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ILLUMINATION DEVICE AND IMAGING DEVICE FOR IMAGING SKIN OF A HUMAN BODY

Abstract

An imaging device includes an illumination device and an imager which images a target. The illumination device includes an objective cover including a light transmissive member, and a light source located nearer the imager than the objective cover to illuminate the target through the objective cover. A sectional shape of a first region outside the illumination device on a target side of the objective cover and a sectional shape of a second region inside the illumination on an imager side of the objective cover are symmetrical with respect to a front surface of the objective cover as an axis of symmetry. The first and second regions are regions bounded by light propagating while the objective cover is in contact with the target, and the light source is provided outside the second region.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a Divisional Application of U.S. application Ser. No. 17/598,168, filed Sep. 24, 2021, which is a U.S. National Stage under 35 USC 371 of PCT Application No. PCT/JP2020/001663, filed Jan. 20, 2020, and is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2019-066958, filed Mar. 29, 2019, and prior Japanese Patent Application No. 2019-098137, filed May 24, 2019, the entire contents of all of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to an illumination device and an imaging device including the illumination device.

BACKGROUND ART

[0003] A known imaging device including an illumination device is described in, for example, Patent Literature 1. The imaging device includes an objective glass to be in contact with human skin through a gel, multiple light sources that emit light, and an imager for imaging. The skin in contact with the objective glass is illuminated by the multiple light sources inside the imaging device and imaged by the imager.

CITATION LIST

Patent Literature

[0004] Patent Literature 1: Japanese Patent No. 5797921

SUMMARY OF INVENTION

Technical Problem

[0005] A typical imaging device for imaging skin includes the objective glass to be in contact with the skin surface through a gel for preventing light reflection from the skin surface. However, light from the light sources illuminating the skin may be reflected by the objective glass depending on the positions of the light sources, possibly disabling proper imaging of the skin. Such reflection may also occur in imaging targets other than skin.

[0006] In response to the above issue, an objective of the present disclosure is to provide an illumination device that allows proper imaging of a target by reducing the likelihood of imaging being affected by reflected light of light sources and an imaging device including the illumination device.

Solution to Problem

[0007] To achieve the above objective, an illumination device according to an aspect of the present disclosure is an illumination device for an imager for imaging a target. The illumination device includes an objective cover including a light transmissive member to direct light from the target to the imager to allow the imager to image the target, and at least one light source located nearer the imager than the objective cover to illuminate the target through the objective cover. The imager includes an image sensor configured to image the target and an imaging lens configured to form an image of the target on the image sensor. The at least one light source is located outward from an inverted region formed by substantially inverting, toward the imager and with respect to the

objective cover, a region defined by predetermined rays of rays nearer the target from the objective cover in a pencil of rays entering, through the imaging lens, the image sensor from the target in contact with the objective cover and in focus with the imaging lens.

Advantageous Effects of Invention

[0008] The technique according to the above aspect of the present disclosure allows proper imaging of a target by reducing the likelihood of imaging being affected by reflected light of the light source.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1A is a perspective view of a dermatoscopy camera according to Embodiment 1 of the present disclosure, without an adapter being attached;

[0010] FIG. 1B is a perspective view of the dermatoscopy camera according to Embodiment 1 of the present disclosure, with the adapter attached;

[0011] FIG. 2 is an exploded perspective view of the dermatoscopy camera;

[0012] FIG. 3 is a perspective cross-sectional view of an imager included in the dermatoscopy camera;

[0013] FIG. 4 is a front view of an illumination device included in the dermatoscopy camera as viewed in the direction indicated by arrow IV in FIG. 1A;

[0014] FIG. 5 is a cross-sectional view of the illumination device taken along line V-V in FIG. 4;

[0015] FIG. 6 is a cross-sectional view of the illumination device with the adapter attached;

[0016] FIG. 7 is a front view of a base included in the body of the illumination device;

[0017] FIG. 8 is a front view of the base included in the body of the illumination device with a first light-emitting diode (LED) board removed from the base;

[0018] FIG. 9 is an enlarged view of portion IX in FIG. 5;

[0019] FIG. 10 is a partial cross-sectional view of the dermatoscopy camera;

[0020] FIG. 11 is a schematic diagram describing light illumination during second dermatoscopy imaging;

[0021] FIG. 12 is a partial cross-sectional view of the dermatoscopy camera with the adapter attached;

[0022] FIG. 13 is a schematic diagram describing light illumination during the second dermatoscopy imaging;

[0023] FIG. 14A is a diagram showing illuminance distribution on a second objective cover obtained through simulation in which LEDs for the second dermatoscopy imaging are turned on;

[0024] FIG. 14B is a diagram showing illuminance distribution on the second objective cover obtained through simulation in which LEDs for first dermatoscopy imaging are turned on;

[0025] FIG. 15 is a flowchart showing an imaging operation performed by the dermatoscopy camera;

[0026] FIG. 16 is a flowchart showing a dermatoscopy imaging operation;

[0027] FIG. 17 is a flowchart showing a first dermatoscopy imaging operation;

[0028] FIG. 18 is a flowchart showing a second dermatoscopy imaging operation;

[0029] FIG. 19 is a diagram describing the focus on a target that is set for imaging;

[0030] FIG. 20 is a partial cross-sectional view of a dermatoscopy camera according to Embodiment 2;

[0031] FIG. 21 is a partial cross-sectional view of the dermatoscopy camera according to Embodiment 2 with an adapter attached;

[0032] FIG. 22A is a diagram describing movement of LED boards in a dermatoscopy camera according to a modification of the present disclosure;

[0033] FIG. 22B is a diagram describing rotation of LED boards in a dermatoscopy camera according to a modification of the present disclosure; and

[0034] FIG. 23 is a flowchart showing an imaging operation of a dermatoscopy camera according to a modification of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0035] A dermatoscopy camera according to one or more embodiments of the present disclosure will now be described with reference to the drawings. The term dermatoscope herein refers to a magnifier (device) for skin examinations, and the term dermatoscopy refers to skin examinations using the magnifier or to the use of (the act of using) the magnifier, similarly to the use of the terms microscope and microscopy.

[0036] As in FIGS. 1A and 1B, the examples will be hereafter described based on an orthogonal coordinate system with the front (front surface) of a dermatoscopy camera **1** being nearer an imaging target (subject), the rear being opposite to the front, and the up-down (vertical) direction and the right-left (lateral) direction being the up-down (vertical) direction and the right-left (lateral) direction of the dermatoscopy camera **1** when viewed from the front. Unless otherwise specified, the components are fastened in any suitable manner, such as with threads or screws or by fitting.

Embodiment 1

[0037] The dermatoscopy camera **1** according to Embodiment 1 is an example of an imaging device that captures an image for examination of skin conditions. The dermatoscopy camera **1** can image an imaging target either with an adapter **70** attached as shown in FIG. 1B or with the adapter **70** detached as shown in FIG. 1A. The adapter **70** is used for imaging narrow areas, such as between fingers or folds in an ear, as described later.

[0038] As shown in FIG. 2, the dermatoscopy camera **1** includes a controller **2**, a camera body **3** in front of the controller **2**, and an illumination device **4** in front of the camera body **3**.

[0039] The controller **2** includes a display **10** that includes a touchscreen liquid crystal display (LCD) monitor **11** to display various items of operating information and captured images and receive, user operations, a body **20** including operation buttons, such as a shutter button **21** and a power button **22**, and a circuit board **30** housed between the display **10** and the body **20**. The circuit board **30** includes a storage **200** that stores captured images and a control unit **300** as at least one controller that controls the components of the dermatoscopy camera **1**.

[0040] The camera body **3** includes an imager **40** and a frame **50**. The frame **50** supports the imager **40** and is attached to a cover **60** (described later). FIG. 3 is a perspective cross-sectional view of the imager **40** included in the dermatoscopy camera **1**. The imager **40** includes an imaging lens system **41** having a lens group aligned with an optical axis OA. The imager **40** also includes a wiring circuit board **43** and an image sensor **44** housed behind the imaging lens system **41**. The imager **40** includes, in front of the image sensor **44**, an infrared cut filter (IRCF) **45**, an ultraviolet transmissive filter **46**, and a polarization filter **47** in the stated order from the front. The imager **40** further includes a flexible circuit board **48** extending from the left of the imager **40**. The controller **2** (FIG. 2) operates the imager **40** with the flexible circuit board **48**.

[0041] The imaging lens system **41** includes the lens group including a first imaging lens **41a** and a second imaging lens **41b** aligned with the optical axis OA, and a lens barrel **41c** housing the second imaging lens **41b**. The first imaging lens **41a** and the second imaging lens **41b** are located between a diseased skin portion being an imaging target and the image sensor **44** and form an image of the imaging target on the image sensor **44**. The first imaging lens **41a** is movable in the front-rear direction, varying the focal length and thus varying magnification. The first imaging lens **41a** and the second imaging lens **41b** together magnify a diseased portion of a patient by 10 to 30 times.

[0042] The image sensor **44** is a known image sensor, such as a charge-coupled device (CCD) or a complementary metal-oxide semiconductor (CMOS). The image sensor **44** converts an optical image of a subject into an electrical signal. The imager **40** uses the image sensor **44** to image an imaging target. The imager **40** can capture, for example, still images and video.

[0043] As shown in FIG. 2, the illumination device 4 includes the cover 60 attached to the body 20 of the controller 2, an illumination device body 100 attached to the front end of the cover 60, and the adapter 70 attached to the cover 60 to cover the front of the illumination device body 100. As described above, the adapter 70 is detachable. The adapter 70 is attached to the cover 60 to image narrow areas, such as between fingers and folds in an ear, and detached to image other parts such as a face and an arm. Thus, the adapter 70 is a part of the illumination device 4 when used in imaging and is not a part of the illumination device 4 when unused in imaging.

[0044] As shown in FIGS. 1A, 1B, 2, 4, and 5, the cover 60 is cylindrical and houses the camera body 3. As shown in FIG. 4, the cover 60 has four protrusions 61 arranged on the outer circumferential surface at equal intervals. The protrusions 61 engage with the adapter 70 when the adapter 70 is attached and disengage from the adapter 70 when the adapter 70 is detached. As shown in FIG. 4, the cover 60 also has two detection switches 62 arranged on the outer circumferential surface at equal intervals adjacent to two of the protrusions 61. The two detection switches 62 are arranged vertically opposite to each other with the optical axis OA between the detection switches 62 when the illumination device 4 is viewed from the front. As shown in FIG. 6, the detection switches 62 are urged by springs 62a in a direction to protrude from the cover 60. When the adapter 70 is detached, the detection switches 62 protrude from the cover 60 and are in an off state. When the adapter 70 is attached with the protrusions 61, the detection switches 62 are pressed by the adapter 70 and retracted. This turns on the detection switches 62. The two detection switches 62 function for detecting attachment and detachment of the adapter 70.

[0045] As shown in FIG. 5, the illumination device body 100 includes a base 110 provided with multiple light-emitting diode (LED) boards on which LEDs are mounted as light sources, an annular first cover 120 covering the periphery of the base 110, and a second cover 130 screwed to the first cover 120.

[0046] As shown in FIGS. 5, 7, and 8, the base 110 includes a base body 180, first to sixth LED boards 111 to 116 on the base body 180, and four polarizer plates 117 on the base body 180.

[0047] The base body 180 is formed from, for example, a black synthetic resin. As shown in FIGS. 5 and 8, the base body 180 includes a cylindrical portion 181, an annular portion 182 at the front end of the cylindrical portion 181, first to fourth walls 183 to 186 located radially inside the annular portion 182 and extending obliquely rearward from the annular portion 182, four connection parts 187 each between adjacent ones of the first to fourth walls 183 to 186, and a fifth wall 188 connected to edges of the first to fourth walls 183 to 186.

[0048] As shown in FIG. 5, the cylindrical portion 181 has an outer diameter that is substantially the same as the inner diameter of the cover 60 and has the outer circumferential surface fitted in the inner circumferential surface of the cover 60. This fastens the base body 180 to the cover 60.

[0049] As shown in FIGS. 7 and 8, the annular portion 182 has a board mounting surface 182a on which the first LED board 111 is mounted. The board mounting surface 182a is flat and faces frontward. The board mounting surface 182a has four screw holes 182b used to mount the first LED board 111.

