United States Patent

[11] 3,593,678

[72] Inventor **Emery P. Miller**
Indianapolis, Ind.

[21] Appl. No. **810,056**
[22] Filed **Jan. 2, 1969**
[23] **Division of Ser. No. 544,594, Apr. 22, 1966, Pat. No. 3,513,011.**
[45] Patented **July 20, 1971**

[73] Assignee **Ransburg Electro-Coating Corp.**
Indianapolis, Ind.

[54] ELECTROSTATIC COATING METHODS AND APPARATUS

10 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **118/630,** 117/33.5, 117/17, 118/400.5, 118/DIG. 5
[51] **Int. Cl.** **B05b 5/02**
[50] **Field of Search** ..... 118/621-—640, 400.5; 117/93.4, 93.41, 17, 18, DIG. 6

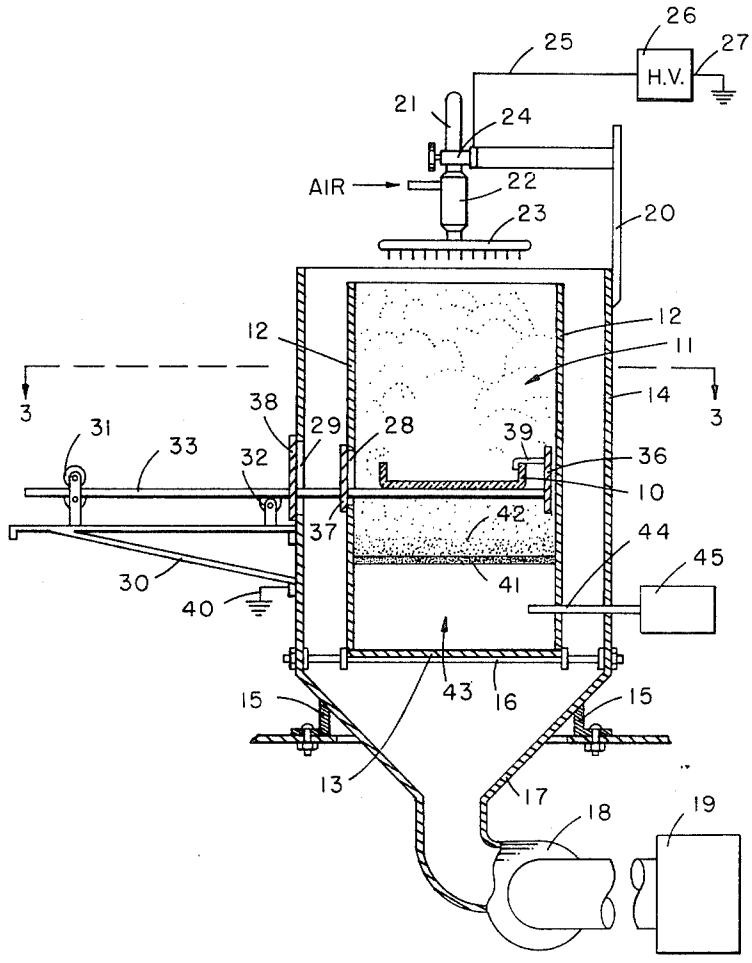
[56] **References Cited**

UNITED STATES PATENTS

2,649,358	8/1953	Palmer	118/400.5
2,719,093	9/1955	Voris	118/400.5
3,248,253	4/1966	Barford et al.	118/630 X
3,336,903	8/1967	Point	118/624
3,401,795	9/1968	Tauveron	117/DIG. 6

Primary Examiner—Peter Feldman
Attorneys—Merrill N. Johnson, Harry E. Downer, Jerry E. Hyland, David H. Badger and Verne A. Trask

ABSTRACT: An apparatus for coating a surface of an article with particles of a powder. A gas-permeable plate is mounted in a chamber and is used to support a layer of particles in the chamber. Means passes gas through the plate to cause the particles to form a cloud in the chamber. The article to be coated is in the cloud of particles. An electrode means is above the article to be coated with particles. Means establishes on electrostatic field between the electrode means and the article for charging the particles and collecting their deposition on the article.



