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CONTROL ARRANGEMENT FOR ELECTROSTATIC SPRAY INSTALLATION

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3 Sheets-Sheet 1

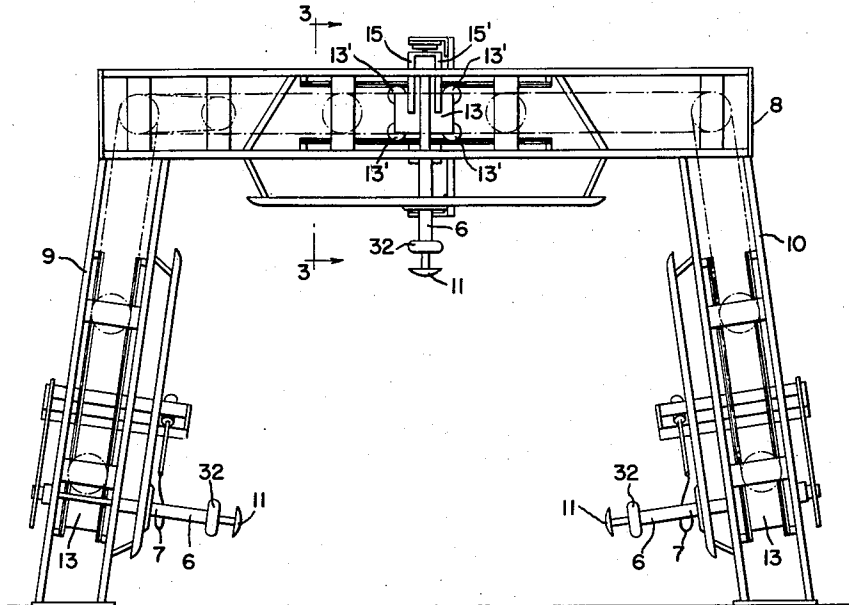


Fig. 1.

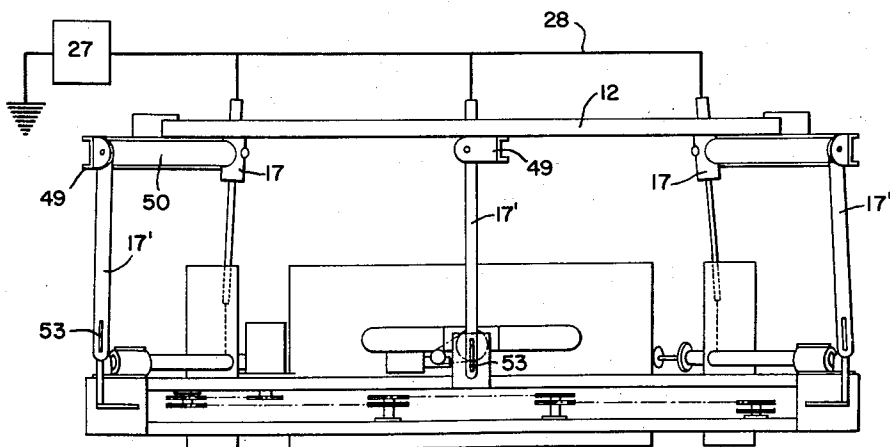


Fig. 2.

INVENTORS
OTTO GENGEBACH
HORST SCHENE

BY

Dicke and Gay

ATTORNEYS

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2,966,880

CONTROL ARRANGEMENT FOR ELECTROSTATIC SPRAY INSTALLATION

Otto Gengenbach and Horst Schene, Sindelfingen Kreis, Boeblingen, Germany, assignors to Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany

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16 Claims. (Cl. 118—8)

The present invention relates to an arrangement for maintaining constant the distance of the spray electrode from the surface or deposition area to be sprayed during the electrostatic coating of large objects provided with uneven surfaces, especially motor vehicles to be coated with a layer of paint, lacquer, enamel, or the like.

In the known installations of the prior art for the electrostatic paint-spraying, the objects to be provided with a cover or coating of paint are moved essentially rectilinearly past one or several stationary spray electrodes. With such installations, it is not possible to provide vehicle bodies of motor vehicles having relatively large surfaces of uneven shape with an even coating or cover of paint over the entire surface thereof.

