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(71) Applicant: HOYA CORPORATION [JP/JP]; 2-7-5 Naka-Ochiai, Shinjuku-ku, Tokyo, 1618525 (JP).

(72) Inventor: YAMABE, Toshiaki; c/o HOYA CORPORATION, 2-7-5 Naka-Ochiai, Shinjuku-ku, Tokyo, 1618525 (JP).

(74) Agents: MATSUOKA, Shuhei et al.; Shin-Toshi-Center Bldg. 6F, 24-1, Tsurumaki 1-chome, Tama-shi, Tokyo, 2060034 (JP).

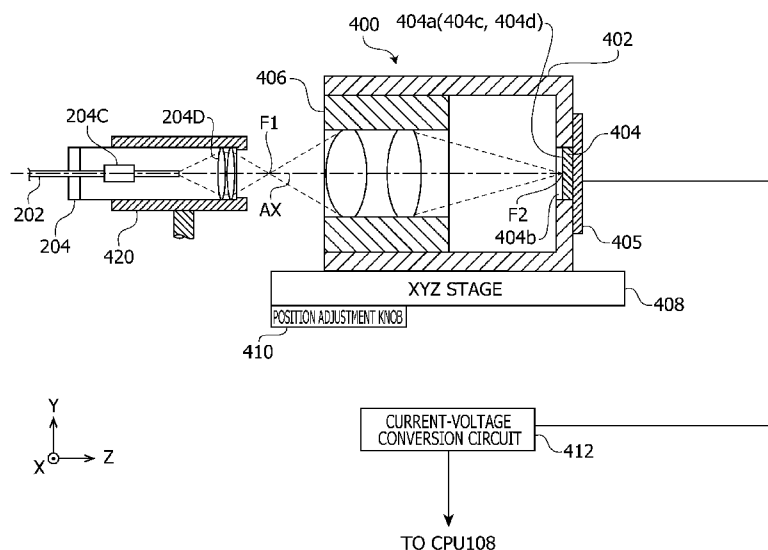
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(54) Title: SCANNING AREA ADJUSTMENT APPARATUS



(57) Abstract: A scanning area adjustment apparatus for a scanning confocal endoscope system comprising: a relay lens which enlarges a scanning area of excitation light; a light detection means configured to detect a scanning position of received excitation light on a light-receiving surface; a fluorescent material arranged at a position optically equivalent to the light-receiving surface; a moving means configured to move the relay lens and the light detection means; an scanning area change means configured to change the scanning area; and a mapping means configured to assign the scanning position to a pixel of the confocal image, and wherein the relay lens is arranged such that a rear focal point substantially coincides with a center position of the light-receiving surface, and the fluorescent material comprises a scale part enabling measurement of a size of the predetermined scanning area.

Description

Title of Invention: SCANNING AREA ADJUSTMENT APPARATUS

Technical Field

- [0001] The present invention relates to a scanning area adjustment apparatus for a scanning confocal endoscope system which has a light scanning device configured to emit excitation light with a predetermined wavelength and to cause the light to scan periodically within a predetermined scanning area and which is configured to display a confocal image by receiving fluorescence produced from a subject excited by the excitation light emitted by the light scanning device.

Background Art

- [0002] Conventionally, a scanning endoscope system configured to cause light guided by an optical fiber to scan in a spiral form with respect to an observation portion, and to image the observation portion by receiving reflected light from the observation portion is known (e.g., Domestic Republication No. JP 2008-514342A1 of PCT international application (hereafter, referred to as "patent document 1")). The scanning endoscope system of this type includes a single mode optical fiber in an endoscope, and a proximal end of the optical fiber is held by a biaxial actuator in a state of a cantilever. The biaxial actuator vibrates (resonate) a tip of the optical fiber in two-dimension in accordance with a characteristic frequency while modulating and amplifying the amplitude of the vibration so that the tip of the optical fiber is driven in a spiral form. As a result, the illumination light guided by the optical fiber from the light source scans on the observation portion in a spiral form, and an image corresponding to an illumination range (a scanning area) is obtained based on returning light from the observation portion.
- [0003] Recently, it has been proposed that the scanning endoscope system as shown in patent document 1 is applied to a scanning confocal endoscope system (e.g., Japanese Patent Provisional Publication No. 2011-255015A (hereafter, referred to as "patent document 2")). The scanning confocal endoscope system is configured to emit laser light to a living tissue to which a medical agent is administered and to extract only a component, obtained through a pin hole arranged at a position conjugate with a focal point of a confocal optical system, of fluorescence emitted from the living tissue so that observation can be achieved at a magnification higher than that of an observation image obtained by a normal endoscope optical system. The scanning confocal endoscope system described in patent document 2 is configured to be able to observe a minute subject which cannot be observed at a magnification of an observation image

obtained by the normal endoscope optical system and to be able to observe a cross section of a living tissue, by scanning in two dimension or three dimension with laser light for a particular narrow area of a living tissue.

[0004] In the system described in each of patent documents 1 and 2, the reflected light or the fluorescence from the scanning area is received at a predetermined period of timing (hereafter, referred to as a "sampling point"), intensity information at each sampling point is assigned to a display coordinate (a pixel position of the endoscope image), and a two-dimensional endoscope image is displayed. Therefore, in order to generate an endoscope image having a high degree of reproducibility with almost no distortion, it is necessary to precisely assign the scanning position of each sampling point to the display coordinate. For this reason, adjustment for the scanning area and for mapping between the sampling point and the display coordinate of a monitor is performed for the scanning endoscope system of this type in a factory.

Summary of Invention

[0005] The adjustment of the scanning area is performed, for example, by illuminating a chart including a predetermined index with illumination light emitted from an optical fiber and by adjusting an amplitude or a phase of a voltage applied to a biaxial actuator so that an ideal scanning pattern is obtained (i.e., so that a circular scanning area having a predetermined size is obtained) while observing, as reflected light or excitation light from the chart, an image on the monitor. A technique of this type can be applied relatively easily to a scanning endoscope system configured to scan within a relatively large scanning area (e.g., a scanning area having a diameter of 10mm) as in the case of the scanning endoscope system described in patent document 1; however, in a scanning endoscope system configured to scan within a narrow scanning area (e.g., a scanning area having a diameter of 500mm) as in the case of the scanning confocal endoscope system described in patent document 2, it was difficult to apply the above described technique because it is necessary to form a minute index on the chart.

[0006] Furthermore, mapping between each sampling point and the display coordinate on the monitor is performed by detecting a position of an illumination spot of each sampling point by receiving the illumination light emitted from an optical fiber with a PSD (Position Sensitive Detector). Such a technique is effective for the scanning endoscope system configured to scan within a relatively large scanning area as in the case of the scanning endoscope system described in patent document 1; however, in a scanning endoscope system configured to scan within a narrow scanning area as in the case of the scanning confocal endoscope system described in patent document 2, a problem arises that the position of an illumination spot cannot be precisely detected due to limitation of resolution of the PSD sensor.

- [0007] Furthermore, if the above described process for adjusting the scanning area and the above described process for mapping between each sampling point and the display coordinate on the monitor are performed as separate processes using different jigs, the position adjustment for the scanning area (i.e., the position adjustment for the scanning area and the chart, and the position adjustment between the scanning area and PSD) needs to be performed for each process, and each work becomes complicated. For this reason, there is a demand for performing the two processes concurrently.
- [0008] The present invention is made in view of the above described circumstances. That is, the object of the present invention is to provide a scanning area adjustment apparatus configured such that adjustment for a scanning area can be performed easily and precisely and mapping between each sampling point and a display coordinate on a monitor can be performed precisely, even for a scanning endoscope system configured to scan within a narrow scanning area.
- [0009] To achieve the above described object, according to the invention, there is provided a scanning area adjustment apparatus for a scanning confocal endoscope system configured to have a light scanning device which causes excitation light with a predetermined wavelength from a light source to periodically scan within a predetermined scanning area on a subject, to receive fluorescence from the subject excited by the excitation light emitted from the light scanning device and thereby to display an confocal image. The scanning area adjustment apparatus comprises: a relay lens to which the excitation light emitted from the light scanning device enters and which enlarges the predetermined scanning area; a light detection means configured to receive the excitation light emerging from the relay lens on a light-receiving surface of the light detection means perpendicularly arranged with respect to an optical axis of the relay lens and to detect a scanning position of the received excitation light on the light-receiving surface; a fluorescent material that is arranged at a position optically equivalent to the light-receiving surface and emits fluorescence when the excitation light emerging from the relay lens is incident on the fluorescent material; a moving means configured to move the relay lens and the light detection means relative to the light scanning device in response to an operation input by a worker; an scanning area change means configured to change the scanning area of the excitation light emitted from the light scanning device in response to an operation input of the worker; and a mapping means configured to assign the scanning position of the excitation light detected by the light detection means to a pixel of the confocal image. The relay lens is arranged such that a rear focal point of the relay lens substantially coincides with a center position of the light-receiving surface. The fluorescent material comprises a scale part enabling measurement of a size of the predetermined scanning area of the excitation light emitted from the light scanning device.

- [0010] With this configuration, it is possible to check the scanning area of the excitation light emitted from the light scanning device on the confocal image as fluorescence of the scale part, and to conduct adjustment so that the scanning area becomes an ideal scanning area. Furthermore, since the scanning area of the excitation light emitted from the light scanning device is enlarged on the light detection means to the extent that the adjustment is not affected by the resolution of the light detection means, it is possible to detect the scanning position with a high degree of precision, even for the scanning endoscope system configured to scan within a narrow scanning area. Consequently, it becomes possible to precisely assign the scanning position of the excitation light to a pixel of the confocal image. Furthermore, since a process for adjusting the scanning area and a process for associating the scanning position of the excitation light with a pixel of the confocal image can be performed with a single apparatus, a manufacturing process can be simplified.
- [0011] The fluorescent material may comprise a indicator part indicating a position equivalent to the center position of the light-receiving surface, and the moving means may move the relay lens and the light detection means so that a center of the scanning area of the excitation light emerging from the relay lens substantially coincides with the indicator part. With this configuration, it is possible to detect the scanning area of the excitation light emitted from the light scanning device at a central portion of the light-receiving surface where the position detection accuracy is stable.
- [0012] The indicator part may be a cross-shaped indicator formed by two lines which perpendicularly intersect with each other and perpendicularly intersect with the optical axis of the relay lens at the position equivalent to the center position of the light-receiving surface. In this case, the scale part may be formed at predetermined intervals to perpendicularly intersect with the cross-shaped indicator in a plane which is equivalent to the light-receiving surface.
- [0013] The scale part may be formed in a grid shape at least within an area corresponding the light-receiving surface. In this case, the scale part may comprise two grid lines perpendicularly intersecting with each other at a position equivalent to the center position of the light-receiving surface, and the two grid lines may be formed to be thicker than other grid lines of the scale part. With this configuration, it becomes possible to easily check the size of the scanning area of the excitation light emerging from the relay lens on the confocal image.
- [0014] The light detection means may comprise a cover glass on a front side of the light-receiving surface, and the fluorescent material may be provided to coat a surface of the cover glass facing the light-receiving surface. In this case, a fluorescence reflection coating which reflects the fluorescence produced by the fluorescent material may be provided on the fluorescent material. With this configuration, it is possible to prevent

the fluorescence from the fluorescent material from being incident on the light-receiving surface. Therefore, it is possible to detect the position of the excitation light being incident on the light-receiving surface with a high degree of precision.

[0015] The scanning area adjustment apparatus may further comprise a beam splitter arranged between the relay lens and the light detection means. The beam splitter divides the excitation light incident thereon through the relay lens to let the incident excitation light proceed to the light detection means and the fluorescent material, and reflects the fluorescence produced by the fluorescent material toward the relay lens.