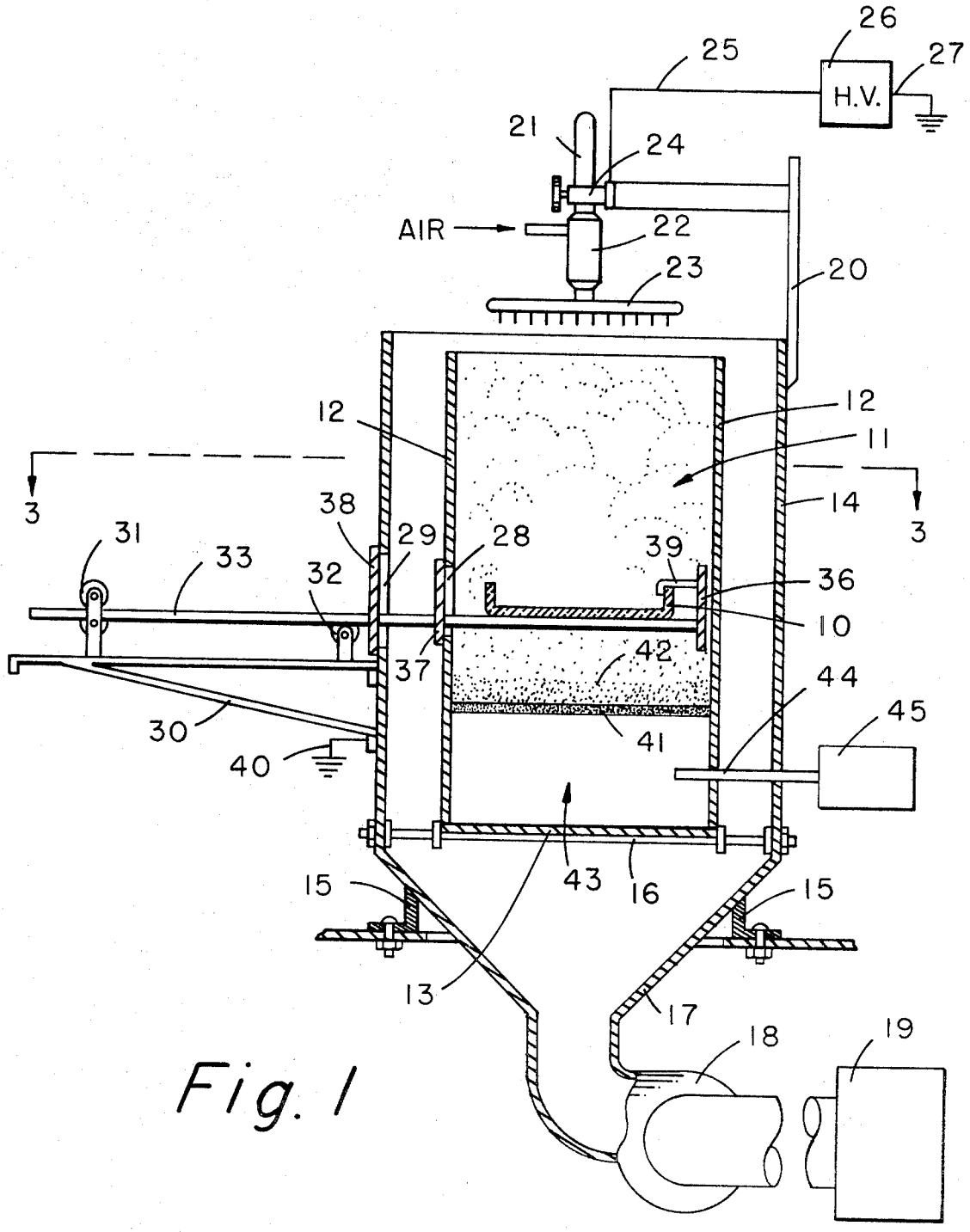


Fig. 1

INVENTOR
EMERY P. MILLER

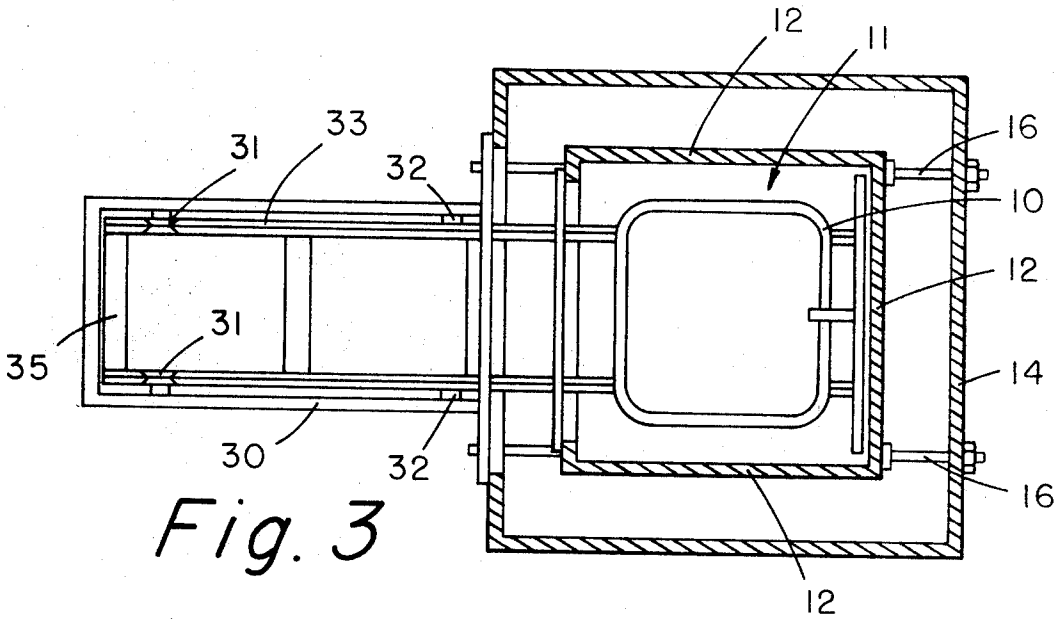


Fig. 3

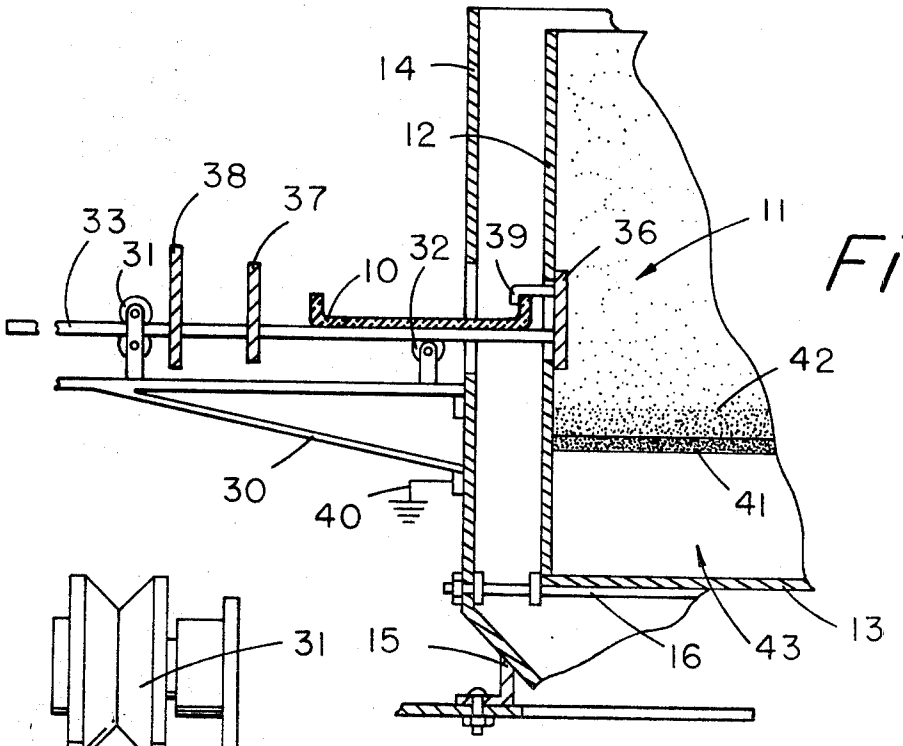


Fig. 2

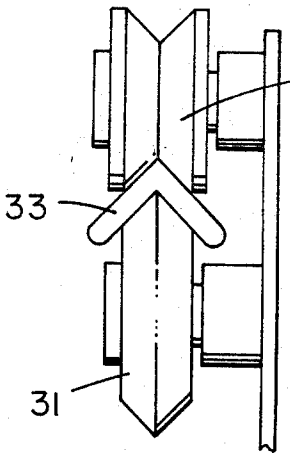


Fig. 4

INVENTOR
EMERY P. MILLER

ELECTROSTATIC COATING METHODS AND APPARATUS

This is a division of application Ser. No. 544,594, filed Apr. 22, 1966, now U.S. Pat. No. 3,513,011.

