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(54) LIGHT EXPOSURE APPARATUS FOR MANUFACTURING COLOUR PICTURE TUBE

(71) We, HITACHI, LTD., a Corporation organised and existing under the laws of Japan of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, 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 light exposure apparatus, and more particularly to light exposure apparatus for forming a fluorescent screen on a colour television picture tube.

A colour picture tube is usually constructed so that a fluorescent screen, which is formed on the inner surface of the face plate of the tube by arranging thereon a plurality of phosphors of red, blue and green colours in the form of dots or stripes, is selectively excited through a colour selection electrode by means of electron beams emanating from an electron gun assembly, whereby to reproduce picture images.

The fluorescent screen is conventionally formed as follows: The light emitted by a light source is transmitted through a correction lens, which is used for the purpose of correcting the apparent position of the light source to expose to the light a photosensitive material containing phosphor material of one colour deposited on the inner surface of the face plate, the light also passing through a colour selection electrode (such as a shadow mask) which is disposed at a predetermined distance from the correction lens with a predetermined relation with respect to the tube face plate. As a result, the photosensitive material coated on the exposed portion of the face plate is exposed, whereby to form the fluorescent screen having desired dots or stripes arrangement.

The dimension of the dots or the width of the stripes formed on the face plate in this

manner is determined in accordance with the quantitative distribution of the light incident on the face plate, which is in turn determined by the required position for the dots or stripes on the face plate. Usually, for the purpose of obtaining the light distribution necessary to obtain the required position for the dots or stripes on the face plate, an illumination intensity correcting filter having a proper density distribution with respect to the incident light is disposed between the light source and the colour selection electrode.

The illumination intensity correcting filter having a proper illumination density distribution is generally prepared by a vacuum deposition technique or photographic process, and it is rather difficult to obtain the desired density distribution more especially, it is very difficult finely to adjust the density of the filter at local areas thereof.

More particularly, since the illumination intensity distribution desired to produce the fluorescent screen is not always symmetrical, the density distribution of the illumination intensity correcting filter would also be asymmetrical if it were to be made to correspond to the desired illumination intensity distribution, so that if such brightness correction filter were to be prepared by a conventional vacuum deposition technique or photographic process, the number of the process steps would be greatly increased. Even then a satisfactory filter having the desired density distribution cannot be obtained, in spite of a large increase in the number of the process steps. Accordingly, fine adjustment of the density of the filter at particular local areas thereof is almost impossible and hence accurate distribution of intensity the light incident on the face plate, by means of an illumination intensity correcting filter, has been deemed to be almost impossible.

Recently, colour picture tubes of the so-

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called "black matrix type", wherein the areas of the fluorescent screen except the portion of the phosphor dots or stripes are coated with graphite, have been commercially produced. In the tubes of this type it is of utmost importance to make the dimension of the phosphor dots or stripes as desirably uniform as possible for the purpose of decreasing non-uniform white, because the phosphor dots or stripes as a whole contribute to luminescence. It is thus necessary to correct the exposure light quantitative distribution in order to maintain the dimension of the phosphor dots or stripes at a definite value. For this reason, it is necessary more accurately to control the density distribution of the filter than in the prior art practice.

Accordingly, it is an object of this invention to provide light exposure apparatus provided with an improved illumination intensity correcting filter capable of forming the phosphor dots or stripes of a colour picture tube with the correct configuration and dimensions.

According to the present invention there is provided a light exposure apparatus comprising a light source, an illumination intensity correcting filter, a correction lens, and a casing wherein said filter and said lens are disposed in predetermined positional relationship with respect to one another and to a colour television picture tube face plate provided with a colour selection electrode, which are removably mounted on the casing to be exposed to light from the light source through said filter and said lens, wherein the effective surface area of said filter is notionally divisible into a predetermined number of mutually adjacent regions, each said region consisting of or including a discretely formed finite area of substantially uniform ability over that finite area, each said region having a mean light transmission ability per unit area discretely different from that of an adjacent said region, whereby in use the light transmission through said filter varies discontinuously over said filter area in substantial correspondence with a required distribution of intensity of light incident on said face plate.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1a is a longitudinal sectional view of one embodiment of the light exposure apparatus of this invention;

Fig. 1b is a longitudinal sectional view of another light exposure apparatus embodying this invention;

Fig. 2 is a front view of one example of the intensity correction filter embodying the invention;

Fig. 3 is a plot showing one example of the filter concentration distribution of the intensity correction filter shown in Fig. 2;

Fig. 4 is a front view of a modified intensity correction filter embodying the invention; and

Fig. 5 shows one example of the concentration of the dots of the intensity correction filter shown in Fig. 4.

