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Encoder device, drive device, stage device, and robot device

Abstract

An encoder device including a position detection unit for detecting position information of a moving part; a magnet having a plurality of polarities along a moving direction of the moving part; and an electric signal generation unit for generating an electric signal, based on a magnetic characteristic of a magnetosensitive part, the electric signal generation unit having the magnetosensitive part whose magnetic characteristic is changed by a change in magnetic field associated with relative movement to the magnet, wherein the magnetosensitive part is disposed so that the magnetosensitive part is spaced apart from a side surface of the magnet in a direction orthogonal to the moving direction and a length direction of the magnetosensitive part is orthogonal to tangential directions of at least some of magnetic field lines of the magnet.

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Background/Summary

(1) This application is a continuation of application Ser. No. 16/962,126 filed Sep. 15, 2020, which is a National Stage of PCT/JP2019/000306 filed Jan. 9, 2019 and is based upon and claims the benefit of priority from Japanese Patent Application No. 2018-004239 filed on Jan. 15, 2018, the entire contents of the prior applications being incorporated herein by reference.

BACKGROUND
1. Technical Field
(1) The present invention relates to an encoder device, a drive device, a stage device, and a robot device.
2. Related Art
(2) An encoder device that detects position information of an object to be detected, such as a rotating angle, a rotating speed and the like is mounted to a variety of devices such as a robot device. As the encoder device of the related art, known is a device that converts a change in magnetic field of a rotating magnet into an electric signal by using a magnetic wire such as a Wiegand wire and obtains a rotating speed by using the electric signal (for example, see Patent Document 1).
(3) For the encoder device in which the magnetic wire is used as described above, it is needed to generate a stable electric signal by reducing noises due to an unnecessary magnetic field of the magnet, thereby improving reliability of a detection result. Patent Document 1: Japanese Unexamined Patent Application Publication No. H08-136558
GENERAL DISCLOSURE
(4) According to a first aspect, there is provided an encoder device comprising a position detection unit for detecting position information of a moving part; a magnet having a plurality of polarities along a moving direction of the moving part; and an electric signal generation unit for generating an electric signal, based on a magnetic characteristic of a magnetosensitive part, the electric signal generation unit having the magnetosensitive part whose magnetic characteristic is changed by a change in magnetic field associated with relative movement to the magnet, wherein the magnetosensitive part is disposed so that the magnetosensitive part is spaced apart from a side surface of the magnet in a direction orthogonal to the moving direction and a length direction of the magnetosensitive part is orthogonal to tangential directions of at least some of magnetic field lines of the magnet.
(5) According to a second aspect, there is provided a drive device comprising the encoder device according to the first aspect, and a power supplying unit for supplying power to the moving part.

According to a third aspect, there is provided a stage device comprising a moving object, and the drive device according to the second aspect for moving the moving object. According to a fourth aspect, there is provided a robot device comprising the drive device according to the second aspect, and an arm for causing relative movement by the drive device.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** shows an encoder device in accordance with a first embodiment.
(2) FIG. **2**A is a perspective view showing a magnet, an electric signal generation unit, and a magnetic sensor in FIG. **1**.
(3) FIG. **2**B is a plan view showing the magnet and the like in FIG. **2**A.
(4) FIG. **2**C is a circuit diagram showing the magnetic sensor in FIG. **2**A.
(5) FIG. **3**A is a plan view showing the magnet and the electric signal generation unit in FIG. **2**A.
(6) FIG. **3**B is a sectional view of FIG. **3**A.
(7) FIG. **3**C is a sectional view of FIG. **3**A.
(8) FIG. **3**D is a plan view showing a modified embodiment.
(9) FIG. **3**E is a side view of FIG. **3**D.
(10) FIG. **4** shows a configuration of an electric power supplying system and a multi-turn information detection unit of the encoder device shown in FIG. **1**.
(11) FIG. **5** shows operations of the encoder device shown in FIG. **1** during forward rotation.
(12) FIG. **6**A is a plan view showing a magnet and an electric signal generation unit in accordance with a second embodiment
(13) FIG. **6**B is a side view of FIG. **6**A.
(14) FIG. **6**C is an enlarged view showing a part of the magnet shown in FIG. **6**A.
(15) FIG. **6**D is a plan view showing a modified embodiment.
(16) FIG. **6**E is a side view of FIG. **6**D.
(17) FIG. **7**A is a plan view showing a magnet and an electric signal generation unit in accordance with a third embodiment.
(18) FIG. **7**B is a sectional view of FIG. **7**A.
(19) FIG. **7**C is a plan view showing a modified embodiment.
(20) FIG. **8**A is a plan view showing a magnet and an electric signal generation unit in accordance with a fourth embodiment
(21) FIG. **8**B is a sectional views of FIG. **8**A.
(22) FIG. **8**C is a sectional views of FIG. **8**A.
(23) FIG. **8**D is a plan view showing a modified embodiment.
(24) FIG. **8**E is a side view of FIG. **8**D.
(25) FIG. **9**A is a plan view showing a magnet, an electric signal generation unit, and a magnetic sensor in accordance with a fifth embodiment.
(26) FIG. **9**B is a sectional view of FIG. **9**A.
(27) FIG. **10**A is a plan view showing an electric signal generation unit, a magnetic sensor and an optical sensor in accordance with a sixth embodiment.
(28) FIG. **10**B is a sectional view of FIG. **10**A.
(29) FIG. **11** shows an example of a drive device.
(30) FIG. **12** shows an example of a stage device.
(31) FIG. **13** shows an example of a robot device.
DESCRIPTION OF EXEMPLARY EMBODIMENTS
First Embodiment
(32) A first embodiment is described with reference to FIGS. **1** to **5**. FIG. **1** shows an encoder

