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PREVENTION OF ARCING IN AN ELECTRODE IMAGING SYSTEM

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2 Sheets-Sheet 1

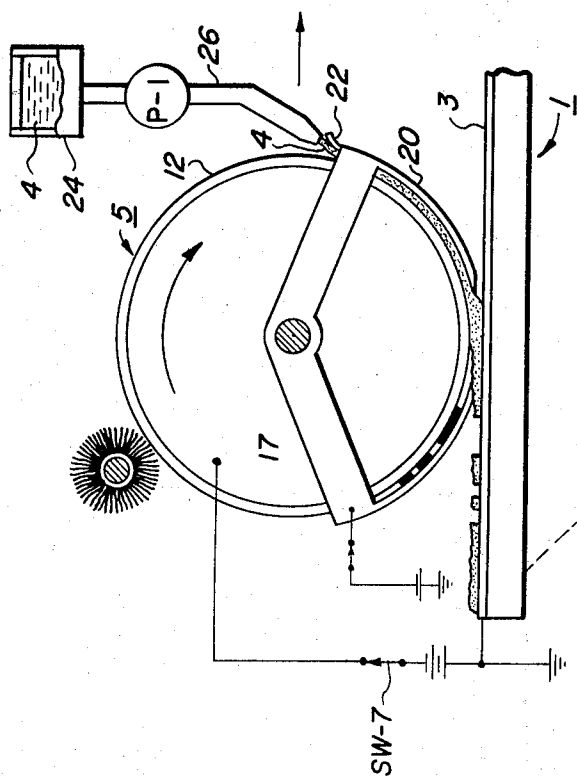


FIG. 2

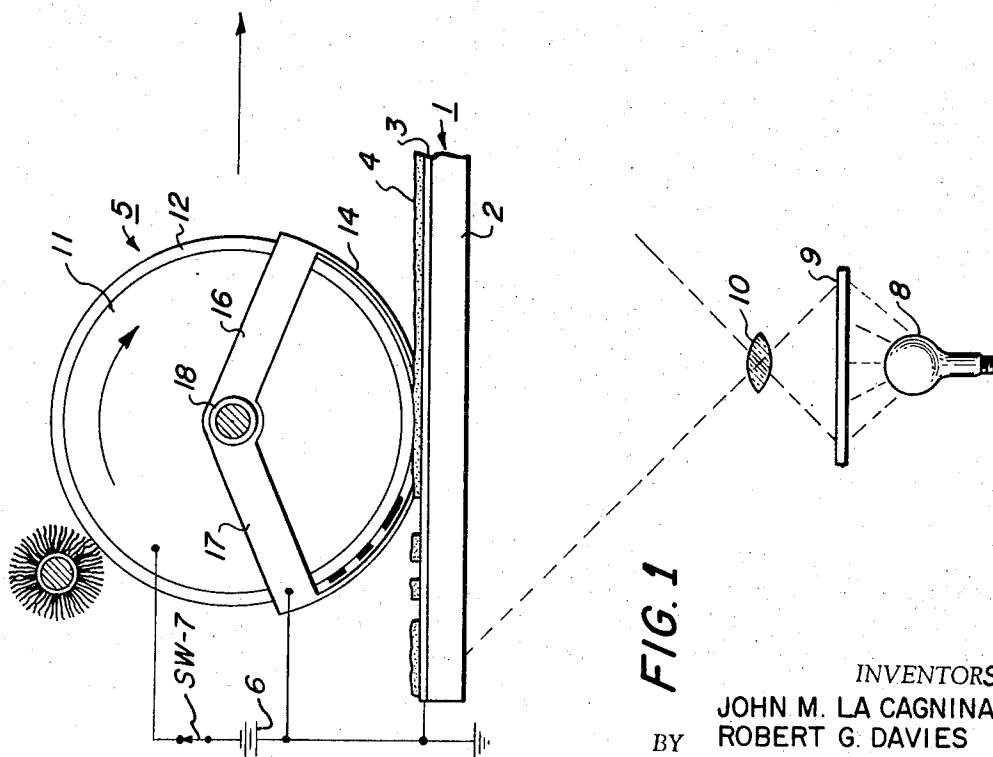