A preferred embodiment of the light exposure apparatus illustrated in Fig. 1a comprises a main casing 1, a light source 2 disposed at the predetermined bottom portion of the casing 1, an illumination intensity correcting filter 3 disposed in the middle portion of the casing 1 at a predetermined distance from the light source 2, and a driving device 5 connected to the illumination intensity correcting filter 3 for imparting an oscillatory motion to the same. A correction lens 4 is disposed near the illumination intensity correcting filter 3 so as to cause the light from the light source 2 to travel along a path approximating the locus of the electron beam in the colour picture tube when it is actually used. The relationship between the positions between the illumination intensity correcting filter and the correction lens will be determined according to the initial design requirement of the light exposure apparatus. Then the exposure light A travels along a predetermined light path A to reach the fluorescent screen 7 coated on the inner surface of the face plate 6 through a colour selection electrode 8, thereby performing the desired light exposure. As shown in Fig. 1b, wherein like parts are designated with like reference numerals as Fig. 1a, another light exposure apparatus of this invention is shown, wherein the illumination intensity correcting filter is integrally formed together with the correction lens, the number of the apparatus components being thereby decreased, thus resulting in decrease of the number of manufacturing steps and simplifying the apparatus and the operation thereof.

Fig. 2 is a front view of one example of an intensity correction filter utilized in the light exposure apparatus of this invention. As shown, the effective surface of the illumination intensity correcting filter 21 is constituted by a combination of a plurality of filter elements having the desired light transmitting ability made of small glass elements, for example, arranged in a grid shape. In other words, the effective surface of the illumination intensity correcting filter 21 is divided into a plurality of small square regions x_{ij} , which are arranged in a grid. Respective filter regions x_{ij} ($i, j=1, 2, 3, \dots, n$) are manufactured and arranged to have predetermined light transmitting

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ability depending upon their positions on the effective surface of the filter. Accordingly the density distribution of the regions $x_{11}, x_{12}, \dots, x_{1n}$ of the illumination intensity correcting filter 21 shown in Fig. 3 taken along a line III—III is presented by a characteristics curve "a" in Fig. 3. In other words, as it is necessary to provide for the filter 21 an ideal density distribution characteristic "b" as shown in Fig. 3 along the section line III—III, the filter regions $x_{11}, x_{12}, \dots, x_{1n}$ respectively having light transmission characteristics commensurate with the density at respective points should be arranged along the section line III—III. The smaller the filter element is, the more accurate becomes the density distribution of the filter 21.

Fig. 4 is a front view of a modified illumination intensity correcting filter utilized in the light exposure apparatus of this invention. The illumination intensity correcting filter 41 shown therein comprises a transparent substrate such as glass and the effective surface 42 of the substrate provided with a plurality of opaque dots.

The construction of the remaining portions of the light exposure apparatus using this modified filter is the same as that shown in Fig. 2. The opaque dots 43 are prepared by vapour depositing opaque material, for example aluminum, on the surface of the substrate, and the density of the opaque dots on the filter 41 is determined by experiments or analytical calculations such that the mean rate of light transmission per unit area adjacent to the dots is equal to the desired value. Instead of varying the density of the dots having the identical diameter it is also possible to arrange at the same pitch dots of different configurations and dimensions. An example of average dot density per unit area taken along the line V—V of Fig. 4 is shown in Fig. 5, in which the same dots are arranged at different pitches.

The configuration of the opaque dots 43 may be circular, triangular, square, polygonal or linear.

In this manner, according to this invention, an appropriate exposure can be made by using light exposure apparatus utilizing an illumination intensity correcting filter having a desired illumination intensity distribution. Although in the first and second embodiments it is possible to obtain illumination intensity correcting filters having higher accuracies by using smaller segments or dots in an increased number, this results in the increase in the manufacturing steps as well as labour and time. In the first embodiment it is advantageous to divide the effective area of the filter into several hundred elemental

regions each less than about 2 mm square. Also in the second embodiment it is advantageous from the practical standpoint to make the pitch of the dots to be less than about 2 mm. With these dimensions, it is possible to eliminate grid shaped stripes due to the boundaries between adjacent elements or to the arrangement of the dots. Heretofore, the discussion has been made regarding the illumination intensity correcting filter formed with a plurality of preferably sized filter elements or provided with a plurality of desirably sized and pitched dots arranged on the effective surface thereof. However, it will be seen in the following description that an even more advantageous and effective light exposure apparatus can be achieved by imparting an oscillatory motion to the illumination intensity correcting lens. Although the preferable size of the filter elemental region or the desirable pitch of dots has been discussed from the practical standpoint so far, another element size or dots pitch can be preferable when the filter is used in conjunction with the improved light exposure apparatus provided with an oscillatory mechanism. In accordance with this aspect of the invention, a suitable oscillatory motion is imparted to the illumination intensity correcting filter to eliminate the undesirable boundary effect, for example, the stripes just mentioned. Thus, the filter 21 or 41 is oscillated in the pertinent direction, for example in the x-direction or in the y-direction or in both directions, for the purpose of eliminating said grid shaped stripe and of averaging the optical effect caused by the boundaries between the filter elements or by the inherent discreteness of the dots.

