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Projector

Abstract

A projector according to an aspect includes a light source device configured to emit white light including blue light, green light, and red light, a lens array including a plurality of lenses, a color filter including a blue filter configured to transmit the blue light, a green filter configured to transmit the green light, and a red filter configured to transmit the red light, a pixel electrode including a blue sub-pixel electrode configured to modulate the blue light transmitted through the blue filter according to image information and emit blue image light, a green sub-pixel electrode configured to modulate the green light transmitted through the green filter according to the image information and emit green image light, and a red sub-pixel electrode configured to modulate the red light transmitted through the red filter according to the image information and emit red image light, and a projection optical system configured to project the blue, green, and red image lights. The area of the second lens is larger than the area of the green filter and is larger than the area of the first lens and the area of the third lens.

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Background/Summary

(1) The present application is based on, and claims priority from JP Application Serial Number 2023-044352, filed Mar. 20, 2023, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

(2) The present disclosure relates to a projector.

2. Related Art

(3) In recent years, there has been known a projector including one liquid crystal panel as a light modulation device that generates, from color light, image light having a color of the color light, that is, a single plate type projector. For example, Chinese Utility Model Registration No. 212515320 (CN-UM-212515320) discloses a single plate type projector in which a light emitting diode (LED) is used as a light source. In the projector disclosed in CN-UM-212515320, a reflector, a reflection mirror, a collimate lens, a liquid crystal display functioning as a light modulation device, a condensing lens, and the like are disposed on an optical path of light emitted from an

LED light source.

(4) JP-A-7-191312 discloses a single plate type projector including a liquid crystal display functioning as a light modulation device and two microlens arrays. The liquid crystal display of the projector disclosed in JP-A-7-191312 includes a plurality of pixels between two transparent substrates. The plurality of pixels are arrayed at predetermined intervals in a direction parallel to plate surfaces of the transparent substrates. The two microlens arrays are disposed on an incident surface and an emission surface of the liquid crystal display. Light made incident on the liquid crystal display is collimated and is condensed on the pixels by microlenses of the microlens arrays disposed on the incident surface of the liquid crystal display. The light condensed on the pixels is modulated according to image information and emitted from the pixels as image lights. The lights emitted from the pixels are collimated by the microlenses of the microlens array disposed on the emission surface of the liquid crystal display.

(5) In the single plate type projectors disclosed in CN-UM-212515320 and JP-A-7-191312, light amount differences among red, green, blue color image lights generated by the liquid crystal display are not particularly considered. In the projector disclosed in JP-A-7-191312, differences among diameters of a plurality of microlenses for the plurality of pixels are not examined either. However, a human who is an observer observing an image and a video projected from the projector perceives green light with a wavelength near 555 nm as the strongest and brightest in a bright place such as the interior. Therefore, there has been a demand for measures for realizing, according to the visibility of a human observing the brightness of an image and a video projected from a projector, an image and a video visually recognized more brightly than an image and a video projected by the projectors of the related art.

SUMMARY

(6) According to an aspect of the present disclosure, a projector includes: a light source device configured to emit white light including blue light, green light, and red light; a lens array disposed on an optical path of the white light emitted from the light source device and including a plurality of lenses; a color filter disposed on an optical path of the white light emitted from the lens array and including a blue filter configured to transmit the blue light, a green filter configured to transmit the green light, and a red filter configured to transmit the red light; a pixel electrode disposed to face the color filter and including a blue sub-pixel electrode configured to modulate the blue light transmitted through the blue filter according to image information and emit blue image light, a green sub-pixel electrode configured to modulate the green light transmitted through the green filter according to the image information and emit green image light, and a red sub-pixel electrode configured to modulate the red light transmitted through the red filter according to the image information and emit red image light; and a projection optical system disposed on traveling paths of the blue image light, the green image light, and the red image light and configured to project the blue image light, the green image light, and the red image light. The plurality of lenses include a first lens that emits the white light toward the blue filter, a second lens that emits the white light toward the green filter, and a third lens that emits the white light toward the red filter. An area of the second lens is larger than an area of the green filter and is larger than an area of the first lens and an area of the third lens.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a schematic diagram showing a configuration of a projector in an embodiment.

(2) FIG. **2** is a schematic diagram of a lens array and a color filter of a light modulation device of the projector shown in FIG. **1**.

(3) FIG. **3** is a schematic diagram of the lens array and the light modulation device of the projector

shown in FIG. **1** and is a sectional view thereof in arrow view taken along a C**1**-C**1** line shown in FIG. **2**.

(4) FIG. **4** is a schematic diagram of the lens array and the light modulation device of the projector shown in FIG. **1** and is a sectional view thereof in arrow view taken along a C**2**-C**2** line shown in FIG. **2**.

(5) FIG. **5** is a perspective view of the lens array of the projector shown in FIG. **1**.

(6) FIG. **6** is a schematic diagram of the lens array and the color filter of the light modulation device of the projector in a first modification of the embodiment.

(7) FIG. **7** is a schematic diagram of the lens array and the color filter of the light modulation device of the projector in a fourth modification of the embodiment.

(8) FIG. **8** is a schematic diagram of the lens array and the color filter of the light modulation device of the projector in a fifth modification of the embodiment.

(9) FIG. **9** is a schematic diagram of the lens array and the light modulation device of the projector shown in FIG. **8** and is a sectional view thereof in arrow view taken along the C**1**-C**1** line shown in FIG. **2**.

(10) FIG. **10** is a schematic diagram of the lens array and the light modulation device of the projector shown in FIG. **8** and is a sectional view thereof in arrow view taken along the C**2**-C**2** line shown in FIG. **2**.

DESCRIPTION OF EMBODIMENTS

(11) An embodiment of the present disclosure is explained below with reference to the drawings. In the drawings, scales of dimensions are sometimes changed depending on components in order to clearly show the components.

(12) First, the embodiment of the present disclosure is explained with reference to FIGS. **1** to **5**. FIG. **1** is a schematic diagram showing a configuration of a projector **301** in the embodiment of the present disclosure. The projector **301** is an image display apparatus including one liquid crystal panel as a light modulation device and is a so-called single plate type projector. As shown in FIG. **1**, the projector **301** includes a light source device **10**, a pickup optical system **20**, a collimating lens **25**, an incident-side polarizing plate **30**, a lens array **40**, a light modulation device **50**, an emission-side polarizing plate **80**, a condensing lens **85**, and a projection optical system **90**.

(13) As shown in FIG. **1**, the light source device **10** includes a light emitting element **12** and a wavelength conversion element **14**. The light emitting element **12** is provided on a plate surface of a not-shown substrate. The light emitting element **12** is formed in a plate shape or a layer shape and includes plate surfaces **12***a* and **12***b*. A plan view shape of the plate surfaces **12***a* and **12***b* is, for example, a rectangle.

(14) The light emitting element **12** emits blue light BL from the plate surface **12***a* and a part of side surfaces. A peak wavelength of the blue light BL is included in, for example, a range of 455 nm to 465 nm. Note that a light emission wavelength band of the light emitting element **12** is, for example, 445 nm to 475 nm but is not limited to the wavelength band and only has to be a wavelength band including a wavelength of a blue component of image lights IM**1** and IM**2** explained below and an excitation wavelength of the wavelength conversion element **14**. The light emitting element **12** is, for example, a blue light emitting diode (LED).

(15) The wavelength conversion element **14** is provided on the plate surface **12***b* of the light emitting element **12** and stacked on the light emitting element **12**. The wavelength conversion element **14** has the same plan view shape and the same size as the plan view shape and the size of the light emitting element **12**, is formed in a plate shape or a layer shape, and includes plate surfaces **14***a* and **14***b*. The plate surface **14***a* of the wavelength conversion element **14** is in contact with the plate surface **12***b* of the light emitting element **12**.

(16) The blue light BL emitted from the plate surface **12***b* of the light emitting element **12** is made incident on the wavelength conversion element **14** from the plate surface **12***b*. The wavelength conversion element **14** is excited by at least a part of the incident blue light BL and emits yellow

light YL from the plate surface **14***b* as fluorescent light. A peak wavelength of the yellow light YL is included in, for example, a range of 530 nm to 570 nm. That is, the yellow light YL is light having a wavelength different from the wavelength of the blue light BL and having a color different from the color of the blue light BL. Specifically, the yellow light YL includes green light and red light and is color light for generating full-color image lights IM**1** and IM**2** in conjunction with the blue light BL.

(17) At least a part of the remainder of the blue light BL made incident on the wavelength conversion element **14** is transmitted through the wavelength conversion element **14** and emitted from the plate surface **14***b*. The wavelength conversion element **14** is formed by, for example, an yttrium aluminum garnet (YAG)-based ceramics phosphor and is, for example, YAG activated by cerium (Ce) (YAG:Ce.sup.3+). Note that the wavelength conversion element **14** may be formed by one kind of a material or may be formed by a material obtained by mixing particles formed by two or more kinds of fluorescent materials.

(18) The blue light BL and the yellow light YL emitted from the plate surface **14***b* of the wavelength conversion element **14** are combined and white light WL**1** is generated. That is, the wavelength conversion element **14** emits the white light WL**1** from the plate surface **14***b*.

(19) In the following explanation and the drawings referred to below, an axis parallel to an optical axis AX of the white light WL**1** emitted from the plate surface **14***b* of the wavelength conversion element **14** is described as Z axis. One side of the Z axis is described as +Z side and the other side of the Z axis is described as −Z side. An axis orthogonal to the Z axis is described as X axis. One side of the X axis is described as +X side and the other side of the X axis is described as −X side. An axis orthogonal to the X axis and the Z axis is described as Y axis. One side of the Y axis is described as +Y side and the other side of the Y axis is described as −Y side. A surface orthogonal to the Z axis and including the X axis and the Y axis is described as XY plane.

(20) The plate surfaces **12***a* and **12***b* of the light emitting element **12** and the plate surfaces **14***a* and **14***b* of the wavelength conversion element **14** are disposed in parallel to the XY plane. The plate surface **14***b* of the wavelength conversion element **14** configures an emission surface **10***s* of the light source device **10**. A light emission surface of the light source device **10** is equal to the area of the plate surface **14***b* of the wavelength conversion element **14**.

(21) The light source device **10** emits the white light WL**1** from the emission surface **10***s* to the +Z side along the Z axis. The white light WL**1** emitted from the light source device **10** is diverging light that spreads in the XY plane as the diverging light travels from the plate surface **14***b* of the wavelength conversion element **14** to the +Z side along the Z axis. The white light WL**1** is not specific polarized light but is nonpolarized light and is, for example, random polarized light. In FIG. **1**, polarized light parallel to the X axis and polarized light parallel to the Y axis among polarized lights included in the white light WL**1** are shown.

(22) The pickup optical system **20** is disposed on an optical path of the white light WL**1** emitted from the light source device **10**. The pickup optical system **20** is disposed further on the +Z side than the light source device **10** and disposed at an interval from the light source device **10** on the Z axis. Between the light source device **10** and the pickup optical system **20**, the white light WL**1** travels along the Z axis and is not deflected. Therefore, the pickup optical system **20** is disposed within a range including the light source device **10** on the X axis and the Y axis. The pickup optical system **20** moderately enlarges a beam diameter on the XY plane of the white light WL**1** made incident thereon and emits the white light WL**1** having a desired beam diameter to the +Z side along the Z axis.

(23) The pickup optical system **20** is configured with, for example, one plano-convex lens **22**. The center on the X axis and the Y axis of the plano-convex lens **22** is disposed on the optical axis AX of the white light WL**1**. An incident surface **22***a* of the plano-convex lens **22** is a flat surface parallel to the XY plane. An emission surface **22***b* of the plano-convex lens **22** is a curved surface convex to the +Z side. A diameter of the plano-convex lens **22** and a shape of the emission surface

22*b* are designed as appropriate according to a radiation characteristic, a spread angle, a divergence degree, and the like of the white light WL**1** made incident on the pickup optical system **20**.

(24) Note that the pickup optical system **20** may be configured with an optical element capable of generating the white light WL**1** having the desired beam diameter as explained above, may be configured with, for example, a biconvex lens or an aspherical lens instead of the plano-convex lens **22**, or may be an optical system obtained by combining a plurality of optical lenses.

(25) The collimating lens **25** is disposed on an optical path of the white light WL**1** emitted from the pickup optical system **20**. The collimating lens **25** is disposed further on the +Z side than the pickup optical system **20** and disposed at an interval from the pickup optical system **20** on the Z axis. Between the pickup optical system **20** and the collimating lens **25**, the white light WL**1** travels along the Z axis and is not deflected. Therefore, the collimating lens **25** is disposed within a range including the light source device **10** on the X axis and the Y axis. The collimating lens **25** collimates the white light WL**1** made incident thereon and emits the collimated white light WL**1** to the +Z side along the Z axis.

(26) The collimating lens **25** is configured with, for example, a Fresnel lens **27**. The center on the X axis and the Y axis of the Fresnel lens **27** is disposed on the optical axis AX. An incident surface **27***a* of the Fresnel lens **27** is a surface obtained by deleting an equal phase component of a lens curved surface designed according to a beam diameter and an intensity distribution on the XY plane of the white light WL**1** and a distance on the Z axis from a light emission position of the white light WL**1** to the incident surface **27***a* in the light source device **10**. The thickness of the equal phase component depends on a center wavelength of the white light WL**1** and a refractive index of the Fresnel lens **27**. When viewed along the Z axis, the surface obtained as explained above is disposed on the incident surface **27***a* in a concentric shape on the XY plane. In the Fresnel lens **27**, the difference between an inner diameter and an outer diameter centering on the optical axis AX of the lens curved surface divided by the thickness of the equal phase component decreases further away in the radial direction from the optical axis AX. An emission surface **27***b* of the Fresnel lens **27** is a flat surface parallel to the XY plane.

(27) Note that the collimating lens **25** is configured with an optical element capable of collimating the white light WL**1** as explained above and may be configured with, for example, a plano-convex lens or an aspherical lens instead of the Fresnel lens **27**. A beam region of the white light WL**1** emitted from the collimating lens **25** includes a modulation region of the light modulation device **50** explained below on the XY plane. The modulation region means a region where a plurality of pixels **64** of a pixel electrode **62** of the light modulation device **50** are disposed. Based on this, the collimating lens **25** has a diameter equal to or larger than dimensions on the X axis and the Y axis of the modulation region of the light modulation device **50** included in the single plate type projector **301**. Since the Fresnel lens **27** is used as the collimating lens **25**, the thickness on the Z axis of the collimating lens **25** is moderately suppressed.

(28) The incident-side polarizing plate **30** is disposed on an optical path of the white light WL**1** emitted from the collimating lens **25**. The incident-side polarizing plate **30** is disposed further on the +Z side than the collimating lens **25** and disposed at an interval from the collimating lens **25** on the Z axis. Between the collimating lens **25** and the incident-side polarizing plate **30**, the white light WL**1** travels along the Z axis and is not deflected. Therefore, the incident-side polarizing plate **30** is disposed within the same range as the range of the collimating lens **25** on the X axis and the Y axis. The incident-side polarizing plate **30** emits white light WL**2**, which is predetermined polarized light, in the white light WL**1** made incident thereon. The predetermined polarized light is, for example, P-polarized light or S-polarized light.

(29) The incident-side polarizing plate **30** is, for example, an absorption type polarizing plate **32** having sensitivity in a visible wavelength band. The center on the X axis and the Y axis of the polarizing plate **32** is disposed on the optical axis AX. An incident surface **32***a* and an emission surface **32***b* of the polarizing plate **32** are parallel to the XY plane.

(30) The lens array **40** is disposed on an optical path of the white light WL**2** emitted from the incident-side polarizing plate **30**. The lens array **40** is disposed further on the +Z side than the incident-side polarizing plate **30** and disposed at an interval from the incident-side polarizing plate **30** on the Z axis. Between the incident-side polarizing plate **30** and the lens array **40**, the white light WL**2** travels along the Z axis and is not deflected. Therefore, the lens array **40** is disposed within the same range as the range of the incident-side polarizing plate **30** on the X axis and the Y axis. The lens array **40** divides the white light WL**2** into a plurality of very small regions on the XY plane and condenses the white light WL**2** in each of the very small regions.

(31) The lens array **40** includes a plurality of microlenses **42** provided in the plurality of very small regions. The plurality of microlenses **42** are disposed side by side along the X axis and the Y axis. An incident surface **40**a of the lens array **40** is configured with incident surfaces of the plurality of microlenses **42**. An emission surface **40**b of the lens array **40** is a flat surface parallel to the XY plane. The plurality of microlenses **42** are explained below. Note that, in FIG. **1**, the plurality of microlenses **42** are omitted.

(32) The light modulation device **50** is disposed on an optical path of the white light WL**2** emitted from the lens array **40**. The light modulation device **50** is disposed further on the +Z side than the lens array **40** and disposed at an interval from the lens array **40** on the Z axis. Between the lens array **40** and the light modulation device **50**, the white light WL**2** travels along the Z axis and is not deflected. Therefore, the light modulation device **50** is disposed within the same range as the range of the lens array **40** on the X axis and the Y axis. The light modulation device **50** modulates the white light WL**2** made incident thereon according to an electric signal input from a not-shown image output device provided on the outside of the projector **301** and generates the full-color image lights IM**1** and IM**2**.

(33) The light modulation device **50** is configured with a color filter **52** and the pixel electrode **62**. The color filter **52** is formed in a plate shape. The center on the X axis and the Y axis of the color filter **52** and the center on the X axis and the Y axis of the pixel electrode **62** are disposed on the optical axis AX. An incident surface **52**a and an emission surface **52**b of the color filter **52** are parallel to the XY plane. The incident surface **52**a of the color filter **52** faces the emission surface **40**b of the lens array **40**.

