

Title of the Invention

ENCODER

Incorporation by Reference

The present disclosure contains subject matter related to that disclosed in Japanese Priority Patent Application JP 2013-229835 filed in the Japan Patent Office on November 5th, 2013, the entire contents of which are hereby incorporated by reference.

BACKGROUND

Field of the Invention

[0001]

The embodiments disclosed herein relate to an encoder.

Description of the Related Art

[0002]

JP 2013-130394 A (page 7, FIG. 2) discloses an encoder in which an oil seal is provided between a disk and a housing to suppress leakage of misted grease of a bearing toward the encoder. The oil seal is made of a material such as black rubber or resin which absorbs light and is coated into black or with a color or a pattern which easily absorbs light.

[0004]

When light emitted from a light source is received at a

light receiving element as scattering light or stray light, not as reflected light to be included in received signals, noise occurs. Such noise is a factor of deteriorating position detection accuracy of an encoder.

[0005]

In the related art described above, the oil seal is made of a material which absorbs light or is coated into a color or a pattern which easily absorbs light, thereby suppressing scattering or reflection of light. However, some components may not be made of the material which absorbs light or may not be subjected to coating which absorbs irradiated light. When such components are arranged between a disk and a housing, there is a possibility that the detection accuracy of the encoder is deteriorated.

SUMMARY

[0007]

A one aspect of the present invention is summarized as an encoder including: a disk; reflectors arranged along a measurement direction on the disk; a light source configured to emit light to the reflectors; a light receiving element configured to receive light which is emitted by the light source and reflected at the reflectors; and a member arranged on an opposite side of the light source on the disk and having a portion which inclines to a light axis of the light source at least in

a position on the light axis.

[0008]

An another aspect of the present invention is summarized as an encoder including: a disk; reflectors arranged along a measurement direction on the disk; a light source configured to emit light to the reflectors; a light receiving element configured to receive light which is emitted by the light source and reflected at the reflectors; and means for changing a direction of light which is emitted by the light source and transmitted through the disk, to a direction inclining to a light axis of the light source.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is an explanatory diagram illustrating a servo system provided with an encoder according to an embodiment;

FIG. 2 is an explanatory diagram illustrating the encoder according to the embodiment;

FIG. 3 is an explanatory diagram illustrating a hub provided in the encoder according to the embodiment;

FIG. 4 is an explanatory diagram illustrating an encoder according to a first modified example;

FIG. 5 is an explanatory diagram illustrating a hub provided in the encoder according to the first modified example;

FIG. 6 is an explanatory diagram illustrating an encoder

according to a second modified example; and

FIG. 7 is an explanatory diagram illustrating a hub provided in the encoder according to the second modified example.

DESCRIPTION OF THE EMBODIMENTS

_ [0011]

Hereinafter, an embodiment of the disclosure will be described with reference to the drawings.

[0012]

<1. Servo system>

First, a configuration of a servo system provided with an encoder according to this embodiment will be described with reference to FIG. 1.

[0013]

As illustrated in FIG. 1, a servo system S includes a servo motor SM and a controller CT. The servo motor SM includes an encoder 100 and a motor M.

[0014]

The motor M is an example of a power generation source not including the encoder 100. The motor M is a rotary-type motor in which a rotor (not illustrated) rotates with respect to a stator (not illustrated) and outputs a rotational force by allowing a shaft SH fixed to the rotor to be rotated around a shaft center AX.

[0015]

Further, the motor M alone may be referred to as a servo motor, but the configuration including the encoder 100 and the motor M is referred to as the servo motor SM in this embodiment. The motor M is not limited in particular, for instance, as long as position data thereof can be detected by the encoder 100. Further, the motor M is not limited to an electric motor that uses electricity as a power source, but may be a motor that uses, for example, another power source, such as a hydraulic motor, an air motor, or a steam motor. However, a case where the motor M is the electric motor will be described for convenience of description.

