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(54) Electrostatic spray head.

(57) An electrostatic spray head for use in agricultural spraying comprises a main body (1) made of electrically non-conductive material, a spray tube (2) of electrically non-conducting material passing through the main body and terminating in a metallic spray nozzle (3) fitted with a centrally apertured cap (4) of electrically non-conducting material, an induction electrode assembly (12) mounted in the main body and including a centrally apertured metal foam electrode (11) positioned in the path of the spray issuing from the nozzle and an annular counter electrode (5) snap-fitted into the forward end of the main body and surrounding the nozzle and induction electrode assembly.

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ELECTROSTATIC SPRAY HEAD

This invention relates to an electrostatic spray head for induction charging of conductive liquids.

The use of electrostatic attraction forces to apply solid and liquid surface coatings in industry has been well-known for over forty years. When early attempts at applying these techniques to agricultural pest control were made, the operational requirements encountered were considerably different to those found in industry, resulting in a lack of long-term success and insufficient understanding of the fundamental charge-transfer methods. This shortage of knowledge was rectified during the 1960's as a result of the research carried out at North Carolina State University into the active phenomena occurring during charged particulate applications onto living plant targets.

Within the last ten years, further engineering research and development to perfect a reliable electrostatic spraying process and prototype machine, specifically suited to the rigorous applications of agricultural crop feeding and pest control, have taken place with the aid of both economic and environmental incentives.

The use of electrostatic forces to augment the action of both gravitational and inertial forces in the control of finely divided matter has long been recognised. The scientific basis for this behaviour was pointed out by Felici (1965), who mathematically established that, in a given electrical field, the ratio of charge imparted to a particle per unit mass varies inversely with particle diameter. Felici also established that a particle's motion is dependent upon the ratio of electrostatic to gravitational forces which is also an inverse relationship. The use of electrostatics to improve spray delivery and deposition overcomes the problems previously encountered with droplet sizes of less than 100 μm

To be able to employ electrostatic forces in spraying applications, two physical conditions have to be met. These conditions are, firstly that each droplet must be given a significant net electrical charge and secondly that the charged droplets must be acted upon by an electric field. The electrical charge required by a droplet, having a diameter of 50 μm is typically between 0.5 and 1.5 x 10^6. The electrostatic field may be self-generated or may be imposed by other adjacent charged bodies such as metallic electrodes or other charged droplets.

In the development of a reliable droplet charging system for crop spraying applications, three field proven methods of imparting the necessary charge to pesticide spray droplets have emerged. These are:

1. Ionized-field droplet charging of both conductive and non-conductive liquids;

2. Direct electrostatic atomisation and charging of non-conductive liquids; and

3. Electrostatic-induction droplet charging of conductive liquids. These three charging methods each have their own advantages and disadvantages but are all complementary approaches.

Electrostatic induction, however, has proven to be a very satisfactory method of charging spray droplets for agriculture and it is the object of the invention to provide an electrostatic spray head for carrying out this method.

In the electrostatic induction method, direct charge-transfer to the droplet-formation zone of a liquid jet results from electrostatic induction of electrons onto the continuous jet in order to maintain it at ground potential in the presence of a closely positioned induction electrode of positive polarity. Surface densities of free electrons of the order of 10^8/mm^2 are typical. Droplets formed from the surface of this negatively charged jet will each depart with net negative charge provided the droplet-formation zone remains subject to the inducing electrostatic field acting between the non-ionizing electrode and the jet. Gauss' law indicates that maximum droplet charging should occur for the droplet-production zone located in the region which provides maximum field strength at the terminal surface of the jet. With regard to polarity, this process is completely reversible.

The level of droplet charge imparted by electrostatic-induction depends upon the time taken to transfer a charge to the droplet-formation zone in relation to the time required for droplet formation. The charge-transfer capability by conduction from a gounded metal nozzle through the issuing liquid jet depends upon the electrical properties of the liquid forming the continuous jet. For pesticides this spray-liquid characteristic may be specified by the charge-transfer time constant and it should be less than the droplet formation time in order to be satisfactorily charged by this induction process. Spray liquids less resistive than 10^6 ohm/m should be charged satisfactorily by the electrostatic-induction method.

