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54 Method of manufacturing an adherent pattern of particles of a substance on a substrate method of manufacturing a display screen of a colour display picture tube, and a colour display picture tube having a display screen manufactured by the method.

57 A colour-display picture tube display screen was made by providing a display screen substrate with a layer of a photosensitive composition which becomes sticky upon exposure to light. A black film matrix pattern and patterns of phosphor elements were formed on the photosensitive composition layer by imagewise exposing the layer to light in accordance with respective patterns of the black film matrix and of the respective phosphor elements, dusting the exposed layer with cobalt oxide particles and with particles of the respective phosphors, and blowing off the non-adhering particles. The photosensitive composition layer was then removed from the display screen substrate by condensing vapour of an organic solvent on the display screen structure so as to dissolve the material of the photosensitive composition layer, and continuing condensation of the solvent vapour until pure solvent falls off the substrate. During condensation of the solvent vapour the display screen is disposed so that the condensate falls off the substrate. The photosensitive composition is soluble in the

solvent but the light-absorbing material and phosphors are insoluble in the solvent. The black film matrix and patterns of phosphor elements are fixed to the display screen substrate, for example, using an inorganic binder such as potassium metasilicate.

METHOD OF MANUFACTURING AN ADHERENT PATTERN OF PARTICLES OF A
SUBSTANCE ON A SUBSTRATE, METHOD OF MANUFACTURING A DISPLAY SCREEN
OF A COLOUR DISPLAY PICTURE TUBE, AND A COLOUR DISPLAY PICTURE TUBE
HAVING A DISPLAY SCREEN MANUFACTURED BY THE METHOD.

5 The invention relates to a method of manufacturing an adherent
pattern of particles of a substance on a substrate. Such a method
may be used to manufacture a display screen of a colour display
picture tube. The invention also relates to a colour display
picture tube having a display screen manufactured by such a
10 method.

For many years the display screens of colour display picture
tubes have been made by a complicated process in which a dispersion
of a green-luminescing phosphor in a solution of polyvinyl alcohol
and ammonium dichromate is used to produce a coating on the
15 face-plate. This coating is dried and exposed to ultra-violet
light through the apertures of a shadow mask. The irradiated
coating is then washed with water to remove the unexposed areas of
the coating. This procedure is then repeated twice, in order to
form a blue-luminescing phosphor pattern and then a red-luminescing
20 phosphor pattern. This process is expensive and slow.

The patterns of phosphor elements may be made by a method
using a photosensitive composition which becomes sticky upon
exposure to light, which method is simpler and is significantly
faster than the above-mentioned method using polyvinyl alcohol and
25 ammonium dichromate. United States Patent Specification 4,273,842
describes a process for forming a patternwise coated layer on a
phosphor screen of a colour picture tube, which comprises:
(1) a first step of applying a photosensitive composition
containing an aromatic diazonium salt decomposable through exposure
30 to ultraviolet light, whose photolytic product is hygroscopic, to
an inside surface of a face plate of the colour picture tube as a
thin layer,
(2) a second step of exposing the thin layer to ultraviolet light
patternwise through a shadow mask, thereby making the exposed parts
35 sticky due to the hygroscopicity of said photolytic product and

absorption of moisture by said photolytic product, and then contacting powder particles with the thin layer, whereby the powder particles adhere to said exposed parts, which are sticky, and then removing residual powder particles from the thin layer, and

- 5 (3) a third step of fixing the photolytic product resulting from the exposure to the ultraviolet light, thereby firmly binding the powder particles to said exposed parts.

This specification makes no mention of the effects which the residual photosensitive composition and the photolytic product have
10 on the luminescent properties of the phosphors as evidenced by the brightness of pictures produced on this phosphor screen. The specification gives no indication that the residual photosensitive composition and photolytic product are removed from the screen. The photolytic product is fixed, for example, by reacting the
15 photolytic product so as to bind the phosphor particles to one another and to the substrate.

During the investigations which led to the present invention, a display screen of a conventional colour display picture tube was produced by a process using a layer of a photosensitive composition
20 which on patternwise exposure to light became sticky so that phosphor particles applied to the layer adhered the sticky areas of the layer. It was found that when using this process, it was necessary to bake the display screen for $3\frac{1}{2}$ hours at 450°C in order to remove the binder, and even after this baking process, a residue
25 was left on the display screen. The use of such a long baking step in order to remove the binder throws away the very considerable economic advantage provided by using the method of forming phosphor patterns on the display screen by using a photosensitive composition which becomes sticky upon exposure to light instead of
30 the long-established method of using photosensitive compositions comprising polyvinyl alcohol and ammonium dichromate. Attempts were made to remove the photosensitive composition from the display screen using organic solvents in liquid form, but it was not possible using this approach to remove the photosensitive
35 composition without destroying the patterns of phosphor elements.