[0050] As shown in FIGS. 5 and 8, the first wall 183 has a rectangular-plate-like shape, with the main surface facing frontward and slightly downward and angled with the optical axis OA. The second LED board 112 is mounted on the first wall 183 from the rear thereof with screws (not shown), and the first wall 183 has an opening 183a to expose LEDs 141, 142, and 143 on the second LED board 112 frontward. A polarizer plate 117 is mounted on the front surface of the first wall 183 as shown in FIG. 8.

[0051] As shown in FIG. 8, the second wall 184 has a rectangular-plate-like shape, with the main surface facing frontward and slightly leftward and angled with the optical axis OA. The third LED board 113 is mounted on the second wall 184 from the rear side thereof with screws (not shown), and the second wall 184 has an opening 184a to expose LEDs 141, 142, and 143 on the third LED board 113 frontward. A polarizer plate 117 is mounted on the front surface of the second wall 184

as shown in FIG. 8.

[0052] As shown in FIGS. 5 and 8, the third wall **185** has a rectangular-plate-like shape, with the main surface facing frontward and slightly upward and angled with the optical axis OA. The fourth LED board **114** is mounted on the third wall **185** from the rear thereof with screws (not shown), and the third wall **185** has an opening **185a** to expose LEDs **141**, **142**, and **143** on the fourth LED board **114** frontward. A polarizer plate **117** is mounted on the front surface of the third wall **185** as shown in FIG. 8.

[0053] As shown in FIG. 8, the fourth wall **186** has a rectangular shape, and has the main surface facing frontward and slightly rightward and angled with the optical axis OA. The fifth LED board **115** is mounted on the fourth wall **186** from the rear thereof with screws (not shown), and the fourth wall **186** has an opening **186a** to expose LEDs **141**, **142**, and **143** on the fifth LED board **115** frontward. A polarizer plate **117** is mounted on the front surface of the fourth wall **186** as shown in FIG. 8.

[0054] The four connection parts **187** are each located between adjacent ones of the rectangular first to fourth walls **183** to **186** extending obliquely rearward from the annular portion **182**. The four connection parts **187** thus connect the adjacent first to fourth walls **183** to **186** and form a circumferentially continuous wall together with the first to fourth walls **183** to **186**.

[0055] As shown in FIGS. 5 and 8, the fifth wall **188** is a front-facing rectangular wall, and is connected to the edges of the first to fourth walls **183** to **186** extending rearward. The sixth LED board **116** is mounted on the fifth wall **188** from the rear thereof with screws (not shown), and the fifth wall **188** has openings **188a** to expose four LEDs **144** on the sixth LED board **116** frontward. The fifth wall **188** has, at the center, a barrel insertion hole **188b** for receiving the lens barrel **41c** in the imager shown in FIG. 3.

[0056] The base body **180** holding the first to sixth LED boards **111** to **116** and the polarizer plates **117** is fitted to the cover **60** shown in FIG. 6.

[0057] As shown in FIGS. 5, 7, and 8, the first LED board **111** is annular and mounted to the board mounting surface **182a** of the base body **180** with screws **189** (FIG. 7). The first LED board **111** includes sixteen LEDs **140** arranged circumferentially. The LEDs **140** emit, for example, white light and function as a ring flash that emits light frontward from the outer circumference of the illumination device body **100**. The LEDs **140** emit light to illuminate a diseased skin portion when the dermatoscopy camera **1** (FIG. 1A) images the diseased skin portion as a common camera (normal imaging).

[0058] As shown in FIGS. 5 and 8, the second LED board **112** is a rectangular board screwed, from the rear, to the first wall **183** in the base body **180**, and a longitudinal direction of the second LED board **112** extends laterally. As shown in FIG. 8, the second LED board **112** has an LED **141** that emits visible light, an LED **142** that emits visible light, an LED **143** that emits ultraviolet light, an LED **142** that emits visible light, and an LED **141** that emits visible light arranged in a row in this order from left to right. The two LEDs **142** are covered with the polarizer plate **117** and thus emit polarized light. As shown in FIG. 5, the second LED board **112** is located on the first wall **183** angled frontward with the vertical direction. The LEDs **141**, **142**, and **143** on the second LED board **112** thus face toward the optical axis OA of the imager **40**, or more specifically, face frontward and slightly downward in FIG. 5.

[0059] As shown in FIG. 8, the third LED board **113** is a vertically-elongated rectangular board screwed, from the rear, to the second wall **184** in the base body **180** and extends orthogonally to the second LED board **112**. As in the second LED board **112**, the third LED board **113** has an LED **141** that emits visible light, an LED **142** that emits visible light, an LED **143** that emits ultraviolet light, an LED **142** that emits visible light, and an LED **141** that emits visible light arranged in a row in this order from top to bottom. Also as in the second LED board **112**, the two LEDs **142** are covered with the polarizer plate **117**. The third LED board **113** is located on the angled second wall **184** in the base body **180**. The LEDs **141**, **142** and **143** on the third LED board **113** face toward the optical

axis OA of the imager **40**, or more specifically, face frontward and slightly leftward in FIG. **8**. [0060] As shown in FIG. **8**, the fourth LED board **114** has the same structure as the second LED board **112** rotated by 180° about the optical axis OA. In other words, the LEDs **141**, **142**, and **143** on the second LED board **112** and the LEDs **141**, **142**, and **143** on the fourth LED board **114** are vertically symmetric with each other about the optical axis OA. The LEDs **141**, **142**, and **143** on the fourth LED board **114** face frontward and slightly upward and thus emit light toward the optical axis OA. The two LEDs **142** on the fourth LED board **114** are covered with the polarizer plate **117**. As shown in FIG. **8**, the fifth LED board **115** has the same structure as the third LED board **113** rotated by 180° about the optical axis OA. In other words, the LEDs **141**, **142**, and **143** on the third LED board **113** and the LEDs **141**, **142**, and **143** on the fifth LED board **115** are laterally symmetric with each other about the optical axis OA. The LEDs **141**, **142**, and **143** on the fifth LED board **115** face frontward and slightly rightward and thus emit light toward the optical axis OA. The two LEDs **142** on the fifth LED board **115** are covered with the polarizer plate **117**. The LEDs **141**, **142**, and **143** on each of the second to fifth LED boards **112** to **115** illuminate a diseased skin portion during dermatoscopy imaging (first dermatoscopy imaging) performed with the adapter **70** (FIG. **6**) detached from the illumination device **4** as shown in FIG. **5**. The LEDs **142** and **143**, except the LEDs **141**, also illuminate a diseased skin portion during dermatoscopy imaging (second dermatoscopy imaging) performed with the adapter **70** attached to the illumination device **4** as shown in FIG. **6**.

[0061] As shown in FIGS. **5** and **8**, the sixth LED board **116** is a rectangular board screwed, from the rear, to the fifth wall **188** in the base body **180**. The sixth LED board **116** has a barrel insertion hole **116a** that aligns with the barrel insertion hole **188b** in the fifth wall **188** in the base body **180**. The sixth LED board **116** has the four LEDs **144** around the barrel insertion hole **188b** (**116a**) to emit visible light during the second dermatoscopy imaging. The four LEDs **144** face frontward and emit light frontward through the openings **188a** in the fifth wall **188** in the base body **180**. The four LEDs **144** on the sixth LED board **116** illuminate a diseased skin portion instead of the LEDs **141** during the second dermatoscopy imaging.

[0062] The illumination device **4** thus includes the LEDs **140** that emit light during normal imaging, the LEDs **141** that emit light during the first dermatoscopy imaging alone, the LEDs **144** that emit light during the second dermatoscopy imaging alone, and the LEDs **142** and **143** that emit light during the first dermatoscopy imaging and the second dermatoscopy imaging.

[0063] As shown in FIG. **5**, the first cover **120** covering the periphery of the front end of the base **110** has a first cover body **121** and a translucent plate **122** on the front surface of the first cover body **121**. The first cover body **121** is formed from, for example, a black synthetic resin. As shown in FIG. **9**, the first cover body **121** has an annular cover portion **121a** covering the front of the first LED board **111**, and an outer wall **121b** and an inner wall **121c** forming a tubular shape and standing from the cover portion **121a**. The first cover **120** is fastened to the base body **180** with the outer wall **121b** and the inner wall **121c** in contact with the annular portion **182**. The first cover body **121** forms, on the rear, a housing space A housing the first LED board **111** and the LEDs **140**. The housing space A is defined by the cover portion **121a**, the outer wall **121b**, the inner wall **121c**, and the annular portion **182** in the base body **180**. The cover portion **121a** has light releasing holes aligned with the LEDs **140**. The first cover **120** thus has sixteen light releasing holes **121d** corresponding to the sixteen LEDs **140** on the first LED board **111** as shown in FIG. **4**. The translucent plate **122** is formed from, for example, a transparent synthetic resin. The translucent plate **122** transmits light emitted from the LEDs **140** through the light releasing holes **121d** and covers the light releasing holes **121d** to prevent dust from entering the interior of the dermatoscopy camera **1**. The illumination device **4** can thus function as a ring flash by emitting light from the LEDs **140** through the multiple light releasing holes **121d** arranged circumferentially.

[0064] As shown in FIG. **9**, the outer wall **121b** of the first cover body **121** covers the radially outer end face **111a** of the first LED board **111**, and the inner wall **121c** covers the radially inner end face

111a. As described above, the base body **180** and the first cover body **121** defining the housing space A are formed from, for example, a black synthetic resin. The base body **180**, the outer wall **121b**, and the inner wall **121c** thus absorb light from the LEDs **140** transmitted through the first LED board **111**. For example, the inner wall **121c** absorbs light L1 transmitted through the first LED board **111** before the light L1 passes through the inner end face **111a**. Also, the base body **180** absorbs light L2 transmitted through the first LED board **111** before the light L2 travels further rearward. Thus, the light emitted from the LEDs **140** travels outward from the housing space A through the light releasing holes **121d** alone, thus reducing light leakage to the interior of the dermatoscopy camera **1** (for example, to a space B housing the distal end of the lens barrel **41c** and the LEDs **141**, **142**, **143**, and **144** for dermatoscopy imaging as shown in FIG. **10**). As shown in FIG. **9**, the inner wall **121c** has internal threads **121e** for engaging with the second cover **130**.

[0065] As shown at least in FIGS. **4** to **6**, the second cover **130** includes a truncated conical cylinder **131** as a first cover, and a first objective cover **132** fitted in an opening **131a** at the top (front end) of the cylinder **131**. The cylinder **131** is formed from a light non-transmissive resin material, such as a polyvinyl chloride derivative and an acrylic resin, to avoid light transmission and conversion of light into an electrical signal by the image sensor. The cylinder **131** may have a surface coated with a paint that prevents light transmission. The cylinder **131** has an inner circumferential surface embossed to reduce light reflection or treated with an anti-reflective coating. As shown in FIG. **9**, the cylinder **131** has, at the bottom (rear end), external threads **131b** screwed with the internal threads **121e** on the inner wall **121c**. The external threads **131b** and the internal threads **121e** on the first cover **120** function as an attachment and detachment part that attaches and detaches the second cover **130** to and from the first cover **120**.

[0066] The first objective cover **132** shown in FIG. **5** is a member that can transmit light, such as a glass piece, and is disk-shaped. The first objective cover **132** has the main surface orthogonal to the optical axis OA. The main surface of the first objective cover **132** has a predetermined first area. Dermatoscopy imaging of a diseased skin portion is to be performed with less diffuse reflection of light on the skin surface. Diffuse reflection of light is reduced with a gel applied to the diseased skin portion against which the first objective cover **132** is pressed. This removes an air layer between the diseased skin portion and the first objective cover **132**, thus reducing diffuse reflection of light on the skin surface. In the manner described above, the first objective cover **132** pressed against the diseased skin portion transmits light from the LEDs **141**, **142**, **143**, and **144** mounted on the second to sixth LED boards **112** to **116** shown in FIG. **8** allows illumination of the diseased skin portion with light, and directs light reflected by the diseased skin portion into the dermatoscopy camera **1** and thus to the imager **40**.