For water-based sprays the charge-transfer limit would be encountered at resistivities greater than 10^5 ohm/m. Whereas for oil-based sprays it would only be encountered at resistivities greater than 10^6 ohm/m.

According to a principal feature of the invention, an electro-static spray head for propelling a spray of induction-charged droplets, comprises a main body of electrically non-conducting material formed at its rear end for detachable connection to a liquid supply pipe, a spray tube of electrically non-conducting material passing through and detachably secured in the main body with its rear end projecting from the rear end of the body for liquid-tight connection with the liquid supply and its forward end carrying a combined filter and nozzle of metallic material which projects beyond the forward end of the body, an induction electrode assembly detachably secured to the forward end of the body and having an electrically non-conducting housing concentrically surrounding and extending forwardly of the nozzle and carrying, at its forward end, a metal foam electrode spaced from the forward end of the nozzle and in the path of the spray issuing therefrom and an annular counter electrode mounted in the forward part of the body and surrounding the rear part of the nozzle and the induction electrode assembly, said counter electrode being maintained at opposite polarity to the induction electrode to minimise spray drift and repel any spray particles likely to foul the spray head.

An embodiment of the invention will be described with reference to the accompanying drawings in which:

Figure 1 is a perspective view of an electrostatic spray head in accordance with the invention;

Figure 2 is a longitudinal section through the spray head of Fig. 1;

Figure 3 is an exploded sectional view through the spray tube assembly;

Figure 4 is a perspective view of the casing of the inductive electrode assembly;

Figures 5, 6 and 7 are perspective, plan and side views respectively of the induction electrode; and

Figure 8 is a section on the line VIII - VIII of Fig. 6.

The electrostatic spray head shown consists mainly of three parts namely, a main body 1, a spray tube 2 and an induction electrode assembly 12 (Fig. 2).

The main body 1 is made from non-conductive material and shaped in the form of a bell with a vertical cylindrical section 15 incorporating a recess 22 to hold a sealing ring (not shown). This section is designed to fit directly into a standard connector (not shown) for non-conductive piping. There is an additional recess 23 (Fig. 1) at the top of the main body 1 to locate lugs 24 on the spray tube 2. The main body 1 also houses a counter electrode 5 (Fig. 2) which is a metallic disc designed so as to snap in and out of the main body relatively easily. The electrostatic potential to the counter electrode 5 is applied through a metal insert 6 of L-shaped section to provide the rigidity to withstand the bending forces acting on it. The end 25 of the insert 6 makes contact directly with the electrode 5 using residual compliance to maintain the contact. The other end of the insert 6 is designed to accept a standard spade connector (not shown) for easy release and reconnection.

The spray tube 2 is a rigid tube of non-conductive material having a cross member or lugs 24 at its head. This cross member 24 locates in the recess 23 at the top of the main body 1, the two parts being held in position by the standard pipe connector. The other end of the tube 2 is provided with a metallic nozzle 3 incorporating a filter which fits into the end of the tube. Two diametrically opposite flats are provided on the outside of the nozzle body for easy separation of nozzle and filter from the tube. A nozzle-cap 4 made of non-conductive material is provided in order to prevent the metallic surface of the nozzle from being exposed to the inducing electrostatic field.

The induction electrode assembly 12 consists of a hollow cylindrical casing 16 of non-conductive material having an outer diameter equal to the width of the central section 17 of the lower end of the main body 1. One end of the casing has embedded therein a metallic ring 9 with internal threads which mate with threads on another metallic ring 8 embedded in the main body 1.