[0016]

The encoder 100 is connected to a side opposite to an output side of the rotational force of the shaft SH of the motor M, but is not necessarily limited to the opposite side. The encoder 100 may be connected to output side of the rotational force of the shaft SH. The encoder 100 detects a position (referred to also as a rotation angle) of the motor M by detecting the position of the shaft SH (rotor) and outputs position data representing the position of the motor M.

[0017]

The encoder 100 may detect at least one of a speed (referred to also as a rotation speed, an angular speed, and the like) of the motor M and an acceleration (referred to also

as rotation acceleration, angular acceleration, and the like) of the motor M in addition to or in place of the position of the motor M. In this case, it is possible to detect the speed and the acceleration of the motor M by, for example, processing such as a first or second order differential of the position with respect to time or a count of a detection signal (for example, an incremental signal, to be described below) for a predetermined period of time. For convenience of description, a physical quantity detected by the encoder 100 will be described as a position in the following.

[0018]

The controller CT acquires position data output from the encoder 100 and controls the rotation of the motor M based on the acquired position data. Therefore, in this embodiment in which an electric motor is used as the motor M, the controller CT controls a current or voltage to be applied to the motor M based on the position data, and thereby controls the rotation of the motor M. Further, the controller CT can also control the motor M by acquiring a host control signal from a host controller (not illustrated) such that a rotational force capable of realizing a position or the like represented by the host control signal is output from the shaft SH. Furthermore, when the motor M uses another power source, such as a hydraulic power source, an air power source, or a steam power source, the controller CT can control the rotation of the motor M by

controlling the supply from such power sources.

[0019]

<2. Encoder>

Next, a configuration of the encoder 100 according to this embodiment will be described below with reference to FIG. 2. The encoder 100 according to this embodiment is configured as a so-called "complete type" encoder provided with an encoder dedicated casing 10 or a shaft sh. In this case, the shaft sh of the encoder is connected to the shaft SH of the motor through a coupling (not illustrated) so as to have the same shaft center. However, the encoder 100 is not limited to the "complete type", but may be configured as a so-called "built-in type" encoder in which the disk 110 is connected to the shaft SH of the motor without using the shaft sh of the encoder. In this case, the casing 10 is configured as a casing of the motor M. For convenience of description, the case will be described below where the encoder 100 is configured as the complete type encoder.

[0020]

Here, for convenience of description of a structure of the encoder 100, an upward-downward direction is defined as follows and appropriately used. In FIG. 2, a direction in which the disk 110 faces an optical module 130, that is, a positive direction along the Z axis is referred to as an "upward" direction and a negative direction along the Z axis is referred

to as a "downward" direction. However, the direction is changed depending on installation aspects of the encoder 100, and thus does not limit a positional relation of each component of the encoder 100.

[0021]

As illustrated in FIG. 2, the encoder 100 according to this embodiment includes the casing 10, a housing 150, a substrate 16, the optical module 130, a hub 160, the disk 110, a position data generation section 140, an encoder cover 101.

[0022]

(2-1. Disk)

The disk 110 is fixed to a disk fixing portion 162 to be described below of the hub 160. The disk 110 is formed in a shape of circular plate, a bolt 14 penetrates through a substantially center of the disk, and a through hole 111 is provided at the center to be fitted with a bolt fastening portion 163 of the hub 160. A lower surface 110B of the disk 110 is fixed to a disk-fixing surface 162A, which is a top surface of the disk fixing portion 162, in a state where the bolt fastening portion 163 is fitted into the through hole 111. Then, the disk 110 is connected to the shaft sh through the hub 160 so as to have the same shaft center as the shaft sh. The shaft sh is rotatably supported by the casing 10 through the bearing 20. The disk 110 is rotated by the rotation of the motor M, that is, the rotation of the shaft sh.