[0016] The scanning area change means may comprise: a first adjustment means that enlarges or reduces the scanning area of scanning light; and a second adjustment means that changes a shape of the scanning area of the scanning light.

[0017] The mapping means may create a remapping table by sampling the scanning position of the excitation light detected by the light detection means at a predetermined timing and by assigning a pixel of the confocal image to each sampling point.

[0018] The relay lens, the light detection means and the fluorescent material may be accommodated in a single case. In this case, the case may be a shielding case which shields the light detection means from external light. With this configuration, since the effect by the external light can be rejected, it becomes possible to detect the scanning trajectory of the scanning light at a high SN ratio.

[0019] According to the scanning area adjustment apparatus of the invention, it is possible to conduct adjustment of the scanning area easily and precisely, even for a scanning endoscope system configured to scan within a narrow scanning area, and thereby it becomes possible to precisely associate a scanning position of excitation light with a pixel of a confocal image.

Brief Description of Drawings

[0020] [fig.1]Fig. 1 is a block diagram illustrating a configuration of a scanning area adjustment apparatus and a scanning confocal endoscope system adjusted by the scanning area adjustment apparatus according to an embodiment of the invention.

[fig.2]Fig. 2 generally illustrates a configuration of a confocal optical unit included in the scanning confocal endoscope system according to the embodiment of the invention.

[fig.3]Fig. 3 illustrates a rotational trajectory of a tip of an optical fiber on a XY approximate plane.

[fig.4]Fig. 4 illustrates a relationship between sampling and braking periods and a changing amount (amplitude) of the tip of the optical fiber in X (or Y) direction on the XY approximate plane.

[fig.5]Fig. 5 illustrates a relationship between a sampling point and a raster coordinate.

[fig.6]Fig. 6 schematically illustrates the scanning area adjustment apparatus according

to the embodiment of the invention.

[fig.7]Fig. 7 is a front view of a PSD according to the embodiment of the invention.

[fig.8]Fig. 8 is a flowchart of a scanning area adjustment program executed by the scanning confocal endoscope system during the scanning area adjustment according to the embodiment of the invention.

[fig.9]Fig. 9 illustrates a relationship between the scanning area of the excitation light and the PSD.

[fig.10]Fig. 10 illustrates a situation where the center of the scanning area moves to the center of the PSD.

[fig.11]Fig. 11 illustrates a variation of the fluorescent material according to the embodiment of the invention.

[fig.12]Fig. 12 illustrates a variation of the fluorescent material according to the embodiment of the invention.

[fig.13]Fig. 13 illustrates a variation of the scanning area adjustment apparatus according to the embodiment of the invention.

Description of Embodiments

[0021] Hereinafter, a scanning area adjustment apparatus according to an embodiment of the invention, and a scanning confocal endoscope system adjusted by the scanning area adjustment apparatus will be explained with reference to the accompanying drawings.

[0022] The scanning confocal endoscope system is a system designed by making use of a fundamental principle of a confocal microscope, and is configured suitable for observing a subject at a high magnification and a high resolution. Fig. 1 is a block diagram illustrating a configuration of a scanning confocal endoscope system 1 according to the embodiment of the invention. As shown in Fig. 1, the scanning confocal endoscope system 1 includes a system main body 100, a confocal endoscope 200 and a monitor 300. Confocal observation using the scanning confocal endoscope system 1 is performed in a state where a tip face of the flexible confocal endoscope 200 having a tube-like shape is operated to contact a subject. Adjustment for a scanning area of the scanning confocal endoscope system 1 is conducted in a factory in a state where the tip face of the confocal endoscope 200 is installed in a scanning area adjustment apparatus 400 and the system main body 100 is electrically connected to the scanning area adjustment apparatus 400 via a cable 500.

[0023] The system main body 100 includes a light source 102, an optical coupler 104, a damper 106, a CPU 108, a CPU memory 110, an optical fiber 112, an optical receiver 114, a video signal processing circuit 116, an image memory 118 and a video signal output circuit 120. The confocal endoscope 200 includes an optical fiber 202, a confocal optical unit 204, a sub CPU 206, a sub memory 208 and a scan driver 210.

- [0024] The light source 102 emits excitation light which excites medical agents administered in a body cavity of a patient in accordance with driving control by the CPU 108. The excitation light enters the optical coupler 104. To one of ports of the optical coupler 104, an optical connector 152 is coupled. To a non-use port of the optical coupler 104, the damper 106 which terminates, without reflection, the excitation light emitted from the light source 102 is coupled. The excitation light which has entered the former port passes through the optical connector 152, and enters an optical system arranged in the confocal endoscope 200. Let us suppose that, in this embodiment, fluorescein is used as fluorochrome to be administered to a patient and the excitation light is laser light having the wavelength of 488nm.
- [0025] A proximal end of the optical fiber 202 is optically coupled to the optical coupler 104 through the optical connector 152. A tip of the optical fiber 202 is accommodated in the confocal optical unit 204 which is installed in a tip portion of the confocal endoscope 200. The excitation light which has exited from the optical coupler 104 enters the proximal end of the optical fiber 202 after passing through the optical connector 152, passes through the optical fiber 202, and thereafter is emitted from the tip of the optical fiber 202.
- [0026] Fig. 2A generally illustrates a configuration of the confocal optical unit 204. In the following, for convenience of explanation, a direction of the longer side of the confocal optical unit 204 is defined as Z-direction, and the two directions which are perpendicular to Z-direction and are perpendicular to each other are defined as X-direction and Y-direction. As shown in Fig. 2A, the confocal optical unit 204 has a metal outer tube 204A which accommodates various components. The outer tube 204A holds, to be slidable in a coaxial direction, an inner tube 204B having an outer wall shape corresponding to an inner wall shape of the outer tube 204A. The tip (a reference symbol "202a" is assigned hereafter) of the optical fiber 202 is accommodated and supported in the inner tube 204B through openings formed in proximal end faces of the outer tube 204A and the inner tube 204B, and functions as a secondary point source of the scanning confocal endoscope system 1. The position of the tip 202a being the point source changes periodically under control by the CPU 108. In Fig. 2A, the center axis AX represents an axis of the optical fiber 202 arranged in Z-direction, and when the tip 202a of the optical fiber 202 does not vibrate, the center axis AX coincides with an optical path of the optical fiber 202.
- [0027] The sub memory 208 stores probe information, such as identification information and various properties of the confocal endoscope 200. The sub CPU 206 reads out the probe information from the sub memory 208 at a time of start-up, and transmits the probe information to the CPU 108 via an electric connector 154 which electrically connects the system main body 100 with the confocal endoscope 200. The CPU 108

stores the transmitted probe information in the CPU memory 110. The CPU 108 generates signals necessary for controlling the confocal endoscope 200 by reading the stored probe information when necessary, and transmits the signals to the sub CPU 206. The sub CPU 206 designates setting values required for the scan driver 210 in accordance with the control signal transmitted from the CPU 108.

[0028] The scan driver 210 generates a drive signal corresponding to the designated setting value, and drives and controls a biaxial actuator 204C adhered and fixed to the outer surface of the optical fiber 202 close to the tip 202a. Fig. 2B generally illustrates a configuration of the biaxial actuator 204C. As shown in Fig. 2B, the biaxial actuator 204C is a piezoelectric actuator in which a pair of X-axis electrodes (X and X' in Fig. 2B) and a pair of Y-axis electrodes (Y and Y' in Fig. 2B) connected to the scan driver 210 are formed on a piezoelectric body.

[0029] The scan driver 210 applies an alternating voltage X between the X-axis electrodes of the biaxial actuator 204C so that the piezoelectric body is resonated in X-direction, and applies an alternating voltage Y which has the same frequency as that of the alternating voltage X and has a phase orthogonal to the phase of the alternating voltage X, between the Y-axis electrodes so that the piezoelectric body is resonated in Y direction. The alternating voltage X and the alternating voltage Y are defined as voltages which linearly increase in amplitude in proportion to time and reach average root-mean-square values (X) and (Y) by taking times (X) and (Y), respectively. The tip 202a of the optical fiber 202 rotates to draw a spiral pattern having the center at the center axis AX on a plane (hereafter, referred to as a "XY approximate plane") which approximates the X-Y plane, due to combining of kinetic energies in X- direction and Y-direction by the biaxial actuator 204C. A rotation trajectory of the tip 202a becomes larger in proportion to the applied voltage, and becomes a circle having the maximum diameter when the alternating voltages having the average root-mean squares (X) and (Y) are applied. In this embodiment, the amplitudes and the phases of the alternating voltages X and Y are adjusted in scanning area adjustment which is described later so that the rotation trajectory of the tip 202a becomes an ideal scanning trajectory. Fig. 3 illustrates the rotation trajectory of the tip 202a on the XY approximate plane adjusted through the scanning area adjustment.

[0030] Fig. 4 illustrates a relationship between various operation timings of the confocal endoscope 200 and the changing amount (amplitude) of the tip 202a of the optical fiber 202 in X- (or Y-) direction on the XY approximate plane. The excitation light is continuous light (or pulse light), and is emitted from the tip 202a of the optical fiber 202 during a time period (hereafter, referred to as "sampling period" for convenience of explanation) between a time just after start of application of the alternating voltage to the biaxial actuator 204C and a time of stop of application of the alternating voltage.

As described above, when the alternating voltage is applied to the biaxial actuator 204C, the tip 202a of the optical fiber 202 rotates to draw a spiral pattern having the center at the center axis AX. Therefore, during the sampling period, the excitation light emitted from the tip 202a of the optical fiber 202 scans in a spiral form in a predetermined circular scanning area having the center at the center axis AX. When application of the alternating voltage to the biaxial actuator 204C is stopped after the sampling period has passed, the vibration of the optical fiber 202 is attenuated. The circular motion of the tip 202a on the XY approximate plane converges in accordance with attenuation of the vibration of the optical fiber 202, and the vibration of the optical fiber 202 becomes almost zero after a predetermined time has passed (i.e., the tip 202a becomes an almost stopped state on the center axis AX). In the following, a time period from an end of the sampling period to a time when the tip 202a becomes an almost stopped state on the center axis AX is referred to as a "braking period" for convenience of explanation. After the braking period has passed and further a predetermined time has passed, a next sampling period is started. In the following, a time period from an end of the braking period to start of the next sampling period is referred to as a "settling period". The settling period is a waiting time for completely stopping the tip 202a of the optical fiber 202 on the center axis AX, and by providing the settling period, it becomes possible to cause the tip 202a to precisely scan. Furthermore, a period corresponding to one frame is formed by one sampling period and one braking period, and by adjusting the settling period, it becomes possible to adjust the frame rate. That is, the settling period can be appropriately set based on the relationship between the frame rate and the time until when the tip 202a of the optical fiber 202 completely stops. To shorten the braking period, a reverse phase voltage may be applied to the biaxial actuator 204C at an initial stage of the braking period so as to positively apply a braking torque.

[0031] On the front side of the tip 202a of the optical fiber 202, an objective optical system 204D is arranged. The objective optical system 204D is formed by a plurality of optical lenses, and is held in the outer tube 204A via a lens frame (not shown). The lens frame is fixed and supported relative to the inner tube 204B in the outer tube 204A. Therefore, an optical lens group held on the lens frame slides in Z-direction together with the inner tube 204B in the outer tube 204A. At the forefront of the outer tube 204A (i.e., on the front side of the objective optical system 204D), a cover glass (not shown) is held.

