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[54] **ELECTROSTATIC COATING APPARATUS**
7 Claims, 2 Drawing Figs.

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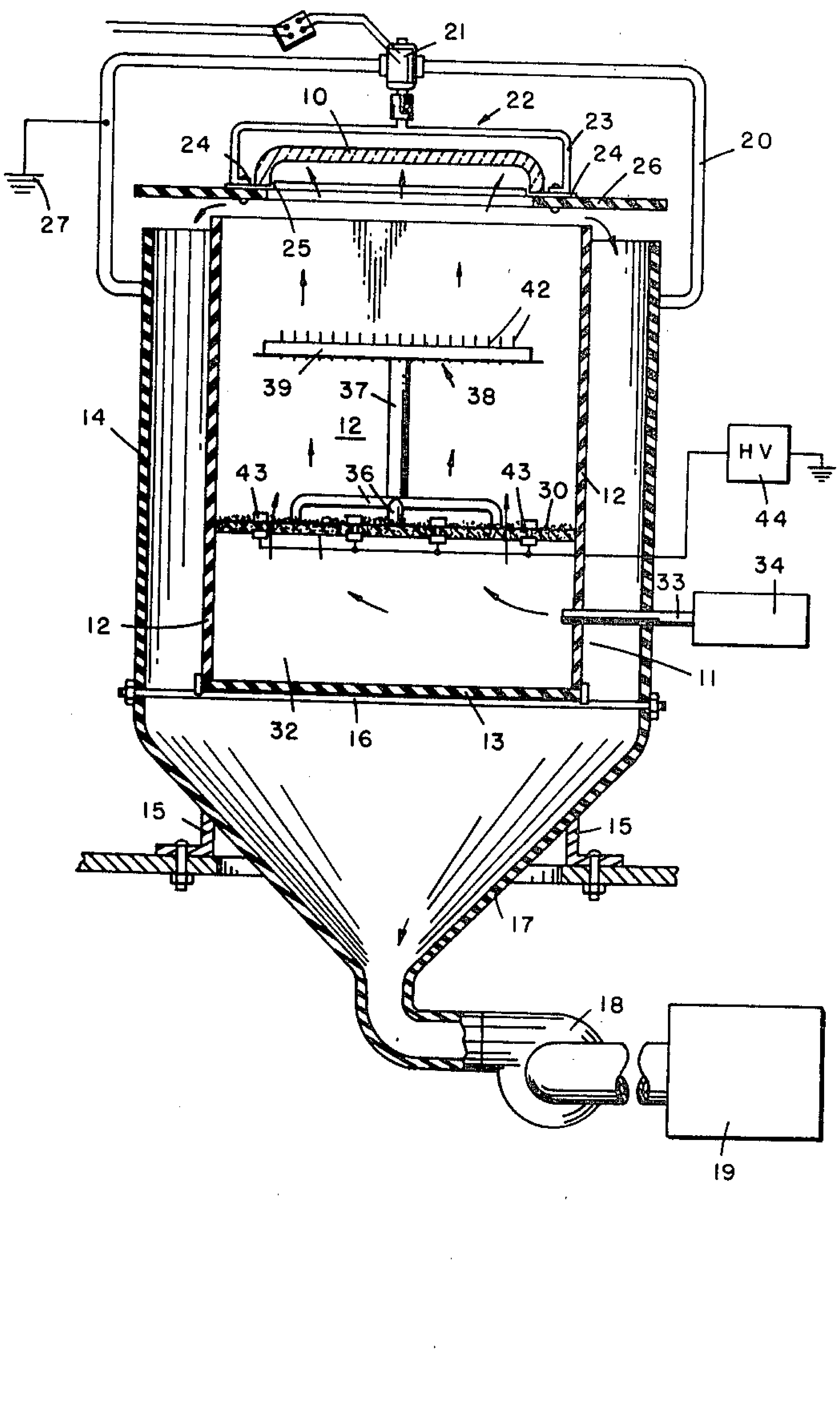
ABSTRACT: Articles, such as the surface of a television picture tube, may be electrostatically coated with powder particles by supporting them over a chamber that contains the particles and includes an air permeable plate, means to force gas through the plate to cause the particles to move upwardly, and an electrode to charge the particles and effect their deposition on the article. Undeposited particles flow into a jacket adjacent the chamber and can be reclaimed. Rotatably supporting the article permits relative rotation between the article and the electrode. Where a nonconductive surface of a television tube is to be coated electrostatically, a conductive sensitized binder is applied to the surface and maintained at a particle-attracting potential.