This is due to the fact that the electrostatic spray process for optimum operating conditions requires the maintenance of a predetermined distance of the spray-electrode from the surface to be covered or coated which distance, for example, may appropriately amount to approximately 30 cm. with a given installation. During the coating of vehicle bodies which move essentially rectilinearly past the spray-electrodes, the distance of the spray-electrodes from the engine hood or rear part of the vehicle, which are usually lower than the roof, may be approximately 70 cm. if the distance from the roof of the vehicle, which forms ordinarily the highest part of the vehicle body, is necessarily maintained at a distance near the above indicated value of approximately 30 cm.

As a result of this variation in the distance of the spray-electrodes from the surface to be covered or coated, losses of spray-material will necessarily occur, an uneven distribution of the spray-material over the surface to be coated will take place and therewith a defective or inadequate quality of the final coating.

A uniform application of this spray-material, especially also with large objects having non-uniformly shaped surfaces is assured by the present invention.

Accordingly, it is an object of the present invention to provide an arrangement for electrostatically spraying large non-uniformly shaped surfaces without incurring the disadvantages of the prior art devices.

It is another object of the present invention to provide an installation for producing an improved uniformly distributed coating of large uneven surfaces by electrostatically spraying the same with a coating material of any suitable type, such as paint, lacquer, enamel, or the like.

Still another object of the present invention is the provision of such an electrostatic spray installation which automatically maintains a predetermined distance between the spray-electrodes and the surface of the object to be coated by the spray-process.

A further object of the present invention resides in the provision of a simple control arrangement which is relatively inexpensive yet reliable, and which is responsive automatically to changes in the distances between the spray-electrodes and the surface of the objects to be

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coated to maintain a predetermined distance therebetween, such control arrangement being responsive in particular to changes in the electric field current of the electrostatic field due to changes in the electric field distribution.

A still further object of the present invention is the provision of an electrostatic spray-installation which reduces the losses of the spray-material and therewith lessens the cost connected with spraying large surfaces, such as vehicle bodies, particularly of motor vehicles, while at the same time improving the quality of the coating, especially as regards uniformity.

According to the present invention it is contemplated that relative movement be achieved between a body to be electrostatically coated and at least one spray-electrode, this relative movement being generally parallel to the surface of the body, and further, it is intended that at least one of these spray electrodes be automatically movable toward and/or away from the body to at all times maintain a desired spraying distance with respect thereto. In the case of spraying bodies, particularly motor vehicles, which have generally flat sides, but very abrupt changes in configuration along the top surface, due, for example, to the different levels of the hood, roof and luggage compartment lid, it is possible to energize a plurality of spray-electrodes from a single high voltage generator where only the overhead spray-electrode needs to be adjusted due to irregularities in the body contour. However, in the case of unrelated body contour changes at more than one spray-electrode, the respective spray-electrodes may be automatically adjusted individually.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, one preferred embodiment in accordance with the present invention and wherein:

Figure 1 is a front view of an electrostatic paint spray installation with a movable spray-electrode in accordance with the present invention;

Figure 2 is a top plan view of the installation of Figure 1;

Figure 3 is a cross-sectional view taken along line 3—3 of Figure 1 on an enlarged scale;

Figure 4 is a view, partially in cross section and also on an enlarged scale, showing the details of the sprayer or diffuser head of the installation which carries the spray electrode; and

Figure 5 is a schematic diagram of the electric control arrangement for the electrostatic spray-installation in accordance with the present invention.

The present invention consists in that changes in the field current of the electrostatic field between the spray-electrode and the object to be coated are used to provide control impulses for controlling an adjusting motor during the movement of the objects provided with non-uniformly shaped surfaces, such as a motor vehicle body, past the spray installation. The control impulses, upon amplification, are then used to control the drive for the movement of the spray-electrode necessary for maintaining constant the distance between the spray-electrode and the respective surface to be coated thereby. For that purpose, the current changes are electronically amplified and are thereupon conducted to a reversing switch which determines the prevailing direction of rotation of the adjusting motor. The adjusting motor causes the movement of an insulating arm carrying the spray or diffuser head provided with the spray-electrode.

