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(54) Method of producing a phosphor screen for a colour cathode ray tube.

(57) A method of producing a phosphor screen for a colour cathode ray tube in which the adherence of the phosphor screen to the face plate panel (11) of a colour cathode ray tube envelope (50) is improved by placing a retroreflective surface (50) opposite the face plate panel (11) during photolithographic forming of the screen in order to reflect transmitted light back onto those areas from which the light emerged, thereby effectively increasing the exposure of those areas.

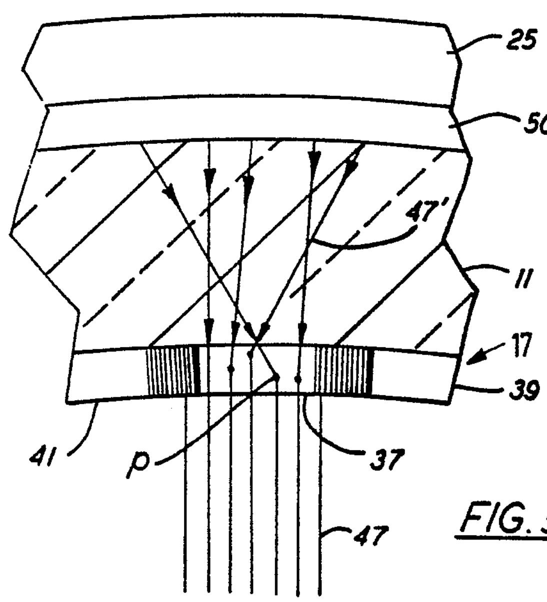

FIG. 5

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Method of producing a phosphor screen for a colour cathode ray tube.

The invention relates to a method of producing a phosphor screen for a colour cathode ray tube (CRT's), and more particularly relates to a method for increasing the adherence of such screens to the face plate panels of the tubes.

In producing colour CRT's for colour television and allied display applications, it is customary to form the phosphor screen photolithographically by forming three interlaced patterns of phosphor elements, one for each of the primary colours red, blue and green. This is accompished by successively exposing and developing three photoresist layers, each containing a different colour phosphor, using a single photomask and a single light source. For each exposure, the light source is moved, resulting in three different beam landing areas for each aperture of the photomask. See, for example, U.S. Patent Specifications 3,140,176; 3,146,368; and 4,070,596.

In forming such phosphor screens, it is known that too little light during exposure results in incomplete polymerization of the photoresist in the phosphor layer, and consequent poor adhesion of the phosphor elements to the face plate of the tube. Increasing the intensity of the light source to compensate for this often results in the unintentional enlargement of the phosphor elements due to spontaneous polymerization beyond the exposed areas.

In U.S. Patent Specification 3,953,621, adhesion of colour CRT phosphor screens is improved by increasing the dosage of light from the exposure table without increasing the intensity of light from the source. This is accomplished by providing a mirror to reflect light transmitted through the phosphor-photoresist layer and the face panel back onto the layer. However, the reflected light tends to scatter beyond the beam landing areas from which it emerged; resulting in relatively little additional exposure in these areas, as well as the undesired exposure of adjacent areas, causing a condition known as "poor wash".

Poor wash occurs because the adjacent areas become insolublised by the unintentional exposure, and thus cannot be removed by development. The residual phosphor contaminates these areas and consequently leads to degradation of colour purity of the resultant display.

Accordingly, it is an object of the invention to improve the adherence of the phosphor screen to the face panel of colour CRT"s.

It is another object of the invention to improve such adherence without increasing the intensity of the light source used to photolithographically form the screen.

It is another object of the invention to improve such adherence without scattering light beyond the intended beam landing areas.

According to the present invention there is provided a method for producing a phosphor screen for a colour cathode ray tube, the method comprising photolithographically disposing an array of phosphor elements of at least two alternating colours on the interior surface of a face plate panel, which will constitute a part of a cathode ray tube envelope, the array being formed by passing light through an adjacent aperture mask to expose portions of photosensitive phosphor layers on the face plate panel corresponding to the aperture array, and developing the layers to remove the unexposed portions, characterized in that during exposure a retroreflective device or a phase conjugate device is placed opposite the exterior surface of the face plate panel to reflect transmitted light back onto those portions of the layers from which such light was transmitted, whereby the exposure dosage of the layers is effectively increased.