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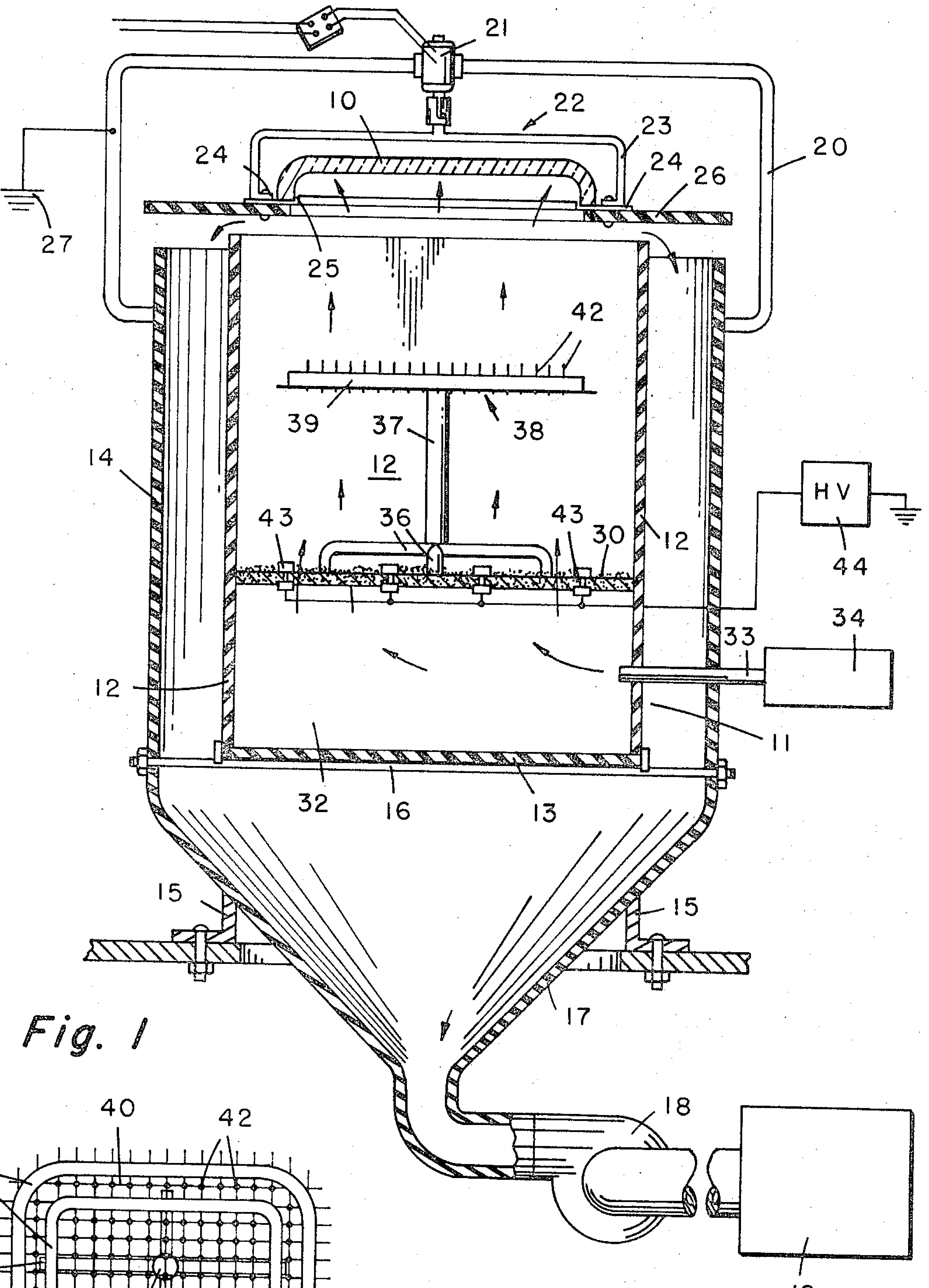