device EC in accordance with the present embodiment. In FIG. **1**, the encoder device EC detects rotational position information of a rotary shaft SF (moving part) of a motor M (power supplying unit). The rotary shaft SF is, for example, a shaft (rotor) of the motor M, but may also be an operation shaft (output shaft) connected to the shaft of the motor M via a power transmission unit such as a transmission and also connected to a load. The rotational position information detected by the encoder device EC is supplied to a motor control unit MC. The motor control unit MC controls rotation (for example, a rotational position, a rotating speed and the like) of the motor M by using the rotational position information supplied from the encoder device EC. The motor control unit MC controls the rotation of the rotary shaft SF.
(33) The encoder device EC comprises a position detection system (position detection unit) **1** and an electric power supplying system (electric power supplying unit) **2**. The position detection system **1** detects the rotational position information of the rotary shaft SF. The encoder device EC is a so-called multi-turn absolute encoder, and detects the rotational position information including multi-turn information indicative of the number of rotations of the rotary shaft SF and angular position information indicative of an angular position (rotating angle) less than one-turn. The encoder device EC comprises a multi-turn information detection unit **3** that detects the multi-turn information of the rotary shaft SF, and an angle detection unit **4** that detects the angular position of the rotary shaft SF.
(34) At least a part (for example, the angle detection unit **4**) of the position detection system **1** operates by receiving electric power supply from a device (for example, a drive device, a stage device, a robot device) on which the encoder device EC is mounted, in a state where a power supply (for example, a main power supply) of the device is on, for example. Also, at least a part (for example, the multi-turn information detection unit **3**) of the position detection system **1** operates by receiving electric power supply from the electric power supplying system **2**, in a state (for example, an emergency state and a backup state) where a power supply (for example, a main power supply) of a device on which the encoder device EC is mounted is off. For example, in a state where the supply of electric power from a device on which the encoder device EC is mounted is cut off, the electric power supplying system **2** intermittently supplies electric power to at least a part (for example, the multi-turn information detection unit **3**) of the position detection system **1**, and the position detection system **1** detects at least a part (for example, the multi-turn information) of the rotational position information of the rotary shaft SF at the time when electric power is supplied from the electric power supplying system **2**.
(35) The multi-turn information detection unit **3** detects the multi-turn information by magnetism, for example. The multi-turn information detection unit **3** includes, for example, a magnet **11**, magnetism detection units **12**, a detection unit **13**, and a storage unit **14**. The magnet **11** is provided on a disc **15** fixed to the rotary shaft SF. Since the disc **15** rotates together with the rotary shaft SF, the magnet **11** rotates in conjunction with the rotary shaft SF. The magnet **11** is fixed to the outside of the rotary shaft SF, and mutual relative positions of the magnet **11** and the magnetism detection units **12** are changed due to the rotation of the rotary shaft SF. The strength and direction of a magnetic field on the magnetism detection unit **12** formed by the magnet **11** are changed by the rotation of the rotary shaft SF. The magnetism detection unit **12** detects a magnetic field that is formed by the magnet, and the detection unit **13** detects the position information of the rotary shaft SF, based on a detection result of the magnetism detection unit **12** detecting the magnetic field that is formed by the magnet **11**. The storage unit **14** stores the position information detected by the detection unit **13**.
(36) The angle detection unit **4** is an optic or magnetic encoder, and detects position information (angular position information) within one-turn of a scale. For example, in a case of the optic encoder, the optic encoder detects the angular position within one-turn of the rotary shaft SF by reading patterning information of the scale with a light-receiving element, for example. The patterning information of the scale is, for example, bright and dark slits on the scale. The angle

