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(12) **United States Patent**
Iwane

(10) **Patent No.: US 12,390,097 B2**
(45) **Date of Patent: Aug. 19, 2025**

(54) **ENDOSCOPE SYSTEM AND METHOD OF OPERATING ENDOSCOPE SYSTEM**

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(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 338 days.

(21) Appl. No.: **17/931,525**

(22) Filed: **Sep. 12, 2022**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/005938, filed on Feb. 17, 2021.

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
A61B 1/06 (2006.01)
A61B 1/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 1/0655*** (2022.02); ***A61B 1/00006*** (2013.01); ***A61B 1/000095*** (2022.02); ***A61B 1/0002*** (2013.01); ***A61B 1/0005*** (2013.01); ***A61B 1/0638*** (2013.01); ***A61B 1/0669*** (2013.01); ***A61B 1/0684*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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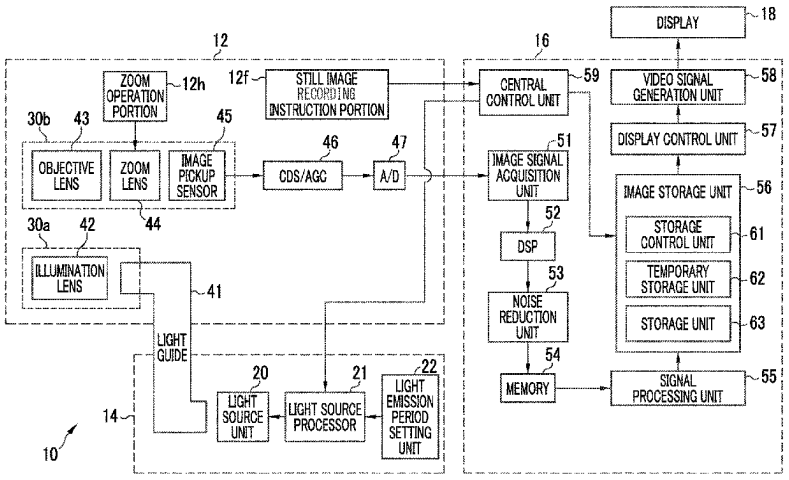
(57) **ABSTRACT**

An image processor selects, when a processing start operation for starting image storage processing is performed, a first image and a second image that satisfy a preset selection condition from a plurality of the first images and a plurality of the second images acquired in a target period including a time when the processing start operation is performed, for the image storage processing. A light source processor performs control to switch, out of a first illumination light beam and a second illumination light beam, one being emitted to the other to emit the other, during a target period.

16 Claims, 22 Drawing Sheets



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2015/0272429	A1*	10/2015	Shigeta	A61B 1/0002 348/65
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An Office Action; mailed by the China National Intellectual Property Administration of the People's Republic of China on Jan. 9, 2025, which corresponds to Chinese Patent Application No. 202180020927.X and is related to U.S. Appl. No. 17/931,525.

"Trial and Appeal Decision" mailed by the Japanese Patent Office on Jul. 1, 2025, which corresponds to Japanese Patent Application No. 2022-505874 and is related to U.S. Appl. No. 17/931,525; with English language translation.

* cited by examiner

FIG. 1

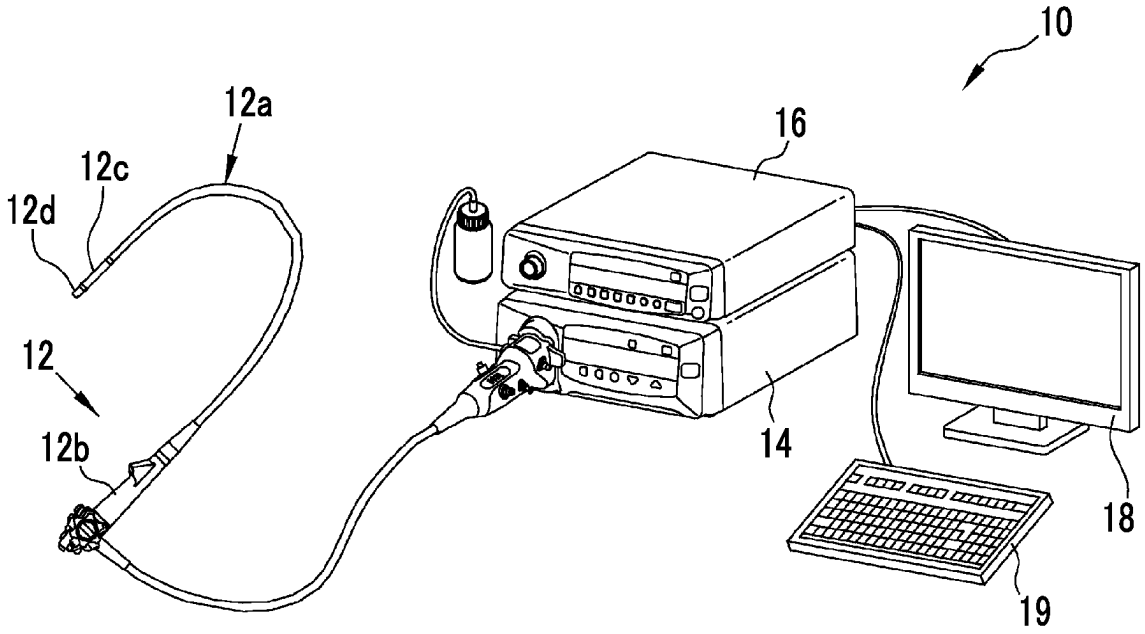


FIG. 2

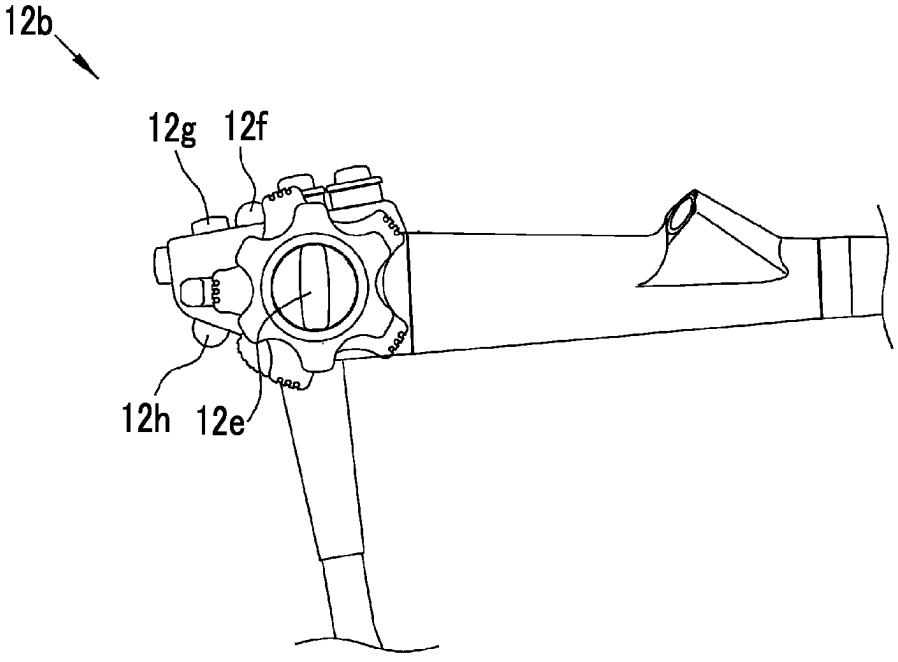


FIG. 3

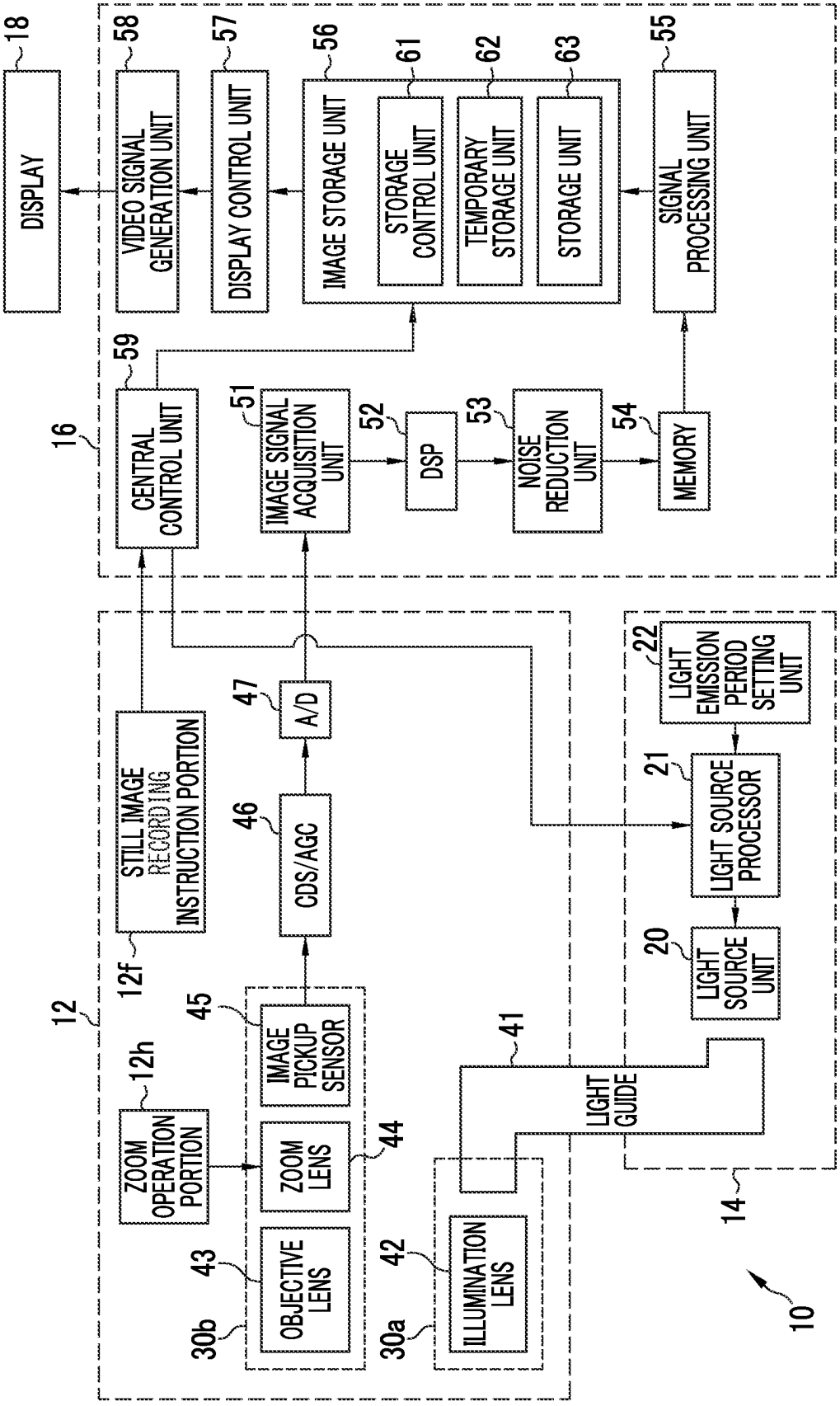

DISPLAY
18
VIDEO SIGNAL GENERATION UNIT
58
DISPLAY CONTROL UNIT
57
IMAGE STORAGE UNIT
56
STORAGE CONTROL UNIT
61
TEMPORARY STORAGE UNIT
62
STORAGE UNIT
63
SIGNAL PROCESSING UNIT
55
16
CENTRAL CONTROL UNIT
59
IMAGE SIGNAL ACQUISITION UNIT
51
DSP
52
NOISE REDUCTION UNIT
53
MEMORY
54
LIGHT EMISSION PERIOD SETTING UNIT
22
LIGHT SOURCE PROCESSOR
21
LIGHT SOURCE UNIT
20
STILL IMAGE RECORDING INSTRUCTION PORTION
12f
A/D
47
CDS/AGC
46
IMAGE PICKUP SENSOR
45
ZOOM OPERATION PORTION
12h
ZOOM LENS
44
OBJECTIVE LENS
43
30b
ILLUMINATION LENS
42
30a
LIGHT GUIDE
41
12
14
10

FIG. 4

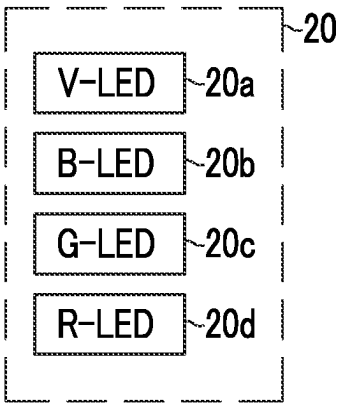

20
V-LED
20a
B-LED
20b
G-LED
20c
R-LED
20d

FIG. 5

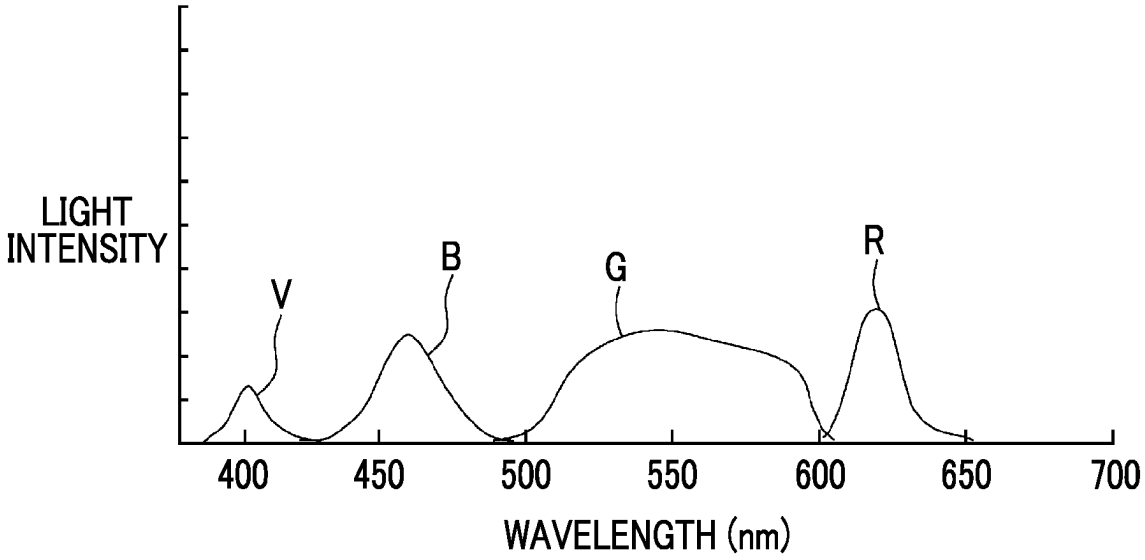

LIGHT INTENSITY
V
B
G
R
400
450
500
550
600
650
700
WAVELENGTH (nm)

FIG. 6

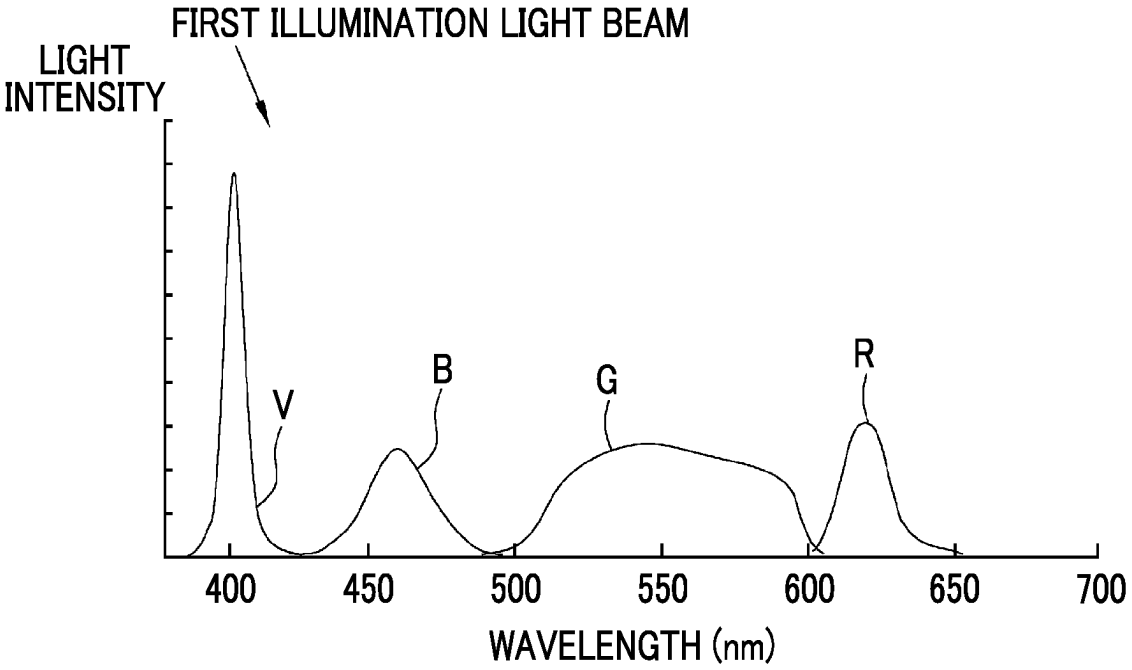

FIRST ILLUMINATION LIGHT BEAM
LIGHT INTENSITY
V
B
G
R
400
450
500
550
600
650
700
WAVELENGTH (nm)

FIG. 7

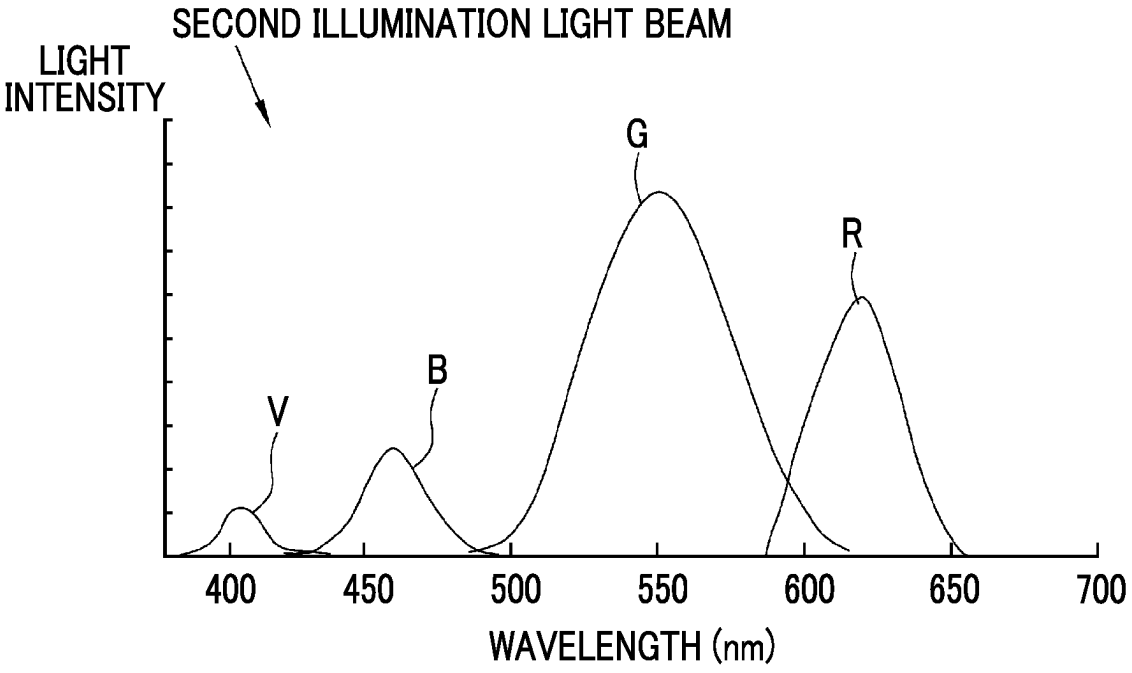

SECOND ILLUMINATION LIGHT BEAM
LIGHT INTENSITY
V
B
G
R
400
450
500
550
600
650
700
WAVELENGTH (nm)