(34) The color filter **52** includes a plurality of blue filters **54**B, a plurality of green filters **54**G, a plurality of red filters **54**R, and a light blocking region **56**. The blue filters **54**B transmit the blue light in the white light WL**2** made incident thereon. The green filters **54**G transmit the green light in the white light WL**2** made incident thereon. A peak wavelength of the green light is included in, for example, a range of 520 nm to 570 nm. The red filters **54**R transmit the red light in the white light WL**2** made incident thereon. A peak wavelength of the red light is included in, for example, a range of 590 nm to 640 nm. The light blocking region **56** blocks the white light WL**2** made incident thereon and does not transmit all of the blue light, the green light, and the red light.

(35) The pixel electrode **62** is thicker than the color filter **52** and is generally formed in a plate shape. An incident surface **62**a and an emission surface **62**b of the pixel electrode **62** are parallel to the XY plane. The incident surface **62**a of the pixel electrode **62** is in contact with the emission surface **52**b of the color filter **52**.

(36) The pixel electrode **62** includes the plurality of pixels **64**. The plurality of pixels **64** are disposed side by side along the X axis and the Y axis. The pixels **64** include blue sub-pixel electrodes **66**B, green sub-pixel electrodes **66**G, and red sub-pixel electrodes **66**R. Relative disposition of the blue filters **54**B, the green filters **54**G, the red filters **54**R, and the light blocking region **56** of the color filter **52** and relative disposition of the blue sub-pixel electrodes **66**B, the green sub-pixel electrodes **66**G, and the red sub-pixel electrodes **66**R of the plurality of pixels **64** of the pixel electrode **62** with respect to a first lens, a second lens, and a third lens of the lens array **40** are explained below.

(37) The not-shown image output device is electrically connected to the pixel electrode **62**. The

image output device is, for example, a computer or a tablet terminal. An electric signal supplied from the image output device to the pixel electrode **62** is converted into, by a circuit, a wire, and the like not shown in FIG. **1** included in the pixel electrode **62**, an electric signal corresponding to a modulation amount of color light to be modulated by each of the blue sub-pixel electrodes **66**B, the green sub-pixel electrodes **66**G, and the red sub-pixel electrodes **66**R of the respective pixels **64** and is supplied to the color sub-pixel electrodes.

(38) The blue sub-pixel electrodes **66**B, the green sub-pixel electrodes **66**G, and the red sub-pixel electrodes **66**R include, for example, switching elements configured with polysilicon thin film transistors (TFTs). The blue sub-pixel electrodes **66**B change, according to an operation of the switching elements corresponding to an electric signal input from the image output device, a polarization direction of the blue light transmitted through the color filters **54**B. Consequently, the blue sub-pixel electrodes **66**B modulate the blue light made incident thereon and emit blue image light. The green sub-pixel electrodes **66**G change, according to an operation of the switching elements corresponding to an electric signal input from the image output device, a polarization direction of the green light transmitted through the green filters **54**G. Consequently, the green sub-pixel electrodes **66**G modulate the green light made incident thereon and emit green image light. The red sub-pixel electrodes **66**R change, according to an operation of the switching elements corresponding to an electric signal input from the image output device, a polarization direction of the red light transmitted through the red filters **54**R. Consequently, the red sub-pixel electrodes **66**R modulate the red light made incident thereon and emit red image light.

(39) The blue image light emitted from the blue sub-pixel electrodes **66**B of the pixel electrode **62**, the green image light emitted from the green sub-pixel electrodes **66**G of the pixel electrode **62**, and the red image light emitted from the red sub-pixel electrodes **66**R of the pixel electrode **62** are combined for each of the pixels to be full-color image light IM**1**. The image light IM**1** is omitted in FIG. **1**. The image light IM**1** is explained below.

(40) The emission-side polarizing plate **80** is disposed on an optical path of the full-color image light IM**1** emitted from the light modulation device **50**. The emission-side polarizing plate **80** is disposed further on the +Z side than the pixel electrode **62** of the light modulation device **50** and is in contact with the light modulation device **50**. The emission-side polarizing plate **80** is disposed within the same range as the range of the light modulation device **50** on the X axis and the Y axis. The emission-side polarizing plate **80** emits the image light IM**2**, which is predetermined polarized light, in the full-color image light IM**1** made incident from the light modulation device **50**.

(41) The emission-side polarizing plate **80** is, for example, an absorption type polarizing plate **82** having sensitivity in a visible wavelength band. The center on the X axis and the Y axis of the polarizing plate **82** is disposed on the optical axis AX. An incident surface **82**a and an emission surface **82**b of the polarizing plate **82** are parallel to the XY plane. The incident surface **82**a of the polarizing plate **82** is in contact with the emission surface **62**b of the pixel electrode **62**.

(42) The condensing lens **85** is disposed on an optical path of the image light IM**2** emitted from the emission-side polarizing plate **80**. The condensing lens **85** is disposed further on the +Z side than the emission-side polarizing plate **80** and disposed at an interval from the emission-side polarizing plate **80** on the Z axis. Between the emission-side polarizing plate **80** and the condensing lens **85**, the image light IM**2** travels along the Z axis and is not deflected. Therefore, the condensing lens **85** is disposed within the same range as the range of the emission-side polarizing plate **80** on the X axis and the Y axis. The condensing lens **85** emits the image light IM**2** made incident thereon to the +Z side along the Z axis and condenses the image light IM**2** on the optical axis AX.

(43) The condensing lens **85** is configured with, for example, a Fresnel lens **87**. The center on the X axis and the Y axis of the Fresnel lens **87** is disposed on the optical axis AX. An incident surface **87**a of the Fresnel lens **87** is a flat surface parallel to the XY plane. An emission surface **87**b of the Fresnel lens **87** is a surface obtained by deleting an equal phase component of a lens curved surface designed according to a beam diameter and an intensity distribution of the image light IM**2** and a

distance on the Z axis from the emission surface **87***b* to the image light IM**2** in the projection optical system **90**. When viewed along the Z axis, the surface obtained as explained above is disposed on the emission surface **87***b* in a concentric shape on the XY plane. In the Fresnel lens **87**, the difference between an inner diameter and an outer diameter centering on the optical axis AX of the lens curved surface divided by the thickness of the equal phase component decreases further away in the radial direction from the optical axis AX.

(44) Note that the condensing lens **85** may be configured with an optical element capable of condensing the image light IM**2** as explained above and configured with, for example, a biconvex lens or an aspherical lens instead of the Fresnel lens **87**. A beam region of the image light IM**2** made incident on the condensing lens **85** includes a modulation region of the light modulation device **50** on the XY plane. Based on this, the collimating lens **85** has a diameter equal to or larger than dimensions on the X axis and the Y axis of the modulation region of the light modulation device **50**. Since the Fresnel lens **87** is used as the condensing lens **85**, the thickness on the Z axis of the condensing lens **85** is moderately suppressed.

(45) The projection optical system **90** is disposed on an optical path of the image light IM**2** condensed on the optical axis AX by the condensing lens **85**. The projection optical system **90** is disposed further on the +Z side than the condensing lens **85** and disposed at an interval from the condensing lens **85** on the Z axis. The projection optical system **90** projects the image light IM**2** condensed by the condensing lens **85** to the +Z side along the Z axis and enlarges and displays the image light IM**2** on a not-shown screen or the like.

(46) The projection optical system **90** includes, for example, a plano-convex lens **91**, a biconcave lens **92**, and a biconvex lens **93**. The center on the X axis and the Y axis of the plano-convex lens **91**, the center on the X axis and the Y axis of the biconcave lens **92**, and the center on the X axis and the Y axis of the biconvex lens **93** are disposed on the optical axis AX. An incident surface of the plano-convex lens **91** is a curved surface convex to the −Z side. An emission surface of the plano-convex lens **91** is a flat surface parallel to the XY plane. An incident surface of the biconcave lens **92** is a curved surface concave to the +Z side. An emission surface of the biconcave lens **92** is a curved surface concave to the −Z side. An incident surface of the biconvex lens **93** is a curved surface convex to the −Z side. An emission surface of the biconvex lens **93** is a curved surface convex to the +Z side. A shape of the incident surface and a shape of the emission surface of each of the plano-convex lens **91**, the biconcave lens **92**, and the biconvex lens **93** are designated as appropriate according to a radiation characteristic, a spread angle, and a divergence degree of the image light IM**2** made incident on the projection optical system **90**, a separation distance between the projection optical system **90** and a display surface of the screen on the Z axis, magnification of the image light IM**2** when being projected onto the screen from the projection optical system **90**, and the like.

(47) Note that the projection optical system **90** may be configured with an optical element capable of enlarging, at predetermined magnification, the image light IM**2** made incident thereon as explained above and projecting the image light IM**2** and may include another optical lens instead of at least one lens of the plano-convex lens **91**, the biconcave lens **92**, and the biconvex lens **93**. The projection optical system **90** may be configured with one optical lens or may be configured with four or more optical lenses. The optical lenses include, for example, a plano-convex lens, a plano-concave lens, a biconvex lens, a biconcave lens, a meniscus lens, an aspherical lens, and a free curved surface lens.

(48) Subsequently, relative disposition of the blue filters **54**B, the green filters **54**G, the red filters **54**R, and the light blocking region **56** of the color filter **52** and relative disposition of the blue sub-pixel electrodes **66**B, the green sub-pixel electrodes **66**G, and the red sub-pixel electrodes **66**R of the plurality of pixels **64** of the pixel electrode **62** with respect to the first lens, the second lens, and the third lens of the lens array **40** are explained.

(49) FIG. **2** is a schematic diagram of the lens array **40** and the color filter **52** of the light

modulation device **50** and is a front view of the lens array **40** and the color filter **52** when viewed from the −Z side along the Z axis. However, the peripheral edges of the microlenses **42** of the lens array **40** is indicated by alternate long and two short dashes lines in order to clearly show the configuration of the color filter **52**.

(50) As shown in FIG. **2**, a shape of each of the red filter **54**R, the green filter **54**G, and the blue filter **54**B of the color filter **52** when viewed along the Z axis is a rectangle. The widths of the red filter **54**R, the green filter **54**G, and the blue filter **54**B on the X axis are equal to one another and are x1. The widths of the red filter **54**R, the green filter **54**G, and the blue filter **54**B on the Y axis are equal to one another and are y1. The width y1 is larger than the width x1 and is, for example, 140% to 180% of the width x1. Note that, in this specification, "width on the X axis" means a dimension on an axis parallel to the X axis and "width on the Y axis" means a dimension on an axis parallel to the Y axis.

(51) In the color filter **52**, the plurality of red filters **54**R, the plurality of green filters **54**G, and the plurality of blue filters **54**B are disposed in a so-called stripe form.

(52) Specifically, the red filter **54**R, the green filter **54**G, and the blue filter **54**B form one set and a plurality of sets are disposed to form one lateral row from the −X side to the +X side along the X axis. A plurality of lateral rows are disposed along the Y axis. In each of the lateral rows, the red filter **54**R, the green filter **54**G, and the blue filter **54**B are sequentially disposed at intervals of width x2 from one another on the X axis. That is, filters adjacent to one another on the X axis are filters of colors different from one another. In each of the lateral rows, the peripheral end on the +Y side parallel to the X axis of the red filter **54**R, the peripheral end on the +Y side parallel to the X axis of the green filter **54**G, and the peripheral end on the +Y side parallel to the X axis of the blue filter **54**B are aligned with one another in the same position on the Y axis. In each of the lateral rows, the peripheral end on the −Y side parallel to the X axis of the red filter **54**R, the peripheral end on the −Y side parallel to the X axis of the green filter **54**G, and the peripheral end on the −Y side parallel to the X axis of the blue filter **54**B are aligned with one another in the same position on the Y axis.

(53) On the other hand, each of the plurality of red filters **54**R, the plurality of green filters **54**G, and the plurality of blue filters **54**B are disposed side by side to form one longitudinal row along the Y axis and disposed to form a plurality of longitudinal rows on the X axis. In each of the longitudinal rows, any one color filters of the red filters **54**R, the green filters **54**G, and the blue filters **54**B are disposed at intervals of width y2 from one another on the Y axis. That is, filters adjacent to one another on the Y axis are filters of the same color. The width y2 is larger than the width x2 and is, for example, 120% to 160% of the width x2.

(54) In a row in which the plurality of red filters **54**R are disposed, the peripheral ends on the −X side parallel to the Y axis of the red filters **54**R adjacent to one another on the Y axis are aligned with one another in the same position on the X axis. The peripheral ends on the +X side parallel to the Y axis of the red filters **54**R adjacent to one another on the Y axis are aligned with one another in the same position on the X axis. In a row in which the plurality of green filters **54**G are disposed, the peripheral ends on the −X side parallel to the Y axis of the green filters **54**G adjacent to one another on the Y axis are aligned with one another in the same position on the X axis. The peripheral ends on the +X side parallel to the Y axis of the green filters **54**G adjacent to one another on the Y axis are aligned with one another in the same position on the X axis. In a row in which the plurality of blue filters **54**B are disposed, the peripheral ends on the −X side parallel to the Y axis of the blue filters **54**B adjacent to one another on the Y axis are aligned with one another in the same position on the X axis. The peripheral ends on the +X side parallel to the Y axis of the blue filters **54**B adjacent to one another on the Y axis are aligned with one another in the same position.

(55) The light blocking region **56** is provided in regions of the width x2 between the red filters **54**R and the green filters **54**G adjacent to each other on the X axis, between the green filters **54**G and the blue filters **54**B adjacent to each other on the X axis, and between the blue filters **54**B and the

red filters **54**R adjacent to each other on the X axis. The light blocking region **56** is provided in regions of the width y2 among the red filters **54**R adjacent to one another on the Y axis, among the green filters **54**G adjacent to one another on the Y axis, and among the blue filters **54**B adjacent to one another on the Y axis. The light blocking region **56** is also provided in any one color filters of the red filters **54**R, the green filters **54**G, and the blue filters **54**B disposed on the outer periphery of the color filter **52** when viewed along the Z axis among the plurality of red filters **54**R, the plurality of green filters **54**G, and the plurality of blue filters **54**B.

(56) The plurality of microlenses **42** of the lens array **40** include first lenses **44**B, second lenses **44**G, and third lenses **44**R. The first lenses **44**B emit the white light WL**2** made incident thereon toward the blue filters **54**B of the color filter **52**. The second lenses **44**G emit the white light WL**2** made incident thereon toward the green filters **54**G of the color filter **52**. The third lenses **44**R emit the white light WL**2** made incident thereon toward the red filters **54**R of the color filter **52**.

(57) In the lens array **40**, the third lens **44**R, the second lens **44**G, and the first lens **44**B form one set. A plurality of sets are disposed to form one lateral row from the −X side to the +X side along the X axis. A plurality of lateral rows are disposed along the Y axis. In each of the lateral rows, the third lenses **44**R, the second lenses **44**G, and the first lenses **44**B are adjacent to one another without intervals on the X axis. A plurality of third lenses **44**R, a plurality of second lenses **44**G, and a plurality of first lenses **44**B are disposed side by side to form one row along the Y axis and disposed to form a plurality of rows on the X axis. In each of the rows, any one color filters of the red filters **54**R, the green filters **54**G, and the blue filters **54**B are adjacent to one another without intervals along the Y axis.

(58) The second lenses **44**G are provided to correspond to the green filters **54**G of the color filter **52**. A total number of the second lenses **44**G in the lens array **40** is the same as a total number of the green filters **54**G in the color filter **52** and is the same as a total number of the green sub-pixel electrodes **66**G included in the plurality of pixels **64** of the pixel electrode **62**. When viewed along the Z axis, the second lenses **44**G overlap at least the green filters **54**G and are larger than the green filters **54**G on the X axis and the Y axis. In the following explanation, the green filters **54**G corresponding to the second lenses **44**G mean the green filters **54**G, at least parts of which overlap the second lenses **44**G when viewed along the Z axis, among the plurality of green filters **54**G of the color filter **52**.

(59) A shape of the second lens **44**G when viewed along the Z axis is a rectangle. The peripheral end on the −x side parallel to the Y axis of the second lens **44**G is disposed further on the −X side than the peripheral end on the −X side parallel to the Y axis of the green filter **54**G corresponding to the second lens **44**G. The peripheral end on the −X side parallel to the Y axis of the second lens **44**G is adjacent to the corresponding green filter **54**G across the light blocking region **56** on the X axis and is disposed in a region of the red filter **54**R further on the −X side than the corresponding green filter **54**G. The distance on the X axis between the peripheral end on the −X side parallel to the Y axis of the second lens **44**G and the peripheral end on the +X side parallel to the Y axis of the red filter **54**R adjacent to, on the −X side, the green filter **54**G corresponding to the second lens **44**G is represented as d1.

(60) The peripheral end on the +X side parallel to the Y axis of the second lens **44**G is disposed further on the +X side than the peripheral end on the +X side parallel to the Y axis of the green filter **54**G corresponding to the second lens **44**G. The peripheral end on the +X side parallel to the Y axis of the second lens **44**G is adjacent to the corresponding green filter **54**G across the light blocking region **56** on the X axis and is disposed in a region of the blue filter **54**B further on the +X side than the corresponding green filter **54**G. The distance on the X axis between the peripheral end on the +X side parallel to the Y axis of the second lens **44**G and the peripheral end on the −X side parallel to the Y axis of the blue filter **54**B adjacent to, on the +X side, the green filter **54**G corresponding to the second lens **44**G is d1.