Our United Kingdom Patent Specification 1,598,888 describes an electron display tube having an envelope comprising a flat, glass face-plate which is sealed in a vacuum-tight manner to a flange of a metal cone by means of a pressure-bonded seal consisting of a pressure-deformable material, such as lead. It is preferred to use a face-plate which comprises thermally toughened glass, for reasons of cost. However, when a toughened glass face-plate is baked at temperatures above 320°C, the glass tends to detoughen, and is not then satisfactory for use in an electron display tube, for safety reasons.

An object of the invention is to provide a method of making a display screen of a colour display picture tube, in which method the patterns of phosphor elements are formed using a photosensitive composition which becomes sticky upon exposure to light, and the photosensitive composition is removed from the display screen by a process which is substantially shorter than the above-mentioned baking process and which is conducted at a temperature which is significantly lower than 300°C, so that a face-plate consisting of toughened glass would not be detoughened when subjected to this process.

The invention provides a method of manufacturing an adherent pattern of particles of a substance on a substrate, the method comprising the steps of providing a layer of a radiation-sensitive composition on the substrate, imagewise irradiating the radiation-sensitive composition layer providing a pattern of particles of the substance on the irradiated radiation-sensitive composition layer, removing the irradiated radiation-sensitive composition layer from the substrate while leaving the pattern of the particles of the substance on the substrate by condensing vapour of an organic solvent on the pattern of particles of the substance and the irradiated radiation-sensitive composition layer, continuing condensation of the solvent vapour until pure solvent falls off the substrate, in which solvent both the radiation-sensitive composition which has reacted as a result of irradiation and the unreacted radiation-sensitive composition are

soluble and the substance is insoluble, the substrate being disposed during condensation of the vapour so that the condensate falls off the substrate, and then fixing the pattern of the particles to the substrate. Preferably the vapour of the organic solvent is initially supplied to the irradiated radiation-sensitive composition layer and the pattern of particles of the substance at a first rate, and the rate of supply of the vapour of the solvent is subsequently increased. By changing the rate of supply of solvent vapour to the condensation surfaces, the time taken to completely remove the binder-comprising layer can be less than that needed when solvent vapour is supplied to the condensation surfaces at a constant rate. It was found during the investigations which led to the present invention that in order to avoid disturbance of the pattern of the particles of the substance, the initial rate of supply of solvent vapour must be less than the rate at which solvent vapour could be supplied to the condensation surfaces without disturbing the pattern of particles when all the material of the irradiated radiation-sensitive composition layer had been removed from the substrate. After this layer has been completely removed from the substrate, the particles of the substance are only weakly held to the substrate. The particles of the substance may be fixed to the substrate, for example, by means of an inorganic binder such as potassium metasilicate or a silica sol.

When the substrate is a substantially flat substrate, it is preferred that the substrate should be inclined to the horizontal during the removal of the material of the irradiated radiation-sensitive composition layer from the substrate, in order that the condensate should run over part of the layer material before falling off the layer, thereby enhancing the efficiency of dissolution of the layer material by the condensate.

The radiation-sensitive composition may comprise, for example, a photosensitive composition which becomes sticky upon exposure to light, and the pattern of particles of the substance is provided on the photosensitive composition layer by exposing the layer to light

in accordance with the pattern so as to make the exposed portions of the layer sticky, then contacting the exposed layer with particles of the substance and removing the non-adhering particles. Such a method may be used to manufacture a display screen of a colour display picture tube, in which method patterns of respective phosphor elements are provided on the photosensitive composition layer by successively making respective patterns of the photosensitive composition layer sticky as a result of exposure to light, contacting the exposed photosensitive composition layer with particles of a respective phosphor, and removing the non-adhering particles of the respective phosphor. When making a display screen having a black matrix film pattern consisting of particles of a light-absorbing material, portions of the photosensitive composition layer corresponding to the matrix pattern are made sticky as a result of exposure to light, the layer is contacted with particles of the light-absorbing substance, and the non-adhering particles of the light-absorbing substance are removed. The display screen may be, for example, a face-plate. The phosphor elements may, for example, be in the form of dots or stripes.