Fig. 1

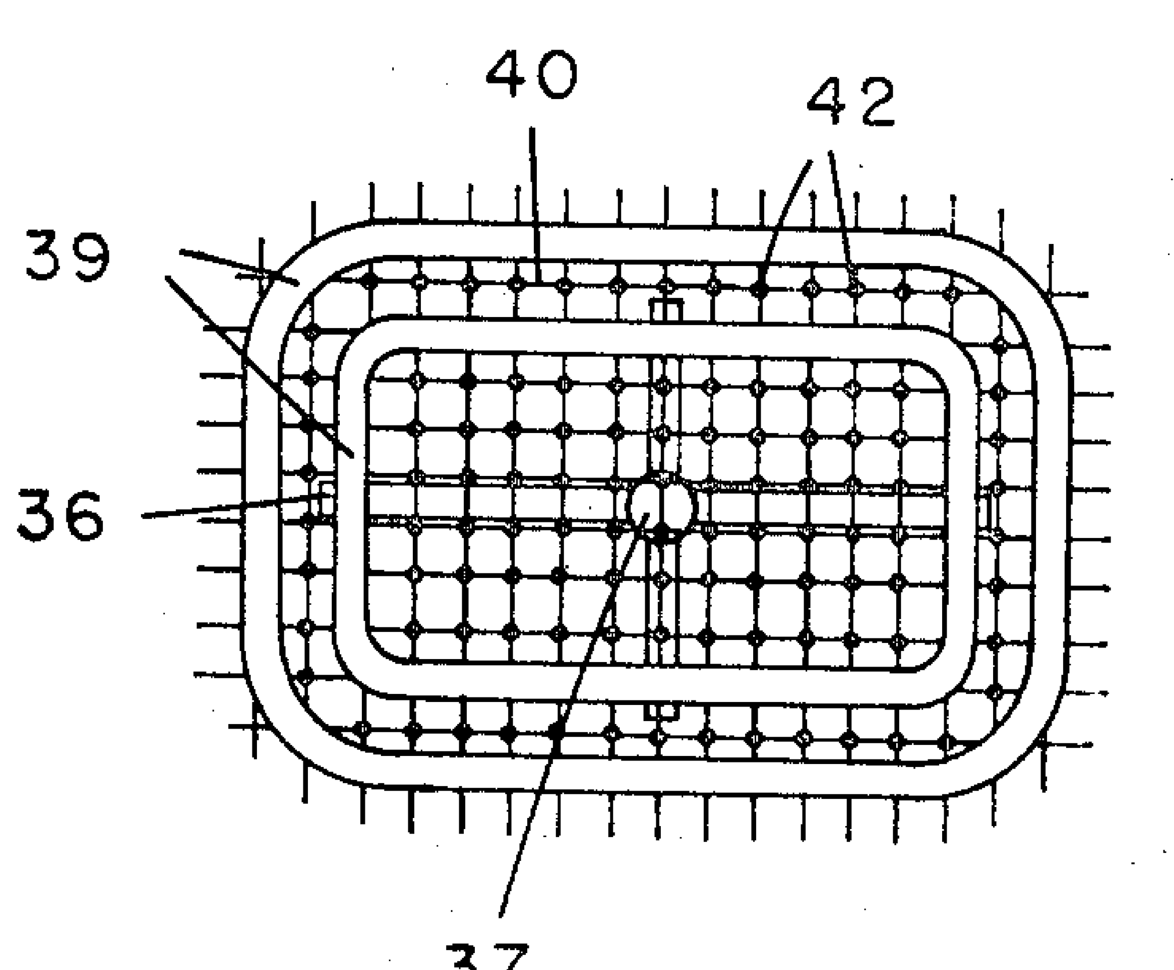

Fig. 2

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ELECTROSTATIC COATING APPARATUS

This is a division of application Ser. No. 350,473, filed Feb. 28, 1966, and now abandoned.