[0032] Between a proximal end face of the inner tube 204B and the inner wall of the outer tube 204A, a helical compression spring 204E and a shape memory alloy 204F are attached. The helical compression spring 204E is initially compressed and sandwiched in Z-direction from a natural length thereof. The shape memory alloy 204F has a rod-

like shape elongated in Z-direction, deforms when an external force is applied thereto under a room temperature condition, and is restored to a predetermined shape by the shape memory effect when heated to be higher than or equal to a predetermined temperature. The shape memory alloy 204F is designed such that the restoring force by the shape memory effect is larger than the restoring force of the helical compression coil 204E. The scan driver 210 generates a driving signal corresponding to the setting value designated by the sub CPU 206, and controls the expanding and contracting amount of the shape memory alloy 204F by electrifying and heating the shape memory alloy 204F. The shape memory alloy 204F causes the inner tube 204B to move forward or backward in Z-direction in response to the expanding and contracting amount.

[0033] The excitation light emitted from the tip 202a of the optical fiber 202 forms a spot on a surface or a surface layer of the subject through the objective optical system 204D. A spot formation position shifts in Z-direction in response to forward or backward movement of the tip 202a being the point source. That is, the confocal optical unit 204 performs the three dimensional scanning on the subject by combining the periodic circular motion of the tip 202a on the XY approximate plane by the biaxial actuator 204C and the movement in Z-direction.

[0034] Since the tip 202a of the optical fiber 202 is arranged at the front focal point of the objective optical system 204D, the tip 202a functions as a confocal pin hole. Of the scattered component (fluorescence) of the subject excited by the excitation light, only fluorescence from the convergence point which is optically conjugate with the tip 202a is incident on the tip 202a. The fluorescence passes through the optical fiber 202, and then enters the optical coupler 104 through the optical connector 152. The optical coupler 104 separates the entered fluorescence from the excitation light emitted from the light source 102, and guides the fluorescence to the optical fiber 112. The fluorescence is transmitted through the optical fiber 112, and then is detected by the optical receiver 114. In order to detect feeble light with a low level of noise, the optical receiver 114 may be configured as a high-sensitivity optical detector, such as a photomultiplier.

[0035] The detection signal detected by the optical receiver 114 is inputted to the video signal processing circuit 116. The video signal processing circuit 116 operates under control of the CPU 108, and generates a digital detection signal by performing sampling-and-holding and AD conversion for the detection signal at a constant rate. When the position (trajectory) of the tip 202a of the optical fiber 202 during the sampling period is determined, the spot formation position in the observation area (the scanning area) corresponding to the determined position and the signal acquisition timing (i.e., the sampling point) for obtaining the digital detection signal by detecting the returning light (fluorescence) from the spot formation position are definitely

defined. As described later, the scanning confocal endoscope system 1 according to the embodiment is subjected to the scanning area adjustment by using the scanning area adjustment apparatus 400 in advance if a factory, and the amplitude and the phase of the application voltage to the biaxial actuator 204C are adjusted so that the measured scanning trajectory becomes an ideal scanning pattern (i.e., an ideal spiral scanning pattern). After the scanning trajectory is adjusted to be an ideal scanning pattern, the relationship between each sampling point on the scanning trajectory and the pixel position of the endoscopic image displayed on the monitor 300 is determined (i.e., mapping is performed). The relationship between the sampling point and the pixel position (a pixel address) of the endoscopic image is stored in the CPU memory 110 as a remapping table. For example, if the endoscopic image is formed by 15 pixels in the horizontal direction (X-direction) and 15 pixels in the vertical direction (Y-direction), the relationship between the position (sampling point) of the excitation light sampled sequentially and the pixel position (raster address) of the endoscopic image becomes a state shown in Fig. 5. The CPU 108 creates the remapping table by obtaining the pixel position (raster coordinate) of the endoscopic image corresponding to each sampling point based on the relationship. In Fig. 5, for convenience of illustration, partial sampling points are shown in the central portion and the peripheral portion of the scanning area; however, actually a number of sampling points exist along the spiral scanning trajectory.

[0036] The video signal processing circuit 116 refers to the remapping table, and assigns the digital detection signal obtained at each sampling point as data of a corresponding pixel address. In the following, the above described assigning work is referred to as remapping, for convenience of explanation. The video signal processing circuit 116 performs buffering by storing the signal of the image formed by the spatial arrangement of point images into the image memory 118 on a frame-by-frame manner. The buffered signal is swept out at a predetermined timing from the image memory 118 to the video signal output circuit 120, and is displayed on the monitor 300 after being converted into a video signal complying with a predetermined standard, such as NTSC (National Television System Committee) or PAL (Phase Alternating Line). On a display screen of the monitor 300, a three-dimensional confocal image (which may be simply referred to as an "endoscopic image" in this specification) with a high magnification and a high resolution is displayed.

[0037] As described above, since the subject image is configured through the remapping operation, the tip 202a needs to be rotated to draw an ideal spiral scanning pattern so that an endoscopic image without distortion can be obtained. However, typically the property of each of the components constituting the scanning confocal endoscope system 1 varies within a certain range. Therefore, it is impossible to obtain an ideal

scanning trajectory shown in Fig. 3 if the components are assembled simply.

Therefore, in the scanning confocal endoscope system 1 according to the embodiment, the scanning area adjustment described later is performed in a factory to cancel the product-specific property of this type and to obtain an ideal spiral scanning pattern.

[0038] Fig. 6 is a schematic diagram illustrating the scanning area adjustment apparatus 400 used for the scanning area adjustment of the scanning confocal endoscope system 1. In the scanning area adjustment, the scanning area of the excitation light emitted from the tip 202a of the optical fiber 202 is observed on the monitor 300, and the amplitude and the phase of the alternating voltages X and Y to be applied to the biaxial actuator 204C are adjusted so that the scanning area being observed becomes an ideal scanning area (i.e., the scanning trajectory of the excitation light emitted from the confocal optical unit 204 becomes a reference scanning trajectory). Then, the remapping table is created. In the following, parameters adjusted in the scanning area adjustment, namely the amplitude and the phase of the alternating voltages X and Y are collectively referred to as "adjustment parameters".

[0039] As shown in Fig. 6, the scanning area adjustment apparatus 400 includes a unit support member 420, a case 402, an XYZ stage 408, a position adjustment knob 410 and a current-voltage conversion circuit 412.

[0040] The unit support member 420 is a cylindrical member fixed to a main body of the scanning area adjustment apparatus 400, and is configured such that an inner diameter thereof is slightly larger than the outer diameter of the confocal optical unit 204. During the scanning area adjustment, the confocal optical unit 204 is inserted into the inside of the unit support member 420, and is positioned in each of X, Y and Z directions.

[0041] To the case 402, a PSD 404, a PSD substrate 405 and a relay lens unit 406 are attached. The PSD 404 which is an optical position detection sensor having a known configuration is mounted on the PSD substrate 405, and is arranged on the proximal side of the case 402 such that a light-receiving surface thereof is located in the XY plane (i.e., such that the light-receiving surface is perpendicular to Z-direction). The PSD 404 is a sensor which receives the excitation light emitted from the confocal optical unit 204, and detects the position of the excitation light (i.e., the position of the excitation light on a light-receiving surface 404a). During the scanning area adjustment which is described later, the PSD 404 detects the position of each sampling point. The relay lens unit 406 is arranged on the tip side (the confocal optical unit 204 side) in the case 402 so that the optical axis thereof is directed to Z-direction. The relay lens unit 206 is a so-called magnifying optical system including a plurality of lenses therein, and is arranged such that the optical axis thereof passes through the center on the light-receiving surface 404a of the PSD 404 and a rear focal point F2 is located at the center

of the light-receiving surface 404a of the PSD 404. Furthermore, the front focal point F1 of the relay lens unit 406 is adjusted by the scanning area adjustment described later such that the front focal point F1 substantially coincides with the focal point of the objective optical system 204D of the confocal optical unit 204 (i.e., a convergence point of the excitation light). That is, the relay lens unit 406 serves to magnify a projected image (i.e., the scanning area (a maximum swing width) of the excitation light) at the convergence point of the excitation light emitted from the confocal optical unit 204. The magnification of the relay lens unit 406 is determined by totally considering various factors including the size of the scanning area of the excitation light, and the size and the position detection resolution of the PSD 404. Assuming a PSD commercially available, it is desirable that, from the position detection resolution thereof, the magnification of the relay lens unit 406 is set so that the size of the scanning area magnified by the relay lens unit 406 has a size larger than or equal to 1mm on the light-receiving surface of the PSD 404. Furthermore, from viewpoints of the device size and the response speed, it is desirable to use the PSD 404 having the light-receiving surface formed to be as small as possible. Therefore, it is desirable that the magnification of the relay lens unit 406 is set to, for example, approximately 2 to 20 magnifications in view of the resolution and the device size. For this reason, in this embodiment, the diameter of the scanning area of the excitation light emitted from the confocal optical unit 204 (i.e., the maximum swing width at the convergence point of the excitation light) is set to 500 mm, and the magnification of the relay lens unit 10 is set to 10 magnifications assuming the size, the position detection resolution and the response speed of a commercially available PSD 404. Therefore, the scanning trajectory of the excitation light emitted from the confocal optical unit 204 is magnified by the relay lens unit 406, and scans on the light-receiving surface of the PSD 404 to draw a circle having the diameter of 5mm at the maximum. The inside of the case 402 is shielded to prevent the external light from entering therein, and the PSD 404 detects the excitation light from the confocal optical unit 204 at a high SN ratio. When the excitation light impinges on the light-receiving surface 404a of the PSD 404, a detection current corresponding to the position of the excitation light is generated, and the detection current is outputted to the current-voltage conversion circuit 412 via the PSD substrate 405.

[0042] Fig. 7 is a front view of the PSD 404 according to the embodiment. The PSD 404 has the rectangular light-receiving surface 404a in the central portion thereof, and the light-receiving surface 404a is sealed by a cover glass 404b (Fig. 6). On the side of the cover glass 404b facing the light-receiving surface 404a, a coating formed of fluorescent material 404c (e.g., SiAlON phosphor) which produces fluorescence by the excitation light having the wavelength of 488nm and a fluorescence reflection coating 404d are

provided in sequence. In this embodiment, each coating is sufficiently thin, and the light-receiving surface 404a, the fluorescent material 404c and the fluorescence reflection coating 404d are regarded as being on substantially the same plane.

[0043] As shown in Fig. 7, the fluorescent material 404c of the embodiment is formed in a grid shape, and is formed in an area substantially equal to the light-receiving surface 404a so that, when the cover glass 404b is placed on the light-receiving surface 404a, the fluorescent material 404c formed in a grid shape is placed on the light-receiving surface 404a. Furthermore, in the fluorescent material 404c formed in a grid shape, grid lines 404cb respectively extending in X-direction and Y-direction (i.e., two grid lines perpendicularly intersecting with each other) and passing through the center of the light-receiving surface 404c are formed to be thick relative to the other grid lines 404ca. As described later, in this embodiment, the cross-shaped two grid lines 404cb form an indicator 404m indicating the center of the light-receiving surface 404a, and the other grid lines 404ca form a scale 404s for measuring the size and the shape of the scanning area of the excitation light.

[0044] When the excitation light is incident on the fluorescent material 404c during the scanning area adjustment, fluorescence produced from the fluorescent material 404c is incident on the tip 202a of the optical fiber 202, and a fluorescent image in a grid shape is displayed on the monitor 300 as an endoscopic image. In this embodiment, the PSD 404 having a light-receiving surface size of 10mm x 10mm which is sufficiently larger than the scanning area (having the diameter of 5mm) of the excitation light is used. The line widths of the scale 404s and the indicator 404m are sufficiently thin so that the position detection of the sampling point by the PSD 404 is not affected. In this embodiment, the line widths of the scale 404s and the indicator 404m are set to approximately 10mm and approximately 20mm, respectively. The scale 404s according to the embodiment is formed at pitches of 0.1mm; however, in Fig. 7 the scale 404s is thinned out for the sake of convenience.