(61) The peripheral end on the +Y side parallel to the X axis of the second lens **44**G is disposed

further on the +Y side than the peripheral end on the +Y side parallel to the X axis of the green filter **54**G corresponding to the second lens **44**G. The peripheral end on the +Y side parallel to the X axis of the second lens **44**G is adjacent to the corresponding green filter **54**G on the Y axis and is disposed in the light blocking region **56** further on the +Y side than the corresponding green filter **54**G. The distance on the Y axis between the peripheral end on the +Y side parallel to the X axis of the second lens **44**G and the peripheral end on the +Y side parallel to the X axis of the green filter **54**G corresponding to the second lens **44**G is represented as d2.

(62) The peripheral end on the −Y side parallel to the X axis of the second lens **44**G is disposed further on the −Y side than the peripheral end on the −Y side parallel to the X axis of the green filter **54**G corresponding to the second lens **44**G. The peripheral end on the −Y side parallel to the X axis of the second lens **44**G is adjacent to the corresponding green filter **54**G on the Y axis and is disposed in the light blocking region **56** further on the −Y side than the corresponding green filter **54**G. The distance on the Y axis between the peripheral end on the −Y side parallel to the X axis of the second lens **44**G and the peripheral end on the −Y side parallel to the X axis of the green filter **54**G corresponding to the second lens **44**G is d2. The distance d2 is approximately 50% of the width y2.

(63) Width XG on the X axis of the second lens **44**G is XG=(x1)+2×(x2)+2×(d1). Width YG on the Y axis of the second lens **44**G is YG=(y1)+2×(d2)=(y1)+2×(y2/2)=(y1)+(y2).

(64) The area of an incident surface **44**a and the area of an emission surface **44**b of the second lens **44**G are larger than the area of an incident surface **54**a and the area of an emission surface **54**b of the green filter **54**G corresponding to the second lens **44**G and are larger than the areas of the incident surfaces **54**a and the areas of the emission surfaces **54**b of the red filter **54**R and the blue filter **54**B adjacent to the corresponding green filter **54**G on the X axis.

(65) The third lenses **44**R are provided to correspond to the red filters **54**R of the color filter **52**. A total number of the third lenses **44**R in the lens array **40** is the same as a total number of the red filters **54**R in the color filter **52** and is the same as a total number of the red sub-pixel electrodes **66**R included in the plurality of pixels **64** of the pixel electrode **62**. When viewed along the Z axis, the third lenses **44**R overlap parts of the red filters **54**R and overlap, for example, portions on the −X side of the red filters **54**R. In the following explanation, the red filters **54**R corresponding to the third lenses **44**R mean the red filters **54**R, at least parts of which overlap the third lenses **44**R when viewed along the Z axis, among the plurality of red filters **54**R of the color filter **52**.

(66) A shape of the third lens **44**R when viewed along the Z axis is a rectangle. The peripheral end on the −X side parallel to the Y axis of the third lens **44**R is disposed further on the −X side than the peripheral end on the −X side parallel to the Y axis of the red filter **54**R corresponding to the third lens **44**R. When viewed along the Z axis, the peripheral end on the −X side parallel to the Y axis of the third lens **44**R is adjacent to the corresponding red filter **54**R on the X axis and overlaps the light blocking region **56** disposed further on the −X side than the corresponding red filter **54**R. The distance on the X axis between the peripheral end on the −X side parallel to the Y axis of the third lens **44**R and the peripheral end on the −X side parallel to the Y axis of the red filter **54**R corresponding to the third lens **44**R is represented as d3. The distance d3 is approximately 50% of the width x2.

(67) The peripheral end on the +X side parallel to the Y axis of the third lens **44**R is disposed, on the X axis, between the peripheral end on the −X side and the peripheral end on the +X side parallel to the Y axis of the red filter **54**R corresponding to the third lens **44**R and overlaps the corresponding red filter **54**R when viewed along the Z axis. When viewed along the Z axis, the peripheral end on the +X side parallel to the Y axis of the third lens **44**R overlaps the light blocking region **56** further on the +X side than the center on the X axis of the corresponding red filter **54**R. The peripheral end on the +X side parallel to the Y axis of the third lens **44**R overlaps the peripheral end on the −X side parallel to the Y axis of the second lens **44**G adjacent to the third lens **44**R on the +X side on the X axis.

(68) The peripheral end on the +Y side parallel to the X axis of the third lens **44R** is disposed further on the +Y side than the peripheral end on the +Y side parallel to the X axis of the red filter **54R** corresponding to the third lens **44R**. The peripheral end on the +Y side parallel to the X axis of the third lens **44R** is disposed, on the Y axis, in the same position as the peripheral end on the +Y side parallel to the X axis of the second lens **44G**. The peripheral end on the −Y side parallel to the X axis of the third lens **44R** is disposed further on the −Y side than the peripheral end on the −Y side parallel to the X axis of the red filter **54R** corresponding to the third lens **44R**. The peripheral end on the −Y side parallel to the X axis of the third lens **44R** is disposed, on the Y axis, in the same position as the peripheral end on the −Y side parallel to the X axis of the second lens **44G**.

(69) Width XR on the X axis of the third lens **44R** is $XR=\{(x1)-(d1)\}+(d3)=\{(x1)-(d1)\}+(x2/2)$ and is smaller than the width XG of the second lens **44G**. Width YR on the Y axis of the third lens **44R** is $YR=YG=(y1)+2\times(d2)=(y1)+2\times(y2/2)=(y1)+(y2)$ and is the same as the width YG of the second lens **44G**.

(70) The first lenses **44B** are provided to correspond to the blue filters **54B** of the color filter **52**. A total number of the first lenses **44B** in the lens array **40** is the same as a total number of the blue filters **54B** in the color filter **52** and is the same as a total number of the blue sub-pixel electrodes **66B** included in the plurality of pixels **64** of the pixel electrode **62**. When viewed along the Z axis, the first lenses **44B** overlap parts of the blue filters **54B** and overlap, for example, portions on the −X side of the blue filters **54B**. In the following explanation, the blue filters **54B** corresponding to the first lenses **44B** mean the blue filters **54B**, parts of which overlap the first lenses **44B** when viewed along the Z axis, among the plurality of blue filters **54B** of the color filter **52**.

(71) A shape of the first lens **44B** when viewed along the Z axis is a rectangle. The peripheral end on the −X side parallel to the Y axis of the first lens **44B** is disposed, on the X axis, between the peripheral end on the −X side and the peripheral end on the +X side parallel to the Y axis of the blue filter **54B** corresponding to the first lens **44B** and overlap the corresponding blue filter **54B** when viewed along the Z axis. When viewed along the Z axis, the peripheral end on the −X side parallel to the Y axis of the first lens **44B** overlaps the light blocking region **56** further on the −X side than the center on the X axis of the blue filter **54B** corresponding to the first lens **44B**. The peripheral end on the −X side parallel to the Y axis of the first lens **44B** overlaps the peripheral end on the +X side parallel to the Y axis of the second lens **44G** adjacent to the first lens **44B** on the −X side on the X axis.

(72) The peripheral end on the +X side parallel to the Y axis of the first lens **44B** is disposed further on the +X side than the peripheral end on the +X side parallel to the Y axis of the blue filter **54B** corresponding to the first lens **44B**. When viewed along the Z axis, the peripheral end on the +X side parallel to the Y axis of the first lens **44B** is adjacent to the corresponding blue filter **54B** on the X axis and overlaps the light blocking region **56** disposed further on the +X side than the corresponding blue filter **54B**. The distance on the X axis between the peripheral end on the +X side parallel to the Y axis of the first lens **44B** and the peripheral end on the +X side parallel to the Y axis of the blue filter **54B** corresponding to the first lens **44B** is d3.

(73) The peripheral end on the +Y side parallel to the X axis of the first lens **44B** is disposed further on the +Y side than the peripheral end on the +Y side parallel to the X axis of the blue filter **54B** corresponding to the first lens **44B**. The peripheral end on the +Y side parallel to the X axis of the first lens **44B** is disposed, on the Y axis, in the same position as the peripheral end on the +Y side parallel to the X axis of the second lens **44G**. The peripheral end on the −Y side parallel to the X axis of the first lens **44B** is disposed further on the −Y side than the peripheral end on the −Y side parallel to the X axis of the blue filter **54B** corresponding to the first lens **44B**. The peripheral end on the −Y side parallel to the X axis of the first lens **44B** is disposed, on the Y axis, in the same position as the peripheral end on the −Y side parallel to the X axis of the second lens **44G**.

(74) Width XB on the X axis of the first lens **44B** is $XB=\{(x1)-(d1)\}+(d3)=\{(x1)-(d1)\}+(x2/2)$ and is smaller than the width XG of the second lens **44G** and is the same as the width XR of the

third lens **44**R. Width YB on the Y axis of the first lens **44**B is YB=YG=(y1)+2×(d2)= (y1)+2×(y2/2)=(y1)+(y2) and is the same as the width YG of the second lens **44**G and the width YR of the third lens **44**R.

(75) The area of the incident surface **44***a* and the area of the emission surface **44***b* of the second lens **44**G are larger than the area of the incident surface **44***a* and the area of the emission surface **44***b* of the first lens **44**B and the area of the incident surface **44***a* and the area of the emission surface **44***b* of the third lens **44**R.

(76) FIG. **3** is a schematic diagram of the lens array **40** and the color filter **52** and the pixel electrode **62** of the light modulation device **50** and is a sectional view thereof in arrow view taken along a C**1**-C**1** line shown in FIG. **2**. As shown in FIG. **3**, the red sub-pixel electrodes **66**R included in the plurality of pixels **64** of the pixel electrode **62** overlap the red filters **54**R of the color filter **52** when viewed along the Z axis. The plurality of red sub-pixel electrodes **66**R are disposed in the same positions as the positions of the plurality of red filters **54**R on the XY plane. The shapes and the areas of incident surfaces **66***a* and emission surfaces **66***b* of the red sub-pixel electrodes **66**R viewed along the Z axis are the same as the shapes and the areas of the incident surfaces **54***a* and the emission surfaces **54***b* of the red filters **54**R.

(77) The green sub-pixel electrodes **66**G included in the plurality of pixels **64** of the pixel electrode **62** overlap the green filters **54**G of the color filter **52** when viewed along the Z axis. The plurality of green sub-pixel electrodes **66**G are disposed in the same positions as the positions of the plurality of green filters **54**G on the XY plane. The shapes and the areas of the incident surfaces **66***a* and the emission surfaces **66***b* of the green sub-pixel electrodes **66**G are the same as the shapes and the areas of the incident surfaces **54***a* and the emission surfaces **54***b* of the green filters **54**G viewed along the Z axis.

(78) The blue sub-pixel electrodes **66**B included in the plurality of pixels **64** of the pixel electrode **62** overlap the blue filters **54**B of the color filter **52** when viewed along the Z axis. The plurality of blue sub-pixel electrodes **66**B are disposed in the same positions as the positions of the plurality of blue filters **54**B on the XY plane. The shapes and the areas of the incident surfaces **66***a* and the emission surfaces **66***b* of the blue sub-pixel electrodes **66**B are the same as the shapes and the areas of the incident surfaces **54***a* and the emission surfaces **54***b* of the blue filters **54**B viewed along the Z axis.

(79) In the pixel electrode **62**, a wiring region **68** is provided among any one sub-pixel electrodes of the red sub-pixel electrodes **66**R, the green sub-pixel electrodes **66**G, and the blue sub-pixel electrodes **66**B on the X axis and the Y axis. In the wiring region **68**, a wire, a circuit, and the like for driving any one sub-pixel electrodes of the red sub-pixel electrodes **66**R, the green sub-pixel electrodes **66**G, and the blue sub-pixel electrodes **66**B according to an electric signal supplied from the not-shown image output device via the circuit board or the like as explained above are formed. The wiring region **68** overlaps the light blocking region **56** of the color filter **52** when viewed along the Z axis. Therefore, the white light WL**2** is not emitted to the wiring region **68**.

(80) One pixel **64** of the light modulation device **50** includes a set of the red filter **54**R, the green filter **54**G, and the blue filter **54**B disposed side by side along the X axis in the color filter **52**, the light blocking region **56** between the red filter **54**R and the green filter **54**G adjacent to each other on the X axis, the light blocking region **56** between the green filter **54**G and the blue filter **54**B, and the light blocking region **56** surrounding the set of the red filter **54**R, the green filter **54**G, and the blue filter **54**B along the X axis and the Y axis when viewed along the Z axis. In one pixel **64**, the width on the Y axis of the light blocking region **56** extending along the X axis while being in contact with the set of the red filter **54**R, the green filter **54**G, and the blue filter **54**B from each of the +Y side and the −Y side is (y2/2). In one pixel **64**, the width on the X axis of the light blocking region **56** extending along the Y axis while being in contact with the red filter **54**R from the −X side is (x2/2). In one pixel **64**, the width on the X axis of the light blocking region **56** extending along the Y axis while being in contact with the blue filter **54**B from the +X side is (x2/2).

(81) One pixel **64** of the light modulation device **50** includes components of the pixel electrode **62** in a region overlapping the components explained above configuring the one pixel **64** in the color filter **52**. That is, the one pixel **64** includes the red sub-pixel electrode **66**R, the green sub-pixel electrode **66**G, and the blue sub-pixel electrode **66**B corresponding to the set of the red filter **54**R, the green filter **54**G, and the blue filter **54**B disposed along the X axis and the wiring region **68** overlapping the light blocking region **56** of the pixel **64** when viewed along the Z axis.

(82) On the X axis, the incident surface **44***a*, that is, a lens surface of the second lens **44**G of the lens array **40** condenses, on a condensing point MG of the green sub-pixel electrode **66**G of the pixel **64**, the green light GL included in the white light WL**2** made incident on the incident surface **44***a*. The condensing point MG is set in, for example, the center on the X axis, the Y axis, and the Z axis of the green sub-pixel electrode **66**G.

(83) The white light WL**2** is made incident on the second lens **44**G in a range of the width XG centering on the condensing point MG on the X axis. The incident surface **44***a* of the second lens **44**G is, for example, a curved surface convex to the −Z side with the same position as the condensing point MG set as a vertex on the X axis and is a curved surface designed according to a separation distance PL on the Z axis between a principal point HG further on the +Z side than the vertex and the condensing point MG. The principal point HG of the second lens **44**G is disposed on a principal plane of the second lens **44**G. The principal plane of the second lens **44**G is present between the vertex of the incident surface **44***a* of the second lens **44**G and the emission surface **44***b* of the second lens **44**G on the Z axis and is parallel to the XY plane. The principal point HG is disposed in the same position as the center of the green sub-pixel electrode **66**G corresponding to the second lens **44**G on the X axis.

(84) The separation distance PL is designed considering the width XG of the second lens **44**G, the width x1 of the green filter **54**G and the green sub-pixel electrode **66**G, and the thickness on the Z axis of the green filter **54**G and the green sub-pixel electrode **66**G. The separation distance PL is appropriately designed such that a beam width on the X axis of the white light WL**2** condensed by the second lens **44**G and emitted to the incident surface **54***a* of the green filter **54**G is smaller than the width x1.

(85) Only the green light GL in the white light WL**2** made incident on the green filter **54**G from the incident surface **54***a* is transmitted through the green filter **54**G, emitted from the emission surface **54***b* of the green filter **54**G, made incident on the green sub-pixel electrode **66**G from the incident surface **66***a*, and condensed on the condensing point MG. Since the beam width on the X axis of the white light WL**2** on the incident surface **54***a* of the green filter **54**G is smaller than the width x1 as explained above, a loss of the white light WL**2** made incident on the green filter **54**G and a loss of the green light GL condensed on the green sub-pixel electrode **66**G are reduced.

(86) When viewed along the Z axis, the vertex of the incident surface **44***a* of the second lens **44**G and the condensing point MG of the green sub-pixel electrode **66**G are disposed in the center on the X axis of the width XG of the second lens **44**G. Therefore, the second lens **44**G does not have eccentricity on the X axis. The emission surface **44***b* of the second lens **44**G is a flat surface disposed further on the +Z side than the incident surface **44***a* of the second lens **44**G and parallel to the XY plane.

(87) On the X axis, the incident surface **44***a*, that is, a lens surface of the third lens **44**R of the lens array **40** condenses, on a condensing point MR of the red sub-pixel electrode **66**R of the pixel **64**, red light RL included in the white light WL**2** made incident on the incident surface **44***a*. The condensing point MR is set in the center on the X axis, the Y axis, and the Z axis of the red sub-pixel electrode **66**R.

(88) The white light WL**2** is made incident on the third lens **44**R in a range of the width XR on the X axis. The condensing point MR of the red sub-pixel electrode **66**R is disposed further on the +X side than the center on the X axis of the width XR of the third lens **44**R. The incident surface **44***a* of the third lens **44**R is, for example, a curved surface convex to the −Z side with the same position

as the condensing point MR set as a vertex on the X axis and is a curved surface designed according to a center wavelength of the red light RL and the separation distance PL on the Z axis between a principal point HR further on the +Z side than the vertex and the condensing point MR. The incident surface **44***a* of the third lens **44**R is designed considering the width XR of the third lens **44**R, the width x1 of the red filter **54**R and the red sub-pixel electrode **66**R, the thickness on the Z axis of the red filter **54**R and the red sub-pixel electrode **66**R, and the separation distance PL. The principal point HR of the third lens **44**R is disposed on a principal plane of the third lens **44**R. The principal plane of the third lens **44**R is present between the vertex of the incident surface **44***a* of the third lens **44**R and the emission surface **44***b* of the third lens **44**R on the Z axis and is parallel to the XY plane. The principal point HR is disposed in the same position as the center of the red sub-pixel electrode **66**R corresponding to the third lens **44**R on the X axis.