detection unit **4** detects the angular position information of the rotary shaft SF that is the same as a detection target of the multi-turn information detection unit **3**. The angle detection unit **4** includes a light-emitting element **21**, a scale S, a light-receiving sensor **22**, and a detection unit **23**.
(37) The scale S is provided on a disc **5** fixed to the rotary shaft SF. The scale S includes an incremental scale and an absolute scale. The scale S may also be provided on the disc **15** or may be a member integrated with the disc **15**. For example, the scale S may be provided on an opposite surface of the disc **15** to the magnet **11**. The scale S may be provided on at least one of the inside and the outside of the magnet **11**.
(38) The light-emitting element **21** (an irradiation unit, a light-emitting unit) irradiates the scale S with light. The light-receiving sensor **22** (a light detection unit) detects light emitted from the light-emitting element **21** and passing through the scale S. In FIG. **1**, the angle detection unit **4** is a transmission type, and the light-receiving sensor **22** detects light having passed through the scale S. Note that the angle detection unit **4** may also be a reflection type. The light-receiving sensor **22** supplies a signal indicative of a detection result to the detection unit **23**. The detection unit **23** detects the angular position of the rotary shaft SF by using the detection result of the light-receiving sensor **22**. For example, the detection unit **23** detects an angular position of a first resolution by using a detection result of light from the absolute scale. Also, the detection unit **23** detects an angular position of a second resolution higher than the first resolution by performing interpolation calculation on the angular position of the first resolution by using a detection result of light from the incremental scale.
(39) In the present embodiment, the encoder device EC comprises a signal processing unit **25**. The signal processing unit **25** calculates and processes a detection result of the position detection system **1**. The signal processing unit **25** includes a synthesis unit **26** and an external communication unit **27**. The synthesis unit **26** acquires the angular position information of the second resolution detected by the detection unit **23**. Also, the synthesis unit **26** acquires the multi-turn information of the rotary shaft SF from the storage unit **14** of the multi-turn information detection unit **3**. The synthesis unit **26** synthesizes the angular position information from the detection unit **23** and the multi-turn information from the multi-turn information detection unit **3**, and calculates the rotational position information. For example, when the detection result of the detection unit **23** is θ(rad) and the detection result of the multi-turn information detection unit **3** is n-turn, the synthesis unit **26** calculates $(2\pi\times n+\theta)$(rad), as the rotational position information. The rotational position information may also be information in which the multi-turn information and the angular position information less than one-turn are combined.
(40) The synthesis unit **26** supplies the rotational position information to the external communication unit **27**. The external communication unit **27** is communicatively connected to a communication unit MCC of the motor control unit MC in a wired or wireless manner. The external communication unit **27** supplies the rotational position information of a digital format to the communication unit MCC of the motor control unit MC. The motor control unit MC appropriately decodes the rotational position information from the external communication unit **27** of the angle detection unit **4**. The motor control unit MC controls the rotation of the motor M by controlling electric power (drive electric power) supplied to the motor M by using the rotational position information.
(41) The electric power supplying system **2** includes first and second electric signal generation units **31**A and **31**B, a battery **32**, and a switching unit **33**. The electric signal generation units **31**A and **31**B each generate an electric signal by the rotation of the rotary shaft SF. The electric signal includes a waveform where electric power (current, voltage) changes over time, for example. The electric signal generation units **31**A and **31**B each generate electric power as the electric signal by a magnetic field that changes based on the rotation of the rotary shaft SF, for example. For example, the electric signal generation units **31**A and **31**B generate electric power by a change in magnetic field that is formed by the magnet **11** that is used for the multi-turn information detection unit **3** to

detect the multi-turn position of the rotary shaft SF. The electric signal generation units **31**A and **31**B are each disposed so that a relative angular position to the magnet **11** is changed by the rotation of the rotary shaft SF. The electric signal generation units **31**A and **31**B generate a pulsed electric signal when relative positions of the electric signal generation units **31**A and **31**B and the magnet **11** each reach predetermined positions, for example.

(42) The battery **32** supplies at least a part of electric power that is consumed in the position detection system **1**, based on the electric signals generated from the electric signal generation units **31**A and **31**B. The battery **32** includes, for example, a primary battery **36** such as a button-shaped battery and a dry-cell battery, and a rechargeable secondary battery **37** (see FIG. **4**). The secondary battery of the battery **32** can be recharged by the electric signals (for example, current) generated from the electric signal generation units **31**A and **31**B, for example. The battery **32** is held in a holder **35**. The holder **35** is, for example, a circuit substrate or the like on which at least a part of the position detection system **1** is provided. The holder **35** holds the detection unit **13**, the switching unit **33**, and the storage unit **14**, for example. The holder **35** is provided with a plurality of battery cases capable of accommodating the battery **32**, and an electrode, a wire and the like connected to the battery **32**, for example.

(43) The switching unit **33** switches whether to supply electric power from the battery **32** to the position detection system **1**, based on the electric signals generated from the electric signal generation units **31**A and **31**B. For example, the switching unit **33** starts supply of electric power from the battery **32** to the position detection system **1** when levels of the electric signals generated from the electric signal generation units **31**A and **31**B become equal to or higher than a threshold value. For example, the switching unit **33** starts supplying electric power from the battery **32** to the position detection system **1** when electric power equal to or higher than the threshold value is generated from the electric signal generation units **31**A and **31**B. Also, the switching unit **33** stops supplying electric power from the battery **32** to the position detection system **1** when the levels of the electric signals generated from the electric signal generation units **31**A and **31**B become lower than the threshold value. For example, the switching unit **33** stops the supply of electric power from the battery **32** to the position detection system **1** when the electric power generated from the electric signal generation units **31**A and **31**B becomes lower than the threshold value. For example, in a case where a pulsed electric signal is generated in the electric signal generation units **31**A and **31**B, the switching unit **33** starts the supply of electric power from the battery **32** to the position detection system **1** at the time when a level (electric power) of the electric signal rises from a low level to a high level, and stops the supply of electric power from the battery **32** to the position detection system **1** after a predetermined time elapses since the level (electric power) of the electric signal changes to the low level. Also, the encoder device EC has a configuration of using the electric signals (pulse signals) generated from the electric signal generation units **31**A and **31**B, as a switching signal (trigger signal) for the supply of electric power from the battery **32** to the position detection system **1**.