FIG. 8

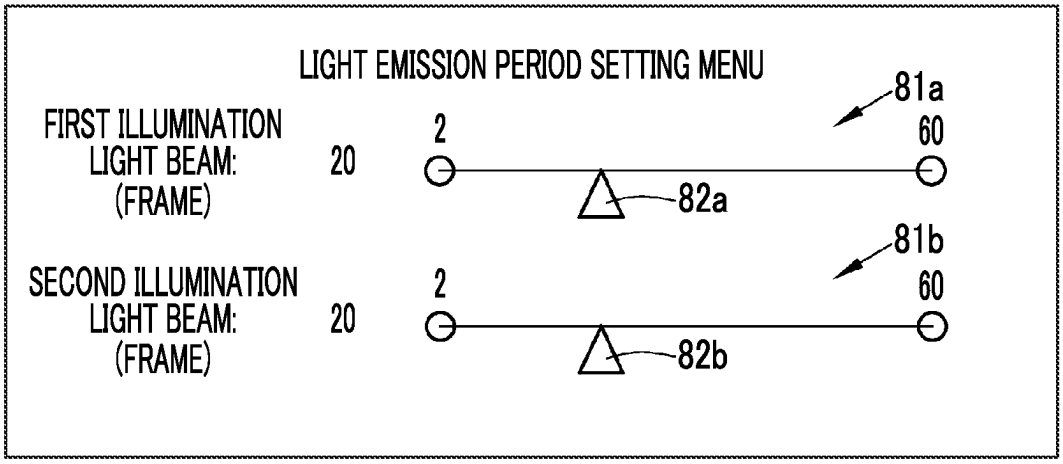

LIGHT EMISSION PERIOD SETTING MENU
81a
FIRST ILLUMINATION LIGHT BEAM: (FRAME)
20
2
60
82a
81b
SECOND ILLUMINATION LIGHT BEAM: (FRAME)
20
2
60
82b

FIG. 9

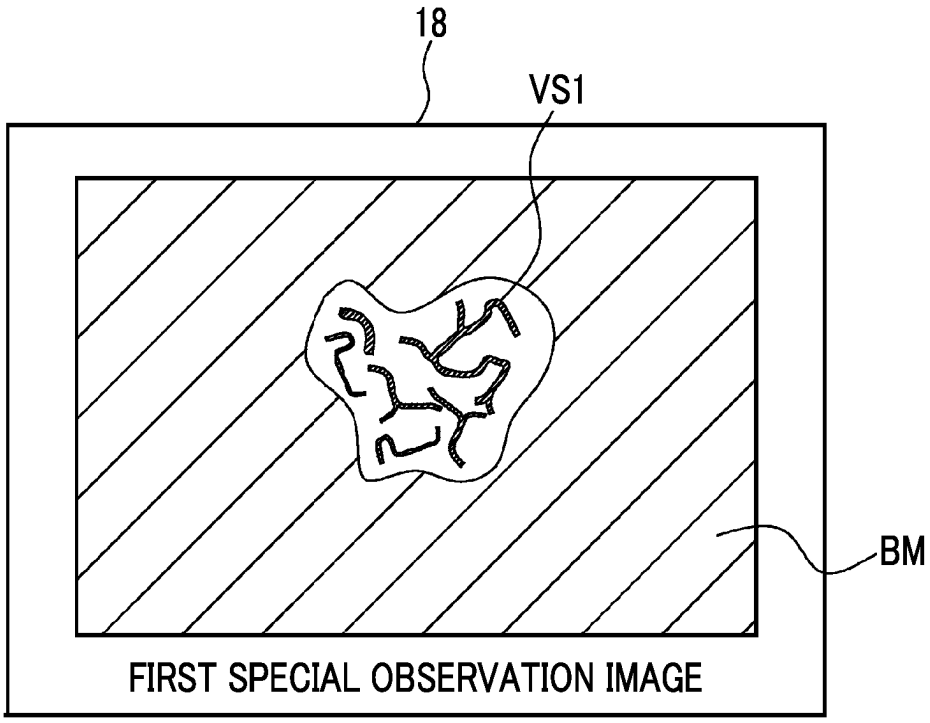

18
VS1
BM
FIRST SPECIAL OBSERVATION IMAGE

FIG. 10

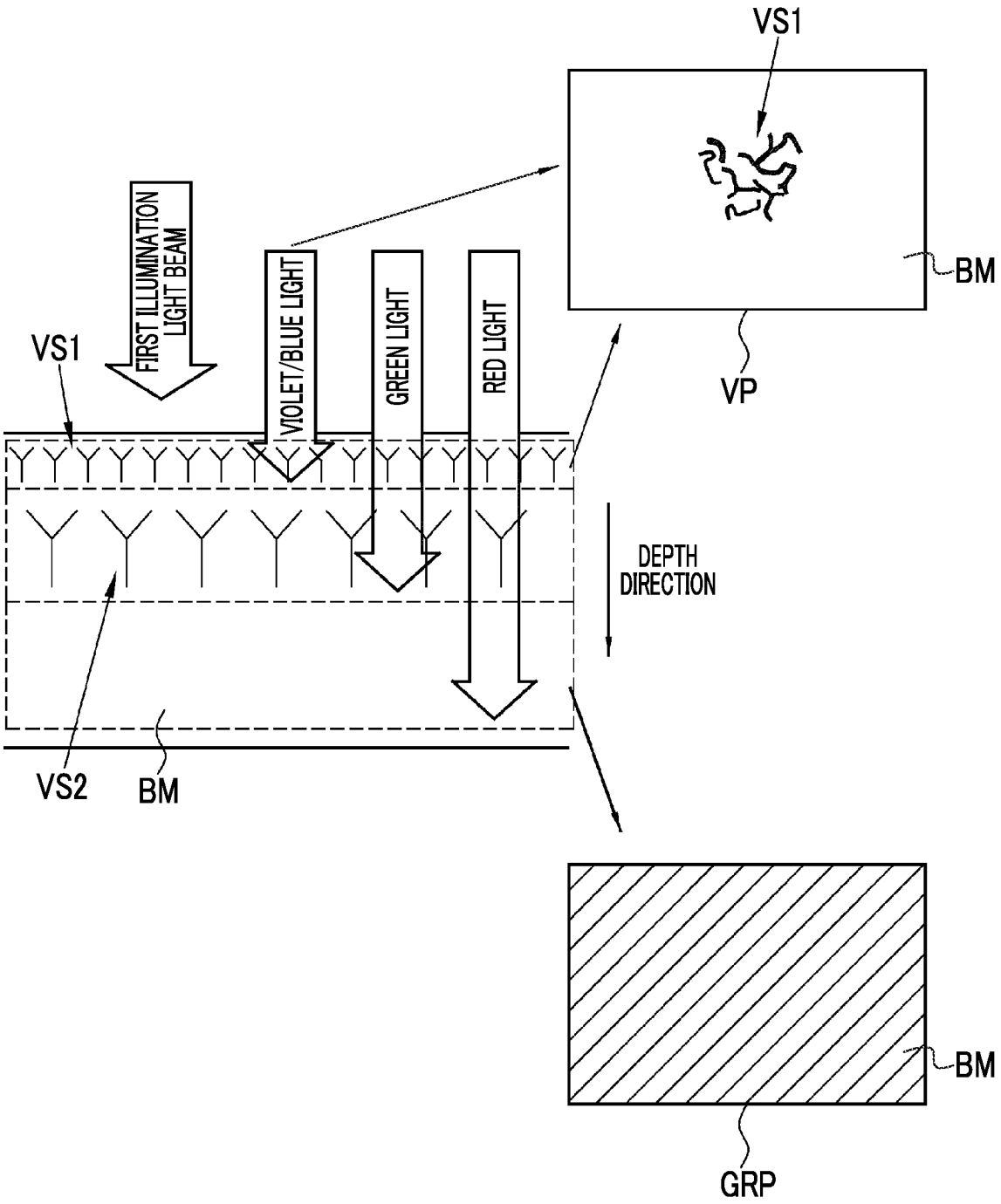

VS1
BM
VP
FIRST ILLUMINATION LIGHT BEAM
VIOLET/BLUE LIGHT
GREEN LIGHT
RED LIGHT
VS1
DEPTH DIRECTION
VS2
BM
BM
GRP

FIG. 11

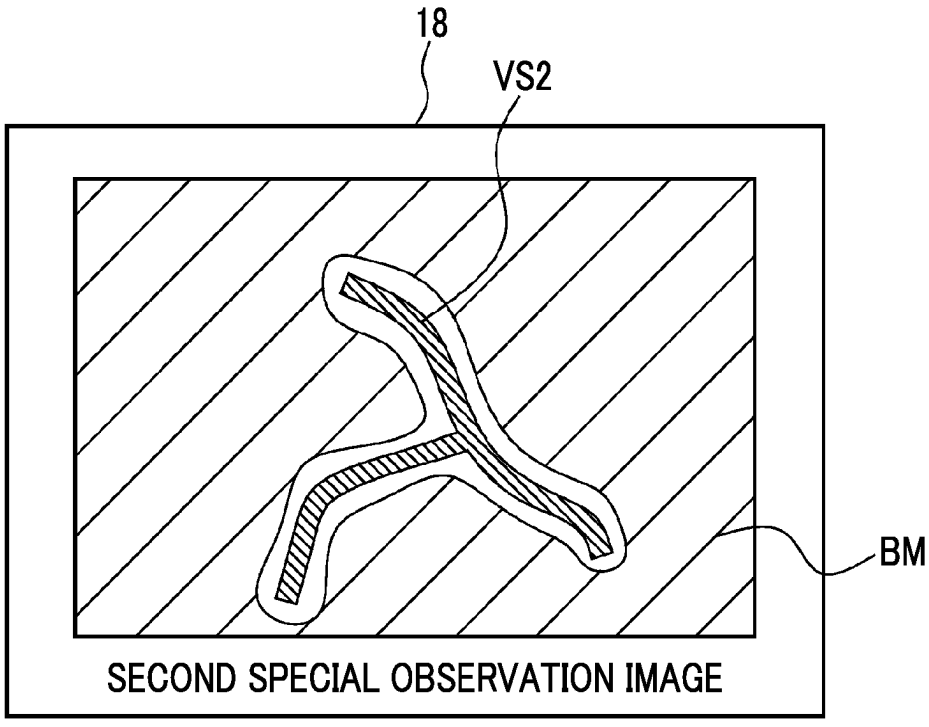


FIG. 12

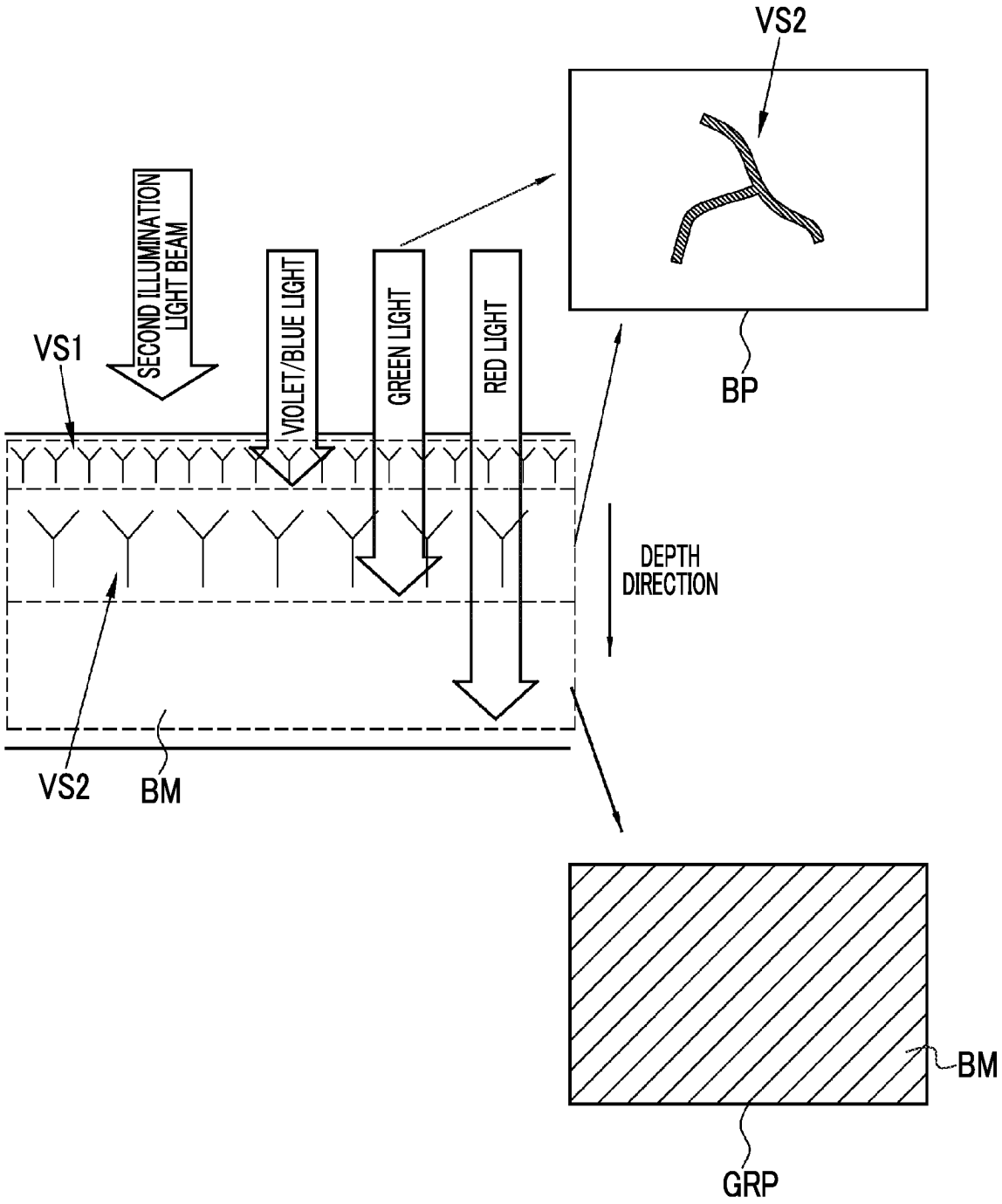

VS2
SECOND ILLUMINATION LIGHT BEAM
VIOLET/BLUE LIGHT
GREEN LIGHT
RED LIGHT
VS1
BP
DEPTH DIRECTION
VS2
BM
BM
GRP

FIG. 13

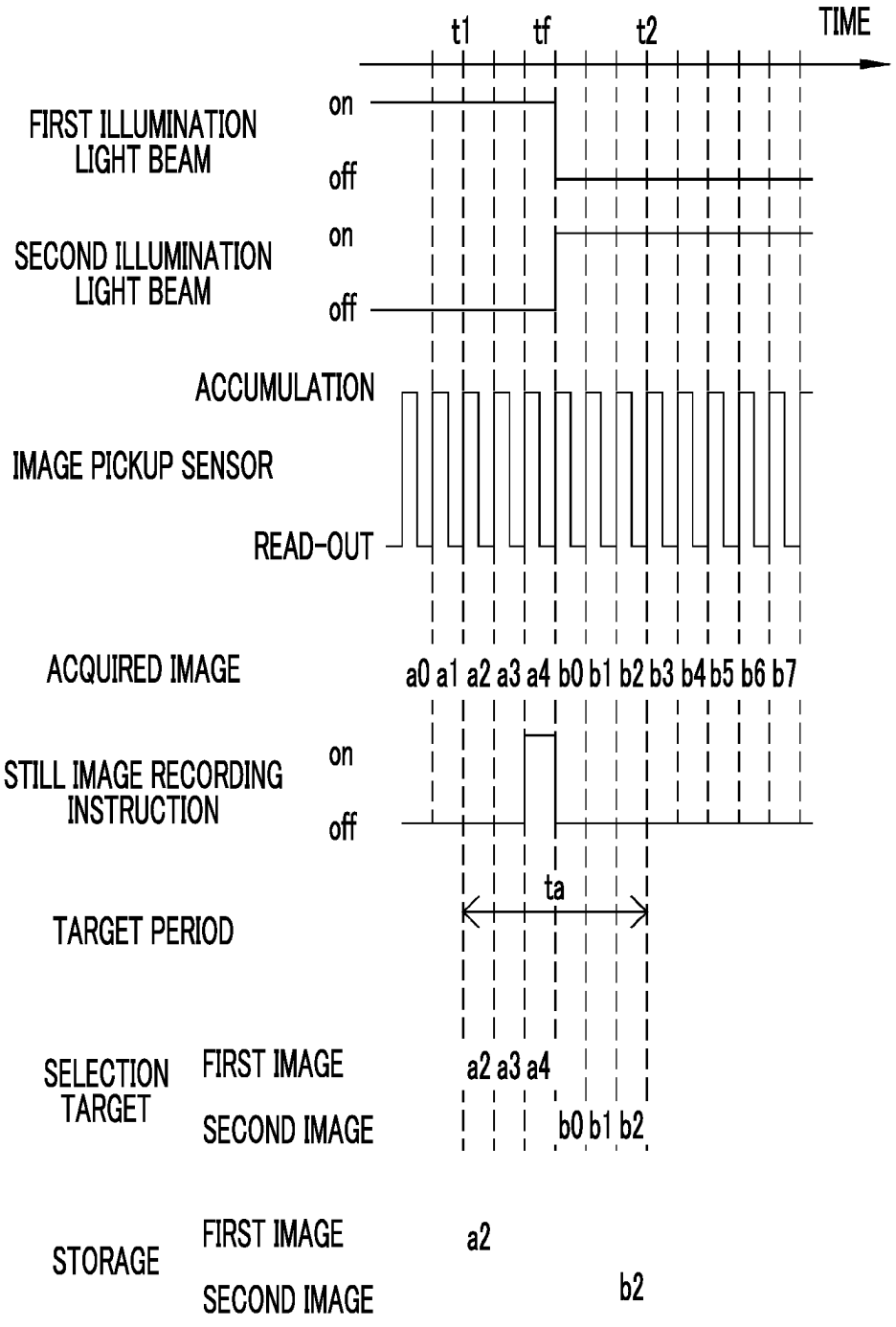

t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 b3 b4 b5 b6 b7
STILL IMAGE RECORDING INSTRUCTION
on
off
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 14

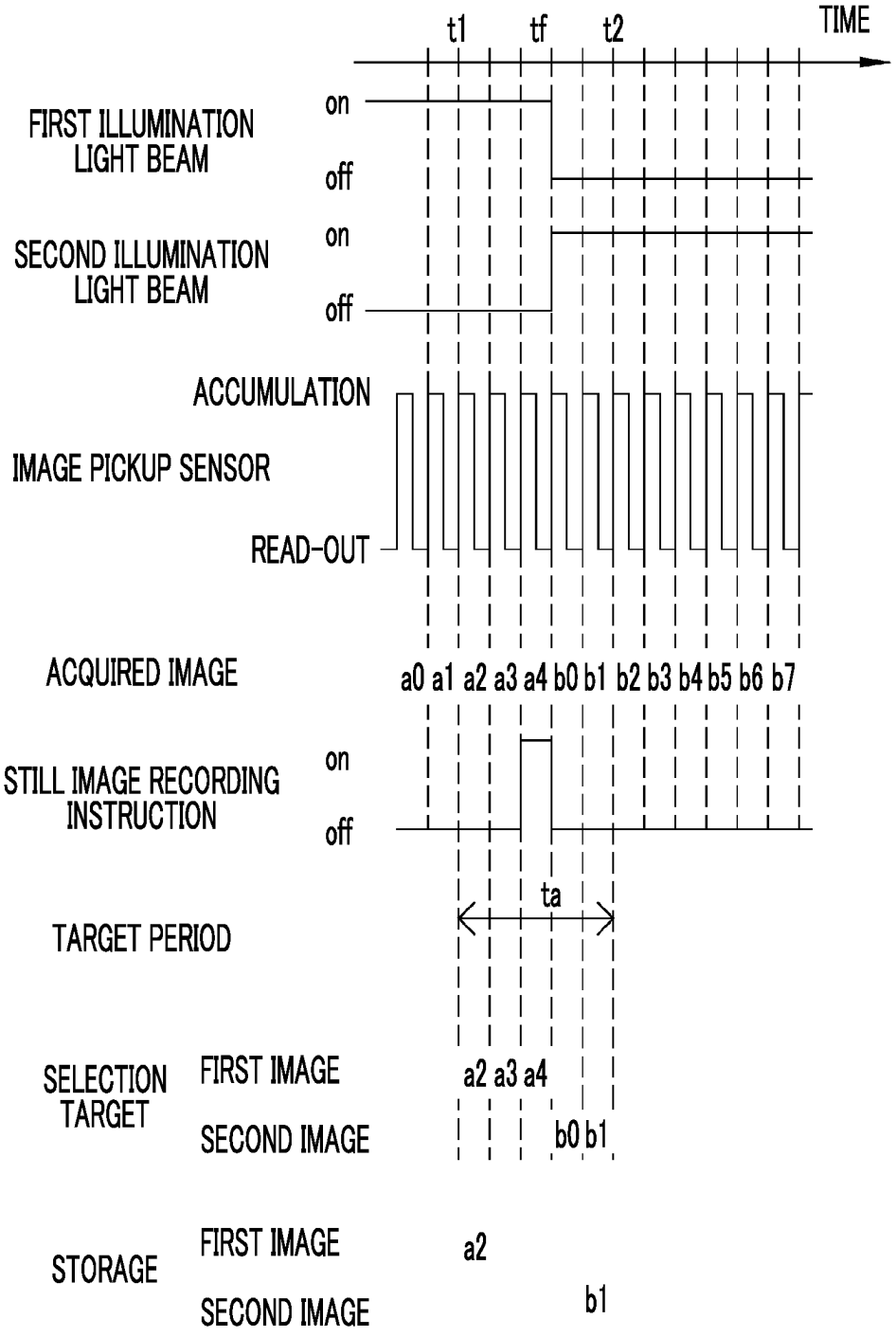

t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 b3 b4 b5 b6 b7
STILL IMAGE RECORDING INSTRUCTION
on
off
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b1

