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(54) Phosphor screen preparation.

(57) A method of forming a plurality of different interspersed arrays of phosphors on the inside of a faceplate for a colour cathode ray tube, in which method a first mask is formed by irradiating an electron sensitive resist layer through a shadow mask with an electron gun arrangement in a demountable tube substantially at the same positions with respect of the arrays as the electron gun arrangement which will energise those arrays in the completed tube, a layer of light blocking material is formed over the first mask, subsidiary masks (sub-masks) are sequentially formed in the blocking layer for respective ones of the arrays of phosphors, each sub-mask being formed by irradiating electron beam resist covering the blocking layer through the shadow mask with an electron beam corresponding to the beam which will energise the associated array in use of the tube and removing the irradiated resist and underlying blocking layer, and phosphor is fixed in

position in the sub mask.

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PHOSPHOR SCREEN PREPARATION

The present invention relates to a method of preparing a phosphor screen.

A colour cathode ray tube (CRT) comprises a screen on which arrays of different phosphors which emit differently coloured light in response to electron beams, are accurately positioned on a screen of the CRT with respect to holes (or slits) in a shadow mask. An electron gun arrangement produces a different electron beam for each colour. Many methods of making the arrays of phosphors are known.

U.S. Patent 4251610 (Tektronix Inc) discloses an illustrative method in which an opaque layer is first formed on the inner surface of holes in a black opaque layer. Assuming three differently "coloured" phosphors are to be used, three arrays of holes are produced in the opaque layer. This is done by coating the opaque layer with photo resist, and illuminating the coating through a shadow mask with light from a light source which simulates the three electron beams, developing the resist, etching the layer using the developed resist as a mask and then removing the resist.

Phosphor of one colour e.g. green is put into one of the arrays using the following process:-

A coating of photo resist is put over the entire opaque layer and the holes. The coating is exposed to ultra-violet (UV) light from a light source simulating the green electron beam through the shadow mask. The coating is then developed to expose the "green" array of holes leaving the two other arrays covered by resist. "Green" phosphor and photosensitive binder are put onto the screen. The phosphor and binder are exposed to ultra violet light through the screen to fix the green phosphor in the green holes. Excess phosphor, binder and photoresist are removed, leaving an array of green phosphor dots.

The process is repeated for the other colours. Each repetition begins with a new coating of photo resist which covers the previously laid-down phosphor, thus protecting the previously laid-down phosphor from cross-contamination.

Light beams travel in straight lines whereas electron beams follow paths which are controlled by magnetic and electrostatic fields. In order to accurately form the arrays of holes in the opaque layer, it is known to use the electron beams themselves. That is known inter alia, for example, from British Patent Application GB 2,176,647A (Rank Electronic Tubes Ltd), published on 31 December 1986.

In one illustrative method disclosed in GB 2,176,647A an opaque layer is first formed on the inner surface of the screen of a CRT. An array of

phosphor is laid down using the following process:-

The layer is coated with electron beam sensitive resist which is exposed to e.g. the "green" electron beam through a shadow mask. The electron beam resist is developed and the layer etched to produce an array of "green" apertures or holes thereon. "Green" phosphor plus photosensitive binder is applied and is exposed to UV light through the screen to fix the phosphor in the apertures. The electron beam resist is removed. A new coating of electron beam resist is then laid down and the process repeated for the or each other coloured phosphor. Although the method is effective, there is in practice some cross contamination of the phosphors which reduces colour purity. Also, making each set of the holes or apertures e.g. "green" in the opaque layer separately from the other sets e.g. "red" and "blue" holes with separate insertions of the mask introduces small inaccuracies which it is desired to reduce.

In another method proposed in GB 2,176,647A, three arrays of apertures are initially produced in the opaque layer using electron beam exposure of an electron beam sensitive resist which is removed. Then another electron beam resist is laid down exposed using e.g. the "green" electron beam, developed, and "green" phosphor and photosensitive binder fixed in the "green" apertures by UV irradiated through the holes in the black opaque layer. The or each other colour phosphor is fixed in its array of apertures in similar fashion. As in Tektronix USP 4251610, the UV light irradiates all the apertures in the opaque layer. In Tektronix, a layer of photo resist blocks the UV light in the apertures other than the apertures associated with the colour of phosphor being laid down. Electron beam resist however, is not normally absorbent enough to completely block the UV light. Consequently, the phosphor and photosensitive binder can be partly sensitized over the other holes which can cause contamination.

In accordance with one aspect of the present invention, it is desired to prepare a phosphor screen having accurate placement of the phosphors, and preferably also with reduced cross-contamination of the phosphors.

