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[54] METHOD AND APPARATUS FOR TREATING A WEB

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[58] **Field of Search**.....317/2 R, 2 A, 262 R, 317/262 A; 204/312

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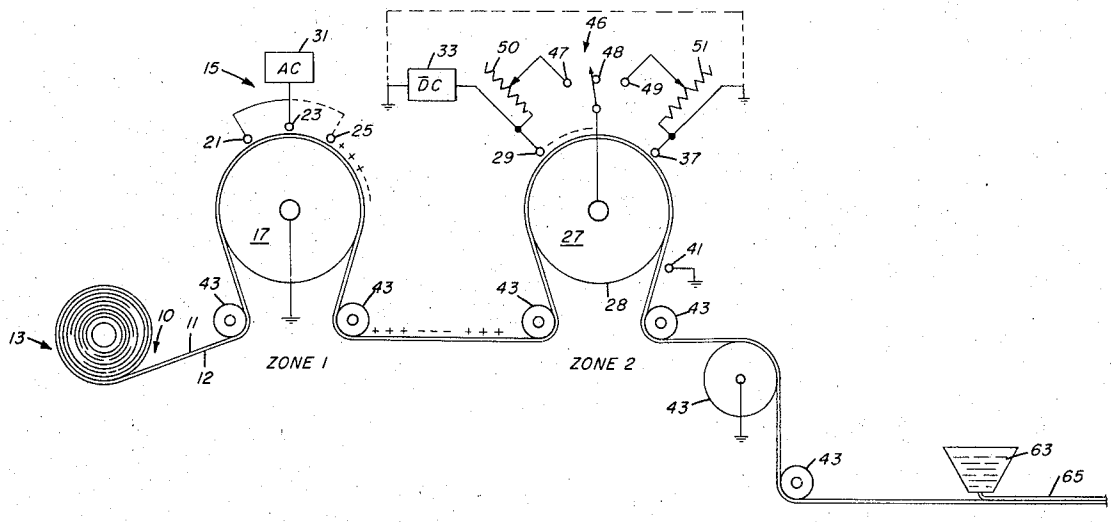
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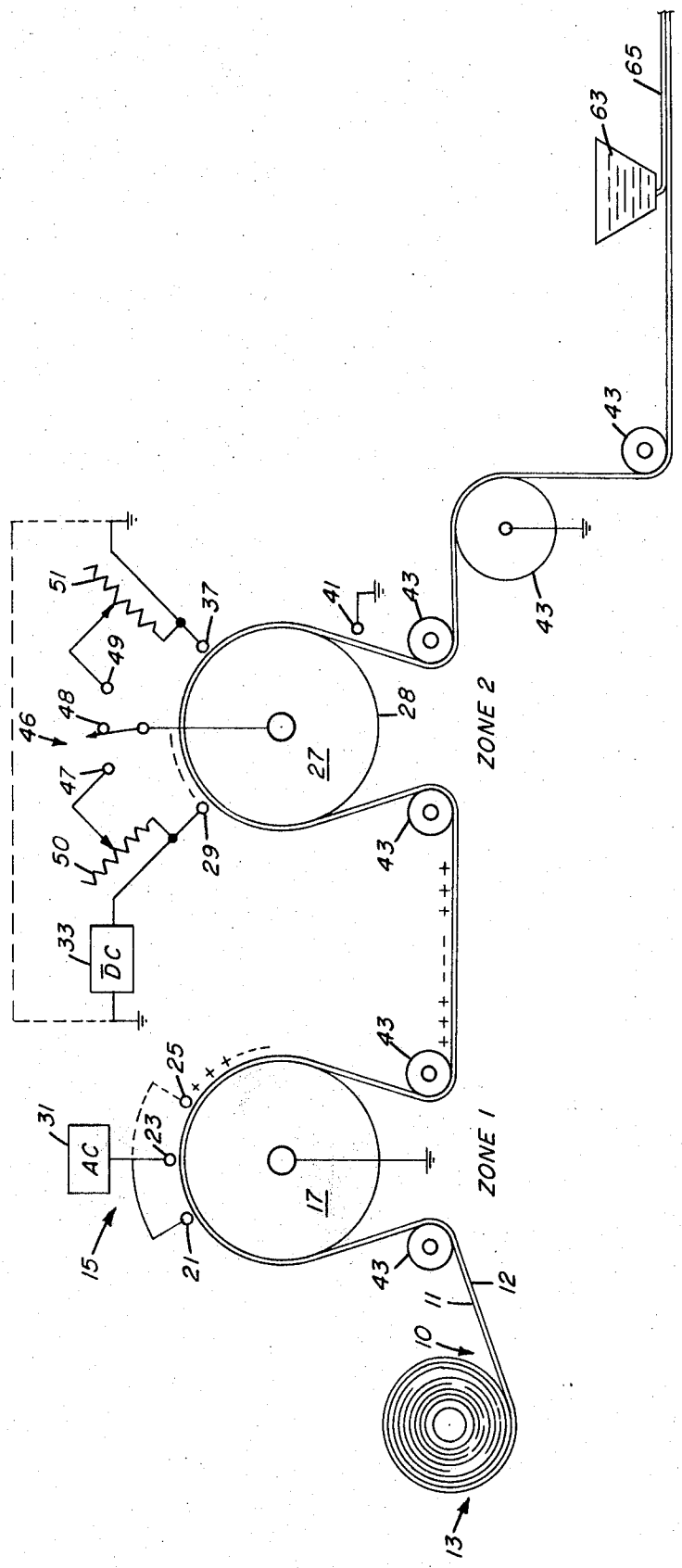
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[57] **ABSTRACT**