[0067] During the first dermatoscopy imaging, as shown in FIG. **10**, the first objective cover **132** is in contact with skin S1 in a region r1. The region r1 is surrounded by a region r2 in which the top of the cylinder **131** is in contact with the skin S1. The cylinder **131** in contact with the skin S1 in the region r2 blocks external light. The skin S1 in contact with the first objective cover **132** is thus less susceptible to external light. This allows the skin S1 in contact with the first objective cover **132** to be efficiently illuminated with light from the LEDs **141**, **142**, **143**, and **144** on the second to sixth LED boards **112** to **116**. The first objective cover **132** pressed against the skin S1 retains a constant distance between the skin S1 and the dermatoscopy camera **1** and constant brightness at the illuminated skin S1, thus enabling stable dermatoscopy imaging under, for example, stable exposure conditions. Additionally, the first objective cover **132** protects the interior of the dermatoscopy camera **1** from moisture and dust.

[0068] As shown in FIGS. **1B** and **6**, the adapter **70** includes a truncated conical cylinder **71** as a second cover and a second objective cover **72** fitted in an opening **71a** at the top (front end) of the cylinder **71**. The cylinder **71** is formed from, for example, a resin such as a polyvinyl chloride derivative and an acrylic resin, and has an inner circumferential surface embossed to reduce light reflection or treated with an anti-reflective coating. The cylinder **71** has a hooked portion **71b** at the

bottom (rear end) as shown in FIG. 6. The hooked portion 71b is engaged with the protrusions 61 on the cover 60 to attach the adapter 70 to the cover 60. This causes an inner wall 70a of the adapter 70 to press the detection switches 62. The detection switches 62 are then retracted and turned on. When the adapter 70 is detached from the cover 60, the hooked portion 71b is pushed outward to be disengaged from the protrusions 61. This releases the detection switches 62 from the state pressed by the inner wall 70a of the adapter 70. The detection switches 62 then protrude from the cover 60 and are turned off. The hooked portion 71b and the protrusions 61 function as an attachment and detachment part that attaches and detaches the adapter 70 to and from the cover 60.

[0069] The second objective cover 72 is a member that can transmit light, such as a glass piece, and is disk-shaped. During the second dermatoscopy imaging, the second objective cover 72 comes in contact with a diseased skin portion as an imaging target. The second objective cover 72 has the main surface orthogonal to the optical axis OA. The main surface of the second objective cover 72 has a predetermined second area that is smaller than the first area of the first objective cover 132. The second objective cover 72 can thus be placed on a diseased skin portion in a narrow area with the tapered cylinder 71. The second objective cover 72 is pressed against a diseased skin portion in a narrow area through a gel applied to the diseased skin portion to reduce diffuse reflection of light on the diseased skin portion. During the second dermatoscopy imaging, the second objective cover 72 transmits light emitted from the LEDs 142 and 143 on the second to fifth LED boards 112 to 115 and from the LEDs 144 on the sixth LED board 116 shown in FIG. 8 to illuminate the diseased skin portion with light, and allows light reflected by the diseased skin portion to enter the second objective cover 72.

[0070] During the second dermatoscopy imaging, as shown in FIG. 12, the second objective cover 72 is in contact with skin S2 in a region r3. The region r3 is surrounded by a region r4 in which the top of the cylinder 71 is in contact with the skin S2. The cylinder 71 in contact with the skin S2 in the region r4 blocks external light. The skin S2 in contact with the second objective cover 72 is thus less susceptible to external light. The second objective cover 72 enables stable dermatoscopy imaging as the same advantageous effects as produced by the first objective cover 132 described above.

[0071] Referring now to FIGS. 10 to 13, the LEDs, each of which is an example of a light emitter in the illumination device 4, are arranged in the manner described below in more detail. In FIGS. 10 to 13, the front portion of the dermatoscopy camera 1 is illustrated to simplify the drawings. FIGS. 10 to 13 are cross-sectional views of the dermatoscopy camera 1 taken along a vertical line aligned with the line along which the cross-sectional views in FIGS. 5 and 6 are taken. In FIGS. 11 and 13, the range illuminated by the LEDs is hatched, with an area illuminated brighter being hatched darker.

[0072] As shown in FIG. 10, the imaging lens system 41 in the dermatoscopy camera 1 includes the lens barrel 41c placed through the barrel insertion holes 116a and 188b and protruding from the base body 180. During the first dermatoscopy imaging, the imaging lens system 41 moves the lens group to focus on the skin S1 in contact with the first objective cover 132. FIG. 10 shows the path of light that enters the dermatoscopy camera 1 and then the image sensor 44 through the lens group, such as the first imaging lens 41a, assuming that the skin S1 is in contact with the first objective cover 132.

[0073] The skin S1 includes a point C at the uppermost position of the imaging range of the image sensor 44. Thus, rays passing through the point C during the first dermatoscopy imaging are at the uppermost (outermost) position among the rays included in the pencil of rays that enters the image sensor 44 through the first objective cover 132 from the imaging target. Light reflected at the point C on the skin S1 travels in various directions and partially enters the image sensor 44 through the lens group. Among the rays passing through the point C and entering the image sensor 44, an upper ray 171 is the uppermost ray and a lower ray 172 is the lowermost ray. The upper ray 171 is also the uppermost (outermost) ray among the multiple upper rays that pass through the first objective

cover **132** and enter the image sensor **44**. The upper ray **171** and the lower ray **172** passing through the point C are transmitted through the first objective cover **132**, refracted by the lens group, including the second imaging lens **41b** and the first imaging lens **41a**, and focused at a point C' at an end of the image sensor **44**. Among the rays passing through the point C, rays between the upper ray **171** and the lower ray **172** (e.g., principal rays) are also transmitted through the first objective cover **132**, refracted by the lens group, such as the second imaging lens **41b**, and focused at the point C' at the end of the image sensor **44**.

[0074] The first objective cover **132** in contact with the skin S1 during the first dermatoscopy imaging allows little or no light to enter from the front. Thus, the upper ray **171** and the lower ray **172** have the portions frontward (nearer the skin S1) from the first objective cover **132** being imaginary and may thus have the portions referred to as an imaginary upper ray **171a** and an imaginary lower ray **172a**.

[0075] The upper ray **171** passing through the point C has a portion (imaginary upper ray **171a**) frontward (nearer the skin S1) from the first objective cover **132**. An inverted upper ray **171'** is an imaginary ray that is obtained by inverting the portion **171a** toward the image sensor **44** with respect to a symmetry axis being a line extending vertically (orthogonally to the optical axis OA) along the front surface **132a** of the first objective cover **132**. The lower ray **172** passing through the point C has a portion (imaginary lower ray **172a**) frontward (nearer the skin S1) from the first objective cover **132**. An inverted lower ray **172'** is an imaginary ray that is obtained by inverting the portion **172a** toward the image sensor **44** with respect to the symmetry axis being the line extending vertically along the front surface **132a** of the first objective cover **132**.

[0076] The skin S1 includes a point D at the lowermost position of the imaging range of the image sensor **44**. Thus, rays passing through the point D during the first dermatoscopy imaging are at the lowermost (outermost) position among the rays included in the pencil of rays that enters the image sensor **44** through the first objective cover **132** from the imaging target. Light reflected at the point D on the skin S1 travels in various directions and partially enters the image sensor **44** through the lens group. Among the rays passing through the point D and entering the image sensor **44**, an upper ray **173** is the uppermost ray and a lower ray **174** is the lowermost ray. The lower ray **174** is also the lowermost (outermost) ray among the multiple lower rays that enter the image sensor **44** through the lens group. The upper and lower rays **173** and **174** are indicated with dashed lines for easy distinction from the upper and lower rays **171** and **172** indicated with solid lines. The upper ray **173** and the lower ray **174** passing through the point D are transmitted through the first objective cover **132**, refracted by the lens group (e.g., the second imaging lens **41b**), and focused at a point D' at another end of the image sensor **44**. Among the rays passing through the point D, rays between the upper ray **173** and the lower ray **174** (e.g., principal rays) are also transmitted through the first objective cover **132**, refracted by the lens group, and focused at the point C' at the end of the image sensor **44**.

[0077] The first objective cover **132** in contact with the skin S1 during the first dermatoscopy imaging allows little or no light to enter from the front. Thus, the upper ray **173** and the lower ray **174** have the portions frontward (nearer the skin S1) from the first objective cover **132** being imaginary and may thus have the portions referred to as an imaginary upper ray **173a** and an imaginary lower ray **174a**.

[0078] The upper ray **173** passing through the point D has a portion (imaginary upper ray **173a**) frontward (nearer the skin S1) from the first objective cover **132**. An inverted upper ray **173'** is an imaginary ray that is obtained by inverting the portion **173a** toward the image sensor **44** with respect to the symmetry axis being the line extending vertically (orthogonally to the optical axis OA) along the front surface **132a** of the first objective cover **132**. The lower ray **174** passing through the point D has a portion (imaginary lower ray **174a**) frontward (nearer the skin S1) from the first objective cover **132**. An inverted lower ray **174'** is an imaginary ray that is obtained by inverting the portion **174a** toward the image sensor **44** with respect to the symmetry axis being the

line extending vertically along the front surface **132a** of the first objective cover **132**.

[0079] The upper ray **171** and the lower ray **174**, being the uppermost ray and the lowermost ray in the pencil of rays that enters the image sensor **44** through the first objective cover **132**, define a region between the rays **171** and **174**, including a first region **501a** located frontward from the first objective cover **132**. The first region **501a** inverted with respect to the symmetry axis being the line extending vertically (orthogonally to the optical axis OA) along the front surface **132a** of the first objective cover **132** is a first inverted region **501b**. The first region **501a** is an imaginary region between the imaginary upper ray **171a** and the imaginary lower ray **174a**. The first inverted region **501b** is also an imaginary region between the inverted upper rays **171'** and the inverted lower rays **174'**. Although the first region **501a** and the first inverted region **501b** each have a trapezoidal cross section, these region **501a** and **501b** are both actually truncated conical, with the first region **501a** defined by the imaginary upper ray **171a** and the imaginary lower ray **174a** being rotated about the optical axis OA and the first inverted region **501b** defined by the first region **501a** being inverted. The LEDs **141**, **142**, and **143** on the second LED board **112** and the fourth LED board **114** are outward from the first inverted region **501b**, as viewed from the optical axis OA. The LEDs **141**, **142**, and **143** arranged in the above manner emit light that is reflected by the rear surface **132b** of the first objective cover **132** and restricted from entering the image sensor **44**. This prevents the central area of a captured image from being affected by light from the LEDs **141**, **142**, and **143** reflected by the rear surface **132b** of the first objective cover **132** and reduces the likelihood of imaging being affected by the reflected light.

[0080] Among the rays entering the image sensor **44** and included in the portion of the pencil of rays frontward from the first objective cover **132**, the outermost rays are the imaginary lower ray **172a** and the imaginary upper ray **173a**. The imaginary lower ray **172a** and the imaginary upper ray **173a** define a region between the rays **172a** and **173a**, including a second region **502a** located frontward from the first objective cover **132**. The second region **502a** inverted with respect to the symmetry axis being the line extending vertically (orthogonally to the optical axis OA) along the front surface **132a** of the first objective cover **132** is a second inverted region **502b**. The second region **502a** is an imaginary region between the imaginary lower ray **172a** and the imaginary upper ray **173a**. The second inverted region **502b** is also an imaginary region between the inverted lower ray **172'** and the inverted upper ray **173'**. Although the second region **502a** and the second inverted region **502b** each have a trapezoidal cross section, they are both actually truncated conical, with the second region **502a** defined by the imaginary lower ray **172a** and the imaginary upper ray **173a** being rotated about the optical axis OA and the second inverted region **502b** defined by the second region **502a** being inverted. The LEDs **141**, **142**, and **143** on the second LED board **112** and the fourth LED board **114** are within the second inverted region **502b**. The LEDs **141**, **142** and **143** are thus unlikely to be located largely outward to avoid upsizing the illumination device **4** and the dermatoscopy camera **1**.