It is advantageous in the manufacture of display screens by a method according to the invention for the irradiated photosensitive composition to be removed from the display screen surface by passing the display screen over a bath of the boiling solvent and increasing the rate of condensation of the solvent on the display screen surface by reducing the height of the display screen above the surface of the liquid solvent as the display screen traverses the said bath.

It was found that the photosensitive composition could be removed from the display screen by this method in approximately 10 minutes. Furthermore, it was observed that pictures produced on the display screen of a picture tube made by a method according to the invention were brighter when judged by the naked eye than pictures display on the display screen of a similar picture tube but in which the residual photosensitive composition had been removed by baking at 450°C for 3½ hours.

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

Figures 1 to 5 show steps in the manufacture of a display screen of a colour picture display tube by a method according to the invention, and

Figure 6 is a side-elevation of one arrangement for removing the photosensitive composition from a display screen during the manufacture of a colour picture display tube by a method according to the invention.

Referring to Figure 1, a 2 μ m thick photosensitive layer 1 was formed on a colour picture display tube flat face-plate 2 (which was 35 cm square) by spraying the face-plate 2 with a solution of a photosensitive composition which becomes sticky upon exposure to ultraviolet light, and allowing the layer 1 to dry in air. The photosensitive composition layer 1 was exposed through a mask 3 to 365 nm light from a 125 watt HPR lamp 4 for 1½ minutes so as to make exposed areas 5 (Fig. 2) sticky at areas where a first black matrix film pattern consisting of particles of cobalt oxide was to be disposed on the face-plate 2. The layer 1 was then dusted with cobalt oxide particles and the non-adhering particles (both those disposed on the non-sticky areas of the layer 1 and those resting on cobalt oxide particles adhering to the sticky areas of the layer 1) were removed by blowing with an air jet, leaving a black matrix film pattern 6. The photosensitive composition layer 1 was then exposed to light from the lamp 4 for 1½ minutes so as to make exposed areas 7 (Figure 3) sticky where elements of a green-luminescing phosphor were to be disposed. The photosensitive composition layer 1 was dusted with particles of the green-luminescing phosphor and the non-adhering phosphor particles were removed by blowing with an air jet, leaving green-luminescing elements 8. A similar process was used to form a pattern of blue-luminescing elements 9 (Figure 4) on the layer 1 and the process was repeated to form a pattern of red-luminescing elements 10 (Figure 5) on the layer 1. The quantity of phosphor present on this display screen was approximately 2 mg per sq.cm.

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The exposure used did not make the layer 1 sticky through its whole thickness.

Referring to Figure 6, a glass cylinder 11 was placed in a beaker 12 containing methyl ethyl ketone 13 which was a solvent for both the photosensitive composition material which had reacted due to exposure to light and the unreacted material, but in which the cobalt oxide and each of the phosphors were insoluble. The cylinder 11 was provided at the lower end with two cut-outs 14 (only one of which is shown), the horizontal boundaries of which were above the level of the liquid 13 in the beaker 12 so as to avoid bumping of the liquid 13 when it boiled, and at the upper end with three fingers 15 (only two of which are shown) which supported a face-plate 16 which had been provided with a display screen structure 17 by the method described above with reference to Figures 1 to 5. The cylinder 11 also served to establish a concentration gradient of methyl ethyl ketone vapour between the surface of the liquid methyl ethyl ketone 13 and the display screen structure 17. The beaker 12 was heated by means of an electric hot-plate 18 which was tilted slightly so that the major surfaces of the face-plate 16 were inclined to the horizontal with the consequence that drops of liquid formed from the methyl ethyl ketone condensing on the display screen structure 17 flowed over the surface of the structure 17 before falling off the face-plate 16 into the liquid methyl ethyl ketone 13. After the face-plate 16 had been placed on the fingers 15, the energy input supplied to the hot-plate 18 was adjusted so that the temperature of the methyl ethyl ketone vapour in contact with the display screen structure was 30°C. This resulted in methyl ethyl ketone condensing at a low rate and forming liquid droplets on the display screen structure, which droplets coalesced to form drops which ran over the face-plate 16 surface and fell into the methyl ethyl ketone liquid 13. After condensation at this low rate for 2 minutes, the heat input to the hot-plate 18 was then increased so that in the course of 3 minutes the temperature of the methyl ethyl ketone vapour in contact with the display screen