[0023]

A track SA is formed on the top surface 110A of the disk 110. The track SA is formed as a track which is arranged in the shape of ring centering a disk center O on the top surface 110A of the disk 110. The track SA has a plurality of reflectors (not illustrated) arranged in a measurement direction over the entire circumference of the track. Here, the "measurement direction" refers to a measurement direction when the track formed on the disk 110 is optically measured by the optical module 130 to be described below. As in this embodiment, in a rotary-type encoder where the object to be measured is the disk 110, the measurement direction coincides with a circumferential direction of the disk 110. Each of the reflectors is configured to reflect light emitted from a light source 131 of the optical module 130 to be described below. That is, the encoder 100 is a so-called "reflection type" encoder in which the light emitted from the light source 131 is reflected by reflectors and is received by light receiving elements to be described below. The plurality reflectors are arranged on the entire circumference of the disk 110 in a circumferential direction so as to, for example, have incremental patterns. The reflector can be called as a "slit (reflect slit)", because the light reflected at the reflector travels a predetermined direction without obstructing the path of the light. Moreover, a plurality of reflectors can be a grid as a whole.

[0024]

The disk 110 is formed by a light transmissive material. In this embodiment, the disk 110 is formed of, for example, glass. The glass has lower heat conductivity than a metal (for example, stainless steel). Accordingly, when the disk 110 is formed of the glass, heat generated at the shaft sh of the motor M can be suppressed to be transmitted to the disk 110 from the hub 160. Then, the reflectors of the track SA can be formed by, for example, vapor deposition of a light reflective material (for example, aluminum) on the top surface 110A of the disk 110 formed of the glass. However, a method of forming the reflectors is not limited to this example.

[0025]

(2-2. Optical module)

The optical module 130 is formed in a substrate shape in this example and is fixed in parallel to the disk 110 at a lower surface of the substrate 16 so as to face a part of the track SA of the disk 110. Accordingly, as the disk 110 rotates, the optical module 130 can relatively move with respect to track SA in the circumferential direction. At the surface of the side facing the disk 110 of the optical module 130, that is, the lower surface, the light source 131 and the light receiving array PA are provided.

[0026]

The light source 131 is configured to emit light to a part

of the track SA passing through a facing position. The light source 131 is not limited in particular as long as it is a light source capable of irradiating an irradiation area with light. For example, it is possible to use a light emitting diode (LED). The light source 131 is particularly formed as a point light source in which no optical lens or the like is arranged and emits diffusion light from a light emitting unit. Further, when referring to a "point light source", the light source does not need to be strictly a point. Light may be emitted from a finite light emission surface as long as the light source is regarded as a light source capable of emitting diffusion light from substantially a point-like position from the standpoint of design and operation principle. In addition, the "diffusion light" is not limited to light emitted toward all orientations from the point light source, but includes light emitted while diffusing toward a finitely certain orientation. That is, the diffusion light described herein includes light having higher diffusivity than that of the parallel light. By using the point light source as described above, it is possible for the light source 131 to substantially uniformly irradiate the track SA passing through the facing positions with the light. Further, since the light need not be collected and diffused by the optical element by using the point light source as described above, errors or the like hardly occurs due to the optical element, and thus it is possible to improve straightness of light toward

the track.

[0027]

The light receiving array PA is arranged around the light source 131 and is configured to receive light reflected at the reflectors of the facing track SA. The light receiving array PA includes a plurality of light receiving elements (not illustrated). For example, a photodiode (PD) may be used as each light receiving element. However, the light receiving element is not limited to the PD. That is, the light receiving element is not particularly limited as long as it can receive the light emitted from the light source 131 and convert the received light into an electric signal. The electricity signal generated at the light receiving element is output to the position data generation section 140.

[0028]

(2-3. Hub)

The hub 160 will be described with reference to FIGS. 2 and 3. The hub 160 is a connecting member for connecting the disk 110 and shaft sh to each other and is arranged on an opposite side of the light source 131 of disk 110. The hub 160 includes a disk fixing portion 162, a bolt fastening portion 163, a main body 164, and a bearing cover 165. In this embodiment, the hub 160 is formed of a metal material such as, for example, brass or stainless, but is not limited to the metal if the material has relatively high rigidity.