This invention is concerned with an apparatus for coating articles, such as television picture tubes with phosphors, by the use of electrostatic forces.

It has heretofore been the practice in the production of picture tubes for television receivers to apply phosphors either as dry powders or as sediments from liquid suspensions to an adherent layer on the glass surface of the tube face. In the case of those tubes to be used in color television receivers, the process has involved the application of a binder containing a sensitizing agent to the inside surface of the tube face, and then dry particles of the phosphor are dusted thereover to produce a thin powder layer. The thin powder layer over the sensitized binder layer is then exposed to a suitable image of an array of dots, and the material within the area of the dots is polymerized, or affixed, onto the tube face. The remaining material, being water soluble, is then removed by a water rinse and a grid of isolated dots is thus formed over the face surface. The process is then repeated again using the sensitized binder and a different phosphor with the polymerization of dots of the material located in different areas than the first set of dots. The process is repeated for a third time using the sensitized binder and still a third different phosphor with the polymerization of the dots of the material being located in still different areas to thus produce a finished coating of the phosphors, preferably one particle deep, over the face surface being coated. Since the three specialized groups of dots are each of a phosphor designed to emit, when excited, a different primary color, the complete surface is thus adapted to reproduce the entire color spectrum.

Such methods are extremely expensive. The necessity for dusting the phosphors over the tube face is time consuming and thus yields low production rates. Further, such hand operations create a high incidence of tube faces which have to be rejected by reason of nonuniform coatings. The phosphors employed in the coating are extremely expensive, and with the high incidence of rejects, substantial quantities of these expensive phosphors are thus wasted.

It is an object of this invention to provide an apparatus for coating articles. In coating television receiver picture tubes use of the apparatus will overcome the difficulties and disadvantages discussed above. More specifically, it is an object of this invention to provide an apparatus which will electrostatically deposit a coating of phosphor powders on television picture tube faces, which will direct said phosphor powders to and deposit them on a tube face by electrostatic forces, which will provide a uniform coating on the surface to be coated, and which will be efficient in operation.

An apparatus of this invention includes a deposition chamber containing particles of powder to be deposited. The particles are supported on an air permeable plate and means are provided to force gas through the plate and to move the particles upwardly. An electrode in the chamber is connected with means for establishing an electrostatic field to an article to be coated which is rotatably supported over the chamber. A jacket is disposed in spaced relation to the chamber and connected to a collector reservoir. Means are provided to evacuate undeposited powder particles collected in the jacket to a reservoir.

In using the invention for coating color television tube faces, the uncoated face has a sensitized binder applied in a uniform layer to its surface to be coated. The layer of the sensitized binder is placed in contact with ground, and the tube face is disposed over a fluidized bed of the phosphor to be deposited. A charging electrode is interposed between the surface of the bed and the tube face, and a plurality of charging members are carried in said bed. Application of a potential difference between the electrode and charging members and the face electrostatically charges the phosphor particles and directs them onto the sensitized layer as said particles are projected upwardly from the bed. Conveniently, during deposition the electrode and the tube face are moved relative to each other.

After the phosphor particles have been deposited, light is projected onto the coated surface through a dotted screen to activate the sensitizing agent, polymerize the binder, and thus cause the deposited phosphor particles to be bound at the dots onto the tube surface. After such polymerization, the nonpolymerized binder and phosphor particles at the areas other than the dots are removed from the surface. The application of the sensitized binder, phosphor powder deposition, and polymerization are repeated twice again, each time using a different phosphor and different dot locations. This results in a finished coating consisting of a triple array of nonoverlapping dots uniformly disposed over the surface of the tube; each dot having uniform thickness of phosphor.