[0081] The LEDs **141**, **142** and **143** on the vertically arranged second LED board **112** and the fourth LED board **114** are arranged in the manner described above with reference to the cross-sectional view (FIG. **10**) taken along a vertical line. The LEDs **141**, **142** and **143** on the laterally arranged third LED board **113** (FIG. **8**) and the fifth LED board **115** (FIG. **8**) can also be arranged in the same manner and may be described with reference to a cross-sectional view taken along a lateral line. More specifically, the LEDs **141**, **142**, and **143** on the third LED board **113** (FIG. **8**) and the fifth LED board **115** (FIG. **8**) are also outward from the first inverted region **501b** and within the second inverted region **502b** as viewed from the optical axis OA.

[0082] As shown in FIG. **11**, the LEDs **141**, **142**, and **143** on the second LED board **112** face frontward and slightly downward. Similarly, the LEDs **141**, **142**, and **143** on the fourth LED board **114** face frontward and slightly upward as shown in FIG. **11**. As shown in FIG. **8**, the LEDs **141**, **142**, and **143** on the third LED board **113** face frontward and slightly leftward, and the LEDs **141**, **142**, **143** on the fifth LED board **115** face frontward and slightly rightward. The LED **141**, **142**, and

143 arranged on the second to fifth LED boards **112** to **115** in the above manner thus emit light toward the first objective cover **132** during the first dermatoscopy imaging. The first objective cover **132** can thus be entirely located within a brightly illuminated space **B1**, allowing the skin **S1** in contact with the first objective cover **132** to be illuminated brightly with reduced unevenness. [0083] As described above, the light emitted from each of the LEDs **141**, **142**, and **143** is directed toward the first objective cover **132** during the first dermatoscopy imaging. This allows the skin **S1** to be illuminated brightly with reduced unevenness. The LEDs **141**, **142**, and **143** are arranged in the manner described above to prevent the central area of the captured image from being affected by light from the LEDs **141**, **142**, and **143** reflected by the first objective cover **132** and to reduce the likelihood of imaging being affected by the reflected light, while avoiding upsizing the illumination device **4** and the dermatoscopy camera **1**.

[0084] The LEDs **144** that emit light during the second dermatoscopy imaging and are arranged on the sixth LED board **116** will now be described. As shown in FIG. **12**, during the second dermatoscopy imaging, the imaging lens system **41** moves the lens group to focus on the skin **S2** in contact with the second objective cover **72**. FIG. **12** shows the path of light that enters the dermatoscopy camera **1** and then the image sensor **44** through the lens group, such as the first imaging lens **41a**, when the skin **S2** is in contact with the second objective cover **72**.

[0085] The skin **S2** includes a point **E** at the uppermost position of the imaging range of the image sensor **44**. Thus, rays passing through the point **E** during the second dermatoscopy imaging are at the uppermost (outermost) position among the rays included in the pencil of rays that enters the image sensor **44** through the second objective cover **72** from the imaging target. Light reflected at the point **E** on the skin **S2** travels in various directions and partially enters the image sensor **44** through the lens group. Among the rays passing through the point **E** and entering the image sensor **44**, an upper ray **175** is the uppermost ray and a lower ray **176** is the lowermost ray. The upper ray **175** is also the uppermost (outermost) ray among the multiple upper rays that pass through the second objective cover **72** and enter the image sensor **44**. The upper ray **175** and the lower ray **176** passing through the point **E** are transmitted through the second objective cover **72** and the first objective cover **132**, refracted by the lens group, and focused at a point **E'** at an end of the image sensor **44**.

[0086] The second objective cover **72** in contact with the skin **S2** during the second dermatoscopy imaging allows little or no light to enter from the front. Thus, the upper ray **175** and the lower rays **176** have the portions frontward (nearer the skin **S2**) from the second objective cover **72** being imaginary and may thus have the portions referred to as an imaginary upper ray **175a** and an imaginary lower ray **176a**.

[0087] The upper ray **175** passing through the point **E** has a portion (imaginary upper ray **175a**) frontward (nearer the skin **S2**) from the second objective cover **72**. An inverted upper ray **175'** is an imaginary ray that is obtained by inverting the portion **175a** toward the image sensor **44** with respect to a symmetry axis being a line extending vertically (orthogonally to the optical axis **OA**) along the front surface **72a** of the second objective cover **72**. The lower ray **176** passing through the point **E** has a portion (imaginary lower ray **176a**) frontward (nearer the skin **S2**) from the second objective cover **72**. An inverted lower ray **176'** is an imaginary ray that is obtained by inverting the portion **176a** toward the image sensor **44** with respect to the symmetry axis being the line extending vertically along the front surface **72a** of the second objective cover **72**.

[0088] The skin **S2** includes a point **F** at the lowermost position of the imaging range of the image sensor **44**. Thus, rays passing through the point **F** during the second dermatoscopy imaging are at the lowermost (outermost) position among the rays included in the pencil of rays that enters the image sensor **44** through the second objective cover **72** from the imaging target. Light reflected at the point **F** on the skin **S2** travels in various directions and partially enters the image sensor **44** through the lens group. Among the rays passing through the point **E** and entering the image sensor **44**, an upper ray **177** is the uppermost ray and a lower ray **178** is the lowermost ray. The lower ray

178 is also the lowermost (outermost) ray among the multiple lower rays that pass through the second objective cover **72** and enter the image sensor **44**. The upper ray **177** and the lower ray **178** passing through the point F are transmitted through the second objective cover **72** and the first objective cover **132**, refracted by the lens group, and focused at a point F at another end of the image sensor **44**.

[0089] The second objective cover **72** in contact with the skin **S2** during the second dermatoscopy imaging allows little or no light to enter from the front. Thus, the upper ray **177** and the lower ray **178** have the portions frontward (nearer the skin **S2**) from the second objective cover **72** being imaginary and may thus have the portions referred to as an imaginary upper ray **177a** and an imaginary lower ray **178a**.

[0090] The upper ray **177** passing through the point F has a portion (imaginary upper ray **177a**) frontward (nearer the skin **S2**) from the second objective cover **72**. An inverted upper ray **177'** is an imaginary ray that is obtained by inverting the portion **177a** toward the image sensor **44** with respect to the symmetry axis being the line extending vertically (orthogonally to the optical axis OA) along the front surface **72a** of the second objective cover **72**. The lower ray **178** passing through the point F has a portion (imaginary lower ray **178a**) frontward (nearer the skin **S2**) from the second objective cover **72**. An inverted lower ray **178'** is an imaginary ray that is obtained by inverting the portion **178a** toward the image sensor **44** with respect to the symmetry axis being the line extending vertically along the front surface **72a** of the second objective cover **72**.

[0091] The upper ray **175** and the lower ray **178**, being the uppermost ray and the lowermost ray in the pencil of rays that enters the image sensor **44** through the second objective cover **72**, define a region between the rays **175** and **178**, including a third region **503a** located frontward from the second objective cover **72**. The third region **503a** inverted with respect to the symmetry axis being the line extending vertically (orthogonally to the optical axis OA) along the front surface **72a** of the second objective cover **72** is a third inverted region **503b**. The third region **503a** is an imaginary region between the imaginary upper ray **175a** and the imaginary lower ray **178a**. The third inverted region **503b** is also an imaginary region between the inverted upper ray **175'** and the inverted lower ray **178'**. Although the third inverted region **503a** and the third inverted region **503b** each have a trapezoidal cross section, they are both actually truncated conical, with the third inverted region **503a** defined by the imaginary upper ray **175a** and the imaginary lower ray **178a** being rotated about the optical axis OA and the third inverted region **503b** defined by the third region **503a** being inverted. The LEDs **144** on the sixth LED board **116** are outward from the third inverted region **503b**. The LEDs **144** on the sixth LED board **116** are arranged in the same manner as in a cross-sectional view taken along a lateral line. The LEDs **144** are outward from the third inverted region **503b** as viewed from the optical axis OA. The LEDs **144** arranged in the above manner emit light that is reflected by the rear surface **72b** of the second objective cover **72** and restricted from entering the image sensor **44**. This prevents the central area of a captured image from being affected by light from the LEDs **144** reflected by the rear surface **72b** of the second objective cover **72** and reduces the likelihood of imaging being affected by the reflected light.

[0092] Among the rays entering the image sensor **44** and included in the portion of the pencil of rays frontward from the first objective cover **72**, the outermost rays are the imaginary lower ray **176a** and the imaginary upper ray **177a**. The imaginary lower ray **176a** and the imaginary upper ray **177a** define a region between the rays **176a** and **177a**, including a fourth region **504a** located frontward from the second objective cover **72**. The fourth region **504a** inverted with respect to the symmetry axis being the line extending vertically (orthogonally to the optical axis OA) along the front surface **72a** of the second objective cover **72** is a fourth inverted region **504b**. The fourth region **504a** is an imaginary region between the imaginary lower ray **176a** and the imaginary upper ray **177a**. The fourth inverted region **504b** is also a region between the inverted lower ray **176'** and the inverted upper ray **177'**. Although the fourth region **504a** and the fourth inverted region **504b** each have a trapezoidal cross section, they are both actually truncated conical, with the fourth

region **504a** defined by the imaginary lower ray **176a** and the imaginary upper ray **177a** being rotated about the optical axis OA and the fourth inverted region **504b** defined by the fourth region **504a** being inverted. The LEDs **144** on the sixth LED board **116** are within the fourth inverted region **504b**. The LEDs **144** on the sixth LED board **116** are arranged in the same manner as in a cross-sectional view taken along a lateral line. The LEDs **144** are within the fourth inverted region **504b**. This allows the LEDs **144** to illuminate the second objective cover **72** from nearer the optical axis OA, reducing unevenness of the light illuminated on the skin **S2**.

[0093] As described above, the four LEDs **144** face frontward. As shown in FIG. **13**, the light emitted frontward from each of the four LEDs **144** during the second dermatoscopy imaging is directed toward the second objective cover **72**. The second objective cover **72** is thus entirely located within a brightly illuminated space **B4**, allowing the skin **S2** in contact with the second objective cover **72** to be illuminated brightly with reduced unevenness.

[0094] As described above, although the dermatoscopy camera **1** emits visible light with the LEDs **141** during the first dermatoscopy imaging, the dermatoscopy camera **1** located nearer the optical axis OA emits visible light with the LEDs **144** during the second dermatoscopy imaging. This facilitates illuminating the second objective cover **72** with a smaller diameter that is coaxial with the optical axis OA. This is also demonstrated by the simulation of the illuminance distribution for the second objective cover as shown in FIGS. **14A** and **14B**. In FIG. **14A**, the LEDs **144** shown in FIG. **8** emit light. In FIG. **14B**, the eight LEDs **141** shown in FIG. **8** emit light. In FIG. **14A**, the second objective cover has an area **73** illuminated uniformly and brightly with reduced unevenness. In FIG. **14B**, the second objective cover has an area **74** partially including a darker area **74a** illuminated insufficiently, causing uneven brightness.

[0095] The second objective cover **72** may cause such uneven brightness when illuminated with the LEDs **141** (FIG. **8**) during the first dermatoscopy imaging. This may result from the LEDs **141** for the first dermatoscopy imaging arranged to emit light toward the first objective cover **132** as described above. As shown in FIG. **11**, light emitted from one of the LEDs **141** passing through the first objective cover **132** partially illuminates the second objective cover **72** instead of entirely illuminating the second objective cover **72**. Thus, part of the second objective cover **72** is located in the brightly illuminated space **B1** whereas the remaining part is located in spaces **B2** and **B3** darker than the space **B1**. This can cause uneven brightness on the second objective cover **72**. Such uneven brightness is caused markedly by the LEDs **141** that are farthest from the optical axis OA among the LEDs **141**, **142**, and **143** that emit light during the first dermatoscopy imaging.

[0096] The LEDs **144** for the second dermatoscopy imaging are located nearer the optical axis OA than the LEDs **141** for the first dermatoscopy imaging. This arrangement enables the second objective cover **72** to be illuminated uniformly with light emitted frontward from the LEDs **144** as shown in FIG. **13**. This reduces uneven brightness in the images resulting from the second dermatoscopy imaging and enables capturing of images that facilitate diagnosis.