An improved method and apparatus for substantially eliminating non-uniform charge patterns from a surface of a corona-treated web, particularly for enhancing the surface's coatability, is disclosed. The improved method and apparatus employs the technique of "flooding" the surface with charge of one polarity from a first electrode so as to generally uniformly charge the surface, and thereafter removing the charge imparted to the surface by applying an equal but opposite charge from a second electrode. To ensure positive control between the amount of charge added to the surface and the amount removed, the invention proposes that the first and second electrodes be connected to a single source of DC power and that the web, when treated in accordance with the invention, be supported by an electrically conductive roller which is electrically isolated from ground.

9 Claims, 1 Drawing Figure





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METHOD AND APPARATUS FOR TREATING A WEB

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to U.S. application Ser. Nos. 804,470, filed Mar. 5, 1969, and 167,758, filed July 30, 1971.

BACKGROUND OF THE INVENTION

This invention relates to the treatment of webs. More particularly, the invention relates to a method for treating a web so as to improve the web's coatability.

In the prior art, it is common practice to coronatreat a surface of a web to improve the surface's receptivity to inks, adhesives, photographic emulsions, subbing layers, etc. For example, a web of photographic paper may be polyethylene-coated; and such coating may be corona-treated before the application of a photographic emulsion thereon. While corona-treatment of the polyethylene surface may enhance the receptivity of the surface to the emulsion, a problem arises in that corona-treatment of the surface usually leaves a non-uniform distribution of, i.e., a pattern of, electrostatic charge on the surface. In coating systems where the coating operation is delicate, i.e., easily disturbed, this charge pattern must be substantially removed before the web is introduced into the coating station, if uniform coatings are to be produced. Otherwise, the charge pattern will cause coating bead disturbances and thus cause the coating to be uneven.

Apparently, in the corona-treatment of the polyethylene surface by conventional alternating-current corona-producing means, the alternating electric field created by the corona-producing means distributes charged particles of different polarities onto the surface in a non-uniform charge pattern. Thus, along the surface there may reside "hills" comprising a relatively large amount of positive charge, and adjacent thereto "valleys" of a relatively large amount of negative charge. As the emulsion coating is deposited on the web, it is affected by the surface charge distribution, and in a sense the emulsion aligns with the charge pattern and forms what has been called "crosslines", thus adversely affecting the photographic quality of the product in question.

A need has developed, therefore, to remove charge from a surface to be coated, or at least to reduce the charge, or the effect of its pattern, to an acceptable level before coating the surface with photographic emulsions.

The problem of removing the non-uniformly distributed charge from the corona-treated surface is believed to be complicated by the nature of such charge. The charge may be comprised of two types:

1. free charges on which the mating charges of opposite polarity are remote from the web, and
2. polar or bound charges in which charges of opposite polarity are on the opposite side of the web.

Prior art methods of removing surface charges from the web work quite well when there are only free charges to be removed. However, polar or bound charges are extremely difficult to reduce to a satisfactory level.