Referring now more particularly to the drawing, wherein like reference numerals are used to designate like parts throughout the various views, and more particularly

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to Figures 1 and 2 in which a gantry-type spraying frame is illustrated, reference numeral 6 designates insulating arms which are arranged at the cross bearer 8 and at the two upright standards or supports 9 and 10. The insulating arms 6 carry the spray- or diffuser-heads provided with the spray electrode 11 and are movably guided at the cross bearer 8 or at the supports 9 and 10 in the longitudinal directions of the respective frame parts. The conduction or supply of current to the electrodes 11 takes place from a frame 12 (Figure 2), which is connected with the spraying frame and arranged parallel thereto, over metallic arms 17 and flexible lines 7 and 7' extending in part through the insulating arms 6 in the longitudinal direction thereof.

In order to prevent undesired discharges at the corners and edges, especially at the free ends of the insulating arms 6, the insulating arms 6 are provided thereat with protective hoods or covers 32.

Each of the insulating arms 6 is arranged at a respective movable carriage 13 (Figures 1 and 3) which are each provided with a plurality of rolls or runners 13'. Each carriage may be moved to and fro along a respective one of the bearer members 8, 9 and 10 by the engagement of rolls 13' with appropriate V-shaped or prismatic guides 113 (Figure 3). The to-and-fro movement of the carriages 13 in the longitudinal direction of the bearer members 8, 9 and 10 during the spraying process takes place by separate appropriate mechanisms of any suitable well-known type which form no part of the present invention and are, therefore, not described in detail herein.

In the apparatus of Figure 1 when it is used for coating a vehicle body, for example, each of the spray-electrodes 11 may be reciprocated to and fro generally parallel to the respective supports or bearers 8, 9 and 10, but the overhead spray electrode 11 movable at the cross bearer 8 may also be provided with automatic axial adjustment to adjust for the different contours of the body portions 46, 46' and 46'' of the vehicle illustrated in Figure 5. Two upright supporting arms 15 and 15' (Figures 1 and 3) are secured at the outer base plate 14 (Figure 3) of the carriage 13 movable at the cross bearer 8. The arms 15 and 15' support an essentially horizontal inwardly extending supporting plate 16. A further supporting plate 19 which is also secured at one end thereof to horizontal supporting plate 16 and which is parallel to the inner base plate 14' of the carriage 13 extends downwardly from the supporting plate 16. The supporting plate 19 is supported in any suitable manner on the inner base plate 14' and carries at the lower end thereof an essentially horizontal inwardly extending base plate 20. An essentially vertically disposed threaded spindle 18, rotatably supported in the horizontal supporting plates 16 and 20, may be selectively driven in the one or the other direction of rotation from a pole reversing electric motor 21 suspended from the supporting plate 19 over a belt drive 22 and over a reduction and angle gear drive (not illustrated herein). A nut member 23 resting on the spindle 18 carries the insulating arm 6 with the spray-electrode 11 and moves the same upwardly or downwardly depending upon the direction of rotation of the spindle 18, i.e., moves the same from the position 11 thereof indicated in full lines to the position 11' thereof indicated in dot-and-dash lines.

A further electric motor 24 is supported on the nut member 23 which sets into rapid rotation the shaft 51 (Figure 4), which is suitably journaled within the insulated arm 6, over an angular gear drive 133 and a belt drive 133' and therewith also sets into rapid rotation the spray-electrode 11 which is dish-shaped and mounted on the shaft 51, in order to distribute evenly over the inner surface of the electrode 11 the spray material introduced into the electrode at 48 through an appropriate nozzle or the like. Each of the spray-electrodes 11 supported at the vertically extending bearers 9 and 10 is

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also provided with an electric motor 24 for providing rapid rotation in a manner similar to that illustrated for the overhead electrode.