(44) FIG. **2**A is a perspective view showing the magnet **11**, the electric signal generation units **31**A and **31**B, and two magnetic sensors **51** and **52** that are the magnetism detection units **12** in FIG. **1**, FIG. **2**B is a plan view of the magnet **11** and the like in FIG. **2**A, as seen from a direction parallel to the rotary shaft SF, and FIG. **2**C is a circuit diagram of the magnetic sensor **51**. Note that in FIG. **2**A and the like, the rotary shaft SF of FIG. **1** is shown with a straight line. In FIGS. **2**A and **2**B, the magnet **11** is configured so that rotation changes the direction and strength of the magnetic field in an axial direction that is a direction parallel to a straight line (symmetrical first axis) passing through a center of the rotary shaft SF, the rotary shaft SF and thus the magnet **11** rotating around the first axis as a center. The magnet **11** is an annular member that is coaxial with the rotary shaft SF, for example. As an example, the magnet **11** is configured by a first annular magnet consisting of an N pole **16**A, an S pole **16**B, an N pole **16**C, and an S pole **16**D, which are sequentially disposed so as to surround the rotary shaft SF and each have an opening angle of 90° and a fan

shape, and a second annular magnet consisting of an S pole **17**A, an N pole **17**B, an S pole **17**C, and an N pole **17**D, which have the same shapes as the N pole **16**A to the S pole **16**D and are each attached and disposed to one surface of the N pole **16**A to the S pole **16**D. The magnet **11** is a permanent magnet that is magnetized to have four pairs of polarities along a circumferential direction (or also referred to as a rotating direction) around the rotary shaft SF and generates a magnetic force. A front surface (a surface opposite to the motor M in FIG. **1**) and a back surface (a surface on the same side as the motor M), which are main surfaces of the magnet **11**, are each substantially perpendicular to the rotary shaft SF. In other words, in the magnet **11**, the N pole **16**A to the S pole **16**D on the front surface-side and the S pole **17**A to the N pole **17**D on the back surface-side are offset by 90° in angle (for example, in positions of the respective N poles and the S poles) (180° in phase), and boundaries between the N poles and the S poles of the N pole **16**A to the S pole **16**D and boundaries between the S poles and the N poles of the S pole **17**A to the N pole **17**D substantially coincide with each other with respect to positions in the circumferential direction (angular positions). Note that the first annular magnet and the second annular magnet may be one magnet integrated continuously in the moving direction (for example, the circumferential direction, the rotating direction) or the axial direction and having a plurality of polarities or may be a hollow magnet having a space at the inside of these magnets.
(45) Herein, for convenience of descriptions, rotation in a counterclockwise direction is referred to as forward rotation, and rotation in a clockwise direction is referred to as reverse rotation, as seen from a tip end side of the rotary shaft SF (an opposite side to the motor M in FIG. **1**). Also, an angle of the forward rotation is indicated by a positive value, and an angle of the reverse rotation is indicated by a negative value. Note that rotation in a counterclockwise direction may be referred to as forward rotation, and rotation in a clockwise direction may be referred to as reverse rotation, as seen from a rear end side of the rotary shaft SF (the motor M-side in FIG. **1**).
(46) Herein, in a coordinate system fixed to the magnet **11**, an angular position of a boundary between the S pole **16**D and the N pole **16**A in the circumferential direction is denoted as a position **11***a*, and angular positions (boundaries between the N pole and the S pole) sequentially rotated by 90° from the position **11***a* are each denoted as positions **11***b*, **11***c* and **11***d*. In a first section from the position **11***a* to the position 90° counterclockwise, the N pole is disposed on the front surface-side of the magnet **11**, and the S pole is disposed on the back surface-side of the magnet **11**. In the first section, a direction of the magnetic field of the magnet **11** in the axial direction is substantially parallel to an axial direction AD**1** (see FIG. **3**C) from the front surface-side toward the back surface-side of the magnet **11**. In the first section, the strength of the magnetic field is maximized in the middle of the position **11***a* and the position **11***b*, and is minimized near the positions **11***a* and **11***b*.
(47) In a second section of 90° in the counterclockwise direction from the position **11***b* (a section in which the S pole is disposed on the front surface-side of the magnet **11**, and the N pole is disposed on the back surface-side of the magnet **11**), a direction of the magnetic field of the magnet **11** in the axial direction is substantially a direction from the back surface-side toward the front surface-side of the magnet **11** (for example, an opposite direction to the axial direction AD**1** (FIG. **3**C)). In the second section, the strength of the magnetic field is maximized in the middle of the position **11***b* and the position **11***c*, and is minimized near the positions **11***b* and **11***c*. Similarly, in a third section from the position **11***c* to the position 90° counterclockwise and in a fourth section from the position **11***d* to the position 90° counterclockwise, directions of the magnetic fields of the magnet **11** in the axial direction are substantially a direction from the front surface-side toward the back surface-side of the magnet **11** and a direction from the back surface-side toward the front surface-side of the magnet **11**, respectively.
(48) As such, the directions of the magnetic field formed by the magnet **11** in the axial direction are sequentially reversed at the positions **11***a* to **11***d*. The magnet **11** forms an AC magnetic field in which the direction of the magnetic field in the axial direction is reversed with the rotation of the