(89) A beam width on the X axis of the white light WL**2** condensed by the third lens **44**R and emitted to the incident surface **54***a* of the red filter **54**R is smaller than the width x1. Only the red light RL in the white light WL**2** made incident on the red filter **54**R from the incident surface **54***a* is transmitted through the red filter **54**R, emitted from the emission surface **54***b* of the red filter **54**R, made incident on the red sub-pixel electrode **66**R from the incident surface **66***a*, and condensed on the condensing point MR. Since the beam width on the X axis of the white light WL**2** on the incident surface **54***a* of the red filter **54**R is smaller than the width x1 as explained above, a loss of the white light WL**2** made incident on the red filter **54**R and a loss of the red light RL condensed on the red sub-pixel electrode **66**R are reduced.

(90) When viewed along the Z axis, the vertex of the incident surface **44***a* of the third lens **44**R and the condensing point MR of the red sub-pixel electrode **66**R deviate to the +X side from the center on the X axis of the width XR of the third lens **44**R. Therefore, the third lens **44**R has eccentricity on the X axis. The emission surface **44***b* of the third lens **44**R is a flat surface disposed further on the +Z side than the incident surface **44***a* of the third lens **44**R and parallel to the XY plane.

(91) On the X axis, the incident surface **44***a*, that is, a lens surface of the first lens **44**B of the lens array **40** condenses, on a condensing point MB of the blue sub-pixel electrode **66**B of the pixel **64**, the blue light BL included in the white light WL**2** made incident on the incident surface **44***a*. The condensing point MB is set in, for example, the center on the X axis, the Y axis, and the Z axis of the blue sub-pixel electrode **66**B.

(92) The white light WL**2** is made incident on the first lens **44**B in a range of the width XB on the X axis. The condensing point MB of the blue sub-pixel electrode **66**B is disposed further on the −X side than the center on the X axis of the width XB of the first lens **44**B. The incident surface **44***a* of the first lens **44**B is, for example, a curved surface convex to the −Z side with the same position as the condensing point MB set as a vertex on the X axis and is a curved surface designed according to a center wavelength of the blue light BL and the separation distance PL on the Z axis between a principal point HB further on the +Z side than the vertex and the condensing point MB. The incident surface **44***a* of the first lens **44**B is designed considering the width XB of the first lens **44**B, the width x1 of the blue filter **54**B and the blue sub-pixel electrode **66**B, the thickness on the Z axis of the blue filter **54**B and the blue sub-pixel electrode **66**B, and the separation distance PL. The principal point HB of the first lens **44**B is disposed on a principal plane of the first lens **44**B. The principal plane of the first lens **44**B is present between the vertex of the incident surface **44***a* of the first lens **44**B and the emission surface **44***b* of the first lens **44**B on the Z axis and is parallel to the XY plane. The principal point HB is disposed in the same position as the center of the blue sub-pixel electrode **66**B corresponding to the first lens **44**B on the X axis.

(93) A beam width on the X axis of the white light WL**2** condensed by the first lens **44**B and emitted to the incident surface **54***a* of the blue filter **54**B is smaller than the width x1. Only the blue light BL in the white light WL**2** made incident on the blue filter **54**B from the incident surface **54***a* is transmitted through the blue filter **54**B, emitted from the emission surface **54***b* of the blue filter **54**B, made incident on the blue sub-pixel electrode **66**B from the incident surface **66***a*, and

condensed on the condensing point MB. Since the beam width on the X axis of the white light WL**2** on the incident surface **54***a* of the blue filter **54**B is smaller than the width x1 as explained above, a loss of the white light WL**2** made incident on the blue filter **54**B and a loss of the blue light BL condensed on the blue sub-pixel electrode **66**B are reduced.

(94) Note that the transmittance of the green light GL in the green filter **54**G is higher than at least the transmittance of the red light RL in the red filter **54**R and the transmittance of the blue light BL in the blue filter **54**B and is equal to the transmittance of the red light RL in the red filter **54**R and the transmittance of the blue light BL in the blue filter **54**B.

(95) FIG. **4** is a schematic diagram of the lens array **40** and the color filter **52** and the pixel electrode **62** of the light modulation device **50** and is a sectional view thereof in arrow view taken along a C**2**-C**2** line shown in FIG. **2**. As shown in FIG. **4**, the incident surface **44***a* of the second lens **44**G is, for example, a curved surface convex to the −Z side with the same position as the condensing point MG set as a vertex on the Y axis and is a curved surface set according to a center wavelength of the green light GL and the separation distance PL. The principal point HG of the second lens **44**G is disposed in the same position as the center of the green sub-pixel electrode **66**G corresponding to the second lens **44**G on the Y axis.

(96) A beam width on the Y axis of the white light WL**2** condensed by the second lens **44**G and emitted to the incident surface **54***a* of the green filter **54**G is smaller than the width y1. Only the green light GL in the white light WL**2** made incident on the green filter **54**G from the incident surface **54***a* is transmitted through the green filter **54**G, emitted from the emission surface **54***b* of the green filter **54**G, made incident on the green sub-pixel electrode **66**G from the incident surface **66***a*, and condensed on the condensing point MG. Since the beam width on the Y axis of the white light WL**2** on the incident surface **54***a* of the green filter **54**G is smaller than the width y1 as explained above, a loss of the white light WL**2** made incident on the green filter **54**G and a loss of the blue light BL condensed on the green sub-pixel electrode **66**G are reduced.

(97) When viewed along the Z axis, the vertex of the incident surface **44***a* of the second lens **44**G and the condensing point MG of the green sub-pixel electrode **66**G are disposed in the center on the Y axis of the width YG of the second lens **44**G. Therefore, the second lens **44**G does not have eccentricity on the Y axis as well.

(98) Although not shown, on the Y axis, the incident surface **44***a* of the third lens **44**R is, for example, a curved surface convex to the −Z side with the same position as the condensing point MR set as a vertex and is a curved surface set according to a center wavelength of the red light RL and the separation distance PL. The principal point HR of the third lens **44**R is disposed in the same position as the center of the red sub-pixel electrode **66**R corresponding to the third lens **44**R on the Y axis. On the Y axis as well, only the red light RL in the white light WL**2** made incident on the red filter **54**R from the incident surface **54***a* is transmitted through the red filter **54**R, made incident on the red sub-pixel electrode **66**R, and condensed on the condensing point MR.

(99) A beam width on the Y axis of the white light WL**2** condensed by the third lens **44**R and emitted to the incident surface **54***a* of the red filter **54**R is smaller than the width y1. On the Y axis as well, a loss of the white light WL**2** made incident on the red filter **54**R and a loss of the red light RL condensed on the red sub-pixel electrode **66**R are reduced.

(100) When viewed along the Z axis, the vertex of the incident surface **44***a* of the third lens **44**R and the condensing point MR of the red sub-pixel electrode **66**R are disposed in the center on the Y axis of the width YR of the third lens **44**R. Therefore, the third lens **44**R does not have eccentricity on the Y axis.

(101) On the Y axis, the incident surface **44***a* of the first lens **44**B is, for example, a curved surface convex to the −Z side with the same position as the condensing point MB set as a vertex and is a curved surface designed according to a center wavelength of the blue light BL and the separation distance PL. The principal point HB of the first lens **44**B is disposed in the same position as the center of the blue sub-pixel electrode **66**B corresponding to the first lens **44**B on the Y axis. On the

Y axis as well, only the blue light BL in the white light WL2 made incident on the blue filter 54B from the incident surface 54a is transmitted through the blue filter 54B, made incident on the blue sub-pixel electrode 66B, and condensed on the condensing point MR.

(102) A beam width on the Y axis of the white light WL2 condensed by the first lens 44B and emitted to the incident surface 54a of the blue filter 54B is smaller than the width y1. On the Y axis as well, a loss of the white light WL2 made incident on the red filter 54R and a loss of the red light RL condensed on the red sub-pixel electrode 66R are reduced.

(103) When viewed along the Z axis, the vertex of the incident surface 44a of the first lens 44B and the condensing point MB of the blue sub-pixel electrode 66B are disposed in the center on the Y axis of the width YB of the first lens 44B. Therefore, the first lens 44B does not have eccentricity on the Y axis.

(104) FIG. 5 is a perspective view of the lens array 40. In FIG. 5, the red filters 54R, the green filters 54G, and the blue filters 54B of the color filter 52 are indicated by alternate long and two short dashes lines. A component parallel to the X axis on the incident surface 44a of the second lens 44G of the lens array 40 is designed with the width XG set as an effective aperture and with the separation distance PL on the Z axis between the principal point HG of the second lens 44G and the condensing point MG of the green sub-pixel electrode 66G, which are not shown in FIG. 5, set as a focal length. A component parallel to the Y axis on the incident surface 44a of the second lens 44G is designed with the width YG larger than the width XG set as an effective aperture and with the separation distance PL on the Z axis between the principal point HG and the condensing point MG set as a focal length. Therefore, a numerical aperture (NA) of the incident surface 44a of the second lens 44G in sectional view along the Y axis is larger than a numerical aperture of the incident surface 44a of the second lens 44G in sectional view along the X axis.

(105) A component parallel to the X axis on the incident surface 44a of the third lens 44R of the lens array 40 is designed with the width XR smaller than the width XG of the second lens 44G set as an effective aperture and with the separation distance PL on the Z axis between the principal point HR of the third lens 44R and the condensing point MR of the red sub-pixel electrode 66R, which are not shown in FIG. 5, set as a focal length. A component parallel to the Y axis on the incident surface 44a of the third lens 44R is designed with the width YR larger than the width XR set as an effective aperture and with the separation distance PL on the Z axis between the principal point HR and the condensing point MR set as a focal length. Therefore, a numerical aperture of the incident surface 44a of the third lens 44R in sectional view along the X axis is smaller than a numerical aperture of the incident surface 44a of the second lens 44G in sectional view along the X axis. A numerical aperture of the incident surface 44a of the third lens 44R in sectional view along the Y axis is larger than a numerical aperture of the incident surface 44a of the third lens 44R in sectional view along the X axis and is equal to a numerical aperture of the incident surface 44a of the second lens 44G in sectional view along the Y axis.

(106) A component parallel to the X axis on the incident surface 44a of the first lens 44B of the lens array 40 is designed with the width XB smaller than the width XG of the second lens 44G set as an effective aperture and with the separation distance PL on the Z axis between the principal point HB of the first lens 44B and the condensing point MR of the blue sub-pixel electrode 66B, which are not shown in FIG. 5, set as a focal length. A component parallel to the Y axis on the incident surface 44a of the first lens 44B is designed with the width YB larger than the width XB set as an effective aperture and with the separation distance PL on the Z axis between the principal point HB and the condensing point MB set as a focal length. Therefore, a numerical aperture of the incident surface 44a of the first lens 44B in sectional view along the X axis is smaller than a numerical aperture of the incident surface 44a of the second lens 44G in sectional view along the X axis. A numerical aperture of the incident surface 44a of the first lens 44B in sectional view along the Y axis is larger than a numerical aperture of the incident surface 44a of the first lens 44B in sectional view along the X axis and is equal to a numerical aperture of the incident surface 44a of

the second lens **44**G in sectional view along the Y axis.

(107) The white light WL**2** made incident on the lens array **40** is collimated by the collimating lens **25**. On the XY plane, a light amount of the white light WL**2** per unit area is set substantially equal. The width XG of the second lens **44**G of the lens array **40** is larger than the width XB of the first lens **44**B and the width XR of the third lens **44**R. The width YG of the second lens **44**G is equal to the width YB of the first lens **44**B and the width YR of the third lens **44**R. Therefore, a light amount of the white light WL**2** taken into the second lens **44**G is larger than a light amount of the white light WL**2** taken into each of the first lens **44**B and the third lens **44**R. A light amount difference between the light amount of the white light WL**2** taken into the second lens **44**G and the light amount of the white light WL**2** taken into each of the first lens **44**B and the third lens **44**R depends on the difference between the area on the XY plane of the second lens **44**G and the area on the XY plane of each of the first lens **44**B and the third lens **44**R. In the configuration explained above, the light amount difference between the light amount of the white light WL**2** taken into the second lens **44**G and the light amount of the white light WL**2** taken into each of the first lens **44**B and the third lens **44**R depends on (XG-XB) and (XG-XR).

(108) A light amount of the green light GL included in the white light WL**2** is equal to or larger than a light amount of the red light RL and a light amount of the blue light BL included in the white light WL**2**. Therefore, a light amount of the green light GL taken into the second lens **44**G and condensed on the green sub-pixel electrode **66**G is larger than a light amount of the red light RL taken into the third lens **44**R and condensed on the red sub-pixel electrode **66**R and a light amount of the blue light BL taken into the first lens **44**B and condensed on the blue sub-pixel electrode **66**B. Therefore, in one pixel **64**, a light amount of the green light GL made incident on the green sub-pixel electrode **66**G is larger than a light amount of the red light RL made incident on the red sub-pixel electrode **66**R and a light amount of the blue light BL made incident on the blue sub-pixel electrode **66**B.

(109) As shown in FIGS. **3** and **4**, the green light GL made incident on the green sub-pixel electrode **66**G of the pixel electrode **62** is modulated into green image light IG by the switching element as explained above. The green image light IG has intensity and a light amount corresponding to an electric signal concerning the green light GL supplied to the switching element and is emitted to the +Z side along the Z axis from the emission surface **66***b* of the green sub-pixel electrode **66**G. Similarly, the red light RL made incident on the red sub-pixel electrode **66**R is modulated into red image light IR by the switching element. The red image light IR has intensity and a light amount corresponding to an electric signal concerning the red light RL supplied to the switching element and is emitted to the +Z side along the Z axis from the emission surface **66***b* of the red sub-pixel electrode **66**R. The blue light BL made incident on the blue sub-pixel electrode **66**B is modulated into blue image light IB by the switching element. The blue image light IB has intensity and a light amount corresponding to an electric signal concerning the blue light BL supplied to the switching element and is emitted to the +Z side along the Z axis from the emission surface **66***b* of the blue sub-pixel electrode **66**B.

(110) As shown in FIG. **3**, the image lights IR, IG, and IB emitted from the emission surfaces **66***b* of the red sub-pixel electrode **66**R, the green sub-pixel electrode **66**G, and the blue sub-pixel electrode **66**B, that is, the emission surface **62***b* of the pixel electrode **62** are combined with one another to form the full-color image light IM**1**. When the intensity of the electric signal at the time when the red light RL is modulated by the red sub-pixel electrode **66**R, the intensity of the electric signal at the time when the green light GL is modulated by the green sub-pixel electrode **66**G, and the intensity of the electric signal at the time when the blue light BL is modulated by the blue sub-pixel electrode **66**B are equal to one another, the light amount of the green image light IG included in the image light IM**1** is larger than the light amounts of the red image light IR and the blue image light IB included in the image light IM**1**.

(111) The image light IM**1** passes through the emission-side polarizing plate **80** and the condensing

lens **85** as explained above and is enlarged and projected toward the not-shown screen by the projection optical system **90** as the image light IM**2** and is displayed on a display surface facing the projection optical system **90** on the optical axis AX on the screen. Since a color balance in the image light IM**2** is retained in an image and a video displayed on the screen, a green light amount is relatively larger than red and blue light amounts. An observer can observe, according to visibility, the image and the video having the larger green light amount and visually recognize the image and the video that are bright as a whole.

(112) Subsequently, results of performing numerical value calculation for brightness and white balance of the image light IM**1** with respect to the transmittance of the red light RL transmitted through the red filter **54**R of the color filter **52**, the transmittance of the green light GL transmitted through the green filter **54**G of the color filter **52**, and the transmittance of the blue light BL transmitted through the blue filter **54**B of the color filter **52** are explained.

(113) In Table 1, numerical value calculation results of a numerical value calculation pattern [1] to a numerical value calculation pattern [7] are shown. In the numerical value calculation pattern [1] to the numerical value calculation pattern [7], a peak wavelength of the red light RL was set as 610 nm, a peak wavelength of the green light GL was set as 550 nm, and a peak wavelength of the blue light BL was set as 450 nm.

(114) TABLE-US-00001 TABLE 1 Color temper- Red F Green F Blue F Brightness ature Pattern [%] [%] [%] [%] [K] Deviation [1] 100 100 100 100 8831 −0.014 [2] 90 106 100 102 9053 −0.009 [3] 100 111 90 107 7372 −0.006 [4] 117 90 100 96 8407 −0.024 [5] 100 90 109 94 11463 −0.022 [6] 90 117 90 109 7595 −0.001 [7] 100 110 100 103 8288 −0.009

(115) The numerical value calculation pattern [1] is a pattern serving as a reference of this numerical value calculation example. In the numerical value calculation pattern [1], it was assumed that the transmittance of the red light RL in the red filter **54**R, the transmittance of the green light GL in the green filter **54**G, and the transmittance of the blue light BL in the blue filter **54**B were equal to one another.

(116) Reference examples in which the transmittances of the color filters in the numerical value calculation pattern [1] are realized include a case in which, in the configuration of this embodiment explained above, the shape and the area of each of the first lens **44**B, the second lens **44**G, and the third lens **44**R of the lens array **40** viewed along the Z axis are equal to the shape and the area of the blue sub-pixel electrode **66**B, the green sub-pixel electrode **66**G, or the red sub-pixel electrode **66**R corresponding to each of the lenses in the pixel electrode **62**. In this case, when viewed along the Z axis, the respective lenses overlap the blue sub-pixel electrode **66**B, the green sub-pixel electrode **66**G, and the red sub-pixel electrode **66**R corresponding thereto. The lenses do not have eccentricity on the X axis and the Y axis.