Other objects and features of the invention will become apparent from the more detailed description which follows and from the accompanying drawings in which:

FIG. 1 is a vertical section through an apparatus embodying the invention; and

FIG. 2 is a plan view of the electrode assembly shown in FIG. 1.

In the production of picture tubes for color television receivers, a coating of phosphors is applied to the tubes. Said coating, which is substantially only one particle thick, is formed of phosphors having a particle size of about 3 microns which are adapted to produce visible red, blue, and green phosphors when bombarded by electrons.

To produce such a coating, we clean the tube face 10 and apply thereto, as by spraying, brushing, or the like, a polar binder solution containing a water soluble light activatable sensitizing agent. Desirably, said solution comprises about 3 percent of polyvinyl alcohol and about one-half ½ of a chromic salt, such as ammonium dichromate, dissolved in isopropyl alcohol and water in a 1:1 ratio. The polyvinyl alcohol serves as a binding agent for the phosphors to be deposited. The chromic salt, in addition to providing light sensitivity, acts in combination with the polar solvents, isopropyl alcohol and water, to increase the conductivity of the solution to thereby give the surface to be coated a surface resistivity in the range of from about 10^4 to about 10^8 ohms per square. After the solution has been applied to the inside surface of the tube face, it is allowed to dry to a tacky condition. The tube face is then ready to have the first phosphor applied thereto and is placed in the coating apparatus illustrated in FIG. 1.

As shown, the coating apparatus comprises a chamber 11 formed from an electrically insulating material and comprises a plurality of interconnected side walls 12 projecting upwardly from a bottom wall 13. Conveniently, a jacket 14 formed from electrically insulating material and supported on a plurality of feet 15 extends around the chamber 11. A pair of arms 16 extend across the jacket 15 to support the chamber 11 in spaced relation thereto whereby said jacket catches any of the phosphor powder that flows over the edges of the chamber. As shown, the upper end of the jacket 14 is spaced slightly below the upper ends of the chamber walls 12, and the lower end 17 of said jacket has a frustoconical configuration for collecting the powders in the jacket. Conveniently, a vacuum pump 18 is mounted at the bottom of the jacket for conveying the nondeposited powder from the jacket to a collector reservoir 19.

A pair of arms 20 project upwardly from the jacket 14 and extend transversely across the chamber 11. Said arms support a rotational driving motor 21 to which a hanger 22 is removably connected. Said hanger has outwardly projecting arms 23 joined at their outer ends to the upper face of a ring 24 having an upturned lip 25 at its inner circumference disposed in contact with the conductive binder layer on the tube face 10 for supporting said tube face in an elevated position about the upper end of the chamber 11. An annular shield 26 formed from an electrically insulating material is connected to the lower face of the ring 24 and projects laterally outwardly over the chamber 11 and jacket 14. The hanger 22, ring 24, and arms are formed from an electrically conductive material and are connected to ground, as at 27, to thus ground the sensitized binder layer on the tube face 10. Thus, upon actuation of the motor 21, the grounded tube face 10 will be rotated with respect to the chamber 11.

An air permeable plate **28** formed from an electrically insulating material is mounted in the chamber **11** above the bottom wall **13** and supports the phosphor particles **30** to be deposited. Air is introduced into the compartment **32** between the bottom wall **13** and plate **28** through an air inlet **33** connected to a source of pressurized air **34**. The air moves upwardly from the compartment **32** through the plate **28** to maintain the phosphor particles **30** in suspension immediately above said plate and thus provide a fluidized bed of said particles. By increasing the flow rate at the inlet **33**, the particles will billow upwardly from the bed in the chamber toward the tube face **10** and thus form a cloud having a particle density substantially less than the bed; the degree of billowing being dependent upon the flow rate at the inlet **33**.

