

[54] **METHOD OF APPLYING BATTERY ELECTRODES ONTO CONTINUOUS CARRIER STRIP**

[75] Inventors: **Geza F. Kosta**, Plainfield; **Anthony W. Pomper**, Edison, both of N.J.

[73] Assignee: **ESB Incorporated**, Philadelphia, Pa.

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[58] Field of Search **117/212, 217, 111, 117/227; 118/262, 261, 249**

[56] **References Cited**

UNITED STATES PATENTS

3,682,133	8/1972	Gomarin et al.	118/262
3,704,164	11/1972	Travis	117/212
3,539,384	11/1970	Kolesinskas	117/111 F
3,239,367	3/1966	Demeter	117/111 R

3,652,332 3/1972 Brand et al. 117/212

Primary Examiner—Alfred L. Leavitt

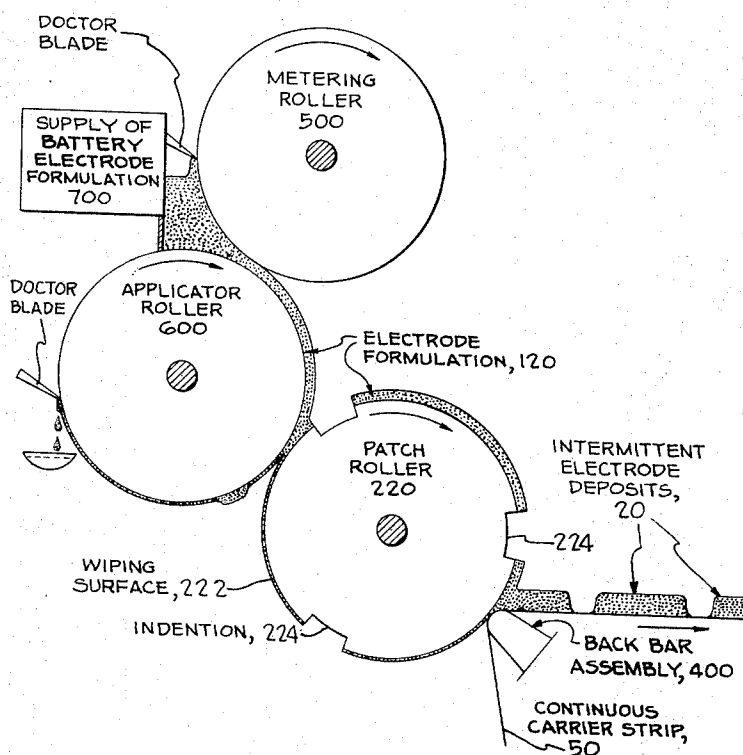
Assistant Examiner—J. W. Massie

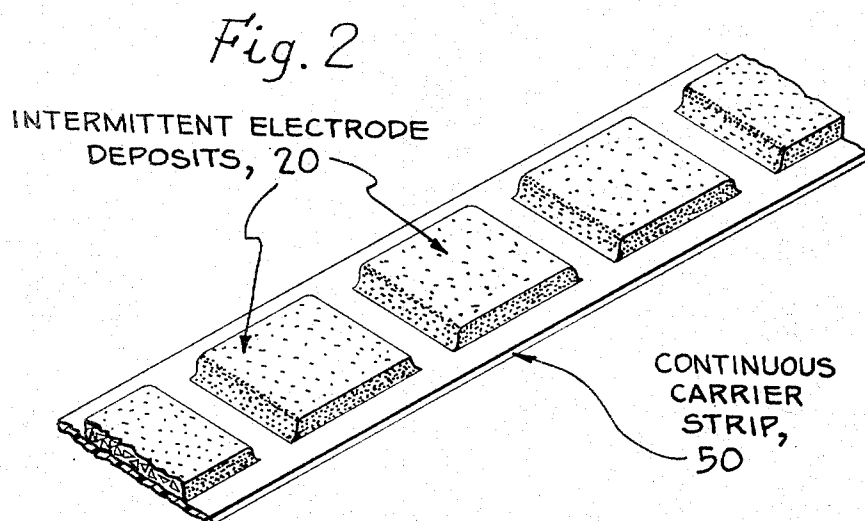
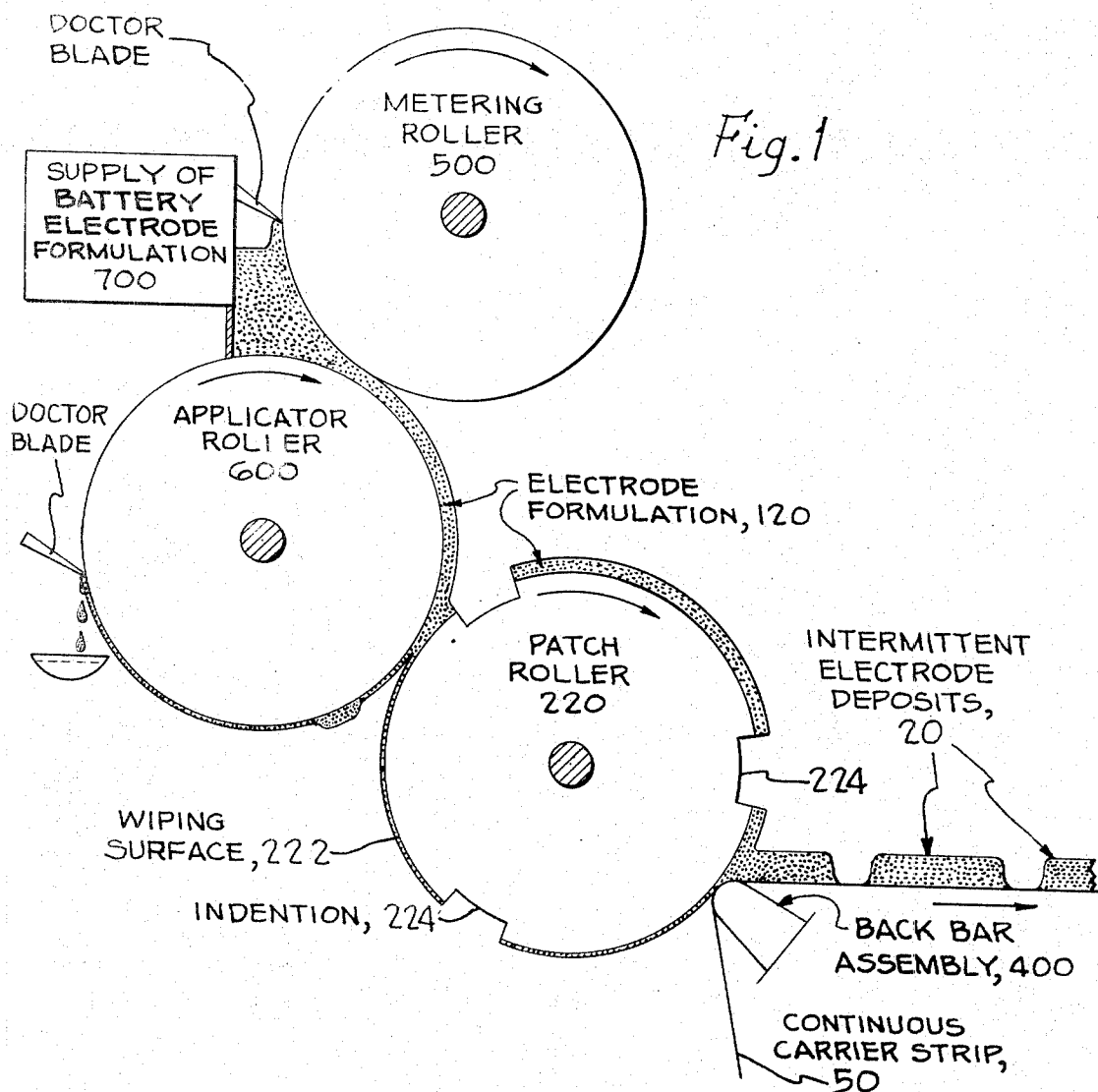
Attorney—Robert H. Robinson et al.