According to said one aspect, there is provided a method of forming a plurality of different interspersed arrays of phosphors on the inside of a faceplate for a colour cathode ray tube, in which method, a first mask is formed by irradiating an electron sensitive resist layer through a shadow mask with an electron gun arrangement in a demountable tube substantially at the same positions with respect to the arrays as the electron gun

arrangement which will energise those arrays in the completed tube, a layer of light blocking material is formed over the first mask, subsidiary masks are sequentially formed in the blocking layer for respective ones of the arrays of phosphors, each subsidiary mask being formed by irradiating electron beam resist covering the blocking layer through the shadow mask with an electron beam corresponding to the beam which will energise the associated array in use of the tube and removing the irradiated resist and underlying blocking layer, and phosphor is fixed in position in the sub-mask.

In an embodiment, each sub-mask and phosphor array is covered by the resist layer used for making the next sub-mask before the next sub-mask and phosphor array is formed, all the resist layers being retained until all the phosphor arrays are formed. The phosphors are fixed in position by irradiating them with light through the sub-masks. The light is preferably UV light and the blocking layer blocks UV light.

In accordance with another aspect of the present invention, it is desired to provide a method of preparing a phosphor screen in which difficulties of removing excess phosphor are reduced, whilst accurately placing different phosphors of good colour purity with respect to the electron beams which, in operation of the screen, will energise them.

According to said another aspect there is provided a method of forming a plurality of interspersed colour phosphor arrays on the inside of a faceplate for a colour cathode ray tube, comprising;

A) forming a conductive layer and an opaque layer on the inside of the faceplate;

B) providing a first layer of electron sensitive resist on the opaque layer;

C) assembling the faceplate into a demountable tube including a shadow mask and electron gun means for generating a plurality of electron beams and pumping down to vacuum;

D) irradiating said layer of resist through the shadow mask with the plurality of said beams to activate the layer of resist in positions corresponding to openings in the shadow mask and said plurality of beams;

E) disassembling the faceplate from the tube;

F) processing the faceplate utilizing the activated electron resist material to form in the opaque layer a mask having apertures at said positions;

G) providing a blocking layer of ultra-violet light blocking material over the mask;

H) providing a layer of electron beam resist on the blocking layer;

I) assembling the faceplate into the demountable tube including the shadow mask and the electron gun means and pumping down to vacuum;

J) irradiating said layer of resist through the shadow mask with one of said beams to activate the layer of resist in positions corresponding to openings in the shadow mask and said one of the beams;

K) disassembling the faceplate from the tube;

L) processing the faceplate utilizing the activated electron resist material and the blocking layer to form in the blocking layer and thus also in the opaque layer a mask having apertures at said positions irradiated by said one of the beams;

M) providing phosphor and photosensitive binder on the formed mask;

N) exposing said phosphor and photosensitive binder through said apertures to light from the other side of the faceplate so that portions thereof located in register with the apertures in the mask are fixed;

O) further processing the faceplate to form a first said array of phosphor dots of a first colour in register with said apertures;

P) providing a further layer of electron sensitive resist over the said blocking layer and over the said previous arrays of phosphors;

Q) repeating steps I) to P) above using a second one of said beams, to form a second said array of phosphors of a second colour;

R) The remaining resist is removed e.g. by baking;

S) The phosphor screen is lacquered and aluminised by conventional methods.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a side view in cross-section of a "demountable" cathode-ray-tube (CRT) for use in the present invention,

Figure 2 comprises Figures 2-1 to 2-13 which are partial schematic views in cross-section of a faceplate of the CRT illustrating different stages in the manufacture of a cathode-ray-tube screen, and

Figure 3 comprises Figures 3-1 to 3-6 which are partial schematic views in cross-section of a faceplate of the CRT illustrating different stages in another process for manufacturing a cathode-ray-tube screen.

Figure 1 illustrates a "demountable" CRT system, which accurately simulates the completed CRT, using the actual CRT faceplate 101 and its matching shadow mask 102 and shadow mask frame 103. These are mounted in the envelope 104, which may be made of metal, glass or ceramic and which is connected by a tube 105 to a

vacuum pump system 106. Inside the neck of the envelope 104 is mounted a multiple electron gun 108 and on the exterior of the neck 107 are mounted the CRT scan coils 109 by which the electron beams emitted by the electron gun 108 can be made to scan by the application of the appropriate voltage waveforms. For clarity only two electron beams are shown although any number of electron beams and their corresponding phosphor arrays may be used. In use, the whole assembly within the envelope 104 is vacuum tight, the faceplate 101 being joined to the envelope 104 by means of a gasket 110.

The process of manufacture of the phosphor screen will now be described with reference to Figures 2-1 to 2-13.