By means of using the retroreflective device or the phase conjugate device the transmitted light is reflected back onto those portions of the layers from which such light was transmitted, regardless of the angle of incidence on the reflective surface.

Using a retroreflective surface of small spheres, up to a 20 percent increase in light dosage to the photoresist, without increase in lamp power, has been achieved.

The present invention will now be explained and described, by way of example, with reference to the accompanying drawings, wherein:

Fig. 1 is a diagram representing ray traces through a mask aperture in the apparatus of Fig. 3;

Figs. 2(a) to (1) are diagrams representing the steps of the photolithographic process used to produce phosphor screens according to an embodiment of the invention;

Fig. 3 is a cross-section view showing the maskpanel assembly of a colour cathode ray tube positioned on a light exposure apparatus, with a reflecting surface positioned above the assembly;

Fig. 4 is a sectional enlargement illustrating a portion of the panel and associated reflective surface of Fig. 1;

Fig. 5 is a further enlargement showing one phosphor element in association with a retroreflective surface which has replaced the reflective surface of Fig.2;

Fig. 6 is a diagram representing ray traces through a sphere, an element capable of forming a retroreflective surface suitable for use in the method in accordance with the invention; and

Figs. 7(a) and (b) are diagrams representing ray traces through two different alternative elements suitable for use in forming a retroreflective surface.

Currently, most of the colour CRTs for colour television employ phosphor screens composed of an array of vertically oriented alternating red, blue and green stripes of phosphor material. The stripes are all formed photolithographically through a single aperture mask having vertically elongate slot-shaped apertures oriented in vertical rows.

In the photolithographic process employed, an aqueous photoresist material, such as polyvinyl alcohol, sensitized with a dichromate, which becomes insoluble in water upon exposure to a source of actinic radiation such as a light, is exposed through a patterned mask, and then developed by washing with water to remove the unexposed portions and leave the exposed pattern. By employing an elongate light source having a length several times that of a single aperture, the shadows cast by the bridges of mask material between the vertically adjacent apertures are almost completely eliminated, resulting in a pattern of continuous vertical strips. In addition, by making multiple exposure, a single aperture row can result in multiple strips. This is illustrated in Fig. 1 in which movement of the light source to three different locations, indicated by the three different strips 250, 270 and 290, results in three different strips 170, 171 and 172, through a single aperture row 490a in mask 40.

As is known, colour screens for colour CRTs can be made either with or without a light absorbing matrix surrounding the phosphor elements. Such a matrix is gnerally thought to improve contrast and/or brightness of the image display.

Referring now to Fig. 2, the screen is depicted during the various steps of a preferred embodiment of the photolithographic process in which prior to the formation of the phosphor array, a light-absorbing matrix is first formed by successively exposing a single photoresist layer 60 to a source of actinic radiation from three different locations through the mask, to result in insolubilised portions 60a and 60b, 61a and 61b, and 62a and 62b (Figs. 2(a), 2-(b) and 2(c). The exposed resist is then developed to remove the unexposed portions and leave an array of photoresist elements corresponding to the contemplated phosphor pattern array (Fig. 2(d)). Next, a light-absorbing layer 70 is disposed over the array, (Fig. 2(e)), and the composite layer is developed to remove the photoresist array and overlying light-absorbing layer, leaving a matrix 71 defining an array of windows corresponding to the contemplated phosphor pattern array (Fig. 2(f)). Because the exposed resist is insoluble in water, a special developer is required for this step, such as hydrogen perioxide or potassium periodate, as is known.

Next, phosphor layers are formed over the windows as follows. First, a layer of a red phosphor and photoresist 72 is disposed over the matrix layer 71 and exposed (Fig. 2(g)), and developed to result in red elements 72a and 72b (Fig. 2(h)). This procedure is then repeated for the blue and green phosphors (Figs. 2(i) through (1)) to result in the phosphor array having alternating red (72a and b), blue (73a and b), and green (74a and b) stripes.

