

PATENT SPECIFICATION

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(54) METHOD FOR COATING PARTICULATE MATERIAL UPON A VIEWING-WINDOW SURFACE OF A CATHODE-RAY TUBE

(71) We, RCA CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, 10020, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method for coating particulate material upon a viewing-window surface of a cathode-ray tube. The method of the invention is particularly applied to coating a layer of phosphor particles upon the inner surface of the viewing window of each of a series of cathode-ray tubes such as color-television picture tubes.

In one method of making a phosphor screen for a color-television picture tube, a slurry is prepared from phosphor particles, a binder such as polyvinyl alcohol, a photosensitizer for the binder such as ammonium dichromate, an organic filler resin, and a liquid vehicle such as water. A series of viewing windows is passed through a semiautomatic machine and a puddle of phosphor slurry is dispensed from a storage container onto the central portion of the inner surface of each slowly-rotating viewing window, each window being part of the faceplate panel of a cathode-ray tube. Each window is rotated and tilted to spread the slurry puddle outwardly to its margins, thereby coating the slurry over the entire window surface. During the spreading step, the coated slurry circulates over the surface and some of the particles therein settle as a layer on the window surface. The excess slurry is then removed, as by rapidly spinning the panel to sling the excess slurry therefrom; recovered; and returned to the storage container, where it is mixed with the slurry therein. The mixture is used for coating subsequent window surfaces.

With prior slurry coating factory practice, the dispensed slurry has a variable tempera-

ture usually in the range of 26 to 30°C, and a variable viscosity of about 50 to 60 centipoises, while the viewing window has a temperature of about 35 to 40°C. The higher viscosity permits a relatively thick uniform layer of slurry, free of streaks and sags, to be formed on the window surface. As the slurry is spread on the window surface, it is heated to a temperature of about 33 to 38°C with a consequent decrease in viscosity, and phosphor particles settle as a layer upon the surface. The lower viscosity permits the phosphor particles to settle as a uniform layer in the short period of time permitted by the machine cycle. The settled layer that is formed is relatively porous, with a screen weight of about 2.50 to 3.60 mg/cm².

One expedient for increasing the screen weight without losing adherence of the layer to the surface is to heat the viewing window to higher temperatures, usually in the range of 40° to 50°C, at the time of dispensing the slurry. The slurry puddle is then heated (during spreading) to higher temperatures, with still greater decreases in viscosity. Being hotter, the excess slurry that is collected and returned to the storage container raises the temperature of the mixed slurry therein, causing its viscosity to drop. There are also corresponding increases in the temperature and decreases in the viscosity of the dispensed slurry. The overall effect of raising the temperature of the viewing window is to disturb the entire system, at times causing catastrophic reductions in the adherence and in the quality of the settled layer.

In the method of the invention, a quantity of slurry is dispensed from a storage container onto the viewing-window surface that has been heated to temperatures above 35°C. The slurry is spread over the surface, and the excess is collected and returned to the storage container. Unlike the prior process, the heat picked up from the viewing window by the excess slurry is removed, so that the temperature and viscosity of the subsequently-dis-

pensed mixed slurry remain substantially constant. The previous experienced losses in adherence and screen quality are thereby avoided. The heat may be removed by cooling the excess slurry as it is returned to the storage container, by cooling the mixed slurry in the storage container, or, preferably, by cooling the mixed slurry just prior to dispensing.

It is further appreciated that it is advantageous to dispense a slurry having a temperature lower than 22°C and a viscosity of about 30 to 50 centipoises, at the time of dispensing. With the lower slurry temperature, the slurry can be compounded to contain less organic binder and/or less or no organic filler resin than previously employed. As the slurry is spread over the surface, its temperature rises and its viscosity drops more than in previous processes. Both the higher window temperature and decreased organic material contribute to more rapid and complete deposition of particles from the slurry, to form a heavier and less porous layer than is produced by prior methods. Weights of 3.8 to 4.3 mg/cm² are easily achieved. In addition, it has been found to be practical for the surface to have a higher temperature, up to 50°C, whereby an even greater drop in viscosity may be achieved during the slurry-spreading step.

In one form of the invention, the viewing window is at average temperatures of 42° to 50°C. Preferably, the surface temperature is graded from center to edge, with the central portion of the surface about 44° to 48°C and the edge portions about 3° to 5°C lower. The graded temperature helps produce a layer that is graded in thickness from center to edge, as desired.