[0045] The fluorescence reflection coating 404d (Fig. 6) is a coating for reflecting the fluorescence produced by the fluorescent material 404c. As described above, the fluorescence reflection coating 404d is arranged between the fluorescent material 404c and the light-receiving surface 404a, and all the fluorescence produced by the fluorescent material 404c is reflected toward the optical fiber 202 side. Therefore, the fluorescence produced by the fluorescent material 404c does not enter the light-receiving surface 404a, and the PSD 404 detects, at a high SN ratio, only the excitation light entering from the confocal optical unit 204 through the scale 404s.

[0046] The case 402 is fixed to the XYZ stage 408 which is movable in X, Y and Z directions through operation to the position adjustment knob 410 by a worker (Fig. 6). During the scanning area adjustment which is described later, the worker operates the

position adjustment knob 410 to adjust a relative positional relationship between the case 402 (i.e., the relay lens unit 406 and the PSD 404) and the confocal optical unit 204 fixed to the unit support member 420.

[0047] During the scanning area adjustment, the current-voltage conversion circuit 412 converts the detected current of the PSD 404 outputted from the PSD substrate 404 into a voltage, and outputs the voltage as a detected voltage to the CPU 108.

[0048] Fig. 8 is a flowchart of a scanning area adjustment program executed on the scanning confocal endoscope system 1 during the scanning area adjustment. Before the scanning area adjustment program is executed, the scanning area adjustment apparatus 400 and the system main body 100 are connected to each other via the cable 500, and the confocal optical unit 204 is inserted into the unit support member 420. In response to a predetermined instruction being inputted by the worker thorough a user interface (not shown) of the system main body 100, the scanning area adjustment program is executed by the CPU 108. For convenience of explanations, each processing step for the scanning area adjustment is abbreviated as "S" in this specification and drawings.

[0049] As shown in Fig. 8, when the scanning area adjustment program is started, the CPU 108 executes S11 to drive the confocal optical unit 204. Specifically, the CPU 108 controls the light source 102 so that the excitation light is emitted continuously, and controls the scan driver 210 to apply the predetermined alternating voltages X and Y to the biaxial actuator 204C. The predetermined alternating voltages X and Y mean reference (default) alternating voltages X and Y which have been determined in advance. When the predetermined alternating voltages X and Y are thus applied to the biaxial actuator 204C, the tip 202a of the optical fiber 202 rotates in response to the applied alternating voltages X and Y. The excitation light being emitted from the optical fiber 202 rotates and scans on the fluorescent material 404c or the light-receiving surface 404a of the PSD 404. When the excitation light is incident on the fluorescent material 404c, the produced fluorescence enters the tip 202a of the optical fiber 202 and is detected by the optical receiver 114, and then the produced fluorescence is displayed on the monitor 300 as an endoscopic image.

[0050] In S13, the CPU 108 judges whether the position adjustment of the PSD by the worker has finished. In order to adjust the scanning area of the excitation light emitted from the confocal optical unit 204, and to precisely detect the scanning trajectory of the excitation light by the PSD 404, it is necessary that the scanning area of the excitation light falls within the central portion of the light-receiving surface 404a of the PSD 404 and the fluorescence from the fluorescent material 404c is displayed on the monitor 300. However, the scanning area of the excitation light does not necessarily fall within the central portion of the light-receiving surface 404a of the PSD 404 by merely attaching the confocal optical unit 204 to the unit support member 420, due to a

product-specific property and a positional error caused when the confocal optical unit 204 is attached to the unit support member 420. For this reason, in this embodiment, the position of the light-receiving surface 404a is made adjustable so that the worker can check the scanning area of the excitation light on the light-receiving surface 404a of the PSD 404 on the monitor 300 and that the scanning area of the excitation light falls within the central portion of the light-receiving surface 404a of the PSD 404.

[0051] Specifically, the worker operates the position adjustment knob 410 to move the case 402 in Z-direction with respect to the confocal optical unit 204 while viewing the endoscopic image being displayed on the monitor 300. Then, the adjustment is conducted so that the fluorescence produced by the fluorescent material 404c is displayed on the monitor 300 as an endoscopic image. As described above, since the light-receiving surface 404a and the fluorescent material 404c are arranged to be on substantially the same plane, the tip 202a of the optical fiber 202 is precisely arranged at the front side focal point of the objective optical system 204D and becomes optically conjugate with the light-receiving surface 404a when the fluorescence produced by the fluorescent material 404c is displayed on the monitor 300 as an endoscopic image. Fig. 9 illustrates a positional relationship between a scanning area A of the excitation light and the PSD 404 when the tip 202a of the optical fiber 202 is arranged at the front focal point of the objective optical system 204D. As shown in Fig. 9, the scanning area A of the excitation light does not necessarily coincide with the center of the PSD 404 due to a product-specific property and a positional error caused when the confocal optical unit 204 is attached to the unit support member 420; however, when the tip 202a of the optical fiber 202 is arranged at the front focal point of the objective optical system 204D, fluorescence is produced from the fluorescent material 404c included in the scanning area A (the upper right side of the peripheral part of the scale 404s on the light-receiving surface 404a in Fig. 9), and a fluorescence image in a grid shape is observed on the monitor 300.

[0052] Then, the worker operates the position adjustment knob 410 while viewing the endoscopic image (the fluorescence image in the scanning area A) displayed on the monitor 300, and moves the case 402 in X and Y directions with respect to the confocal optical unit 204. Then, the worker moves the case 402 so that the fluorescence (i.e., a thick cross-shaped fluorescence image) from the indicator 404m is displayed on the monitor 300, and conducts the adjustment so that the center of the scanning area A substantially coincides with the center of the PSD 404 (i.e., the center of the indicator 404m). Fig. 10 schematically illustrates a situation where the center of the scanning area A moves to the center of the PSD 404. In Fig. 10, the worker moves the confocal scanning unit 204 in the upper right direction based on the fluorescence image displayed on the monitor 300 so that the center of the scanning area A moves to

the center of the PSD 404. When the center of the scanning area A is adjusted to substantially coincide with the center of the PSD 404 (i.e., the center of the indicator 404m), the center axis AX (i.e., the axis center of the optical fiber 202 arranged in Z-direction) coincides with the optical axis of the relay lens unit 406, and the thick cross-shaped fluorescence image is displayed at a central portion of a screen in a state where the thick cross-shaped fluorescence image is included in the fluorescence image in a grid shape produced in the scale 404s.

[0053] As described above, in S13, the worker operates the position adjustment knob 410 while viewing the endoscopic image displayed on the monitor 300 to move the case 402 in X, Y and Z directions with respect to the confocal optical unit 204. Then, the worker conducts the adjustment so that the scanning trajectory of the excitation light is located at the center of the light-receiving surface 404a of the PSD 404, and, after the adjustment, the worker enters a predetermined input through the user interface (not shown) of the system main body 100. The CPU 108 waits until the predetermined input is received from the worker (S13: NO). When the predetermined input is received from the worker, the CPU 108 judges that the position adjustment of the PSD 404 has finished (S13: YES), and the process proceeds to S15.

[0054] In S15, the CPU 108 changes the adjustment parameter (the scanning parameter) of the alternating voltages X and Y applied to the biaxial actuator 204C in accordance with the operation for the user interface (not shown) by the worker. As described above, since the scanning area A of the excitation light varies due to a product-specific property, the scanning area A does not necessarily become an ideal scanning area (i.e., the reference scanning trajectory) in the nonadjusted state. For this reason, in this step, the worker conducts the adjustment so that the scanning area A of the excitation light becomes an ideal scanning area by operating the user interface while viewing the endoscopic image displayed on the monitor 300. By S13, the fluorescence produced by the scale 404s and the indicator 404m is displayed on the monitor 300. Therefore, by counting the number of squares of the scale 404s displayed on the monitor 300 in the vertical and horizontal directions, the worker is able to know the size and shape (circularity) of the scanning area A. When the worker judges that the scanning area A has not become the predetermined size and operates the user interface, the CPU 108 adjusts the amplitudes of the alternating voltages X and Y in response to the input from the user interface so as to enlarge or reduce the scanning area A. When the worker judges that the scanning area A has not become the predetermined shape and operates the user interface, the CPU 108 adjusts the phases of the alternating voltages X and Y in response to the input from the user interface so as to change the shape of the scanning area A. In this step, the scanning area A of the excitation light is adjusted so that the scanning area A becomes an ideal scanning area (i.e., a circular scanning area

having the diameter of 5mm), and when an input for terminating the scanning area adjustment is inputted through the user interface, the process proceeds to S17.

[0055] In S17, the CPU 108 detects the scanning trajectory of the excitation light scanning spirally on the light-receiving surface of the PSD 404. Specifically, the CPU 108 detects the current outputted from each electrode of the PSD 404 at a predetermined timing, and executes a known calculation so as to figure out the spot formation position of the excitation light on the PSD 404. As described above, the scanning area A has been adjusted so as to become an ideal scanning area in S15, the spot formation position of the excitation light moves along the ideal scanning trajectory formed in a circular spiral shape. Then, the process proceeds to S19.

[0056] In S19, the CPU 108 obtains the relationship between the sampling point and the pixel position (pixel address) of the endoscopic image, and creates a remapping table. Then, the CPU 108 stores the created remapping table in the CPU memory 110 together with the adjusted adjustment parameter (i.e., the amplitude and the phase of the alternating voltages X and Y), and terminates the scanning area adjustment program.

[0057] As described above, in the scanning area adjustment according to the embodiment, the scanning trajectory (scanning area) of the excitation light emitted from the confocal optical unit 204 is enlarged by the relay lens unit 406 and is received by the PSD 404. The cover glass 404b of the PSD 404 is coated with the fluorescent material 404c, and the worker is able to conduct the adjustment so that the scanning area A is located at the center of the light-receiving surface 404a of the PSD 404 while viewing the endoscopic image (i.e., the fluorescence image in the scanning area A) displayed on the monitor 300 and that the scanning area A becomes an ideal scanning area. As described above, the scanning trajectory of the excitation light emitted from the confocal optical unit 204 is enlarged to the extent that the adjustment is not affected by the resolution of the PSD 404, and the scanning trajectory of the excitation light is adjusted to an ideal scanning trajectory and is received securely on the light-receiving surface 404a of the PSD 404. Therefore, even for the scanning confocal endoscope system 1 according to the embodiment configured to scan within a narrow scanning area, it is possible to securely detect the scanning trajectory of the scanning light with a high degree of precision. As a result, it becomes possible to precisely determine the relationship between each sampling point on the scanning trajectory and the pixel position of the endoscopic image displayed on the monitor 300.

[0058] The foregoing is the explanation about the embodiment of the invention. However, the present invention is not limited to the above described embodiment, and can be varied within the technical concept of the invention. For example, in the above described embodiment, the scanning area adjustment program is executed by the CPU

108; however, the invention is not limited to such a configuration. The scanning area adjustment program may be executed by the current-voltage conversion circuit 412. In this case, the current-voltage conversion circuit 412 may be configured to change the adjustment parameter through communication with the CPU 108.