The other end of the cylindrical casing 16 is cut away at 18 to leave four symmetrical lobes 13 which engage the convex rear surface of an induction electrode 11 made of metallic foam of a few mm thickness. The sides of the electrode 11 are concave and define between them four lobes or corners 19 which project laterally beyond the walls of the casing 16 when the electrode is secured to the end of the casing with the assistance of four metallic inserts 10. One end of each of the inserts 10 enters apertures 20 (Fig. 4) in the metal ring 9 whereas the other end is soldered in apertures 21 in the induction electrode 11. The electrostatic potential is applied to the induction electrode 11 via a metal insert 7, the rings 8 and 9 and the inserts 10. The ring 8 and the metal insert 7 are both embedded in the main body 1.

In operation, the spray liquid, which is maintained at ground or earth potential, is supplied from a pressurised source to the spray head via the spray tube 2. A liquid film a few mm in diameter and length, is formed at the nozzle orifice 26 which in turn, will break up into droplets as the spray is generated. The induction electrode 11 is arranged concentrially of the liquid film issuing from the nozzle and separated by a few mm therefrom such that the droplet formation zone is well within the width of the induction electrode, to ensure maximum transfer of charge. Positive potential (2 - 6) kv is applied to the induction electrode 11 while maintaining the liquid film at earth potential so that a negative charge will be imparted to the spray droplets by induction. Some of the smaller droplets due to high specific charge will be attracted towards the induction electrode 11.

This is an inherent disadvantage of an induction charging system. However, the purpose of using a metal foam electrode is to absorb the liquid impacting on it by capillary action. Due to the matrix structure of the metal foam electrode a dynamic equilibrium will eventually be reached and small quantities of the liquid will appear at the lobes. These liquid films at the lobes will be acted on by the high intensity electrostatic field resulting in the formation of Taylor cones which will disrupt into positively charged droplets. The induction electrode area is optimised for minimum collection of fine spray. Furthermore, the presence of the induction electrode voltage (opposite polarity) will enhance the electrostatic field at the apex of the Taylor cone and will aid the disruption process.

The volume of the secondary droplets sprayed from the lobes is small compared to the main spray. With this system it is also possible to supply auxiliary gas via pasages 14 in the main body 1 which gas would diffuse through the induction electrode 11 to repel the fine spray tending to coat it. The applied potential and the geometrical positioning of the induction electrode 11 are not unique but any changes that may be incorporated must avoid the onset of corona in the system.

The counter electrode 5 is maintained at a negative potential (-2 to -6)kv such that the local electrostatic field set up prevents the spray from fouling the spray head and minimises spray drift. The polarities of both electrodes can be reversed if desired.

Claims

1. An electrostatic spray head for propelling a spray of induction-charged droplets, comprising a main body of electrically non-conducting material for connection to a liquid supply, a spray tube passing through the main body for connection to the liquid supply and carrying at its forward end a nozzle of conductive material which projects beyond the forward end of the body, an induction electrode assembly secured to the forward end of the body in an electrically non-conducting housing concentrically surrounding and extending forwardly of the nozzle and carrying, at its forward end, a concentric electrode spaced from the forward end of the nozzle and in the path of the spray issuing therefrom and a concentric counter electrode mounted in the forward part of the body and surrounding the rear part of the nozzle and the induction electrode assembly, said counter electrode being maintained at opposite polarity to the induction electrode.

2. A spray head according to claim 1, wherein said main body is provided at its forward end with a screw-threaded metallic ring which cooperates with a similar ring on the rear end of said housing to secure the housing in said main body.

3. A spray head according to claim 2, wherein said electrode is secured to said housing by metal inserts extending longitudinally through the wall of the housing from the metal ring thereon and soldered at their forward ends to said electrode.

4. A spray head according to claim 3, wherein said electrode is adapted to be connected to a source of electrical potential through said metal inserts, said metal rings and a metallic conductor passing rearwardly through said cylindrical part and out of the rear end of said main body.

5. A spray head according to claim 3 or 4, wherein said electrode is arcuate in cross-section and is secured in position with its convex face in engagement with the forward end of said housing.