For producing this oscillatory motion any known driving device 5 can be applied. In Fig. 1 the oscillatory device comprises a supporting member 53 for the brightness correction lens, a cam mechanism 52 connected to said supporting member 53 and a motor 51, for driving the correcting filter in the proper direction. However, other devices are capable of providing the desired oscillating motion to the correcting filter. To improve the effect of such motion, in the aforementioned embodiments, it is desirable to make the amplitude of the motion (peak to peak) to be equivalent to length of one side of the filter elements or to the pitch of dots (in the equal pitch arrangement). The oscillatory motion should have a uniform speed. It is also possible to average the effect caused by the different optical characteristics of respective regions of the correcting filter by changing the periods of the motions in the x and y directions.

In the above, although the oscillatory

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5 motion in the direction of the x axis or y
axis or its combination is only discussed, it
should be noted that an oscillatory motion
in the radial direction of the lens or in an
arcuate direction about the lens axis is also
effective to eliminate the grid shaped
stripes. Further it should be noted that the
amplitude of the oscillatory motion is not
always required to be equivalent length of
one side of the filler element or the pitch of
dots, and that oscillation having a very tiny
amplitude is useful for this purpose. In
short, any proper oscillatory motion can be
effectively used in accordance with the
mode of dots or filter element arrangement
on the illumination intensity correcting
filter.

10 Although this method is relatively simple
because it is only necessary to impart an
oscillatory motion to said correcting filter,
it is extremely effective to reduce the
adverse effect mentioned above to a
negligible value.

15 Instead of using square shaped filter
elements it is also possible for the elements
to be triangular or hexagonal or the like.
The dimensions of the elements may be
uniform or varied in accordance with the
area having an equal light restricting
characteristics.

20 Further it will be clear that instead of
arranging opaque dots on the substrate it is
also possible to use transparent dots, with
opaque areas between them.

25 From the foregoing description it will be
clear that the invention provides light
exposure apparatus provided with an
illumination intensity correcting filter
having a desired density distribution which
can form a fluorescent screen of high
quality.

WHAT WE CLAIM IS:—

30 1. Light exposure apparatus comprising a
light source, an illumination intensity
correcting filter, a correction lens, and a
casing wherein said filter and said lens are
disposed in predetermined positional
relationship with respect to one another and
to a colour television picture tube face plate
provided with a colour selection electrode,
which are removably mounted on the
casing to be exposed to light from the light
source through said filter and said lens,
wherein the effective surface area of
said filter is notionally divisible into
a predetermined number of mutually
adjacent regions, each region consisting
of or including a discretely formed
finite area of substantially uniform
light transmission ability over that finite
area, each said region having mean light
transmission ability per unit area discretely

different from that of an adjacent said
region, whereby in use the light
transmission through said filter varies
discontinuously over said filter area in
substantial correspondence with a required
distribution of intensity of light incident on
said face plate.

2. Apparatus as claimed in claim 1,
wherein each said region consists of only
one said discretely formed finite area of
uniform light transmission ability over that
finite area, and wherein said regions are of
identical area to one another.

3. Apparatus as claimed in claim 2,
wherein said regions are regular polygons in
a regular pattern.

4. Apparatus as claimed in claim 3,
wherein said regions are squares in grid
pattern.

5. Apparatus as claimed in any one of
claims 2 to 4, wherein said filter comprises a
plurality of discretely formed filter
elements, said regions corresponding to the
effective surface areas of said elements.

6. Apparatus as claimed in claim 1,
wherein each said region includes a said
discretely formed finite area of
substantially uniform first light transmission
ability over that finite area, and the
remainder of each said region is of a
substantially uniform second light
transmission ability over that remainder
area.

7. Apparatus as claimed in claim 6,
wherein said regions are equal area squares
in a regular grid pattern, each said finite
area being one or more dots arranged
within a said square.

8. Apparatus as claimed in claim 7,
wherein each said finite area is a single dot,
the areas of the dots being different in
adjacent said regions.

