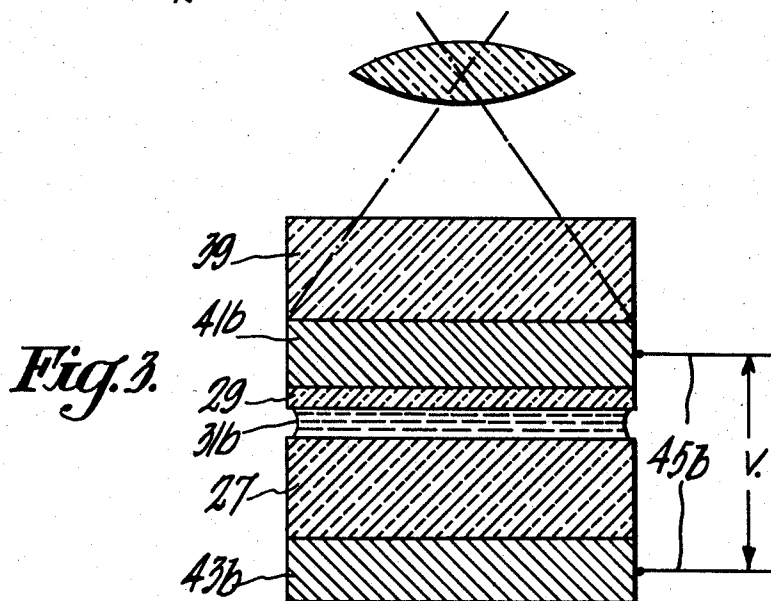
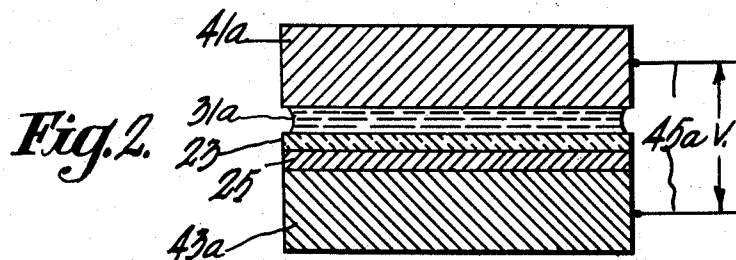
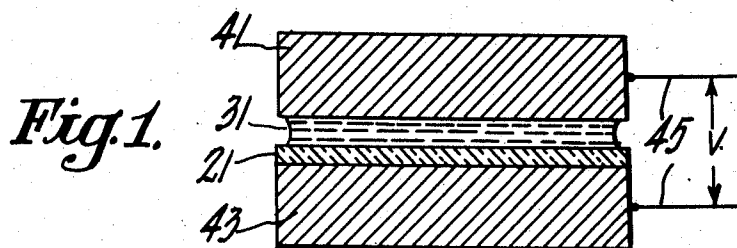


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ELECTROGRAPHOTOGRAPHIC CHARGING MEANS

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ELECTROGRAPHOTGRAPHIC CHARGING
MEANS

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This invention relates to improved methods of and means for producing electric connection to solid bodies of semiconductors and dielectrics, and to improved methods of and means for electrostatic printing.

Ordinarily, it is difficult to provide an electrical connection between an electrode and a body of semiconductive or dielectric material. Poor contact may be caused by barrier layers at the surfaces of the electrode and the body, or by improper physical contact between the body and the electrode, such as by discontinuous physical contact between the surface of the body and the surface of the electrode.

Prior methods for providing electric contact to such bodies include: ionizing the gas in the space between the electrode and the surface of the semiconductive or dielectric body which requires either high voltages or high electric currents and is inefficient; pyroelectric methods which are inconvenient; and triboelectric methods which are difficult to control.

Another method for providing an electric contact is to apply an electrode to the surface of the body of semiconductive or dielectric material and then to apply a known voltage with respect to the body to the electrode. While small amounts of charge are transferred by this method, the transfer is unequal across the electrode surface, even when high voltages are applied.

It has been proposed to sandwich a thin sheet of pliable semiconducting material such as rubber, paper or plastic sheets between the electrode and the body in order to improve the connection. While this method is an improvement over the structure having no such semiconducting sheet, still the required voltages are high and the transfer is uneven.