structure rose to 50°C. Initially the liquid falling off the face-plate was discoloured due to the material of the layer 1 contained therein. After condensation of vapour had continued for liquid falling off the face-plate 16 was colourless, indicating that essentially all the photosensitive film materials had been removed from the display screen structure, and condensation of vapour was continued for a further minute. The energy input to the hot-plate 18 was reduced and the face-plate 16 was lifted out of the beaker 12. The black matrix film pattern and the phosphor elements 8, 9 and 10 remained in positions on the face-plate 16, (Figure 5) but were only relatively loosely held on the face-plate 16. The black matrix film pattern and the patterns of phosphor elements were bonded to the face-plate 16 by carefully applying a solution of silica sol in ethyl alcohol (approximately 1 to 2% by volume) over the display screen surface until the patterns were completely wetted, allowing the screen to dry in air, then heating the screen to 120°C. Further fixing can then be provided in a conventional way using potassium metasilicate by spraying an aqueous solution of potassium metasilicate on to the display screen surface, allowing the solution to dry and then baking the display screen around 150°C. The display screen was then completed by lacquering and aluminising.

The display screen was then built into a colour picture display tube with a cone portion, electron gun system and other circuit components.

The method described above with reference to Figures 1 to 6 was also used to make display screens of conventional 35 cm (14 inch) colour picture display tubes having curved face-plates. Since these face-plates were curved, there was no need to tilt the hotplate in order for the condensate to run over the display screen surface before falling off into the beaker.

CLAIMS:

1. A method of manufacturing an adherent pattern of particles of a substance on a substrate, the method comprising the steps of providing a layer of a radiation-sensitive composition on the substrate, imagewise irradiating the radiation-sensitive composition layer, providing a pattern of particles of the substance on the irradiated radiation-sensitive composition layer, removing the irradiated radiation-sensitive composition layer from the substrate while leaving the pattern of the particles of the substance on the substrate by condensing vapour of an organic solvent on the pattern of particles of the substance and the irradiated radiation-sensitive composition layer, in which solvent both the radiation-sensitive composition which has reacted as a result of irradiation and the unreacted radiation-sensitive composition are soluble and the substance is insoluble, continuing condensation of the solvent vapour until pure solvent falls off the substrate, the substrate being disposed during condensation of the vapour so that the condensate falls off the substrate, and then fixing the pattern of the particles to the substrate.
2. A method as claimed in Claim 1, wherein the vapour of the organic solvent is initially supplied to the irradiated radiation sensitive composition layer and the pattern of particles of the substance at a first rate, and the rate of supply of the vapour of the solvent is subsequently increased.
3. A method as claimed in Claim 1 or Claim 2, wherein the pattern of the particles of the substance is fixed to the substrate by means of an inorganic binder.
4. A method as claimed in any preceding Claim, wherein the substrate is a substantially flat substrate which is inclined to the horizontal during the removal of the irradiated radiation-sensitive composition layer from the substrate.
5. A method as claimed in any preceding Claim, wherein the radiation-sensitive composition is a photosensitive composition which becomes sticky upon exposure to light, and the pattern of particles of the substance is provided on the photosensitive

composition layer by exposing the layer to light in accordance with the pattern so as to make the exposed portions of the layer sticky, then contacting the layer with particles of the substance, and removing the non-adhering particles.

5 6. A method as claimed in Claim 5 for manufacturing a display screen of a colour display picture tube, wherein patterns of respective phosphor elements are provided on the photosensitive composition layer by successively making respective patterns of the photosensitive composition layer sticky as a result of exposure to
10 light, contacting the exposed photosensitive composition layer with particles of a respective phosphor, and removing the non-adhering particles of the respective phosphor.

 7. A method as claimed in Claim 6, wherein a black matrix film pattern of particles of a light-absorbing substance is
15 provided on the photosensitive composition layer by making portions of the layer corresponding to the matrix pattern sticky as a result of exposure to light, contacting the exposed layer with particles of the light-absorbing substance, and removing the non-adhering particles of the light-absorbing substance.

20 8. A method as claimed in Claim 6 or Claim 7, wherein the substrate is a picture tube face-plate.

 9. A method as claimed in Claim 9 wherein the face-plate comprises thermally toughened glass.

 10. A colour display picture tube having a display screen
25 manufactured by a method as claimed in any of Claims 6 to 10.

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Fig.1.

