferred continuously to the sheet 10. The inked design 20 is now printed on the sheet 10 and will soon dry so that another layer of a different metallic ink may be printed thereover to make a primary cell.

The “inks” employed herein are suspensions of magnetic powders of metals of the iron family in a suitable vehicle which should have the properties of an electrolyte or should contain an electrolyte. As suitable powders of the class described I may employ iron, cobalt, nickel, salts and oxides of these metals and alloys thereof. The principal
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3 requirement for the powder is that it have magnetic properties.

As suitable vehicles in which to suspend the magnetic powders I may use any of the well known printing ink vehicles, such as those containing drying oils and resinous materials, for example, linseed oil and resin oil. Zeln is one particular type of vehicle which is especially suitable because it does not require the addition of an auxiliary electrolyte. It is also contemplated that other proteinaceous materials which have properties similar to zeln may be employed. In the case of the drying oils and resinous materials and solvents therefor it should be recognized that a suitable electrolyte should be added in order to permit the ion transfers necessary in a battery. Any of the commonly known humectants may be employed, such as the glycols and glycerols.

The “inks” employed in this invention are applied to the non-conducting sheet material from conventional printing presses and by known methods, either intermittently or continuously as by letterpress or offset printing. The term “transfer printing” is used herein to define printing techniques in which the ink is first applied to a roller or platen and is then transferred to the ink receiving surface. The sheet material used herein as a base should be a non-conductor of electricity and should be thin, strong and light in weight. A smooth surface is also advantageous. As examples of suitable sheet materials I may use printable smooth papers, thin fabrics, rubber sheeting and any one of a large number of plastic films. Extruded polystyrene films are admirably suited for the sheet material of this invention, as are the films made from the vinylite plastics and cellulose derivatives.

In the following example a particular embodiment of the invention will be presented in detail:

Example

An ink suitable for printing on ordinary printing apparatus was prepared according to the following formula, in parts by weight and was designated ink A:

40 parts fine iron powder (magnetic)
35-53 parts bodied linseed oil
5-10 parts volatile solvent
1-5 parts humectant
1-5 parts electrolyte solution

A similar ink designated ink B was prepared substituting fine nickel powder (magnetic) for the iron powder of ink A.

A sheet of thin extruded polystyrene was printed with ink A and immediately passed over a strong magnetic field developed by electromagnets to align the iron particles so that they touch one another in the formation of an electrical conducting film. The ink is allowed to set by exposure to the air which may be heated if desired.

After the film of ink A has become set, the printed sheet is printed with ink B and immediately passed over a strong magnetic field to align the nickel particles in the same manner as described for ink A. Ink B is then allowed to set and fix the nickel particles in touching relation.

Suitable connections are made to each of the separate, individual layers of inks A and B and, upon attachment to a suitable electrical measuring motor, it will be found that an effective battery has been made.

The vehicle may be varied in the above formula to give different drying conditions and speeds. For example, heat setting oils and varnishes may be used if desired and larger quantities of volatile solvents will speed up drying. Oils, waxes and greases may be added to keep the inks from drying too rapidly on the printing apparatus. A cobalt type dryer may be added to speed up drying on the sheet. As electrolytes may be mentioned solutions of ammonium chloride and zinc chloride as the proteinaceous substances of the zeln type.

The method of making the printed batteries according to this invention is well suited to continuous and high speed operations in which printed films of a magnetic ink are applied successively to a continuously moving sheet and pass over the orienting magnetic field before the ink becomes set. Since this operation may take place in a matter of a few seconds, it will be apparent that a number of printing presses can be arranged in series with orienting magnetic fields located between each press and the whole operation conducted continuously to lay down and orient separate alternate layers or films of different metallic inks.

From the foregoing disclosure it will be apparent that the present invention provides a new and unusual type of battery which is characterized by light weight and high voltage, while at the same time being extremely thin. The invention also provides a new and novel method of making batteries rapidly and inexpensively in a continuous operation by printing alternate layers of inks containing particles of different magnetic metals followed by orientation of the particles to touch one another only in the separate layers, thereby forming an electrical conductor and a battery.

The invention is hereby claimed as follows:

1. The method of making printed batteries which comprises printing a layer of an ink having suspended therein discrete particles of a magnetic substance on a non-conducting sheet, passing said printed sheet over a magnetic field to orient the particles before said ink is set, setting said ink, printing a second layer of an ink having particles of a different magnetic substance suspended therein over said first layer, passing said sheet over an orienting magnetic field before said ink is set, and setting said ink.

2. The method of making printed batteries which comprises printing a layer of an ink having suspended therein discrete particles of a magnetic substance on a non-conducting sheet, passing said printed sheet over a magnetic field to orient the particles before said ink is set, setting said ink, printing a second layer of an ink having particles of a different magnetic substance suspended therein over said first layer, passing said sheet over an orienting magnetic field before said ink is set, drying said ink and repeating the printing, orienting and drying of alternate separate layers of said different inks a predetermined number of times, thereby to make a battery having substantial voltage.

3. The method according to claim 1 in which one of the magnetic substances is a magnetic iron substance.

4. The method according to claim 1 in which one of the magnetic substances is a magnetic iron substance and the other is a magnetic nickel substance.

5. The method of making printed batteries which comprises repeatedly printing alternate layers of inks each containing particles of different magnetic substances.
ferent magnetic substances successively on a non-conducting sheet material, passing said printed sheet over a magnetic field after each impression to orient said particles before the ink is set and setting the ink.

6. A dry primary cell which comprises a sheet of non-conducting material, a first layer of one electrical conducting metallic ink printed on said sheet and a second printed layer of a different electrical conducting metallic ink superimposed on said first layer, the two layers being in electrically non-conducting relationship, and electrolyte in said ink, and said printed layers being applied by transfer printing techniques.

7. A battery comprising a plurality of the dry primary printed cells of claim 6.

8. As a new article of manufacture a thin, lightweight, high voltage battery comprising electrodes and an electrolyte deposited on a thin sheet material in the form of inks by the application of transfer printing techniques.

9. A primary cell according to claim 6 in which one of the metallic inks contains magnetic iron as the metallic substance.

10. A primary cell according to claim 6 in which one of the metallic inks contains magnetic nickel as the metallic substance.

11. A primary cell according to claim 6 in which one of the metallic inks contain magnetic iron and the other metallic ink contains magnetic nickel.

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