This invention is concerned with apparatus for coating television picture tubes with phosphors with the aid of electrostatic forces. It is also concerned with the application of powders generally to any surface where extreme uniformity of coating is required such as in the formation of electroluminescent plates and the like.

It has heretofore been the practice in the production of picture tubes for television receivers to apply the phosphor coating to the tube face either as dry powders sprayed onto an adherent layer on the glass surface or as sediments from liquid suspensions which are substantially adhered by being sprayed with an overlay of suitable resin. In the case of those tubes to be used in color television receivers, the process has involved the application of a binder containing a light sensitizing agent to the inside surface of the tube face, and then the dusting of the dry particles of the phosphor thereover to produce a thin adherent powder layer. The thin powder layer over the sensitized binder layer is then exposed to a suitable light image of an array of dots, and the material within the area of the dots is polymerized onto the tube face as insoluble resin areas to which the powder is adhered. The remaining material, being soluble, is then removed by a rinse and a grid of isolated dots in definite array and location is thus formed over the face surface. The process is then repeated again using the sensitized binder and a different phosphor. A new array of light dots is projected onto the surface to promote the polymerization 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, the dots of the polymerized material being located in still different areas. There is thus produced 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, in addition to being wasteful of powder, is time consuming and thus yields low production rates. Further, such 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 television receiver picture tubes which will overcome the difficulties and disadvantages discussed above. More specifically, it is an object of this invention to provide an apparatus which will rapidly 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 with the aid of electrostatic forces, which will provide a uniform coating on the surface to be coated, which will produce such surfaces with consistent characteristics, and which will be efficient in operation and in the use of powders. A further object of the invention is to provide a method of coating such tube faces in which the sensitized binder for adhering the phosphors onto the tube face will serve as an agent for supplying surface conductivity to said face for reception of the electrostatically charged phosphor particles.

According to one form of 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 powdered phosphor to be deposited is placed in a fluidized bed and gas, such as air, is passed through it so as to fluidize the material and form a powder cloud above the bed. The fluidizing air is turned off and the face inserted into the cloud above the powder bed with its surface to be coated facing upward and with the sensitized binder layer in electrical contact with ground. A charging electrode is positioned above and spaced from the tube face. Application of a potential difference between the electrode and the face electrostatically charges the phosphor particles and in an accelerated manner directs them onto the sensitized layer as said particles tend to settle gravitationally from the cloud. 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 under the illuminated dots, and thus cause the deposited phosphor particles at the dots to be bound 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 by rinsing the surface with a solvent liquid. The sensitized binder application, 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 to 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 with the tube face in place to be coated;

FIG. 2 is a partial section through the apparatus with the tube face withdrawn from the coating chamber;

FIG. 3 is a plan view of the assembly taken through A–A in FIG. 1; and

FIG. 4 is an in view of the carriage mounting arrangement.

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 a visible red, blue, and green phosphor escence when bombarded by electrons.

To produce such a coating, we clean the tube face **10** and apply thereto, as by spraying, brushing, slushing, 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 percent 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 while in the wet or partially dried state to thereby given the surface to be coated a surface resistivity in the range of from about 10^4 to about 10^6 ohms per square. After the solution has been uniformly applied to the inside surface of the tube face, it is allowed to dry to a tacky condition. The tube face is then ready for the first phosphor application. It is placed in the coating apparatus illustrated in FIG. 1 in the position shown in FIG. 2.

As shown, the coating apparatus comprises a chamber **11** formed from four interconnecting sidewalls **12** of electrically insulating material projecting upwardly from a bottom wall **13**. Conveniently, an outer jacket **14** formed from electrically insulating material and supported on a plurality of feet **15** extends around the chamber **11**. A pair of rods **16** extend across the jacket **14** to support the chamber **11** in spaced relation thereto whereby said jacket catches any of the phosphor powder that flows over the upper edges of the chamber. As shown, the upper end of the jacket **14** is spaced slightly above 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 fan **18** is mounted

at the bottom of the jacket for conveying the nondeposited powder from the jacket to a collector reservoir **19**.

An arm **20** also of insulating material projects upwardly from the jacket **14** and extends transversely across the chamber **11**. Adjustably affixed to said arm is a rod of conducting material **21** to which is attached an air-driving motor **22**. Attached to the rotatable shaft of air motor **22** is a charging electrode system **23** composed of a plurality of points extending outwardly of a plane frame member. The electrode is of the same planar shape as the tube face to be coated. In the modification shown this is essentially square. The rod **21** is connected electrically by way of fitting **24** and wire **25** to a high-voltage supply **26** whose other end is grounded as at **27**. Thus, upon actuation of the motor **22** and energization of the high-voltage supply **26**, the electrode **23** will be electrically charged with respect to ground and will be rotated with respect to the chamber **11**.