- [0059] In the above described embodiment, the magnification of the relay lens unit 406 is 10 magnifications; however, the magnification of the relay lens unit 406 may be set to 2 to 20 magnifications. By increasing the magnification of the relay lens unit 406 within a range where the scanning area of the excitation light on the PSD 404 falls within the light-receiving surface 404a of the PSD 404, it becomes possible to more precisely detect the scanning trajectory of the excitation light.
- [0060] A system to which the present invention can be applied is not limited to the scanning confocal endoscope system according to the embodiment. For example, the present invention may be applied to a scanning confocal endoscope system employing a raster scanning manner in which light horizontally scans on a scanning area to reciprocate or a Lissajous scanning manner in which light sinusoidally scans on a scanning area.
- [0061] In the above described embodiment, the confocal optical unit 204 is installed in the tip of the confocal endoscope 200. However, the confocal optical unit 204 may be installed in a confocal probe inserted into an instrument insertion channel of an endoscope.
- [0062] A position detection device to be installed in the scanning area adjustment apparatus 400 is not limited to a PSD. The PSD 404 may be replaced with another device which is able to detect the position and the light amount, such as a CCD (Charge Coupled Device) and an array type PMT (Photomultiplier Tube).
- [0063] In the scanning area adjustment according to the embodiment, the worker operates the position adjustment knob 410 while viewing the endoscopic image displayed on the monitor 300, so as to move the case 402 in X, Y and Z directions with respect to the confocal optical unit 204. However, the present invention is not limited to such a configuration. For example, the XYZ stage 408 may be moved by a motor, and in this case the CPU 108 may automatically execute the position adjustment so that the scanning area A of the excitation light is located at the center of the light-receiving surface 404a of the PSD 404.
- [0064] The fluorescent material 404c according to the embodiment is formed as a coating applied to the back side (the light-receiving surface 404a side) of the cover glass 404b. However, the present invention is not limited to such a configuration. The fluorescent material 404c may be material that produces fluorescence by receiving excitation light having the wavelength of 488nm. Therefore, for example, the fluorescent material 404c may be formed by adhering yellow cloth (a fiber which produces yellow fluorescence) containing fluorescent paint to the cover glass 404b. The scale 404s and the

indicator 404m may be formed by forming mark-off lines on the back side of the cover glass 404b and applying fluorescent paint to the mark-off lines.

- [0065] In the above described embodiment, the fluorescent reflection coating 404d is provided on the coating of the fluorescent material 404c. However, when the fluorescence produced by the fluorescent material does not affect the position detection of the excitation light by the PSD 404, the fluorescence reflection coating 404d may be omitted.
- [0066] In the above described embodiment, the fluorescent material 404c forms the scale 404s in a grid form and the thick cross-shaped indicator 404m. However, when the effect by positional errors caused when the confocal optical unit 204 is attached to the unit support member 420 or by a product-specific property is sufficiently low and thereby the scanning area A of the excitation light is surely located at the central portion on the light-receiving surface 404a of the PSD 404, the scale 404s situated in the peripheral part of the light-receiving surface 404a of the PSD 404 is not necessary, and therefore the scale 404s in a grid shape is not necessarily required. In this case, as shown in Fig. 11, by forming scale lines 404ma at predetermined positions on the indicator 404m to perpendicularly intersect with the indicator 404m, it is possible to measure the size and the shape of the scanning area A as in the case of the above described embodiment.
- [0067] In the above described embodiment, the fluorescent material 404c is formed within the area which is substantially equal to the light receiving surface 404a of the PSD 404. However, when the effect by positional errors caused when the confocal optical unit 204 is attached to the unit support member 420 or by a product-specific property is large, the scale 404s in a grid shape may be enlarged in an area which is larger than the light-receiving surface 404a of the PSD 404 as shown in Fig. 12.
- [0068] In the above described embodiment, the cross-shaped indicator 404m is formed by the two grid lines 404cb perpendicularly intersecting with each other and passing through the center of the light-receiving surface 404a. However, since the indicator 404m may be configured to locate the central portion of the light-receiving surface 404a, and the indicator 404m is not limited to the grid lines extending in X and Y directions. For example, the indicator 404m may be a mark having a predetermined shape (e.g. a x-shaped mark or a circular mark).
- [0069] In the above described embodiment, the scale 404s is formed by the grid lines in a grid shape extending in X and Y directions. However, the scale 404s may be a scale enabling measuring the size and the shape of the scanning area A, and therefore the scale 404s is not limited to the grid lines in a grid shape extending in X and Y directions.
- [0070] In the above described embodiment, the fluorescent material 404c is formed in the

inside of the PSD 404 (on the back side (the light-receiving surface 404a side) of the cover glass 404b); however, the present invention is not limited to such a configuration. Fig. 13 illustrates a variation of the scanning area adjustment apparatus 400 according to the embodiment. A scanning area adjustment apparatus 400M according to the variation is different from the scanning area adjustment apparatus 400 according to the embodiment in that the scanning area adjustment apparatus 400M includes a beam splitter 403, and includes a fluorescent material 407 on the outside of the PSD 404 in place of the fluorescent material 404c.

[0071] The beam splitter 403 is arranged between the relay lens unit 406 and the PSD 404, and lets 50% of the excitation light proceeding from the relay lens unit 406 to the PSD 404 pass therethrough and lets the other 50% of the excitation light proceeding from the relay lens unit 406 to the PSD 404 be reflected therefrom. The excitation light which has passed through the beam splitter 403 is incident on the PSD 404 and the scanning trajectory thereof is detected as in the case of the embodiment. On the other hand, the excitation light reflected by the beam splitter 403 is incident on the fluorescent material 407 to produce the fluorescence. A surface of the fluorescent material 407 is coated with a fluorescent material having the same pattern as the scale 404s and the indicator 404m according to the embodiment, and is arranged at a position which is optically equivalent to the position of the light-receiving surface 404a of the PSD 404. Therefore, the fluorescence produced in the fluorescent material 407 enters the tip 202a of the optical fiber 202 after proceeding along the same path for the excitation light and, and then is displayed, as an endoscopic image, on the monitor 300. Therefore, even for the above described configuration where the fluorescent material 407 is arranged outside the PSD 404, it is possible for the worker to conduct adjustment so that the scanning area A is located at the center of the light-receiving surface 404a of the PSD 404 while viewing the endoscopic image (i.e., a fluorescent image in the scanning area A) displayed on the monitor 300, and to conduct adjustment so that the scanning area A becomes an ideal scanning area.

Claims

[Claim 1]

A scanning area adjustment apparatus for a scanning confocal endoscope system configured to have a light scanning device which causes excitation light with a predetermined wavelength from a light source to periodically scan within a predetermined scanning area on a subject, to receive fluorescence from the subject excited by the excitation light emitted from the light scanning device and thereby to display an confocal image,

the scanning area adjustment apparatus comprising:

- a relay lens to which the excitation light emitted from the light scanning device enters and which enlarges the predetermined scanning area;
- a light detection means configured to receive the excitation light emerging from the relay lens on a light-receiving surface of the light detection means perpendicularly arranged with respect to an optical axis of the relay lens and to detect a scanning position of the received excitation light on the light-receiving surface;
- a fluorescent material that is arranged at a position optically equivalent to the light-receiving surface and emits fluorescence when the excitation light emerging from the relay lens is incident on the fluorescent material;
- a moving means configured to move the relay lens and the light detection means relative to the light scanning device in response to an operation input by a worker;
- an scanning area change means configured to change the scanning area of the excitation light emitted from the light scanning device in response to an operation input of the worker; and
- a mapping means configured to assign the scanning position of the excitation light detected by the light detection means to a pixel of the confocal image,

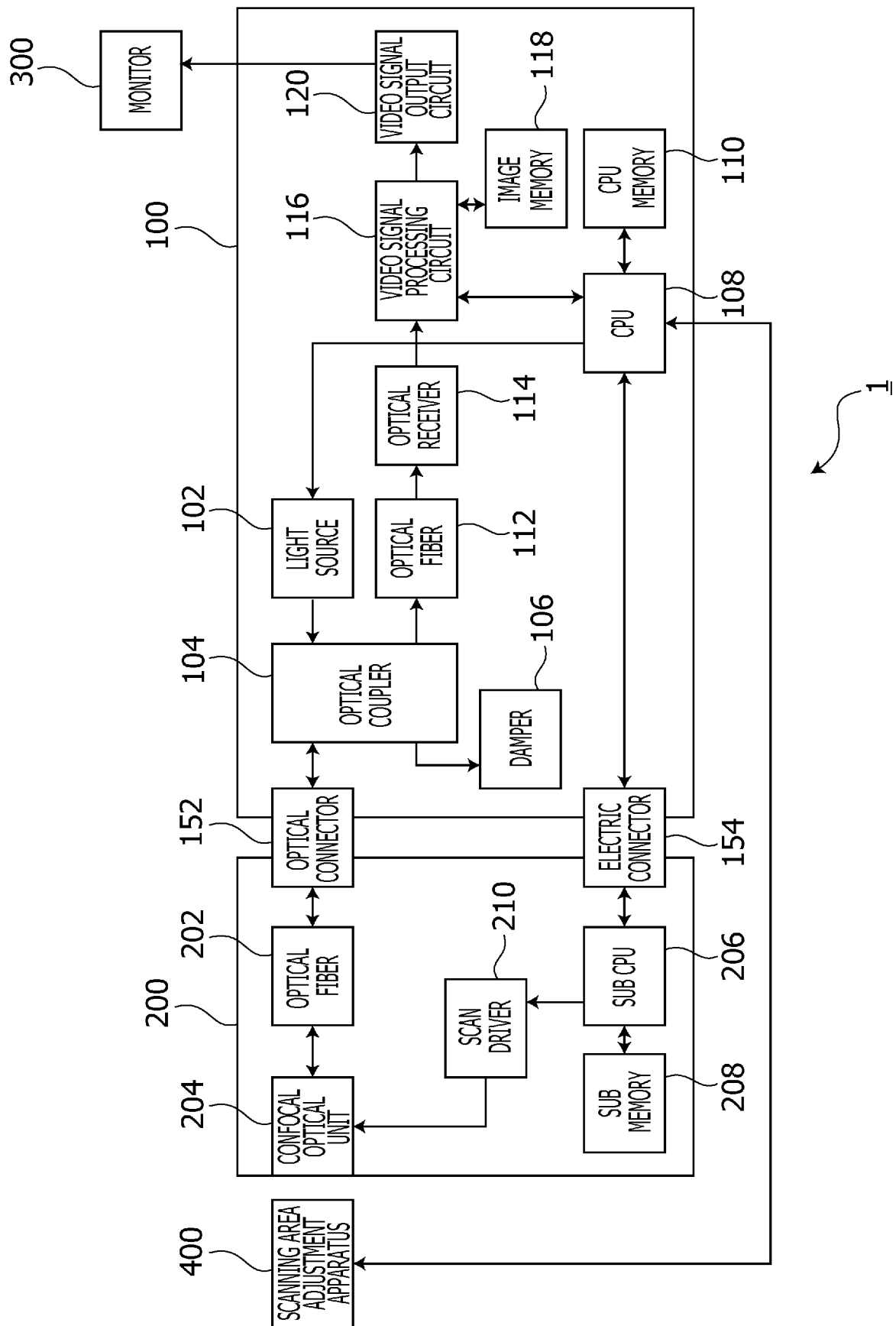
wherein:

- the relay lens is arranged such that a rear focal point of the relay lens substantially coincides with a center position of the light-receiving surface; and
- the fluorescent material comprises a scale part enabling measurement of a size of the predetermined scanning area of the excitation light emitted from the light scanning device.