Referring now to Fig. 3, there is illustrated a face plate panel 11 of a colour cathode ray tube having an aperture mask 13 positioned adjacent to the face panel 11 by means not shown. An opaque matrix 15, disposed on the interior surface of the viewing area of the face panel 1, defines windows corresponding to the apertures of the mask 13. A coating 17 of a negative photoresist material and particles of an associated phosphor is disposed over matrix 15 in preparation for the formation of one set of pattern elements comprising the patterned screen structure. As shown, the mask-panel assembly 19 is positioned on an optical exposure apparatus 21 including light source 23 for exposing the coating 17 through the apertures in the mask over the window areas of the matrix. Positioned above the panel 11 is a substrate member 25 having surface 27 facing the panel, which is contoured to correspond with the exterior contour 29 of the panel. Disposed on the surface 27 is a layer 31 of a light reflective medium. In U.S. Patent Specification 3,953,621 this layer 31 is preferably continuous and may be formed, for example, by vapor deposition of a reflective material such as aluminum, silver or rhenium.

Substrate movement means 33 enables positioning of the reflective medium against the exterior surface of the panel 11 prior to exposure and removal therefrom after exposure, such movement being necessitated to facilitate placement and removal of the panels for exposure. While vertical movement is shown, other forms such as angular movement, e.g., a side oriented hinge, may also be appropriate.

Fig. 4 shows an enlarged portion of the panel 11, the associated matrix 15 and coating 17, and a contiguous reflective medium 31 of a type disclosed in U.S. Patent Specification 3 953 621. Pattern elements 37 of the screen structure are being exposed in coating 17. Pattern elements 39 and 41 respectively, have been previously disposed between respective window areas of matrix 15. The third pattern areas 37 are receiving rays 47 of light which have traversed the mask apertures, not shown, to effect desired polymerization of the photoresist. A portion of the rays 47 traverse the phosphor and associated coating, while others are randomly scattered from points p within the coating. Those rays which traverse the panel 11 are reflected back by reflective medium 31, thereby producing reflected rays 47′. Depending upon the angle of incidence of rays 47 on medium 31, the reflected rays 47′ strike areas 37 to enhance the exposure of those areas, or may land on matrix 15 or on adjacent areas 39 and 41, leading to a condition known as "poor wash". That is, during development, portions of these adjacent areas remain to contaminate the other phosphor colours, leading to a degradation in colour purity of the resultant display image.

Referring now to Fig. 5, another enlargement of the cross-section of Fig. 4 showing one area 37 and portions of adjacent areas 39 and 41 of coating 17 is shown. However, the reflective medium 31 of the prior art has been replaced by retroreflective surface 50. Due to the properties of a retroreflective surface, all of the scattered rays return along substantially the same path or a slightly displaced parallel path, regardless of the angle of incidence of the ray on the surface 50. This condition has the beneficial result of causing essentially all of the transmitted rays, whether scattered or not, to return to the area 37 and enhance its exposure, thus improving the adherence of the phosphor element to the surface of the face panel 11. In addition, this condition prevents the spurious landing of scattered rays on adjacent areas 39 and 41, thus avoiding the occurrence of poor wash.

In one embodiment of the invention, a simple retroreflective surface comprises a layer of microspheres on a supporting substrate. As shown in Fig. 6, each sphere has the ability to reverse the direction of an incoming ray to a parallel path which is offset from the incoming ray by an amount which is determined primarily by the size of the sphere, and to a lesser extent, by the angle of incidence of the incoming ray.

In general, employing microspheres having diameters on the order of about 0.0254 mm (0.001 inch) to 0.254 mm (0.01 inch) results in offsets of the retroreflected beam from the incident beam which are essentially negligible. That is, the advantage of increased adherence without accompanying poor wash is achieved using a retroreflective surface having microspheres within the above size range. Using such a retroreflector, up to a 20 percent increase in light dosage to the layer of phosphor and photoresist, without increasing lamp power or exposure time, has been achieved.

While it is not essential that the retroreflective surface be in contact with the exterior surface of the face panel during exposure, such contact is preferred in that it tends to reduce attenuation of the light by reducing the number of surfaces through which the rays must travel. Other types of retroreflective elements include the cube corner, and the "cat's eye", ray traces of which are shown in Figs. 7(a) and (b), respectively. Some mass produced large area retroreflectors employ a hybrid of the "cat's eye" and spherical elements. Another type of simple retroreflective surface is comprised of right angle corners. A device employing such a surface is shown in U.S. Patent 4,588,258.