FIG. 15

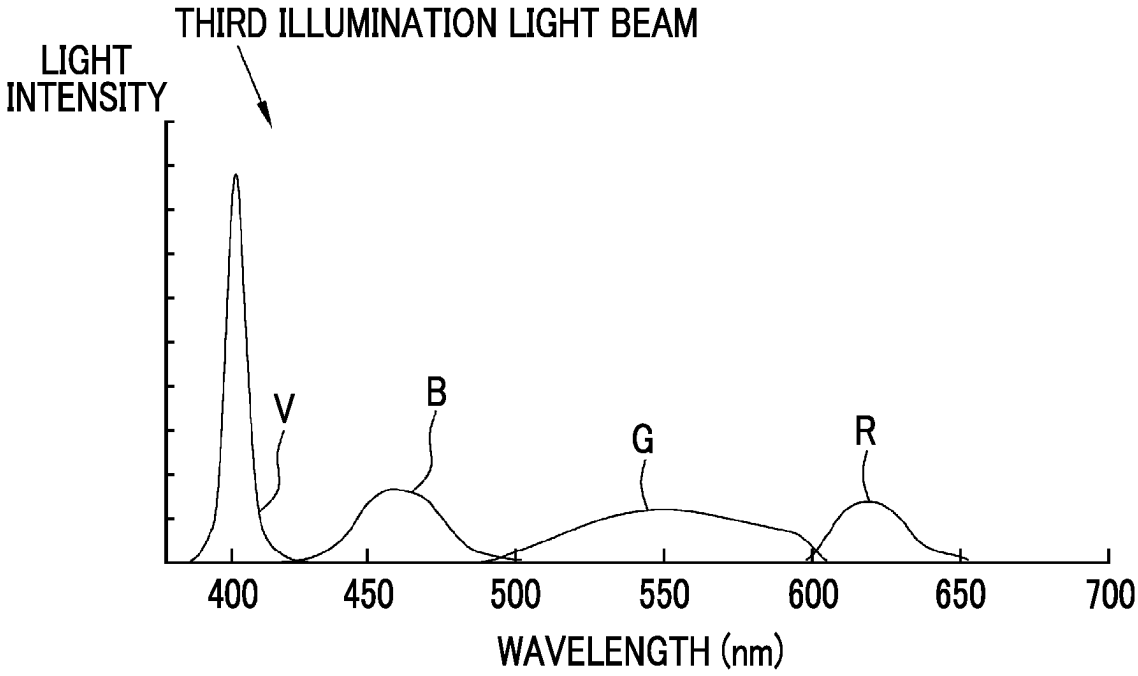

THIRD ILLUMINATION LIGHT BEAM
LIGHT INTENSITY
V
B
G
R
400
450
500
550
600
650
700
WAVELENGTH (nm)

FIG. 16

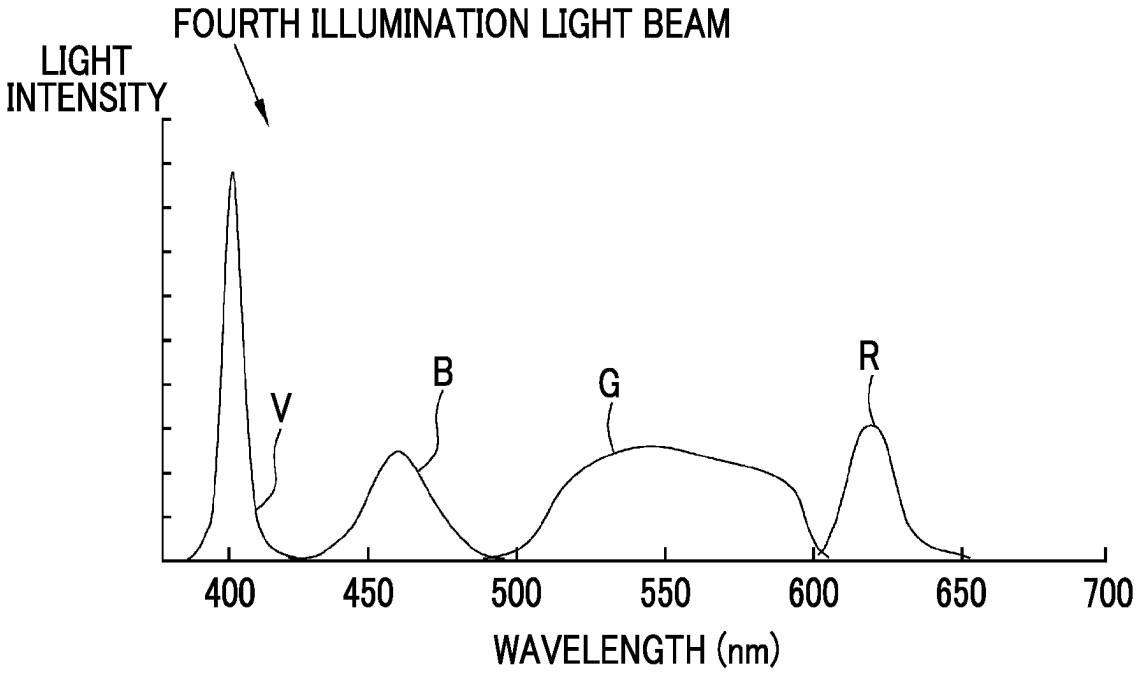

FOURTH ILLUMINATION LIGHT BEAM
LIGHT INTENSITY
V
B
G
R
400
450
500
550
600
650
700
WAVELENGTH (nm)

FIG. 17

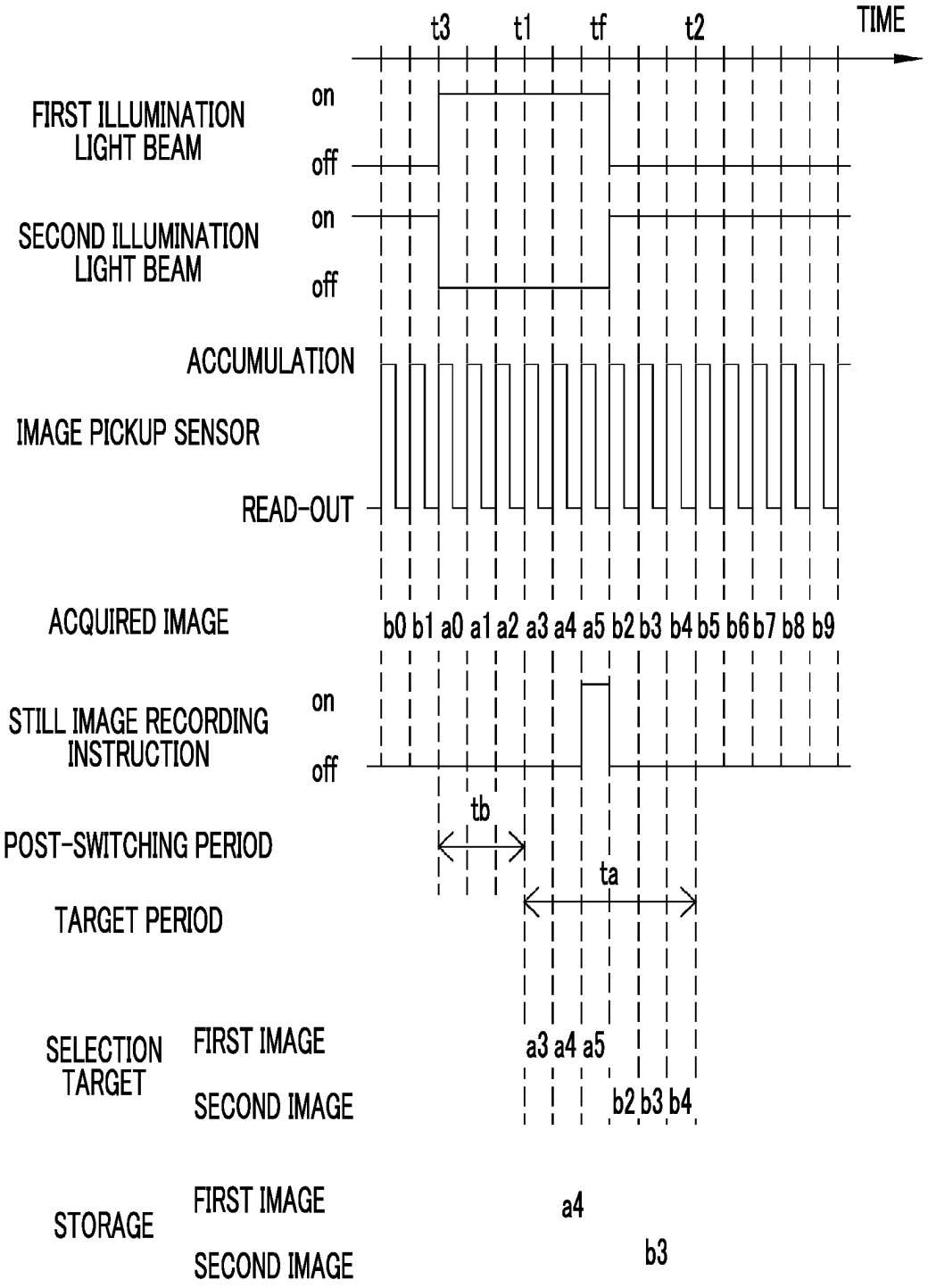

t3
t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
b0 b1 a0 a1 a2 a3 a4 a5 b2 b3 b4 b5 b6 b7 b8 b9
STILL IMAGE RECORDING INSTRUCTION
on
off
tb
POST-SWITCHING PERIOD
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a3 a4 a5
SECOND IMAGE
b2 b3 b4
STORAGE
FIRST IMAGE
a4
SECOND IMAGE
b3

FIG. 18

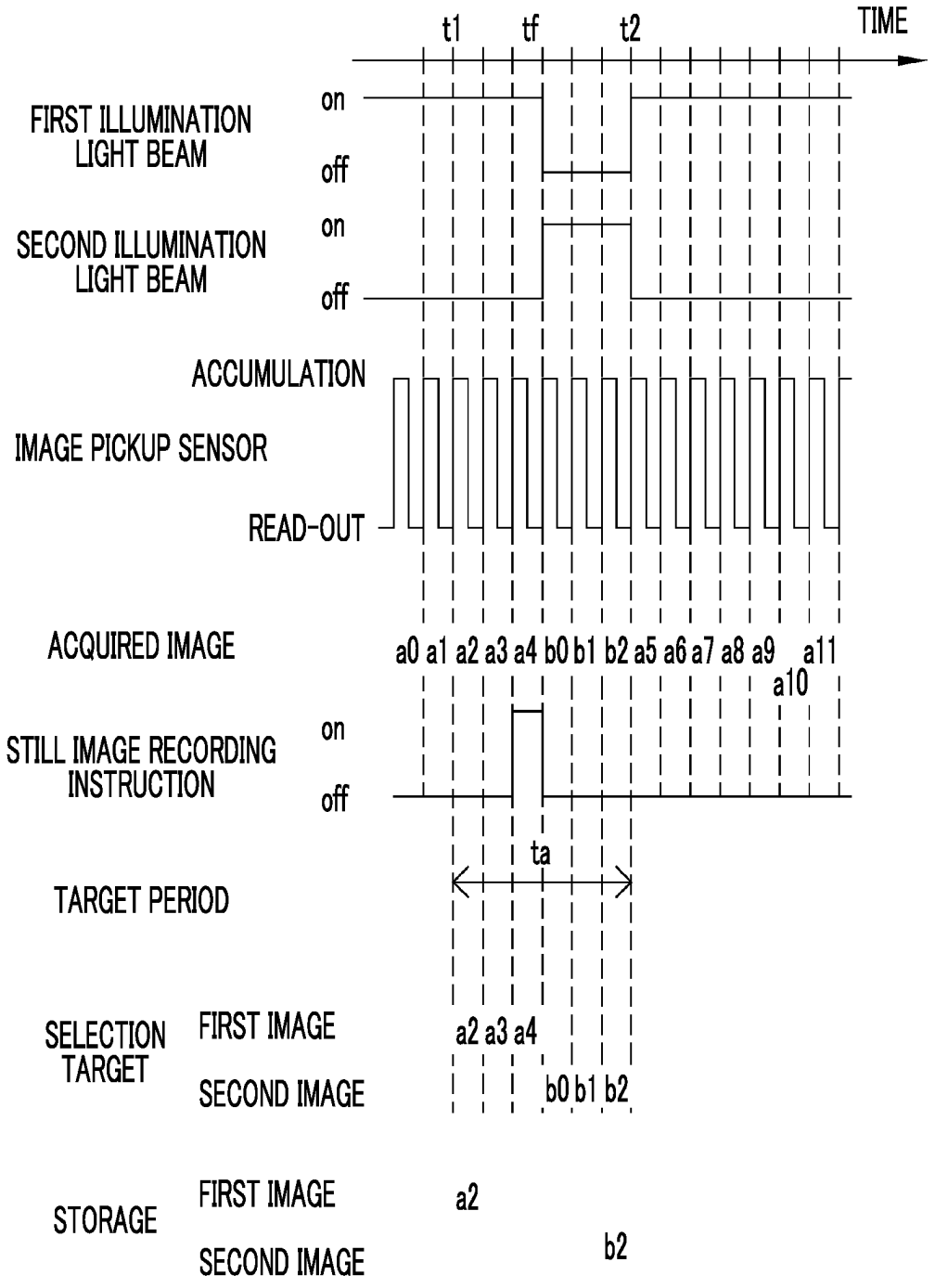

t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 a5 a6 a7 a8 a9 a10 a11
STILL IMAGE RECORDING INSTRUCTION
on
off
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 19

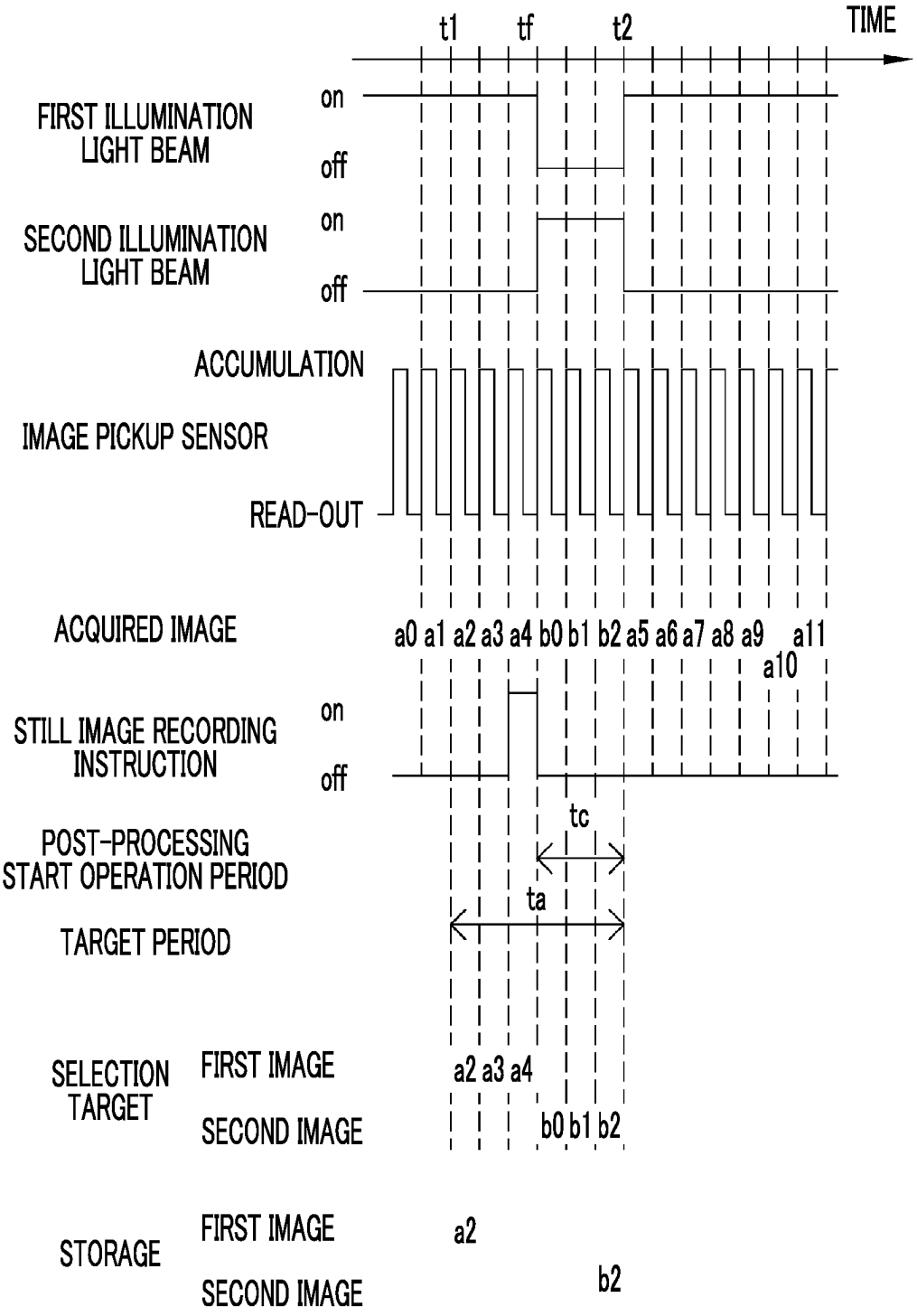

t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 a5 a6 a7 a8 a9 a10 a11
STILL IMAGE RECORDING INSTRUCTION
on
off
POST-PROCESSING START OPERATION PERIOD
tc
TARGET PERIOD
ta
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 20