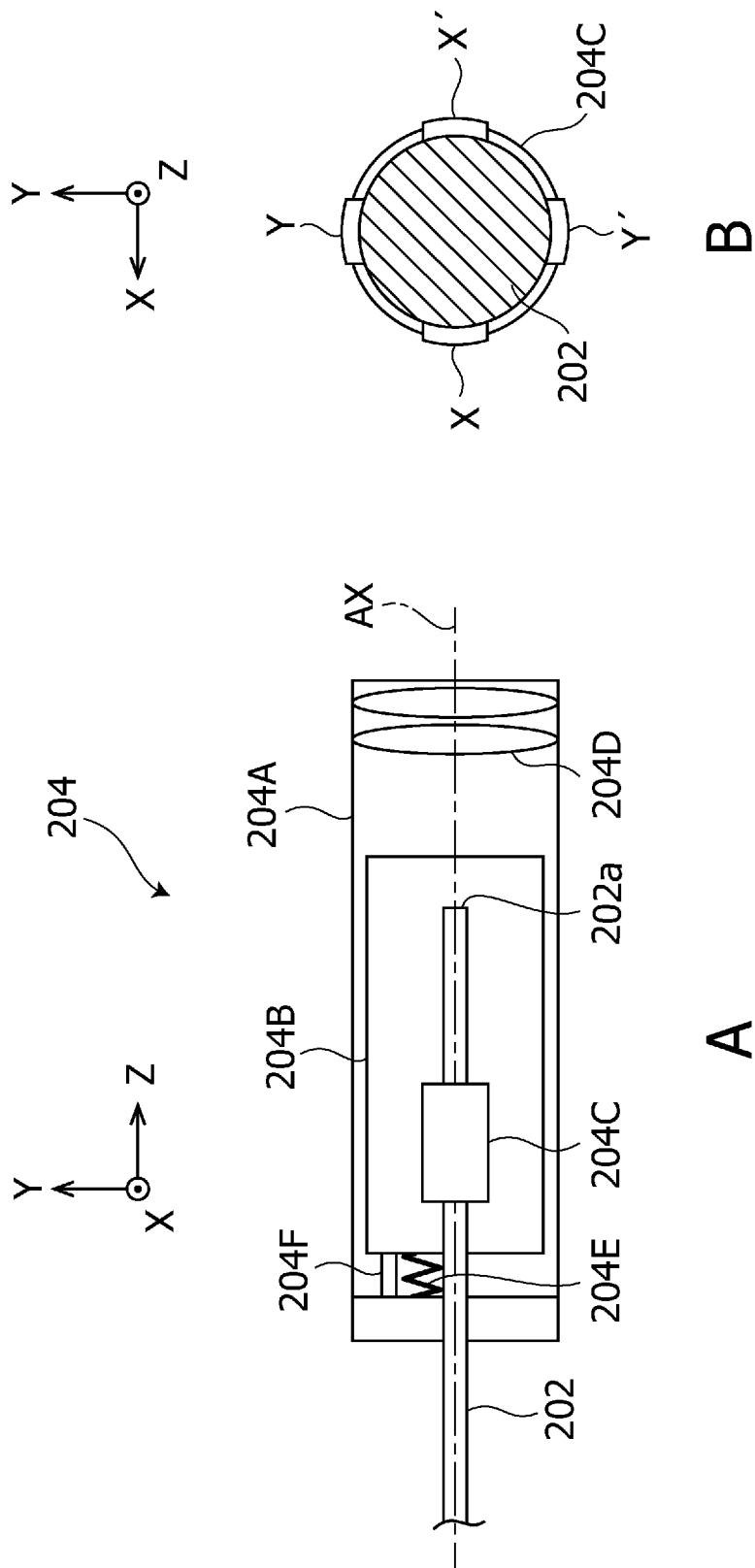
- [Claim 2] The scanning area adjustment apparatus according to claim 1, wherein:
the fluorescent material comprises a indicator part indicating a position equivalent to the center position of the light-receiving surface; and
the moving means moves the relay lens and the light detection means so that a center of the scanning area of the excitation light emerging from the relay lens substantially coincides with the indicator part.
- [Claim 3] The scanning area adjustment apparatus according to claim 2, wherein the indicator part is a cross-shaped indicator formed by two lines which perpendicularly intersect with each other and perpendicularly intersect with the optical axis of the relay lens at the position equivalent to the center position of the light-receiving surface.
- [Claim 4] The scanning area adjustment apparatus according to claim 3, wherein the scale part is formed at predetermined intervals to perpendicularly intersect with the cross-shaped indicator in a plane which is equivalent to the light-receiving surface.
- [Claim 5] The scanning area adjustment apparatus according to any of claims 1 to 4, wherein the scale part is formed in a grid shape at least within an area corresponding the light-receiving surface.
- [Claim 6] The scanning area adjustment apparatus according to claim 5, wherein:
the scale part comprises two grid lines perpendicularly intersecting with each other at a position equivalent to the center position of the light-receiving surface; and
the two grid lines are formed to be thicker than other grid lines of the scale part.
- [Claim 7] The scanning area adjustment apparatus according to any of claims 1 to 6; wherein:
the light detection means comprises a cover glass on a front side of the light-receiving surface; and
the fluorescent material is provided to coat a surface of the cover glass facing the light-receiving surface.
- [Claim 8] The scanning area adjustment apparatus according to claim 7, wherein a fluorescence reflection coating which reflects the fluorescence produced by the fluorescent material is provided on the fluorescent material.

- [Claim 9] The scanning area adjustment apparatus according to any of claims 1 to 8, further comprising a beam splitter arranged between the relay lens and the light detection means,
wherein the beam splitter divides the excitation light incident thereon through the relay lens to let the incident excitation light proceed to the light detection means and the fluorescent material, and reflects the fluorescence produced by the fluorescent material toward the relay lens.
- [Claim 10] The scanning area adjustment apparatus according to any of claims 1 to 9,
wherein the scanning area change means comprises:
a first adjustment means that enlarges or reduces the scanning area of scanning light; and
a second adjustment means that changes a shape of the scanning area of the scanning light.
- [Claim 11] The scanning area adjustment apparatus according to any of claims 1 to 10,
wherein the mapping means creates a remapping table by sampling the scanning position of the excitation light detected by the light detection means at a predetermined timing and by assigning a pixel of the confocal image to each sampling point.
- [Claim 12] The scanning area adjustment apparatus according to any of claims 1 to 11,
wherein the relay lens, the light detection means and the fluorescent material are accommodated in a single case.
- [Claim 13] The scanning area adjustment apparatus according to claim 12,
wherein the case is a shielding case which shields the light detection means from external light.

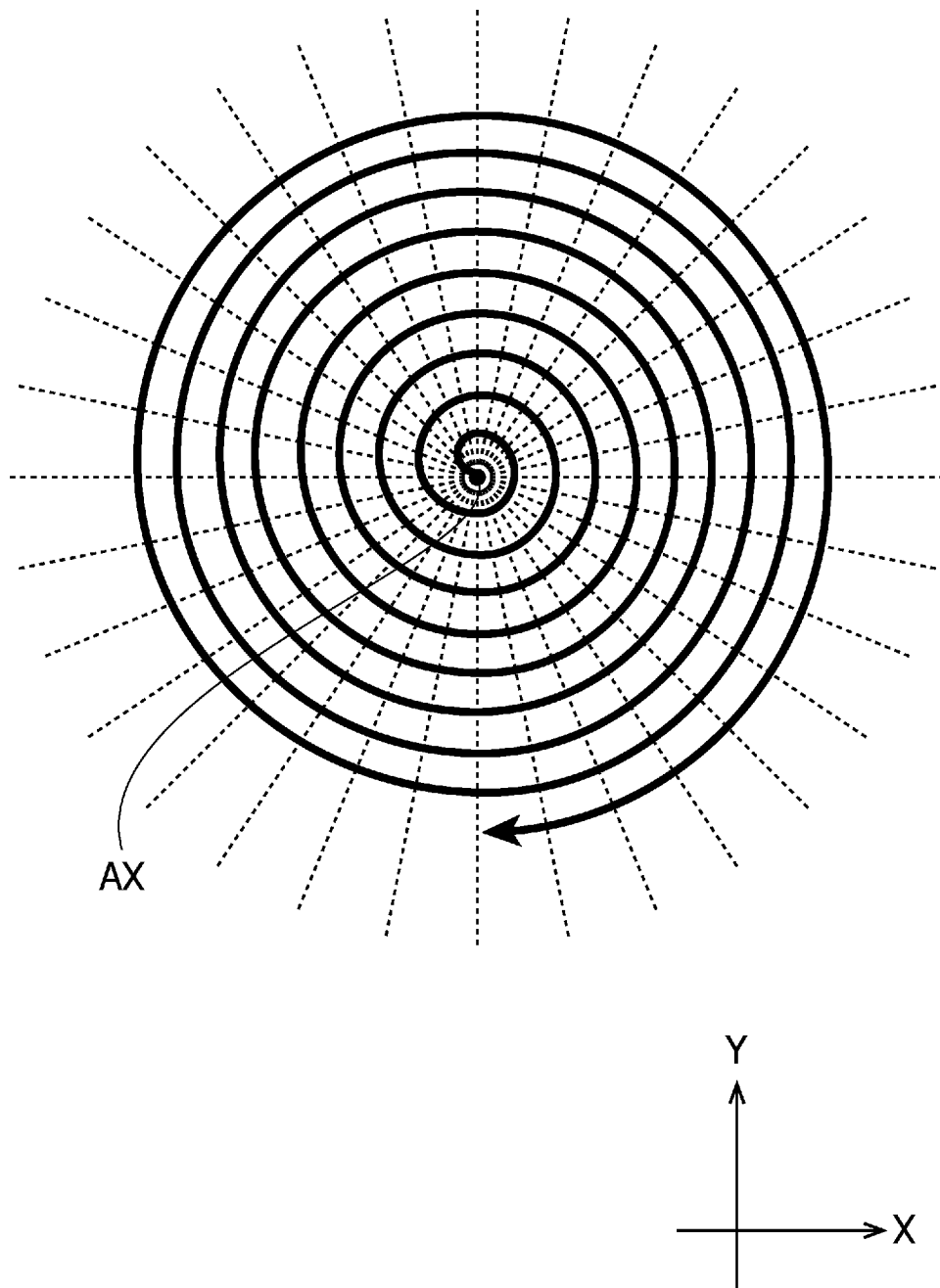
[Fig. 1]



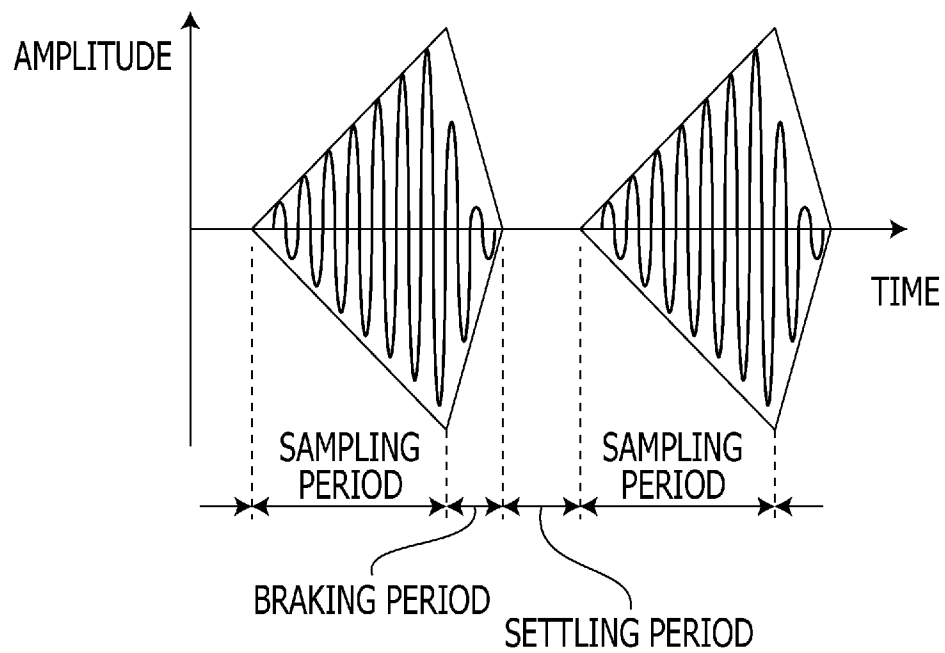
[Fig. 2]