[0029]

The bolt fastening portion 163 is formed approximately at a center of the disk fixing portion 162 in the shape projecting upward. The bolt fastening portion 163 is fitted to a through hole 111 of the disk 110 such that the disk 110 and the hub 160 have the same shaft center. A through hole 161, through which the bolt 14 penetrates, is provided inside the bolt fastening portion 163. The bolt 14 penetrates through the through hole 111 of the disk 110 and the through hole 161 of the hub 160 in a vertical direction and is screwed in a bolt hole 13 provided in the shaft sh. Thus, the hub 160 is fixed to an upper end of the shaft sh, and simultaneously, the disk 110 fixed to the disk fixing portion 162 of the hub 160 is connected to the shaft sh.

[0030]

The disk fixing portion 162 can include a disk-fixing surface 162A on which the disk 110 is fixed and a radius-equaller 162B. The radius-equaller 162B can be positioned between the disk-fixing surface 162A and a taper 164A to be described below such that lengths in a radial direction are same within a range in which a distance from the disk-fixing surface 162A in a direction of the shaft center (Z-axis direction) is a predetermined distance. That is, the disk fixing portion 162 is formed in a cylindrical shape with the through hole 161 formed at the center thereof, the top surface thereof is the

disk-fixing surface 162A, and a main body is the radius-equalled 162B. The disk-fixing surface 162A is abutted on a lower surface 110B of the disk 110 and is fixed thereto by a suitable adhesive.

[0031]

The main body 164 is formed in a substantially truncated cone shape in which a length in a radius direction centering a shaft center AX of the shaft sh becomes increasing with distance from the disk 110. The taper 164A is provided in an outer periphery surface of the main body. The hub 160 is arranged such that the taper 164A is positioned on at least the light axis h of the light source 131 and the taper 164A is inclined to the light axis h so that reflected light is directed to the outside in the radius direction. Further, the "inclined taper" described herein refers to neither the taper parallel to the light axis h nor to the taper vertical to the light axis h. That is, the "inclined taper" refers to the taper having a tolerance with a constant inclination angle (but, excluding 90 degrees) to the light axis h.

[0032]

The bearing cover 165 is positioned at the bottom of the main body 164 (taper 164A). The bearing cover 165 can have an outer diameter larger than that of the bearing 20 which rotatably supports the shaft sh. Thus the bearing cover can be configured to cover an entire surface on a side of disk 110

on the bearing 20. By such a configuration, the bearing cover 165 can reduce a leakage of grease of the bearing 20, which is misted by temperature rising caused by a rotation of the shaft sh, to the side of the encoder 100. In addition, a concave oil pool 166 can be formed on a surface of the bearing cover 165 facing the bearing 20.

[0033]

The taper 164A corresponds to an example of a portion which inclines to a light axis h of the light source 131 at least in a position on the light axis h, and the hub 160 corresponds to an example of a member provided with the portion. In addition, the hub 160 corresponds to an example of a means for receiving light emitted from the light source 131 and transmitted through the disk 110 at a surface inclined to the light axis h of the light source 131.

[0034]

(2-4. Substrate and Housing)

[0035]

The substrate 16 is, for example, a circular plate-like printed wiring substrate, and the optical module 130 and a plurality of circuit elements are mounted on the lower surface of the substrate. The substrate 16 is formed to have substantially the same diameter as the housing 150, and an edge of the substrate 16 is placed on a surface 151 of the housing 150. The edge of the substrate 16 is provided with a plurality

of through holes 16A, through which a fixing screw 15 penetrates, at equal intervals in a circumferential direction. The housing 150 is formed in, for example, a cylindrical shape and is configured to support the substrate 16 and contain the disk 110, the optical module 130, and the hub 160 of the encoder 100. The housing 150 has a plurality of through holes 152 through which the fixing screw 15 penetrates. The fixing screw 15 penetrates the through holes 16A of the substrate 16 and the through holes 152 of the housing 150 in a vertical direction and is screwed into a screw hole provided in the casing 10. Thus, the substrate 16 and the housing 150 are fixed to the casing 10.