magnet **11**, with respect to the coordinate system fixed to the outside of the magnet **11**. The electric signal generation units **31**A and **31**B are disposed on the outer surface of the magnet **11** in a direction intersecting with a normal direction of the main surfaces of the magnet **11**. In the present embodiment, the electric signal generation units **31**A and **31**B are provided without contacting the magnet **11** with each going away in a diametrical direction (for example, a radial direction) of the magnet **11** orthogonal to the rotary shaft SF or in a direction parallel to the diametrical direction. The first electric signal generation unit **31**A includes a first magnetosensitive part **41**A, a first electric power generation part **42**A, and a first set of first magnetic body **45**A and a first set of second magnetic body **46**A. Note that one of the first magnetic body **45**A and the second magnetic body **46**A may be omitted. The first magnetosensitive part **41**A, the first electric power generation part **42**A, the first magnetic body **45**A, and the second magnetic body **46**A are fixed to the outside of the magnet **11**, and relative positions thereof to each position on the magnet **11** are changed with the rotation of the magnet **11**. For example, in FIG. **2**B, the position **11***b* of the magnet **11** is disposed at a position 45° in the counterclockwise from the first electric signal generation unit **31**A. When the magnet **11** rotates one-turn in the forward direction (counterclockwise) from this state, the positions **11***a*, **11***d*, **11***c* and **11***b* sequentially pass near the electric signal generation unit **31**A.

(49) The first magnetosensitive part **41**A is a magnetosensitive wire such as a Wiegand wire. In the first magnetosensitive part **41**A, large Barkhausen jump (Wiegand effect) is generated by the change in magnetic field associated with the rotation of the magnet **11**. The first magnetosensitive part **41**A is a cylindrical member whose projection image is rectangular, and an axial direction thereof is set in the circumferential direction of the magnet **11**. Hereinafter, the axial direction of the first magnetosensitive part **41**A, i.e., a direction perpendicular to a circular (or which may be polygonal or the like) cross-section of the first magnetosensitive part **41**A is referred to as the length direction of the first magnetosensitive part **41**A. Also, for example, a length of the magnetosensitive part in the direction (the axial direction, the length direction, the longitudinal direction) perpendicular to the cross-section of the magnetosensitive part (for example, the first magnetosensitive part **41**A) is set to be longer than a length of the magnetosensitive part in a direction (width direction) parallel to the cross-section of the magnetosensitive part. When the AC magnetic field is applied in the axial direction (length direction) of the first magnetosensitive part **41**A and the AC magnetic field is reversed, the first magnetosensitive part **41**A generates a magnetic domain wall from one end toward the other end in the axial direction. As such, the length direction (axial direction) of the magnetosensitive part (for example, the first magnetosensitive part **41**A and the like) of the present embodiment is also referred to as an easy magnetization direction that is a direction in which magnetization is easily oriented.

(50) The first and second magnetic bodies **45**A and **46**A are formed of a ferromagnetic material such as iron, cobalt, nickel, for example. The first and second magnetic bodies **45**A and **46**A can also be referred to as yokes. The first magnetic body **45**A is provided between the front surface of the magnet **11** and one end of the first magnetosensitive part **41**A, and the second magnetic body **46**A is provided between the back surface of the magnet **11** and the other end of the first magnetosensitive part **41**A. Tip end portions of the first and second magnetic bodies **45**A and **46**A are disposed at the same angular position in the circumferential direction on the front surface and back surface of the magnet **11**. The polarities of the magnet **11** are always opposite to each other at the tip end portions of the first and second magnetic bodies **45**A and **46**A, and when the tip end portion of the first magnetic body **45**A is positioned near the N pole **16**A (or the S pole **16**B), the tip end portion of the second magnetic body **46**A is located near the S pole **17**A (or the N pole **17**B). For this reason, the first and second magnetic bodies **45**A and **46**A guide magnetic field lines from the two parts of the magnet **11** (for example, the N pole **16**A and the S pole **17**A), which are located at the same position in the circumferential direction of the magnet **11** and have polarities different from each other, to the length direction of the first magnetosensitive part **41**A. By the magnet **11**, the first magnetic body **45**A, the first magnetosensitive part **41**A, and the second