It has been further proposed to improve the connection between an electrode and a body of semiconducting or dielectric material by interposing therebetween a thin layer of an electrically-conducting liquid. While this method provides improved electric contacts between the electrode and the body, it has the disadvantage that the liquid must be insulated from adjacent conductors. Furthermore, the liquid layer is conductive laterally along its length as well as transversely through its thickness. Where it is desired to pass a pattern of electric charge or current, this method dissipates the pattern laterally.

It is an object of this invention to provide improved electrical connections to bodies of semiconductors and dielectrics.

Another object is to provide improved electrical connections to semiconductive and dielectric bodies which minimize lateral conduction along the surface of the contact.

A further object is to provide improved methods and means for producing a blanket electrostatic charge on the surface of a body of semiconductive or dielectric material.

Another object is to provide improved methods and means of electrostatic printing.

In general, the invention includes a method for providing electrical connection to a body of semiconductive

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or dielectric material which comprises closely spacing the surface of an electrode from the surface of the body to which connection is to be made, with a film forming liquid such as propyl alcohol which is electrically-insulating in bulk. When a voltage with respect to the body is applied to the electrode, the electric field across the liquid unexpectedly causes the liquid to behave as a conductor transversely through the layer while continuing to behave as an insulator in the lateral direction. By semiconductive or dielectric material is meant a material having a resistivity greater than 10^6 ohm-cm.

The invention includes a method of electrically charging the surface of a body of semiconductive or dielectric material which includes the above described step for providing an electrical connection in combination with the subsequent steps of applying a voltage with respect to the body to the electrode, removing said electrode from said body, removing the voltage from said electrode and then removing the liquid remaining on the surface of said body.

The invention includes improved methods and means for electrostatic printing including the improved electrical connections and the improved methods of charging.

The invention will be described in greater detail by reference to the accompanying drawing in which:

Figure 1 is a sectional, elevational view of an improved means for making an electrical connection between a conductor and a dielectric.

Figure 2 is a sectional, elevational view of an improved means for making an electrical connection between a conductor and a semiconductor, and

Figure 3 is a sectional, elevational view of an improved means for making an electrical connection between a semiconductor and a dielectric.

Similar reference characters are applied to similar elements throughout the drawing.

Example 1

Referring to Figure 1, an improved electrical connection means between a conductor and a dielectric comprises a sheet 21 of dielectric material sandwiched between an upper electrode 41 and a lower electrode 43. The dielectric material 21 may be for example a sheet of polystyrene 0.0005 to 0.010 inch thick preferably about 0.003 inch thick. The electrodes 41 and 43 may be of any conducting material, for example, brass.

In order to improve the electrical connection between the upper electrode 41 and the dielectric sheet 21, a thin liquid layer 31 of propyl alcohol is interposed therebetween. The layer may be about 0.00002 to 0.003 inch thick, preferably 0.0001 inch thick.

A uniform electric charge is formed on the upper surface of the dielectric sheet 21 by applying between about 100 and 2000 volts to leads 45 attached to the electrodes 41 and 43. For the preferred thicknesses of elements, about 200 volts is preferred. With thicker elements the higher voltages are preferred.

In order to produce a similar charge on the upper surface of the dielectric sheet 21 without the liquid layer 31, between about 1000 and 30,000 volts are required. For the preferred thicknesses of elements, about 7000 volts are required. Furthermore, the resulting charge on the surface of the dielectric sheet is not as uniform as the charge formed by the method of Example 1. This lack of uniformity may be due to surface irregularities of the surfaces of the dielectric sheet or the electrode or both resulting in discontinuous physical contact therebetween.

If a thin sheet of a pliable, semiconductor, such as paper about 0.002 inch thick is substituted for the liquid layer 31, about 1000 to 7000 volts is required to charge the surface of the dielectric sheet 21. For the preferred thickness about 5000 volts is required.

The charged surface may be uncovered by removing the electrodes 41 and 43 and evaporating the propyl alcohol remaining on the surface of the dielectric sheet 21. The charged surface may then be used for any desired purpose.