[57] **ABSTRACT**

Intermittent deposits of battery electrodes are applied onto a continuous carrier strip by a rotating patch roller which has an outer wiping surface and at least one indentation recessed from and interrupting the continuity of the wiping surface. The electrode formulation is wiped from the wiping surface of the patch roller onto the carrier strip to produce the electrode deposits, and the indentation in the patch roller causes the electrode deposits to be intermittent. A back bar assembly causes the carrier strip to undergo a sharp change in direction at the point where the electrode formulation is wiped onto the carrier strip. The battery electrode formulation comprises a plurality of electrochemically active particles contained in and dispersed throughout a binder matrix.

1 Claim, 2 Drawing Figures





METHOD OF APPLYING BATTERY ELECTRODES ONTO CONTINUOUS CARRIER STRIP

BACKGROUND OF THE INVENTION

It has previously been proposed to apply intermittent deposits of battery electrodes onto a continuous carrier strip. See U.S. Pat. No. 3,494,796. See also U.S. Ser. Nos. 156,686; 100,257; 100,267; 100,268; 100,269; 100,237; and 99,981. The implementation of these concepts requires that methods and machinery be devised which are capable of applying electrodes of the formulation and thickness desired in the completed battery. The consistency or viscosity required in the electrode formulation and/or the thickness of the required electrode deposits may be such that conventional coating techniques used to apply coatings onto a substrate are unsatisfactory.

SUMMARY OF THE INVENTION

This invention provides a method and means for applying intermittent deposits of battery electrodes onto a continuous carrier strip. The electrode deposits are applied by a rotating patch roller which has an outer wiping surface and at least one indentation recessed from and interrupting the continuity of the wiping surface. The electrode formulation is wiped from the wiping surface of the patch roller onto the carrier strip to produce the electrode deposits, and the indentation causes the electrode deposits to be intermittent.

The carrier strip is preferably presented to the patch roller by a back bar assembly which causes the carrier strip to undergo a sharp change in its direction at the point where the electrode formulation is wiped onto the carrier strip.

The electrode formulation used to apply the electrode deposits preferably comprises a plurality of electrochemically active particles contained in and dispersed throughout a binder matrix.

The method of applying the electrode formulation onto the wiping surface of the patch roller preferably involves using a metering roller and an applicator roller, both of which rotate in the same direction as the patch roller. The electrode formulation is passed between the metering roller and the applicator roller to meter the electrode formulation to a predetermined thickness on the surface of the applicator roller. The wiping surface of the patch roller is then presented to the applicator roller in a manner so that the electrode formulation is wiped from the surface of the applicator roller onto the wiping surface of the patch roller.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustrating the patch roller applying intermittent deposits of battery electrodes onto a continuous carrier strip.

FIG. 2 illustrates a segment of the carrier strip with the electrodes applied thereon.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates schematically the method of this invention and the means for implementing it, and FIG. 2 illustrates the result.

FIG. 1 shows a rotating patch roller 220 which has an outer wiping surface 222 and at least one (three are shown) indentation 224 recessed from and interrupting the continuity of the wiping surface 222. A continuous

carrier strip 50 is shown moving in a direction opposite that of the wiping surface 222 of the patch roller 220. The continuous carrier strip 50 is presented to the rotating wiping surface 222 of the patch roller 220 in a manner so that a quantity of battery electrode formulation 120 is wiped from the wiping surface 222 onto the carrier strip 50. The indentions 224 interrupt the continuity of the electrode formulation on the carrier strip and thus cause the electrode formulation to appear as intermittent deposits 20 along the carrier strip.

The term "indention" refers generally to a portion of the patch roller which will produce interruptions in the electrode formulation as the formulation is deposited onto the carrier strip. The indentions may also, but are not required to, leave a continuous margin along both edges of the carrier strip where electrode formulation is not deposited.