magnetic body **46**A, a magnetic circuit MC**1** (see FIG. **3**A) including the magnetic field lines toward the length direction of the first magnetosensitive part **41**A is formed. Note that a peripheral edge portion of the disc **15** of FIG. **1** is provided with a step (not shown), so that a space into which the second magnetic body **46**A can be inserted is secured between the peripheral edge portion of the disc **15** and the back surface the magnet **11**.
(51) The first electric power generation part **42**A is, for example, a high-density coil wound and disposed on the first magnetosensitive part **41**A. In the first electric power generation part **42**A, electromagnetic induction is generated due to the generation of the magnetic domain wall in the first magnetosensitive part **41**A, so that an induction current flows. When the positions **11***a* to **11***d* of the magnet **11** shown in FIG. **2**B pass near the electric signal generation unit **31**A (the tip end portions of the magnetic bodies **45**A and **46**A), a pulsed current (electric signal, electric power) is generated in the first electric power generation part **42**A.
(52) A direction of the current generated in the first electric power generation part **42**A is changed in accordance with the direction of the magnetic field before and after the reversal. For example, a direction of the current that is generated upon the reversal from the magnetic field toward the front surface-side to the magnetic field toward the back surface-side of the magnet **11** is opposite to a direction of the current that is generated upon the reversal from the magnetic field toward the back surface-side to the magnetic field toward the front surface-side of the magnet **11**. The electric power (induction current) that is generated in the first electric power generation part **42**A can be set by the number of turns in the high-density coil, for example.
(53) As shown in FIG. **2**A, the first magnetosensitive part **41**A, the first electric power generation part **42**A, and the parts of the first and second magnetic bodies **45**A and **46**A on the first magnetosensitive part **41**A-side are accommodated in a case **43**A. The case **43**A is provided with terminals **42**Aa and **42**Ab. The high-density coil of the first electric power generation part **42**A has one end and the other end thereof that are electrically connected to the terminals **42**Aa and **42**Ab, respectively. The electric power generated in the first electric power generation part **42**A can be extracted outside of the first electric signal generation unit **31**A via the terminals **42**Aa and **42**Ab.
(54) The second electric signal generation unit **31**B is disposed in an angular position forming an angle larger than 0° and smaller than 180° from the angular position in which the first electric signal generation unit **31**A is disposed. An angle between the electric signal generation units **31**A and **31**B is selected within a range from 22.5° to 67.5°, for example, and is about 45° in FIG. **2**B. The second electric signal generation unit **31**B has a similar configuration to the first electric signal generation unit **31**A. The second electric signal generation unit **31**B includes a second magnetosensitive part **41**B, a second electric power generation part **42**B, and a second set of first magnetic body **45**B and a second set of second magnetic body **46**B. The second magnetosensitive part **41**B, the second electric power generation part **42**B, and the second set of first and second magnetic bodies **45**B and **46**B are similar to the first magnetosensitive part **41**A, the first electric power generation part **42**A, and the first set of first and second magnetic bodies **45**A and **46**A, respectively, and the descriptions thereof are thus omitted. The second magnetosensitive part **41**B, the second electric power generation part **42**B, and the parts of the first and second magnetic bodies **45**B and **46**B on the second magnetosensitive part **41**B-side are accommodated in a case **43**B. The case **43**B is provided with terminals **42**Ba and **42**Bb. The electric power generated in the second electric power generation part **42**B can be extracted outside of the second electric signal generation unit **31**B via the terminals **42**Ba and **42**Bb. Note that at least a part of the magnetosensitive part (for example, the first magnetosensitive part **41**A and the second magnetosensitive part **41**B) is disposed spaced apart outside of the magnet **11** in the diametrical direction of the magnet **11** or in the parallel direction thereof. For example, when the surfaces (i.e., the surfaces on which the plurality of polarities of the magnet is aligned) of the magnet **11** orthogonal to the rotary shaft SF are each referred to as one surface and the other surface, the magnetosensitive part is disposed spaced apart outside with respect to a side surface (or a side surface parallel to the axial direction of