(117) In the numerical value calculation pattern [1], a color temperature of the image light IM**1** at the time when color lights respectively transmitted through the red filter **54**R, the green filter **54**G, and the blue filter **54**B were combined was calculated as 8831 [K] and a color deviation of the image light IM**1** was calculated as −0.014.

(118) Numerical values in fields of "red F", "green F", and "blue F" of Table 1 represent transmittances of color lights in the red filter **54**R, the green filter **54**G, and the blue filter **54**B in the numerical value calculation patterns at the time when the transmittances of the color lights in the red filter **54**R, the green filter **54**G, and the blue filter **54**B assumed in the numerical value calculation pattern [1] were set to 100%. Numerical values in a field of "brightness" of Table 1 represent the brightness of the image light IM**1** in the numerical value calculation patterns at the time when the brightness of the image light IM**1** in the numerical value calculation pattern [1] was set to 100%. Note that, for all the numerical value calculation patterns, the brightness of the image light IM**1** was represented by a unit of lumen [lm] and converted into a ratio to the brightness of the numerical value calculation pattern [1] as explained above. "Color temperature" and "color deviation" were used as evaluation values for white balance of the image light IM**1** in the

numerical value calculation patterns of Table 1. Numerical values in fields of "deviation" of Table 1 represent the color deviation explained above.

(119) In the numerical value calculation pattern [2], the transmittance of the red light RL in the red filter **54**R was reduced to 90%, the transmittance of the green light GL in the green filter **54**G was increased to 106%, and the transmittance of the blue light BL in the blue filter **54**B was maintained at 100% with respect to the assumption of the numerical value calculation pattern [1]. In order to realize the transmittances of the color filters in the numerical value calculation pattern [2], for example, a peripheral end facing the third lens **44**R on the X axis in the second lens **44**G can be moved to be closer to the third lens **44**R from the configuration of the reference example of the numerical value calculation pattern [1]. A peripheral end facing the second lens **44**G in the third lens **44**R can be moved to be closer to the peripheral end on the opposite side on the X axis from the configuration of the reference example of the numerical value calculation pattern [1]. Consequently, the light amount of the white light WL**2** taken into the second lens **44**G becomes larger than the light amount of the white light WL**2** taken into the second lens **44**G.

(120) The brightness of the image light IM**1** in the numerical value calculation pattern [2] increased 2% with respect to the numerical value calculation pattern [1]. This result is considered to have been obtained because the light amount of the green image light IG with respect to the blue image light IB and the red image light IR increased in the numerical value calculation pattern [2] to be larger than the light amount in the numerical value calculation pattern [1] and visibility at the time of observation was improved. In the numerical value calculation pattern [2], compared with the numerical value calculation pattern [1], a light amount difference of the green image light IG with respect to the red image light IR is larger than a light amount difference of the green image light IG with respect to the blue image light IB. Therefore, a spectrum of the image light IM**1** in the numerical value calculation pattern [2] slightly deviates from the human visibility.

(121) A color temperature of the image light IM**1** in the numerical value calculation pattern [2] was calculated as 9053 [K] and a color deviation of the image light IM**1** in the numerical value calculation pattern [2] was calculated as −0.009. The color temperature of the image light IM**1** in the numerical value calculation pattern [2] is considered to have become higher than the color temperature in the numerical value calculation pattern [1]. The image light IM**1** in the numerical value calculation pattern [2] is considered to have become more bluish compared with the image light IM**1** in the numerical value calculation pattern [1]. As explained above, the color deviation of the image light IM**1** in the numerical value calculation pattern [2] is considered to have been reduced be smaller than the color deviation in the numerical value calculation pattern [1] because the spectrum of the image light IM**1** in the numerical value calculation pattern [2] came closer to the human visibility.

(122) In the numerical value calculation pattern [3], the transmittance of the red light RL in the red filter **54**R was maintained at 100%, the transmittance of the green light GL in the green filter **54**G was increased to 111%, and the transmittance of the blue light BL in the blue filter **54**B was reduced to 90% with respect to the assumption of the numerical value calculation pattern [1]. In order to realize the transmittances of the color filters in the numerical value calculation pattern [3], for example, a peripheral end facing the first lens **44**B on the X axis in the second lens **44**G can be moved to be closer to the first lens **44**B from the configuration of the reference example of the numerical value calculation pattern [1]. A peripheral end facing the second lens **44**G in the first lens **44**B can be moved to be closer to the peripheral end on the opposite side on the X axis from the configuration of the reference example of the numerical value calculation pattern [1]. Consequently, the light amount of the white light WL**2** taken into the second lens **44**G becomes larger than the light amount of the white light WL**2** taken into the third lens **44**R.

(123) The brightness of the image light IM**1** in the numerical value calculation pattern [3] increased 7% with respect to the numerical value calculation pattern [1]. This result is considered to have been obtained because the light amount of the green image light IG with respect to the blue image

light IB and the red image light IR increased in the numerical value calculation pattern [3] as well to be larger than the light amount in the numerical value calculation pattern [1] and the visibility at the time of observation was improved. In the numerical value calculation pattern [3], compared with the numerical value calculation pattern [1], a light amount difference of the green image light IG with respect to the red image light IR is smaller than a light amount difference of the green image light IG with respect to the blue image light IB. Therefore, a spectrum of the image light IM**1** in the numerical value calculation pattern [3] slightly deviates from the human visibility and is different from the spectrum of the image light IM**1** in the numerical value calculation pattern [2] as well.

(124) A color temperature of the image light IM**1** in the numerical value calculation pattern [3] was calculated as 7372 [K] and a color deviation of the image light IM**1** in the numerical value calculation pattern [3] was calculated as −0.006. The color temperature of the image light IM**1** in the numerical value calculation pattern [3] is considered to have become lower than the color temperature in the numerical value calculation pattern [1]. The image light IM**1** in the numerical value calculation pattern [3] is considered to have become more reddish compared with the image light IM**1** in the numerical value calculation pattern [1]. As explained above, the color deviation of the image light IM**1** in the numerical value calculation pattern [3] is considered to have been reduced to be smaller than the color deviation in the numerical value calculation pattern [1] because the spectrum of the image light IM**1** in the numerical value calculation pattern [3] came closer to the human visibility. The color deviation of the image light IM**1** in the numerical value calculation pattern [3] is considered to have been reduced to be smaller than the color deviation in the numerical value calculation pattern [2] because the image light IM**1** in the numerical value calculation pattern [3] became less bluish and came closer to white.

(125) In the numerical value calculation pattern [4], the transmittance of the red light RL in the red filter **54**R was increased to 117%, the transmittance of the green light GL in the green filter **54**G was reduced to 90%, and the transmittance of the blue light BL in the blue filter **54**B was maintained at 100% with respect to the assumption of the numerical value calculation pattern [1]. In order to realize the transmittances of the color filters in the numerical value calculation pattern [4], for example, a peripheral end facing the second lens **44**G on the X axis in the third lens **44**R can be moved to be closer to the second lens **44**G from the configuration of the reference example of the numerical value calculation pattern [1]. A peripheral end facing the third lens **44**R in the second lens **44**G can be moved to be closer to the peripheral end on the opposite side on the X axis from the configuration of the reference example of the numerical value calculation pattern [1]. Consequently, the light amount of the white light WL**2** taken into the third lens **44**R becomes larger than the light amount of the white light WL**2** taken into the second lens **44**G.

(126) The brightness of the image light IM**1** in the numerical value calculation pattern [4] decreased 4% with respect to the numerical value calculation pattern [1]. This result is considered to have been obtained because the light amount of the green image light IG with respect to the blue image light IB and the red image light IR was reduced in the numerical value calculation pattern [4] to be smaller than the light amount in the numerical value calculation pattern [1] and the visibility at the time of observation decreased. In the numerical value calculation pattern [4], compared with the numerical value calculation pattern [1], a light amount difference of the green image light IG with respect to the red image light IR is larger than a light amount difference of the green image light IG with respect to the blue image light IB. Therefore, a spectrum of the image light IM**1** in the numerical value calculation pattern [4] deviates from the human visibility.

(127) A color temperature of the image light IM**1** in the numerical value calculation pattern [4] was calculated as 8047 [K] and a color deviation of the image light IM**1** in the numerical value calculation pattern [4] was calculated as −0.024. The color temperature of the image light IM**1** in the numerical value calculation pattern [4] is considered to have become lower than the color temperature in the numerical value calculation pattern [1]. The image light IM**1** in the numerical

value calculation pattern [4] is considered to have become slightly more reddish compared with the image light IM**1** in the numerical value calculation pattern [1]. As explained above, the color deviation of the image light IM**1** in the numerical value calculation pattern [4] is considered to have increased to be larger than the color deviation in the numerical value calculation pattern [1] because a relative light amount of the green image light IG included in the image light IM**1** decreased and the spectrum of the image light IM**1** in the numerical value calculation pattern [4] moved away from the human visibility.

(128) In the numerical value calculation pattern [5], the transmittance of the red light RL in the red filter **54**R was maintained at 100%, the transmittance of the green light GL in the green filter **54**G was reduced to 90%, and the transmittance of the blue light BL in the blue filter **54**B was increased to 109% with respect to the assumption of the numerical value calculation pattern [1]. In order to realize the transmittances of the color filters in the numerical value calculation pattern [5], for example, a peripheral end facing the second lens **44**G on the X axis in the first lens **44**B can be moved to be closer to the second lens **44**G from the configuration of the reference example of the numerical value calculation pattern [1]. A peripheral end facing the first lens **44**B in the second lens **44**G can be moved to be closer to the peripheral end on the opposite side on the X axis from the configuration of the reference example of the numerical value calculation pattern [1]. Consequently, the light amount of the white light WL**2** taken into the first lens **44**B becomes larger than the light amount of the white light WL**2** taken into the second lens **44**G.

(129) The brightness of the image light IM**1** in the numerical value calculation pattern [5] decreased 6% with respect to the numerical value calculation pattern [1]. This result is considered to have been obtained because the light amount of the green image light IG with respect to the blue image light IB and the red image light IR was reduced in the numerical value calculation pattern [5] to be smaller than the light amount in the numerical value calculation pattern [1] and the visibility at the time of observation decreased. In the numerical value calculation pattern [5], compared with the numerical value calculation pattern [1], a light amount difference of the green image light IG with respect to the red image light IR is smaller than a light amount difference of the green image light IG with respect to the blue image light IB. Therefore, a spectrum of the image light IM**1** in the numerical value calculation pattern [5] deviates from the human visibility and is different from the spectrum of the image light IM**1** in the numerical value calculation pattern [4] as well.

(130) A color temperature of the image light IM**1** in the numerical value calculation pattern [5] was calculated as 11463 [K] and a color deviation of the image light IM**1** in the numerical value calculation pattern [5] was calculated as −0.022. The color temperature of the image light IM**1** in the numerical value calculation pattern [5] is considered to have become extremely higher than the color temperature in the numerical value calculation pattern [1]. The image light IM**1** in the numerical value calculation pattern [5] is considered to have become more bluish compared with the image light IM**1** in the numerical value calculation pattern [1]. As explained above, the color deviation of the image light IM**1** in the numerical value calculation pattern [5] is considered to have increased to be larger than the color deviation in the numerical value calculation pattern [1] and reached the same degree as the color deviation in the numerical value calculation pattern [4] because the relative light amount of the green image light IG included in the image light IM**1** decreased and the spectrum of the image light IM**1** in the numerical value calculation pattern [5] moved away from the human visibility.

(131) In the numerical value calculation pattern [6], the transmittance of the red light RL in the red filter **54**R was reduced to 90%, the transmittance of the green light GL in the green filter **54**G was maintained at 100%, and the transmittance of the blue light BL in the blue filter **54**B was reduced to 90% with respect to the assumption of the numerical value calculation pattern [1]. A relative relation among the transmittances of the color lights in the color filters in the numerical value calculation pattern [6] is the same as the relative relation among the transmittances of the color

lights in the color filters realized by the pixel electrode **62** of the projector **301** in this embodiment explained above. In order to realize the transmittances of the color filters in the numerical value calculation pattern [6], for example, a peripheral end facing each of the first lens **44**B and the third lens **44**R on the X axis in the second lens **44**G can be moved to be closer to each of the first lens **44**B and the third lens **44**R from the configuration of the reference example of the numerical value calculation pattern [1]. A peripheral end facing the second lens **44**G on the X axis in each of the first lens **44**B and the third lens **44**R can be moved to be closer to the peripheral end on the opposite side and away from the second lens **44**G from the configuration of the reference example of the numerical value calculation pattern [1]. Consequently, the light amount of the white light WL**2** taken into the second lens **44**G becomes larger than the light amount of the white light WL**2** taken into the first lens **44**B and the third lens **44**R.

(132) The brightness of the image light IM**1** in the numerical value calculation pattern [6] increased 9% with respect to the numerical value calculation pattern [1]. This result is considered to have been obtained because, in the numerical value calculation pattern [6], the light amount of the green image light IG with respect to each of the blue image light IB and the red image light IR was higher than the light amount in the numerical value calculation pattern [1] and the visibility at the time of observation satisfactorily increased. In the numerical value calculation pattern [6], compared with the numerical value calculation pattern [1], a light amount difference of the green image light IG with respect to the blue image light IB and a light amount difference of the green image light IG with respect to the red image light IR are equal. Therefore, a spectrum of the image light IM**1** in the numerical value calculation pattern [6] is the closest to the human visibility among the numerical value calculation patterns [1] to [6] and the numerical value calculation pattern [7] explained below.

(133) A color temperature of the image light IM**1** in the numerical value calculation pattern [6] was calculated as 7595 [K] and a color deviation of the image light IM**1** in the numerical value calculation pattern [6] was calculated as −0.001. The color temperature of the image light IM**1** in the numerical value calculation pattern [6] is considered to have become lower than the color temperature in the numerical value calculation pattern [1]. The image light IM**1** in the numerical value calculation pattern [6] is considered to have become intensely more bluish compared with the image light IM**1** in the numerical value calculation pattern [1]. As explained above, the color deviation of the image light IM**1** in the numerical value calculation pattern [6] decreased to be smaller than the color deviation at least in the numerical value calculation pattern [1] and was the smallest among the numerical value calculation patterns [1] to [7] because the relative light amount of the green image light IG included in the image light IM**1** increased and the spectrum of the image light IM**1** in the numerical value calculation pattern [6] came closer to the human visibility than in the numerical value calculation pattern [1].

(134) In the numerical value calculation pattern [7], the transmittance of the red light RL in the red filter **54**R was maintained at 100%, the transmittance of the green light GL in the green filter **54**G was increased to 110%, and the transmittance of the blue light BL in the blue filter **54**B was maintained at 100% with respect to the assumption of the numerical value calculation pattern [1]. In order to realize the transmittances of the color filters in the numerical value calculation pattern [7], for example, at least one of the peripheral end on the +Y side and the peripheral end on the −Y side parallel to the X axis in the second lens **44**G can be moved in the outward direction of the second lens **44**G when viewed along the Z axis from the configuration of the reference example of the numerical value calculation pattern [1] and increase a dimension on the Y axis of the second lens **44**G to be larger than the dimensions of the first lens **44**B and the third lens **44**R. Consequently, since the white light WL**2**, which is emitted to a light blocking region when the second lens **44**G is absent, is taken in by the second lens **44**G. Therefore, a light amount of the white light WL**2** taken into the second lens **44**G becomes larger than the light amount of the white light WL**2** taken into the first lens **44**B and the third lens **44**R.

(135) The brightness of the image light IM**1** in the numerical value calculation pattern [7] increased 3% with respect to the numerical value calculation pattern [1]. This result is considered to have been obtained because, in the numerical value calculation pattern [7], the light amount of the green image light IG with respect to each of the blue image light IB and the red image light IR was higher than the light amount in the numerical value calculation pattern [1] and the visibility at the time of observation increased. In the numerical value calculation pattern [7], compared with the numerical value calculation pattern [1], a light amount difference of the green image light IG with respect to the blue image light IB and a light amount difference of the green image light IG with respect to the red image light IR are equal to each other. A spectrum of the image light IM**1** in the numerical value calculation pattern [7] is closer to the human visibility compared with the spectrum in the numerical value calculation pattern [1]. However, the light amount difference of the green image light IG with respect to the blue image light IB and the light amount difference of the green image light IG with respect to the red image light IR in the numerical value calculation pattern [7] are smaller compared with the light amount differences in the numerical value calculation pattern [6]. Therefore, the brightness of the image light IM**1** in the numerical value calculation pattern [7] was lower than the brightness of the image light IM**1** in the numerical value calculation pattern [1] and was at a degree close to the brightness in the numerical value calculation pattern [2].

(136) A color temperature of the image light IM**1** in the numerical value calculation pattern [7] was calculated as 8288 [K] and a color deviation of the image light IM**1** in the numerical value calculation pattern [7] was calculated as −0.009. The color temperature of the image light IM**1** in the numerical value calculation pattern [7] is considered to have become slightly lower than the color temperature in the numerical value calculation pattern [1]. The image light IM**1** in the numerical value calculation pattern [7] is considered to have become slightly more reddish compared with the image light IM**1** in the numerical value calculation pattern [1]. As explained above, the color deviation of the image light IM**1** in the numerical value calculation pattern [7] decreased to be smaller than the color deviation in the numerical value calculation pattern [1] because the relative light amount of the green image light IG included in the image light IM**1** increased and the spectrum of the image light IM**1** in the numerical value calculation pattern [7] came closer to the human visibility than in the numerical value calculation pattern [1]. Actually, the color deviation of the image light IM**1** in the numerical value calculation pattern [7] was equal to the color deviation in the numerical value calculation pattern [2].