[0097] The operation of the dermatoscopy camera **1** will now be described with reference to FIGS. **15** to **19**. For ease of understanding, FIG. **19** simply shows the components of the dermatoscopy camera **1** used to describe the focus position. The operation of each component of the dermatoscopy camera **1** is controlled by the control unit **300** on the circuit board **30** shown in FIG. **2**. The control unit **300** includes a central processing unit (CPU). The circuit board **30** includes an input-output (I/O) interface, a read-only memory (ROM), and a random-access memory (RAM). The CPU is, for example, a microprocessor, or is a central processing unit that performs various processes and arithmetic operations. The control unit **300** controls the operation of each component of the dermatoscopy camera **1** by reading a control program stored in the ROM and executing the control program on the CPU while using the RAM as a work memory.

[0098] The dermatoscopy camera **1** is activated in response to a user operating the power button **22** (FIGS. **1A** and **1B**) and receives an imaging mode selected by the user (step **S11**) as shown in FIG. **15**. As described above, the imaging mode includes a normal imaging mode for normal imaging, a

first dermatoscopy (DC) imaging mode for the first dermatoscopy imaging, and a second DC imaging mode for the second dermatoscopy imaging. The dermatoscopy camera **1** displays three selectable imaging modes on the touchscreen LCD monitor **11** included in the display **10** shown in FIG. **2**. The user selects one of the three imaging modes by touching the LCD monitor **11**. In response to the selection, the control unit **300** sets an imaging mode to the selected imaging mode. [0099] The control unit **300** determines whether the normal imaging mode is set (step S12). When the normal imaging mode is set in step S12 (Yes in step S12), the control unit **300** determines whether the adapter **70** is attached to the illumination device **4** (step S13). The determination as to whether or not the adapter **70** is attached thereto is made based on the on-off states of the detection switches **62**. In other words, the control unit **300** determines that the adapter **70** is detached when the two detection switches **62** protrude from the cover **60** and are in the off state. When the two detection switches **62** are retracted and are in the on state, or when one of the two detection switches **62** is in the on state and the other is in the off state, the control unit **300** determines that the adapter **70** is attached. When one of the detection switches **62** alone is in the on state, the adapter **70** is attached to the cover **60** incompletely.

[0100] When the control unit **300** determines that the adapter **70** is detached from the illumination device **4** in step S13 (No in step S13), the LEDs **140** (FIG. **5**) for normal imaging are turned on (step S14). This illuminates a diseased skin portion brightly.

[0101] When determining, in step S13, that the adapter **70** is attached (Yes in step S13), the control unit **300** indicates that the adapter **70** is to be detached (step S17). For example, the control unit **300** displays a message “Detach the adapter” on the LCD monitor **11** (FIG. **2**) to prompt the user to detach the adapter **70**. This causes the user to detach the adapter **70** and thus allows the light from the LEDs **140** to illuminate the diseased skin portion brightly during the normal imaging without being blocked by the adapter **70**.

[0102] Subsequently, in response to the user half-pressing the shutter button **21** shown in FIG. **1A**, the control unit **300** moves the lens group in the imaging lens system **41** to automatically focus on the target diseased skin portion within a focus range of P1 to infinity (step S15). The position P1 is a focus start position from which the lens group is moved to infinity to search for a position at which the focus is achieved.

[0103] The focus start position P1 will now be described. The two-dot chain lines in FIG. **19** indicate virtual images of the components of the dermatoscopy camera **1** that appear on the rear surface **132b** of the first objective cover **132**. The virtual images occur symmetrically to the real components about the rear surface **132b**. More specifically, a virtual image **41c'** of the lens barrel **41c** at a distance d1 from the rear surface **132b** of the first objective cover **132** occurs oppositely at a distance d1 from the rear surface **132b**. Also, virtual images **144'** of the LEDs **144** at a distance d2 from the rear surface **132b** of the first objective cover **132** occur oppositely at a distance d2 from the rear surface **132b**. Similarly, a virtual image **180'** of the base body **180** at a distance d3 from the rear surface **132b** of the first objective cover **132** occurs oppositely at a distance d3 from the rear surface **132b**. When the focus is adjusted to a position within a virtual image range D1 in which the virtual images appear on the rear surface **132b**, the distal end of the virtual image **41c'** of the lens barrel **41c**, the recesses and protrusions and various fixtures on the surface of the virtual image **180'** of the base body **180**, or the virtual images **144'** of the LEDs **144** may be in focus and appear in the captured image. The focus start position P1 is thus set outside the virtual image range D1.

[0104] During normal imaging, the user can view the distance between a diseased skin portion as an imaging target and the front surface **132a** of the first objective cover **132**. Thus, in response to the normal imaging mode set in step S11, the LCD monitor **11** shown in FIG. **2** may display an interval between the diseased skin portion and the first objective cover **132** at which no virtual image appears and prompt the user to adjust the focus position outside the virtual image range D1. This allows the diseased skin portion as an imaging target at a position from the focus start position P1 to infinity, thus allowing autofocus to be smoothly complete.

[0105] Subsequently, in response to the user depressing the shutter button **21** shown in FIG. **1A**, the control unit **300** captures an image of the diseased skin portion normally and stores the normally captured image (step **S16**). This completes the normal imaging of the diseased skin portion.

[0106] When determining that the first DC imaging mode or the second DC imaging mode is set in step **S11** (No in step **S12**), the control unit **300** performs a dermatoscopy imaging operation (step **S20**).

[0107] In the dermatoscopy imaging operation (step **S20**), the control unit **300** first determines whether the first DC imaging mode is set (step **S21**) as shown in FIG. **16**. In the first DC imaging mode (Yes in step **S21**), the control unit **300** determines whether the adapter **70** is attached to the illumination device **4** (step **S22**). As described above, the determination as to whether or not the adapter **70** is attached thereto is made based on the on-off states of the detection switches **62**. When determining, in step **S22**, that the adapter **70** is not attached (No in step **S22**), the control unit **300** performs the first dermatoscopy imaging operation (step **S30**).

[0108] In step **S22**, when determining that the adapter **70** is attached (Yes in step **S22**), the control unit **300** indicates that the adapter **70** is to be detached (step **S23**). This prompts the user to detach the adapter **70**, thus allowing the first dermatoscopy imaging operation (**S30**) to be performed appropriately without the adapter **70** attached.

[0109] In the first dermatoscopy imaging operation (step **S30**) shown in FIG. **17**, the control unit **300** temporarily adjusts the focus position on the diseased skin portion as an imaging target to **P2** (step **S31**). As shown in FIG. **19**, the focus position **P2** is aligned with the front surface **132a** of the first objective cover **132** that comes in contact with the diseased skin portion. The focus can thus be preadjusted to a position to be aligned with the diseased skin portion as an imaging target.

[0110] The control unit **300** then turns on the eight LEDs **141** (FIG. **8**) that emit visible light (step **S32**). This brightly illuminates the diseased skin portion in contact with the first objective cover **132** (FIG. **11**) with visible light. Subsequently, in response to the user half-pressing the shutter button **21** shown in FIG. **1A**, the control unit **300** automatically focuses on the diseased skin portion as an imaging target (step **S33**). As described above, the focus position is preadjusted to a position to be aligned with the diseased skin portion that comes in contact with the first objective cover **132** in step **S31**, thus allowing autofocus to be smoothly complete. Subsequently, in response to the user depressing the shutter button **21** shown in FIG. **1A**, the control unit **300** performs the first dermatoscopy imaging of the diseased skin portion and stores the captured image (step **S34**).

The control unit **300** then turns off the eight LEDs **141** (FIG. **8**) (step **S35**). In steps **S32** to **S35**, the first dermatoscopy imaging is performed on the diseased skin portion illuminated with visible light. [0111] The control unit **300** then turns on the eight LEDs **142** (FIG. **8**) that emit visible light to emit light polarized by the polarizer plates **117** (FIG. **8**) (step **S36**). This brightly illuminates the diseased skin portion in contact with the first objective cover **132** (FIG. **11**) with the polarized light. The control unit **300** then performs the first dermatoscopy imaging of the diseased skin portion and stores the captured image (step **S37**). The control unit **300** then turns off the eight LEDs **142** (FIG. **8**) (step **S38**). In steps **S36** to **S38**, the first dermatoscopy imaging is performed on the diseased skin portion illuminated with the polarized light.

[0112] The control unit **300** then turns on the four LEDs **143** (FIG. **8**) that emit ultraviolet light (step **S39**). This brightly illuminates the diseased skin portion in contact with the first objective cover **132** (FIG. **11**) with ultraviolet light. The control unit **300** then performs the first dermatoscopy imaging of the diseased skin portion and stores the captured image (step **S40**). The control unit **300** then turns off the four LEDs **143** (FIG. **8**) (step **S41**). In steps **S39** to **S41**, the first dermatoscopy imaging is performed on the diseased skin portion illuminated with ultraviolet light.

[0113] As described above, in the first dermatoscopy imaging, a single operation on the shutter button **21** (FIG. **1A**) enables sequential imaging of the diseased skin portion illuminated with visible light, polarized light, and then ultraviolet light, as well as storing of the captured images. The diseased skin portion is automatically adjusted in focus in step **S33**, thus eliminating the

autofocusing operation in the subsequent processing in the first dermatoscopy imaging.

[0114] As shown in FIG. 16, in the second DC imaging mode (No in step S21), the control unit 300 determines whether the adapter 70 is attached to the illumination device 4 (step S24). When at least one of the two detection switches 62 is retracted and in the on state, the control unit 300 determines that the adapter 70 is attached (Yes in step S24), and advances to step S25. When the two detection switches 62 are in the off state (No in step S24), the control unit 300 indicates that the adapter 70 is to be attached (step S26). For example, the control unit 300 displays a message “Attach the adapter” on the LCD monitor 11 (FIG. 2) to prompt the user to attach the adapter 70. This causes the user to attach the adapter 70 and thus allows the second dermatoscopy imaging to be performed appropriately with the adapter 70 attached.

[0115] When determining that the adapter 70 is attached (Yes in step S24), the control unit 300 determines whether the adapter 70 is properly attached (step S25). When the two detection switches 62 are in the on state, the control unit 300 determines that the adapter 70 is properly attached (Yes in step S25) and performs a second dermatoscopy imaging operation (step S50).

[0116] When determining that the adapter 70 is not properly attached in step S25 (No in step S25), the control unit 300 indicates that the adapter 70 is to be reattached (step S27). For example, the control unit 300 displays, on the LCD monitor 11 (FIG. 2), a message “The adapter is not properly attached. Reattach the adapter.” and prompts the user to reattach the adapter 70. This allows the second dermatoscopy imaging operation (S50) to be performed with the adapter 70 properly attached.

[0117] In the second dermatoscopy imaging operation (step S50) shown in FIG. 18, the control unit 300 temporarily adjusts the focus position on the diseased skin portion as an imaging target to P3 (step S51). As shown in FIG. 19, the focus position P3 is aligned with the front surface 72a of the second objective cover 72 that comes in contact with the diseased skin portion during the second dermatoscopy imaging. The focus position can thus be preadjusted to a position to be aligned with the diseased skin portion that comes in contact with the second objective cover 72.

[0118] Subsequently, the control unit 300 turns on the four LEDs 144 (FIG. 8) that emit visible light (step S52). The four LEDs 144 are light sources located nearer the optical axis OA for the second dermatoscopy imaging. This brightly illuminates the diseased skin portion in contact with the second objective cover 72 (FIG. 13) with visible light. Subsequently, in response to the user half-pressing the shutter button 21 shown in FIG. 1B, the control unit 300 automatically focuses on the diseased skin portion as an imaging target (step S53). As described above, the focus position is preadjusted to a position to be aligned with the diseased skin portion that comes in contact with the second objective cover 72 in step S34. The control unit 300 thus allows autofocus to be smoothly complete. Subsequently, in response to the user depressing the shutter button 21 shown in FIG. 1B, the control unit 300 performs the second dermatoscopy imaging of the diseased skin portion and stores the captured image (step S54). The control unit 300 then turns off the four LEDs 144 (FIG. 8) (step S55). In steps S52 to S55, the second dermatoscopy imaging is performed on the diseased skin portion illuminated with visible light.