FIG. 1

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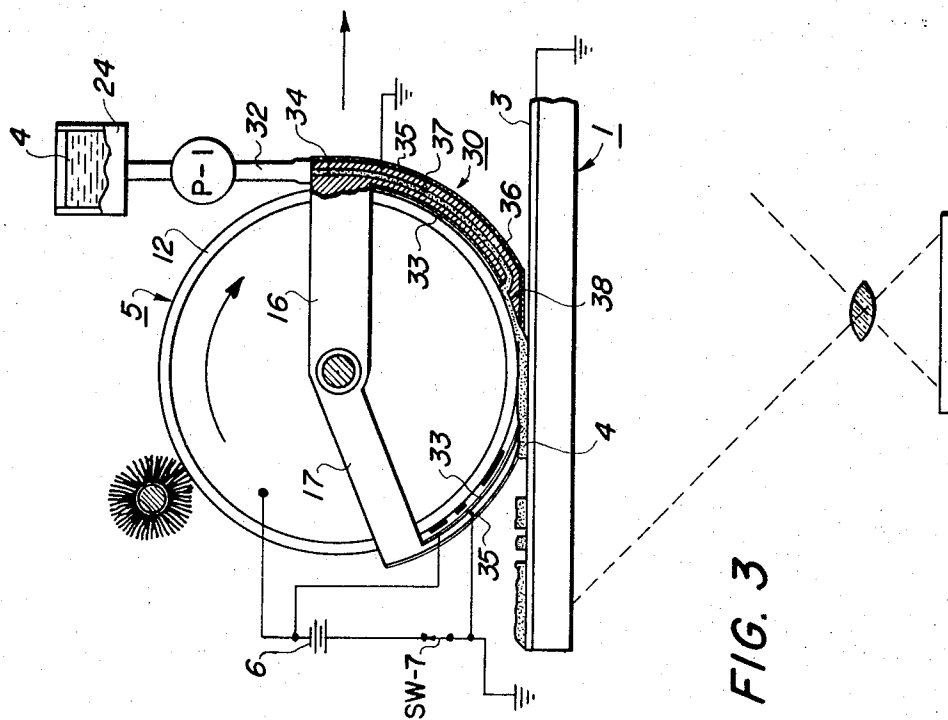
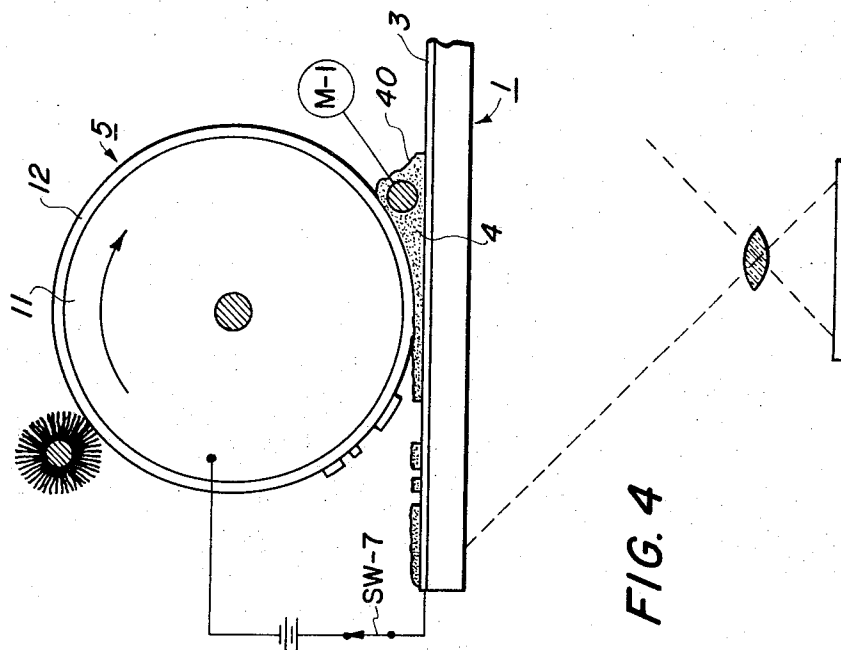
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PREVENTION OF ARCING IN AN ELECTRODE IMAGING SYSTEM