(137) It is seen from the evaluation of the numerical value calculation patterns [1] to [7], in patterns in which the transmittance of the green light GL in the green filter **54**G is higher than the transmittance of the red light RL in the red filter **54**R and the transmittance of the blue light BL in the blue filter **54**B like at least the numerical value calculation patterns [2], [3], [6], and [7], the brightness of the image light IM**1** increased to be larger than the brightness in the numerical value calculation pattern [1] and the color deviation of the image light IM**1** was reduced to be smaller than the color deviation in the numerical value calculation pattern [1]. As explained above, it was assumed that the transmittances per unit area of the three color filters, that is, the red filter **54**R, the green filter **54**G, and the blue filter **54**B were equal to one another and it was assumed that the areas of the three color filters viewed along the Z axis were equal to one another. Therefore, by setting the area of the second lens **44**G viewed along the Z axis larger than the area of each of the first lens **44**B and the third lens **44**R, the light amount of the green light GL transmitted through the green filter **54**G can be increased to be larger than the light amount of the red light RL transmitted through the red filter **54**R and the light amount of the blue light BL transmitted through the blue filter **54**B. As a result, the light amount of the green image light IG included in the image light IM**1** becomes larger than the light amounts of the blue image light IB and the red image light IR. The spectra of the full-color image lights IM**1** and IM**2** match the human visibility of the observer and correspond to the human visibility. Therefore, the brightness of the image lights IM**1** and IM**2** increases, color deviations of the white balance of the image lights IM**1** and IM**2** are reduced, and

the visibility of the image lights IM**1** and IM**2** for the observer increases.

(138) In the numerical value calculation pattern [6] among the numerical value calculation patterns [2], [3], [6], and [7], the light amount difference between the image lights IG and IB and the light amount difference between the image lights IG and IR were equal to each other and were 27%. when the light amount difference between the image lights IG and IB and the light amount difference between the image lights IG and IR are, for example, 20% or more and 40% or less, since the spectra of the image lights IM**1** and IM**2** satisfactorily match the human visibility, the brightness of the image lights IM**1** and IM**2** further increases. The color temperatures and the color deviations of the white balance of the image lights IM**1** and IM**2** can be adjusted by changing the light amount difference between the image lights IG and IB or the light amount difference between the image lights IG and IR. Note that the color temperatures and the color deviations of the image lights IM**1** and IM**2** are also adjusted when the peak wavelengths of the red light RL, the green light GL, and the blue light BL are changed.

(139) The projector **301** in this embodiment explained above includes the light source device **10**, the lens array **40**, the color filter **52**, the pixel electrode **62**, and the projection optical system **90**. The light source device **10** emits the white lights WL**1** and WL**2** including the blue light BL, the green light GL, and the red light RL. The lens array **40** is disposed on the optical path of the white light WL**2** emitted from the light source device **10** and includes the plurality of microlenses **42**. The microlenses **42** are equivalent to the "lens". The plurality of microlenses **42** include the first lenses **44**B, the second lenses **44**G, and the third lenses **44**R. The color filter **52** is disposed on the optical path of the white light WL**2** emitted from the lens array **40** and includes the blue filters **54**B, the green filters **54**G, and the red filters **54**R. The blue filters **54**B transmit the blue light BL included in the white light WL**2** emitted from the first lenses **44**B among the plurality of microlenses **42**. The green filters **54**G transmit the green light GL included in the white light WL**2** emitted from the second lenses **44**G among the plurality of microlenses **42**. The red filters **54**R transmit the red light RL included in the white light WL**2** emitted from the third lenses **44**R among the plurality of microlenses **42**. The pixel electrode **62** is disposed on the optical paths of the red light RL, the green light GL, and the blue light BL transmitted through the color filter **52** and is disposed to face the color filter **52**. The pixel electrode **62** includes the blue sub-pixel electrodes **66**B, the green sub-pixel electrodes **66**G, and the red sub-pixel electrodes **66**R. The blue sub-pixel electrodes **66**B modulate, according to image information, the blue light BL transmitted through the blue filters **54**B and emit the blue image light IB. The green sub-pixel electrodes **66**G modulate, according to the image information, the green light GL transmitted through the green filters **54**G and emit the green image light IG. The red sub-pixel electrodes **66**R modulate, according to the image information, the red light RL transmitted through the red filters **54**R and emits the red image light IR. The projection optical system **90** is disposed on the optical paths of the blue image light IB, the green image light IG, and the red image light IR and projects the blue image light IB, the green image light IG, and the red image light IR. That is, the projection optical system **90** is disposed on the optical path of the image light IM**2** obtained by combining the image lights IB, IG, and IR with one another and projects the image light IM**2**.

(140) In the projector **301** in this embodiment, the plurality of microlenses **42** of the lens array **40** include the first lenses **44**B that emit the white light WL**2** toward the blue filters **54**B, the second lenses **44**G that emit the white light WL**2** toward the green filters **54**G, and the third lenses **44**R that emit the white light WL**2** toward the red filters **54**R. The areas of the incident surface **44***a* and the emission surface **44***b* of the second lens **44**G are larger than the area of the incident surface **54***a* of the green filter **54**G and larger than the areas of the incident surface **44***a* and the emission surface **44***b* of the first lens **44**B and the areas of the incident surface **44***a* and the emission surface **44***b* of the third lens **44**R.

(141) In the projector **301** in this embodiment, the size of the second lens **44**G corresponding to the green light GL, that is, the area of the second lens **44**G viewed along the optical axis AX and the Z

axis is larger than the areas of the first lens **44**B corresponding to the blue light BL and the third lens **44**R corresponding to the red light RL. With the projector **301** in this embodiment, a light amount of the green light GL made incident on the green sub-pixel electrode **66**G using the second lens **44**G can be increased to be larger than a light amount of the blue light BL made incident on the blue sub-pixel electrode **66**B using the first lens **44**B and a light amount of the red light RL made incident on the red sub-pixel electrode **66**R using the third lens **44**R. That is, a larger amount of the green light GL can be made incident on the green sub-pixel electrode **66**G using the second lens **44**G and the green filter **54**G. As a result, in an image and a video projected from the projector **301** in this embodiment, it is possible to easily increase the brightness of the green image light IG, for which the human visibility is high, to be higher than the brightness of the blue image light IB and the red image light IR. With the projector **301** in this embodiment, the observer can visually recognize an image and a video displayed on the screen or the like more brightly than an image and a video projected by the projector of the related art. That is, with the projector **301** in this embodiment, even when light amount ratios of the red light RL, the green light GL, and the blue light BL included in the white lights WL**1** and WL**2** emitted from the light source device **10** are equal to one another, the light amount of the green image light IG included in the image light IM**2** can be increased to be larger than the light amounts of the blue image light IB and the red image light IR. Therefore, with the projector **301** in this embodiment, illumination ratios and spectra of red, green, and blue image lights in an image and a video to be projected can be adjusted to the visibility of a human observing the image and the video. It is possible to realize an image and a video recognized more brightly than an image and a video projected by the projector of the related art.

(142) As a method of adjusting spectra of the image lights IM**1** and IM**2** emitted from the light modulation device **50** to the human visibility and changing white balance, for example, a method of changing characteristics of each of the red filters **54**R, the green filters **54**G, and the blue filters **54**B of the color filter **52**, that is, a method of changing the transmittance of the red light RL in the red filters **54**R, the transmittance of the green light GL in the green filters **54**G in the green filter **54**G, and the transmittance of the blue light BL in the blue filters **54**B in the blue filter **54**B is conceivable. As another method of adjusting spectra of the image lights IM**1** and IM**2** to the human visibility and changing white balance, a method of changing the area of each of the green sub-pixel electrodes **66**G and the blue sub-pixel electrodes **66**B viewed along the Z axis is conceivable. However, in these methods, the light modulation device **50** including the color filter **52** and the pixel electrodes **62** needs to be individually designed according to white balance of the image lights IM**1** and IM**2** that should be realized. This leads to an increase in cost of the projector **301**.

(143) On the other hand, with the projector **301** in this embodiment, the areas of the first lens **44**B, the second lens **44**G, and the third lens **44**R of the lens array **40**, which is a component separate from the light modulation device **50**, can be suitably set according to spectra matching the human visibility to be adjusted to the transmittance of the color lights of the color filters, the areas of the color sub-pixel electrodes, and the like in the light modulation device **50**. The area of the second lens **44**G can be set larger than the areas of the first lens **44**B and the third lens **44**R. With this method, the cost of the projector **301** can be reduced compared with when the light modulation device **50** is individually designed.

(144) As another method of adjusting spectra of the image lights IM**1** and IM**2** to the human visibility and changing white balance, a method of suitably adjusting, according to spectra matching the human visibility, gradation in each of the red sub-pixel electrodes **66**R, the green sub-pixel electrodes **66**G, and the blue sub-pixel electrodes **66**B of the pixel electrode **62** is conceivable. However, with this method, the brightness of the image lights IM**1** and IM**2** decreases.

(145) In order to adjust the spectra of the image lights IM**1** and IM**2** to the human visibility, a light amount of the green light GL included in the image lights IM**1** and IM**2** is preferably equal to or more than 110% and equal to or less than 150% and more preferably equal to or more than 120%

and equal to or less than 140% with respect to a light amount of each of the red light RL and the blue light BL included in the image lights IM**1** and IM**2**.

(146) Note that the lens array **40** may be in contact with the light modulation device **50** on the Z axis. when the lens array **40** and the light modulation device **50** are components separate from each other, for example, the emission surfaces **44***b* of the first lenses **44**B, the second lenses **44**G, and the third lenses **44**R of the lens array **40** may be in contact with the incident surface **52***a* of the color filter **52** of the light modulation device **50**. In this case, a separation distance on the Z axis between the lens array **40** and the light modulation device **50** is extremely short and the separation distance PL is reduced. Therefore, the microlenses **42** of the lens array **40** need to have high power. A spot diameter of color light at each of the condensing points MR, MG, and MB decreases. On the other hand, there is an advantage that it is easy to align the microlenses **42** and the color filters corresponding thereto and positional deviation between the microlenses **42** and the color filters corresponding thereto less easily occurs.

(147) When the lens array **40** and the light modulation device **50** are separated from each other on the Z axis as in the projector **301** in this embodiment, since the separation distance PL is long compared with when the lens array **40** and the light modulation device **50** are in contact with each other as explained above, the microlenses **42** of the lens array **40** may have low power. The spot diameter of the color light at each of the condensing points MR, MG, and MB increases. Restrictions on the material of the microlenses **42**, a shape error and the like allowed at the time of manufacturing, and the like decrease. On the other hand, accurate alignment of the microlenses **42** and the color filters corresponding thereto is necessary.

(148) In the projector **301** in this embodiment, the first lenses **44**B, the second lenses **44**G, and the third lenses **44**R of the lens array **40** are disposed along the X axis and the Y axis. Note that the Z axis is an axis parallel to the optical axis AX of the white light WL**2** made incident on the lens array **40** and is equivalent to the "first axis". The X axis is orthogonal to the Z axis and is equivalent to the "second axis". The Y axis is orthogonal to the Z axis and the X axis and is equivalent to the "third axis". On the X axis, the width XG of the second lens **44**G is larger than the width XB of the first lens **44**B and the width XR of the third lens **44**R. Specifically, in the projector **301** in this embodiment, the red filters **54**R, the green filters **54**G, and the blue filters **54**B of the color filter **52** of the light modulation device **50** are sequentially repeatedly disposed on the X axis. The red sub-pixel electrodes **66**R, the green sub-pixel electrodes **66**G, and the blue sub-pixel electrodes **66**B of the pixel electrode **62** of the light modulation device **50** are sequentially repeatedly disposed along the X axis according to the disposition of the color filters. The third lenses **44**R, the second lenses **44**G, and the first lenses **44**B of the lens array **40** are sequentially repeatedly disposed along the X axis according to the disposition of the color filters and the sub-pixel electrodes explained above.

(149) With the projector **301** in this embodiment, since the width XG of the second lens **44**G is larger than the width XB of the first lens **44**B and the width XR of the third lens **44**R, a light amount of the white light WL**2** taken into the second lens **44**G can be increased to be larger than a light amount of the white light WL**2** taken into each of the first lens **44**B and the third lens **44**R on the X axis. As a result, the brightness of the image lights IM**1** and IM**2** can be increased. The observer can observe an image and a video more brightly than an image and a video projected by the projector of the related art.

(150) In the projector **301** in this embodiment, when viewed along the Z axis, the end portion on the −X side of the second lens **44**G of the lens array **40** overlaps the red filter **54**R of the color filter **52**. When viewed along the Z axis, the end portion on the +X side of the second lens **44**G of the lens array **40** overlaps the blue filter **54**B of the color filter **52**. The end portion on the −X side and the end portion on the +X side of the second lens **44**G are equivalent to the "part of the second lens".

(151) In the projector **301** in this embodiment, when the end portion on the −X side of the second

lens **44**G does not overlap the red filter **54**R, the white light WL**2** passing through the red filter **54**R is collected on the green filter **54**G by the second lens **44**G and passes through the green filter **54**G. Similarly, when the end portion on the +X side of the second lens **44**G does not overlap the blue filter **54**B, the white light WL**2** passing through the blue filter **54**B is collected on the green filter **54**G by the second lens **44**G and passes through the green filter **54**G. With the projector **301** in this embodiment, a light amount of the white light WL**2** made incident on the green filter **54**G can be increased and light amounts of the white light WL**2** made incident on the red filter **54**R and the blue filter **54**B can be reduced by the end portion on the −X side and the end portion on the +X side of the second lens **44**G. As a result, the differences between a light amount of the green light GL transmitted through the green filter **54**G and light amounts of the red light RL transmitted through the red filter **54**R and the blue light BL transmitted through the blue filter **54**B increase. With the projector **301** in this embodiment, a spectrum of the image light IM**2** to be projected can be easily adjusted to the visibility of a human observing the spectrum.

(152) In the projector **301** in this embodiment, the color filter **52** includes, in a plane orthogonal to the optical axis AX of the white light WL**2**, between any filters of the red filter **54**R, the green filter **54**G, and the blue filter **54**B adjacent to one another, the light blocking region **56** that blocks the white light WL**2**. The light blocking region **56** is provided, on the X axis, in a region further on the −X side than the red filter **54**R disposed most on the −X side in the color filter **52**, a region between the red filter **54**R and the green filter **54**G, a region between the green filter **54**G and the blue filter **54**B, a region between the blue filter **54**B and the red filter **54**R, and a region further on the +X side than the blue filter **54**B disposed most on the +X side in the color filter **52**. The light blocking region **56** is provided, on the Y axis, in a region further on the +Y side than each of the red filter **54**R, the green filter **54**G, and the blue filter **54**B disposed most on the +Y side in the color filter **52**, a region between the red filters **54**R adjacent to each other, a region between the green filters **54**G adjacent to each other, a region between the blue filters **54**B adjacent to each other, and a region further on the −Y side than each of the red filter **54**R, the green filter **54**G, and the blue filter **54**B disposed most on the −Y side in the color filter **52**.

(153) In the projector **301** in this embodiment, when viewed along the Z axis, the first lens **44**B, the second lens **44**G, and the third lens **44**R overlap the light blocking region **56**. Therefore, the white light WL**2** that is emitted to the light blocking region **56** and is not utilized as the image lights IM**1** and IM**2** when the first lens **44**B, the second lens **44**G, and the third lens **44**R are absent can be allowed to pass through the blue filter **54**B, the green filter **54**G, and the red filter **54**R using the lenses. As a result, a maximum light amount of color light passing through each of the first lens **44**B, the second lens **44**G, and the third lens **44**R increases compared with when the light blocking region **56** is not provided. With the projector **301** in this embodiment, an adjustable range of the area of each of the first lens **44**B, the second lens **44**G, and the third lens **44**R can be enlarged according to the width on the X axis and the Y axis of the light blocking region **56**. Consequently, it is possible to increase flexibility of adjustment of spectra in the image lights IM**1** and IM**2**.

(154) In the projector **301** in this embodiment, the red filters **54**R, the green filters **54**G, and the blue filters **54**B of the color filter **52** are disposed along the X axis and the Y axis in the XY plane as explained above. The XY plane is equivalent to the "surface crossing the first axis". The light blocking region **56** is disposed in a region extending in parallel to the Y axis between the red filter **54**R and the green filter **54**G adjacent to each other on the X axis, a region extending in parallel to the Y axis between the green filter **54**G and the blue filter **54**B adjacent to each other on the X axis, and a region extending in parallel to the Y axis between the blue filter **54**B and the red filter **54**R adjacent to each other on the X axis. The light blocking region **56** is disposed in a region extending in parallel to the X axis between the red filters **54**R adjacent to each other on the Y axis, a region extending in parallel to the X axis between the green filters **54**G adjacent to each other on the Y axis, and a region between the blue filters **54**B adjacent to each other on the Y axis. Further, the light blocking region **56** is disposed in a region extending in parallel to the Y axis further on the −X

side than the red filter **54**R disposed most on the −X side in the color filter **52** and a region extending in parallel to the Y axis further on the +X side than the blue filter **54**B disposed most on the +X side. That is, when viewed along the Z axis, the light blocking region **56** is disposed in a region extending in parallel to the X axis and a region extending in parallel to the Y axis at a peripheral edge portion further on the outer side than a region where the plurality of color filters are disposed in the color filter **52**. In the projector **301** in this embodiment, the width y2 on the Y axis of the light blocking region **56** extending in parallel to the X axis is larger than the width x2 on the X axis of the light blocking region extending in parallel to the Y axis. The first lenses **44**B, the second lenses **44**G, and the third lenses **44**R of the lens array **40** have power on the Y axis.