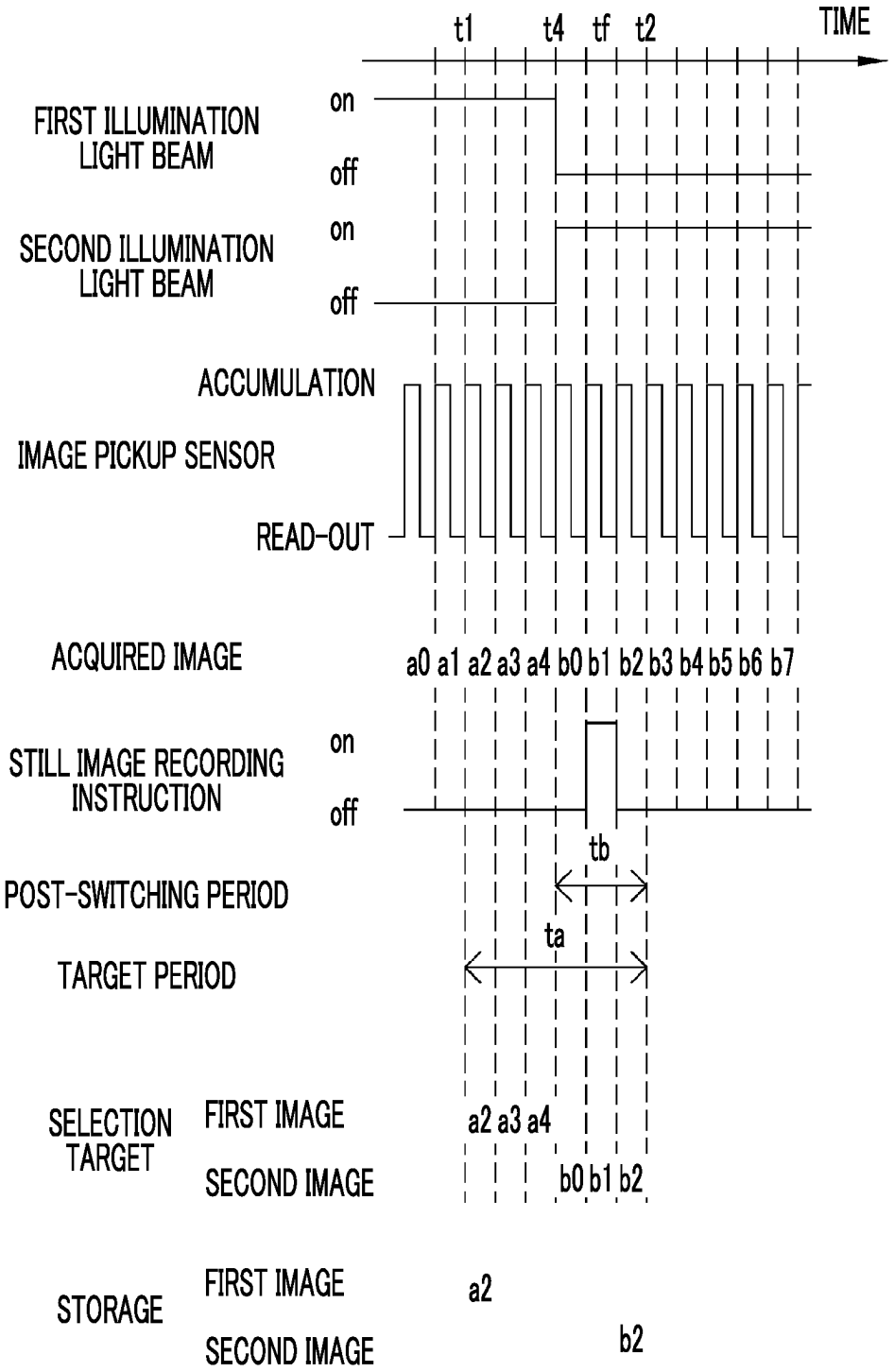

t1
t4
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 b3 b4 b5 b6 b7
STILL IMAGE RECORDING INSTRUCTION
on
off
tb
POST-SWITCHING PERIOD
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 21

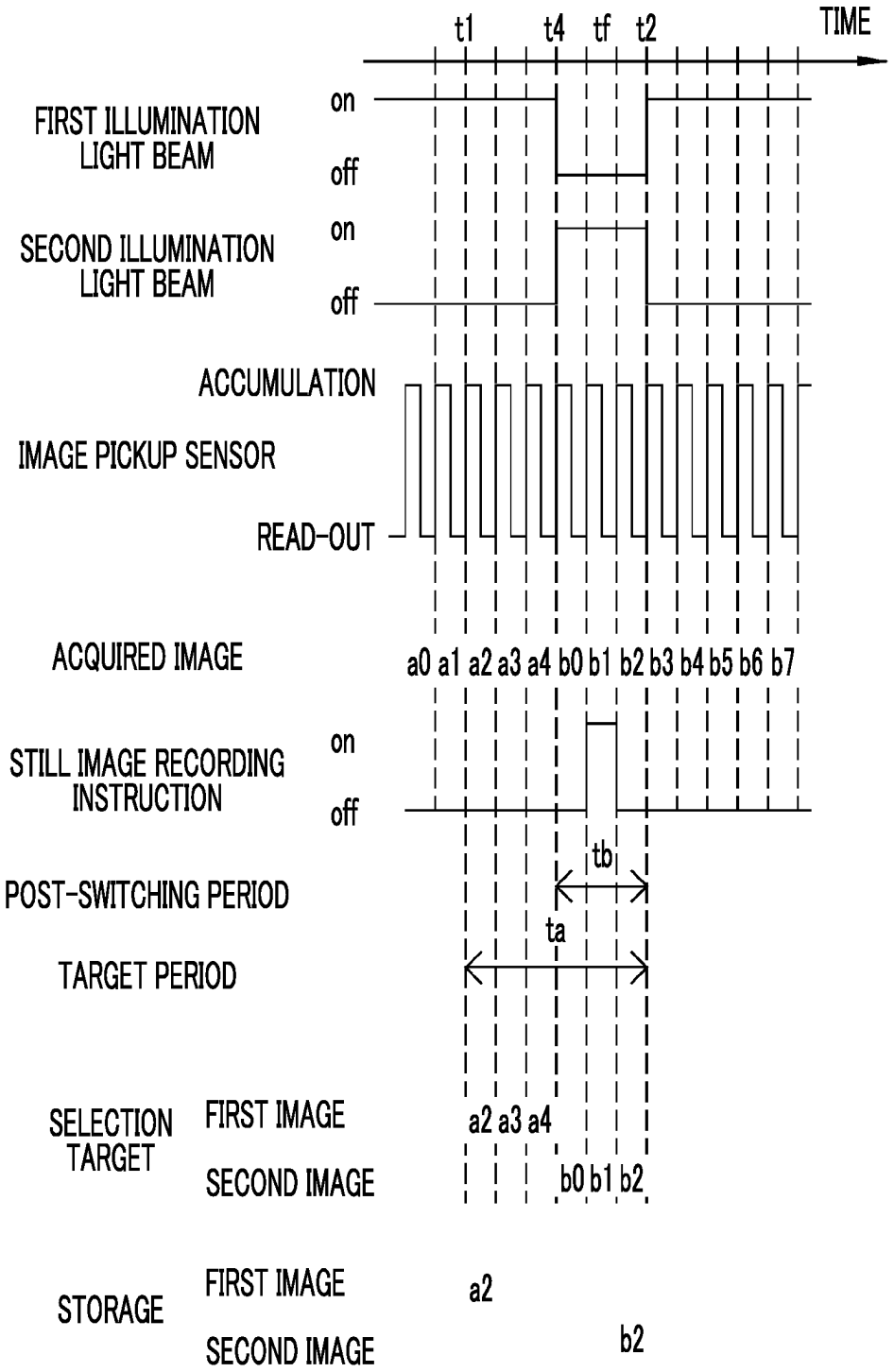

t1
t4
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 b3 b4 b5 b6 b7
STILL IMAGE RECORDING INSTRUCTION
on
off
tb
POST-SWITCHING PERIOD
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 22

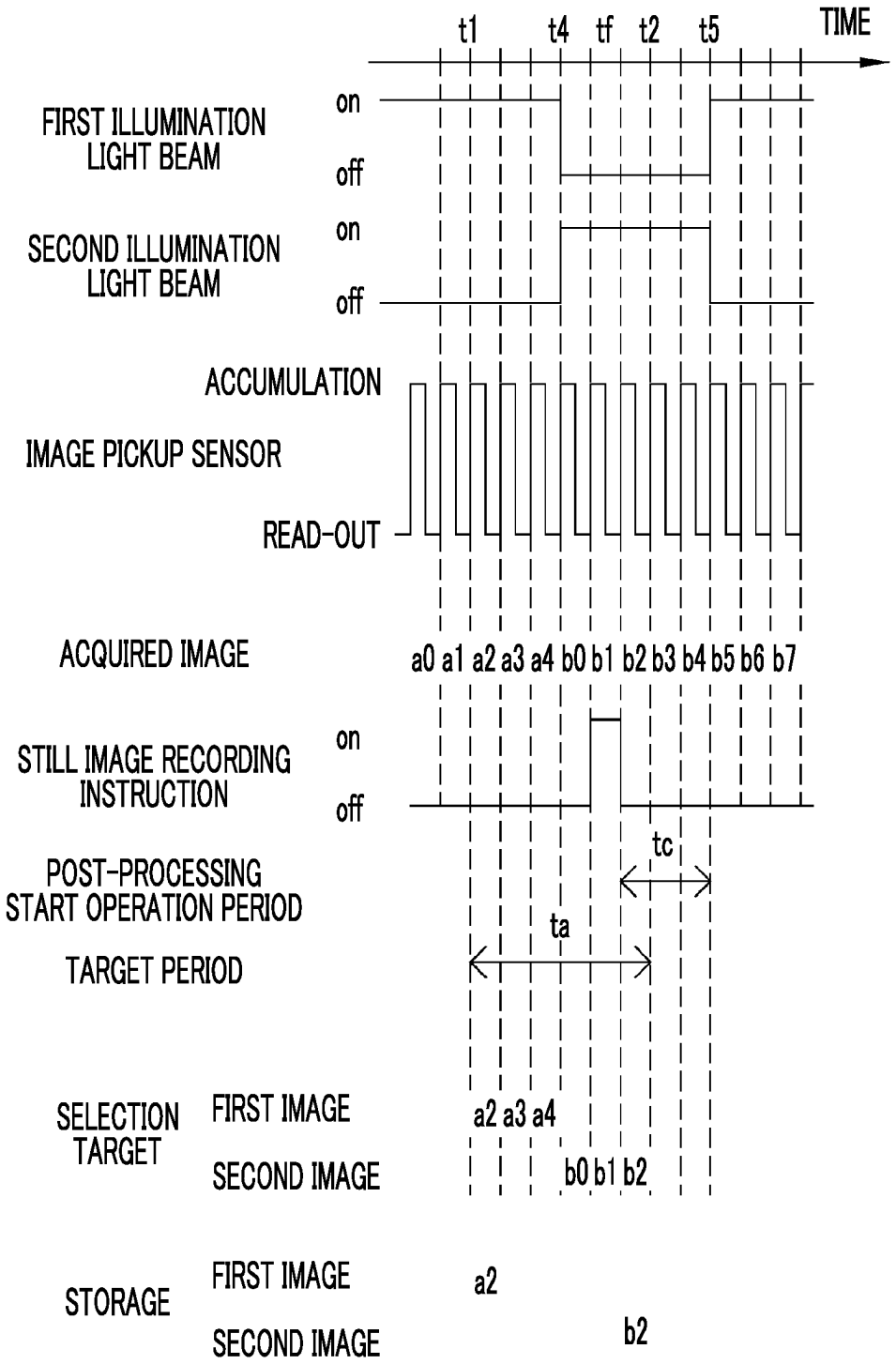

t1
t4
tf
t2
t5
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 b3 b4 b5 b6 b7
STILL IMAGE RECORDING INSTRUCTION
on
off
tc
POST-PROCESSING START OPERATION PERIOD
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 23

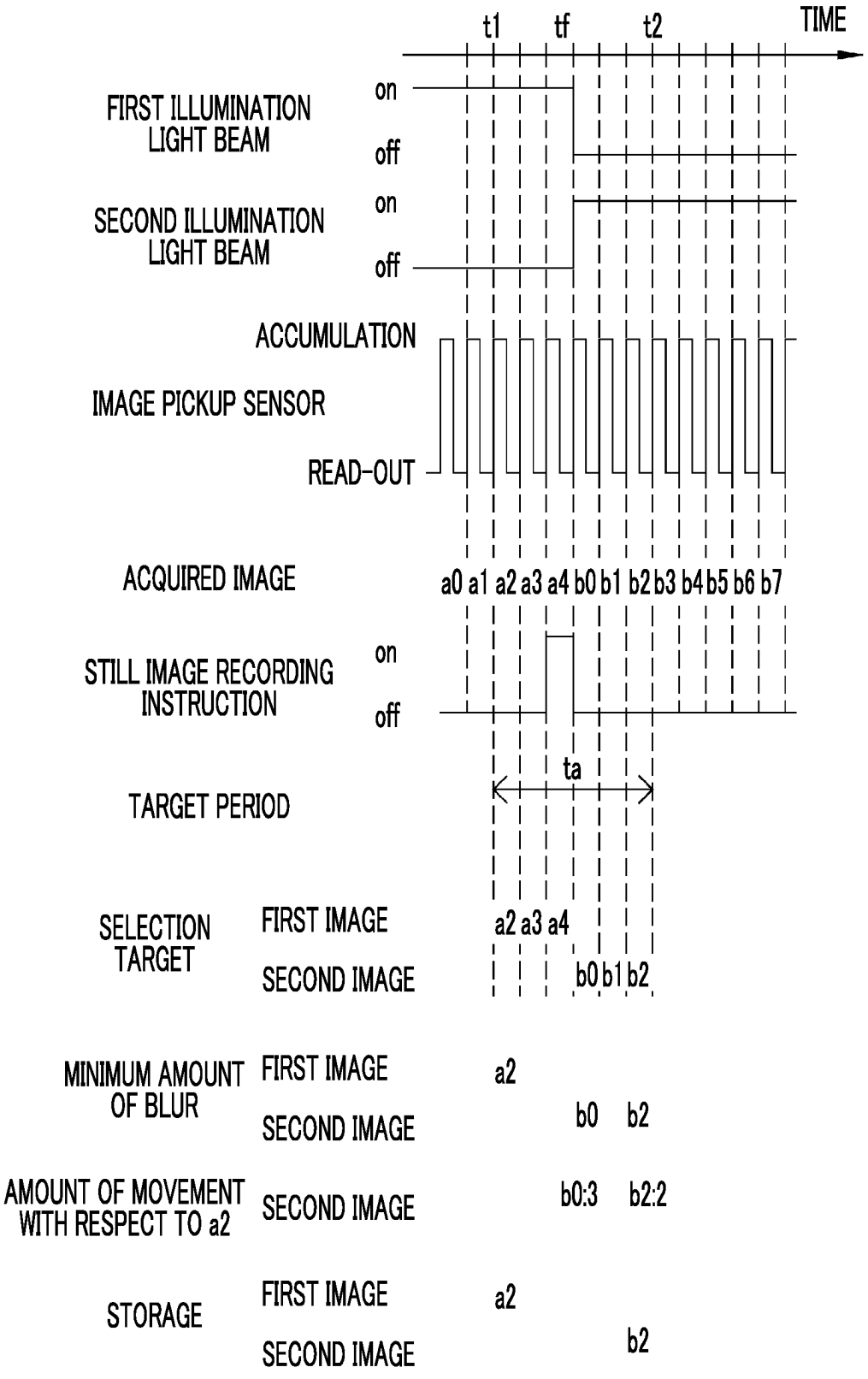

t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 b3 b4 b5 b6 b7
STILL IMAGE RECORDING INSTRUCTION
on
off
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
MINIMUM AMOUNT OF BLUR
FIRST IMAGE
a2
SECOND IMAGE
b0 b2
AMOUNT OF MOVEMENT WITH RESPECT TO a2
SECOND IMAGE
b0:3 b2:2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2

FIG. 24

71

IMAGE (AMOUNT OF BLUR)	a2 (3)		a3 (2)		a4 (4)	
	AMOUNT OF BLUR, AMOUNT OF MOVEMENT	TOTAL	AMOUNT OF BLUR, AMOUNT OF MOVEMENT	TOTAL	AMOUNT OF BLUR, AMOUNT OF MOVEMENT	TOTAL
b0 (2)	5, 3	8	4, 6	10	6, 7	13
b1 (3)	6, 4	10	5, 7	12	7, 8	15
b2 (1)	4, 2	6	3, 6	9	5, 7	12

FIG. 25

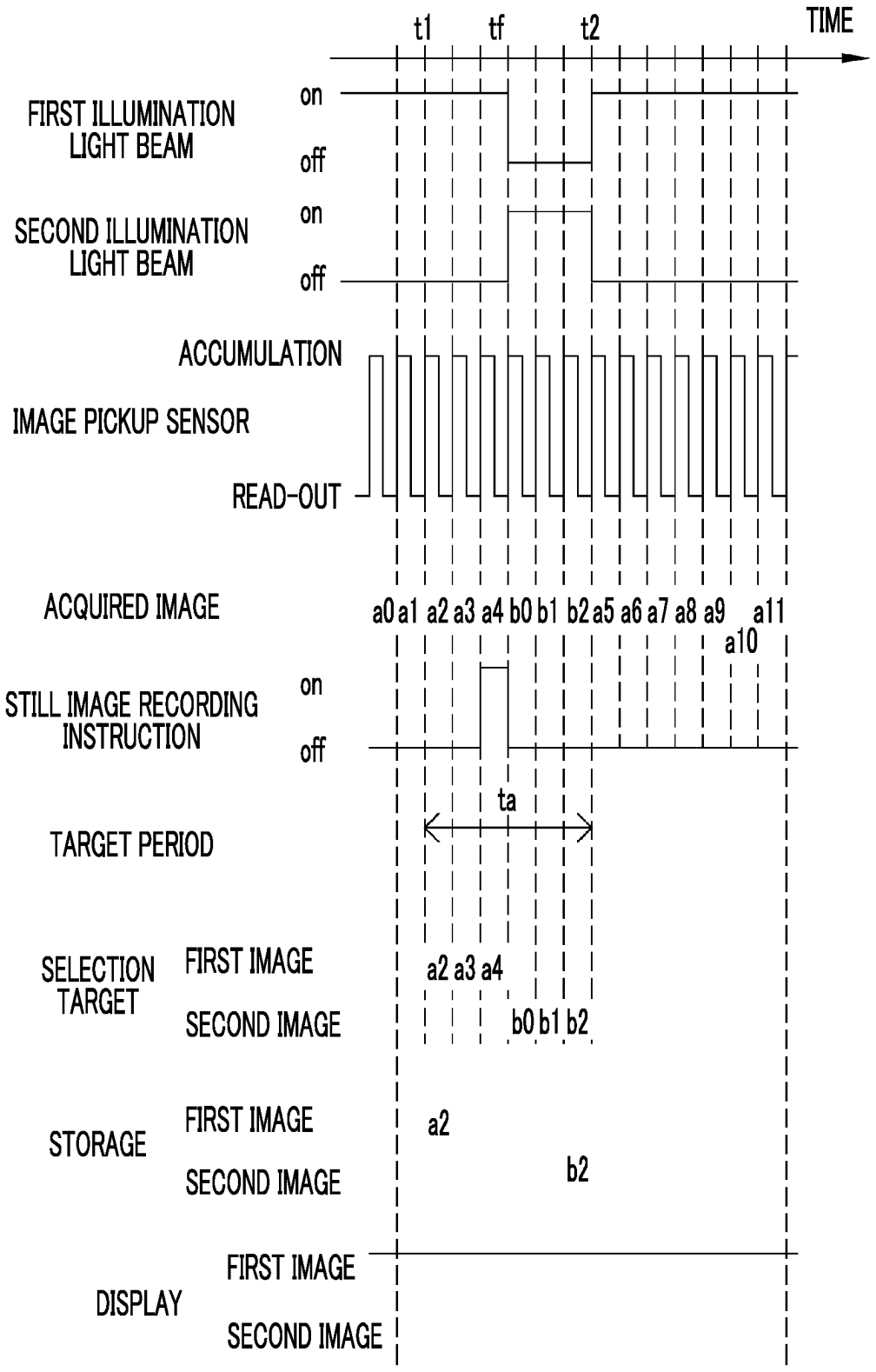

t1
tf
t2
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 a5 a6 a7 a8 a9 a10 a11
STILL IMAGE RECORDING INSTRUCTION
on
off
ta
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
SECOND IMAGE
b0 b1 b2
STORAGE
FIRST IMAGE
a2
SECOND IMAGE
b2
DISPLAY
FIRST IMAGE
SECOND IMAGE