One of the walls **12** of chamber **11** has an opening **28** in it located above the level of the fluidized powder bed which is large enough and so shaped to admit the tube face **10** when it is held in a horizontal position. A similar matching opening **29** of slightly larger dimension is located in the corresponding surrounding wall **14**.

Attached to the side of the enclosure having openings **28** and **29**, there is a bracket member **30** which forms a support frame. Attached to the side members of this frame there are two sets of rollers **31** and two sets of rollers **32**. These rolls are arranged to carry the tube face support carriage **33**. Rolls at **31** are arranged above and below the angle side bars of carriage **33** as shown in FIG. **4**. Rolls at **32** are single rolls arranged to support the angle only from below in the manner of the lower roll of rollers **31**. The carriage thus can be moved from the position shown in FIG. **2** to that shown in FIG. **1** without tipping.

The carriage carries at its one end a cross bar **35** and at its other end a flexible thin metal plate **36**. Appropriately placed along the carriage is another similar plate **37**. Plates **36** and **37** are sized so that they will completely close the opening **28** from opposite sides of the panel **14** when the carriage is all the way toward the right as in FIG. **1** or all the way to the left as in FIG. **2**. A third flexible plate **38** is attached to the carriage **33** at a position such that it will close opening **29** in wall **14** when the carriage is all the way toward the right. It is therefore made slightly larger than opening **29**.

An air permeable plate **41** is mounted on the chamber **11** above the bottom wall **13** and supports the phosphor particles **42** to be deposited. Air is introduced into the compartment **43** between the bottom wall **16** and the plate **41** through an air inlet **44** connected to a source of pressurized air **45**. The air moves upwardly from the compartment **43** through the plate **41** to maintain the phosphor particles **42** in suspension immediately above said plate and thus provide a fluidized bed of said particles. By increasing the flow rate at the inlet **44**, the particles will billow upwardly from the bed in the chamber and thus form a cloud having a particle density substantially less than the bed extending from the bed to the top opening of enclosure **11**; the degree of billowing being dependent upon the flow rate at the inlet **44**. The cloud will essentially pour out over the sidewalls **12** and settle into the space between **12** and **14** to be recovered by fan **18** and collector **19**.

With the carriage all the way to the left, the tube face to which the alcohol solution has been applied, is positioned on carriage **33** as shown in FIG. **2**. A spring clip **39** is attached to the carriage and arranged so that when the face is slipped under it, electrical contact will be made between the coating on the face and the carriage. The carriage is electrically grounded as at **40**.

When the cloud of phosphor particles has billowed to the top opening of enclosure **12** and has become reasonably uniform in the space above the bed, the fluidizing air is shut off and the carriage with the tube face on it is moved to the right. Once the face is in place in the chamber **11**, the high voltage is applied to the electrode **23**. The voltage is negative and provides an average voltage gradient between the points on electrode **23** and the tube face of at least 5 kilovolts per inch. With the coating on the tube face being grounded and the electrode being charged, the phosphsr particles in the cloud from the bed which are in the field extending between the electrode and tube face acquire an electrostatic charge and are thus attracted to and deposited onto the tube face. With the electrode rotating, a uniform voltage gradient will be established between the head and tube face to insure a uniform deposition of the phosphor particles onto the tube face.

Phosphor particles which were generated in the cloud before the introduction of the face will flow over into the space between the chamber **11** and jacket **14** and can be reclaimed in the reservoir **45**.

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. It was then in a tacky condition. The face was then placed on the carriage **33** outside of the chamber **11**, which chamber had a length and width of 12 inches and an overall height of 15 inches. The plate **42** was located 5 inches above the chamber bottom wall **16**. The pins of electrode head **23** were 1 inch above the top of chamber **11**. When the face was moved into the chamber, it was 4 inches above the porous plate **42**. This provided a 12-inch spacing between the electrode and tube face. The electrode was rotated at 90 r.p.m., and air was introduced into the compartment **43** at the rate of 5 c.f.m. When the phosphor particles had billowed to fill the chamber **11** and the face had been introduced, the electrode was charged at 60 kv. This produced a uniform coating over the inside surface of the tube face, and said face was removed. If a heavier coating is desired, the cycle can be repeated. When the desired coating is obtained, the face can be passed on to further 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 illuminated areas. After polymerization, the coating is rinsed with a suitable solvent, and the non-polymerized 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 in another fluidizing chamber charged with 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 application. 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 from a third chamber 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 application. 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.