The carrier strip 50 is preferably presented to the patch roller 220 by a back bar assembly 400 which causes the carrier strip 50 to undergo a sharp change in its direction at the point where the electrode formulation 120 is wiped onto the carrier strip 50. This change in direction of the carrier strip contributes to the successful wiping or transfer of the electrode formulation, and in this respect the present invention borrows from the process described in U.S. Pat. No. 2,842,092. It should be pointed out, however, that the process described in that patent is one in which the deposit wiped onto the carrier strip is continuous rather than intermittent.

The electrode formulation 120 which is first applied onto the wiping surface of the patch roller and subsequently wiped off onto the continuous carrier strip comprises a plurality of electrochemically active particles suspended in a liquid or semi-liquid. After the electrode deposits 20 have been applied to the carrier strip the liquid may be removed by evaporation or other means from the electrode deposits to leave behind a series of solid electrode patches. The electrode formulation preferably also contains a binder material which, after the liquid is removed, holds the active particles together and binds, bonds, or otherwise secures the particles to the carrier strip. The active particles are contained in and dispersed throughout the binder matrix both before and after removal of the liquid from the electrode formulation. The liquid may be part of a dispersion binder system in which the solid binder contained in the finally constructed electrode comprises tiny particles of binder material dispersed throughout and not dissolved in the liquid of the electrode formulation; alternatively, the liquid may be part of a solution binder system in which the solid binder contained in the finally constructed electrode is dissolved in the liquid which is later removed. Electrode formulations using combinations of the dispersion and solution systems may be used. Examples of binder materials which may be used in dispersion systems include polyvinyl acetate latex, acrylic latex, butyl latex, styrene butadiene rubber latex, polychloroprene latex, acrylonitrile latex, and epoxy emulsions. Examples of binders which may be used in solution systems include polyvinyl chloride, acrylonitrile rubber, and polyisobutylene. The electrode formulation may also contain particles of carbon, graphite, or other electrically conductive materials to improve and control the internal conductivity of the dried electrode deposits. The electrode formulation may additionally contain if desired small amounts of

additional ingredients used for such purposes as maintaining uniform dispersion of active material particles during electrode construction, aiding the diffusion of battery electrolyte through the pores of the finally constructed electrodes, controlling viscosity during processing, controlling surface tension of battery electrolyte in the resultant electrode, controlling pot life, or for other reasons. The consistency or viscosity required in the electrode formulation to obtain electrodes having desired characteristics, taken together with the thickness sometimes required in the electrode deposits, may be such that conventional coating techniques used to apply coatings onto a substrate are unsatisfactory.

The preferred method of applying the battery electrode formulation onto the wiping surface of the patch roller 220 involves the use of the patch roller 220 and two other rollers, a metering roller 500 and an applicator roller 600, as shown in FIG. 1. All three rollers rotate in the same direction. The electrode formulation is first passed between the metering roller 500 and the applicator roller 600 to meter the electrode formulation to a predetermined thickness on the surface of the applicator roller 600; this thickness is determined by the gap or clearance between the rollers 500 and 600, and this gap is preferably adjustable. The wiping surface 222 of the patch roller 220 is presented to the applicator roller 600 in a manner so that the electrode formulation 120 is wiped from the surface of the applicator roller 600 onto the wiping surface 222 of the patch roller 220. The clearance or gap between the surfaces of the applicator roller 600 and the patch roller 220, which is adjustable, will determine the thickness of the formulation on the surface of the patch roller 220. Other techniques by which the electrode formulation may be applied to the wiping surface 222 of the patch roller 220 include other roller systems, spraying, and brushing.

It may be desirable to have a doctor blade to remove residual electrode formulation from the applicator roller 600 after the electrode formulation has been transferred from the applicator roller 600 to the patch roller 220. Such a doctor blade and a collector for receiving the electrode formulation removed by the doctor blade are illustrated in FIG. 1.