6. A spray head according to claim 5, wherein the forward end of said housing is cut away to leave symmetrically arranged lobes which engage the concave surface of said electrode and provide passages for said metal inserts.

7. A spray head according to any preceding claim, wherein said electrode has concave edges which define between them lobes which project laterally outside the wall of the housing when the electrode is secured in position thereon.

8. A spray head according to any preceding claim, wherein said counter electrode is a metallic disc snap-fitted into the forward end of said main body.

9. A spray head according to any preceding claim, wherein said counter electrode is engaged by one end of a metallic contact member passing longitudinally through said main body and projecting at its other end from the rear end of the main body for detachable connection to a source of electrical potential.

10. A spray head according to any preceding claim, wherein said nozzle is fitted with a cap of non-conductive material for preventing its surface from being exposed to the inducing electrostatic field.

11. A spray head according to any preceding claim, wherein said main body is provided with longitudinally extending passages for connecting the interior of said housing to an auxiliary supply of gas which will diffuse through said electrode to repel the fine spray tending to coat it.

FIG.1.

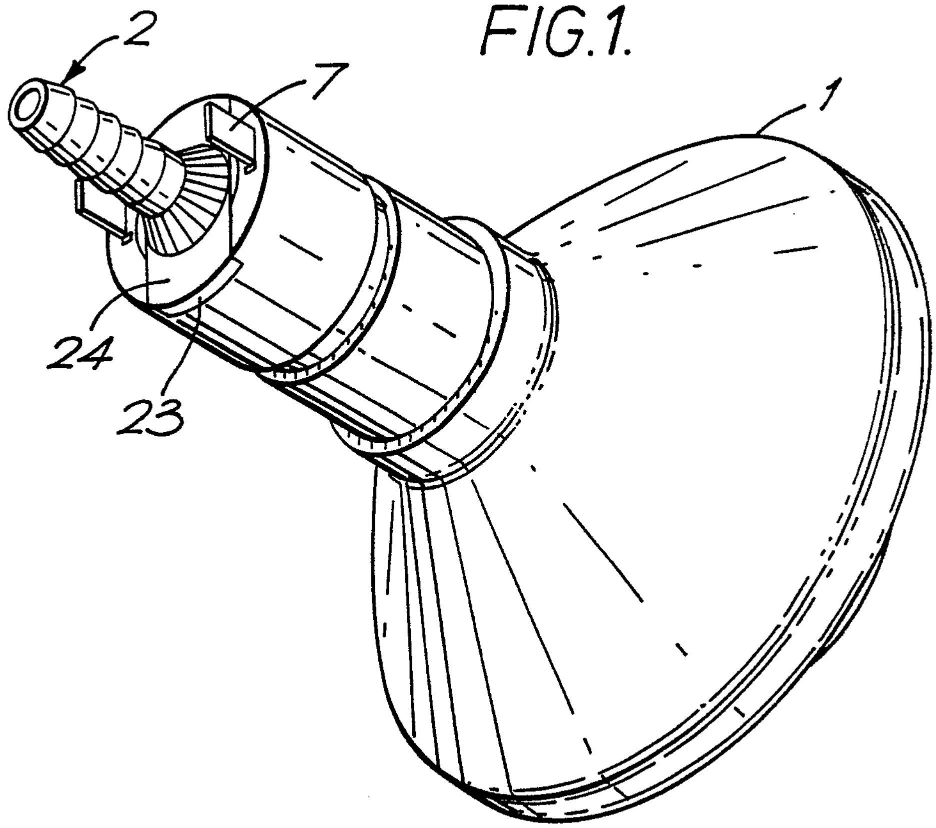


FIG.4.