9. Apparatus as claimed in claim 7,
wherein said finite areas are each one or
more dots of equal area, the effective
number of dots being different in adjacent
said regions.

10. Apparatus as claimed in any one of
claims 6 to 9, wherein said finite areas are
substantially opaque and the remaining
portions are substantially transparent.

11. Apparatus as claimed in any one of
claims 6 to 9, wherein said finite portions
are substantially transparent and the
remaining portions are substantially
opaque.

12. Apparatus as claimed in any one of
claims 1 to 11, wherein said filter is
integrally formed on said correction lens.

13. Apparatus as claimed in any one of
claims 1 to 12, wherein said filter is
mounted for oscillation.

14. Light exposure apparatus for the face

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5 motion in the direction of the x axis or y axis or its combination is only discussed, it should be noted that an oscillatory motion in the radial direction of the lens or in an arcuate direction about the lens axis is also effective to eliminate the grid shaped stripes. Further it should be noted that the amplitude of the oscillatory motion is not always required to be equivalent length of one side of the filler element or the pitch of dots, and that oscillation having a very tiny amplitude is useful for this purpose. In short, any proper oscillatory motion can be effectively used in accordance with the mode of dots or filter element arrangement on the illumination intensity correcting filter.

20 Although this method is relatively simple because it is only necessary to impart an oscillatory motion to said correcting filter, it is extremely effective to reduce the adverse effect mentioned above to a negligible value.

25 Instead of using square shaped filter elements it is also possible for the elements to be triangular or hexagonal or the like. The dimensions of the elements may be uniform or varied in accordance with the area having an equal light restricting characteristics.

30 Further it will be clear that instead of arranging opaque dots on the substrate it is also possible to use transparent dots, with opaque areas between them.

35 From the foregoing description it will be clear that the invention provides light exposure apparatus provided with an illumination intensity correcting filter having a desired density distribution which can form a fluorescent screen of high quality.

WHAT WE CLAIM IS:—

45 1. Light exposure apparatus comprising a light source, an illumination intensity correcting filter, a correction lens, and a casing wherein said filter and said lens are disposed in predetermined positional relationship with respect to one another and to a colour television picture tube face plate provided with a colour selection electrode, which are removably mounted on the casing to be exposed to light from the light source through said filter and said lens, wherein the effective surface area of said filter is notionally divisible into a predetermined number of mutually adjacent regions, each region consisting of or including a discretely formed finite area of substantially uniform light transmission ability over that finite area, each said region having mean light transmission ability per unit area discretely

different from that of an adjacent said region, whereby in use the light transmission through said filter varies discontinuously over said filter area in substantial correspondence with a required distribution of intensity of light incident on said face plate.

2. Apparatus as claimed in claim 1, wherein each said region consists of only one said discretely formed finite area of uniform light transmission ability over that finite area, and wherein said regions are of identical area to one another.

3. Apparatus as claimed in claim 2, wherein said regions are regular polygons in a regular pattern.

4. Apparatus as claimed in claim 3, wherein said regions are squares in grid pattern.

5. Apparatus as claimed in any one of claims 2 to 4, wherein said filter comprises a plurality of discretely formed filter elements, said regions corresponding to the effective surface areas of said elements.

6. Apparatus as claimed in claim 1, wherein each said region includes a said discretely formed finite area of substantially uniform first light transmission ability over that finite area, and the remainder of each said region is of a substantially uniform second light transmission ability over that remainder area.

7. Apparatus as claimed in claim 6, wherein said regions are equal area squares in a regular grid pattern, each said finite area being one or more dots arranged within a said square.

8. Apparatus as claimed in claim 7, wherein each said finite area is a single dot, the areas of the dots being different in adjacent said regions.

9. Apparatus as claimed in claim 7, wherein said finite areas are each one or more dots of equal area, the effective number of dots being different in adjacent said regions.

10. Apparatus as claimed in any one of claims 6 to 9, wherein said finite areas are substantially opaque and the remaining portions are substantially transparent.

11. Apparatus as claimed in any one of claims 6 to 9, wherein said finite portions are substantially transparent and the remaining portions are substantially opaque.

12. Apparatus as claimed in any one of claims 1 to 11, wherein said filter is integrally formed on said correction lens.

13. Apparatus as claimed in any one of claims 1 to 12, wherein said filter is mounted for oscillation.

14. Light exposure apparatus for the face

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5 plate of a colour television picture tube substantially as described herein with reference to Figure 1A together with either Figure 2 or Figure 4, or with reference to Figure 1B together with either Figure 2 or Figure 4, of the accompanying drawings.

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