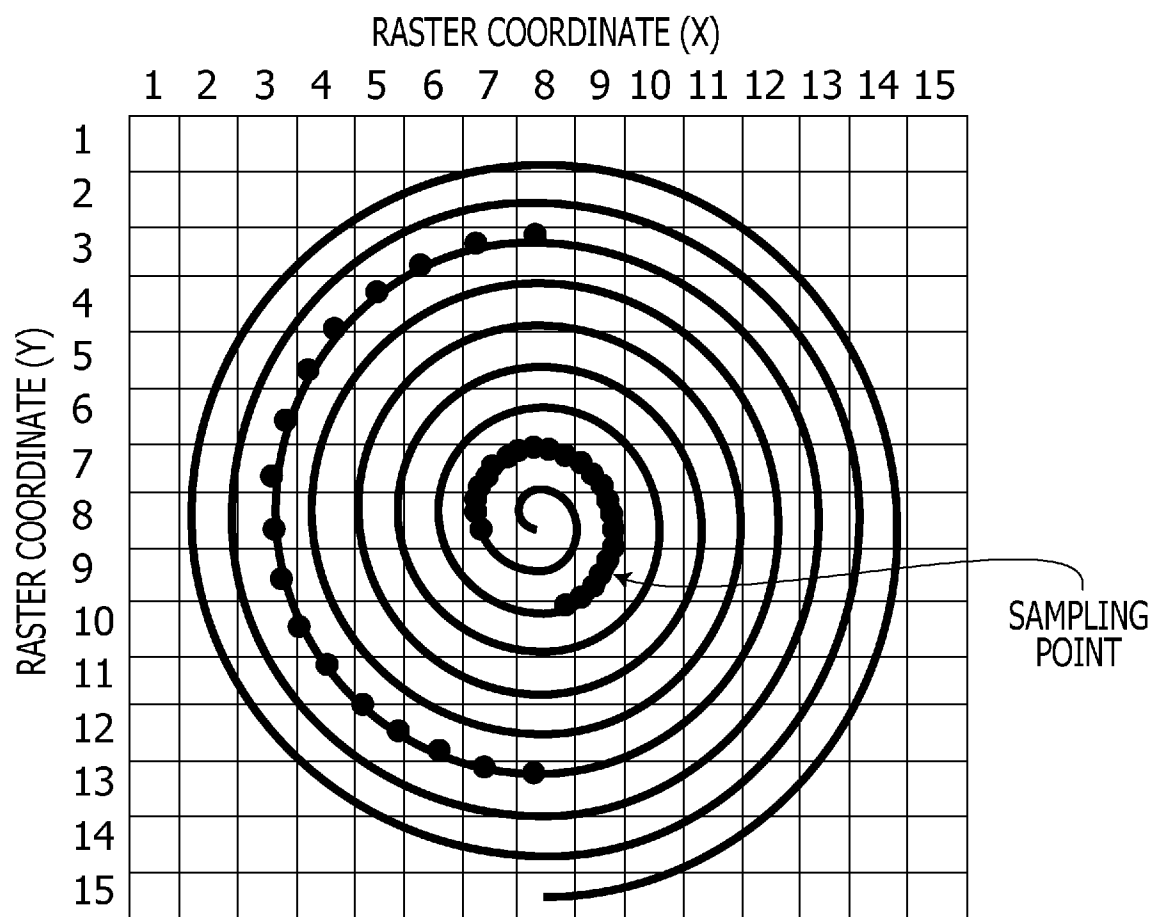
[Fig. 3]



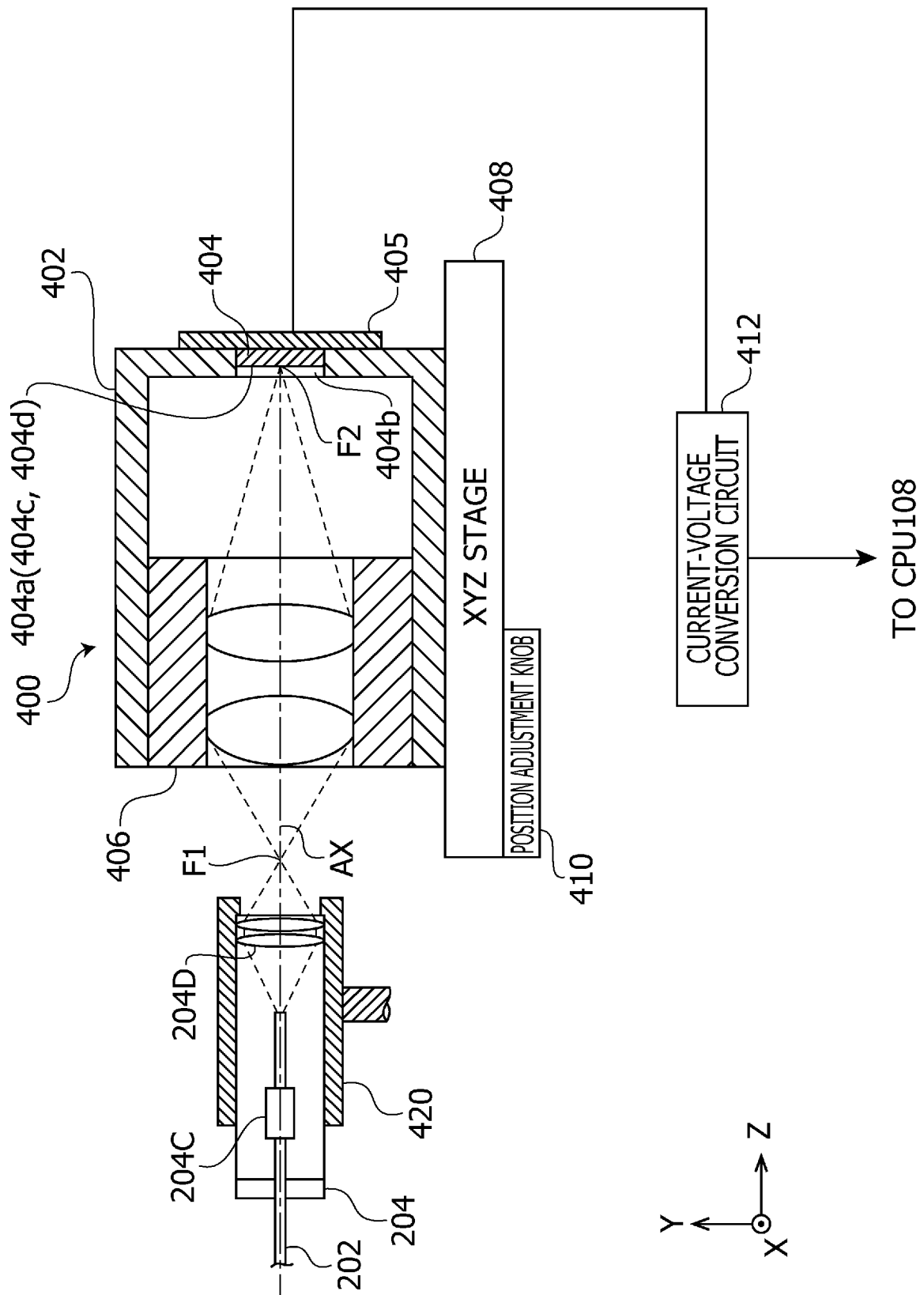
[Fig. 4]



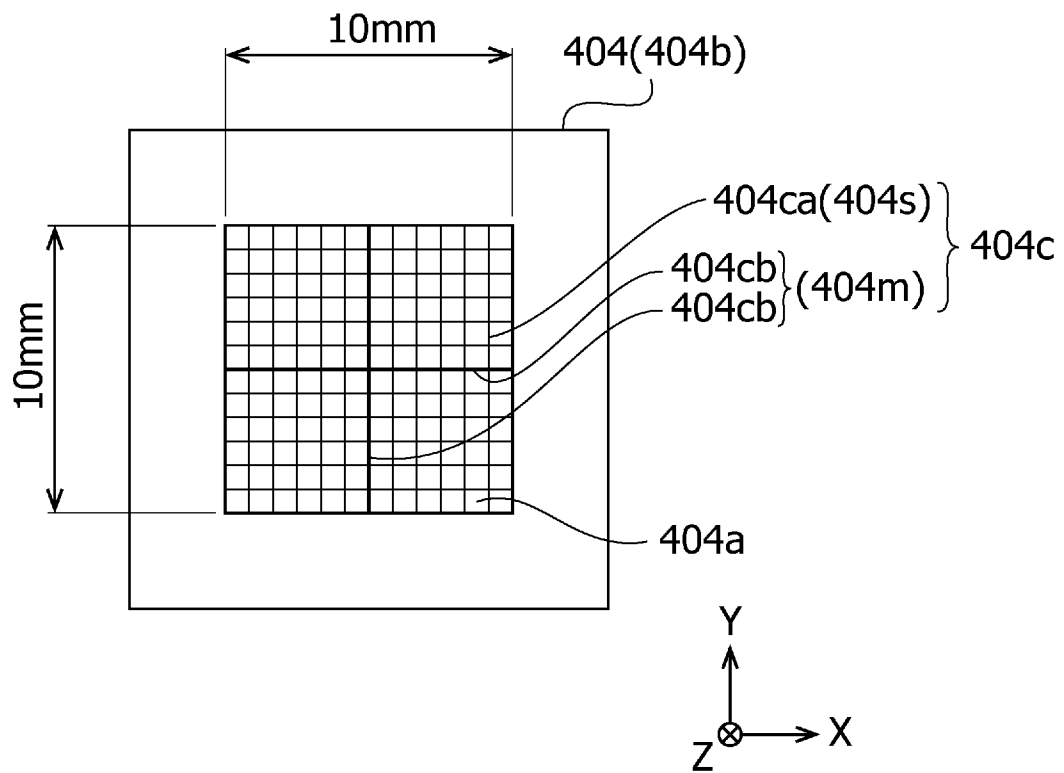
[Fig. 5]



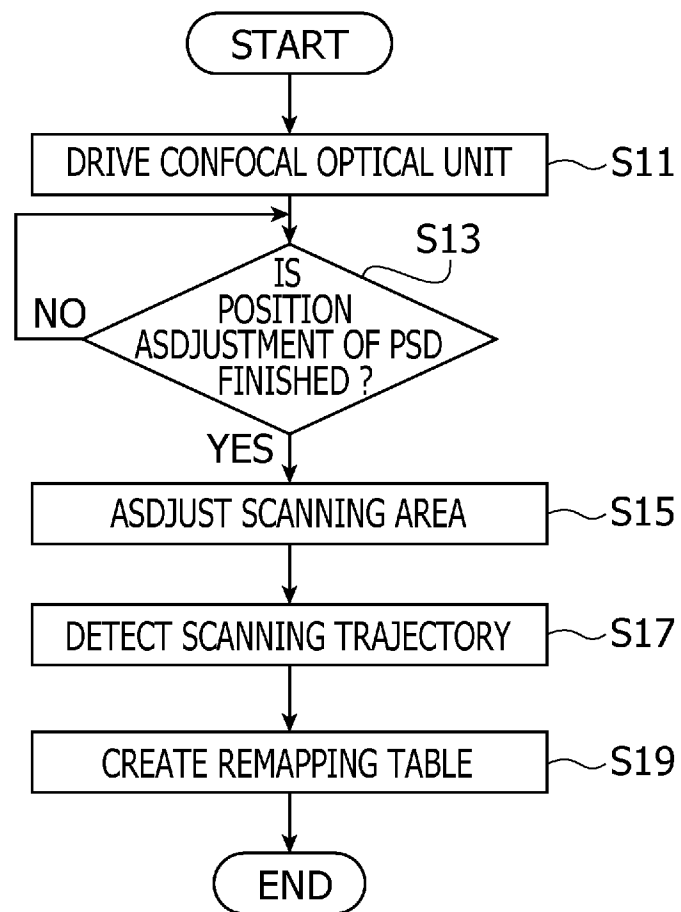
[Fig. 6]