Example 2

The electrical connecting means of the invention may be used in an electrostatic printing process to provide an improved method of blanket charging. An electrostatic printing process is that type of process for producing a visible image, reproduction or copy which includes, as an intermediate step, converting a light image or electric signal to an electrostatic charge pattern on an electrically-insulating base. The process may include the conversion of the charge pattern into a visible image which may be a substantial reproduction of an original except that it may be different in size. A detailed description of the steps of such a process may be found in U.S. Patent 2,297,691, issued October 6, 1942, to C. F. Carlson.

In a typical electrostatic printing process, a layer of photoconductive material disposed upon an electrically-conductive backing is provided with a blanket electrostatic charge. A light image is then focused upon the photoconductive layer. The electrical resistance of the illuminated areas of the photoconductive layer is reduced, allowing an electrostatic image corresponding to the light image to form on the photoconductive layer.

The blanket electrostatic charge may be provided triboelectrically, pyroelectrically, by irradiation with electrons or ions or by physical contact with a charged electrode. Each of these processes has disadvantages as described above.

Referring to Figure 2, a layer 23 of a photoconductive material such as selenium supported upon an electrically conducting backing 25, such as paper, is sandwiched between an upper electrode 41a and a lower electrode 43a. The backing 25 rests upon the lower electrode 43a. The electrodes may be of any conductive material such as brass.

In order to improve the electrical connection between the upper electrode 41a and the photoconductive layer 23, a thin liquid layer 31a of gasoline is interposed therebetween. The liquid layer may be about .0001 to .002 inch thick but is preferably .0005 inch thick.

A uniform electric charge is formed on the upper surface of the photoconductive layer 23 by applying between 100 and 500 volts preferably about 300 volts to leads 45a attached to the electrodes 41a and 43a. The structure is then disassembled and the gasoline remaining on the surface of the photoconductive layer 23 is evaporated leaving a dry surface having a uniform electrostatic charge thereon. The surface may then be exposed photographically and developed by conventional means.

Example 3

The electrical connecting means of the invention may be used to provide an improved electrostatic printing process. In another typical electrostatic printing process, an electric field is applied through a layer of photoconductive insulating material; for example, by contacting a first electrode with one side of the photoconductive layer, spacing a second electrode from the other side of said photoconductive layer and applying voltage between said electrodes. When a light image is focused on the photoconductive layer, the electric resistance of the illuminated areas of the photoconductive layer is reduced allowing an electrostatic image to form in the photoconductive layer. The electrostatic image is conducted to a dielectric surface and then developed in the usual way.

Referring to Figure 3, a sheet 27 of dielectric material such as a polystyrene resin is sandwiched between a lower electrode 43b, for example, brass, and an upper transparent electrode 41b having a layer 29 of photoconductive material on the inner surface thereof. The trans-

parent electrode may comprise a sheet of glass 39 having a surface treated with tin chloride at about 400° C. to produce a conductive layer 41b thereon. The photoconductive layer 29 may be cadmium sulphide bonded in 20% by weight of a silicone resin, but is preferably photoconductive selenium about .001 inch thick.

In order to improve the electrical connection between the photoconductive layer 29 and the dielectric sheet 27, a thin liquid film 31b of cyclohexanol is interposed therebetween. The layer may be about .0005 to .003 inch thick but preferably about .002 inch thick.

A negative voltage of about 400 volts is applied to the upper electrode 41b with respect to the lower electrode 43b by leads 45b attached thereto. About 2000 volts is required to obtain the same result if the liquid film of the invention is not used. Simultaneously, a light image is focused upon the photoconductive layer 29, for example with a lens 71. The electrical resistance in the illuminated areas of the photoconductive layer is reduced, allowing an electric charge to pass therethrough and to deposit in the dielectric sheet 27 thereby forming an electrostatic image thereon corresponding to the light image focused on the photoconductive layer.

The voltage and the light image are removed and the apparatus disassembled. The liquid remaining on the dielectric sheet 27 is evaporated and the electrostatic image thereon is developed by conventional methods. The use of liquid film 31b not only improves the electrical connection between the photoconductive layer 29 and the dielectric sheet 27, but also the electric charge pattern is transferred with a minimum dissipation of the pattern laterally along the contact surface.