(155) In the projector **301** in this embodiment, since the width y2 of the light blocking region **56** is larger than the width x2, an adjustable width on the Y axis of each of the first lenses **44**B, the second lenses **44**G, and the third lenses **44**R can be secured larger than an adjustable width on the X axis.

(156) In the projector **301** in this embodiment, when viewed along the Z axis, the principal point HB of the first lens **44**B of the lens array **40** overlaps the center of the blue filter **54**B of the color filter **52** and the center of the blue sub-pixel electrode **66**B of the pixel electrode **62**. The principal point HG of the second lens **44**G of the lens array **40** overlaps the center of the green filter **54**G of the color filter **52** and the center of the green sub-pixel electrode **66**G of the pixel electrode **62**. The principal point HR of the third lens **44**R of the lens array **40** overlaps the center of the red filter **54**R of the color filter **52** and the center of the red sub-pixel electrode **66**R of the pixel electrode **62**.

(157) In the projector **301** in this embodiment, when viewed along the Z axis, the white light WL**2** emitted from the first lens **44**B is less easily blocked by the peripheral end of the blue filter **54**B and the blue light BL transmitted through the blue filter **54**B is less easily blocked by the peripheral end of the blue sub-pixel electrode **66**B. Therefore, the blue light BL can be efficiently made incident on the blue sub-pixel electrode **66**B. Similarly, when viewed along the Z axis, the white light WL**2** emitted from the second lens **44**G is less easily blocked by the peripheral end of the green filter **54**G and the green light GL transmitted through the green filter **54**G is less easily blocked by the peripheral end of the green sub-pixel electrode **66**G. Therefore, the green light GL can be efficiently made incident on the green sub-pixel electrode **66**G. Similarly, when viewed along the Z axis, the white light WL**2** emitted from the third lens **44**R is less easily blocked by the peripheral end of the red filter **54**R and the red light RL transmitted through the red filter **54**R is less easily blocked by the peripheral end of the red sub-pixel electrode **66**R. Therefore, the red light RL can be efficiently made incident on the red sub-pixel electrode **66**R.

(158) Subsequently, modifications of the embodiment of the present disclosure are explained.

(159) Note that, in the modifications, components common to the embodiment explained above are denoted by the same reference numerals and signs as the reference numerals and signs of the components in the embodiment corresponding to the components and redundant explanation of the explanation in the embodiment is omitted. In the modifications, components and contents different from the components and the contents in the embodiment explained above are explained.

First Modification

(160) FIG. **6** is a schematic diagram of the lens array **40** and the color filter **52** of the light modulation device **50** of the projector **301** in a first modification of the embodiment of the present disclosure and is a front view of the lens array **40** and the color filter **52** viewed from the −Z side along the Z axis. As shown in FIG. **6**, in the first modification, for example, in the pixel electrode **62** of the light modulation device **50**, the wiring region **68** between the red sub-pixel electrode **66**R and the green sub-pixel electrode **66**G on the X axis and the wiring region **68** between the green sub-pixel electrode **66**G and the blue sub-pixel electrode **66**B on the X axis of each of the pixels **64** may not be provided. According to such a configuration, in the color filter **52** of the light modulation device **50**, the light blocking region **56** between the red filter **54**R and the green filter **54**G on the X axis and the light blocking region **56** between the green filter **54**G and the blue filter

54B on the X axis may not be provided.

(161) In the projector **301** in the first modification as well, the width XB on the X axis of the first lens **44**B, the width XG on the X axis of the second lens **44**G, and the width XR on the X axis of the third lens **44**R are respectively set such that the area of the second lens **44**G is appropriately larger than the areas of the first lens **44**B and the third lens **44**R. "Appropriately" described above means a state in which spectra of the image lights IM**1** and IM**2** correspond to the human visibility such that desired brightness of the image light IM**2** to be projected can be obtained. In the projector **301** in the first modification, the same action effects as the action effects of the projector **301** in the embodiment explained above can be obtained. With the projector **301** in the first modification, an image and a video visually recognized more brightly than an image and a video projected by the projector of the related art can be realized according to the visibility of a human observing brightness of red, green, and blue image lights in an image and a video to be projected.

Second Modification

(162) Although not shown, in a second modification, for example, in the pixel electrode **62** of the light modulation device **50**, the wiring region **68** between the red sub-pixel electrodes **66**R on the Y axis, the wiring region **68** between the green sub-pixel electrodes **66**G on the Y axis, and the wiring region **68** between the blue sub-pixel electrodes **66**B on the Y axis may not be provided.

(163) In the second modification as well, the width XB of the first lens **44**B, the width XG of the second lens **44**G, and the width XR of the third lens **44**R are respectively set such that the area of the second lens **44**G is appropriately larger than the areas of the first lens **44**B and the third lens **44**R. With the projector **301** in the second modification, since the same action effects as the action effects of the projector **301** in the embodiment explained above can be obtained, an image and a video visually recognized more brightly than an image and a video projected by the projector of the related art can be realized according to the visibility of a human observing brightness of red, green, and blue image lights in an image and a video to be projected.

Third Modification

(164) Although not shown, in a third modification, for example, the wiring region **68** may be disposed outside the region of each of the pixels **64** of the pixel electrode **62** when viewed along the Z axis. The width x2 on the X axis and the width y2 on the Y axis of the wiring region **68** may be negligibly extremely small in each of the pixels **64**. According to the disposition of the pixel electrode **62**, the light blocking region **56** may be disposed outside the region of the set of the red filter **54**R, the green filter **54**G, and the blue filter **54**B of the color filter **52** when viewed along the Z axis. The width x2 on the X axis and the width y2 on the Y axis of the light blocking region **56** may be negligibly extremely small. In such a disposition configuration, when viewed along the Z axis, all of the first lenses **44**B, the second lenses **44**G, and the third lenses **44**R of the microlenses **42** of the lens array **40** sometimes do not overlap the light blocking region **56**.

(165) In the third modification as well, the widths XB and YB of the first lens **44**B, the widths XG and YG of the second lens **44**G, and the widths XR and YR of the third lens **44**R are respectively set such that the area of the second lens **44**G is appropriately larger than the areas of the first lens **44**B and the third lens **44**R. With the projector **301** in the third modification, since the same action effects as the action effects of the projector **301** in the embodiment explained above can be obtained, an image and a video visually recognized more brightly than an image and a video projected by the projector of the related art can be realized according to the visibility of a human observing brightness of red, green, and blue image lights in an image and a video to be projected.

(166) As illustrated in the first modification to the third modification, the disposition and the widths of the light blocking region **56** in the color filter **52** of the light modulation device **50** and the wiring region **68** of the pixel electrode **62** viewed along the Z axis are not limited to the disposition and the widths in the embodiment explained above and may be changed as appropriate.

Fourth Modification

(167) FIG. **7** is a schematic diagram of the lens array **40** and the color filter **52** of the light

modulation device **50** of the projector **301** in a fourth modification of the embodiment of the present disclosure and is a front view of the lens array **40** and the color filter **52** viewed from the −Z side along the Z axis. As shown in FIG. **7**, in the fourth modification, for example, the width XB of the first lens **44**B, the width XG of the second lens **44**G, and the width XR of the third lens **44**R of the lens array **40** are equal to one another. On the other hand, the width YG of the second lens **44**G is larger than the width YB of the first lens **44**B and the width YR of the third lens **44**R.

(168) In the fourth modification as well, the width YB of the first lens **44**B, the width YG of the second lens **44**G, and the width YR of the third lens **44**R are respectively set such that the area of the second lens **44**G is appropriately larger than the areas of the first lens **44**B and the third lens **44**R. With the projector **301** in the fourth modification, since the same action effects as the action effects of the projector **301** in the embodiment explained above can be obtained, an image and a video visually recognized more brightly than an image and a video projected by the projector of the related art can be realized according to the visibility of a human observing brightness of red, green, and blue image lights in an image and a video to be projected.

(169) In the fourth modification, when viewed along the Z axis parallel to the optical axis AX of the white light WL**2** made incident on the lens array **40**, the second lens **44**G does not overlap the blue filter **54**B and the red filter **54**R. The configuration in the fourth modification is suitable when the light blocking region **56** having sufficient width y2 is provided in the color filter **52** and the wiring region **68** having sufficient width y2 is provided in the pixel electrode **62** in order to set the area of the second lens **44**G appropriately larger than the areas of the first lens **44**B and the third lens **44**R.

(170) Note that, although not shown, when viewed along the Z axis, a part of the second lens **44**G may overlap one color filter of the blue filter **54**B and the red filter **54**R in order to set the area of the second lens **44**G appropriately larger than the areas of the first lens **44**B and the third lens **44**R. One color filter is selected according to a desired color temperature and a desired color deviation of white balance realized by the image lights IM**1** and IM**2**.

(171) Although not shown, in the configuration in the fourth modification, further, the width XG of the second lens **44**G of the lens array **40** may be larger than the width XB of the first lens **44**B and the width XR of the third lens **44**R. In this case, when the widths on the X axis are increased, the differences between the area of the second lens **44**G and the areas of the first lens **44**B and the third lens **44**R increase. The action effects described above can be obtained by setting the area of the second lens **44**G appropriately larger than the areas of the first lens **44**B and the third lens **44**R.

Fifth Modification

(172) FIG. **8** is a perspective view of the second lens **44**G of the lens array **40** of the projector **301** in a fifth modification of the embodiment of the present disclosure. FIG. **9** is a schematic diagram of the lens array **40** and the color filter **52** and the pixel electrode **62** of the light modulation device **50** in the fifth modification and is a sectional view thereof in arrow view taken along the C**1**-C**1** line shown in FIG. **2**. FIG. **10** is a schematic diagram of the lens array **40** and the color filter **52** and the pixel electrode **62** of the light modulation device **50** in the fifth embodiment and is a sectional view thereof in arrow view taken along the C**2**-C**2** line shown in FIG. **2**.

(173) As shown in FIGS. **8** to **10**, the incident surface **44**a of the second lens **44**G of the lens array **40** includes an incident surface **44**p and an incident surface **44**q. Width x3 on the X axis of the incident surface **44**p is the same as the width x1 of the green filter **54**G of the color filter **52**. The incident surface **44**p is a flat surface parallel to the XY plane. Width y3 on the Y axis of the incident surface **44**p is the same as the width y1 of the green filter **54**G. When viewed along the Z axis, the incident surface **44**p overlaps the green filter **54**G and the green sub-pixel electrode **66**G of the pixel electrode **62**.

(174) The incident surface **44**q is, for example, a part of a curved surface convex to the −Z side with the same position as the condensing point MG set as a vertex on the X axis and the Y axis and is a part of a curved surface designed according to the separation distance PL. The incident surface

44q is configured with the remaining portion excluding a portion overlapping the green filter **54**G and the green sub-pixel electrode **66**G when viewed along the Z axis in the curved surface explained above and is the curved surface explained above disposed between the width x1 and the width XG on the X axis and between the width y1 and the width YG on the Y axis centering on the principal point HG when viewed along the Z axis.

(175) Since the second lens **44**G includes the incident surfaces **44**p and **44**q as the incident surface **44**a as explained above, when viewed along the Z axis, the second lens **44**G does not have power in a portion overlapping the green filter **54**G and has positive power in a portion not overlapping the green filter **54**G. Therefore, in the white light WL**2** made incident on the incident surface **44**a of the second lens **44**G, the white light WL**2** made incident on the incident surface **44**p in a region overlapping the green filter **54**G when viewed along the Z axis travels straight along the Z axis without being refracted on the X axis and the Y axis and is made incident on the green filter **54**G. The green light GL transmitted through the green filter **54**G is emitted to the +Z side along the Z axis, made incident on the green sub-pixel electrode **66**G, and converted into the green image light IG.

(176) In the fifth modification as well, the width XB of the first lens **44**B, the width XG of the second lens **44**G, and the width XR of the third lens **44**R are respectively set such that the area of the second lens **44**G is appropriately larger than the areas of the first lens **44**B and the third lens **44**R. The green lights GL included in the white light WL**2** made incident on the incident surfaces **44**p and **44**q of the second lens **44**G travel in different routes each other. However, as a result, the green lights GL are made incident on the same green sub-pixel electrode **66**G and converted into the green image light IG. Therefore, with the projector **301** in the fifth modification, since the same action effects as the action effects of the projector **301** in the embodiment explained above can be obtained, an image and a video visually recognized more brightly than an image and a video projected by the projector of the related art can be realized according to the visibility of a human observing brightness of red, green, and blue image lights in an image and a video to be projected.

(177) In the fifth modification, the center of the incident surface **44**a of the second lens **44**G viewed along the Z axis is configured with the incident surface **44**p, which is the flat surface parallel to the XY plane. In the configuration in the fifth modification, it is possible to reduce the thickness on the Z axis of the second lens **44**G and achieve a reduction in the thickness of the second lens **44**G compared with when the incident surface **44**a of the second lens **44**G is configured with one curved surface and the entire incident surface **44**a has positive power.

(178) With the projector **301** in the fifth modification, the light intensity of the green light GL made incident on the green sub-pixel electrode **66**G can be dispersed in the entire green sub-pixel electrode **66**G. Therefore, it is possible to suppress generation of the green light GL locally having high light intensity in the green sub-pixel electrode **66**G and reduce a load that occurs when the green light GL locally having high light intensity is generated.

(179) Note that, in the fifth modification, as shown in FIGS. **9** and **10**, the first lens **44**B may not have power in a portion overlapping the blue filter **54**B and the blue sub-pixel electrode **66**B and may have positive power in a portion not overlapping the blue filter **54**B and the blue sub-pixel electrode **66**B. The third lens **44**R may not have power in a portion overlapping the red filter **54**R and the red sub-pixel electrode **66**R and may have positive power in a portion not overlapping the red filter **54**R and the red sub-pixel electrode **66**R. That is, at least one lens of the first lens **44**B, the second lens **44**G, and the third lens **44**R may not have power in a portion overlapping a color filter disposed to correspond to the lens when viewed along the Z axis and may have positive power in a portion not overlapping the color filter disposed to correspond to the lens.

(180) In the fifth modification, at least a part of the white light WL**2** emitted to the +Z side generally along the Z axis from both the ends on the X axis and both the ends on the Y axis of the incident surface **44**p of the second lens **44**G is likely to be blocked by the light blocking region **56** adjacent, on the X axis and the Y axis, to the green filter **54**G disposed to correspond to the second

lens **44**G. In order to suppress a loss of the white light WL**2**, when at least one lens of the first lens **44**B, the second lens **44**G, and the third lens **44**R includes the incident surfaces **44**p and **44**q as the incident surface **44**a, the width f the incident surface **44**p of the lens may be x3 of appropriately smaller than the width x1 and the width y3 of the incident surface **44**p of the lens may be appropriately smaller than the width y1.

Sixth Modification

(181) Although not shown, in a sixth modification, when viewed along the Z axis parallel to the optical axis AX of the white light WL**2** made incident on the lens array **40**, the principal points HR and HB of at least one lens of the first lens **44**B and the third lens **44**R of the lens array **40** may not overlap the center of a color filter of the color filter **52** disposed to correspond to the lens and may be disposed in a position different from the center of the color filter disposed to correspond to the lens.

(182) In the sixth modification, for example, when viewed along the Z axis, the principal point HR and the condensing point MR of the third lens **44**R may be disposed further on the +X side than the center on the X axis of the red filter **54**R. The principal point HB and the condensing point MB of the first lens **44**B may be disposed further on the −X side than the center on the X axis of the blue filter **54**B. In this case, a light beam of the white light WL**2** emitted from the third lens **44**R and condensed on the condensing point MR tends to pass the center portion on the X axis of the red filter **54**R. Therefore, a loss of the white light WL**2** and the red light RL can be suppressed. Similarly, a light beam of the white light WL**2** emitted from the first lens **44**B and condensed on the condensing point MB tends to pass the center portion on the X axis of the blue filter **54**B. Therefore, a loss of the white light WL**2** and the blue light BL can be suppressed.

(183) In the sixth modification as well, the widths XB and YB of the first lens **44**B, the widths XG and YG of the second lens **44**G, and the widths XR and YR of the third lens **44**R are respectively set such that the area of the second lens **44**G is appropriately larger than the areas of the first lens **44**B and the third lens **44**R. Therefore, with the projector **301** in the sixth modification, since the same action effects as the action effects of the projector **301** in the embodiment explained above can be obtained, an image and a video visually recognized more brightly than an image and a video projected by the projector of the related art can be realized according to the visibility of a human observing brightness of red, green, and blue image lights in an image and a video to be projected.

Seventh Modification

(184) Although not shown, in a seventh modification, when viewed along the Z axis, positive power of the microlens **42** disposed in an outer periphery centering on the optical axis AX of the white light WL**2** among the plurality of microlenses **42** disposed in the lens array **40** may be stronger than positive power of the microlens **42** disposed on the center centering on the optical axis AX. For example, the condensing points MB, MG, and MR of the first lens **44**B, the second lens **44**G, and the third lens **44**R of the microlens **42** disposed in the outer periphery of the lens array **40** are disposed in the centers on the X axis, the Y axis, and the Z axis of the blue sub-pixel electrode **66**B, the green sub-pixel electrode **66**G, and the red sub-pixel electrode **66**R of the pixel electrode **62**. Consequently, the white light WL**2** made incident on the microlens **42** disposed in the outer periphery of the lens array **40** is made incident on the color filter disposed to correspond to the microlens **42** as in the projector **301** in the embodiment explained above. The red light RL, the green light GL, or the blue light BL transmitted through each of the color filters is efficiently made incident on the color sub-pixel electrode corresponding to the color filter.