The faceplate 1 of the CRT is separated from the shadow mask 102 and an opaque coating 2 is applied. The coating which is conductive, may be reflective, for example aluminium, or may be a black coating, for example a layer of black chromium (which is non-conductive) together with a conductive material such as indium tin oxide or tin oxide. The black chromium is applied by evaporation in an oxidising gassy atmosphere by methods which are well known and long established. A first layer of electron sensitive resist 3 is then applied to the faceplate 1 for example by spinning. The resist layer is then hardened by baking. (The type of resist may be described as "positive" or "negative" according to whether it softens or hardens respectively under the action of an electron beam; for convenience the method here described is the process for the "positive" resist). Various types of electron sensitive resist may be used, for example, one comprising copolymers of methylmethacrylic acid and methacryloyl chloride and other methacrylates i.e. PM type resists. Alternatively, PMMA types of electron sensitive resist comprising polymethylmethacrylates in cellusolve acetate may be used. A particular commercially available electron sensitive resist which may be used is ISOFINE E-B positive resist grade P7.

The faceplate 1 and the shadow mask 102 are then assembled together and placed on the demountable CRT as in Figure 1. Appropriate voltages are applied and the resist 3 is exposed, through the shadow mask 102 to scanning electron beams from the directions indicated by the arrows in Figure 2-3 from all of the electron guns in the electron gun housing 108. Those parts of the resist 3 which receive the electron beam through the shadow mask holes become softened. The faceplate assembly is then removed from the demountable CRT and the resist layer 3 is treated with developer, whereupon the exposed dots or lines, as appropriate, are removed and the unexposed areas remain to produce an opaque layer 2

on the faceplate 1 with an apertured layer of developed resist 3 superimposed thereon.

The exposed parts of the opaque layer 2 are then etched away through the apertures or holes in the resist 3, and the unexposed parts of the opaque layer 2 are allowed to remain, as shown in Figure 2-4, thus forming a mask having apertures 5 therein. If the opaque layer 30 is black chromium then the etching agent used can be a mixture of ammonium ferric nitrate, perchloric acid and demineralised water. If aluminium forms the opaque layer 30 then this can be etched using dilute caustic soda. Thus, there is formed a mask containing apertures or holes, e.g. dots or lines, for red, green and blue emitting phosphors.

In the next step shown in Figure 2-5, the remaining layer of resist 3 and the apertures 5 are coated firstly with a blocking layer of material which blocks (or absorbs) ultra-violet light, and secondly with a layer of electron beam resist over the blocking layer. The coating is indicated by reference 6.

The blocking layer is for example a coating called Anti-Reflection Coating (ARC) obtainable from Brewer Science Inc. of (address please). ARC comprises heavily dyed polyimide and is a highly UV light absorbing coating. Another coating which is considered helpful is D ARC also available from Brewer Science Inc.

The blocking layer must be compatible with the electron beam resist, survive baking, and block UV light. To be compatible with the resist it must at least not inhibit the resist and preferably also be miscible with the resist. The faceplate 1 is then reunited with the shadowmask 102 and the assembly is placed on the demountable tube shown in Figure 1. The tube is pumped down to vacuum, and one, e.g. green, of the electron guns is energised to expose the resist 6 over the "green" apertures 5 to the "green" beam GB (Fig 2-6). The assembly is then removed from the tube and the resist 6 is developed. Developing the resist 6 removes the resist 6 from the "green" holes; in addition the ARC in the "green" holes may be simultaneously removed. Alternatively, the ARC can be removed from the "green" holes in a separate developing step. Thus, as shown in Fig 2-6, ARC and resist 6 is left in the "red" and "blue" holes and over the mask of black chrome.

A first phosphor material which emits a first colour, e.g. green, when bombarded by electrons, is then mixed with an U.V. sensitive photobinder, for example, polyvinylalcohol sensitised with ammonium bichromate, to form a mixture 7 which is slurried or settled onto the faceplate layers. This stage is shown in Figure 2-7. The faceplate 1 is exposed to U.V. from a source shone through the glass faceplate 1 in the direction of the arrows

shown in Figure 2-7 so that the parts of the photo resist and phosphor mixture 7 which are in the "green" apertures are polymerised. The presence of the ARC in the "red" and "blue" apertures blocks the UV light so that the green phosphor is not polymerised in the "red" and "blue" apertures. Washing away the excess phosphor mixture 7 with water or the appropriate solvent results in hardened phosphor dots or lines 9 remaining in the apertures 5 as shown in Figure 2-8. The remaining electron sensitive resist 6 is retained.

A second layer of electron sensitive resist 8 is now applied. The second layer of resist 8 covers the e.g. green phosphor and the first layer of resist and ARC 6. The faceplate 1 together with the shadow mask 102 are then assembled together and placed on the demountable CRT shown in Figure 1 and the first 6 and second 8 layers of resist are exposed, through the shadow mask 2 to a scanning electron beam from the direction indicated by the arrows in Figure 2-9. A different one of the electron guns is used to generate the beam RB in this case, for example, the gun responsible for the red content on the screen. Those parts of the first and second layers of resist 6, 8 which receive the electron beam RB through the shadow mask holes become softened and, as before, the faceplate assembly is then removed from the demountable CRT and the first and second resist layers 6 and 8 are treated with developer, whereupon the exposed dots or lines 35 of resist 6, 8 are removed and the unexposed areas remain. Additionally, where the apertures 35 of resist 6, 8 are removed, the ARC is also removed.