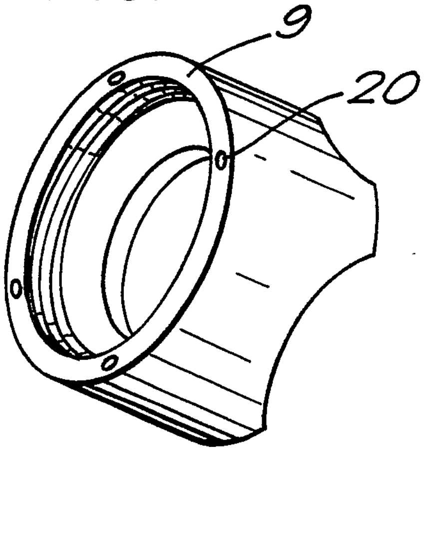


FIG.5.

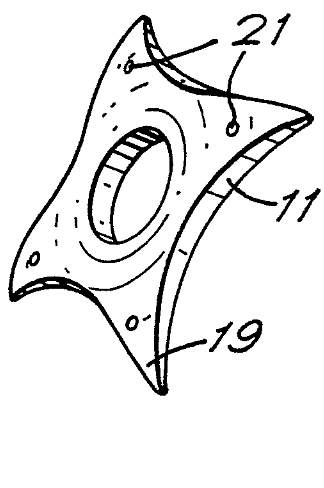
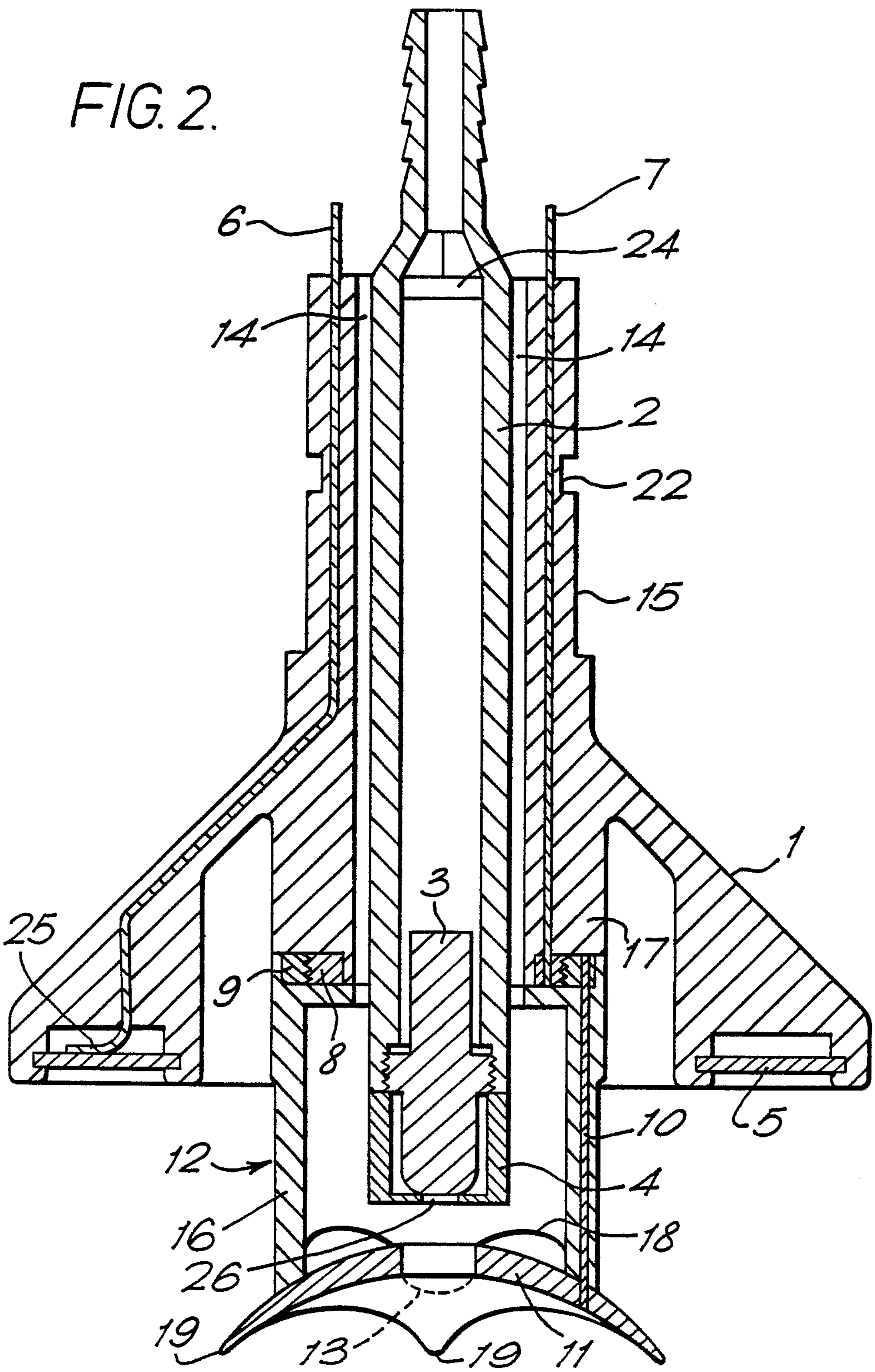