[0119] In the subsequent steps S56 to S58, the control unit 300 turns on the LEDs 142 to illuminate the diseased skin portion with polarized light and performs the second dermatoscopy imaging. The processing in steps S56 to S58 is the same as the processing in steps S36 to S38 for the first dermatoscopy imaging shown in FIG. 17, except the use of the adapter 70. In the subsequent steps S59 to S61, the control unit 300 turns on the LEDs 143 to illuminate the diseased skin portion with ultraviolet light and performs the second dermatoscopy imaging. The processing in steps S59 to S61 is the same as the processing in steps S39 to S41 for the first dermatoscopy imaging shown in FIG. 17, except the use of the adapter 70. These steps are thus not described in detail.

[0120] As described above, in the second dermatoscopy imaging as well, a single operation on the shutter button 21 (FIG. 1B) enables sequential imaging of the diseased skin portion illuminated with visible light, polarized light, and then ultraviolet light, as well as storing of the captured

images. The diseased skin portion is automatically adjusted in focus in step S53, thus eliminating the autofocus operation in the subsequent processing in the second dermatoscopy imaging. [0121] As described above, the dermatoscopy camera **1** using the illumination device **4** according to one or more embodiments of the present disclosure includes the LEDs **141**, **142**, and **143** for the first dermatoscopy imaging arranged outward from the first inverted region **501b** and within the second inverted region **502b**. The LEDs **144** for the second dermatoscopy imaging are arranged outward from the third inverted region **503b** and within the fourth inverted region **504b**. This prevents the central area of the captured image from being affected by light from the LEDs **141** to **144** reflected by the first objective cover **132** and reduces the likelihood of imaging being affected by the reflected light, while avoiding upsizing the devices.

[0122] The LEDs **144** for the second dermatoscopy imaging are arranged outward from the third inverted region **503b** that is formed by inverting, with respect to the symmetry axis being the line along the front surface **72a**, the third region **503a** located between the imaginary upper ray **175a** and the imaginary lower ray **178a** being the outermost upper and lower rays in the pencil of rays that enters the image sensor **44**, or more specifically, outward from the third inverted region **503b** located between the inverted upper ray **175'** and the inverted lower ray **178'**. This arrangement prevents the central area of a captured image from being affected by light from the LEDs **144** arranged in this manner reflected by the second objective cover **72** and reduces the likelihood of imaging being affected by the reflected light.

[0123] The LEDs **144** are arranged within the fourth inverted region **504b** that is formed by inverting, with respect to the symmetry axis being the line along the front surface **72a** of the second objective cover **72**, the fourth region **504a** located between the imaginary lower ray **176a** and the imaginary upper ray **177a**, or more specifically, within the fourth inverted region **504b** located between the inverted lower ray **176'** and the inverted upper ray **177'**. The imaginary lower ray **176a** and the imaginary upper ray **177a** are the outermost rays located at the outermost position among the rays entering the image sensor **44** from the imaging target. The LEDs **144** are arranged within the region defined by these outermost rays to avoid upsizing the devices.

[0124] The LEDs **141**, **142**, and **143** are located away from the optical axis OA. The LEDs **141**, **142**, and **143** arranged in this manner are angled to face the first objective cover **132** and emit light directed toward the first objective cover **132**, thus illuminating the imaging target brightly without unevenness.

[0125] The LEDs **144** are separately arranged nearer the optical axis OA for the second dermatoscopy imaging that uses the adapter **70** including the second objective cover **72** with a smaller area. The LEDs **144** nearer the optical axis OA facilitate illumination of the second objective cover **72**, thus allowing the imaging target to be illuminated brightly without unevenness.

[0126] The base body **180** and the first cover body **121** defining the housing space A for the first LED board **111** provided with the LEDs **140** are formed from a black synthetic resin. The first cover body **121** covers the end faces **111a** of the first LED board **111**. In other words, the components (the annular portion **182** of the base body **180** and the inner wall **121c**) that define the housing space A for the light sources for normal imaging (LEDs **140**) and are in the space between the first objective cover **132** (second objective cover **72**) and the imager **40** are formed from a material having higher light absorptivity than the other components (e.g., first LED board **111**). The base body **180** and the first cover body **121** thus absorb light transmitted through the first LED board **111**, preventing the components (e.g., LEDs **144**) of the dermatoscopy camera **1** from being illuminated with such light and from appearing in a captured image.

[0127] The three types of light sources for dermatoscopy imaging, including the light source that emits visible light, the light source that emits polarized light, and the light source that emits ultraviolet light, allow the diseased skin portion to be illuminated with various rays, thus enabling capturing of images that are useful in diagnosing the skin conditions. Additionally, the diseased skin portion illuminated with visible light, polarized light, and then the ultraviolet light can be

imaged in sequence, and the captured images are stored, thus reducing the operation time.

[0128] The focus position on the diseased skin portion as an imaging target is temporarily set in accordance with the dermatoscopy imaging mode selected by the user through the LCD monitor **11**, or more specifically, in accordance with the imaging mode selected from the first DC imaging mode and the second DC imaging mode in the present embodiment. This temporary focus position is set based on the expected position of the diseased skin portion to be actually imaged, thus allowing quick focus adjustment during actual imaging.

[0129] When the normal imaging mode is selected by the user, the focus start position for the diseased skin portion is set outside the virtual image range **D1** in which virtual images occur due to the components of the dermatoscopy camera **1** appearing on the first objective cover **132**. This prevents the virtual images of the distal end of the lens barrel **41c**, the protrusions and recesses and various fixtures on the surface of the base body **180**, or the LEDs **144** from appearing in the captured images, and allows proper imaging of the diseased skin portion.

[0130] The two detection switches **62** for detecting the adapter **70** are located on the outer circumferential surface of the cover **60** to allow the control unit **300** to determine whether the adapter **70** is attached in each imaging operation. This prevents failures to attach the adapter **70** in the second dermatoscopy imaging to be performed with the adapter **70** attached and failures to detach the adapter **70** in the normal imaging and the first dermatoscopy imaging to be performed without the adapter **70** attached.

[0131] The two detection switches **62** are vertically away from each other with the optical axis OA between the switches **62** when the illumination device **4** is viewed from the front. The detection switches **62** away from each other in this manner have, for example, one of the detection switches **62** alone in the on state when the adapter **70** is attached incompletely. This facilitates the control unit **300** to determine whether the adapter **70** is properly attached.

Embodiment 2

[0132] An illumination device according to Embodiment 2 and an imaging device including the illumination device will now be described with reference to FIGS. **20** and **21**. The structure in Embodiment 1 reduces the likelihood of imaging being affected by reflected light of the LEDs **141**, **142**, and **143** used in the first dermatoscopy imaging, while avoiding upsizing the illumination device **4** and the dermatoscopy camera **1**. The LEDs **144** used in the second dermatoscopy imaging are located nearer the optical axis OA to facilitate illumination of the second objective cover **72** and reduce the reflected light of the LEDs **144** appearing in the captured image. The structure in Embodiment 2 further reduces the likelihood of (or prevents) imaging being affected by the reflected light. The structure in Embodiment 2 is basically the same as the structure in Embodiment 1 except the dimensions of the components. The components of a dermatoscopy camera **400** according to Embodiment 2 are thus given the same reference numerals as in Embodiment 1.

[0133] As shown in FIG. **20**, the dermatoscopy camera **400** has the LEDs **141**, **142**, and **143** for emitting light during the first dermatoscopy imaging located more outward than in Embodiment 1. The LEDs **141**, **142**, and **143** on the second LED board **112** and the fourth LED board **114** arranged within the second inverted region **502b** in Embodiment 1 are arranged outward from the second inverted region **502b** in the present embodiment. The LEDs **141**, **142**, and **143** are arranged in the same manner as in a cross-sectional view taken along a lateral line, or more specifically, the LEDs **141**, **142**, and **143** on the third LED board **113** (FIG. **8**) and the fifth LED board **115** (FIG. **8**) are arranged outward from the second inverted region **502b**. This prevents imaging from being affected by reflected light of the LEDs **141**, **142**, and **143** used in the first dermatoscopy imaging.

[0134] As shown in FIG. **21**, the dermatoscopy camera **400** has the LEDs **144** for emitting light during the second dermatoscopy imaging located more outward than in Embodiment 1. The LEDs **144** on the sixth LED board **116** are outward from the fourth inverted region **504b**. The LEDs **144** on the sixth LED board **116** are arranged in the same manner as in a cross-sectional view taken along a lateral line and located outward from the fourth inverted region **504b**. This arrangement

prevents a captured image from being affected by reflected light of the LEDs **144**.
[0135] Although the devices are larger in Embodiment 2 than in Embodiment 1, the structure in Embodiment 2 prevents a captured image from being affected by reflected light of the LEDs **141** to **144** and reduces the likelihood of the captured image being affected by stray light.
[0136] The present disclosure is not limited to the above embodiments and can be modified and altered variously. In the above embodiments, the LEDs **141** that emit visible light during the first dermatoscopy imaging are arranged separately from the LEDs **144** that also emit visible light during the second dermatoscopy imaging. However, as shown in FIGS. **22A** and **22B**, the first dermatoscopy imaging and the second dermatoscopy imaging may commonly use the same light sources that can change the positions or orientations. The LED boards **150** and **160** and the LEDs **151** and **161** indicated by the dashed lines in FIGS. **22A** and **22B** are at positions during the first dermatoscopy imaging, and the LED boards **150** and **160** and the LEDs **151** and **161** indicated by the solid lines are at positions during the second dermatoscopy imaging.
[0137] As shown in FIG. **22A**, during the first dermatoscopy imaging, the LED boards **150** (dashed line) are positioned outward, and the LEDs **151** (dashed line) are angled to face the first objective cover **132**. For the second dermatoscopy imaging, as indicated by arrows **Y1**, the LED boards **150** are moved inward by an actuator (not shown) while changing the postures to allow the LEDs **151** to face frontward. During the second dermatoscopy imaging, the LED boards **150** (solid line) are thus nearer the optical axis OA, with the LEDs **151** (solid line) facing frontward. The LED boards **150** with the LEDs **151** mounted thereon are moved in the above manner to allow the LEDs **151** to serve as light sources for the first dermatoscopy imaging and for the second dermatoscopy imaging.
[0138] As shown in FIG. **22B**, during the first dermatoscopy imaging, the LED boards **160** (dashed line) are positioned outward and the LEDs **161** (dashed line) are angled to face the first objective cover **132**. For the second dermatoscopy imaging, as indicated by arrows **Y2**, the LED boards **160** are rotated by an actuator (not shown) to have the LEDs **161** facing the second objective cover **72**. The LEDs **161** facing the second objective cover **72** in the above manner illuminate the second objective cover **72** entirely, thus illuminating the diseased skin portion in contact with the second objective cover **72** brightly without unevenness. In the manner described above, the LED boards **160** with the LEDs **161** mounted thereon are rotated to allow the LEDs **161** to serve as light sources for the first dermatoscopy imaging and for the second dermatoscopy imaging.
[0139] In the above embodiments, the control unit **300** determines whether the adapter **70** is properly attached, and then performs imaging based on the imaging mode input by the user. In other words, the imaging mode is selected basically through an input from the user. The imaging mode may be selected differently. For example, the control unit **300** may determine whether the adapter **70** is attached or detached and then determine the imaging mode without any input from the user about the imaging mode. Such an imaging operation will be described with reference to FIG. **23**.
[0140] In the imaging operation (step **S70**), the control unit **300** first determines whether the adapter **70** is attached to the illumination device **4** (step **S71**). As described above, the determination as to whether or not the adapter **70** is attached thereto is made based on the on-off states of the detection switches **62**. In step **S71**, when determining that the adapter **70** is attached (Yes in step **S71**), the control unit **300** enters the second DC imaging mode and performs the second dermatoscopy imaging operation in response to an imaging operation performed by the user (step **S72**). The second dermatoscopy imaging operation (step **S72**) is the same as the second dermatoscopy imaging operation (**S50**) shown in FIG. **18**. The control unit **300** may display, on the LCD monitor **11** shown in FIG. **2**, an indication that the imaging mode is the DC imaging mode before advancing to step **S72**. This informs the user of the current imaging mode of the camera.
[0141] When detecting detachment of the adapter **70** (Yes in step **S73**) after the second dermatoscopy imaging operation (step **S72**), the control unit **300** switches to the normal imaging mode or the first DC imaging mode. The control unit **300** then performs the normal imaging

operation or the first dermatoscopy imaging operation in accordance with an imaging operation performed by the user (step S74). As described above, in response to detecting detachment of the adapter **70**, the control unit **300** switches from the second DC imaging mode to the normal imaging mode or the first DC imaging mode without any operation input by the user. In step S74, the user may select the normal imaging mode or the first DC imaging mode through the LCD monitor **11** shown in FIG. 2.