A second phosphor material 10 which emits a second colour, for example red when bombarded by electrons, is then mixed with U.V sensitive photobinder to form a mixture which is slurried onto the faceplate layers as before. The faceplate is exposed to U.V from a diffuse source shone through the glass faceplate 1 so that the parts of the photoresist and phosphor mixture which are in the apertures 35 are polymerised. The ARC prevents the mixture polymerising elsewhere. Developing the photobinder results in hardened phosphor dots or lines remaining in the apertures 10 as shown in Figure 2-12. The first layer of ARC and electron sensitive resist 6 is retained, and the second layer of resist 8 is also retained.

The process is repeated by applying a third layer of resist over the first and second layers and over the red and green phosphors. The third layer is exposed to the "blue" electron gun through the shadow mask, and developed, the opaque layer etched and "blue" phosphor fixed in the apertures as described above. The result is shown in Figure 2-13.

As shown in Figure 2-13 arrays of the red,

green and blue phosphors 33', 36 and 37 are arranged in interspersed relation on the faceplate 1 in registry with the points at which the red, green and blue electron beams, respectively, irradiate the faceplate 1 during use.

The second repeat of the process may be omitted if required to produce a screen with only two colours of phosphor. Similarly, further repeats may be necessary to produce a screen with more than three colours.

By retaining the ARC and resist layers, each phosphor to be fixed in position is protected from cross-contamination by the other phosphors.

Because all the sets of red, green and blue apertures are made at one time in the opaque layer which thus acts as a mask, using electron beams accuracy is increased.

Electron-sensitive resists are normally insufficiently absorbent to act as masks to the UV light themselves even when two or more layers of resist are present with U.V absorbing dye. The ARC however, makes possible the process in which all the sets of apertures are formed in the mask simultaneously.

Once all the required phosphors have been fixed in place on the screen, the various layers of resist are removed and the phosphors and opaque layer are lacquered and aluminised (12) in a manner known in the art as shown in Figure 2-13.

Whilst reference has been made to red, green and blue phosphors, other colours of phosphor can be used, e.g. yellow, magenta and cyan.

Figure 3 shows an alternative method, in accordance with a further aspect of the invention, for preparing a phosphor screen and which avoids irradiating phosphor through the black absorbing layer as shown in Figures 2-7 to 2-13. The starting point for the process shown in Figure 3 is a mask of e.g. black chromium formed on the faceplate 1 using the steps shown in Figures 2-1, 2-2, 2-3 and 2-4 as described above. The mask 2 is thus formed using the electron beams to produce three arrays of apertures for the red, green and blue phosphors.

The mask is covered in e.g. a slurry of green phosphor 7 as shown in Figure 3-2. The shadow mask 102 is then remounted on the faceplate and the assembly of faceplate and shadow mask is then exposed, in a known form of light house, to ultra violet light corresponding to e.g. the green electron beam. The light irradiates the phosphor slurry 7 through the shadow mask and activates the green phosphor at positions corresponding to positions which would be irradiated by the green electron gun in use of the faceplate. The faceplate is disassembled from the light house and shadow mask and the excess phosphor removed with water or the appropriate solvent leaving the green dots or

lines 9 as shown in Figure 3-4. The mask 2 and the green dots or lines are then coated with a thin layer or lacquer of material such as methymethacrylate, a slurry of e.g. red phosphor and photobinder 10 is then laid down. The shadow mask 102 is then reassembled into the faceplate, the assembly is then assembled into a light house and irradiated with ultra violet light corresponding to the red electron beam. After disassembly, the irradiated red phosphor is washed with water or the appropriate solvent leaving the red dot array, a further lacquer of methymethacrylate provided over the mask 2 and the red and green dots or lines and the process repeated for the third e.g. blue phosphor. Subsequently, the electron beam resist layers, lacquers and photosensitive binders are removed by baking.

The phosphor screen is lacquered and aluminised by conventional means.

Claims

1. A method of forming a plurality of different interspersed arrays of phosphors on the inside of a faceplate for a colour cathode ray tube, in which method a first mask is formed by irradiating an electron sensitive resist layer through a shadow mask with an electron gun arrangement in a demountable tube substantially at the same positions with respect of the arrays as the electron gun arrangement which will energise those arrays in the completed tube, a layer of light blocking material is formed over the first mask, subsidiary masks (sub-masks) are sequentially formed in the blocking layer for respective ones of the arrays of phosphors, each sub-mask being formed by irradiating electron beam resist covering the blocking layer through the shadow mask with an electron beam corresponding to the beam which will energise the associated array in use of the tube and removing the irradiated resist and underlying blocking layer, and phosphor is fixed in position in the sub-mask.

2. A method according to claim 1, wherein each sub-mask and phosphor array is covered by the resist layer used for making the next sub-mask before the next sub-mask and phosphor array is formed, all the resist layers being retained until all the phosphor arrays are formed.