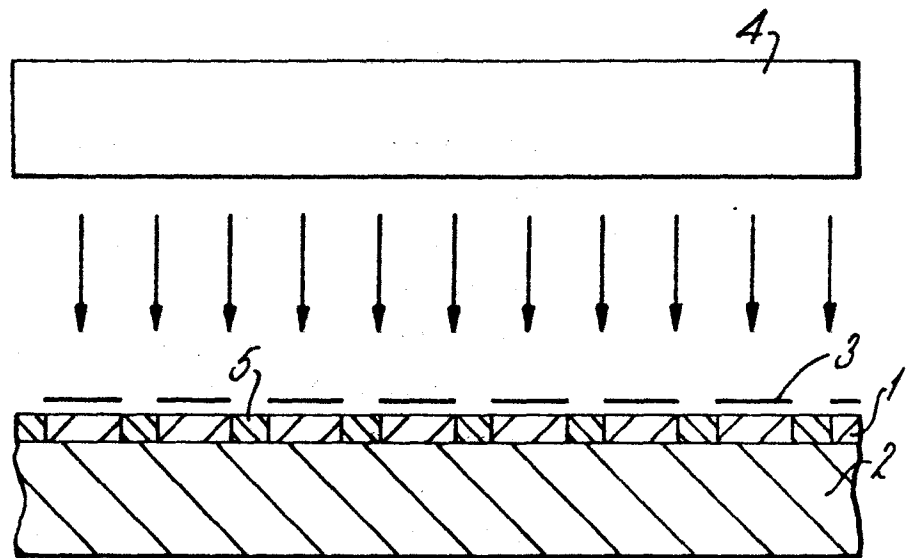


Fig.2.

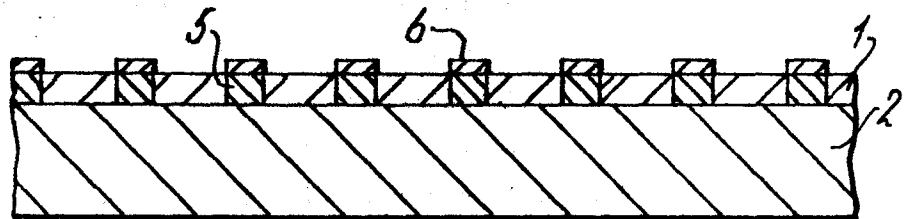


Fig.3.

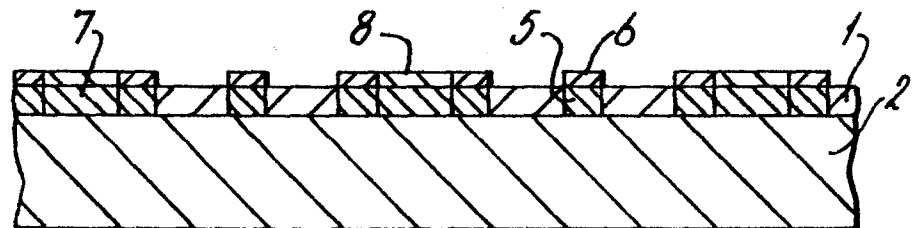


Fig.4.

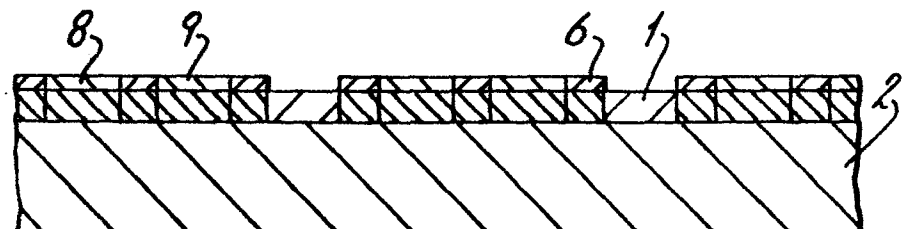


Fig.5.

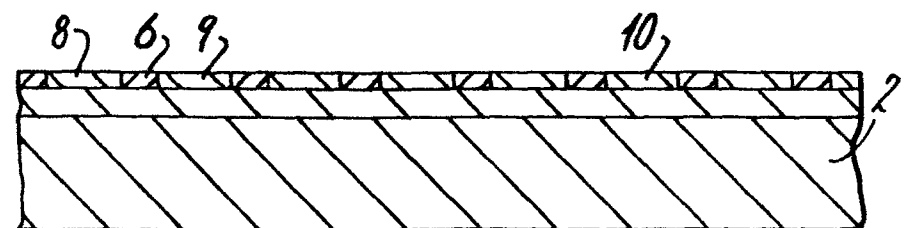


Fig.6.