An electrode assembly is mounted on the plate **28** and comprises a base **36** supporting an upwardly projecting spindle **37**. The upper end of the spindle is connected to a charging head **38** conveniently having the same general shape and size as the surface to be coated and comprising a plurality of annuluses **39** interconnected by a wire grid **40**. A plurality of electrode points **42** project upwardly from the head **38** toward the tube face with their ends substantially equally spaced from said face. Conveniently, a plurality of pins **43** may also be mounted in the plate **28** to project thereabove into the fluidized powder bed. The electrode assembly and the pins **43**, when the latter are employed, are formed from an electrically conductive material and are connected to a high voltage source **44** for electrostatically charging the phosphor particles.

When the cloud of phosphor particles has billowed around the electrode head above the points **42**, the tube face **10** is rotated and the voltage is applied to the head; preferably in an interrupted manner in two successive applications. The voltage is negative and provides an average voltage gradient between the points **42** and the tube face of at least 5 kilovolts per inch. With the tube face being grounded and the electrode being charged, the phosphor particles projected upwardly from the bed around the head and in the field extending between the head and tube face acquire an electrostatic charge and are thus attracted to and deposited onto the tube face. When the pins **43** are employed, they charge the adjacent particles in the bed and help to direct the particles to the tube face to help ensure a uniform coating thereon. With the head rotating, a uniform voltage gradient will be established between the head and tube face to ensure a uniform deposition of the phosphor particles onto the tube face. Any of the upwardly projected phosphor particles which are not deposited will flow over into the space between the chamber **11** and jacket **14** and be reclaimed in the reservoir **19**. The shield **26**, being nonconductive, will not have any of the particles deposited on it and will serve to direct the nondeposited particles into the space between the chamber and jacket.

An example of the deposition step of our invention may be described as follows: The inside of an 11-inch-tube face was cleaned and then washed with the sensitized binder, after which it was allowed to dry for 6 minutes at a relative humidity of 40 percent and a room temperature of 80°F. until it was in a tacky condition. The face was then mounted on the hanger **22** over the deposition chamber **11**, which chamber had a length and width of 12 inches and an overall height of 15 inches. The plate **28** containing four equally spaced pins **43** was located 5 inches above the chamber bottom wall, and the electrode head **38** was 5½ inches above the plate **28**. This provided a 6 inch spacing between the electrode head and tube face. The tube face was rotated at 90 r.p.m., and air was introduced into the compartment **32** at the rate of 5 c.f.m. When the phosphor particles had billowed around the head **38**, the head and pins were charged at 60 kv. in two successive intervals of 1 second each with about a 1-second interval between each charging interval. This produced a uniform coating over the inside surface of the tube face, and said face was removed for subsequent processing.

After the phosphor particles have been deposited, the tube face **10** is removed from the coating chamber, and a beam of light is projected through a dotted image-producing screen and onto the coated surface. The light passing through said screen will polymerize the polyvinyl alcohol to thus retain or affix the phosphor particles as a coating on the tube face within the dotted areas not masked by the screen. After polymerization, the coating is rinsed with water, and the nonpolymerized polyvinyl alcohol and the phosphor particles not within the dotted areas are rinsed away.

After the dotted coating has dried, a second layer of the binder solution is applied thereover. The deposition process is repeated in the manner previously described using a phosphor having a different color phosphorescence. After deposition, the polyvinyl alcohol in the binder solution is polymerized by projecting a beam of light through a second dotted image-producing screen and onto the coated surface. Said screen has its dotted pattern offset from the dotted pattern of the first screen whereby the second layer of binder solution will be polymerized in dotted areas adjacent the polymerized dots of the first layer of solution. In this manner, a double array of nonoverlapping dots of the first and second phosphors will be affixed to the tube face.

After this second coating has dried, the sequence is again repeated using a third layer of binder solution and depositing a third phosphor having still a different color phosphorescence. After deposition of the third phosphor, the polyvinyl alcohol in the third layer of binder solution is polymerized by projecting a beam of light through a third dotted image-producing screen and onto the coated surface. The dot pattern in the third screen is offset from the dot patterns in the first and second screens whereby the third layer of binder solution will be polymerized in dotted areas adjacent the polymerized dots of the first and second layers of solution. In this manner, a finished coating is produced having a triple array of nonoverlapping dots of the first, second, and third phosphors affixed to the tube face.