3. A method according to claim 1 or 2, wherein the phosphors are fixed in position by irradiating them with light through the sub-masks.

4. A method according to claim 3, wherein the light is ultra violet light and the blocking layer blocks ultra violet light.

5. A method of forming a plurality of interspersed colour phosphor arrays on the inside of a faceplate for a colour cathode ray tube, comprising:

A) forming an opaque layer on the inside of the faceplate;

B) providing a first layer of electron sensitive resist on the opaque layer;

C) assembling the faceplate into a demountable tube including a shadow mask and electron gun means for generating a plurality of electron beams and pumping down to vacuum;

D) irradiating said layer of resist through the shadow mask with the plurality of said beams to activate the layer of resist in positions corresponding to openings in the shadow mask and said plurality of beams;

E) disassembling the faceplate from the tube;

F) processing the faceplate utilizing the activated electron resist material to form in the opaque layer a mask having apertures at said positions;

G) providing a blocking layer of ultra-violet light blocking material over the mask;

H) providing a layer of electron beam resist on the blocking layer;

I) assembling the faceplate into the demountable tube including the shadow mask and the electron gun means and pumping down to vacuum;

J) irradiating said layer of resist through the shadow mask with one of said beams to activate the layer of resist in positions corresponding to openings in the shadow mask and said one of the beams;

K) disassembling the faceplate from the tube;

L) processing the faceplate utilizing the activated electron resist material and the blocking layer to form in the blocking layer and thus also in the opaque layer a mask having apertures at said positions irradiated by said one of the beams;

M) providing phosphor and photosensitive binder on the formed mask;

N) exposing said phosphor and photosensitive binder through said apertures to light from the other side of the faceplate so that portions thereof located in register with the apertures in the mask are activated;

O) further processing the faceplate to form a first said array of phosphors of a first colour in register with said apertures;

P) providing a second layer of electron sensitive resist over the said blocking layer and over the said first array of phosphors; and

Q) repeating steps I) to P) above using a second one of said beams, to form a second said array of phosphors of a second colour.

6. A method of forming a plurality of interspersed colour phosphor arrays on the inside of a faceplate for a colour cathode ray tube, comprising forming an opaque layer on the inside of the

faceplate, providing a first layer of electron sensitive resist on the opaque layer, assembling the faceplate into a demountable tube including a shadow mask and electron gun means for generating a plurality of electron beams and pumping down to vacuum, irradiating said layer of resist through the shadow mask with the plurality of said beams to activate the layer of resist in positions corresponding to openings in the shadow mask and said plurality of beams, disassembling the faceplate from the tube, processing the faceplate utilizing the activated electron resist material to form in the opaque layer a mask having apertures at said positions, providing phosphor and photosensitive binder on the formed mask, assembling the faceplate into a light house including the shadow mask and exposing said phosphor and photosensitive binder through the shadow mask to light emulating one of said electron beams so that portions thereof located at positions corresponding to the positions which would be irradiated with said one of the electron beams are activated, further processing the faceplate to form a first said array of phosphors of a first colour in register with said apertures, providing a protective layer over the array of phosphors and repeating the steps above to form a second said array of phosphors of a second colour.