One technique for removing the non-uniform distribution of charge on a corona-treated polymeric surface is described in U.S. Pat. No. 3,531,314. In this patent, a corona-treated web is advanced to a charging station, wherein a charged roller floods the "hills" and "valleys" of surface charge and imparts a highly uniform charge level to one surface of the web. Simultaneously, a counter electrode positioned on the other side of the web imparts a highly uniform charge of opposite polarity to the other side of the web. Thereafter, both sides may be passed over grounded rollers, or wound into rolls, to reduce the level of the charge — to below arc-threshold — so that a photographic or light-sensitive emulsion may be coated on one of the sides without substantial fogging of the emulsion. Obviously, winding of the web into rolls is undesirable where one wishes to corona-treat and coat in a continuous operation. The use of grounded rollers to dissipate the high level of charge imparted to both sides of the web while removing much of the charge still leaves a relatively high level of (bound) charge on the surface.

An improvement upon the technique recited in the afore-mentioned patent is described in U.S. application Ser. No. 804,470, filed on Mar. 5, 1969. This improvement employs the flooding technique disclosed in U.S. Pat. No. 3,531,314, but includes a series circuit feature wherein first and second electrodes — such as rollers — are connected to the oppositely charged terminals of a source of DC potential and are located on the face side of the web. Counter electrodes for the rollers are located on the other (hereinafter called the wire) side of the web; the counter electrodes being electrically connected to each other. In operation, at a first charging station the first roller applies, say, a large amount of positive charge to the face side of the web and induces its counter electrode to deposit an equal amount of negative charge onto the wire side of the web. The application of negative charge is able to neutralize the polar positive charge on the wire side, and thereby frees the polar negative charge on the face side, which may then be either conducted away or neutralized by the positively charged roller. The web is then conveyed to a second charging station comprising a relatively negatively charged roller and its relatively positively charged counter electrode. At this point, positively charged particles are applied to the wire side of the web to neutralize the negative charge, thereby freeing the positive charge on the face side which may then be removed by the relatively negatively charged roller. One important feature of this technique is that because of the series circuit feature, the amount of charge applied to each surface at the second charging station is equal to the amount of charge of opposite polarity applied to each surface at the first charging station.

While the apparatus and method described in the aforementioned application Ser. No. 804,470 generally gives satisfactory results, a problem arises in that when the web is conveyed about the two rollers which are charged relative to the web, the web has an undesirable tendency to adhere to the rollers and, thus, creases are likely to form in the web. A reduction in the number of relatively charged rollers about which the web is conveyed represents a highly desirable improvement.

SUMMARY OF THE INVENTION

The invention provides an improved method and apparatus for use in removing non-uniform charge pat-

terns from a corona-treated web. The invention employs the series circuit feature described in the aforementioned application Ser. No. 804,470, i.e., two electrodes which are exposed to one side of a web are connected to the opposite poles of a source of DC potential for first uniformly charging the said one side with charge of a first polarity and for thereafter removing the uniform charge. The invention improves upon this feature by providing an electrically conductive support member about which the opposite side of the web may be wrapped; the electrically conductive support member is electrically isolated from ground and is so disposed as to comprise a common counter electrode for both said electrodes.

The series circuit of the invention may be described, in effect, as the flow of current from the DC source to one electrode, then through the web to the electrically conductive support member, and back through the web to the second electrode and to the DC source. By the term electrically conductive support member, it is meant that, with the use of the support member in the series circuit of the invention, the effective electrical resistance of the circuit is no more than about 10^9 ohms, i.e., the potential of the source divided by the current flowing in the series circuit is no greater than about 10^9 ohms.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing, there is shown a representation of an apparatus for carrying out the improved method and apparatus described herein.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

With regard to the drawings, a coating apparatus is shown wherein a web **10** of dielectric material or one having a dielectric coating is conveyed from an unwind station **13** to a corona-treatment station **15**, hereafter referred to as Zone **1**. As used herein, the term "dielectric" refers to any surface with a surface resistivity of about 10^{13} ohms per square or greater. At Zone **1**, the web **10** is conveyed about an electrically grounded roller **17** so that one web surface, **12**, is in intimate contact with the surface of the roller. On the opposite side of the web, web surface **11** is exposed to a conventional alternating-current corona-treatment, so as to enhance its receptivity to a coating, such as, for example, inks, adhesives, photographic emulsions, subbing layers, etc. In corona-treatment of the surface, a glow of corona may be seen to extend from electrodes **21**,**23**, and **25** to the surface **11**. The electrodes may be connected to a suitable alternating-current power supply **31** for providing a suitable level of potential for ionizing the air between the electrodes and the surface. As used herein, alternating-currents and voltages are any such currents and voltages which vary, such, for example, as sinusoidal and pulsating currents and voltages. If desired, provision may be made in Zone **1** for corona-treating web surface **12**.