A cylindrical part 50 (Figures 2 and 3) rotatably supported at a supporting bow-shaped member 49 carries at the lower end thereof the arm 17 which supports the current inlet line and at the upper end thereof a guide arm 17'. A pin 52 secured to the supporting plate 16 of the carriage 13 extends through a slot 53 (Figure 2) of the guide arm 17' so that the guide arm 17' and the arm 17 rigidly connected therewith by the part 50 carries out a to-and-fro movement in the same direction during the to-and-fro movement of the carriage 13 in order that the current supply line 7 may follow the cross movement of the insulating arm 6 carried by the carriage 13. The supply lines 25 and 26 for the spray material and for the air pressure determining the amount of spray material respectively, are formed flexibly, at least in part or sections thereof.

The control arrangement for the supply of current to the pole reversing motor 21 is illustrated in the schematic diagram of Figure 5.

The discharge current supplied from a high-voltage source with constant-current supply or from an electrostatic generator 27 is conducted over current lines 28 and 7 to the respective insulating arms 6 and over a metallic plate 29 arranged thereat, the securing bolts of which (Figure 4) conductively connect the same with a counter plate 31 on the inside of the insulating arm 6. An insulated line 7' leads from the counter plate 31 to the bearing 33 arranged at the head of the insulating arm 6 for the rotary movement of the spray-electrode 11 and which conducts the current to the spray-electrode 11. As a result thereof, the spray-electrode 11 and the spray material supplied thereto through orifice 48 are charged to a relatively high voltage with respect to ground.

The high-voltage constant current electrical source 27 may be of a type known in the present state of the art and referred to, for example, in an article of Mr. W. Herchenbach entitled, "High-Voltage Production by Transportation of Induced Charges on Rotating Insulating Surfaces," in the Zeitschrift fuer Angerwandte Physik, 1955, volume 7, issue 1, pages 32 to 43, published by Springer Verlag, Berlin-Goettingen-Heidelberg.

If a grounded metallic body, in the present case a motor vehicle body 46, 46' and 46'' connected with ground through the conveyor mechanism at 54, moves along below the electrode 11, then the spray-material, under the effect of the strong electric field which exists between the electrode 11 and the grounded vehicle body, is sprayed off the electrode 11, moved to and fro by the carriage 13, along the field lines 55 in the direction toward the surface of the vehicle body in order to provide the same with a thin paint cover. In view of the fact that the roof 46'' of the vehicle body projects a considerable distance with respect to the engine hood 46' and the rear luggage compartment lid 46, considerable variations of the field current would take place during movement of the vehicle body below and past the electrode 11 and therewith a strong, noticeable non-uniformity of the sprayed-on paint cover at the different places of the vehicle body 46 would result. In order to avoid this, the insulating arm 6 together with the spray-electrode 11 is arranged movably also in the axial or longitudinal direction thereof in a manner described hereinabove so that the electrode 11 during passage of the vehicle body 46, 46', 46'' maintains continuously the same distance from the individual parts of the surface of the vehicle body corresponding to the dot-and-dash line 56 of Figure 5.

To obtain an automatic follow-up of an axially adjustable spray electrode 11, the following control arrangement is provided in accordance with the present invention:

A circuit consisting of a plurality of series-connected

resistances 34 and 34' which are effective as voltage divider is connected in parallel with the electric circuit through which the current for the electric field 55 is conducted to the spray-electrode 11. During changes in the distance of the vehicle body surface from the spray-electrode, the characteristic of the field current is also changed due to the accompanying changes in the field intensity connected therewith. Since the sum total of current supplied by the high-voltage constant-current source 27 remains constant, the current through the parallel resistance branch circuit 34, 34' changes to the same extent as the field current and therewith the voltage appearing between resistances 34 and 34' also changes correspondingly which voltage is applied to the control grid 35' of the amplifier tube 35. Thus there is a change in the electrical condition in the control circuit as a result of the change in distance between the spray electrode and the vehicle body surface. Accordingly, the voltage on the control grid 35' changes from a fixed predetermined electrical condition or electrostatic field characteristic corresponding to a desired constant distance between the spray electrode and the body surface, this change acting as pointed out hereinafter to effect restoration of the spray electrode to a desired distance from the body surface. The resistances 34 and 34' are connected with ground over an indicating instrument 36, such as an ammeter to indicate changes in a current. The anode or plate circuit of the vacuum tube 35 includes the anode or plate 35'', the two resistances 37' and 137' connected in series and the plate voltage supply 37 the negative terminal of which is connected to ground. The cathode 35''' of the amplifier tube 35 is also connected to ground.