(185) On the other hand, the condensing points MB, MG, and MR of the first lens **44**B, the second lens **44**G, and the third lens **44**R of the microlens **42** disposed in the center of the lens array **40** are disposed in the centers on the X axis and the Y axis of the blue sub-pixel electrode **66**B, the green sub-pixel electrode **66**G, and the red sub-pixel electrode **66**R and, on the Z axis, are disposed in regions further on the +Z side than the emission surfaces **66**b of blue sub-pixel electrode **66**B, the green sub-pixel electrode **66**G, and the red sub-pixel electrode **66**R. On each of the X axis and the

Y axis, a curvature radius of the incident surfaces **44***a* of the first lens **44**B, the second lens **44**G, and the third lens **44**R in the center of the lens array **40** centering on the optical axis AX is larger than a curvature radius of the incident surfaces **44***a* of the first lens **44**B, the second lens **44**G, and the third lens **44**R in the outer periphery of the lens array **40**. In this case, a part of the white light WL**2** made incident on the microlens **42** disposed in the center of the lens array **40** is blocked by the light blocking region **56** adjacent to, on the XY plane, the color filter disposed to correspond to the microlens **42** and is not made incident on the color sub-pixel electrode corresponding to the color filter.

(186) The projector **301** in this embodiment is the single plate type projector as explained above. In the single plate type projector, white light including blue light, green light, and red light is converted into full-color image light by one light modulation device. As components other than the single plate type projector, a two plate type projector and a three plate type projector are known. In the two plate type projector, two light modulation devices are used. For example, one color light of blue light, green light, and red light is converted into image light in time series by one light modulation device. The other color light of the green light and the red light is converted into image light in synchronization with one color light by the other light modulation device. In the three plate type projector, three light modulation devices are used. Each color light of blue light, green light, and red light is converted into image light by each of the light modulation devices. The number of components of the single plate type projector including the projector **301** in this embodiment is reduced to be smaller than the numbers of components of the two plate type projector and the three plate type projector. On the other hand, in the single plate type projector, the areas of an incident surface and an emission surface of the one light modulation device tend to be larger than the areas of the other types. The illuminance of the white light in the center centering on an optical axis on the incident surface of the light modulation device tends to be higher than the illuminance of the white light in the outer periphery of the incident surface.

(187) In the seventh modification, positive power of the microlens **42** disposed in the outer periphery of the lens array **40** is stronger than positive power of the microlens **42** disposed in the center of the lens array **40**. Therefore, the illuminance of color light transmitted through the color filter of the color filter **52** and color light made incident on the sub-pixel electrode of the pixel electrode **62** of the light modulation device **50** corresponding to the microlens **42** disposed in the outer periphery is relatively lower than the illuminance of color light transmitted through the color filter and color light made incident on the sub-pixel electrode corresponding to the microlens **42** disposed in the center. Therefore, in the seventh modification, when the illuminance of the center centering on the optical axis AX of the white light WL**2** emitted to the lens array **40** is relatively higher than the illuminance in the outer periphery and an illuminance difference of the white light WL**2** between the center and the outer periphery is large, the illuminance difference of the white light WL**2** is reduced by a difference in positive power of the microlens **42** between the center and the outer periphery. Therefore, in the seventh modification, even when the illuminance in the center of the white light WL**2** emitted to the lens array **40** is higher than the illuminance in the outer periphery, it is possible to uniformize illuminance distributions on the XY plane centering on the optical axis AX of the image lights IM**1** and IM**2** emitted from the light modulation device **50**.

(188) Note that, in the seventh modification, on each of the X axis and the Y axis, the curvature radius of the incident surfaces **44***a* of the first lens **44**B, the second lens **44**G, and the third lens **44**R in the center of the lens array **40** centering on the optical axis AX may be equal to the curvature radius of the incident surfaces **44***a* of the first lens **44**B, the second lens **44**G, and the third lens **44**R in the outer periphery of the lens array **40**. In that case, a refractive index of the material of the first lens **44**B, the second lens **44**G, and the third lens **44**R in the center of the lens array **40** is higher than a refractive index of the material of the first lens **44**B, the second lens **44**G, and the third lens **44**R in the outer periphery of the lens array **40**. Consequently, the positive power of the microlens **42** disposed in the outer periphery of the lens array **40** becomes stronger than the positive power of

the microlens **42** disposed in the center of the lens array **40**. It is possible to uniformize illuminance distributions on the XY plane of the image lights IM**1** and IM**2** emitted from the light modulation device **50**.

(189) The preferred embodiment of the present disclosure is explained in detail above. However, the present disclosure is not limited to such a specific embodiment. Various modifications and changes are possible within the scope of the gist of the present disclosure described in the claims.

(190) For example, in the projector **301** in the embodiment explained above, the shapes, the widths XR, XG, and XG, and the width YR, YG, and YB of the red filters **54**R, the green filters **54**G, and the blue filters **54**B viewed along the Z axis are equal to one another in the color filter **52** of the light modulation device **50**. In the projector **301** in the embodiment explained above, the red filters **54**R, the green filters **54**G, and the blue filters **54**B are disposed in a so-called stripe form. However, the shape and the area of each of the red filters **54**R, the green filters **54**G, and the blue filters **54**B and relative disposition of the color filters in the color filter **52** are not limited to specific types and may be changed as appropriate.

(191) For example, in the color filter **52** of the light modulation device **50**, the red filters **54**R, the green filters **54**G, and the blue filters **54**B may be disposed in, for example, a mosaic form, a pentile form, a diamond pentile form, or any form other than these forms. Irrespective of in which form the red filters **54**R, the green filters **54**G, and the blue filters **54**B are disposed, disposition including presence or absence and width of a light blocking region only have to be considered and the areas of the incident surface **44**a and the emission surface **44**b of the second lens **44**G of the lens array **40** only have to be larger than the area of the incident surface **54**a of the green filter **54**G of the color filter **52** and larger than the areas of the incident surface **44**a and the emission surface **44**b of each of the first lens **44**B and the third lens **44**R. According to the relative disposition of the red filter **54**R, the green filter **54**G, and the blue filter **54**B and the third lens **44**R, the second lens **44**G, and the first lens **44**B, the second lens **44**G may have eccentricity and at least one of the first lens **44**B and the third lens **44**R may not have eccentricity.

(192) In the projector **301** in the embodiment explained above, the optical axis AX of the white lights WL**1** and WL**2** and the image lights IM**1** and IM**2** between the light source device **10** and the projection optical system **90** is parallel to the Z axis and the components are linearly disposed along the Z axis. However, the optical axis AX may be refracted as appropriate according to restrictions in design, an installation environment, and the like of the projector **301**.

SUMMARY OF THE PRESENT DISCLOSURE

(193) A summary of the present disclosure is noted below.

Note 1

(194) A projector includes: a light source device configured to emit white light including blue light, green light, and red light; a lens array disposed on an optical path of the white light emitted from the light source device and including a plurality of lenses; a color filter disposed on an optical path of the white light emitted from the lens array and including a blue filter configured to transmit the blue light, a green filter configured to transmit the green light, and a red filter configured to transmit the red light; a pixel electrode disposed to face the color filter and including a blue sub-pixel electrode configured to modulate the blue light transmitted through the blue filter according to image information and emit blue image light, a green sub-pixel electrode configured to modulate the green light transmitted through the green filter according to the image information and emit green image light, and a red sub-pixel electrode configured to modulate the red light transmitted through the red filter according to the image information and emit red image light; and a projection optical system disposed on traveling paths of the blue image light, the green image light, and the red image light and configured to project the blue image light, the green image light, and the red image light. The plurality of lenses include a first lens that emits the white light toward the blue filter, a second lens that emits the white light toward the green filter, and a third lens that emits the white light toward the red filter. An area of the second lens is larger than an area of the green filter

and is larger than an area of the first lens and an area of the third lens.

(195) With the configuration of Note 1, a light amount of the green image light included in the image light emitted from the light modulation device can be increased to be larger than light amounts of the blue image light and the red image light. With the configuration of Note 1, it is possible to adjust illuminance ratios of red, green, and blue image lights in an image and a video to be projected to the visibility of a human observing the image and the video and realize an image and a video that are more brightly visually recognized than an image and a video projected by the projector of the related art.

Note 2

(196) In the projector of Note 1, the first lens, the second lens, and the third lens may be disposed along a second axis in a plane crossing a first axis parallel to an optical axis of the white light made incident on the lens array and a third axis orthogonal to the second axis, and, on the second axis, width of the second lens may be larger than width of the first lens and width of the third lens.

(197) With the configuration of Note 2, on the second axis, a light amount of the white light taken into the second lens can be increased to be larger than a light amount of the white light taken into each of the first lens and the third lens.

Note 3

(198) In the projector of Note 2, on the third axis, the width of the second lens may be larger than the width of the first lens and the width of the third lens.

(199) With the configuration of Note 3, on the third axis in addition to the second axis, the light amount of the white light taken into the second lens can be increased to be larger than the light amount of the white light taken into each of the first lens and the third lens.

Note 4

(200) In the projector of any one of Notes 1 to 3, the first lens, the second lens, and the third lens may be disposed along a second axis in a plane crossing a first axis parallel to an optical axis of the white light made incident on the lens array and a third axis orthogonal to the second axis, and, on the third axis, width of the second lens may be larger than width of the first lens and width of the third lens.

(201) With the configuration of Note 4, on the third axis, a light amount of the white light taken into the second lens can be increased to be larger than a light amount of the white light taken into each of the first lens and the third lens.

Note 5

(202) In the projector of Note 1, when viewed along a first axis parallel to an optical axis of the white light made incident on the lens array, a part of the second lens may overlap at least one filter of the blue filter and the red filter.

(203) With the configuration of Note 5, a light amount of the white light made incident on the green filter increases according to an area of a part of the second lens and a light amount of the white light made incident on at least one of the red filter and the blue filter decreases. With the configuration of Note 5, a difference between a light amount of the green light transmitted through the green filter and at least one of a light amount of the red light transmitted through the red filter and a light amount of the blue light transmitted through the blue filter can be easily adjusted.

Note 6

(204) In the projector of any one of Notes 1 to 5, when viewed along a first axis parallel to an optical axis of the white light made incident on the lens array, a portion overlapping the green filter in the second lens may not have power, and a portion not overlapping the green filter in the second lens may have positive power.

(205) In the configuration of Note 6, the white light made incident on the portion overlapping the green filter when viewed along the first axis in the second lens travels along the first axis and is made incident on the green filter. The white light made incident on the portion not overlapping the green filter when viewed along the first axis in the second lens is made incident on the green filter

while being condensed on the first axis. In both of the white lights, the green light transmitted through the green filter is made incident on a green sub-pixel electrode of the pixel electrode. Therefore, with the configuration of Note 6, as in a configuration in which the entire second lens has positive power, the green light can be efficiently made incident on the green sub-pixel electrode. With the configuration of Note 6, a reduction in the thickness of the second lens can be achieved compared with when the entire second lens has positive power. With the configuration of Note 6, since the intensity of light made incident on the green sub-pixel electrode can be dispersed in the entire sub-pixel electrode, it is possible to reduce a load due to the green light locally having high light intensity in the sub-pixel electrode.

Note 7

(206) In the projector of any one of Notes 1 to 5, the color filter may include, between any filters among the red filter, the green filter, and the blue filter adjacent to one another, a light blocking region for blocking the white light.

(207) In the configuration of Note 7, when viewed along the Z axis, width of each of the first lens, the second lens, and the third lens can be set such that the end portion of each of the first lens, the second lens, and the third lens overlaps the light blocking region. Consequently, the white light emitted to the light blocking region and not utilized as the image light when the first lens, the second lens, and the third lens are absent can be allowed to pass through the blue filter, the green filter, and the red filter using the lenses and made incident on the blue sub-pixel electrode, the green sub-pixel electrode, and the red sub-pixel electrode to increase light amounts of the color lights converted into the image light in the sub-pixel electrodes. With the configuration of Note 7, it is possible to increase flexibility of adjustment of a spectrum in the image light emitted from the light modulation device and projected.

Note 8

(208) In the projector of Note 7, the red filter, the green filter, and the blue filter may be disposed along a second axis in a plane crossing a first axis parallel to an optical axis of the white light made incident on the color filter and a third axis orthogonal to the second axis, the light blocking region may be disposed in a region extending in parallel to the third axis between any lenses among the first lens, the second lens, and the third lens adjacent to one another on the second axis, a region extending in parallel to the second axis between any lenses among the first lens, the second lens, and the third lens adjacent to one another on the third axis, and a region extending in parallel to the second axis and a region extending in parallel to the third axis at a peripheral edge portion of the color filter, width along the third axis of the light blocking region extending in parallel to the second axis may be larger than width along the second axis of the light blocking region extending in parallel to the third axis, and the first lens, the second lens, and the third lens may have power on the third axis.

(209) With the configuration of Note 8, an adjustable width on the third axis of each of the first lens, the second lens, and the third lens can be secured larger than an adjustable width on the second axis. With the configuration of Note 8, when viewed along the first axis, the white light made incident on a region, which overlaps the light blocking region more widely than width along the second axis, along the third axis in the color filter can be taken into each of the first lens, the second lens, and the third lens and condensed on the blue filter, the green filter, and the red filter of the color filter and the blue sub-pixel electrode, the green sub-pixel electrode, and the red sub-pixel electrode of the pixel electrode. As a result, brightness of the image light emitted from the light modulation device is improved.

Note 9

(210) In the projector of any one of Notes 1 to 8, when viewed along a first axis parallel to an optical axis of the white light made incident on the lens array, a principal point of the first lens may overlap a center of the blue filter, a principal point of the second lens may overlap a center of the green filter, and a principal point of the third lens may overlap a center of the red filter.

(211) With the configuration of Note 9, the blue light included in the white light emitted from the first lens can be efficiently made incident on the blue sub-pixel electrode. The green light included in the white light emitted from the second lens can be efficiently made incident on the green sub-pixel electrode. The red light included in the white light emitted from the third lens can be efficiently made incident on the red sub-pixel electrode. As a result, brightness of the image light emitted from the light modulation device is improved.

Claims

1. A projector comprising: a light source device configured to emit white light including blue light, green light, and red light; a lens array disposed on an optical path of the white light emitted from the light source device and including a plurality of lenses; a color filter disposed on an optical path of the white light emitted from the lens array and including a blue filter configured to transmit the blue light, a green filter configured to transmit the green light, and a red filter configured to transmit the red light; a pixel electrode disposed to face the color filter and including a blue sub-pixel electrode configured to modulate the blue light transmitted through the blue filter according to image information and emit blue image light, a green sub-pixel electrode configured to modulate the green light transmitted through the green filter according to the image information and emit green image light, and a red sub-pixel electrode configured to modulate the red light transmitted through the red filter according to the image information and emit red image light; and a projection optical system disposed on traveling paths of the blue image light, the green image light, and the red image light and configured to project the blue image light, the green image light, and the red image light, wherein the plurality of lenses include a first lens that emits the white light toward the blue filter, a second lens that emits the white light toward the green filter, and a third lens that emits the white light toward the red filter, and an area of the second lens is larger than an area of the green filter and is larger than an area of the first lens and an area of the third lens.
2. The projector according to claim 1, wherein the first lens, the second lens, and the third lens are disposed along a second axis in a plane crossing a first axis parallel to an optical axis of the white light made incident on the lens array and a third axis orthogonal to the second axis, and on the second axis, width of the second lens is larger than width of the first lens and width of the third lens.
3. The projector according to claim 2, wherein, on the third axis, the width of the second lens is larger than the width of the first lens and the width of the third lens.
4. The projector according to claim 1, wherein the first lens, the second lens, and the third lens are disposed along a second axis in a plane crossing a first axis parallel to an optical axis of the white light made incident on the lens array and a third axis orthogonal to the second axis, and on the third axis, width of the second lens is larger than width of the first lens and width of the third lens.
5. The projector according to claim 1, wherein, when viewed along a first axis parallel to an optical axis of the white light made incident on the lens array, a part of the second lens overlaps at least one filter of the blue filter and the red filter.
6. The projector according to claim 1, wherein, when viewed along a first axis parallel to an optical axis of the white light made incident on the lens array, a portion overlapping the green filter in the second lens does not have power, and a portion not overlapping the green filter in the second lens has positive power.
7. The projector according to claim 1, wherein the color filter includes, between any filters among the red filter, the green filter, and the blue filter adjacent to one another, a light blocking region for blocking the white light.
8. The projector according to claim 7, wherein the red filter, the green filter, and the blue filter are disposed along a second axis in a plane crossing a first axis parallel to an optical axis of the white light made incident on the color filter and a third axis orthogonal to the second axis, the light

blocking region is disposed in a region extending in parallel to the third axis between any lenses among the first lens, the second lens, and the third lens adjacent to one another on the second axis, a region extending in parallel to the second axis between any lenses among the first lens, the second lens, and the third lens adjacent to one another on the third axis, and a region extending in parallel to the second axis and a region extending in parallel to the third axis at a peripheral edge portion of the color filter, width on the third axis of the light blocking region extending in parallel to the second axis is larger than width on the second axis of the light blocking region extending in parallel to the third axis, and the first lens, the second lens, and the third lens have power on the third axis.

9. The projector according to claim 1, wherein, when viewed along a first axis parallel to an optical axis of the white light made incident on the lens array, a principal point of the first lens overlaps a center of the blue filter, a principal point of the second lens overlaps a center of the green filter, and a principal point of the third lens overlaps a center of the red filter.