The width of the indentation 224, together with the peripheral speed of the patch roller 220 relative to the speed of the continuous carrier strip 50, will determine the clear spacing between successive intermittent deposits of electrode formulation. The depth of the indentations 224 should be such that, even if some electrode formulation finds its way into the indentations, the electrode deposits applied onto the carrier strip 50 will be intermittent. Since the amount of electrode formulation finding its way into the indentations will depend upon a number of factors (including the depth and consistency of the formulation on the wiping surface 222 of the patch roller 220, the speed rotation of the patch roller 220, and the amount of the electrode formulation remaining on the surface of the patch roller 220 after application of the formulation to the carrier strip), the optimum depth of the indentations 224 can best be determined empirically. If it should be necessary to remove electrode formulation from the indentations 224 in order to get consistently well defined electrode deposits on the carrier strip, the patch roller 220 may be provided with retractable cams which eject the electrode formulation from the indentations; alternatively, other systems

including techniques such as wiping, brushing, spraying, or suction may be used to clean the indentations. As will be shown in the examples below, sometimes it is not necessary to include systems for the purpose of removing electrode formulation from the indentations.

The length and depth of the intermittent electrode deposits 20 along the carrier strip 20 will depend upon the thickness of the electrode formulation 120 on the wiping surface 222 of the patch roller 220, the peripheral speed of the patch roller 220 relative to the speed of the continuous carrier strip 50, and the gap or clearance (which is preferably adjustable) between the surface of the carrier strip 50 and the wiping surface 222 of the patch roller.

If it is desired to transfer all of the electrode formulation from the patch roller 220 to the carrier strip 50, then the surface of the patch roller should preferably be elastomeric and make actual contact with the carrier strip. If it is intended to have a residual amount of electrode formulation remain on the surface of the patch roller after the transfer of electrode formulation to the carrier strip, then the surface of the patch roller may be rigid and the clearance between the surfaces of the patch roller and the carrier strip may be fixed. Rollers having elastomeric surfaces have the advantage of being able to adjust and compensate for minor irregularities in the rollers and/or the thicknesses of the carrier strip.

The nature and character of the intermittent electrode deposits produced by the patch roller 220 is such that the leading and trailing edges will be tapered while the sides will be more sharply defined. Between each consecutive pair of electrode deposits, i.e., between the trailing edge of one deposit and the leading edge of the following deposit there will be an area in which the continuity of the deposits on the carrier strip is completely interrupted.

After intermittent electrode deposits have been applied to one surface of the carrier strip and properly dried, the application techniques of this invention may again be used to produce intermittent electrodes of opposite polarity on the opposite side of the carrier strip. When this is done, the carrier strip becomes a continuous chain of duplex electrodes.

Examples will illustrate how the concepts of this invention have been used in actual production lines.

EXAMPLE No. 1

The process and equipment illustrated in FIG. 1 were used to produce intermittent deposits of negative electrodes along one side of a continuous carrier strip made from electrically conductive plastic. The carrier strip 50 was 2 mils in thickness, traveled at approximately 50 feet per minute and underwent a change in direction of approximately 60° at the point where it was presented to the patch roller 220. The patch roller 220, which was made from rubber covered steel, had a diameter approximately 10 inches and rotated approximately 60 rpm. Three indentations 224, each of which subtended an arc of approximately 20° and was approximately one-eighth inch deep, interrupted the continuity of the wiping surface 22. A layer of negative electrode formulation approximately 1 mil thick was applied onto the wiping surface 222 by the combined efforts of a metering roller 500 and an applicator roller 600, each of which was 10 inches in diameter and made from steel. The metering roller 500 rotated at from 1 to 2 rpm

while the applicator roller 600 rotated at approximately 60 rpm. The negative electrode formulation comprised a plurality of electrochemically active zinc particles contained in and dispersed throughout a binder matrix; the binder was polymeric material dispersed in water. The intermittent positive electrode deposits were about $2\frac{3}{4}$ inches long and 3 mils thick on the carrier strip before being dried. It was not necessary to clean electrode formulation from the indentions 224 as the process continued. After the electrode deposits were applied, the carrier strip was passed through an oven where the electrodes were dried.