After corona-treatment, the dielectric surface becomes highly charged with charge that is, as indicated in the drawing, non-uniformly distributed along the surface **11**. To remove this charge, which may be comprised of both polar and free charges, the web is conveyed to Zone **2**. At Zone **2**, the web **10** is wrapped about a metal roller **27** which is electrically isolated from, i.e., virtually floated, with respect to ground. The web surface **12** is in intimate contact with the conductive surface **28** of the roller **27**. While the roller **27** is preferably a metal roller, the roller **27** may include a covering of dielectric material with the proviso that, as stated above, the total effective electrical resistance in the series circuit should be no greater than about 10^9 ohms.

The web surface **11** is exposed to first and second electrodes **29** and **37**, respectively; and which electrodes are spaced from the web surface **11** a distance of about, say, 1 to 1.5 centimeters. The first electrode **29** is located proximate to roll **27** and is connected to one pole of a source **33** of DC potential. The source **33** is preferably of the order of **25** to **30** Kv or more, and draws about 2 m.a. of current. Thus, the effective electrical resistance in the preferred embodiment is about, say, 15 megohms. While the source **33** may be either of negative or positive potential, the discussion of the preferred embodiment will assume it is negative. The second electrode **37** is located downstream of the first electrode **29**. The second electrode **37** is located proximate to the roll **27** and is connected to the positive pole of the source **33**. It will be noted from the drawing that such connection may be through ground.

The conductive roller **27** may be electrically connected to a three-position switch **46**. With the switch **46** coupled to a terminal **47**, the roller **27** is biased negatively by being coupled through a rheostat **50** to negative electrode **29**. Conversely, when the switch **46** is coupled to a terminal **49**, the roller **27** will be biased relatively positively by being coupled through a rheostat **51** to the positive electrode **37**. When switch **46** is coupled in the third position, i.e., coupled to terminal **48**, the switch **46** will be open and roller **27** will be insulated from ground. In each of the three switch positions, the roller is electrically isolated from ground; that is, the roller **27** will be either electrically insulated from ground or connected to ground through a high impedance.

The operation of the apparatus in Zone **2** is as follows: Electrode **29**, being highly negatively charged, ionizes the air in the vicinity of the electrode and deposits or "floods" surface **11** with a large amount of negative charge. The "flood" of negative charge eliminates the non-uniform charge pattern applied to the web during corona-treatment of the web in Zone **1**, and provides the surface **11** with a high negative charge. It should be appreciated that while a corona glow appears about the electrode **29**, such glow does not, and preferably should not, extend to the surface **11**, as it would during conventional corona-treatment operations.

Simultaneously with the application of negative charge to the surface **11**, the roller **27** — functioning as a counter electrode for electrode **29** — applies to the surface **12** a high positive charge which is equal but opposite in polarity to the charge on the surface **11**. The positive charging of the side **12** by the roller **27** may be either by the depositing of positively charged ions or particles onto the surface **12** or by the removal of electrons from the surface **12**. Since the roller **27** is isolated from ground, a negative potential will be induced upon the roller by the electrode **29**. The magnitude of this

potential may be approximately one-half that of the source 33 with switch 46 positioned in the open position, i.e., connected to the terminal 48. As the web surface 11 comes between the roller 27 and the grounded electrode 37, the potential difference between the roller 27 and the electrode 37 induces the electrode 37 to strip electrons from the air in the vicinity of the electrode 37, thereby causing positively charged ions or particles to be deposited on the surface 11 to neutralize the negative charge applied on the surface by electrode 29. Thus, bound charges are removed from the surface 11 of the web. Again, it should be appreciated that while a corona glow may appear around the electrode 37, the glow does not, and preferably should not, extend to the surface 11. With the removal of substantially all of the bound charge from the surface 11, the bound positive charge on surface 12 is eliminated by depositing electrons or negatively charged ions onto the surface 12 by the roller 27. Preferably after the web is separated from the roller 27, any charge remaining on the surface 11 may be removed by a grounded electrode 41. Thereafter, the web may be conveyed about grounded conveyance rollers 43 to a coating station 63, wherein one or more coatings 65 may be deposited on the web.