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15 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for eliminating corona arcing between electrodes in an electrophoretic imaging system by introducing a member at the entrance and exit of the nip between adjacent electrodes during the application of an electric field for imaging of an electrophoretic suspension between the electrodes.

This invention relates in general to imaging systems and, more specifically, to an improved electrophoretic imaging system.

The system improved by this invention is of the type using photosensitive radiant energy absorbing particles believed to bear charge when suspended in a non-conductive liquid carrier and placed in an electroded system and exposed to an image radiation configuration. A detailed description of this imaging system is described in Pats. Nos. 3,384,565; 3,384,566; and 3,383,993, all issued May 21, 1968 in the names of V. Tulagin and L. M. Carreira; H. E. Clark and S. Yeh, respectively. The particles of this suspension migrate in image configuration presenting a visual image at one or both of the electrodes between which they are placed. The system employs particles which are photosensitive and which apparently undergo a net charge alteration upon exposure to activating radiation by interaction with one of the electrodes. Mixtures of two or more different colored particles are used to secure various colors of images and imaging mixes having different spectral responses. These colors may be used independently or even in subtractive color synthesis. In a monochromatic system the particles will migrate if energy of any wavelength within the panchromatic spectrum of the particle response strikes the particle.

It has been found that images produced by the system already described above may be uneven and during imaging may even impair the surfaces of the electrodes because of corona arcing near the contact point between the electrodes used in the imaging process. It is theorized that the difficulties aforementioned are caused by varying corona discharge or air ionization between the electrodes as one electrode approaches the particle suspension in proximity to the other electrode. While the system described above is often capable of producing excellent images, at times, especially during periods of high relative humidity the images produced are of lower quality due to electric arcing. Thus, there is the continuing need for image improvement under all ambient conditions.

It may be that other systems exist or will be discovered or invented that require operations similar to those described above and this invention can be used therein to improve such a system and such use is contemplated hereby. Therefore, it is an object of this invention to improve electrophoretic imaging systems by making prints devoid of defects caused by corona arcing. Another object of this invention is to improve means for eliminating varying corona discharge or air ionization between the electrodes used for the imaging system as one electrode approaches the particle suspension in proximity to the other electrodes.

Yet another object of this invention is to improve electrophoretic imaging systems making them capable of producing images of uniform quality under various humidity conditions.

Still another object of this invention is to improve suspension distributing systems to eliminate air ionization between electrodes while providing a more or less uniform layer of suspension for imaging.

The foregoing objects and others are accomplished in accordance with this invention by introducing a mechanical member in the air gap located between the approaching electrodes in an electrophoretic imaging system as well as to provide suspension supply means in conjunction with the member to prevent air ionization between the electrodes during the imaging process.

The advantages of this improved electrophoretic imaging system will become further apparent upon consideration of the following detailed disclosure of the invention, especially when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic presentation of the side view of a simple system for illustrating this invention,

FIG. 2 shows another schematic embodiment illustrating this invention including suspension supply means, and FIGS. 3 and 4 show other embodiments of this invention.

Referring now to the figures, FIG. 1, shows a transparent electrode generally designated 1 which is made up of a layer of optically transparent glass 2 overcoated with a thin optically transparent layer of tin oxide 3, commercially available under the name of NESA glass from Pittsburgh Plate Glass Company. This electrode shall hereafter be referred to as the "injecting electrode" because it is thought to inject electrical charges into activated particles during imaging. Coated on the injecting electrode 1 is a thin layer 4 of finely divided photosensitive particles dispersed in an insulating carrier.