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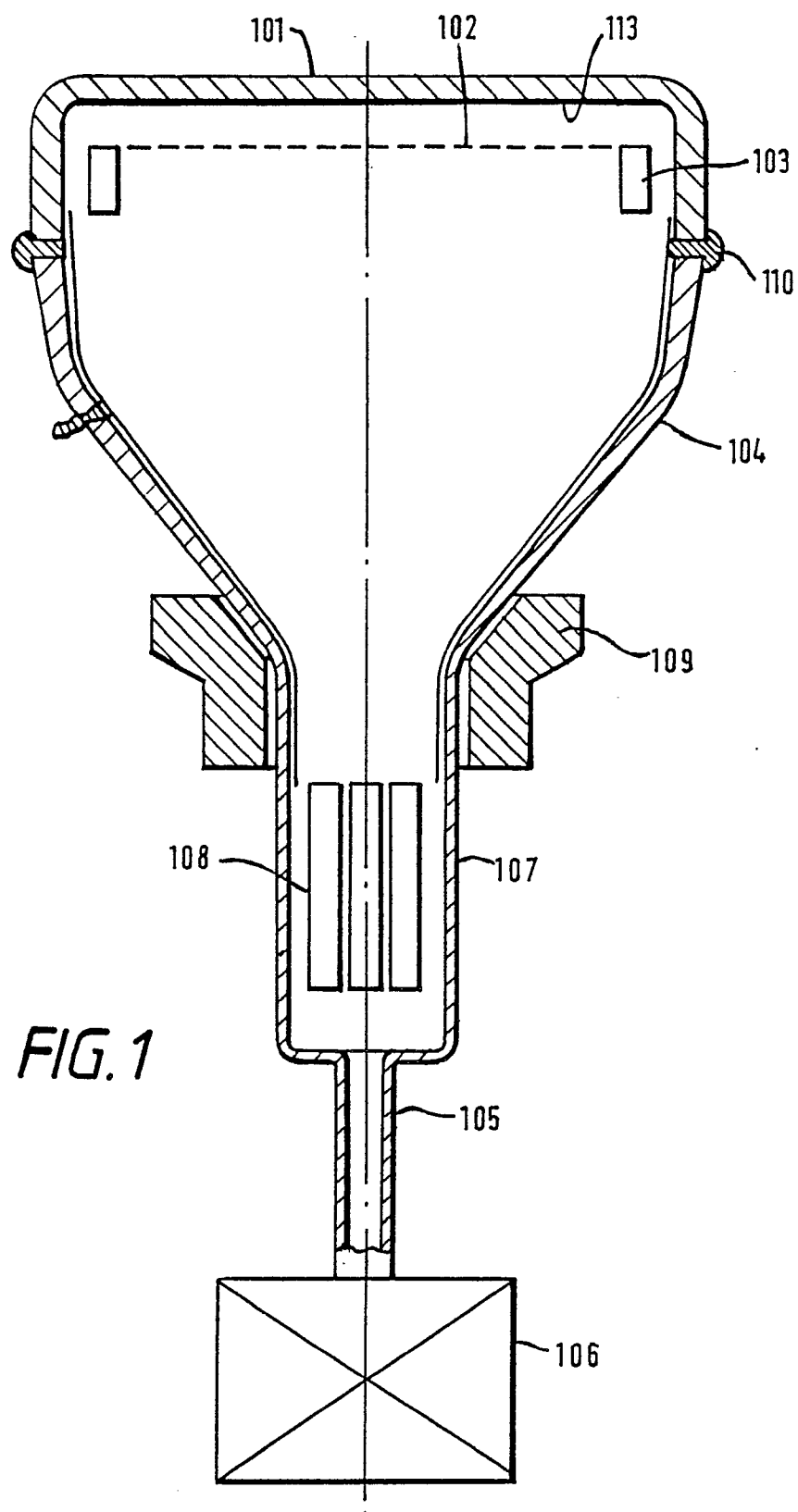