A circuit connected in parallel with the amplifier plate circuit 35'', 37' and 137' and consisting of series connected resistances 37'' and 137'' is connected across the battery 37. The two circuits 35, 37', 137' and 37'', 137'', respectively, form a bridge with four legs formed by amplifier 35 and resistance 37', resistance 137', variable resistance 37'', and resistance 137''. Since such types of bridge circuits in which any unbalance causes a voltage to appear between the points 138 and 138' are known a detailed description of the operation thereof is dispensed with herein.

A high-resistance current-indicating measuring device 38 such as, for example, an electromagnetic relay means comprising a moving-coil galvanometer with a zero position in the center of its scale and the usual movable indicator shaft of which is connected with a movable contact arm 47 to control the latter, is responsive to any current which may exist due to unbalances in the bridge between the points 138 and 138' intermediate resistances 37' and 137', on the one hand, and resistances 37'' and 137'', on the other. The resistances 37' and 137' and 37'' and 137'' are so matched to one another that with a predetermined distance of the spray electrode 11 from the vehicle body 46 and therewith under predetermined current conditions the bridge cross-current flowing through the bridge current indicating device 38 is equal to zero. With a change in the distance of the spray-electrode 11 from the vehicle body a bridge cross-current will flow from point 138 to point 138' or vice versa, depending on the sign of the deviation, i.e., increase or decrease of this distance, whereby the movable contact 47 is moved by movement of the indicator shaft of the moving-coil galvanometer 38 into current-conducting contact with one of the stationary contact members 40 or 41. As a result thereof, the reversible adjustment motor 21 is energized, to rotate in one or the other direction of rotation, over the electromagnetical relays 44 or 45 connected to a suitable power source (not shown) at terminals D, as seen in Figure 5, whereby the electric motor 21 moves the spray-electrode 11 in the axial direction thereof for such a length of time until the desired relative distance to the vehicle body is re-established and therewith the transverse bridge current again has become zero. The predeter-

mined distance to be maintained may be adjusted by varying the variable resistance 37''.

Since the lateral surfaces of the vehicle body shown in the drawing lie essentially at all times in one and the same plane so that the distance thereof from the frame supports 9 and 10 and therewith from the lateral spray electrodes 11 arranged thereat are not changed to any extent during passage of the vehicle body past these electrodes, it is not necessary in the illustrated embodiment to form the lateral insulating arms 6 also axially movable. However, it is within the purview of the present invention, when coating objects with the strongly projecting lateral surfaces on the side walls thereof, to form these lateral electrodes 11 also axially movable and to control the movements thereof individually in the same manner as described hereinabove with the overhead electrode 11 which follows the contour of the objects of non-uniform shape which are to be coated.

While we have shown and described one preferred embodiment in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of many changes and modifications within the spirit of the present invention, and we intend to cover all such changes and modifications except as defined in the appended claims.

We claim:

1. In an electrostatic spray installation an arrangement for maintaining constant the distance of the spray-electrode with respect to the surface of an object to be covered during the electrostatic spraying of objects provided with relatively large non-uniformly shaped surfaces comprising spray-electrode means, and control means responsive to changes in an electric field between the object and said spray electrode, said changes being changes from a predetermined fixed field characteristic caused by changes in distance between the object and said spray electrode, said control means being operatively connected with said spray-electrode means for maintaining constant said distance.

2. In an electrostatic spray apparatus the combination according to claim 1, wherein said control means includes amplifier means for controlling the position of the spray electrode and responsive to changes in the electrostatic field between said spray-electrode means and the object, means operated by the output of said amplifier means to adjust the position of said spray-electrode means with respect to said object.