The term "photosensitive" for the purpose of this invention refers to the properties of a particle which, once attracted to the injecting electrode, will reverse its polarity and migrate away from the electrode under the influence of an applied electric field when exposed to activating electromagnetic radiation. The term "suspension" may be defined as a system having solid particles dispersed in a solid, liquid or gas. Nevertheless, the suspension described in the following preferred illustrations are of the general type including those having a solid suspended in a liquid carrier. For a detailed theoretical explanation of the apparent mechanism of this imaging process, see the above mentioned patents, the disclosures of which are incorporated by reference herein.

Adjacent to the liquid suspension 4 is a second electrode 5, hereinafter called the "blocking electrode," which is connected to one side of a potential source 6 giving it a potential with respect to ground. The injecting electrode 1 can be considered to be maintained at ground potential relative to the blocking electrode 5 so that when the switch 7 is closed, an electric field is applied across the liquid suspension 4 between the electrodes 1 and 5 as the blocking electrode 5 passes over the liquid suspension 4. An image projection made up of a light source 8, a transparency 9, and a lens 10 is provided to expose the suspension 4 to a light image of the original transparency 9 to be reproduced.

Electrode 5 is made in the form of a roller having conductive central core 11 connected to the potential source 6. The core is covered with a layer of blocking electrode material 12, which may be Tedlar, a polyvinyl fluoride commercially available from E. I. du Pont de Nemours and Co., or other suitable dielectric materials having a resistivity greater than 10^7 ohm-cm. and

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a dielectric constant of at least 20. The blocking electrode may, of course, be in any configuration capable of contacting the suspension in rolling contact therewith.

The particle suspension is exposed to the image to be reproduced while potential is applied across the blocking and injecting electrodes by closing the switch 7. The electrode 5 is caused to roll across the top surface of the injecting electrode 1 with the switch 7 closed during the period of image exposure. The particles within the suspension are non-conductive when not being struck with activating radiation. The particles do have an inherent charge on them, however. The negative particles come into contact with or are closely adjacent to the injecting electrode 1 and remain in that position under the influence of the applied electric field until they are subjected to exposure to activating electromagnetic radiation. The particles bound on the surface of the injecting electrode 1 include the potential imaging particles of the final image to be reproduced thereon. When activating radiation strikes the particles within the field, the radiation is absorbed by the photosensitive particles making it conductive "creating" hole-electron pairs of charge carriers which may be considered mobile in nature. These newly created hole-electron pairs within the particles are thought to remain separated before they can combine due to the electrical field surrounding the particles between the two electrodes. Charge exchange then occurs with the injecting electrode and the negative charge carriers of these hole-electron pairs move toward the positive electrode 1 while the positive charge carriers move toward the electrode 5. The field can be reversed and imaging will occur.

This process, utilizing only components exemplified by those discussed herein, is in itself capable of ordinarily producing good images. However, under certain circumstances such as high humidity the image produced tends to have variable density caused by corona arcing. The arcing may also damage the sensitive surface 12 of the blocking electrode 5 by forming pin holes therein or by building up unwanted charges thereafter limiting the effectiveness of the imaging system. The above noted problems are eliminated by this invention by interposing at the interface of the electrodes 1 and 5 and arcing suppression member 14. The arcing suppression member extends the length of the blocking electrode 5 is formed to fit into the entrance and/or exit of the nip formed at the interface of the two electrodes. In the embodiment shown in FIG. 1, the suppression member 14 is formed of a conductive material such as aluminum or steel or the like.

The suppression member travels across the injecting electrode 1 as the blocking electrode 5 rotates in non-skid contact across the injecting electrode. The suppression member is maintained in its spacing with blocking electrode 5 by bracing members 16 and 17. It translates across the injecting electrode 1 without rotating by being suitably journaled at the central axis of rotation of the blocking electrode 5 through a set of bearings 18 at either end of the blocking electrode.