[0142] When detecting attachment of the adapter **70** (Yes in step S75) after the normal imaging operation or the first dermatoscopy imaging operation (step S74), the control unit **300** advances to step S72 and switches the imaging mode to the second DC imaging mode. As described above, in response to detecting attachment of the adapter **70**, the control unit **300** switches from the normal imaging mode or the first DC imaging mode to the second DC imaging mode without any operation input by the user.

[0143] When the control unit **300** does not detect detachment of the adapter **70** in step S73 (No in step S73), the control unit **300** remains in the second DC imaging mode without switching the imaging mode and performs the second dermatoscopy imaging operation in response to an imaging operation performed by the user (step S72). When the control unit **300** does not detect attachment of the adapter **70** in step S75 (No in step S75), the control unit **300** remains in the normal imaging mode or the first DC imaging mode without switching the imaging mode.

[0144] When the control unit **300** determines, in step S71, that the adapter **70** is not attached (No in step S71), the control unit **300** switches to the normal imaging mode or the first DC imaging mode and performs the normal imaging operation or the first dermatoscopy imaging operation in accordance with an imaging operation performed by the user (step S74).

[0145] After the normal imaging operation or the first dermatoscopy imaging operation (step S74), the control unit **300** advances to step S71. When determining that the adapter **70** is not attached (Yes in step S71), the control unit **300** switches to the second DC imaging mode. As described above, in response to detecting attachment or detachment of the adapter **70**, the control unit **300** switches the imaging mode between the second dermatoscopy imaging operation and the normal imaging operation or the first dermatoscopy imaging operation without any user operation.

[0146] In the above embodiments, although the two detection switches **62** are used to detect the adapter **70**, any number of detection switches **62**, for example more than two detection switches **62**, may be used. More than two detection switches **62** allow more accurate determination on whether the adapter **70** is attached. The use of a single detection switch **62** can simplify the structure.

[0147] In the above embodiments, when the imaging mode being set does not correctly correspond to the state of the adapter **70** being attached or detached, the LCD monitor **11** shown in FIG. 2 displays the incorrectness. However, other informers may inform the user of such an error. In one example, the dermatoscopy camera **1** may include a speaker that outputs a sound and produces a beep or a voice to inform the user of an error. In another example, an operation on the shutter button **21** or imaging may be disabled when the imaging mode being set does not correctly correspond to the state of the adapter **70**. The user may be informed of an incorrect operation on the shutter button **21** by the LCD monitor **11** displaying a message or by the speaker producing a beep or a voice.

[0148] An incorrect correspondence between the imaging mode being set and the state of the adapter **70** being attached or detached may not be indicated in all the situations described above. The indication steps may be eliminated as appropriate. For example, the indication steps S21 to S23 may be eliminated in the first DC imaging mode shown in FIG. 16, or the indication steps S24 to S27 may be eliminated in the second DC imaging mode. The steps S25 and S27 for indicating an incorrect attachment of the adapter **70** may also be eliminated.

[0149] Although the detection switches **62** that are turned on and off in response to physical pressure applied by the adapter **70** are used as a detector that detects the adapter **70**, other detectors may be used. For example, the adapter **70** and the cover **60** include electrical contacts that come in

contact with each other and pass a current when the adapter **70** is attached. The detection of the flowing current allows determination on whether the adapter **70** is attached.

[0150] In the above embodiments, the light sources are arranged based on the inverted regions formed by inverting, with respect to the objective cover as the symmetry axis, the regions defined by the upper and lower rays from the skin as an imaging target. However, the light sources at a distance from the optical axis OA are less likely to appear in a captured image, thus permitting slight displacement of the symmetry axis about which the inverted region is formed. The inverted region and the region not inverted may not be exactly the same and may be slightly different in shape or dimensions.

[0151] The LEDs **141**, **142**, and **143** may be arranged outward from the second inverted region **502b** or arranged, for example, outward from an inverted region defined by imaginary rays using the angle of view of the imager **40** during the first dermatoscopy imaging. The LEDs **144** may also be arranged outward from the fourth inverted region **504b** or arranged, for example, outward from an inverted region defined by imaginary rays using the angle of view of the imager **40** during the second dermatoscopy imaging. This arrangement also reduces the likelihood of a captured image being affected by reflected light of the LEDs **141** to **144**.

[0152] In the embodiments described above, the first to fourth regions **501a** to **504a** and the first to fourth inverted regions **501b** to **504b** are truncated conical. However, depending on the aperture in the lens group, these regions may be elliptical truncated conical, rather than being circular truncated conical. For an elliptical truncated conical region, the rays are defined using the major and minor axes of the ellipse to position the light sources.

[0153] The illumination device used in the dermatoscopy camera **1** in the above embodiment may also be used in other imaging devices. The illumination device according to one or more embodiments of the present disclosure can be used in any imaging device that illuminates and images an imaging target on one end nearer a light transmissive cover with an imager and a light source on the other end. For example, the illumination device may be used in an imaging device that captures images for inspection of a structure surface or in an imaging device that performs imaging while illuminating an area with a gap into which the imaging device is inserted.

[0154] Although the three types of light sources for dermatoscopy imaging include a light source that emits visible light, a light source that emits polarized light, and a light source that emits ultraviolet light, the number of different light sources can be specified as appropriate in accordance with an imaging target. In one example, the illumination device may simply include one of these types of light sources. In another example, the illumination device may include more different types of light sources including, for example, a light source that emits near infrared light.

[0155] Although the LEDs **144** that emit visible light for the second dermatoscopy imaging using the adapter **70** are located nearer the optical axis OA, the illumination device may or may not include such a light source for the second dermatoscopy imaging. Other types of light sources may be located nearer the optical AX for the second dermatoscopy imaging, such as a light source that emits polarized light and a light source that emits ultraviolet light. Thus, the light sources for the first dermatoscopy imaging may include all the different types of light sources, and the light sources for the second dermatoscopy imaging may also include all the different light sources.

[0156] The second cover **130** with the first objective cover **132** is attachable and detachable with screws, and the adapter **70** with the second objective cover **72** is attachable and detachable with a hooked engagement member. However, the imaging device may include other attachment and detachment parts. For example, the second cover **130** and the adapter **70** may pivot on a pivot axis between the position at which the front of the imaging device is covered and the position at which the front of the imaging device is uncovered.

[0157] For the second dermatoscopy imaging, although the adapter **70** is attached with the second cover **130** attached as shown in FIG. **6**, the second cover **130** may be detached before the adapter **70** is attached. This eliminates the second cover **130** for the first dermatoscopy imaging located

between the adapter **70** and the imager **40** during the second dermatoscopy imaging, thus facilitating the design of the dermatoscopy camera **1** suitable for the second dermatoscopy imaging. To have the second cover **130** detached reliably for the second dermatoscopy imaging, the second cover **130** may have a larger outer diameter or a protrusion to prevent the adapter **70** from being attached over the second cover **130**. The adapter **70** may have external threads on the bottom (rear end) to be engaged with the internal threads **121e** (FIG. **9**) on the inner wall **121c**.

[0158] The second cover **130** with the first objective cover **132** may not be detachable, and may be fixed to, for example, the first cover **120** (FIG. **5**). In another example, the second cover **130** may be integral with the first cover **120** (FIG. **5**). This simplifies the structure of the dermatoscopy camera **1**.

[0159] When the focus position on the imaging target is in the virtual image range **D1** during the normal imaging, an operation on the shutter button **21** or imaging may be disabled. In this case, the LCD monitor **11** may display an image that prompts moving the dermatoscopy camera **1** further away from the imaging target. This allows the user to image the imaging target from an appropriate position without causing a virtual image to appear.

[0160] Although a single operation on the shutter button **21** enables imaging to be repeated using different types of light sources emitting light in sequence during dermatoscopy imaging, one or more light sources specified by the user may be used to emit light for dermatoscopy imaging.

[0161] The adapter **70** for imaging narrow areas is optional. An imaging device that is not designed for imaging narrow areas can eliminate the adapter **70**. Such an imaging device not designed for the second dermatoscopy imaging can eliminate the light source for the second dermatoscopy imaging (e.g., LEDs **144**).

[0162] Although the base body **180** and the first cover body **121** defining the housing space **A** for the first LED board **111** are formed from, for example, a black synthetic resin to avoid illuminating the interior of the dermatoscopy camera **1** with light from the light sources for normal imaging (LEDs **140**), the base body **180** and the first cover body **121** may be formed from a synthetic resin of another color that easily absorbs light. To reduce light leakage to the interior of the dermatoscopy camera **1**, the base body **180** and the first cover body **121** separating the space **A** from the space **B** shown in FIG. **9** may include other structures that appropriately block light from the light sources located in the space **A** for normal imaging.

[0163] For example, as shown in FIG. **9**, the outer surface **A1** of the first cover body **121** and the outer surface **A2** of the base body **180** may be mirror-finished to reflect light **L1** and light **L2**, thus preventing light from entering the first cover body **121** and the base body **180**. For mirror-finishing, known mirror-finishing techniques can be used, such as a silver film or chrome plating applied to the surface. As described above, the first cover body **121** and the base body **180** including light reflector with higher light reflectivity may reduce light leakage to the interior of the dermatoscopy camera **1**.

[0164] In another example, a commercially available masking tape, rubber plate, or metal plate may be attached to the outer surface **A1** of the first cover body **121** and the outer surface **A2** of the base body **180** to block light from the light sources (LEDs **140**).

[0165] In still another example, the first cover body **121** and the base body **180** may be formed from a lightproof material, for example, from a metal such as aluminum or stainless steel, or from a black rubber material.

[0166] As described above, the base body **180** and the first cover body **121** separating the housing space **A** from the space **B** include a light blocker for blocking light to reduce leakage of light from the LEDs **140** located in the housing space **A** for normal imaging to the distal end of the lens barrel **41c** or to the space **B** housing the LEDs **141**, **142**, **143**, and **144** for dermatoscopy imaging. Various light blockers described above may be used.

[0167] The foregoing describes some example embodiments for explanatory purposes. Although the foregoing discussion has presented specific embodiments, persons skilled in the art will

recognize that changes may be made in form and detail without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. This detailed description, therefore, is not to be taken in a limiting sense, and the scope of the invention is defined only by the included claims, along with the full range of equivalents to which such claims are entitled.

[0168] This application claims the benefit of Japanese Patent Application No. 2019-66958, filed on Mar. 29, 2019, and Japanese Patent Application No. 2019-98137, filed on May 24, 2019, of which the entirety of the disclosures is incorporated by reference herein.

INDUSTRIAL APPLICABILITY

[0169] The technique according to one or more embodiments of the present disclosure is particularly useful for allowing proper imaging of a target by reducing the likelihood of imaging being affected by reflected light of a light source.