FIG. 2

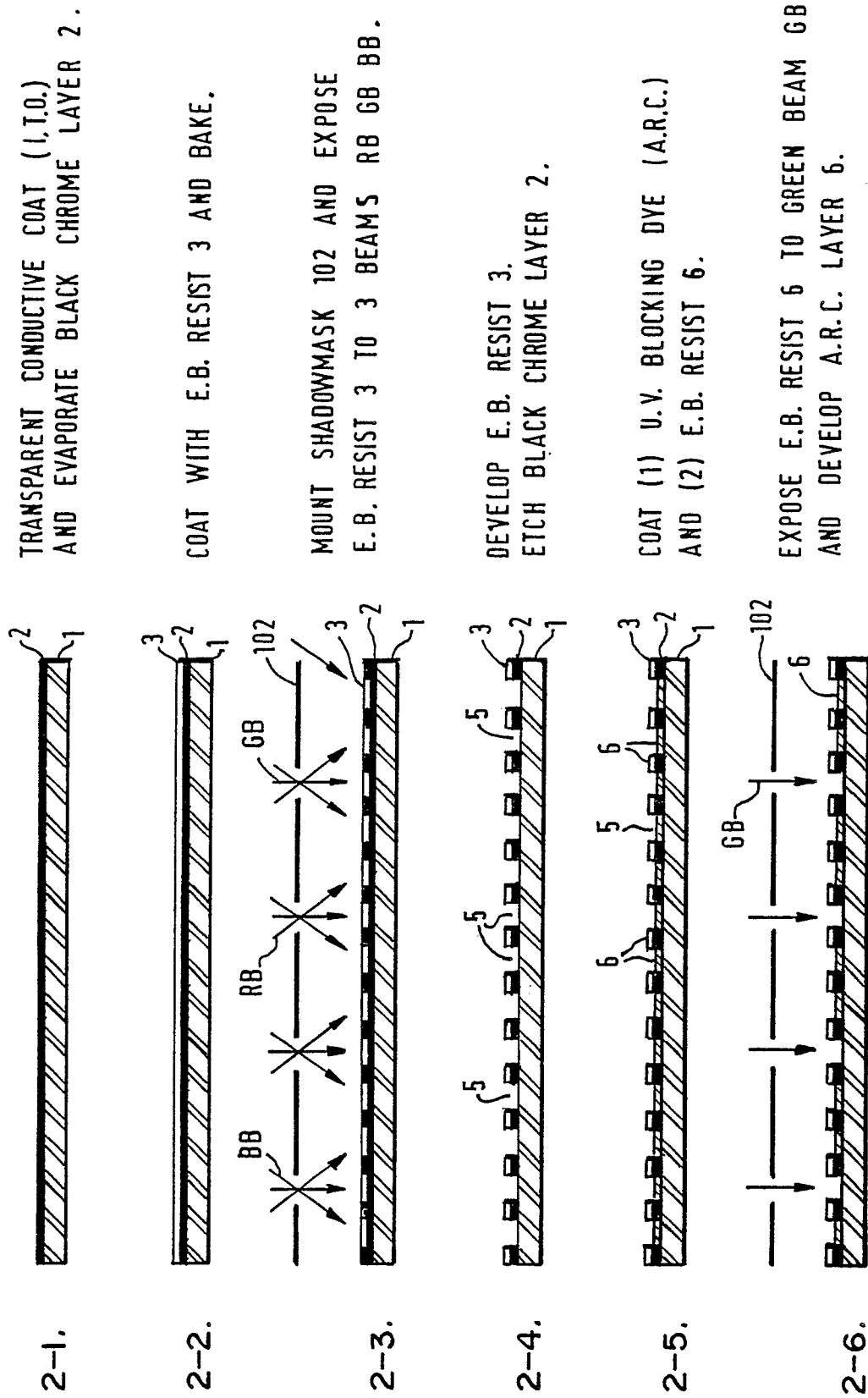


FIG. 2

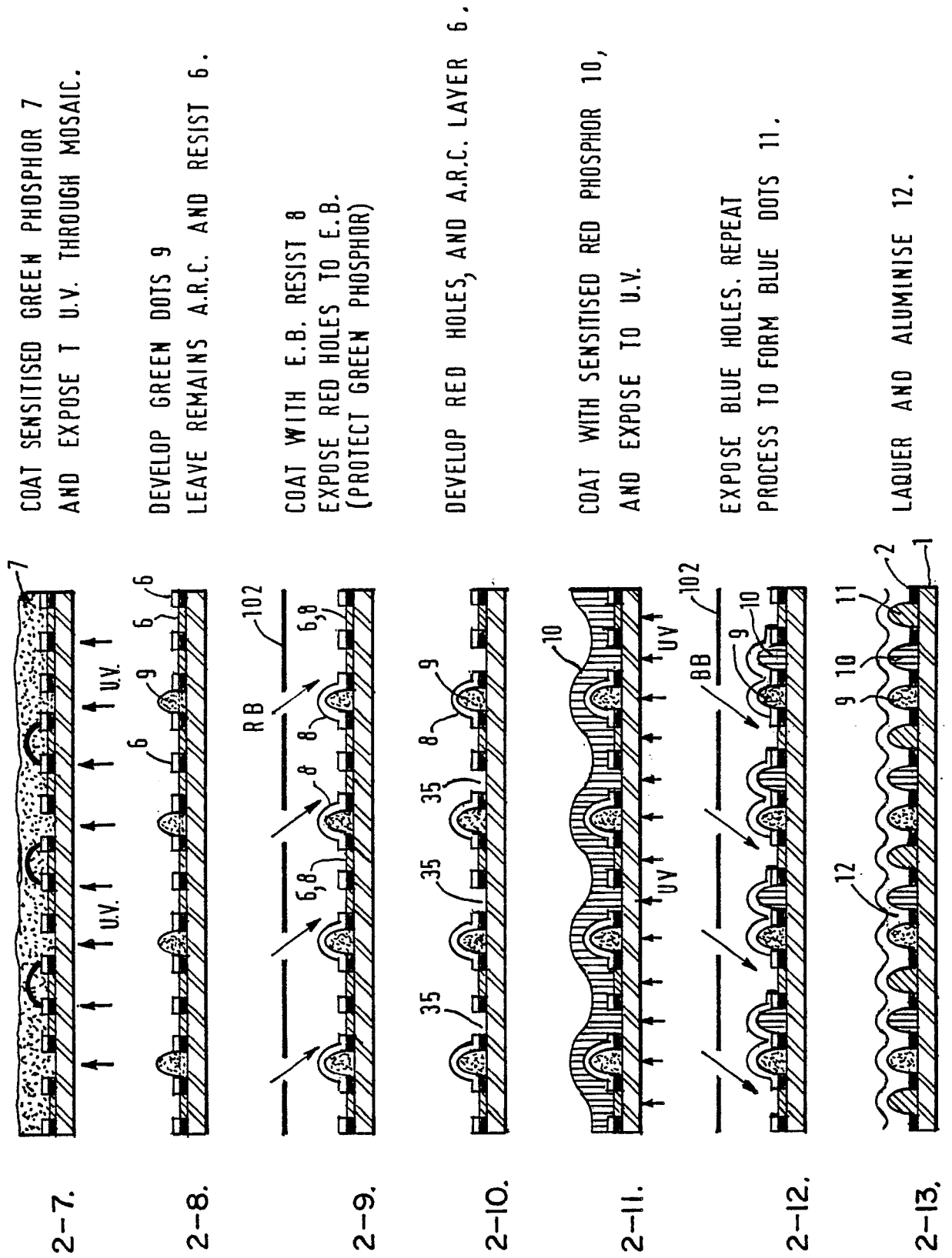
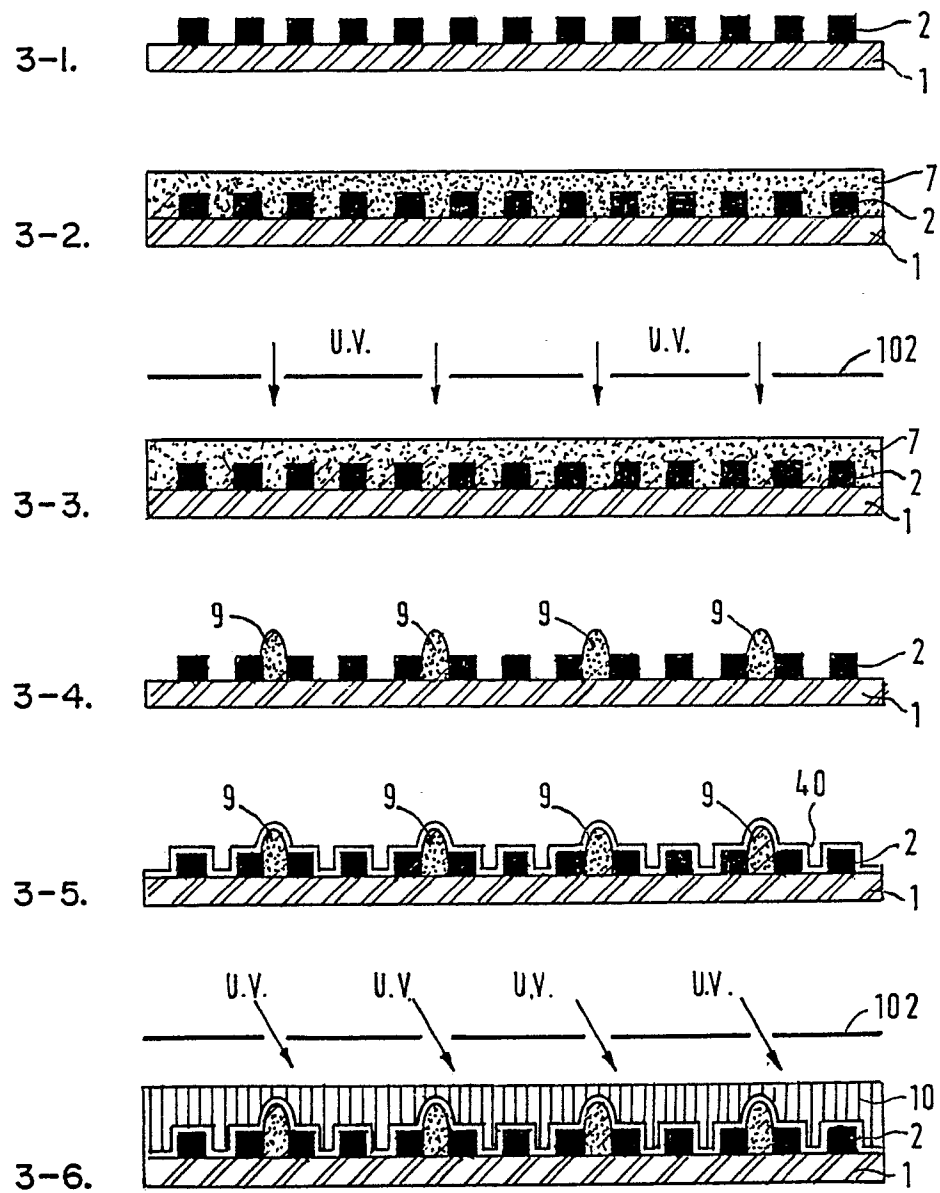


FIG. 3





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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D, A	<u>GB - A - 2 176 647</u> (RANK ELECTRONIC TUBES) * Page 2, line 41 - page 3, line 61; claims * --	1, 5, 6	H 01 J 9/227 G 03 F 7/26 G 03 C 5/00
A	PATENT ABSTRACTS OF JAPAN, unexamined applications, E field, vol. 8, no. 221, October 9, 1984 THE PATENT OFFICE JAPANESE GOVERNMENT page 121 E 271 * Kokai-no. 59-105 241 (SONY) * --	1, 5, 6	
A	<u>EP - A2 - 0 135 965</u> (NORTH AMERICAN PHILIPS CONSUMER ELECTRONICS) --		
A	<u>EP - A2 - 0 091 163</u> (NORTH AMERICAN PHILIPS CORPORATION) ----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.4) H 01 J 9/00 H 01 J 29/00
Place of search VIENNA		Date of completion of the search 08-08-1989	Examiner BRUNNER
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			