EXAMPLE No. 2

Using rollers having the same dimensions and speeds and made from the same materials as stated in Example No. 1, intermittent deposits of positive electrodes were applied to the same electrically conductive plastic carrier strip. The positive electrodes were opposite the negative electrodes. The positive electrode formulation, which was placed on the wiping surface 222 to a depth of 3 mils, comprised a plurality of electrochemically active manganese dioxide particles contained in and dispersed throughout a binder matrix; the binder was a polymeric material dispersed in water. The intermittent positive electrode deposits were $2\frac{3}{4}$ inches long and 9 mils thick on the carrier strip before being dried. It was not necessary to clean electrode formulation from the indentions 224 as the process continued. The positive electrodes were also subsequently dried in an oven.

While FIG. 2 shows only one row of intermittent electrode deposits being applied along the continuous carrier strip, the widths of the carrier strip and rollers may be increased so that two or more rows of intermittent electrode deposits are applied to the carrier strip simultaneously, and the dimensions of the deposits in one row may differ from those in another row.

Carrier strips made from a variety of different materials may be used with this invention. Besides the electrically conductive plastic mentioned above in the examples, nonconductive plastics may be used. Metals having surfaces designed to be either reactive or nonreactive in batteries may be used. Carrier strips comprising a combination of materials such as the metal foils and nonconductive plastics shown in U.S. Pat. No. 3,494,796 may also be used with this invention. The electrode deposits may also be placed along carrier strips of battery separator material.

The electrode formulations, which may include recipes for either positive or negative electrodes, may employ a wide variety of positive and negative electrode materials. Among the positive electrode materials are such commonly used inorganic metal oxides as manganese dioxide, lead dioxide, nickel oxyhydroxide, mercuric oxide and silver oxide, inorganic metal halides such as silver chloride and lead chloride and organic materials capable of being reduced such as dinitrobenzene and azodicarbonamide compounds. Among the negative electrode materials are such commonly used metals as zinc, aluminum, magnesium, lead, cadmium,

and iron. Batteries made from the carrier strips with the electrodes deposited thereon may employ the electrolytes commonly used in the LeClanche system (ammonium chloride and/or zinc chloride), various alkaline electrolytes such as the hydroxides of potassium, sodium and/or lithium, acidic electrolytes such as sulfuric or phosphoric acid and nonaqueous electrolytes, the electrolytes of course being chosen to be compatible with the positive and negative electrodes.

Among the wide variety of electrochemical systems which may be used in batteries made from the carrier strips with the electrodes deposited there are those in which the positive electrodes comprise manganese dioxide, the negative electrodes comprise metals such as zinc, aluminum, or magnesium, and the electrolyte substantially comprises an acidic solution of inorganic salts. Another commonly known system is the alkaline manganese system in which the positive electrodes comprise manganese dioxide, the negative electrodes comprise zinc, and the electrolyte substantially comprises a solution of potassium hydroxide. Other aqueous electrolyte systems including those of nickel-zinc, silver-zinc, mercury-zinc, mercury-cadmium, and nickel-cadmium may also be used. Systems employing organic positive electrodes and acidic electrolytes may also be used, including rechargeable systems using azodicarbonamide compound electrodes and LeClanche electrolyte.

We claim:

1. The method of applying intermittent deposits of battery electrodes onto a continuous carrier strip using
 - a. a rotating patch roller having an outer wiping surface and at least one indentation recessed from and interrupting the continuity of the wiping surface,
 - b. a metering roller rotating in the same direction as the patch roller,
 - c. an applicator roller rotating in the same direction as the patch roller, and
 - d. a continuous carrier strip moving in a direction opposite that of the wiping surface of the patch roller, the method comprising:
 - e. passing a battery electrode formulation between the metering roller and the applicator roller to meter the electrode formulation to a predetermined thickness on the surface of the applicator roller;
 - f. presenting the wiping surface of the patch roller to the applicator roller in a manner so that the electrode formulation is wiped from the surface of the applicator roller onto the wiping surface of the patch roller; and;
 - g. presenting the continuous carrier strip to the rotating wiping surface of the patch roller in a manner so that the electrode formulation is wiped from the wiping surface onto the carrier strip, so that the indentation interrupts the continuity of the electrode formulation on the carrier strip, and by a back bar assembly so that the carrier strip undergoes a sharp change in its direction at the point where the electrode formulation is wiped onto the carrier strip.

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