More sophisticated than simple retroreflectors are so-called phase-conjugate structures which have the ability to reverse the direction of light waves, and even to amplify these waves. Thus, the effective reflectivity can be increased to very high numbers, well above 100 percent. This amplification feature enables reduction of the power of the light source, enabling better definition (sharper beam edges) than for a higher power source. Some of these structures are described, for example, in Optical Phase Conjugation, SCIENTIFIC AMERICAN, Vol. 293, No. 6, p. 54 (1985), and Application of Optical Phase Conjugation, SCIENTIFIC AMERICAN, Vol. 254, No. 1, p. 74 (1986).

Claims

1. A method for producing a phosphor screen for a colour cathode ray tube, the method comprising photolithographically disposing an array of phosphor elements of at least two alternating colours on the interior surface of a faceplate panel, which will constitute a part of a cathode ray tube envelope, the array being formed by passing light through an adjacent aperture mask to expose portions of photosensitive phosphor layers on the face plate panel corresponding to the aperture array, and developing the layers to remove the unexposed portions,

characterised in that during exposure a retroreflective device or a phase conjugate device is placed opposite the exterior surface of the face plate panel to reflect transmitted light back onto those portions of the layers from which such light was transmitted, whereby the exposure dosage of the layers is effectively increased.

2. A method as claimed in Claim 1, characterized in that the retroreflective device comprises a layer of microspheres on a supporting substrate.

3. A method as claimed in Claim 2, characterized in that the diameter of the microspheres ranges from about 0.0254 mm (0.001 inch) to 0.254 mm (0.01 inch).

4. A method as claimed in Claim 2 or 3, characterized in that the microspheres are approximately equal in size.

5. A method as claimed in any one of Claims 1 to 4, characterized in that the device is placed in contact with the exterior surface of the face plate panel.