In the drawing, the sole FIGURE is a schematic layout of a system for dispensing slurry and recycling the recovered excess slurry in accordance with the inventive method.

Embodiments of the invention are described below with respect to coating the inner surfaces of the viewing windows of a series of cathode-ray tubes, particularly color-television picture tubes. In such tubes, each of three phosphors (red-emitting, green-emitting, and blue-emitting) is incorporated into a separate slurry, separately coated on the inner surface of each window, and then processed to produce a phosphor dot pattern. However, in general, the pattern may be of materials other than phosphors and in shapes other than dots, for example, lines. Apparatus for carrying out the coating step are disclosed in the prior art; see, for example, United States patent nos. 2,902,973, 3,364,054, 3,672,932 and 3,653,941.

In the system shown in the sole FIGURE, a face-plate panel 11 is held in a work holder (not shown), which is rotated and

tilted to carry out the method steps. The work holder may move from station to station where the various method steps in the fabrication process are carried out. As part of this fabrication, a puddle of slurry is dispensed onto each window surface. The slurry is stored in a dispenser storage container 13 and continually agitated by being pumped with a pump 15, through a dispenser recirculating line 17, back to the container 13 and also through the dispenser feed line 19, through a dispensing means including a dispenser three-way valve 21 and a dispenser return line 23, back to the dispenser storage container 13. When a quantity of slurry is to be dispensed, the three-way valve 21 is actuated to release a metered quantity of slurry through a dispensing nozzle 49 onto the panel 11. The apparatus includes also a water-cooled heat exchanger 51 through which pass the dispensing feed line 19 and the return feed line 23. Cooling water passes into the water jacket through an inlet 53 and leaves by an outlet 55.

The work holder is made to rotate and tilt according to a prescribed program, to produce a coating or layer of phosphor particles on the surface of the viewing window of the panel. The rate of rotation and the angle of tilt of the rotation axis are adjusted to cause a puddle of phosphor slurry to spiral outwardly around the inner surface of the viewing window until the entire surface has been covered. Then, the excess slurry material is removed and returned to the slurry storage container for use on subsequent panels to be coated. As shown in the sole FIGURE, the panel 11 is moved to another station, where a circular toroidal-shaped trough 25 is positioned around the rotating panel 11. The panel 11 is made to rotate fast enough to fling the excess slurry from the panel 11, by centrifugal force, into the trough 25. The collected excess slurry drains from the trough 25 back to the dispenser storage container 13 through a drain return line 27.

The slurry that has been used to coat the panel 11 is replaced by makeup slurry that is stored in a makeup slurry storage container 29. The makeup slurry is continuously agitated by being pumped with a pump 31, through a makeup recirculating line 33, back to the container 29 and also through a makeup feed line 35, through a makeup feeding means including a makeup three-way valve 37 and a makeup return line 39, back to the container 29. When a quantity of makeup slurry is called for, the makeup three-way valve 37 is actuated to release the desired quantity of makeup slurry into the dispenser storage container 13 through a connecting line 41.

A typical faceplate panel 11 is a unitary glass structure comprised of a glass viewing window 12 that is generally concave on the inside, flatlike and nonporous. The panel 11

has sidewalls 10 which rise along the margins of the viewing window 12 and terminate with the seal land, which is subsequently sealed to the seal land of the funnel portion of the tube. In this embodiment, the viewing window 12 has a generally rectangular shape; however, the viewing window may be round or have any other shape. The panel 11 is mounted in the work holder of the coating apparatus, and the panel and work holder are made to rotate about an axis 14 which is normal to and passes through the central portion (a generalized region) of the inner surface of the viewing window 12. The axis 14 of rotation may be tilted from vertical by a tilt angle.

The rotating panel 11 is subjected to several preliminary processing steps on the coating apparatus, including heating so that the viewing window is at about the temperatures indicated in the TABLE for the respective phosphor slurries. In one form of the invention, the central portion of the surface is at about 44 to 48°C and the edge portions are at about 40 to 44°C. However, the temperature of the surface may be substantially constant from center to edge and may be at any temperature above about 35°C.