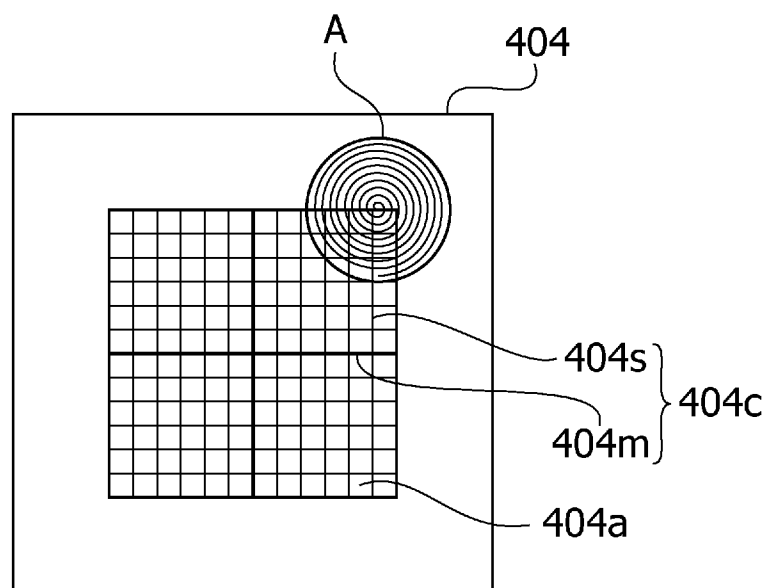
[Fig. 7]



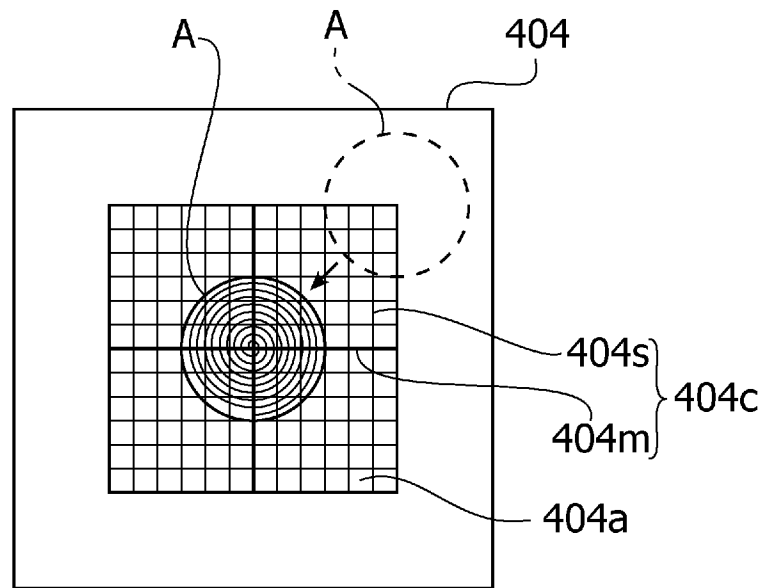
[Fig. 8]



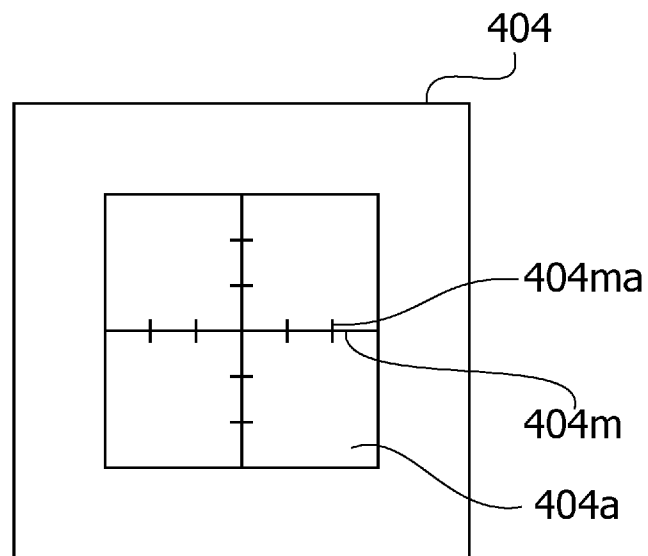
[Fig. 9]



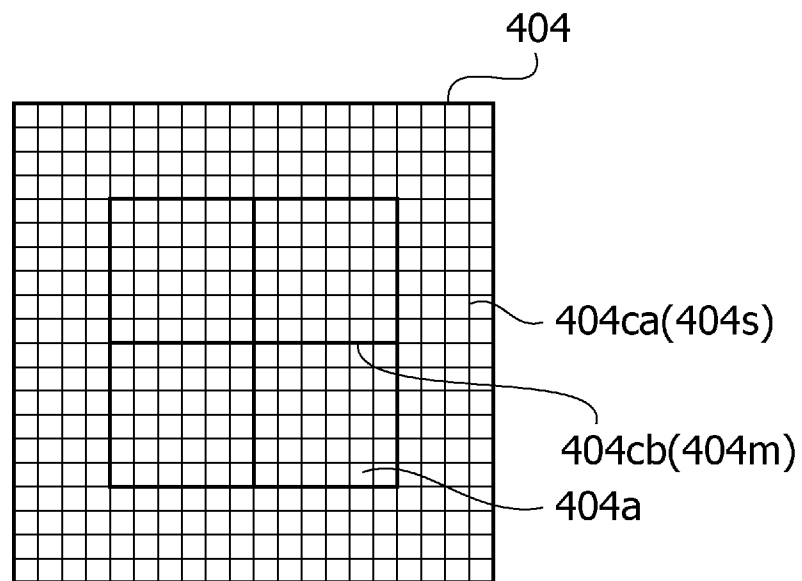
[Fig. 10]



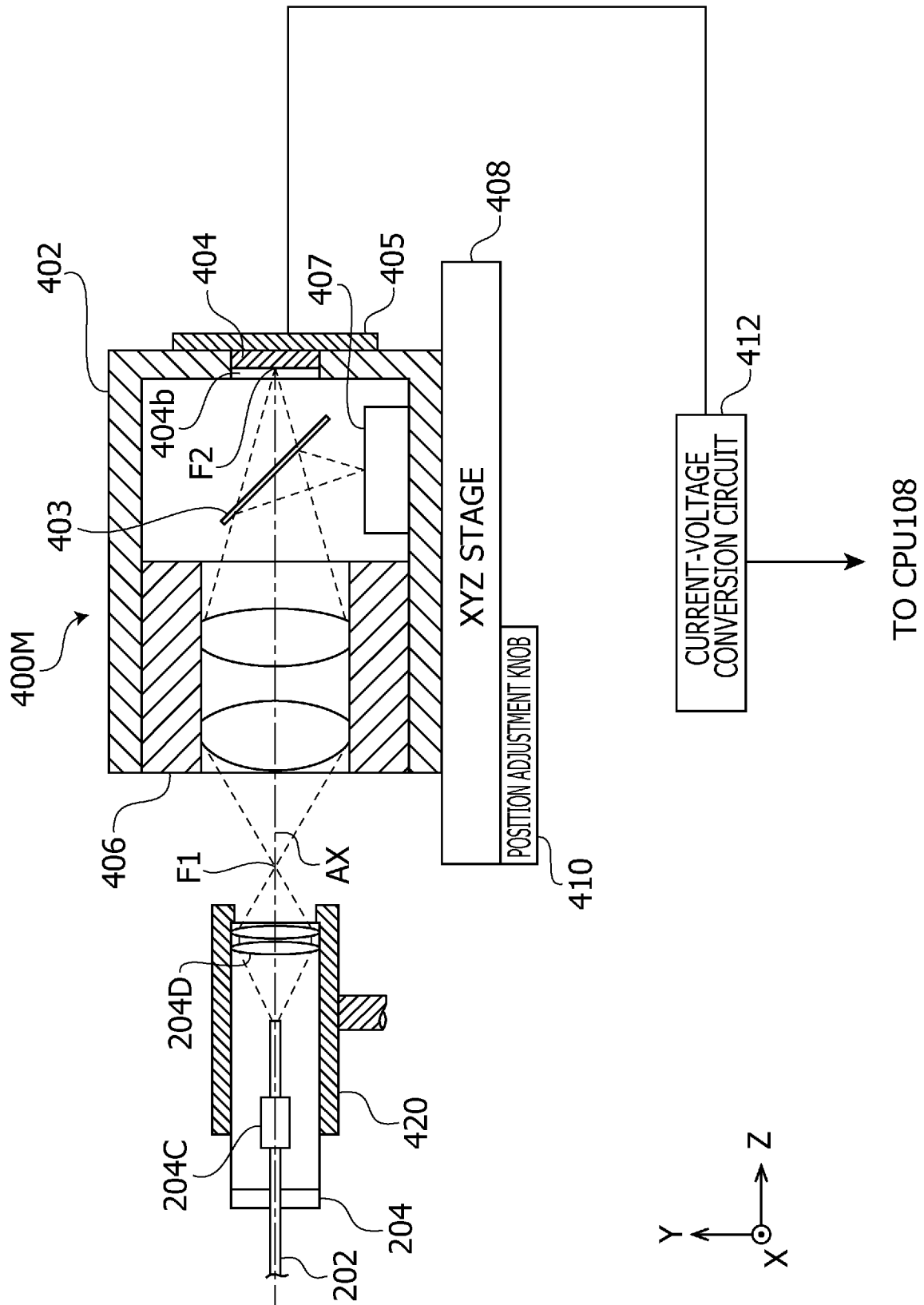
[Fig. 11]



[Fig. 12]



[Fig. 13]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/004441

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. A61B1/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. A61B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2013
 Registered utility model specifications of Japan 1996-2013
 Published registered utility model applications of Japan 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-110479 A (HOYA CORPORATION) 2012.06.14, 【0008】, 【0032】, 【0033】, FIG.1-3 & WO 2012/070298 A1 & AU 2011333119 A	1-13
A	JP 2008-514342 A (UNIVERSITY OF WASHINGTON) 2008.05.08, 【0034】 - 【0046】, FIG.5 & EP 1805779 A & WO 2006/041452 A1	1-13
A	JP 2005-6854 A (OLYMPUS CORPORATION) 2005.01.13, 【0010】, FIG.1 (No Family)	1-13
A	JP 2011-24891 A (HOYA CORPORATION) 2011.02.10, 【0014】, FIG.3 (No Family)	1-13

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

13.08.2013

Date of mailing of the international search report

20.08.2013

Name and mailing address of the ISA/JP

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan

Authorized officer

MASAKAZU HIGUMA

Telephone No. +81-3-3581-1101 Ext. 3292

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