Poor electrical connection is ordinarily encountered where the contact is between conductor and semiconductor, conductor and dielectric, semiconductor and semiconductor and dielectric. In each of the above described examples electrical connection is improved by interposing a thin film of a liquid which is ordinarily electrically-insulating in bulk. When such a material is reduced to a thin film or layer, it behaves as if it is a conductor or a semiconductor. Thus, the film will conduct electric charges through the film but remains electrically-insulating laterally along the length of the contact. The practice of the invention affords the equivalent of optimum physical contact between the bodies and a minimum in electric barriers to the flow of electricity.

The liquid used to produce the improved electrical connection of the invention is preferably a film-forming material so as to provide a continuous layer over the surface. The liquid has preferably, a bulky resistivity greater than 10^9 ohm-cm. so as to minimize the lateral flow of electric charge along the length of the contact. The liquid has, preferably, a dielectric constant greater than 5 so as to obtain a minimum drop in voltage across the liquid layer. The liquid should be of a material that is substantially non-ionizing in order to avoid hydrolysis. The liquid should be chemically stable for the duration of its use and should not attack the electrode or the contacted body.

Examples of other suitable liquids are propyl alcohol, gasoline, cyclohexanol, cyclohexane, amylacetate propylene glycol, acetone, polystyrene dissolved in acetone, polyvinyl chloride in diethylene chloride, water soluble cellulose, distilled water and kerosene.

The electrode is preferably a good conductor of electricity but may be a body having a resistivity as high as 10^{10} ohm-cm. The body to which connection is made may be a dielectric or semi-conductor and preferably has a resistivity greater than 10^6 ohm-cm.

There have been described improved electrical connection means to semiconductors and dielectrics. These connection means may be used to provide a uniform electrostatic charge on the surface of a body of semiconduc-

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tive or dielectric material, and to provide improved methods and means of electrostatic printing.

What is claimed is:

1. A method of electrostatic printing comprising the steps of coating the surface of a photoconductive insulating material on a conductive backing member with a thin film of a liquid having a bulk resistivity of at least 10^9 ohm-centimeters, closely spacing an electrode which is conductive in bulk from said photoconductive insulating material and in area contact with the surface of said film of liquid, establishing an electric potential between said electrode and said backing member of a magnitude sufficient to produce an electrostatic charge at the surface of said photoconductive insulating material, removing said electrode from said closely spaced relationship, removing the liquid remaining on the surface of said photoconductive insulating material, photographically exposing the surface of said photoconductive insulating material thereby producing an electrostatic latent image on the surface of said photoconductive insulating material and then developing said electrostatic latent image with an electrostatically attractable substance.

2. A method of electrostatic printing comprising the steps of coating the surface of a photoconductive insulating material on a conductive backing member with a thin film of a liquid having a bulk resistivity of at least 10^9 ohm-centimeters, closely spacing an electrode which is conductive in bulk from said photoconductive insulating material and in area contact with the surface of said film of liquid, establishing an electric potential between said electrode and said backing member of a magnitude sufficient to produce an electrostatic charge at the surface of

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said photoconductive insulating material, photographically exposing the surface of said photoconductive insulating material thereby producing an electrostatic latent image on the surface of said photoconductive insulating material, then removing said electrode from said closely spaced relationship and removing the liquid remaining on the surface of said photoconductive insulating material and then developing said electrostatic latent image with an electrostatically attractable substance.

References Cited in the file of this patent

UNITED STATES PATENTS

779,190	Thomson	Jan. 3, 1905
1,977,263	Meissner	Apr. 9, 1935
2,181,946	Lindenblad	Dec. 5, 1939
2,277,013	Carlson	Mar. 17, 1942
2,297,691	Carlson	Oct. 6, 1942
2,438,959	Bartelheim et al.	Apr. 6, 1948
2,464,405	Knauf	Mar. 15, 1949
2,538,554	Cherry	Jan. 16, 1951
2,618,551	Walkup	Nov. 18, 1952
2,689,830	Sadowski et al.	Sept. 21, 1954
2,692,948	Lion	Oct. 26, 1954
2,740,184	Thomas	Apr. 3, 1956
2,758,939	Sugarman	Aug. 14, 1956
2,774,921	Walkup	Dec. 18, 1956
2,825,814	Walkup	Mar. 4, 1958

OTHER REFERENCES

Wainer: Photographic Engineering, vol. 3, No. 1, pages 12-22 (1952). (Copy in Scientific Library.)