A metered amount of slurry is dispensed as a puddle onto the central portion of the inner surface of the viewing window 12 (facing upward). Prior to dispensing, the slurry in the dispenser storage container has a variable temperature of about 23 to 25°C or lower, or it may be at higher temperatures up to about 30°C as in the prior art. On the way to and from the dispensing means, the slurry is passed through the water-cooled heat exchanger 51, where the slurry is cooled to a substantially constant temperature not exceeding 22°C, e.g. in the range of 17 to 22°C. Specific temperatures for each phosphor slurry are indicated in the TABLE.

As compared with prior formulations, lesser proportions of organic binder and organic filler resin are required to impart the required viscosity to the slurry at the time of dispensing. Typically, the weight ratio of polyvinyl alcohol to phosphor is dropped from about 0.12 (0.11—0.13) to about 0.09 (0.08—0.10), and weight ratio of filler resin to polyvinyl alcohol is dropped from 0.50—1.00 to about 0.05. The reduction in organic material is permitted because the slurry is cooler at the time of dispensing. This reduction in turn permits uniform, less porous layers of particles to be formed by the slurry-coating method. The less porous layers subsequently yield screens which exhibit higher luminescent light output.

The dispensed slurry is formed into a puddle and is spread over the inside window surface by the rotation of the panel 11 and the tilting of the rotation axis. The puddle referred to herein is a quantity of slurry

which moves over the window surface as an entity having a leading edge and leaving a trail of material behind. The puddle may pick up material from previous trails during its travel over the surface. The material left behind generally moves downwardly by gravity so that the slurry is constantly distributing itself over the surface, obliterating the edges of previous trails and to some extent draining back into the puddle.

As the puddle travels over the surface, the slurry is warmed by the heat of the panel and the panel is correspondingly cooled. The slurry temperature is estimated to rise to temperatures of about 30 to 35°C in this embodiment. This causes the viscosity of the slurry to drop from the dispensing value indicated in the TABLE to a relatively low value below 25 centipoises. This drop in viscosity permits particles in the slurry to settle by gravity onto the window surface at a more rapid rate than by prior processes; also, more of the particles settle out of the slurry.

The reduced proportion of organic material and the much increased drop in viscosity of the slurry during spreading permit the settled particles to pack together into a less porous layer than by prior processes. The presence of voids in the settled layer is easily detected in a finished cathode-ray tube. When the layer is excited by an electron beam, the particles luminesce. However, close examination shows a void in the layer to appear as a dark spot which is not emitting light. The relative amount of area of the layer which appears as dark spots is substantially lower in layers prepared by the inventive method.

The tilt angle of the rotation axis and the rotational speed of the surface are selected to produce the desired spreading of the slurry as in the prior art. Also, the viscosity, specific gravity, and other characteristics of the slurry are chosen to give the desired effect in combination with the selected tilt angle and rotational speed. Some suitable phosphor slurries, which may be modified as described herein, are described in United States patents nos. 3,269,838 and 3,313,643. Suitable slurries usually have viscosities at the dispensing nozzle, i.e., at the time of dispensing, in the range of about 30 to 50 centipoises, preferably about 35 to 45 centipoises.

After the spreading of the slurry over the surface is completed, the panel is spun rapidly to sling the excess slurry out of the panel by centrifugal force. The excess slurry which is spun off in this manner is caught and returned to the dispenser storage container 13 to form a mixed or reconstituted slurry for use in coating subsequent panels. Both the salvage slurry and the makeup slurry carry with them variable amounts of heat which impart a variable temperature and viscosity to the slurry in the container 13. By cooling the mixed slurry to a substantially constant

temperature, the variable amount of heat carried into the slurry in the dispenser storage container is removed, and the coating process is started at substantially the same slurry temperature and viscosity for successive panels. The heat may be removed by cooling the slurry flowing to and/or from the dispensing nozzle 49. Alternatively, the heat may be removed by cooling the slurry flowing through the dispenser recirculating line 17, the excess slurry return line 27, or a combination thereof.

The TABLE shows some specific values for the temperatures (in °C) of the panel and viscosities (in centipoises) of the slurry for each of the green, blue and red slurries. Some screen weights (in mg/cm²) achieved with these conditions are also shown. The colors green, blue and red refer to the cathodo-

luminescent emission colors of the phosphor particles contained in the slurry. For comparison, some typical values of similar parameters associated with a prior method are also given. Further included are some comparative values for the typical weight ratios of filler resin/pva and phosphor/pva in slurries containing polyvinyl alcohol (pva) as the binder and an acrylic resin in emulsion form as the filler resin. The values for temperatures, viscosities, and weight ratios given for the prior method are necessarily approximate and may be varied from the values given in the TABLE. The prior method includes the direct return of salvage slurry to the dispenser storage container, but does not include the step of removing heat carried into the system with the salvaged slurry as provided in the inventive method.