6. A colour cathode ray tube having a phosphor screen produced by the method as claimed in any one of Claims 1 to 5.

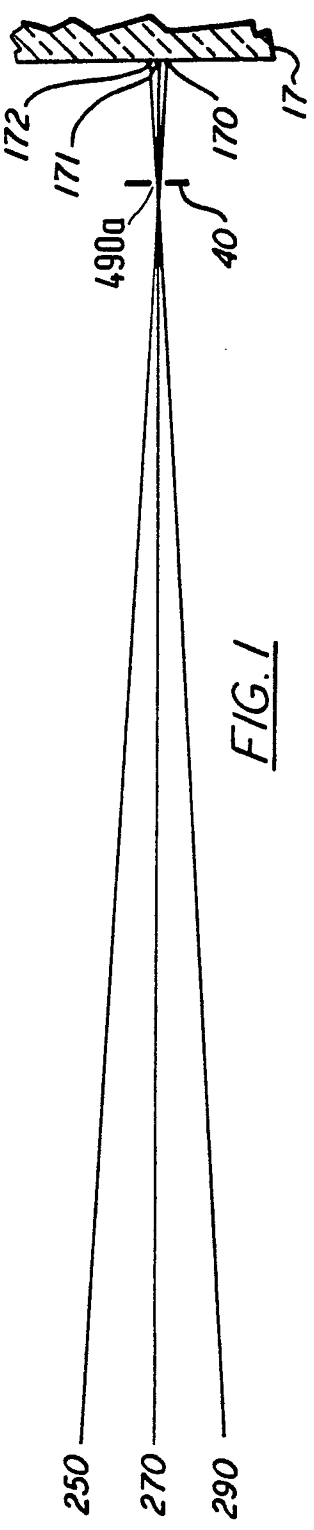


FIG. 1

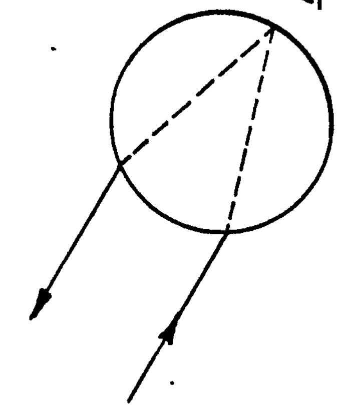


FIG. 6

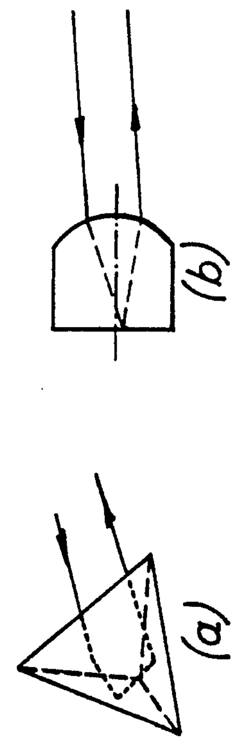


FIG. 7

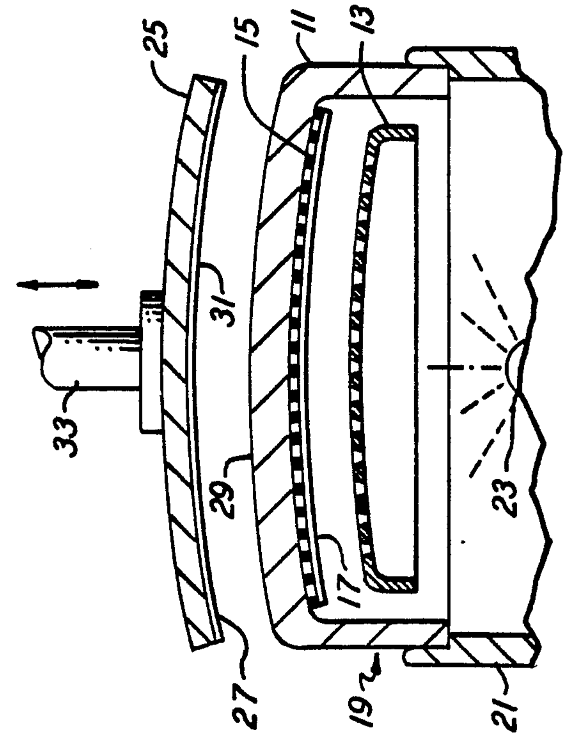


FIG. 3

FIG. 2 (a)

FIG. 2 (b)

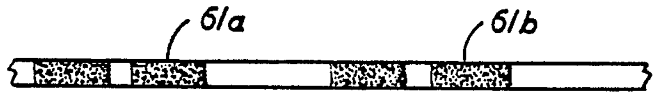


FIG. 2 (c)

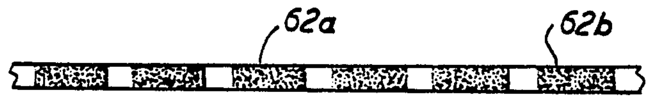


FIG. 2 (d)

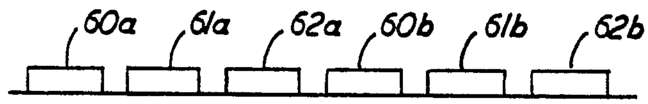


FIG. 2 (e)

FIG. 2 (f)

FIG. 2 (g)

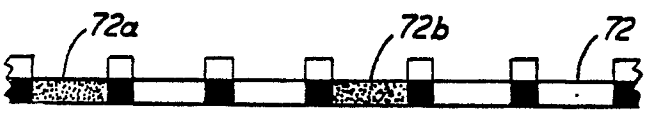


FIG. 2 (h)

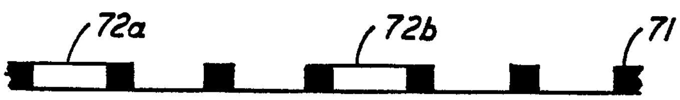


FIG. 2 (i)

FIG. 2 (j)

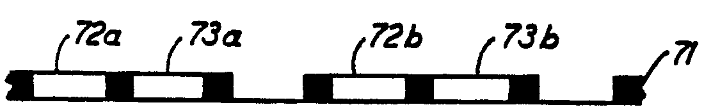


FIG. 2 (k)

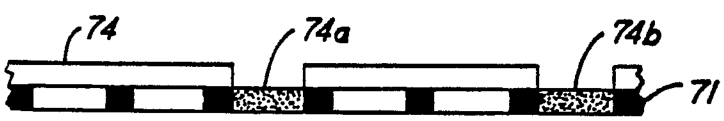
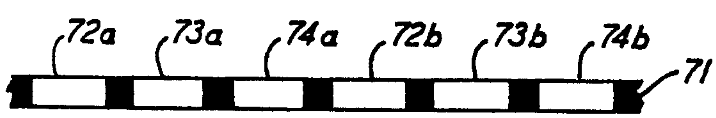