3. In an electrostatic spray installation an arrangement for maintaining constant the distance of the spray electrode with respect to the surface of an object to be coated during the electrostatic spraying of objects having relatively large non-uniformly shaped surfaces, comprising an electrical control system including a high-voltage electrical source producing a constant current supply for coating of objects, spray electrode means energized from said source, and electrical control means responsive to changes in the spraying distance between said electrode means and a surface of the object being coated by electrical changes induced in said control means, said changes being changes from a predetermined electrical condition at said control means corresponding to a desired constant distance between the spray electrode and a surface of the object to be coated, said control means being operatively connected with said spray electrode means and responsive to the electrical changes induced therein for maintaining constant the distance between the electrode means and said surface.

4. The combination according to claim 3, including means connecting said high-voltage source to produce an electrostatic field between said spray electrode means and the object being coated, said control means being operatively connected to said electrode means for sensing changes in, and adjusting, said distance to maintain it substantially constant during movement of said objects past the spray electrode means.

5. An apparatus according to claim 4, wherein said

control means is responsive to changes in said electrostatic field.

6. An apparatus according to claim 4, wherein said control means is responsive to changes in the field current of said electrostatic field.

7. An apparatus according to claim 4, wherein said control means is responsive to changes in said electrostatic field and includes amplifier means for controlling the position of the spray electrode and having an input means, and voltage divider means connected across the output of said means which applies a high voltage to said electrode means, and a circuit for connecting said input means to said voltage divider means.

8. An apparatus according to claim 7, wherein said amplifier means includes an output circuit, and further comprising an adjusting motor for said spray-electrode means, and means for selectively energizing said adjusting motor by said output circuit.

9. An apparatus according to claim 8, wherein said output circuit includes a bridge circuit, and means including switch means for energizing said adjusting motor upon the occurrence of voltages due to unbalance in said bridge circuit.

10. Apparatus according to claim 9, wherein said bridge circuit includes a plurality of electrical resistances in which current is dependent on a condition of said electrostatic field.

11. An apparatus according to claim 4, wherein said control means includes amplifier means for controlling the position of the spray electrode and operated in response to changes of said electrostatic field, said amplifier means including an output circuit, rotatable drive means for adjusting the position of said spray-electrode means, and means connected with said output circuit including electromagnetic relay means for actuating said driving means for operation in one or the other direction of rotation.

12. An apparatus according to claim 11, wherein said output circuit includes a moving-coil galvanometer and means connecting the coil of said galvanometer with a movable arm of said relay means to adjust the latter in response to unbalances in said bridge circuit.

13. An apparatus according to claim 11, further comprising an insulating arm for supporting thereon said spray-electrode means, nut means connected with said insulating arm, and a threaded spindle rotatable by said drive means and cooperating with said nut means to adjust said spray-electrode means in the longitudinal direction of said insulating arm upon rotation of said spindle.

14. An apparatus according to claim 4, wherein said control means is responsive to changes in said electrostatic field and includes drive means selectively operated by said last-mentioned changes, insulating arm means with nut means for supporting thereon said spray-electrode means, and a spindle operatively connected with said nut means and driven by said drive means for adjusting said spray-electrode upon rotation of said spindle by said drive means.

15. In an electrostatic spray installation an arrangement for maintaining constant the distance of the spray-electrode with respect to the surface of an object to be covered during the electrostatic spraying of objects provided with relatively large non-uniformly shaped surfaces, comprising spray-electrode means, means for applying a high voltage between said spray electrode means and said object to create an electrical field current therebetween during spraying, and electrical control means responsive to changes of the field current between said spray-electrode and said objects caused by changes in said distance by irregularities of the surface of said object and operatively connected with said spray-electrode means for maintaining constant said distance at a predetermined value.

16. In an electrostatic spray installation, an arrangement for maintaining constant the distance of the spray electrode with respect to the surface of an object to be coated during the electrostatic spraying of objects provided with relatively large non-uniformly shaped surfaces comprising spray electrode means, electrical sensing means for sensing changes in said distance by electrical changes induced therein, said changes being changes from a predetermined electrical condition corresponding to a desired constant distance between the spray electrode and the object to be coated and control means responsive to the electrical changes induced in the electrical sensing means and operatively connected with said spray electrode means for maintaining constant the distance between the spray electrode means and the object.

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