[0036]

In addition, the housing 150 includes a protrusion 153 projecting to a side of the taper 164A of the hub 160 at an inner periphery surface of a portion below the disk 110. The protrusion 153 is provided on the entire inner periphery surface of the housing 150 in the circumferential direction.

[0037]

The housing 150 can be made by a color (hereinafter, a first light-absorbing color) which absorbs light more than a color of a member other than the housing 150 or an inside of the housing can be coated into the first light-absorbing color. The member other than the housing 150 can be the surface of the disk 110, the surface of the substrate 16 and so on. The first light-absorbing color can be a color having a lower reflectance

ratio than the first light-absorbing color. For example, when the light source 131 emits a white light and the disk 10 is made by glass, the reflectance ratio of the surface of the glass is about 3%. As a result, the first light-absorbing color can be a color (for example, black) having a reflectance ratio less than 3%. Furthermore, since a reflectance ratio is changed according to the wavelength of light emitted by the light source 131, the first light-absorbing color can be selected according to the light source 131. It is preferable to take measures of coating the surface of the casing 10 to be exposed to at least the disk 110 into the first light-absorbing color.

[0038]

<3. Operation of encoder>

An example of the operation of the encoder 100 will be described. By supplying external power to the motor M, when the shaft sh rotates and the disk 110 rotates, the track SA passing through a facing position is irradiated with light from the light source 131 and a light receiving array PA receives the light reflected at the track SA. Then, light receiving elements of the light receiving array PA generates electric signals and outputs the generated signals to the position data generation section 140, and the position data generation section 140 generates position data representing a position within one rotation of the disk 110 based on the input signals and continuously outputs the position data to the controller

CT.

[0039]

<4. Effects according to the embodiment>

As described above, the encoder 100 of this embodiment includes the hub 160 arranged on the opposite side of the light source 131 of the disk 110. The hub 160 includes the taper 164A which is inclined to the light axis h of the light source 131 at least in the position on the light axis h. Thus, it is possible to receive the light (in particular, light transmitted between the respective reflectors of the track SA) emitted from the light source 131 and transmitted through the disk 110 at the taper 164A of the hub 160 and reflect the light in a direction in which the light is not received by the light receiving array PA. As a result, it is possible to reduce a case where scattering light or stray light causing a noise is received at the light receiving array PA and thus to improve detection accuracy of the encoder 100, the scattering light or stray light being other than the reflected light (reflected light reflected at the reflectors) to be included in signals of the light received at the light receiving array PA.

[0040]

In this embodiment, particularly, the hub 160 connecting the disk 110 and the shaft sh to each other has the taper 164A. As described above, the hub 160 is formed of the glossy metal material (stainless, brass or the like) to have the rigidity.

For this reason, if the hub 160 has a plane on the light axis h substantially vertical to the light axis, the light emitted from the light source 131 and transmitted through the disk 110 is reflected at the hub 160 and is received at the light receiving array PA, which is the cause of the noise. In this embodiment, since the hub 160 has the taper 164A at least in the position on the light axis h of the outer periphery surface, the light can be reflected to the outside in the radius direction. Accordingly, even when the hub 160 is formed of a metal material having a relatively large amount of reflected light, it is possible to reduce the case where the reception of the scattering light or stray light causing the noise is received at the light receiving array PA.