REFERENCE SIGNS LIST

[0170] **1** Dermatoscopy camera [0171] **2** Controller [0172] **3** Camera body [0173] **4** Illumination device [0174] **10** Display [0175] **11** LCD monitor [0176] **20** Body [0177] **21** Shutter button [0178] **22** Power button [0179] **30** Circuit board [0180] **40** imager [0181] **41** Imaging lens system [0182] **41a** First imaging lens [0183] **41b** Second imaging lens [0184] **41c** Lens barrel [0185] **43** Wiring circuit board [0186] **44** Image sensor [0187] **45** Infrared cut filter [0188] **46** Ultraviolet transmissive filter [0189] **47** Polarization filter [0190] **48** Flexible circuit board [0191] **50** Frame [0192] **60** Cover [0193] **61** Protrusion [0194] **62** Detection switch [0195] **62a** Spring [0196] **70** Adapter [0197] **70a** Inner wall [0198] **71** Cylinder [0199] **71a** Opening [0200] **71b** Hooked portion [0201] **72** Second objective cover [0202] **72a** Front surface [0203] **73**, **74** Second objective cover area [0204] **74a** Darker area [0205] **100** Illumination device body [0206] **110** Base [0207] **111** to **116** First to sixth LED boards [0208] **116a** Barrel insertion hole [0209] **117** Polarizer plate [0210] **120** First cover [0211] **121** First cover body [0212] **121a** Cover portion [0213] **121b** Outer wall [0214] **121c** Inner wall [0215] **121d** light releasing hole [0216] **121e** Internal thread [0217] **122** Translucent plate [0218] **130** Second cover [0219] **131** Cylinder [0220] **131a** Opening [0221] **131b** External thread [0222] **132** First objective cover [0223] **132a** Front surface [0224] **132b** Rear surface [0225] **140** to **144** LED [0226] **150** LED board [0227] **151** LED [0228] **160** LED board [0229] **161** LED [0230] **171**, **173**, **175**, **177** Upper ray [0231] **171'**, **173'**, **175'**, **177'** Inverted upper ray [0232] **172**, **174**, **176**, **178** Lower ray [0233] **172'**, **174'**, **176'**, **178'** Inverted lower ray [0234] **180** Base body [0235] **181** Cylindrical portion [0236] **182** Annular portion [0237] **182** Board mounting surface [0238] **183** to **186** First to Fourth walls [0239] **187** Connection part [0240] **188** Fifth wall [0241] **188b** Barrel insertion hole [0242] **189** Screw [0243] **200** Storage [0244] **300** Control unit [0245] **400** Dermatoscopy camera [0246] **404** Illumination device [0247] **501a** First region [0248] **501b** First inverted region [0249] **502a** Second region [0250] **502b** Second inverted region [0251] **503a** Third region [0252] **503b** Third inverted region [0253] **504a** Fourth region [0254] **504b** Fourth inverted region [0255] A Housing space [0256] **D1** Virtual image range [0257] **P1** Focus start position [0258] **P2**, **P3** Focus position [0259] **S1**, **S2** Skin [0260] **OA** Optical axis [0261] **r1** to **r4** Region

Claims

1. An imaging device comprising: an illumination device; and an imager, the illumination device comprising: an objective cover comprising a light transmissive member; and at least one light source located nearer the imager than the objective cover and configured to illuminate a target through the objective cover; and the imager comprising: an image sensor configured to image the target; and an imaging lens configured to form an image of the target on the image sensor, wherein: the objective cover directs reflected light reflected from the target and incident on a front surface of the objective cover to the imaging lens, whereby the image of the target is formed on the image

sensor based on the reflected light received through the objective cover, a first region is defined outside the illumination device on a target side of the objective cover, a sectional shape of the first region being bounded by outermost light rays among light rays included in the reflected light incident on the objective cover and in focus with the imaging lens in a state in which the objective cover is in contact with the target, a second region is defined inside the illumination device on an imager side of the objective cover, a sectional shape of the second region and the sectional shape of the first region are symmetrical with respect to the front surface of the objective cover as an axis of symmetry, and the at least one light source is located outside the second region along a direction orthogonal to an optical axis of the imager.

2. The illumination device according to claim 1, wherein the at least one light source includes a plurality of light sources arranged symmetrically with respect to one another about the optical axis of the imager in the direction orthogonal to the optical axis of the imager.

3. The illumination device according to claim 2, wherein each of the plurality of light sources is located to emit light directed toward the objective cover to focus on an overall area of the objective cover.

4. The illumination device according to claim 2, wherein the plurality of light sources include at least one type of light source selected from the group consisting of a light source to emit visible light, a light source to emit ultraviolet light, and a light source to emit polarized light of visible light.

5. The illumination device according to claim 1, wherein: the objective cover includes a first objective cover and a second objective cover, and at least one of the first objective cover or the second objective cover is selectively usable, the front surface of the first objective cover is orthogonal to the optical axis of the imager and has a first predetermined area, the front surface of the second objective cover is orthogonal to the optical axis of the imager and has a second predetermined area smaller than the first predetermined area, the at least one light source includes at least one first light source to illuminate the target through the first objective cover and at least one second light source to illuminate the target through the second objective cover, the at least one first light source is located outside the second region as defined with respect to the first objective cover in a state in which the first objective cover is in contact with the target, and the at least one second light source is located outside the second region as defined with respect to the second objective cover in a state in which the second objective cover is in contact with the target.

6. The illumination device according to claim 5, wherein: the at least one first light source includes a plurality of first light sources each located to emit light directed toward the first objective cover and to focus on an overall area of the first objective cover, and the at least one second light source includes a plurality of second light sources each located to emit light directed toward the second objective cover and to focus on an overall area of the second objective cover.

7. The illumination device according to claim 6, wherein: the plurality of first light sources and the plurality of second light sources include common light sources, and the common light sources selectively function as the plurality of first light sources or the plurality of second light sources by changing positions of the common light sources relative to the first objective cover or the second objective cover or changing an angle of light emitted from each of the common light sources.

8. The illumination device according to claim 5, wherein the at least one first light source includes at least one type of light source selected from the group consisting of a light source for visible light, a light source for ultraviolet light, and a light source for polarized light of visible light.

9. An imaging device for imaging skin of a human body as a target, the imaging device comprising: an illumination device; and an imager, wherein: the imager comprises: an image sensor configured to image a target; and an imaging lens configured to form an image of the target on the image sensor, the illumination device comprises: a first objective cover comprising a first light transmissive member having a first predetermined area, the first objective cover being configured to direct light reflected from the target and incident on a front surface of the first objective cover to

the imaging lens, the image of the target being formed on the image sensor based on the reflected light received through the first objective cover, and the front surface of the first objective cover being orthogonal to an optical axis of the imager; a second objective cover comprising a second light transmissive member having a second predetermined area smaller than the first predetermined area, the second objective cover directing reflected light reflected from the target and incident on a front surface of the second objective cover to the imaging lens, the image of the target being formed on the image sensor based on the reflected light received through the second objective cover, the front surface of the second objective cover being orthogonal to the optical axis of the imager, and the second objective cover being selectively usable with the first objective cover; at least one first light source to illuminate the target through the first objective cover; and at least one second light source to illuminate the target through the second objective cover, the first objective cover is provided on a first cover included in the illumination device, the first cover being cylindrical, the second objective cover is provided on a second cover, the second cover being cylindrical and including an attachment and detachment part by which the second cover is selectively attachable to and detachable from the illumination device, the first objective cover is used as the objective cover to be in contact with the target, in a state in which the second cover is detached from the illumination device, the second objective cover is used as the objective cover to be in contact with the target, in a state in which the second cover is attached to the illumination device by the attachment and detachment part and is covering the first cover, in the state in which the second cover is detached from the illumination device and the first objective cover is in contact with the target, (i) a first region is defined outside the illumination device on a target side of the first objective cover, a sectional shape of the first region being bounded by outermost light rays among light rays included in the reflected light incident on the first objective cover and in focus with the imaging lens, and (ii) a second region is defined inside the illumination device on an imager side of the first objective cover, such that a sectional shape of the second region and the sectional shape of the first region are symmetrical with respect to the front surface of the first objective cover as an axis of symmetry, in the state in which the second cover is attached to the illumination device and the second objective cover is in contact with the target, (i) the first region is defined outside the illumination device on a target side of the second objective cover, a sectional shape of the first region being bounded by outermost light rays among light rays included in the reflected light incident on the second objective cover and in focus with the imaging lens, and (ii) the second region is defined inside the illumination device on an imager side of the second objective cover, such that a sectional shape of the second region and the sectional shape of the first region are symmetrical with respect to the front surface of the second objective cover as an axis of symmetry, the at least one first light source is located outside the second region as defined with respect to the first objective cover in the state in which the second objective cover is detached from the illumination device and the first objective cover is in contact with the target, and the at least one second light source is located outside the second region as defined with respect to the second objective cover in the state in which the second objective cover is attached to the illumination device and the second objective cover is in contact with the target.

10. The imaging device according to claim 9, further comprising at least one controller configured to: selectively set, in accordance with an operation performed by a user of the imaging device, an imaging mode to image the target with the imager to one of a plurality of imaging modes including a first imaging mode to image the target illuminated by the at least one first light source without the at least one second light source and a second imaging mode to image the target illuminated by the at least one second light source without the at least one first light source; detect whether the second cover is attached to or detached from the illumination device; and inform, in response to at least one of conditions being satisfied, the user that the at least one condition is satisfied, the conditions including a condition that the at least one controller detects that the second cover is attached to the illumination device and the imaging mode is set to the first imaging mode, and a condition that the

at least one controller detects that the second cover is detached from the illumination device and the imaging mode is set to the second imaging mode.

11. The imaging device according to claim 9, further comprising at least one controller configured to: selectively set, in accordance with an operation performed by a user of the imaging device, an imaging mode to image the target with the imager to one of a plurality of imaging modes including a first imaging mode to image the target illuminated by the at least one first light source without the at least one second light source and a second imaging mode to image the target illuminated by the at least one second light source without the at least one first light source; and detect attachment and detachment of the second cover to and from the illumination device, wherein the at least one controller switches the imaging mode to the second imaging mode in response to detecting attachment of the second cover to the illumination device in a state where the imaging mode is set to the first imaging mode, and switches the imaging mode to one of the plurality of imaging modes other than the second imaging mode in response to detecting detachment of the second cover from the illumination device in a state where the imaging mode is set to the second imaging mode.

12. An imaging device comprising: an illumination device; and an imager, the imager comprising: an image sensor configured to image a target; and an imaging lens configured to form an image of the target on the image sensor, and the illumination device comprising: a first objective cover comprising a first light transmissive member having a first predetermined area, the first objective cover being configured to direct light reflected from the target and incident on a front surface of the first objective cover to the imaging lens, the image of the target being formed on the image sensor based on the reflected light received through the first objective cover, and the front surface of the first objective cover being orthogonal to an optical axis of the imager; a second objective cover comprising a second light transmissive member having a second predetermined area smaller than the first predetermined area, the second objective cover directing reflected light reflected from the target and incident on a front surface of the second objective cover to the imaging lens, the image of the target being formed on the image sensor based on the reflected light received through the second objective cover, the front surface of the second objective cover being orthogonal to the optical axis of the imager, and the second objective cover being selectively usable with the first objective cover; a first light source configured to illuminate the target through the first objective cover; and a second light source configured to illuminate the target through the second objective cover, wherein: in a state in which the first objective cover is in contact with the target, (i) a first region is defined outside the illumination device on a target side of the first objective cover, a sectional shape of the first region being bounded by outermost light rays among light rays included in the reflected light incident on the first objective cover and in focus with the imaging lens, and (ii) a second region is defined inside the illumination device on an imager side of the first objective cover, such that a sectional shape of the second region and the sectional shape of the first region are symmetrical with respect to the front surface of the first objective cover as an axis of symmetry, in a state in which the second objective cover is in contact with the target, (i) the first region is defined outside the illumination device on a target side of the second objective cover, a sectional shape of the first region being bounded by outermost light rays among light rays included in the reflected light incident on the second objective cover and in focus with the imaging lens, and (ii) the second region is defined inside the illumination device on an imager side of the second objective cover, such that a sectional shape of the second region and the sectional shape of the first region are symmetrical with respect to the front surface of the second objective cover as an axis of symmetry, the first light source is located outside the second region as defined with respect to the first objective cover in the state in which the first objective cover is in contact with the target, and the second light source is located outside the second region as defined with respect to the second objective cover in the state in which the second objective cover is in contact with the target.

13. The imaging device according to claim 1, wherein: each of the first region and the second region is a region having a truncated conical shape, and a cross section of each of the first region

and the second region taken along the direction orthogonal to the optical axis of the imager has a trapezoidal shape bounded by the outermost light rays and the front surface of the objective cover.

14. The imaging device according to claim 13, wherein the region having the truncated conical shape is defined by rotating the outermost light rays about the optical axis of the imager.

15. The imaging device according to claim 1, wherein the at least one light source is located at a position in an interior of the illumination device that does not overlap with the second region.

16. The imaging device according to claim 1, wherein each of the outermost light rays corresponds to a light ray passing through one of an uppermost position and a lowermost position of an imaging range of the image sensor along the direction orthogonal to the optical axis of the imager, from among the light rays included in the reflected light incident on the objective cover and in focus with the imaging lens in the state in which the objective cover is in contact with the target.