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TABLE

	New Method			Prior Method		
	Green	Blue	Red	Green	Blue	Red
Dispenser Storage Container Temp. °C	23	24	24	28*	28*	28*
Dispensing Nozzle Temp. °C	20	22	21.5	28*	28*	28*
Center of Window Temp. °C	44+	45	48	38	38	38
Edge of Window Temp. °C	40+	42	44+	32	32	32
Dispenser Storage Container Viscosity cps	38.0	40.0	40.0	55	55	55
Dispensing Nozzle Viscosity cps	43.0	45.5	43.5	55	55	55
Ratio — Filler Resin/pva	0.05	0.05	0.05	0.50	0.50	1.00
Ratio — pva/Phosphor	0.09	0.09	0.09	0.12	0.12	0.12
Center Screen Weight	4.3	4.3	3.8	3.4	3.6	2.7
Edge Screen Weight	3.8	3.7	3.4			
Specific Gravity of Slurry	1270	1270	1270			

*temperature fluctuates in range of about 26° to 30°C

WHAT WE CLAIM IS:—

1. A method for coating a surface of a cathode-ray-tube viewing window with particulate material, comprising the steps of heating said window to temperatures about 35°C; dispensing from a storage container onto the heated surface a quantity of slurry comprised of said particulate material mixed with a liquid vehicle, said quantity of slurry being in excess of that required for coating said surface; spreading said quantity of slurry over said surface, whereby said quantity of slurry is heated thereby; and collecting the excess slurry from said surface and returning

it to said storage container; comprising the additional step of removing the heat transferred to said excess slurry from said surface.

2. The method according to claim 1, wherein said slurry is dispensed through a dispensing means and said heat is removed by cooling said slurry to temperatures not exceeding 22°C as it passes between said storage container and said dispensing means.

3. The method according to claim 1, wherein said heat is removed by cooling said slurry in said storage container to temperatures not exceeding 22°C.

4. The method according to claim 1,



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TABLE

	New Method			Prior Method		
	Green	Blue	Red	Green	Blue	Red
Dispenser Storage Container Temp. °C	23	24	24	28*	28*	28*
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Center of Window Temp. °C	44+	45	48	38	38	38
Edge of Window Temp. °C	40+	42	44+	32	32	32
Dispenser Storage Container Viscosity cps	38.0	40.0	40.0	55	55	55
Dispensing Nozzle Viscosity cps	43.0	45.5	43.5	55	55	55
Ratio — Filler Resin/pva	0.05	0.05	0.05	0.50	0.50	1.00
Ratio — pva/Phosphor	0.09	0.09	0.09	0.12	0.12	0.12
Center Screen Weight	4.3	4.3	3.8	3.4	3.6	2.7
Edge Screen Weight	3.8	3.7	3.4			
Specific Gravity of Slurry	1270	1270	1270			

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it to said storage container; comprising the additional step of removing the heat transferred to said excess slurry from said surface.

2. The method according to claim 1, wherein said slurry is dispensed through a dispensing means and said heat is removed by cooling said slurry to temperatures not exceeding 22°C as it passes between said storage container and said dispensing means.

3. The method according to claim 1, wherein said heat is removed by cooling said slurry in said storage container to temperatures not exceeding 22°C.

4. The method according to claim 1,



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6 wherein said slurry is dispensed with a temperature of from 20 to 21°C and at a viscosity of from 30 to 50 centipoises.

5 5. The method according to claim 1, wherein the central portion of said surface has a temperature of 42 to 50°C.

6. The method according to claim 5, wherein the edge portions of said surface are 3° to 5° cooler than said central portion.

10 7. The method according to claims 2 or 3, wherein said excess slurry is mixed with the remaining slurry in said storage container to produce a mixed slurry for subsequent dispensing and said steps are repeated to coat a surface of a subsequent cathode-ray-tube viewing window.

8. The method according to claim 7, wherein a makeup slurry is also added to said storage container.

9. A method of coating a surface with particulate material substantially as hereinbefore described with reference to the accompanying drawing. 20

10. Windows coated by the method of any of Claims 1—9. 25

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