[0041]

Furthermore, in this embodiment, the hub 160 has particularly the disk-fixing surface 162A and the radius-equaller 162B positioned between the disk-fixing surface 162A and the taper 164A. Thus, the following effects can be obtained. That is, in a manufacturing process of the reflective type encoder, the length in the direction of the shaft center (Z-axis direction) is adjusted by cutting the disk-fixing surface 162A of the hub 160 prior to bonding the disk 110 to the disk-fixing surface 162A of the hub 160, and thus a gap between the light source 131 and the light receiving array PA, and the disk 110 is obtained with the accuracy. At

this time, in this embodiment, since the hub 160 has the radius-equaller 162B, a bonding area of the disk-fixing surface 162A can become constant without being changed by the cutting process. Accordingly, it is possible to suppress variation of a bonding force between the hub 160 and the disk 110 and improve reliability of the encoder 100. In addition, since the hub 160 has the radius-equaller 162B, the distance between the light source 131 and the taper 164A can be increased. Consequently, the amount of light reflected at the taper 164A can be reduced by attenuation of light, and the effect of reducing the scattering light or stray light can be further improved.

[0042]

Furthermore, in this embodiment, the hub 160 has particularly the bearing cover 165 configured to cover the surface on the side of the disk 110 on the bearing 20. Thus, the following effects can be obtained. That is, generally, when a temperature of the encoder 100 rises by the rotation of the shaft sh, the grease of the bearing 20 is misted and scattered. When the misted grease is leaked to the side of the encoder 100, the grease is adhered to the disk 110 or optical components such as the light source 131 or the light receiving array PA, the amount of light from the light source 131 to the light receiving array PA may be reduced, and the reliability of the result detected by the encoder 100 may be deteriorated. In this embodiment, the hub 160 has the bearing cover 165 configured

to cover the surface on the side of the disk 110 on the bearing 20. Thus, the grease of the bearing 20 misted due to heat generated by the rotation of the shaft sh can be suppressed to be leaked to the side of the encoder 100. Accordingly, the reliability of the encoder 100 can be improved.

[0043]

Furthermore, in this embodiment, the hub 160 has particularly the concave oil pool 166 on the surface of the bearing cover 165 facing the bearing 20. Thus, a lot of misted grease of the bearing 20 can be adhered to the oil pool 166 and can be effectively suppressed to be leaked to the side of the encoder 100.

[0044]

Furthermore, in this embodiment, the housing 150 of the encoder 100 can be particularly made by the material having the first light-absorbing color or the inside of the housing 150 can be coated into the first light-absorbing color. Thus, the effect of reducing the scattering light or stray light can be further improved.

[0045]

Furthermore, in this embodiment, the housing 150 has particularly the protrusion 153 projecting to the side of the taper 164A. By such a protrusion 153, an inner wall of the housing 150 can be close to the taper 164A. As a result, the protrusion 153 can absorb the light reflected by the taper 164A,

and the effect of reducing the scattering light or stray light can be further improved.

[0046]

<5. Modified Example>

The embodiment has been described in detail with reference to the accompanied drawings as above. However, the scope of the technical idea disclosed in claims is not limited to the above-described embodiment. It is possible for persons having the ordinary knowledge in the field to which the embodiment of the invention belongs to further perform various changes, modifications, and combinations within the scope of the technical idea. Consequently, the techniques based on these changes, modifications, and combinations should naturally be regarded to belong to the scope of the technical idea of the invention.

[0047]

(1) Case where the outer periphery surface of the hub is a curved surface of an arc shape

In the embodiment described above, the taper 164A having the constant inclination angle to the light axis h is formed on the outer periphery surface of the main body 164 of hub 160, but the inclination angle to the light axis h may be continuously changed. An example of a modified example is illustrated in FIGS. 4 and 5. Further, in FIGS. 4 and 5, the same components as in FIGS. 2 and 3 will be denoted by the same reference numerals

and the description thereof will be approximately omitted or simplified.