FIG. 26

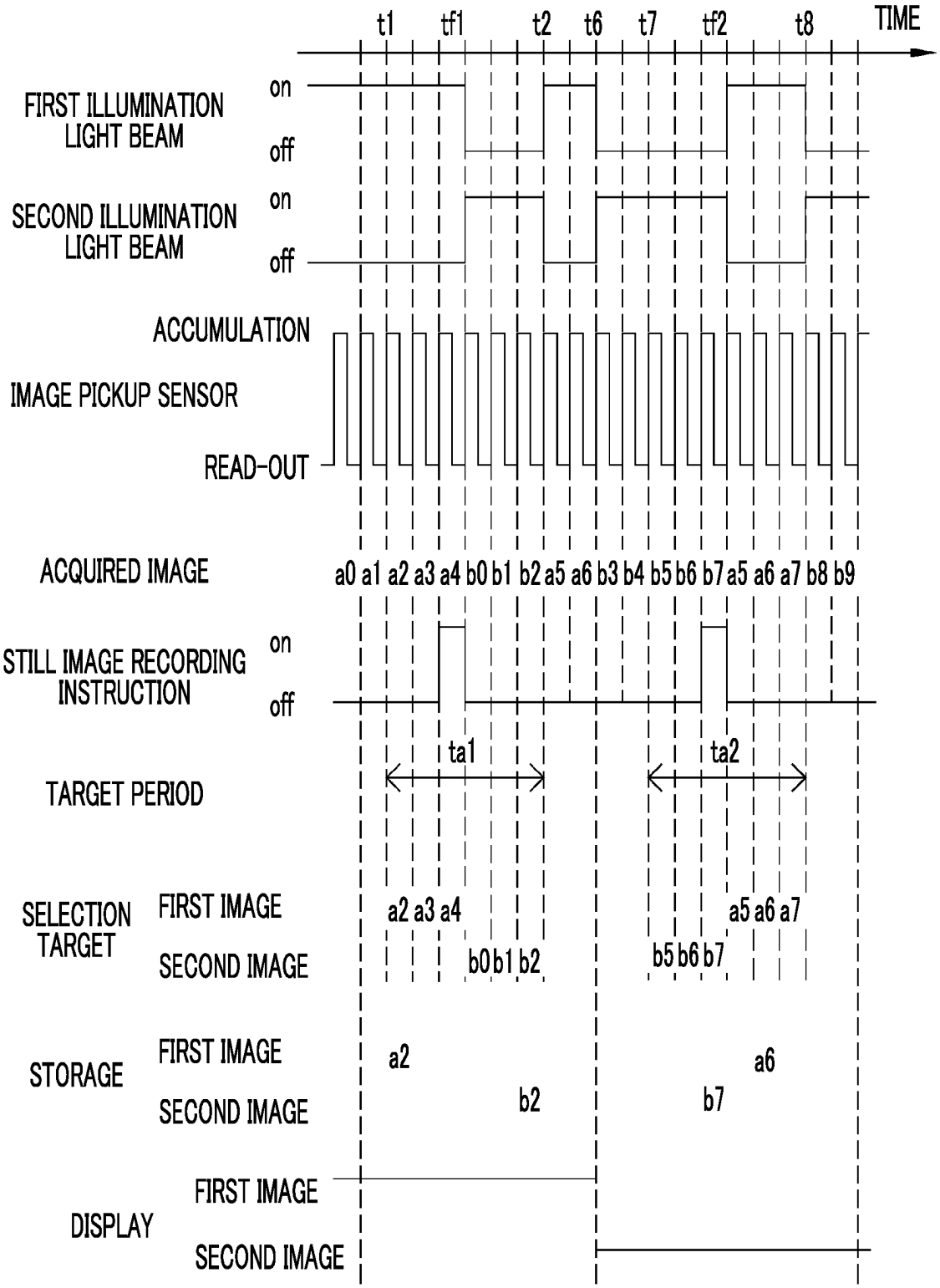
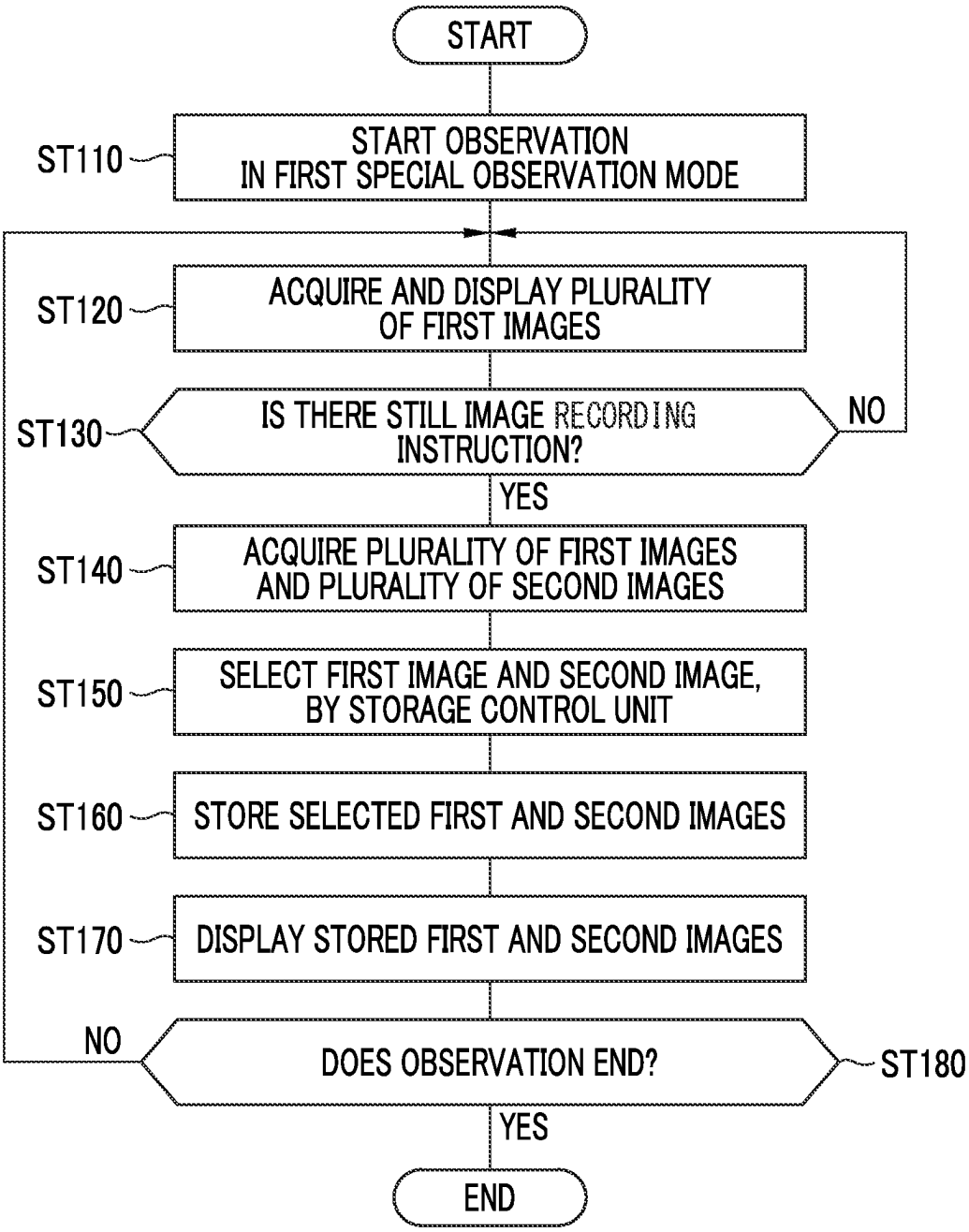

t1
tf1
t2
t6
t7
tf2
t8
TIME
FIRST ILLUMINATION LIGHT BEAM
on
off
SECOND ILLUMINATION LIGHT BEAM
on
off
ACCUMULATION
IMAGE PICKUP SENSOR
READ-OUT
ACQUIRED IMAGE
a0 a1 a2 a3 a4 b0 b1 b2 a5 a6 b3 b4 b5 b6 b7 a5 a6 a7 b8 b9
STILL IMAGE RECORDING INSTRUCTION
on
off
ta1
ta2
TARGET PERIOD
SELECTION TARGET
FIRST IMAGE
a2 a3 a4
a5 a6 a7
SECOND IMAGE
b0 b1 b2
b5 b6 b7
STORAGE
FIRST IMAGE
a2
a6
SECOND IMAGE
b2
b7
DISPLAY
FIRST IMAGE
SECOND IMAGE

FIG. 27


START
ST110
START OBSERVATION IN FIRST SPECIAL OBSERVATION MODE
ST120
ACQUIRE AND DISPLAY PLURALITY OF FIRST IMAGES
ST130
IS THERE STILL IMAGE RECORDING INSTRUCTION?
NO
YES
ST140
ACQUIRE PLURALITY OF FIRST IMAGES AND PLURALITY OF SECOND IMAGES
ST150
SELECT FIRST IMAGE AND SECOND IMAGE, BY STORAGE CONTROL UNIT
ST160
STORE SELECTED FIRST AND SECOND IMAGES
ST170
DISPLAY STORED FIRST AND SECOND IMAGES
NO
DOES OBSERVATION END?
ST180
YES
END

ENDOSCOPE SYSTEM AND METHOD OF OPERATING ENDOSCOPE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of PCT International Application No. PCT/JP2021/005938 filed on 17 Feb. 2021, which claims priority under 35 U.S.C § 119(a) to Japanese Patent Application No. 2020-044552 filed on 13 Mar. 2020. The above application is hereby expressly incorporated by reference, in its entirety, into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an endoscope system that stores a plurality of types of still images through an instruction, and a method of operating the endoscope system.

2. Description of the Related Art

In the medical field, a diagnosis using an endoscope system, which comprises a light source device, an endoscope, and a processor device, has been widely performed. In the diagnosis using the endoscope system, various types of information regarding a surface structure of an observation target, a mucous membrane surface layer, or the like may be obtained by using an image (hereinafter, referred to as an endoscopic image) obtained by imaging the observation target with the endoscope through image-enhanced observation (IEE, image enhanced endoscopy) in which an illumination light beam or the like is devised.

In the diagnosis using IEE, an appropriate diagnosis may be made by acquiring a plurality of types of endoscopic images obtained by a plurality of types of illumination light beams and the like, and comparing in detail or superimposing these endoscopic images. As an endoscope system that uses a plurality of types of images including a normal image obtained through white light observation, an image obtained through IEE, and the like, an endoscope system in which an oxygen saturation observation moving image, a normal observation moving image, and a blood vessel-enhanced observation moving image are juxtaposed and displayed on a display device, and an exposure condition is set and then each observation moving image is stored as a still image in a case where a freeze button is operated while the moving images are displayed, and the like are disclosed (JP2013-188364A, corresponding to US2013/0245411A1).

SUMMARY OF THE INVENTION

In the related art, a plurality of types of still images having less blur is selected and stored, for example, at a point in time back to the past by a certain period from a point in time when an instruction to store the still image is given by the operation of the freeze button while the moving image is displayed. In a plurality of types of illumination light beams, for example, two types of images are compared: an image using the illumination light beam that is used to enhance superficial blood vessels or the like of the observation target and an image using the illumination light beam that is used to enhance medium-depth blood vessels or the like of the same observation target so that information on the depth direction of the observation target can be obtained, which is effective, for example, in a case where a diagnosis on the extent of a lesion is performed.

In order to store a plurality of types of still images corresponding to a plurality of types of illumination light beams, for example, as in the related art, the illumination light beams are switched and the still image is stored for each illumination light beam, whereby various still images are stored. In a case where an observation target is observed and an image thereof is picked up while the plurality of illumination light beams is repeatedly switched, it is preferable that the switching cycle between the illumination light beams used for observation is as long as possible because of problems, such as photosensitivity. However, in this case, it is necessary to select an image of an illumination light beam that is not used for observation when a still image recording instruction is given, and the longer the switching cycle between the illumination light beams is, the larger the difference in time between the plurality of types of stored images is. Since the larger the difference in time between the plurality of types of stored images is, the higher the probability that the positional deviation between the images may occur significantly is due to the motion of the observation target and the like, there is a concern that still images unsuitable for comparison or superimposition may be stored.

On the other hand, in order to reduce the difference in time between the plurality of types of stored images, it is conceivable to reduce the switching cycle between the plurality of illumination light beams to shorten the illumination time of each illumination light beam. However, there is a concern that this method may cause problems, such as light flicker or photosensitivity, which is a trade-off with the difference in time between images.

Further, in JP2013-188364A, in addition to the above, a plurality of illumination light beams is automatically switched in a predetermined order, and moving images corresponding to the respective illumination light beams are simultaneously displayed on a monitor. In this case, a frame rate in a case of one type of illumination light beam is equal to or less than half that of a case where illumination light beams are not switched, and it may be difficult to diagnose, for example, the observation target that may move, through comparison or superimposition between the plurality of types of images.

An object of the present invention is to provide an endoscope system that stores a plurality of types of still images in a state suitable for comparison or superimposition, through a single instruction, and a method of operating the endoscope system.

According to the present invention, there is provided an endoscope system comprising: a plurality of semiconductor light sources that emits light beams having wavelength bands different from each other; a light source processor that performs control to emit each of a plurality of types of illumination light beams of which combinations of light intensity ratios between the plurality of semiconductor light sources are different from each other; and an image processor. The image processor acquires a first image and a second image obtained by imaging an observation target illuminated with a first illumination light beam and a second illumination light beam included in the plurality of types of illumination light beams, respectively, for each frame, performs image storage processing of storing a first image selected from a plurality of the acquired first images and a second image selected from a plurality of the acquired second images, and selects, when a processing start operation for starting the image storage processing is performed, a first image and a second image that satisfy a preset selection

condition from the plurality of first images and the plurality of second images acquired in a target period including a time when the processing start operation is performed, for the image storage processing. The light source processor switches, out of the first illumination light beam and the second illumination light beam, one being emitted to the other to emit the other in the target period.

It is preferable that the target period is a period in which the image processor acquires a plurality of the first images which is a preset number and a plurality of the second images which is a preset number.

It is preferable that the target period is a period in which the image processor acquires the first image and the second image that satisfy the selection condition.

It is preferable that the light source processor alternately switches and emits the first illumination light beam and the second illumination light beam at a preset cycle.

It is preferable that the light source processor switches, out of the first illumination light beam and the second illumination light beam, one which is emitted before the processing start operation to the other to emit the other, through the processing start operation, in a case where the processing start operation is performed after a preset period starting from a time when light emission is switched between the first illumination light beam and the second illumination light beam. It is preferable that the light source processor switches, out of the first illumination light beam and the second illumination light beam, one which is emitted after the processing start operation to the other to emit the other, when the target period is passed. It is preferable that the light source processor switches, out of the first illumination light beam and the second illumination light beam, one which is emitted after the processing start operation to the other to emit the other, when a preset period starting from the time of the processing start operation is passed.

It is preferable that the light source processor emits, out of the first illumination light beam and the second illumination light beam, one which is emitted before the processing start operation even after the processing start operation, in a case where the processing start operation is performed in a preset period starting from a time when light emission is switched between the first illumination light beam and the second illumination light beam. It is preferable that the light source processor switches, out of the first illumination light beam and the second illumination light beam, one which is emitted at the time of the processing start operation to the other to emit the other, when the preset period starting from the time when the light emission is switched between the first illumination light beam and the second illumination light beam is passed. It is preferable that the light source processor switches, out of the first illumination light beam and the second illumination light beam, one which is emitted at the time of the processing start operation to the other to emit the other, when a preset period starting from the time of the processing start operation is passed.

It is preferable that the image processor sets the selection condition that a first image having least blur out of the plurality of acquired first images or a second image having least blur out of the plurality of acquired second images is selected.

It is preferable that the image processor sets the selection condition that a first image and a second image having smallest positional deviation between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected.

It is preferable that the image processor sets the selection condition that a first image and a second image having a smallest difference in brightness between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected.

It is preferable that the image processor sets the selection condition that a first image and a second image having a smallest difference in acquisition time between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected.

It is preferable that a display that displays the first image and/or the second image is further provided and the image processor displays the stored first image and/or the stored second image on the display in the target period.

According to the present invention, there is provided a method of operating an endoscope system including a plurality of semiconductor light sources that emits light beams having wavelength bands different from each other, a light source processor that performs control to emit each of a plurality of types of illumination light beams of which combinations of light intensity ratios between the plurality of semiconductor light sources are different from each other, and an image processor. The method comprises: acquiring, by the image processor, a first image and a second image obtained by imaging an observation target illuminated with a first illumination light beam and a second illumination light beam included in the plurality of types of illumination light beams, respectively, for each frame; performing, by the image processor, image storage processing of storing a first image selected from a plurality of the acquired first images and a second image selected from a plurality of the acquired second images; and selecting, by the image processor, when a processing start operation for starting the image storage processing is performed, a first image and a second image that satisfy a preset selection condition from the plurality of first images and the plurality of second images acquired in a target period including a time when the processing start operation is performed, for the image storage processing; and switching, by the light source processor, out of the first illumination light beam and the second illumination light beam, one being emitted to the other to emit the other in the target period.

According to the present invention, it is possible to store a plurality of types of still images in a state suitable for comparison or superimposition, through a single instruction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an external view of an endoscope system.

FIG. **2** is an external view of an operation part of an endoscope.

FIG. **3** is a block diagram showing a function of the endoscope system.

FIG. **4** is a diagram illustrating four-color LEDs provided in a light source unit.

FIG. **5** is a graph showing spectra of violet light V, blue light B, green light G, and red light R.

FIG. **6** is a graph showing a spectrum of a first illumination light beam.

FIG. **7** is a graph showing a spectrum of a second illumination light beam.

FIG. **8** is a diagram illustrating a light emission period setting menu.

FIG. **9** is an image diagram showing a first special observation image.

FIG. **10** is a diagram illustrating a violet and blue light image and a green and red light image that are obtained in a case where an observation target is illuminated with the first illumination light beam.

FIG. **11** is an image diagram showing a second special observation image.

FIG. **12** is a diagram illustrating a violet and blue light image and a green and red light image that are obtained in a case where an observation target is illuminated with the second illumination light beam.

FIG. **13** is a diagram illustrating an example of storage of a still image in the first special observation mode.

FIG. **14** is a diagram illustrating another example of the storage of the still image in the first special observation mode.

FIG. **15** is a graph showing a spectrum of a third illumination light beam.

FIG. **16** is a graph showing a spectrum of a fourth illumination light beam.

FIG. **17** is a diagram illustrating an example of storage of a still image in a case where a processing start operation is performed after a post-switching period.

FIG. **18** is a diagram illustrating an example of storage of a still image in a case of performing light emission by switching between illumination light beams when a target period is passed.

FIG. **19** is a diagram illustrating an example of storage of a still image in a case of performing light emission by switching between illumination light beams when a post-processing start operation period is passed.

FIG. **20** is a diagram illustrating an example of storage of a still image in a case where the processing start operation is performed in the post-switching period.

FIG. **21** is a diagram illustrating an example of a case of performing light emission by switching an illumination light beam to the first illumination light beam which is emitted before switching between illumination light beams, after the post-switching period is passed.

FIG. **22** is a diagram illustrating another example of the case of performing light emission by switching an illumination light beam to the first illumination light beam which is emitted before switching between illumination light beams, after the post-processing start operation period is passed.

FIG. **23** is a diagram illustrating a selection condition and a stored endoscopic image.

FIG. **24** is a table illustrating the selection condition and the stored endoscopic image.

FIG. **25** is a diagram illustrating an example of selection of an image to be displayed on a display.

FIG. **26** is a diagram illustrating another example of the selection of an image to be displayed on the display.

FIG. **27** is a flowchart showing a series of flows of storage of the still image in the first special observation mode.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1**, an endoscope system **10** includes an endoscope **12**, a light source device **14**, a processor device **16**, a display **18**, and a keyboard **19**. The endoscope **12** is optically connected to the light source device **14** and is electrically connected to the processor device **16**. The endoscope **12** includes an insertion part **12***a* inserted into a body of a subject to be examined having an observation target, an operation part **12***b* provided at the proximal end portion of the insertion part **12***a*, and a bendable portion **12***c* and a distal end portion **12***d* that are provided in the insertion part **12***a* on the distal end side. The bendable portion **12***c* is bent by the operation of an angle knob **12***e* (see FIG. **2**) of the operation part **12***b*. The bendable portion **12***c* is bent so that the distal end portion **12***d* faces a desired direction.

As shown in FIG. **2**, the operation part **12***b* includes a mode changeover switch **12***g* used for an observation mode switching operation, a zoom operation portion **12***h* that is used to change an image pickup magnification, and a still image recording instruction portion **12***f* through which a still image recording instruction is given, in addition to the angle knob **12***e*. An operation or an instruction using the keyboard **19**, a foot switch (not shown), or the like, in addition to the mode changeover switch **12***g* or a scope switch of the still image recording instruction portion **12***f*, may be used for the observation mode switching operation, the zoom operation, or the still image recording instruction.