In the embodiment shown in FIG. 1 the arcing suppression member is maintained at the same potential as the injecting electrode 1. Therefore, there is no field between the surface 3 of the injecting electrode 1 and the portions 14 of the arc suppressing member. There is, however, a field between the arc suppressing member 14 and the blocking electrode surface 12. Therefore, any air ionization between the electrodes will occur between the surface 12 of the blocking electrode 5 and the arcing suppression member 14.

The arcing suppression member at the entrance to the nip between the electrodes is positioned to be immersed in the suspension layer 4 so that there is no air between it and the surface 3 of the injecting electrode 1. At the exit of the nip the member 14 is preferably placed as

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close to the nip as is practicable without causing a scraping across the image portion of the suspension 4 which remains on the injecting electrode 1 in this embodiment.

The embodiment schematically shown in FIG. 2 employs a suppression member 20 shaped similarly to the suppression member 14 of FIG. 1. Here, however, the member 20 is made of an electrically insulating material. It also has a lip portion 22 to accept a supply of the ink suspension 4 between it and the surface 12 of the blocking electrode 5. As the suspension is moved through the space between the member 20 and the blocking electrode surface 12, it enters the nip area between the blocking electrode 5 and injecting electrode 1 where it is imaged in the manner previously mentioned. Any arcing that otherwise might occur because of a conductor near the high field between the approaching electrodes is eliminated or substantially reduced because of the filling of the gap between the electrodes with the insulating material of the member 20 and the carrier of the suspension. For this reason, the suppression member 20 is again placed as near as practicable to the interface between the electrodes and the suspension 4. It should be positioned far enough from the surface 3 of the electrode 1 to not scrape or interfere with the image of the suspension 4 left remaining on the injecting electrode 1.

A suspension supply tank 24 maintains a supply of the suspension 4 which is pumped through a pump P-1 and tubing 26 to the lip portion 22 of the suppression member 20 where it is brought, through the motion of the blocking electrode 5, to the nip between the two electrodes for imaging in the usual manner.

FIG. 3 schematically represents an alternative embodiment of the arc suppression member with a suspension feeding capability. The member 30 is shaped in much the same manner as the respective members in FIGS. 1 and 2. There is a difference in the design, however, to accommodate a suspension feeding system within the physical confines of a portion of the arc suppression member 30. Pump P-1 removes suspension from the container 24 through suitable tubing 32 to a slot 34 within the internal structure of the member 30. The slot extends across the entire width of the member 30 and the tubing 32 is formed to cause a suspension flow across the entire length of the slot which extends the length of the blocking electrode 5. The suspension flows confined within the slot 34 of the arc suppression member 30 to an exit position in close proximity to the interface between the surfaces 12 and 3 of the electrodes 5 and 1 respectively. The suspension is forced out of the exit of the slot 34 by the action of the pump and the movement of the surface 12 past the exit position as well as gravity.

The inner surface 33 and outer surface 35 of the suppression member 30 are electrically conductive. They are not connected to each other but are maintained on opposite sides of the insulating core 37 of the member 30. The outer surface 35, which is physically closest to the injecting electrode 1, is maintained at the same electrical potential as is the injecting electrode 1. The inner surface 33 is maintained at the same electrical potential as is the blocking electrode 5. The two surfaces are electrically isolated from each other so that each can have a different electrical potential.

Because the surfaces are electrically biased as described above, there is no corona generated between each surface and the electrode close thereto since no field exists therebetween. As long as the core 37 of the member is sufficiently electrically insulating and of a high enough dielectric strength, there is no electrical flow or discharge thereacross. There is no electric arcing between either electrode and the arc suppression member 30 because there is no field between them. Imaging is not affected since the suppression member does not protrude through the imaging zone between the two electrodes.

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FIG. 4 schematically represents a somewhat different embodiment incorporating the main feature of this invention. This embodiment prevents air breakdown at the entrance to the interface between the blocking electrode 5 and the injecting electrode 1.