As explained above, the production of picture tubes for color television receivers requires the use of three different phosphors with their particles affixed to the tube face in a triple array of adjacent nonoverlapping dots. In the production of picture tubes for black and white television receivers only one phosphor need be employed, and it does not have to be deposited in any dotted pattern on the tube face, but only in a uniform thin coating over said tube face. Therefore, a single application of the binder solution and the electrostatic deposition of only one phosphor need be employed in the production of such picture tubes. Further, because such tubes do not require the phosphor to be in a dotted pattern, the entire deposited coating is subjected to light projected onto it directly, and no image-producing screens need be employed

While we have described the tube face as being rotated with respect to the fixed electrode assembly, it is to be understood, of course, that the tube face may be fixed while the electrode assembly is rotated with respect to it, or in some applications it may even be desirable to retain both the tube face and electrode assembly fixed during deposition.

For convenience reference has been made herein to powder particles suspended in air. However, said particles may be suspended in gaseous medium other than air, and "air" is intended to include other suitable gases.

We claim:

1. An apparatus for coating an article with particles of a powder, comprising a chamber, an air permeable plate mounted in the chamber supporting the particles in the chamber, electrode means in the chamber, rotatable support means for supporting the article above the electrode means and maintaining it at a particle-attracting potential, means to rotate the rotatable support means, means for forcing gas through the plate to cause the particles to move upwardly toward the article and adjacent the electrode means, means for establishing an electrostatic field between the electrode means and article for charging the particles and effecting their deposition on the articles, and means to evacuate undeposited powders adjacent the chamber and to convey them to a reservoir.

2. The invention as set forth in claim 1 in which said chamber has an open upper end and the means to evacuate undeposited particles adjacent the chamber includes a jacket disposed around said chamber in spaced relation thereto and a vacuum pump mounted at the bottom of the jacket.

3. The invention as set forth in claim 2 with the addition that the vacuum pump is connected to the reservoir.

4. An apparatus for coating an article with particles of a powder; comprising a deposition chamber; an air permeable plate mounted in said chamber supporting the particles in the chamber; electrode means carried in said chamber, said electrode means including a base supported on said plate, a spindle projecting upwardly from said base and a charging head mounted on the upper end of said spindle and having a plurality of annuluses interconnected by a wire grid and a plurality of upwardly projecting electrode points; support means for supporting the article above said electrode means; means for forcing gas through said plate to cause said particles to move upwardly toward said article around said electrode means; and means for establishing an electrostatic field between said electrode means and article for charging said particles and effecting their deposition on the article.

5. An apparatus for coating an article with particles of a powder; comprising a deposition chamber; and air permeable plate mounted in said chamber supporting the particles in the chamber; electrode means carried in said chamber; support means for supporting the article above said electrode means, said support means being operatively interconnected to said chamber and including a hanger having a plurality of arms connected to a ring adapted to engage and support said article and an annular shield mounted on said ring and projecting outwardly over said chamber, said hanger and ring being formed from electrically conductive material and said shield being formed from electrically insulating material; means for forcing gas through said plate to cause said particles to move upwardly toward said article around said electrode means; and means for establishing an electrostatic field between said electrode means and article for charging said particles and effecting their deposition on the article.

6. An apparatus for coating an article with particles of a powder, comprising a deposition chamber, an air permeable plate mounted in said chamber supporting the particles in the chamber, a hanger having a plurality of arms connected to a ring adapted to engage and support said article, and an annular shield mounted on said ring, electrode means carried in said chamber, means for forcing gas through said plate to cause said particles to move upwardly toward said article around said electrode means, a jacket around said chamber in spaced relation thereto, a pair of arms on said jacket extending across said chamber for supporting said hanger, and means for establishing an electrostatic field between said electrode means and hanger means for charging said particles and effecting their deposition on said article.

7. The invention as set forth in claim 6 in which said hanger is connected to a motor mounted on said pair of arms for rotating the article with respect to the electrode means.