The endoscope system **10** has three modes, that is, a normal observation mode, a special observation mode, and a multi-observation mode. The normal observation mode is a mode for displaying a normal observation image (hereinafter, referred to as a normal image), which is an image with natural color tones obtained by picking up an image of the observation target using white light as an illumination light beam, on the display **18**. The special observation mode includes a first special observation mode and a second special observation mode. The first special observation mode is a mode for displaying a first special observation image (hereinafter, referred to as a first image) in which surface layer information such as a superficial blood vessel is enhanced, on the display **18**, and the second special observation mode is a mode for displaying a second special observation image (hereinafter, referred to as a second image) in which deep layer information such as a deep blood vessel is enhanced, on the display **18**. The multi-observation mode is a mode for automatically switching between the first special observation mode and the second special observation mode.

The processor device **16** is electrically connected to the display **18** and the keyboard **19**. The display **18** outputs and displays, for example, the normal image, the first image, the second image, and/or accessory information on these images. The keyboard **19** functions as a user interface that receives an input operation, such as function settings. An external recording unit (not shown) that records images, image information, or the like may be connected to the processor device **16**.

In FIG. **3**, the light source device **14** emits illumination light beams with which the observation target is irradiated, and comprises a light source unit **20** and a light source processor **21** that controls the light source unit **20**. The light source unit **20** is composed of, for example, a semiconductor light source, such as a multi-color light emitting diode (LED), a combination of a laser diode and a phosphor, or a xenon lamp or halogen light source. In addition, the light source unit **20** includes, for example, an optical filter that is used to adjust the wavelength band of a light beam emitted by the LED or the like. The light source processor **21** turns on/off each LED or the like or adjusts the drive current and drive voltage of each LED or the like, thereby controlling the amount of the illumination light beam. Further, the light source processor **21** controls the wavelength band of the illumination light beam by changing the optical filter or the like.

As shown in FIG. **4**, in the present embodiment, the light source unit **20** has four-color LEDs, that is, a violet light emitting diode (V-LED) **20***a*, a blue light emitting diode

(B-LED) **20***b*, a green light emitting diode (G-LED) **20***c*, and a red light emitting diode (R-LED) **20***d*.

As shown in FIG. **5**, the V-LED **20***a* generates violet light V having a central wavelength of 410±10 nm and a wavelength range of 380 to 420 nm. The B-LED **20***b* generates blue light B having a central wavelength of 450±10 nm and a wavelength range of 420 to 500 nm. The G-LED **20***c* generates green light G having a wavelength range of 480 to 600 nm. The R-LED **20***d* generates red light R having a central wavelength of 620 to 630 nm and a wavelength range of 600 to 650 nm.

The light source processor **21** controls the V-LED **20***a*, the B-LED **20***b*, the G-LED **20***c*, and the R-LED **20***d*. The light source processor **21** controls the respective LEDs **20***a* to **20***d* such that a normal light beam of which the combination of light intensity ratios between violet light V, blue light B, green light G, and red light R is Vc:Bc:Gc:Rc is emitted in the normal observation mode.

The light source processor **21** controls the respective LEDs **20***a* to **20***d* such that a first illumination light beam of which the combination of the light intensity ratios between violet light V, blue light B, green light G, and red light R is Vs1:Bs1:Gs1:Rs1 is emitted in a case where the first special observation mode is set. It is preferable that the first illumination light beam enhances superficial blood vessels. For this purpose, it is preferable that the light intensity of violet light V of the first illumination light beam is set to be higher than the light intensity of blue light B. For example, as shown in FIG. **6**, a ratio of the light intensity Vs1 of violet light V to the light intensity Bs1 of blue light B is set to "4:1".

In the present specification, the combination of the light intensity ratios includes a case where the ratio of at least one semiconductor light source is zero. Therefore, the combination of the light intensity ratios includes a case where any one or two or more of the semiconductor light sources are not turned on. For example, a case where only one semiconductor light source is turned on and the other three semiconductor light sources are not turned on as in a case where the combination of the light intensity ratios between violet light V, blue light B, green light G, and red light R is 1:0:0:0 is also regarded that the light source unit **20** has light intensity ratios, and is one of the combinations of the light intensity ratios.

The light source processor **21** controls the respective LEDs **20***a* to **20***d* such that a second illumination light beam of which the combination of the light intensity ratios between violet light V, blue light B, green light G, and red light R is Vs2:Bs2:Gs2:Rs2 is emitted in a case where the second special observation mode is set. It is preferable that the second illumination light beam enhances deep blood vessels. For this purpose, it is preferable that the light intensity of blue light B of the second illumination light beam is set to be higher than the light intensity of the violet light V. For example, as shown in FIG. **7**, a ratio of the light intensity Vs2 of violet light V to the light intensity Bs2 of blue light B is set to "1:3".

As described above, in the normal observation mode, the first special observation mode, or the second special observation mode, the combinations of the light intensity ratios between violet light V, blue light B, green light G, and red light R, that is, the types of the illumination light beam, are different from each other. It should be noted that an observation mode using a different type of illumination light beam of which a combination of the light intensity ratios is different from the illumination light beams in these observation modes may be used.

The light source processor **21** alternately repeats specific types of illumination light beams, for example, a first period in which the first illumination light beam is continuously emitted and a second period in which the second illumination light beam is continuously emitted, in a case where the multi-observation mode is set. The light emission control performed by the light source processor **21** in the multi-observation mode will be described in detail. The first period in which the first illumination light beam is emitted is followed by the second period in which the second illumination light beam is emitted, and then the first period is repeated, and this cycle is repeated. In the present embodiment, the first period and the second period each correspond to 20 frames.

"Frame" means a unit that is used to control an image pickup sensor **45** (see FIG. **3**) that picks up the image of the observation target. For example, "one frame" means a period including at least an exposure period in which the image pickup sensor **45** is exposed to light beams emitted from the observation target and a read-out period in which image signals are read out. In the present embodiment, various types of periods, such as the first period or the second period, are each defined so as to correspond to the "frame" that is a unit of image pickup.

The first period that is the light emission period of the first illumination light beam and the second period that is the light emission period of the second illumination light beam can be appropriately changed by a light emission period setting unit **22** that is connected to the light source processor **21**. In a case where an operation for changing the light emission period is received by the operation of the keyboard **19**, the light emission period setting unit **22** displays a light emission period setting menu shown in FIG. **8** on the display **18**. The first period can be changed, for example, from 2 frames to 60 frames, and the respective light emission periods are assigned onto a slide bar **81***a*. The second period can be also changed, for example, from 2 frames to 60 frames, and the respective light emission periods are assigned onto a slide bar **81***b*.

In a case where the first period is changed, a slider **82***a* is positioned at a position on the slide bar **81***a* indicating a light emission period to be changed by the operation of the keyboard **19**, so that the first period is changed. Also in the second period, a slider **82***b* is positioned at a position on the slide bar **81***b* indicating a light emission period to be changed by the operation of the keyboard **19**, so that the second period is changed. The slide bar **81***b* is also assigned the light emission periods, for example, from 2 frames to 60 frames. In the present embodiment, in the multi-observation mode, the first period is assigned the light emission period for 20 frames through the slide bar **81***a*, and the second period is assigned the light emission period for 20 frames through the slide bar **81***b*.

Further, the light source processor **21** performs control to switch, out of the first illumination light beam and the second illumination light beam, one being emitted to the other to emit the other in a target period including a time when a processing start operation for starting image storage processing is performed, when the processing start operation is performed. Therefore, illumination light beams are switched once in the target period. For example, in a case where the image storage processing is performed in the first special observation mode, the light source processor **21** switches the first illumination light beam being emitted to the second illumination light beam during the target period. In the second special observation mode, the light source processor **21** switches the second illumination light beam

being emitted to the first illumination light beam during the target period. Further, in the multi-observation mode, the light source processor **21** switches the first illumination light beam to the second illumination light beam in a case where the first illumination light beam is being emitted, and switches the second illumination light beam to the first illumination light beam in a case where the second illumination light beam is being emitted. However, in a case where the illumination light beams are periodically switched in the target period as the multi-observation mode, the illumination light beams may not be necessarily further switched. The light source processor **21** is configured as described above, whereby a plurality of types of still images is stored through a single instruction.

A light beam emitted from each of the LEDs **20***a* to **20***d* is incident on a light guide **41** through an optical path coupling unit (not shown) that is composed of a mirror, a lens, or the like. The light guide **41** is incorporated in the endoscope **12** and a universal cord (a cord that connects the endoscope **12** to the light source device **14** and the processor device **16**). The light guide **41** propagates the light beam from the optical path coupling unit to the distal end portion **12***d* of the endoscope **12**.

The distal end portion **12***d* of the endoscope **12** is provided with an illumination optical system **30***a* and an image pickup optical system **30***b*. The illumination optical system **30***a* has an illumination lens **42**, and the observation target is irradiated with the illumination light beam propagated by the light guide **41**, through the illumination lens **42**. The image pickup optical system **30***b* has an objective lens **43**, a zoom lens **44**, and an image pickup sensor **45**. Various types of light beams, such as light reflected from the observation target, scattered light, and fluorescence, are incident on the image pickup sensor **45** through the objective lens **43** and the zoom lens **44**. With this, the image of the observation target is formed on the image pickup sensor **45**. The zoom lens **44** freely moves between the telephoto end and the wide end with the operation of the zoom operation portion **12***h*, and magnifies and reduces the observation target of which the image is formed on the image pickup sensor **45**.

The image pickup sensor **45** is a color image pickup sensor provided with any one of a red (R) color filter, a green (G) color filter, or a blue (B) color filter for each pixel, and picks up the image of the observation target to output image signals of respective RGB colors. A charge coupled device (CCD) image pickup sensor or a complementary metal-oxide semiconductor (CMOS) image pickup sensor can be used as the image pickup sensor **45**. Alternatively, a complementary color image pickup sensor provided with color filters of complementary colors, that is, cyan (C), magenta (M), yellow (Y), and green (G), may be used instead of the image pickup sensor **45** provided with color filters of the primary colors. In a case where the complementary color image pickup sensor is used, the image signals of four colors of CMYG are output. Therefore, the same RGB image signals as those of the image pickup sensor **45** can be obtained by converting the image signals of the four colors of CMYG into the image signals of the three colors of RGB through the complementary color-primary color conversion. Alternatively, a monochrome image pickup sensor that is not provided with color filters may be used instead of the image pickup sensor **45**.

The image pickup sensor **45** is driven and controlled by an image pickup control unit (not shown). The image pickup control unit is controlled by a central control unit **59** (see FIG. **3**). The control performed by the image pickup control unit differs depending on the respective modes. In the normal observation mode, the image pickup control unit controls the image pickup sensor **45** to pick up the image of the observation target illuminated with the normal light beam. With this, Bc image signals are output from B pixels of the image pickup sensor **45**, Gc image signals are output from G pixels thereof, and Rc image signals are output from R pixels thereof. In the special observation mode or the multi-observation mode, the image pickup control unit controls the image pickup sensor **45** to pick up the image of the observation target illuminated with a special light beam. With this, in the first special observation mode, Bs1 image signals are output from the B pixels of the image pickup sensor **45**, Gs1 image signals are output from the G pixels thereof, and Rs1 image signals are output from the R pixels thereof. Similarly, in the second special observation mode, Bs2 image signals are output from the B pixels of the image pickup sensor **45**, Gs2 image signals are output from the G pixels thereof, and Rs2 image signals are output from the R pixels thereof.

A correlated double sampling/automatic gain control (CDS/AGC) circuit **46** performs correlated double sampling (CDS) or automatic gain control (AGC) on the analog image signals obtained from the image pickup sensor **45**. The image signals that have been passed through the CDS/AGC circuit **46** are converted into digital image signals by an analog/digital (A/D) converter **47**. The digital image signals that have been subjected to A/D conversion are input to the processor device **16**.

In the processor device **16**, a program related to processing such as image storage processing is stored in a program memory (not shown). In the processor device **16**, the program stored in the program memory operates through the central control unit **59** composed of the image processor, whereby functions of an image signal acquisition unit **51**, a digital signal processor (DSP) **52**, a noise reduction unit **53**, a memory **54**, a signal processing unit **55**, an image storage unit **56**, a display control unit **57**, a video signal generation unit **58**, and the central control unit **59** are realized. The image storage unit **56** comprises a storage control unit **61**, a temporary storage unit **62**, and a storage unit **63**, and the program stored in the program memory operates through the central control unit **59** composed of the image processor, whereby these functions are also realized as in the above. Further, the central control unit **59** receives information input from the endoscope **12** and the light source device **14**, and controls each unit of the processor device **16** and controls the endoscope **12** or the light source device **14**, on the basis of the received information. Further, the central control unit **59** also receives information, such as an instruction input from the keyboard **19**.

The image signal acquisition unit **51**, which is an image acquisition unit, acquires the digital image signals of an endoscopic image, which are input from the endoscope **12**. The image signal acquisition unit **51** acquires image signals obtained by imaging the observation target illuminated with each illumination light beam, for each frame. The acquired image signals are transmitted to the DSP **52**. The DSP **52** performs digital signal processing, such as color correction processing, on the received image signals. The noise reduction unit **53** performs noise reduction processing, which is performed through, for example, a moving average method or median filtering method, on the image signals that have been subjected to the color correction processing and the like by the DSP **52**. The image signals with reduced noise are stored in the memory **54**.

The signal processing unit **55** acquires the noise-reduced image signals from the memory **54**. Then, signal processing,

such as color conversion processing, hue enhancement processing, and structure enhancement processing, is performed as necessary on the acquired image signals, and a color endoscopic image in which the observation target is imaged is generated.

In the normal observation mode, the signal processing unit **55** performs image processing for a normal observation mode, such as color conversion processing, hue enhancement processing, and structure enhancement processing, on the input noise-reduced image signals for one frame. The image signals that have been subjected to the image processing for a normal observation mode are input to the image storage unit **56** as a normal image.

In the special observation mode or the multi-observation mode, the signal processing unit **55** performs image processing for a first special observation mode or for a second special observation mode, such as color conversion processing, hue enhancement processing, and structure enhancement processing, on the noise-reduced image signals for one frame input in the first special observation mode or the second special observation mode. The image signals that have been subjected to the image processing for a first special observation mode or for a second special observation mode are input to the image storage unit **56** as the first image or the second image.

Since the endoscopic image generated by the signal processing unit **55** is a normal observation image in a case where the observation mode is the normal observation mode and the endoscopic image generated by the signal processing unit **55** is a special observation image in a case where the observation mode is the special observation mode, the contents of the color conversion processing, the hue enhancement processing, and the structure enhancement processing differ depending on the observation modes. In the case of the normal observation mode, the signal processing unit **55** generates the normal observation image by performing the above various types of signal processing for making the observation target have natural color tones. In the case of the special observation mode, the signal processing unit **55** generates the special observation image including the first image and the second image by performing the above various types of signal processing for enhancing, for example, the blood vessels of the observation target.

The semiconductor light sources include a first semiconductor light source that emits violet light V (first narrow-band light beam) having a wavelength band of which the central wavelength is 410±10 nm and the wavelength range is 420 to 500 nm, and a second semiconductor light source that emits blue light B (second narrow-band light beam) having a wavelength band of which the central wavelength is 450±10 nm and the wavelength range is 380 to 420 nm. Therefore, in the special observation image generated by the signal processing unit **55**, blood vessels (so-called superficial blood vessels) or blood located at a relatively shallow position in the observation target with a surface of the mucous membrane as a reference has magenta-based color (for example, brown color) in the first image, and blood vessels (so-called medium-depth blood vessels) located at a relatively deep position in the observation target with the surface of the mucous membrane as a reference have cyan-based color (for example, green color) in the second image. Therefore, the blood vessels or hemorrhage (blood) of the observation target is enhanced by a difference in color with respect to the mucous membrane represented by pink-based color.

As shown in FIG. **9**, an image in which a background mucous membrane BM and superficial blood vessels VS**1**, out of the observation targets, are shown is displayed in the first image. The first image is obtained on the basis of the first illumination light beam including violet light, blue light, green light, and red light. As shown in FIG. **10**, in a case where the observation target is illuminated with the first illumination light beam, violet light V and blue light B of the first illumination light beam reach a surface layer where the superficial blood vessels VS**1** are distributed. Accordingly, a violet light image VP obtained on the basis of the reflected light of violet light V and blue light B includes an image of the superficial blood vessels VS**1**. Here, since the light intensity of violet light V is higher than the light intensity of blue light B, the image obtained on the basis of the reflected light of violet light V and blue light B is referred to as a violet light image VP. Further, green light G and red light R of the first illumination light beam reach the background mucous membrane BM that is distributed at a position deeper than the positions of the superficial blood vessels VS**1** and deep blood vessels VS**2** (blood vessels located at positions deeper than the positions of the superficial blood vessels VS**1**). Accordingly, a green and red light image GRP obtained on the basis of the reflected light of green light G and red light R includes an image of the background mucous membrane BM. As described above, since the first image is an image in which the violet light image VP and the green and red light image GRP are combined with each other, the image of the background mucous membrane BM and the superficial blood vessels VS**1** is displayed.

As shown in FIG. **11**, an image in which the background mucous membrane BM and deep blood vessels VS**2**, out of the observation targets, are shown is displayed in the second image. The second image is obtained on the basis of the second illumination light beam including violet light, blue light, green light, and red light. As shown in FIG. **12**, in a case where the observation target is illuminated with the second illumination light beam, violet light V and blue light B of the second illumination light beam reach a deep layer where the deep blood vessels VS**2** are distributed. Accordingly, a blue light image BP obtained on the basis of the reflected light of violet light V and blue light B includes an image of the deep blood vessels VS**2**. Here, since the light intensity of blue light B is higher than the light intensity of violet light V, the image obtained on the basis of the reflected light of violet light V and blue light B is referred to as a blue light image BP. Further, green light G and red light R of the second illumination light beam reach the background mucous membrane BM that is distributed at a position deeper than the positions of the superficial blood vessels VS**1** and the deep blood vessels VS**2** (blood vessels located at positions deeper than the positions of the superficial blood vessels VS**1**). Accordingly, a green and red light image GRP obtained on the basis of the reflected light of green light G and red light R includes an image of the background mucous membrane BM. As described above, since the second image is an image in which the blue light image BP and the green and red light image GRP are combined with each other, the image of the background mucous membrane BM and the deep blood vessels VS**2** is displayed.

The image storage unit **56** performs image storage processing. The image storage processing is processing of storing an image, and processing of, for example, storing a first image and a second image selected from a plurality of the first images acquired by the image signal acquisition unit **51** and a plurality of the second images acquired by the image signal acquisition unit **51**, respectively.

The storage control unit **61** controls the image storage processing. Specifically, when the processing start operation

for starting the image storage processing is performed, the storage control unit **61** selects a first image and a second image that satisfy a preset selection condition from the plurality of first images and the plurality of second images acquired in the target period that is set so as to include the time when the processing start operation is performed, in order to store the first image and the second image in the storage unit **63**, respectively.

The processing start operation in the image storage processing is, for example, a still image recording instruction (freeze instruction or release instruction) operation through the still image recording instruction portion **12***f*. In a case where the still image recording instruction is input by the operation of the still image recording instruction portion **12***f*, the processing start operation is performed and the image storage processing or the like is started, through the central control unit **59**. The image storage unit **56** stores endoscopic images such as the first image and the second image selected by the preset selection condition in the storage unit **63** or a storage (not shown), under the control performed by the storage control unit **61**. The storage is an external storage device connected to the processor device **16** through a local area network (LAN) or the like, and is, for example, a file server of a system for filing an endoscopic image, such as a picture archiving and communication system (PACS), or a network attached storage (NAS).

The target period setting performed by the storage control unit **61**, the switching control between illumination light beams performed by the light source processor **21**, and the like, in addition to the start of the image storage processing, are performed on the basis of the processing start operation. The target period is a period for deciding a target, in which the first image and the second image to be stored in the storage unit **63** are selected, and the first image and the second image to be stored in the storage unit **63** are selected from the plurality of first images and the plurality of second images acquired in this period. The target period includes the time when the processing start operation is performed. Further, the target period is preferably a period in which the image processor acquires a plurality of the first images which is a preset number and a plurality of the second images which is a preset number. As described above, the switching control between illumination light beams is a control in which the light source processor **21** switches, out of the first illumination light beam and the second illumination light beam, one being emitted to the other to emit the other in the target period.

As shown in FIG. **13**, the image storage processing is specifically performed as follows. For example, in the first special observation mode, the first illumination light beam is continuously emitted as the illumination light beam (first period). The image pickup sensor **45** acquires image signals by performing charge accumulation and read-out for each frame. The acquired image signals are temporarily stored in the temporary storage unit **62**. The temporary storage unit **62** always stores a fixed number of images set in advance. Therefore, for example, a first image a**0** in a first frame shown in FIG. **13**, a first image a**1** in the next frame, a first image a**2** in the next frame, and a first image a**3** in the next frame are continuously temporarily stored until the type of illumination light beam is switched.