An important feature of this invention, like that of application Ser. No. 804,470, is that the amount of negative charge deposited by the electrode 29 on the surface 11 must be the same as the amount of positive charge deposited thereon by the electrode 37. Since there is but one source of potential — source 33 — and since the two electrodes are connected to opposite poles of this source with switch 46 in the open position, any electrons which are stripped from the air by the electrode 37 are put back into the air by the electrode 29. Thus, from the above, it will be appreciated that the balancing of the charge applied and removed from the web by the two electrodes is inherent in their operation. However, as stated previously in the discussion relative to application Ser. No. 804,470, there are instances where one electrode may deposit more charge than the other can remove. In these instances, such as where an electrically conductive layer comprises one layer of the web, it may be necessary to bias the roller 27 either positively or negatively by positioning the switch 46 to the positions 49 or 47, respectively. If it is found that an excess of negative charge is being placed on the surface 11, then the roller may be negatively biased so as to reduce the potential difference between the roller 27 and electrode 29. Conversely, if an excess of positive charge is being placed on the web, then the roller 27 may be positively biased so as to reduce the potential difference between the roller and electrode 37.

It should be appreciated that while the drawing shows the surface being exposed to electrodes 29 and 37 as the surface which is to be coated, this is not a necessity, as the surface which contacts the roller 27 will also have a non-uniform charge pattern removed from such surface in the Zone 2 treatment described above.

The invention has been described in relation to preferred embodiments wherein a web has received a non-uniform distribution of charge on its surface(s) during a corona-treatment process; however, in its broader aspects, the invention is applicable to the removal of charge from webs which have been charged by other processes.

Furthermore, the invention in its broader aspects is not linked to particular web compositions nor to particular coatings to be placed thereon. The method for carrying out the invention may be quite useful in the treatment of webs comprised of films and surfaces of various materials, including polyolefins such as polyethylenes, polypropylenes, and ethylene-propylene copolymers, polystyrene, polybutenes, polypentenes, polyacrylic acid esters, linear polyesters and polycarbonates such as polyethylene terephthalates, polyamides such as nylon, cellulose esters, polyacrylonitrile, polyvinylidene chloride and other copolymers of the indicated monomers, such as ethylene-vinyl acetate copolymers. Although it has special advantages in connection with photographic products, coatings other than the preferred light-sensitive silver halide gelatin emulsions may be placed on the web. Thus, non-light-sensitive gelatin emulsions, as well as other compositions which may be coated by a hopper, such as coatings including magnetic oxides, organic solvents, etc, may be coated in accordance with the invention described herein.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

What is claimed is:

1. An apparatus for treating a moving web, which apparatus comprises:
   a. an electrical source of DC potential,
   b. a first electrode means coupled to one pole of said source, said first electrode means being positioned in facing relationship to one side of said web so as to generally uniformly electrically charge the said one side, and
   c. a second electrode means coupled to an opposite pole of said source, said second electrode means being positioned in facing relationship to said one side of said web so as to substantially remove the charge imparted to the said one side by said first electrode; and the improvement which comprises:
   d. means for supporting said web, said supporting means including an electrically conductive support member which is isolated from ground and which is adapted to contact the opposite side of said web, said member being charged by said source to a potential between those applied to said first and second electrodes, and said member cooperating with said electrodes so as to comprise a common counter electrode for said electrodes.

2. The invention according to claim 1 wherein the first and second electrode means are spaced from said one side of said web, and said support member is comprised of a roller.

3. The invention according to claim 1, in combination with apparatus for corona-treating the web, the corona-treating apparatus being adapted to corona-treat the web at a location upstream of the support member.

4. The invention according to claim 3, in combination with means for coating the web, the coating means

being adapted to coat the web at a location downstream of the support member.

5. The invention according to claim 1, wherein said electrically conductive support member is insulated from ground.

6. The invention according to claim 1, wherein a switch is electrically connected to the electrically conductive support member, the switch including at least three positions which comprise:

a. means to bias the support member to a first pole of the DC source,

b. means to bias the support member to a second pole of the DC source, and

c. an open position wherein the support member is insulated from ground.

7. A process for the preparation of a web for deposition of a coating thereon, the web including a non-uniform distribution of electric charge that is to be substantially removed from the web prior to coating, the process including the steps of:

a. providing an electrical source of DC potential, the source having first and second electrodes with the DC potential applied between the electrodes;

b. exposing one side of the web to the first electrode so as to generally uniformly electrically charge the said one side; and

c. exposing the said one side to the second electrode so as to remove the charge imparted to the said one side in step (b), and the improvement which comprises:

d. supporting the web so that the opposite side thereof is in contact with an electrically conductive support member that is isolated from ground, said support member being charged by said source to a potential between those applied to said first and second electrodes, whereby said support member comprises a common counter electrode for said first and second electrodes.

8. The invention according to claim 7 wherein a side of said web is a dielectric.

9. The invention according to claim 8 wherein the non-uniform distribution of electric charge was placed on the web during a corona-treatment process.

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