Generally, as the blocking electrode 5 rolls across the imaging electrode 1 it tends to build up a bead of suspension at the entrance to the interface. This bead of suspension helps to prevent electric arcing between the rollers but causes other problems. Since the portion of suspension in the bead goes to waste rather than forming an image, it causes inefficient use of the imaging suspension. Further, other complications in the formation of the image can occur because of uneven spreading of the suspension or other features of the imaging system and the suspension. By placing a relatively small diameter rod 40 at the entrance to the nip formed between the electrodes, an ink bead does not form in a size as large as would occur without this rod. The rod is preferably the size of the bead of suspension that would otherwise form. The rod prevents air ionization between the two electrodes by filling the gap which would normally be in the path of the air ionization or discharge. The rod itself is preferably an electrical insulator.

The rod may be rotated in the direction shown by the arrow by any driving means, such as a motor M-1. This rotation further tends to eliminate a bead formation of suspension and insures that the gap between the electrodes and behind the rod is filled with suspension for imaging. The rotation feature is utilized to gather the suspension into the imaging area between the two electrodes. By rotating the rod clockwise as viewed in FIG. 4, all of the suspension can be moved into the imaging area. This would eliminate the wasting of otherwise unused suspension. The remainder of the system is the same as that shown in the previous figures.

While this invention has been described with reference to the structures disclosed herein and while certain theories have been expressed to explain the experimentally obtainable results obtained, it is not confined to the details set forth; and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

What is claimed is:

1. Apparatus for imaging electrophoretic particle suspensions including:

a first electrode adapted to support an image formed from the suspension,

a second electrode for interfacing with the first electrode such that suspension is between said electrodes, means for causing relative movement between the first and second electrodes,

means to couple an electric field across the interface between the electrodes during imaging,

means to apply activating electromagnetic radiation across the interface between said electrodes,

a suppression member adjacent at least one of said electrodes during imaging for reducing at least one of the electrical field and gap between the electrodes, said member at least partially contacting the suspension to prevent electrical arcing between the suspension and said adjacent electrode.

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2. The apparatus of claim 1 wherein said second electrode is a blocking electrode.

3. The apparatus of claim 2 wherein said blocking electrode is contoured and said member is adjacent and spaced from said electrode and shaped to the same contour.

4. The apparatus of claim 1 wherein said member is electrically conductive.

5. The apparatus of claim 1 wherein said member adjacent the electrode is electrically insulating.

6. The apparatus of claim 1 wherein said member is electrically biased relative to said electrodes.

7. The apparatus of claim 6 wherein said electrical bias is at a potential between those on the electrodes.

8. The apparatus of claim 1 wherein said member includes a first and a second electrically conductive surface and an insulating core between said conductive surfaces for blocking electrical contact therebetween.

9. The apparatus of claim 8 wherein said first surface is adjacent said first electrode, said second surface is adjacent said second electrode and said first surface is electrically coupled to a source to be biased to the electrical potential of the first electrode and the second surface is electrically coupled to be electrically biased to the potential of the second electrode.

10. The apparatus of claim 1 wherein said member has further associated therewith suspension dispensing means.

11. The apparatus of claim 10 wherein said dispensing means includes conduit means within said member said conduit means positioned to inject suspension onto the adjacent electrode for imaging between the electrodes.

12. The apparatus of claim 10 wherein said dispensing means includes a container adapted to maintain a supply of suspension and having an opening therein, positioned to release suspension for flow between said member and the electrode adjacent thereto.

13. The apparatus of claim 1 wherein said member includes an electrically insulating rod positioned adjacent one of said electrodes to contact the suspension for imaging prior the adjacent electrode.

14. The apparatus of claim 13 said rod having associated therewith means to rotate it relative to at least one of said electrodes.

15. The apparatus of claim 4 including means to couple said member to an electrical source for electrically biasing the member to substantially the same electrical potential as one of the electrodes.

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