[0048]

As illustrated in FIGS. 4 and 5, the main body 167 of the hub 160 is provided with a curved surface 167A of the arc shape at the outer periphery surface thereof. The curved surface 167A is positioned between the radius-equaller 162B positioned at a top and the bearing cover 165 positioned at a bottom, an upper end thereof is in a direction approximately parallel to the light axis h (that is, the inclination angle is zero degree), and a lower end thereof is in a direction approximately vertical to the light axis h (that is, the inclination angle is 90 degrees). In this embodiment, as illustrated in FIG. 4, the curved surface 167A is formed in the arc shape in which the radius of curvature is a distance r , but a curved degree of the curved surface is not limited thereto. Further, a distance d illustrated in FIG. 4 is a thickness of the radius-equaller 162B (distance in the direction of the shaft center).

[0049]

According to this modified example, the following effects can be obtained. That is, generally, when the portion having a constant inclination angle receives diffusion light emitted from the light source 131 which is a point light source, the light reflected at the portion positioned on the inner periphery side relative to the light axis h is easily directed to the light

receiving array PA, and the light reflected approximately at the portion positioned on the outer periphery side relative to the light axis h is easily directed to a direction away from the light receiving array PA. In this modified example, the portion can be configured such that the inclination angle to the light axis h is changed. Specifically, the portion can be configured as the curved surface 167A whose inclination angle is continuously changed. Thus, since the inclination angle of the curved surface 167A positioned on the inner periphery side relative to the light axis h becomes smaller, the reflected light can be kept away from the light receiving array PA. On the other hand, since the inclination angle of the curved surface 167A positioned on the outer periphery side relative to the light axis h becomes larger, the direction of the reflected light can be maintained in the direction away from the light receiving array PA. As a result, the effect of reducing the scattering light or stray light can be further enhanced, and the detection accuracy of the encoder 100 can be further improved.

[0050]

(2) Case where the inclination angle of the outer periphery surface of the hub is changed in stages

In the embodiment described above, the taper 164A having the constant inclination angle to the light axis h is formed on the outer periphery surface of the main body 164 of the hub

160, but the inclination angle to the light axis h may be changed in stages. An example of this modified example is illustrated in FIGS. 6 and 7. In FIGS. 6 and 7, the same components as in FIGS. 2 and 3 will be denoted by the same reference numerals and the description thereof will be approximately omitted or simplified.

[0051]

As illustrated in FIGS. 6 and 7, the main body 168 of the hub 160 is configured such that the inclination angle of the outer periphery surface thereof to light axis h is changed in two stages by considering a neighborhood position of the light axis h as a border. Specifically, the main body 168 includes a first taper 168A positioned at a top and a second taper 168B positioned at a bottom, on the outer periphery surface thereof. The inclination angle of the first taper 168A is configured to be smaller than that of the second taper 168B. In the example illustrated in FIG. 6, the border between the first taper 168A and the second taper 168B is positioned at the inner periphery side relative to the light axis h , but is not limited thereto. For example, the border may be positioned at the outer periphery side relative to the light axis h and the position of the border may coincide to that of the light axis h . That is, the border may be positioned in the vicinity of the light axis h .

[0052]

According to this modified example, the inclination angle

of the outer periphery surface of the hub 160 to the light axis h can become relatively small at the inner periphery side, in which the reflected light is easily directed to the light receiving array PA, relative to the vicinity of the light axis h and can become relatively large at the outer periphery side, in which the reflected light is easily directed to the direction away from the light receiving array PA, relative to the vicinity of the light axis h. Thus, the direction of the reflected light can be away from the light receiving array PA even at any position of the inner periphery side and outer periphery side of the light axis h. As a result, the effect of reducing the scattering light or stray light can be further enhanced, and the detection accuracy of the encoder 100 can be further improved.

[0053]

The case is described above as an example where the inclination angle is changed in two stages, but the inclination angle may be changed in three or more stages.

[0054]

(3) Case where the hub is made by a material having a color (hereinafter, a second light-absorbing color) which absorbs light more than a color of a member other than the hub and coated into the second light-absorbing color

In the embodiment described above, the hub 160 is not subjected to coating, but the hub 160 may be coated into the second light-absorbing color (for example, black).