Here, in a case where the still image recording instruction is given at time tf by the operation of the still image recording instruction portion **12***f*, the still image recording instruction becomes the processing start operation of the image storage processing, and the setting of a target period ta, the switching between illumination light beams, the selection of images to be stored, and the storage of the selected images are performed. In the setting of the target period ta, since the target period ta includes a time when the still image recording instruction which is the processing start operation is given, and in the case of FIG. **13**, the target period is preset to a period in which three first images and three second images are acquired, the target period is set to a period in which three first images and three second images are acquired, that is, a period of three frames for each image. Since the target period ta is a period in which both the first image and the second image can be acquired, the light source processor **21** switches, out of the first illumination light beam and the second illumination light beam, one being emitted to the other in a case where an illumination light beam being emitted is not switched in the target period ta. In the case of FIG. **13**, since the first illumination light beam is emitted in the first special observation mode, the light source processor **21** switches the first illumination light beam to the second illumination light beam in response to the still image recording instruction.

The switched second illumination light beam is continuously emitted (second period). As in the acquisition of the first image, the image pickup sensor **45** acquires image signals by performing charge accumulation and read-out for each frame. A second image b**0** in the first frame, a second image b**1** in the next frame, and a second image b**2** in the next frame are temporarily stored in the temporary storage unit **62**. Since the image signal acquisition unit **51** acquires an image for each frame, for example, a second image b**3** and a second image b**4** are continuously temporarily stored until the type of illumination light beam is switched. Since the target period ta for temporary storage is set to be a period in which three first images and three second images are acquired, the start of the target period ta is time t**1** that goes back by three frames from the time when the still image recording instruction is given, and the end point of the target period ta is time t**2** advanced by three frames from the time when the still image recording instruction is given. Specifically, the target period ta is a period from time t**1** to time t**2**, in which time tf when the still image recording instruction is given is sandwiched therebetween. At this point in time, the storage control unit **61** decides the first images a**2**, a**3**, and a**4**, and the second images b**0**, b**1**, and b**2**, as images acquired in the target period ta, and selects images to be stored in the storage unit **63**, out of these images.

The storage control unit **61** selects, out of the plurality of first images and the plurality of second images stored by the temporary storage unit **62**, a first image and a second image that satisfy the preset selection condition from the plurality of first images and the plurality of second images acquired in the target period ta, respectively. The preset selection condition is a condition that the first image and the second image to be stored are in a state suitable for comparison or superimposition. For example, the storage control unit **61** preferably sets the selection condition that a first image having the least blur out of the plurality of acquired first images or a second image having the least blur out of the plurality of acquired second images is selected.

As a method of selecting the first image having the least blur or the second image having the least blur, a known method can be used. For example, it is possible to select an image having the smallest amount of blur by calculating the amount of blur in each image. A method based on image analysis, a method based on the image pickup sensor **45**, or the like is mainly used as a method of calculating the amount of blur, and there is a method of estimating a point spread function (PSF) for each of a plurality of regions in an image

and estimating the direction and magnitude of blur from the point spread function with high accuracy, as the method based on image analysis (see JP5499050B, corresponding to U.S. Pat. No. 8,723,965B2). In addition, there is a method of detecting a movement vector from image signals and detecting the amount of blur of an image on the basis of the movement vector (see JP1991-16470A (JP-H03-16470A)). Further, a method of calculating a contrast and detecting an image having a large contrast as an image having a small amount of blur is also preferably used.

In FIG. **13**, the first image a**2** decided to have the least blur, out of the first images a**2**, a**3**, and a**4**, and the second image b**2** decided to have the least blur, out of the second images b**0**, b**1**, and b**2**, are selected. The first image a**2** and the second image b**2** selected by the storage control unit **61** are stored in the storage unit **63** by the storage control unit **61**. The image storage unit **56** uses the image signals sent from the signal processing unit **55** to perform image storage processing, and also sends the image signals to the display control unit **57** for display.

The image acquired by the image signal acquisition unit **51** or the image stored by the storage unit **63** has a time acquired as accessory information on the image, but it is preferable that the storage unit **63** stores the first image and the second image after adding information regarding the corresponding illumination light beams. In this case, it is preferable to have information, such as the type of illumination light beam, or information on the observation mode, as the accessory information. Further, for example, identification information or an identifier associated with the illumination light beam or the observation mode, such as a tag, may be added to the file name of the image. According to the above, it is possible to easily recognize at what time the acquired or stored image is the first image or the second image acquired.

The display control unit **57** performs control to display the image on the display **18**, which is a display means. For example, the display control unit **57** performs control to continuously display the normal image as a moving image on the display **18** in the normal observation mode, to continuously display the first image or the second image as a moving image on the display **18** in the special observation mode, and to automatically switch any one of the first image or the second image to continuously display the switched image as a moving image on the display **18** in the multi-observation mode. Further, in a case where the still image recording instruction is given, the display control unit **57** performs control to display the endoscopic images such as the stored first image and the stored second image, as still images, on the display **18**.

In a case where the still images such as the first image and the second image are displayed, the display control unit **57** displays the still images in a display method set according to the purpose. Examples of the display method include a method of displaying the still images side by side on the display **18**, a method of adjusting the transparency of each image to superimpose and display the still images, or a method of switching between the still images in a short time of 1 second or less on the same region of the display **18** to display the still images like an animation.

The video signal generation unit **58** converts the normal image and the special image, which are output from the display control unit **57**, or the first image and the second image, which are stored in the storage unit **63** into video signals that allow full-color display on the display **18**. The video signals that have been converted are input to the display **18**. With this, the normal image, the special image, the accessory information, or the like is displayed on the display **18**.

As described above, with the endoscope system **10** having the above configuration, the switching to the different type of illumination light beam, the selection of images for respective types of illumination light beams, and the storage of the plurality of selected images are performed by a single operation of the still image recording instruction portion **12***f*, while performing observation using the desired illumination light beam. Since selection is performed on the basis of the preset selection condition, it is possible to select and store appropriate images according to the purpose, for example, images between which a difference in time caused by the plurality of types of illumination light beams is small or images having less blur. Accordingly, with the endoscope system **10**, it is possible to store a plurality of types of still images corresponding to a plurality of illumination light beams in a state suitable for comparison or superimposition, through a single instruction.

The target period may be a period in which the image processor acquires the first image and the second image that satisfy the selection condition. Therefore, for example, the target period may be a period up to the point in time when the first image and the second image that satisfy the selection condition can be acquired. Specifically, as shown in FIG. **14**, in a case where the illumination light beams or the like are the same as in FIG. **13**, the storage control unit **61** selects the first image a**2**, and then selects the second image b**1** in a case where the second image b**0** does not satisfy the selection condition but the second image b**1** satisfies the selection condition, and ends the target period ta. Therefore, the storage control unit **61** stores the first image a**2** and the second image b**1**. As soon as the first image or the second image is stored in the temporary storage unit **62**, the storage control unit **61** checks whether the image satisfies the preset selection condition for each image, and selects the image satisfying the selection condition. Further, in this case, the target period ta from time t**1** to time t**2** is shorter by one frame than in the case of FIG. **13**. The above configuration is preferable because the period for storing the first image and the second image can be shortened.

The light source processor **21** may alternately switch and emit the first illumination light beam and the second illumination light beam at a preset cycle. Further, it is preferable to use a combination of illumination light beams with which the obtained first and second images have the same base color tone. The base color tone is a color tone that is a base in an endoscopic image, and is, for example, a color tone that occupies a large proportion of an area in the endoscopic image. In a case where the base color tone is the same even for different endoscopic images, the overall color tone does not differ significantly when compared, and it is easy to recognize the difference in parts other than the base color tone. In the first image using the first illumination light beam and the second image using the second illumination light beam as described above, examples of obtaining observation images of which the base color tones have natural color tones include performing white balance processing by using a specific gain coefficient through the DSP **52**. This base color tone is referred to as a first base color tone.

It is assumed that the specific gain coefficient in a case where the first base color tone is obtained is corrected by using the endoscopic image acquired in the past. For example, in the first image, the gain coefficient is corrected in the subsequent first image by using the second image.

Further, in the second image, the gain coefficient is corrected in the subsequent second image by using the first image.

As described above, the first illumination light beam is set as an illumination light beam that enhances the superficial blood vessels, and the second illumination light beam is set as an illumination light beam that enhances the medium-depth layer blood vessels, and the first illumination light beam and the second illumination light beam are automatically switched at a fixed cycle. With this, since the base color tones are the same first base color tone, the color tone of the part having a large proportion of the area in the endoscopic image does not change, and only the different part is enhanced and displayed. Accordingly, since the superficial blood vessels and the medium-depth blood vessels of the same observation target are enhanced and displayed like an animation, the blood vessel information in the depth direction can be obtained in an easy-to-see state.

Further, it is also preferable to use a combination of a third illumination light beam and a fourth illumination light beam by using the third illumination light beam instead of the above-described first illumination light beam and the fourth illumination light beam instead of the second illumination light beam, as illumination light beams. The light source processor **21** controls the respective LEDs **20***a* to **20***d* such that the third illumination light beam of which the light intensity ratios between violet light V, blue light B, green light G, and red light R are Vs3:Bs3:Gs3:Rs3 is emitted. The light intensity ratios Vs3:Bs3:Gs3:Rs3 correspond to the light amount condition of the third illumination light beam. It is preferable that the third illumination light beam enhances superficial blood vessels. For this purpose, it is preferable that the light intensity of violet light V of the third illumination light beam is set to be higher than the light intensity of blue light B. For example, as shown in FIG. **15**, the ratio between the light intensity Vs3 of violet light V and the light intensity Bs3 of blue light B is set such that the light intensity Vs3 of violet light V is high.

Further, the light source processor **21** controls the respective LEDs **20***a* to **20***d* such that the fourth illumination light beam of which the light intensity ratios between violet light V, blue light B, green light G, and red light R are Vs4:Bs4:Gs4:Rs4 is emitted. The light intensity ratios Vs4:Bs4:Gs4:Rs4 correspond to the light amount condition of the fourth illumination light beam. It is preferable that the fourth illumination light beam enhances the superficial blood vessels and makes the image bright even in a distant view. For this purpose, it is preferable that the light intensity of blue light B, the light intensity of green light G, and the light intensity of red light R in the fourth illumination light beam are set to be slightly higher than the respective light intensities in the third illumination light beam. For example, as shown in FIG. **16**, the ratios between the light intensity Bs4 of blue light B, the light intensity Gs4 of green light G, and the light intensity Rs4 of red light R are set to be slightly higher than the respective light intensities in the third illumination light beam.

The endoscopic images obtained by the third illumination light beam and the fourth illumination light beam have the same base color tone, that is, a second base color tone. The endoscopic image having the second base color tone is an endoscopic image having a color tone with a small amount of red component, in which the structure of the mucous membrane surface layer, for example, microvessels are enhanced. The third illumination light beam is set as an illumination light beam that enhances the superficial blood vessels, and the fourth illumination light beam is set as an illumination light beam that enhances the superficial blood vessels and that makes the image bright even in a distant view, and the third illumination light beam and the fourth illumination light beam are automatically switched at a fixed cycle. With this, since the base color tones are the second base color tone, the color tone of the part having a large proportion of the area in the endoscopic image does not change, and only the different part is enhanced and displayed. Accordingly, since the subtle differences between the superficial blood vessels of the same observation target are enhanced and displayed like an animation, microvessel information in the superficial blood vessels can be obtained in an easy-to-see state.

The light source processor **21** may perform control to switch, out of the first illumination light beam and the second illumination light beam, one which is emitted before the processing start operation to the other to emit the other, in a case where the processing start operation is performed after a preset period starting from the time when light emission is switched between the first illumination light beam and the second illumination light beam. The preset period starting from the time when light emission is switched between the first illumination light beam and the second illumination light beam is defined as a post-switching period. Although it is not important whether light emission is switched between the first illumination light beam and the second illumination light beam because the user switches between the observation modes or because the light source processor **21** periodically switches between the illumination light beams in the multi-observation mode, the light source processor **21** switches and emits illumination light beams through the processing start operation in a case where the processing start operation is performed after the post-switching period starting from the time when light emission is switched between the illumination light beams is passed. Therefore, the target period ta in this case need only be set on the basis of the processing start operation.

Specifically, as shown in FIG. **17**, in a case where the second illumination light beam is switched to the first illumination light beam at time t**3**, a post-switching period tb starts at time t**3**, and the post-switching period tb ends at time t**1** because, for example, the post-switching period tb corresponds to three frames. Since time tf of the still image recording instruction is after time t**1** when the post-switching period tb ends is passed, the light source processor **21** performs control to switch the first illumination light beam which is emitted before the processing start operation of the image storage processing to the second illumination light beam to emit the second illumination light beam in response to the still image recording instruction. The post-switching period tb is preferably, for example, a period equal to or longer than the number of frames corresponding to the number of endoscopic images acquired for one type of illumination light beam in the target period ta. In the case of FIG. **17**, since the number of endoscopic images acquired for one type of illumination light beam in the target period ta is three, the post-switching period tb is set to three frames. With the above configuration, the switching between the illumination light beams is performed in the target period ta, so that the difference in time between the first image and the second image as selection targets can be made smaller.

Further, the light source processor **21** may perform control to switch, out of the first illumination light beam and the second illumination light beam, one which is emitted after the processing start operation to the other to emit the other, when the target period ta is passed. Specifically, as shown in FIG. **18**, since the processing start operation is the still image recording instruction, the light source processor **21** performs

control to switch the second illumination light beam which is emitted after the still image recording instruction to the first illumination light beam which is emitted before the still image recording instruction to emit the first illumination light beam when time t2 which is the end point of the target period ta is passed. The target period ta may be a period in which the image processor acquires a plurality of the first images which is a preset number and a plurality of the second images which is a preset number, or a period in which the image processor acquires a first image and a second image that satisfy the selection condition.

With the above configuration, for example, in a case where the observation target is observed in the first special observation mode, the still image recording instruction is given once, so that it is possible to automatically store images using different illumination light beams, such as the first image and the second image, and the switching to the second illumination light beam is limited to the required period. Accordingly, the user can obtain different types of still images while continuing the observation in the mode the user is observing.

Further, the light source processor **21** may perform control to switch, out of the first illumination light beam and the second illumination light beam, one which is emitted after the processing start operation to the other to emit the other, when a preset period starting from the time of the processing start operation is passed. The preset period starting from the time of the processing start operation is defined as a post-processing start operation period. The target period ta in this case need only be set on the basis of the processing start operation.

Specifically, as shown in FIG. **19**, since the processing start operation of the image storage processing is the still image recording instruction, the light source processor **21** performs control to switch the second illumination light beam which is emitted after the still image recording instruction to the first illumination light beam which is emitted before the still image recording instruction to emit the first illumination light beam, at time t2 when a post-processing start operation period tc is passed from time tf of the still image recording instruction. The post-processing start operation period tc is preferably, for example, a period equal to or longer than the number of frames corresponding to the number of endoscopic images acquired for one type of illumination light beam in the target period ta. In the case of FIG. **19**, since the number of endoscopic images acquired for one type of illumination light beam in the target period ta is three, it is preferable to lengthen the post-processing start operation period tc to three frames or more. Therefore, in FIG. **19**, the post-processing start operation period tc is set to three frames.

With the above configuration, for example, in a case where the observation target is observed in the first special observation mode, the still image recording instruction is given once, so that it is possible to automatically store images using different illumination light beams, such as the first image and the second image, and the switching to the second illumination light beam is limited to the set required period. Accordingly, the user can more reliably obtain different types of still images, such as the first image and the second image as selection targets, in a state in which a difference in time therebetween is small while continuing the observation in the mode the user is observing.

Further, the light source processor **21** may perform control to emit, out of the first illumination light beam and the second illumination light beam, one which is emitted before the processing start operation even after the processing start operation, in a case where the processing start operation is performed in a preset period starting from a time when light emission is switched between the first illumination light beam and the second illumination light beam. That is, in a case where the processing start operation is performed within the post-switching period tb, the illumination light beam is not switched in response to the processing start operation, and the illumination light beam which is emitted at the time of the processing start operation is extended. The target period ta in this case need only include a light emission period of the illumination light beam before the switching.

Specifically, as shown in FIG. **20**, in a case where the light source processor **21** switches the illumination light beam at time t4, for example, by periodically switching between the illumination light beams in the multi-observation mode, when the still image recording instruction is given at time tf, the still image recording instruction is given within the post-switching period tb because the post-switching period tb is set to the period of three frames from time t4 to time t2. In this case, the light source processor **21** does not switch between the illumination light beams even in a case where the still image recording instruction is given, and the target period ta is set on the basis of the switching between the illumination light beams at time t4. Therefore, the storage control unit **61** sets the target period ta to a period from time t1 to time t2 including the period before the switching between the illumination light beams. The post-switching period tb is the same as described above, and is set to three frames.

With the above configuration, the difference in time between the first image and the second image as selection targets can be more reliably made smaller, and it is possible to restrain the flicker of the images displayed on the display **18** caused by the frequent switching between illumination light beams and to restrain the occurrence of the problem of photosensitivity.

Furthermore, the light source processor **21** may perform control to switch, out of the first illumination light beam and the second illumination light beam, one which is emitted at the time of the processing start operation to the other to emit the other, after a preset period starting from the time when the light emission is switched between the first illumination light beam and the second illumination light beam, that is, the post-switching period tb, is passed. The target period ta in this case need only be set on the basis of the time when the light emission is switched between the first illumination light beam and the second illumination light beam.

Specifically, as shown in FIG. **21**, since the processing start operation of the image storage processing is the still image recording instruction, the light source processor **21** performs control to switch the second illumination light beam which is emitted at the time of the still image recording instruction to the first illumination light beam which is emitted before the light emission is switched between the first illumination light beam and the second illumination light beam, at time t2 when the post-switching period tb starting from time t4 when the light emission is switched between the first illumination light beam and the second illumination light beam is passed. The post-switching period tb is preferably, for example, a period equal to or longer than the number of frames corresponding to the number of endoscopic images acquired for one type of illumination light beam in the target period ta. In the case of FIG. **21**, since the number of endoscopic images acquired for one type of illumination light beam in the target period ta is three, it is preferable to lengthen the post-switching period

tb to three frames or more. Therefore, in the case of FIG. **21**, the post-switching period tb is set to three frames.

Further, the light source processor **21** may perform control to switch, out of the first illumination light beam and the second illumination light beam, one which is emitted at the time of the processing start operation to the other to emit the other, after a preset period starting from the time of the processing start operation, that is, the post-processing start operation period tc, is passed. The target period ta in this case need only be set on the basis of the time when the light emission is switched between the first illumination light beam and the second illumination light beam.

Specifically, as shown in FIG. **22**, since the processing start operation of the image storage processing is the still image recording instruction, the light source processor **21** performs control to switch the second illumination light beam which is emitted at the time of the still image recording instruction to the first illumination light beam which is emitted before the light emission is switched between the first illumination light beam and the second illumination light beam, at time t**5** when the post-processing start operation period tc starting from time tf of the still image recording instruction is passed. The post-processing start operation period tc is preferably, for example, a period equal to or longer than the number of frames corresponding to the number of endoscopic images acquired for one type of illumination light beam in the target period ta. In the case of FIG. **22**, since the number of endoscopic images acquired for one type of illumination light beam in the target period ta is three, it is preferable to lengthen the post-processing start operation period tc to three frames or more. Therefore, in FIG. **22**, the post-processing start operation period tc is set to three frames.

With the above configuration, for example, in a case where the observation target is observed in the multi-observation mode, it is possible to restrain the flicker of images displayed on the display **18** caused by the frequent switching between illumination light beams, and to restrain the occurrence of the problem of photosensitivity, even in a case where the light source processor **21** automatically switches between illumination light beams regardless of the still image recording instruction. Further, the still image recording instruction is given once, so that it is possible to more reliably obtain different types of still images, such as the first image and the second image as selection targets, in a state in which a difference in time therebetween is small. Accordingly, the user can more reliably obtain different types of still images, such as the first image and the second image as selection targets, in an appropriate state, for example, while continuing the observation in the multi-observation mode the user is observing.

The preset selection condition may be a condition that a first image and a second image having the smallest positional deviation between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected. The positional deviation between the selected first and second images is small, so that it is possible to store the first image and the second image in a state suitable for comparison or superimposition.