FIG. 2.



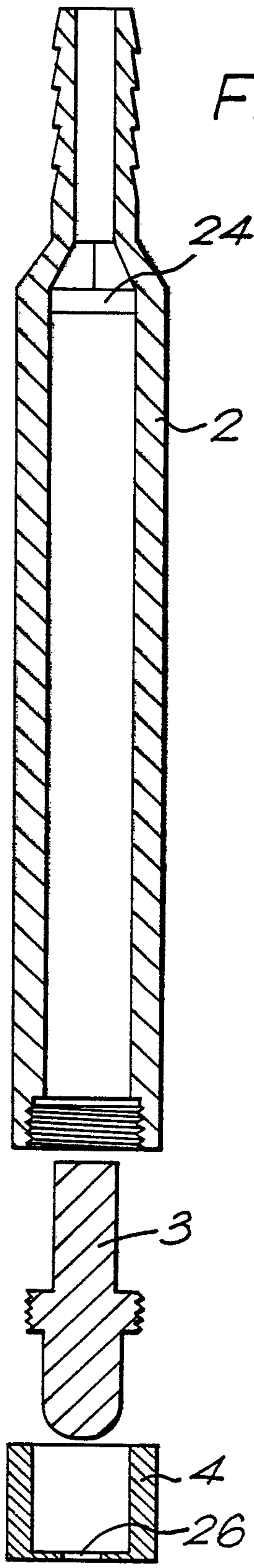
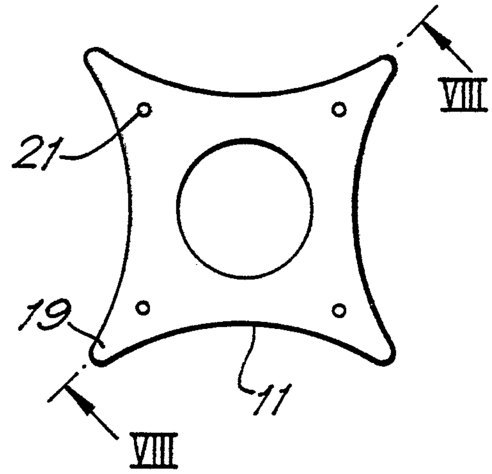


FIG.3

FIG.6.



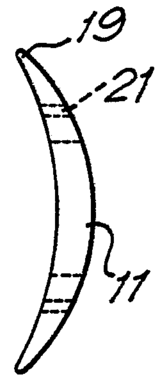


FIG.7.

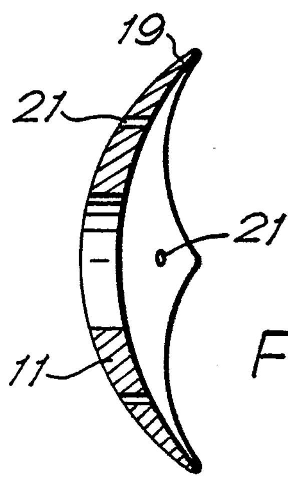


FIG.8.