the rotary shaft SF) of the magnet **11** orthogonal to one surface or the other surface of the magnet **11** and along the moving direction of the magnet.
(55) The magnetism detection unit **12** includes magnetic sensors **51** and **52**. The magnetic sensor **51** is disposed in an angular position greater than 0° and smaller than 180° with respect to the second magnetosensitive part **41**B (second electric signal generation unit **31**B) in the rotating direction of the rotary shaft SF. The magnetic sensor **52** is disposed in an angular position (about 45°, in FIG. **2**B) greater than 22.5° and smaller than 67.5° with respect to the magnetic sensor **51** in the rotating direction of the rotary shaft SF.
(56) As shown in FIG. **2**C, the magnetic sensor **51** includes a magnetoresistive element **56**, a bias magnet (not shown) for applying a magnetic field having predetermined strength to the magnetoresistive element **56**, and a waveform shaping circuit (not shown) for shaping a waveform from the magnetoresistive element **56**. The magnetoresistive element **56** has a full bridge shape where elements **56***a*, **56***b*, **56***c* and **56***d* are connected in series. A signal line between the elements **56***a* and **56***c* is connected to a power supply terminal **51***p*, and a signal line between the elements **56***b* and **56***d* is connected to a ground terminal **51***g*. A signal line between the elements **56***a* and **56***b* is connected to a first output terminal **51***a*, and a signal line between the elements **56***c* and **56***d* is connected to a second output terminal **51***b*. The magnetic sensor **52** has a similar configuration to the magnetic sensor **51**, and the descriptions thereof are thus omitted.
(57) Subsequently, operations of the first electric signal generation unit **31**A of the present embodiment are described. Hereinafter, the first magnetosensitive part **41**A and the first electric power generation part **42**A of the first electric signal generation unit **31**A shown in FIG. **2**B are collectively described as a magnetosensitive member **47**. A length direction of the magnetosensitive member **47** is the same as the length direction of the first magnetosensitive part **41**A, and the center in the length direction of the magnetosensitive member **47** is the same as the center in the length direction of the first magnetosensitive part **41**A. Note that since operations of the second electric signal generation unit **31**B are similar to those of the first electric signal generation unit **31**A, the descriptions thereof are omitted.
(58) FIG. **3**A is a plan view depicting the magnet **11** and the electric signal generation unit **31**A shown in FIG. **2**A, and FIGS. **3**B and **3**C are sectional views of the magnet **11** shown in FIG. **3**A. In FIGS. **3**A and **3**B, the magnet **11** has a flat plate shape along a rotating direction (hereinafter, also referred to as the θ direction) around the rotary shaft SF, has a plurality of polarities (the N pole **16**A to the S pole **16**D) different from each other in the θ direction, and has two polarities (the N pole **16**A and the S pole **17**A, and the like) different from each other in a thickness direction (in the present embodiment, the axial direction AD**1** of the rotary shaft SF) orthogonal to the θ direction. For this reason, the axial direction AD**1** can also be referred to as an orientation direction (magnetization direction) of parts of the magnet **11** having polarities different from each other (the N pole **16**A, the S pole **17**A, and the like). As the magnet **11** rotates in the θ direction, the direction and strength of the magnetic field in the axial direction or the orientation direction AD**1** are changed.
(59) Also, the magnetosensitive member **47** (or the magnetosensitive part) is disposed near the outer surface of the magnet **11** so that the length direction thereof is parallel to the front surface (one surface or back surface) of the magnet **11** having a flat plate shape. In FIG. **3**A, when the length direction of the magnetosensitive member **47** is referred to as a direction LD**1**, the length direction LD**1** is parallel to the front surface of the magnet **11**. In the present embodiment, the length direction LD**1** of the magnetosensitive member **47** is substantially parallel to the θ direction (circumferential direction), and is also substantially orthogonal to the axial direction AD**1** that is the magnetization direction of the magnet **11** (for example, a specific direction in which a direction of a magnetic pole is fixed). Also, as shown in FIG. **3**C, the length direction of the magnetosensitive member **47** is disposed so as to be substantially orthogonal to a tangential direction (herein, a direction parallel to the axial direction AD**1**) of a magnetic field line MF**1**,

which passes through a substantial center (for example, a position of a half of a length in the length direction of the magnetosensitive member **47** or the magnetosensitive part (**41**A, **41**B)) in the length direction of the magnetosensitive member **47**, of the magnetic field lines of the magnet **11**. Note that the length direction LD**1** of the magnetosensitive member **47** is disposed so as to be substantially orthogonal to the thickness direction orthogonal to the θ direction. Also, the first and second magnetic bodies **45**A and **46**A guide magnetic field lines from the two parts of the magnet **11** (for example, the N pole **16**A and the S pole **17**A), which are located at the same angular position in the θ direction and have polarities different from each other, to the length direction LD**1** of the magnetosensitive member **47** via one end **47***a* and the other end **47***b* of the magnetosensitive member **47**.
(60) A magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**A including magnetic field lines generated on a side surface of the magnet **11** is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end of the magnetosensitive member **47** due to large Barkhausen jump (Wiegand effect) in the length direction of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**. For this reason, even when the magnetosensitive member **47** is disposed near the magnet **11** and the electric signal generation unit **31**A is thus downsized, it is possible to effectively generate the stable high-output pulse by using the electric signal generation unit **31**A through the reversal of the AC magnetic field in the axial direction due to the rotation of the magnet **11**, without being affected by the unnecessary magnetic field component.
(61) FIG. **4** shows a circuit configuration of the electric power supplying system **2** and the multi-turn information detection unit **3** in accordance with the present embodiment. In FIG. **4**, the electric power supplying system **2** includes the first electric signal generation unit **31**A, a rectifier stack **61**, the second electric signal generation unit **31**B, a rectifier stack **62**, and the battery **32**. Also, the electric power supplying system **2** includes a regulator **63**, as the switching unit **33** shown in FIG. **1**. The rectifier stack **61** is a rectifier that rectifies a current flowing from the first electric signal generation unit **31**A. A first input terminal **61***a* of the rectifier stack **61** is connected to the terminal **42**Aa of the first electric signal generation unit **31**A. A second input terminal **61***b* of the rectifier stack **61** is connected to the terminal **42**Ab of the first electric signal generation unit **31**A. A ground terminal **61***g* of the rectifier stack **61** is connected to a ground line GL to which the same potential as a signal ground SG is supplied. During the operation of the multi-turn information detection unit **3**, the potential of the ground line GL becomes a reference potential of the circuit. An output terminal **61***c* of the rectifier stack **61** is connected to a control terminal **63***a* of the regulator **63**.
(62) The rectifier stack **62** is a rectifier that rectifies a current flowing from the second electric signal generation unit **31**B. A first input terminal **62***a* of the rectifier stack **62** is connected to the terminal **42**Ba of the second electric signal generation unit **31**B. A second input terminal **62***b* of the rectifier stack **62** is connected to the terminal **42**Bb of the second electric signal generation unit **31**B. A ground terminal **62***g* of the rectifier stack **62** is connected to the ground line GL. An output terminal **62***c* of the rectifier stack **62** is connected to the control terminal **63***a* of the regulator **63**.
(63) The regulator **63** regulates electric power that is supplied from the battery **32** to the position detection system **1**. The regulator **63** may include a switch **64** provided on an electric power supply path between the battery **32** and the position detection system **1**. The regulator **63** controls an operation of the switch **64**, based on the electric signals generated from the electric signal generation units **31**A and **31**B. An input terminal **63***b* of the regulator **63** is connected to the battery **32**. An output terminal **63***c* of the regulator **63** is connected a power supply line PL. A ground terminal **63***g* of the regulator **63** is connected to the ground line GL. The control terminal **63***a* of the regulator **63** is an enable terminal, and the regulator **63** keeps a potential of the output terminal **63***c* to a predetermined voltage in a state where a voltage equal to or higher than a threshold value is