Similarily, this same technique can be used to produce a uniform powder layer on any flat surface by simply placing the plate in the position occupied by the tube face. The powders need not be of the type referred to as phosphors, but can be any finely ground powder capable of being fluidized. The surface need not be nonconducting, but can equally well be made of metal. In such case, the adhesive liquid need not supply the electrical conductivity. Where a uniform layer is required, the binding layer need not possess photo chemical properties, but can simply harden upon drying to bind the particles to the surface.

In case the coating applied by a single application is not adequate, the face or surface can be given further treatment by removing it from the chamber, reestablishing the powder cloud by again turning on and off the fluidizing air, and again inserting the surface into the chamber.

While we have described the electrode as being rotated with respect to the fixed tube face, it is to be understood, of course, that the electrode may be fixed. It is also to be understood that deposition may be obtained without the use of the electric field by following all steps of the invention with the exception of applying the field. Gravitational settling of the powder cloud will depsoit the phosphors on the face but this occurs at a much slower rate.

For convenience, reference has been made here in 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.

I claim:

1. An apparatus for coating a surface of an article with particles of a powder comprising a deposition chamber, a gas-permeable plate mounted in said chamber supporting a bed of particles in the chamber, electrode means carried above said chamber, means for passing gas through said plate to cause said particles to move upwardly toward the top of said chamber to form a cloud of particles suspended in the gas and then terminating the flow of gas, means for introducing the article into said chamber and supporting the article below said electrode means and above the bed of particles, and means for establishing an electrostatic field between said electrode means and the article for charging said particles and accelerating their downward deposition on the article.

2. The invention as set forth in claim 1 with the addition that means are provided for moving said article and electrode means relative to each other while maintaining a constant spacing therebetween.

3. The invention as set forth in claim 1 in which said chamber has an open upper end and a jacket is disposed around said chamber in spaced relation thereto for collecting any nondeposited particles exiting said chamber.

4. The invention as set forth in claim 3 with the addition that said jacket is connected to a collector reservoir and means are provided for conveying the powder in said jacket to said reservoir.

5. The invention as set forth in claim 1 in which said support means is arranged relative to said chamber in such a way as to provide a loading position outside of said chamber and a coating position within said chamber.

6. An apparatus for coating an article with particles of a powder, comprising a deposition chamber, a gas-permeable plate mounted in said chamber supporting a layer of the particles in the chamber, an electrode means carried above said chamber, an article support means in said chamber, means for forcing gas through said plate to cause said particles to move upwardly toward the top of said chamber and toward said electrode means, a jacket around said chamber in spaced relation thereto, a support on said jacket for supporting said electrode means, and means for establishing an electrostatic field between said electrode means and an article on said support means for charging said particles and effecting their deposition on an article on said article support means.

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

8. An apparatus for coating an article with particles of a powder, comprising a deposition chamber having an open upper end, an gas-permeable plate mounted in the chamber for supporting a layer of particles in said chamber, electrode means carried on said chamber, electrically conductive support means associated with the chamber and adapted to engage and support the article above said layer, means for forcing gas through said plate to cause said particles to move upwardly toward the top of said chamber, electrode means positioned adjacent the open upper end of said chamber and above the article to have particles deposited thereon, and means for establishing an electrostatic field between said electrode means and the article for charging said particles and effecting their deposition on the article.

9. The invention as set forth in claim 8 in which a jacket is disposed around said chamber in spaced relation thereto for collecting any nondeposited particles.

10. An apparatus for coating an article with particles of a powder, comprising a deposition chamber having an open upper end, a gas-permeable plate mounted in the chamber for supporting a layer of the particles in said chamber, electrode means carried in said chamber, hanger means adapted to support the article and to move it from without into said chamber through a suitable opening, means for forcing gas through said plate to cause said particles to move upwardly toward the open top of said chamber, means associated with the movement of said support means for closing said opening when said gas forcing means is active, a second means associated with the movement of said support means for closing said opening when said gas means is not active, an electrode positioned near the top of said chamber and above the article to have particles deposited thereon, and means for establishing an electrostatic field between said electrode means and article in said chamber for charging said particles and effecting their deposition on the article.