Alternatively, the hub 160 may be made by, for example, a black material such as a carbon fiber or a material having the second light-absorbing color. Thus, the light can be reflected by the taper 164A in the direction in which the light is not received at the light receiving array PA and the amount of reflected light can be reduced. Accordingly, the effect of reducing the scattering light or stray light can be further enhanced.

[0055]

(4) Others

The case is described above as an example where the hub 160 for connecting the disk 110 and the shaft sh to each other includes the incline which is inclined to the light axis h, but a member having the incline is not limited to the hub 160. For example, the housing 150 or the casing 10 may be configured to include the incline, which is inclined to the light axis h of the light source 131 at least in the position on the light axis h, thereby reflecting the light in the direction in which the light is not received at the light receiving array PA.

[0056]

The case is described above as an example where the hub 160 is fixed to the upper end of the shaft sh by the bolt 14, but the hub 160 may be fixed to the shaft sh using adhesive without being limited thereto.

[0057]

In the above description, meanings of "vertical" and

"parallel" are not strictly applied. That is, the "vertical" and "parallel" means "substantially vertical" and "substantially parallel", respectively, in which a tolerance and an error in design or manufacturing is allowed. Similarly, in the above description, meaning of "equal" is not strictly applied. That is, the "equal" means "substantially equal", in which a tolerance and an error in design or manufacturing is allowed.

[0058]

The embodiment and the modified example are described above. However, in addition to those previously described, the invention may be used by appropriately combining methods of the embodiment or each of the modified examples described above.

[0059]

Although not specifically described, the embodiment or each of the modified examples described above may be variously changed without departing from the scope of the invention.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. An encoder comprising:

a disk;

reflectors arranged along a measurement direction on the disk;

a light source configured to emit light to the reflectors;

a light receiving element configured to receive light which is emitted by the light source and reflected at the reflectors; and

a member arranged on an opposite side of the light source on the disk and having a portion which inclines to a light axis of the light source at least in a position on the light axis.

2. The encoder according to claim 1, wherein

the light source is a point light source configured to emit diffusion light; and

an inclination angle of the portion to the light axis is configured to change.

3. The encoder according to claim 2, wherein

the inclination angle is configured to change in two stage by considering a neighborhood position of the light axis as a border.

4. The encoder according to any one of claims 1 to 3, wherein

the member is a connecting member configured to connect the disk and a shaft; and

the portion is a taper which is formed in an outer periphery surface of the connecting member and increases a length in a radius direction centering a shaft center of the shaft with distance from the disk.

5. The encoder according to claim 4, wherein

the connecting member comprising:

a disk-fixing surface on which the disk can be fixed; and

a radius-equaller positioned between the disk-fixing surface and the taper, the lengths in the radius-equaller being same within a range within which a distance from the disk-fixing surface in a direction of the shaft center is a predetermined distance.

6. The encoder according to claim 4 or 5, wherein

the connecting member has a bearing cover configured to cover a surface on a side of the disk on a bearing which supports the shaft rotatably.

7. The encoder according to claim 6, wherein

the connecting member has a concave oil pool on a surface of the bearing cover facing the bearing.

8. The encoder according to any one of claims 1 to 7, wherein
the connecting member is made by a material having a color
which absorbs light more than a color of a member other than
the connecting member

; or

the connecting member is coated into a color which
absorbs light more than a color of a member other than the
connecting member.

9. The encoder according to any one of claims 1 to 8, further
comprising:

a housing configured to contain at least the disk, the
light source, the light receiving element and the member,
wherein

the housing is made by a material having a color which
absorbs light more than a color of a member other than the
connecting member; or

an inside of housing is coated into a color which absorbs
light more than a color of a member other than the connecting
member.

10. The encoder according to claim 9, wherein

the housing has a protrusion projecting to a side of the
incline.