FIG. 2 (l)



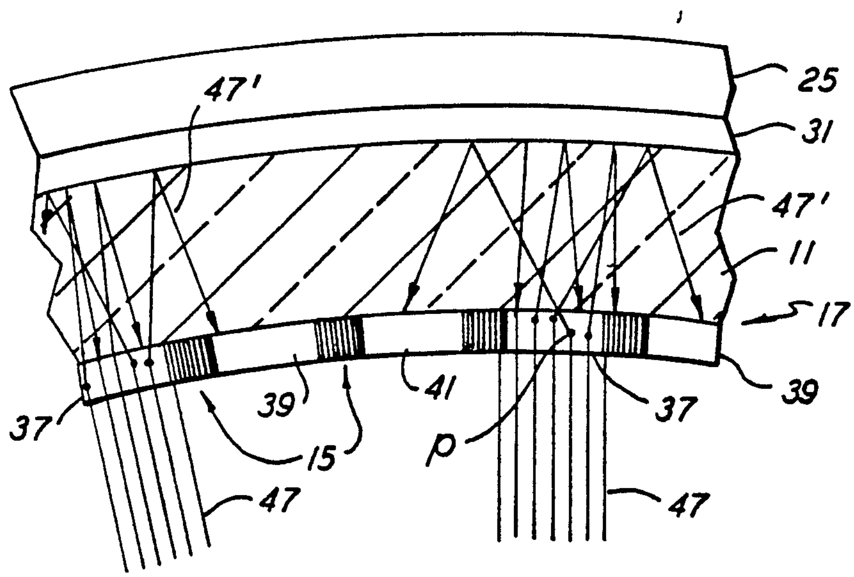


FIG. 4

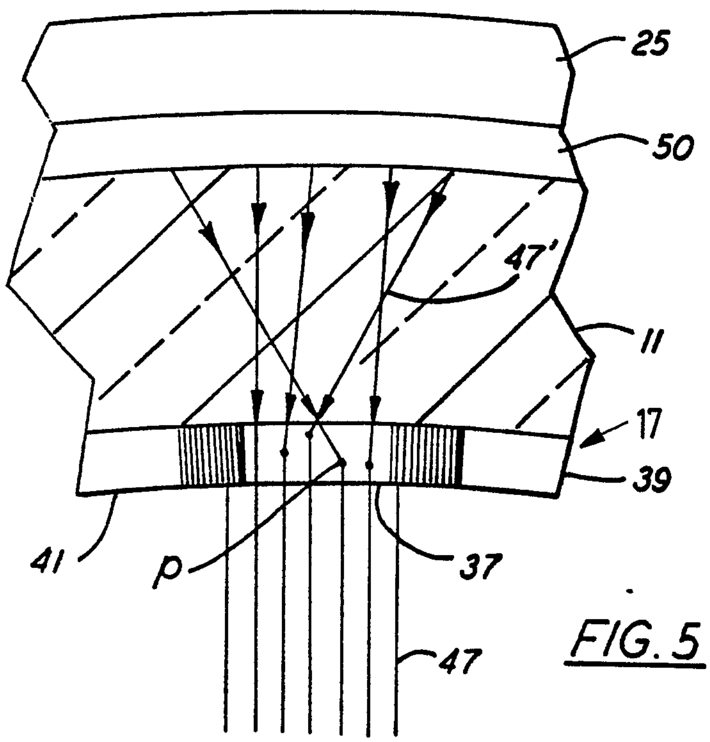


FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 20 1406

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	PATENT ABSTRACTS OF JAPAN, vol. 4, no. 75 (E-13)[557], 31st May 1980; & JP-A-55 41 677 (MATSUSHITA DENSHI KOGYO K.K.) 24-03-1980 * Whole abstract * ---	1,2,5, 6	H 01 J 9/227
X	PATENT ABSTRACTS OF JAPAN, vol. 4, no. 59 (E-9)[541], 2nd May 1980; & JP-A-55 28 255 (MATSUSHITA DENSHI KOGYO K.K.) 28-02-1980 * Whole abstract * -----	1,5,6	

DOCUMENTS CONSIDERED TO BE RELEVANT

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

H 01 J 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16-11-1987	DROUOT M.C.

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

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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