As a method of selecting the first image and the second image having the smallest positional deviation therebetween, a known method can be used. Examples of the method based on image analysis include a method of dividing the first image and the second image and comparing and obtaining the cumulative amounts of the G image signals of the first image and the G image signals of the second image having similar signal characteristics in respective regions.

The preset selection condition may be a condition that a first image and a second image having a smallest difference in brightness between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected. The difference in brightness between the selected first and second images is small, so that it is possible to store the first image and the second image in a state suitable for comparison or superimposition.

As a method of selecting the first image and the second image having the smallest difference in brightness therebetween, a known method can be used. For example, brightness Y is calculated for each image, and a combination having the smallest difference in brightness Y is selected from the plurality of first images and the plurality of second images acquired in the target period ta. As a method of calculating the brightness Y, a known method can be used, and the brightness Y is set according to the purpose. For example, in a case where the brightness Y is calculated from the image signals of each image, the brightness Y may be calculated by the brightness $Y=\alpha\times R+\beta\times G+\gamma\times B$. Here, "R" represents the pixel value of the R image signal of each image, "G" represents the pixel value of the G image signal, and "B" represents the pixel value of the B image signal. Further, "α, β, and γ" each represent a certain coefficient.

Further, the storage control unit **61** preferably sets the selection condition that a first image and a second image having a smallest difference in acquisition time between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected. The smaller the difference in acquisition time between the selected first and second images is, for example, the less likely it is that the blur of the first image or the blur of the second image, the positional deviation between the first image and the second image, the difference in brightness between the first image and the second image, and the like occur, so that it is possible to store the first image and the second image in a state suitable for comparison or superimposition.

The preset selection condition exemplified above may be used alone or in combination of two or more. In a case where the plurality of selection conditions is used in combination, images can be selected on the basis of the rate of match between the first image and the second image calculated by combining the plurality of selection conditions.

The rate of match can be, for example, the sum of the amount of blur and the amount of movement (the amount of positional deviation) between the selected first and second images. Specifically, first, out of the plurality of first images acquired in the target period ta, a first image having the smallest amount of blur is selected. Then, out of the plurality of second images acquired in the target period ta, a second image having the smallest amount of blur is selected. After that, out of the selected second images, a second image having the minimum amount of movement with respect to the selected first image is selected and stored. In this case, it is assumed that the smaller the amount of movement is, the higher the rate of match is.

As shown in FIG. **23**, in a case where the selection targets are the first images a**2**, a**3**, and a**4** and the second images b**0**, b**1**, and b**2**, the amount of blur is calculated in the first images a**2**, a**3**, and a**4** and the first image a**2** having the smallest amount of blur is selected, and the amount of blur is calculated in the second images b**0**, b**1**, and b**2** and the second images b**0** and b**2** having the smallest amount of blur

are selected. After that, the amount of movement from the first image a2 is calculated for the second images b0 and b2. In a case where the amount of movement with respect to the first image a2 is calculated to be 3 for the second image b0 and is calculated to be 2 for the second image b2, the first image a2 and the second image b2 are stored.

Further, the rate of match may be decided, for example, by calculating the amount of movement as described above for all of the plurality of first images and the plurality of second images obtained in the target period ta. After that, the pair of the first image and the second image, which corresponds to the case where the calculated value is the smallest, is selected and stored. The smaller the calculated value is, the higher the rate of match is.

As shown in FIG. **24**, in a table **71**, in a case where the selection targets are the first images a2, a3, and a4 and the second images b0, b1, and b2, the amount of blur is calculated for each of the first images a2, a3, and a4 and the second images b0, b1, and b2. The amount of blur in each image is the numerical value in parentheses. After that, the amounts of movement from the first images a2, a3, and a4 are calculated for the respective second images b0, b1, and b2. In the table **71**, the subtotal of the amount of blur between the first image and the second image and the amount of movement between the first image and the second image are described in the columns of "amount of blur, amount of movement", respectively. The value obtained by adding the amount of blur and the amount of movement is described in the column of "total". In this way, nine total values are calculated in three first images and three second images.

In the table **71**, the amount of blur of each image is as shown in parentheses, the amount of blur of the first image a2 is 3, the amount of blur of the first image a3 is 2, and the amount of blur of the first image a4 is 4. Further, the amount of blur of the second image b0 is 2, the amount of blur of the second image b1 is 3, and the amount of blur of the second image b2 is 1. At the portion intersecting the first image a2 and the second image b0 in the table **71**, it is described that the subtotal of the amount of blur between the first image a2 and the second image b0 is 5, and that the amount of movement (positional deviation) calculated from the first image a2 and the second image b0 is 3. Further, in the column of total in this portion, it is described that the total of the amount of movement and the subtotal of the above amounts of blur is 8. In all of the first images a2, a3, and a4 and the second images b0, b1, and b2, the total of the amount of movement and the subtotal of the amount of blur is calculated in the above manner, and the total is shown in the predetermined column in the table **71**. Out of these nine values, the first image a2 and the second image b2, which corresponds to the smallest case, are stored. In the case of the table **71**, the first image a2 and the second image b2 having a total of 6 are stored.

The rate of match is a storage determination value, and may be calculated on the basis of the amount of blur and the amount of movement, or may be quantified and calculated using another selection condition such as a difference in brightness or a difference in time.

The display control unit **57** may perform control to display the first image and/or the second image stored by the storage unit **63** on the display in the target period ta. In the target period ta, the first illumination light beam is switched to the second illumination light beam and the second illumination light beam is emitted, and the image pickup sensor **45** acquires image signals for each frame. However, the stored first image and/or the stored second image may be continuously displayed on the display **18**, in at least the target period ta.

As shown in FIG. **25**, in the first special observation mode, the light source processor **21** switches the first illumination light beam to the second illumination light beam at time tf of the still image recording instruction, and switches the second illumination light beam to the first illumination light beam which is emitted before the still image recording instruction to emit the first illumination light beam when time t2 which is the end point of the target period ta is passed. The display control unit **57** displays the first image on the display **18** in the first special observation mode. Then, the illumination light beam is switched from the first illumination light beam to the second illumination light beam at time tf of the still image recording instruction, but the first image is continuously displayed in the target period ta.

It is assumed that the first image displayed in the target period ta is the first image a2 stored by the still image recording instruction. As the first image displayed in the target period ta, the first image a4 which is a first image acquired immediately before the illumination light beam is switched from the first illumination light beam to the second illumination light beam at time tf of the still image recording instruction may be extended and displayed, and another first image may be displayed. Alternatively, the stored first image a2 and the stored second image b2 may be, for example, juxtaposed and displayed.

As shown in FIG. **26**, in the multi-observation mode, the light source processor **21** switches the first illumination light beam to the second illumination light beam at time tf1 of the still image recording instruction, and switches the second illumination light beam to the first illumination light beam which is emitted before the still image recording instruction to emit the first illumination light beam when time t2 which is the end point of a target period ta1 is passed. Then, the first illumination light beam is switched to the second illumination light beam at time t6 by the periodic switching between illumination light beams performed by the light source processor **21**. The light source processor **21** switches the second illumination light beam to the first illumination light beam at time tf2 of the still image recording instruction, and switches the first illumination light beam to the second illumination light beam which is emitted before the still image recording instruction to emit the second illumination light beam when time t8 which is the end point of a target period ta2 is passed.

The display control unit **57** displays the first image on the display **18** during the period in which the illumination light beam is the first illumination light beam, in the multi-observation mode. Then, the illumination light beam is switched from the first illumination light beam to the second illumination light beam at time tf1 of the still image recording instruction, but the first image is continuously displayed in the target period ta1. It is assumed that the first image displayed in the target period ta1 is the first image a2 stored by the still image recording instruction. After that, the second image is displayed on the display **18** in the period in which the illumination light beam is the second illumination light beam. Then, the illumination light beam is switched from the second illumination light beam to the first illumination light beam at time tf2 of the still image recording instruction, but the second image is continuously displayed in the target period ta2.

It is assumed that the second image displayed in the target period ta2 is a second image b7 stored by the still image recording instruction. As the first image displayed in the

target period ta1, the first image a4 which is a first image acquired immediately before the illumination light beam is switched from the first illumination light beam to the second illumination light beam at time tf1 of the still image recording instruction may be extended and displayed, and another first image may be displayed. Alternatively, the stored first image a2 and the stored second image b2 may be, for example, juxtaposed and displayed. As the second image displayed in the target period ta2, the second image b7 which is a second image acquired immediately before the illumination light beam is switched from the second illumination light beam to the first illumination light beam at time tf2 of the still image recording instruction may be extended and displayed, and another second image may be displayed. Alternatively, the stored second image b7 and the stored first image a6 may be, for example, juxtaposed and displayed.

As described above, the display control unit **57** performs control to continuously display the first image on the display **18** during the first period in which the illumination light beam is the first illumination light beam, and continuously displays the second image on the display **18** during the second period in which the illumination light beam is the second illumination light beam, so that it is possible to display selected endoscopic images in a state suitable for comparison on the display **18** without the flicker or the like, while acquiring image signals of a mode different from the mode the user is observing. Accordingly, the user can perform observation and the like more stably.

In the plurality of first images and the plurality of second images acquired in the target period, there may be no image satisfying the condition depending on the selection condition. In this case, for example, it is preferable to provide an alert unit that gives an alert to notify the user. The alert unit gives an alert to notify the user that there is no image satisfying the selection condition. Details on alerts, such as whether or not to give an alert in a case where there is not even one image satisfying the selection condition, how to give an alert, or whether to store images even in a case where the images do not satisfy the selection condition are preset.

Further, in this case, it is preferable to provide a retry unit that performs a retry. The retry unit performs the image storage processing again in a case where there is no image satisfying the selection condition. Details, such as whether or not to perform a retry in a case where there is not even one image satisfying the selection condition, the number of times of retries, the setting of the time to perform a retry, and whether to prompt the user to perform the processing start operation, are preset.

With the above configuration, a case where the alert unit is provided is preferable because a flexible selection condition can be set and the user can immediately know that there is no image satisfying the selection condition even in a case where there is no image satisfying the selection condition. Further, a case where the retry unit is provided is preferable because the user can easily acquire images in a state suitable for storage.

Next, a series of flows of still image storage will be described with reference to the flowchart shown in FIG. **27**. In the case of the first special observation mode, observation is performed in the first special observation mode (step ST**110**). During the observation, the image signal acquisition unit **51** acquires the first image (step ST**120**). In this case, as the endoscopic image to be displayed on the display **18**, the first image may be continuously displayed, or the first image and the already stored second image may be, for example, juxtaposed and displayed.

When there is a still image recording instruction (YES in step ST**130**), since the still image recording instruction is the processing start operation of the image storage processing, the illumination light beam is switched from the first illumination light beam to the second illumination light beam in the target period including the time of the still image recording instruction, and the image signal acquisition unit **51** acquires the plurality of first images and the plurality of second images (step ST**140**). The plurality of acquired first images and the plurality of acquired second images are stored in the temporary storage unit **62**, and the storage control unit **61** selects one first image and one second image that satisfy the preset selection condition, from the temporary storage unit **62** (step ST**150**). In a case where there is no still image recording instruction (NO in step ST**130**), observation and the acquisition of the first image are continued. The selected first and second images are stored by the storage unit **63** (step ST**160**). The display control unit **57** displays the stored first and second images on the display **18** (step ST**170**). The display format is a preset format, and for example, two images are juxtaposed and displayed on the display **18**. When the observation is completed (YES in step ST**180**), the series of flows ends. In a case where the observation is continued (NO in step ST**180**), the process returns to the observation in the first special observation mode.

In the above embodiment, the present invention is applied to the endoscope system that performs processing on the endoscopic image, but the present invention can also be applied to a medical image processing system that processes medical images other than the endoscopic image, in a case where the still image is stored.

In the above embodiment, the hardware structures of the light source processor, the image processor, and the processing units that execute various types of processing, such as the central control unit **59**, the image signal acquisition unit **51**, the DSP **52**, the noise reduction unit **53**, the memory **54**, the signal processing unit **55**, the image storage unit **56**, the storage control unit **61**, the temporary storage unit **62**, the storage unit **63**, the display control unit **57**, and the video signal generation unit **58**, which are provided in the processor device **16**, are various processors to be described below. The various processors include, for example, a central processing unit (CPU) which is a general-purpose processor that executes software (programs) to function as various processing units, a programmable logic device (PLD) which is a processor having a changeable circuit configuration after manufacture, such as a field programmable gate array (FPGA), and a dedicated electrical circuit which is a processor having a dedicated circuit configuration designed to execute various processing.

One processing unit may be composed of one of these various processors or a combination of two or more of the processors of the same type or different types (for example, a plurality of FPGAs, or a combination of a CPU and an FPGA). Alternatively, a plurality of processing units may be composed of one processor. A first example in which a plurality of processing units is composed of one processor is an aspect in which one or more CPUs and software are combined to constitute one processor and the processor functions as a plurality of processing units, as typified by a computer such as a client or a server. A second example is an aspect in which a processor that realizes all of the functions of a system including a plurality of processing units with one integrated circuit (IC) chip is used, as typified by a system on chip (SoC) or the like. As described above,

various processing units may be formed of one or more of the above various processors as hardware structures.

More specifically, the hardware structure of these various processors is an electrical circuit (circuitry) in which circuit elements, such as semiconductor elements, are combined.

EXPLANATION OF REFERENCES

10: endoscope system
12: endoscope
12*a*: insertion part
12*b*: operation part
12*c*: bendable portion
12*d*: distal end portion
12*e*: angle knob
12*f*: still image recording instruction portion
12*g*: mode changeover switch
12*h*: zoom operation portion
14: light source device
16: processor device
18: display
19: keyboard
20: light source unit
20*a*: V-LED
20*b*: B-LED
20*c*: G-LED
20*d*: R-LED
21: light source processor
22: light emission period setting unit
30*a*: illumination optical system
30*b*: image pickup optical system
41: light guide
42: illumination lens
43: objective lens
44: zoom lens
45: image pickup sensor
46: CDS/AGC circuit
47: A/D converter
51: image signal acquisition unit
52: DSP
53: noise reduction unit
54: memory
55: signal processing unit
56: image storage unit
57: display control unit
58: video signal generation unit
59: central control unit
61: storage control unit
62: temporary storage unit
63: storage unit
71: table
81*a*, **81***b*: slide bar
82*a*, **82***b*: slider
BM: background mucous membrane
BP: blue light image
VS**1**: superficial blood vessel
VS**2**: deep blood vessel
VP: violet light image
GRP: green and red light image
t**1** to t**5**: time
tf, tf**1**, tf**2**: time when a still image recording instruction is given
ta, ta**1**, ta**2**: target period
tb: post-switching period
tc: post-processing start operation period
a**0** to a**11**: first image
b**0** to b**9**: second image
ST**110** to ST**180**: step

What is claimed is:

1. An endoscope system comprising:
a plurality of semiconductor light sources that emits light beams having wavelength bands different from each other;
a light source processor that is configured to emit each of a plurality of illumination light beams of which combinations of light intensities among the plurality of semiconductor light sources are different from each other; and
an image processor,
wherein the image processor is configured to:
acquire a first image and a second image obtained by imaging an observation target illuminated with a first illumination light beam and a second illumination light beam included in the plurality of illumination light beams, respectively, for each frame, each frame corresponding to a period including at least an exposure period and a readout period of an image sensor;
continuously irradiate the first illumination light across a plurality of the frames and continuously acquire a plurality of the first images across the plurality of the frames;
continuously irradiate the second illumination light across a plurality of the frames and continuously acquire a plurality of the second images across the plurality of the frames;
perform image storage processing of storing a first image selected from a plurality of the continuously acquired first images and a second image selected from a plurality of the continuously acquired second images; and
select, when a processing start operation for starting the image storage processing is performed, a first image and a second image that satisfy a preset selection condition from the plurality of continuously acquired first images and the plurality of continuously acquired second images acquired in a target period including a time when the processing start operation is performed, for the image storage processing, and
the light source processor is configured to switch once and not more than once, out of the first illumination light beam and the second illumination light beam, from one being emitted to the other to be emitted in the target period.

2. The endoscope system according to claim **1**,
wherein the target period is a period in which the image processor acquires a plurality of the first images which is a preset number and a plurality of the second images which is a preset number.

3. The endoscope system according to claim **1**,
wherein the target period is a period in which the image processor acquires the first image and the second image that satisfy the selection condition.

4. The endoscope system according to claim **1**,
wherein the light source processor is configured to alternately switch and emit the first illumination light beam and the second illumination light beam at a preset cycle.

5. The endoscope system according to claim **1**,
wherein the light source processor is configured, in a case where the processing start operation is performed after a preset post-switching period has elapsed from a previous switch time between the first illumination

light beam and the second illumination light beam, to switch from one which is emitted before the processing start operation to the other to be emitted, wherein the post-switching period is a preset period defined by a predetermined number of frames.

6. The endoscope system according to claim **5**,

wherein the light source processor is configured to switch, out of the first illumination light beam and the second illumination light beam, from one which is emitted after the processing start operation to the other to be emitted, when the target period is passed.

7. The endoscope system according to claim **5**,

wherein the light source processor is configured to switch, out of the first illumination light beam and the second illumination light beam, from one which is emitted after the processing start operation to the other to be emitted, when a preset period starting from the time of the processing start operation is passed.

8. The endoscope system according to claim **1**,

wherein the light source processor is configured, in a case where the processing start operation is performed in a preset post-switching period starting from a previous switch time between the first illumination light beam and the second illumination light beam, to continuously emit one which is emitted before the processing start operation wherein the post-switching period is a preset period defined by a predetermined number of frames.

9. The endoscope system according to claim **8**,

wherein the light source processor is configured to switch, out of the first illumination light beam and the second illumination light beam, from one which is emitted at the time of the processing start operation to the other to be emitted, when the preset period starting from the time when the light emission is switched between the first illumination light beam and the second illumination light beam is passed.

10. The endoscope system according to claim **8**,

wherein the light source processor is configured to switch, out of the first illumination light beam and the second illumination light beam, from one which is emitted at the time of the processing start operation to the other to be emitted, when a preset period starting from the time of the processing start operation is passed.

11. The endoscope system according to claim **1**,

wherein the image processor is configured to set the selection condition that a first image having least blur out of the plurality of acquired first images or a second image having least blur out of the plurality of acquired second images is selected.

12. The endoscope system according to claim **1**,

wherein the image processor is configured to set the selection condition that a first image and a second image having smallest positional deviation between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected.

13. The endoscope system according to claim **1**,

wherein the image processor is configured to set the selection condition that a first image and a second image having a smallest difference in brightness between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected.

14. The endoscope system according to claim **1**,

wherein the image processor is configured to set the selection condition that a first image and a second image having a smallest difference in acquisition time between the first image selected from the plurality of acquired first images and the second image selected from the plurality of acquired second images are selected.

15. The endoscope system according to claim **1**, further comprising:

a display that displays the first image and/or the second image,

wherein the image processor is configured to display the stored first image and/or the stored second image on the display in the target period.

16. A method of operating an endoscope system including

a plurality of semiconductor light sources that emits light beams having wavelength bands different from each other,

a light source processor that is configured to emit each of a plurality of illumination light beams of which combinations of light intensities among the plurality of semiconductor light sources are different from each other, and

an image processor, the method comprising:

acquiring, by the image processor, a first image and a second image obtained by imaging an observation target illuminated with a first illumination light beam and a second illumination light beam included in the plurality of illumination light beams, respectively, for each frame, each frame corresponding to a period including at least an exposure period and a readout period of an image sensor;

continuously irradiating, by the image processor, the first illumination light across a plurality of the frames and continuously acquiring a plurality of the first images across the plurality of the frames;

continuously irradiating, by the image processor, the second illumination light across a plurality of the frames and continuously acquiring a plurality of the second images across the plurality of the frames;

performing, by the image processor, image storage processing of storing a first image selected from a plurality of the continuously acquired first images and a second image selected from a plurality of the continuously acquired second images;

selecting, by the image processor, when a processing start operation for starting the image storage processing is performed, a first image and a second image that satisfy a preset selection condition from the plurality of continuously acquired first images and the plurality of continuously acquired second images acquired in a target period including a time when the processing start operation is performed, for the image storage processing; and

switching once and not more than once, by the light source processor, out of the first illumination light beam and the second illumination light beam, from one being emitted to the other to be emitted in the target period.

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