applied to the control terminal **63***a*. An output voltage (predetermined voltage) of the regulator **63** is, for example, 3V when a counter **67** is configured by a CMOS and the like. An operating voltage of a non-volatile memory **68** of the storage unit **14** is set to the same voltage as the predetermined voltage, for example. Note that the predetermined voltage is a voltage necessary for electric power supply, and may be not only a constant voltage value, but also a voltage changing in a stepwise manner.

(64) A first terminal **64***a* of the switch **64** is connected to the input terminal **63***b*, and a second terminal **64***b* is connected to the output terminal **63***c*. The regulator **63** switches conduction and insulation states between the first terminal **64***a* and the second terminal **64***b* of the switch **64** by using the electric signals supplied from the electric signal generation units **31**A and **31**B to the control terminal **63***a*, as a control signal (enable signal). For example, the switch **64** includes a switching device such as a MOS, a TFT and the like, the first terminal **64***a* and the second terminal **64***b* are a source electrode and a drain electrode, and a gate electrode is connected to the control terminal **63***a*. The switch **64** is in a state (on state) where the source electrode and the drain electrode can be conductive therebetween, when the gate electrode is charged by the electric signals (electric power) generated from the electric signal generation units **31**A and **31**B and a potential of the gate electrode becomes equal to or higher than a threshold value. Note that the switch **64** may also be provided outside the regulator **63**, and may be externally attached such as a relay, for example.

(65) The multi-turn information detection unit **3** includes, as the magnetism detection unit **12**, the magnetic sensors **51** and **52**, and analog comparators **65** and **66**. The magnetism detection unit **12** detects the magnetic field formed by the magnet **11** by using the electric power supplied from the battery **32**. Also, the multi-turn information detection unit **3** includes a counter **67**, as the detection unit **13** shown in FIG. **1**, and includes a non-volatile memory **68**, as the storage unit **14**. The electric power supply terminal **51***p* of the magnetic sensor **51** is connected to the power supply line PL. The ground terminal **51***g* of the magnetic sensor **51** is connected to the ground line GL. An output terminal **51***c* of the magnetic sensor **51** is connected to an input terminal **65***a* of the analog comparator **65**. In the present embodiment, the output terminal **51***c* of the magnetic sensor **51** outputs a voltage corresponding to a difference between a potential of the second output terminal **51***b* shown in FIG. **2**C and the reference potential. The analog comparator **65** is a comparator that compares a voltage output from the magnetic sensor **51** with a predetermined voltage. A power supply terminal **65***p* of the analog comparator **65** is connected to the power supply line PL. A ground terminal **65***g* of the analog comparator **65** is connected to the ground line GL. An output terminal **65***b* of the analog comparator **65** is connected to a first input terminal **67***a* of the counter **67**. The analog comparator **65** outputs an H-level signal from the output terminal when an output voltage of the magnetic sensor **51** is equal to or higher than a threshold value, and outputs an L-level signal from the output terminal when the output voltage of the magnetic sensor **51** is lower than the threshold value.

(66) The magnetic sensor **52** and the analog comparator **66** have similar configurations to the magnetic sensor **51** and the analog comparator **65**. A power supply terminal **52***p* of the magnetic sensor **52** is connected to the power supply line PL. A ground terminal **52***g* of the magnetic sensor **52** is connected to the ground line GL. An output terminal **52***c* of the magnetic sensor **52** is connected to an input terminal **66***a* of the analog comparator **66**. A power supply terminal **66***p* of the analog comparator **66** is connected to the power supply line PL. A ground terminal **66***g* of the analog comparator **66** is connected to the ground line GL. An output terminal **58***b* of the analog comparator **66** is connected to a second input terminal **67***b* of the counter **67**. The analog comparator **66** outputs an H-level signal from the output terminal when an output voltage of the magnetic sensor **52** is equal to or higher than a threshold value, and outputs an L-level signal from the output terminal **66***b* when the output voltage of the magnetic sensor **52** is lower than the threshold value.

(67) The counter **67** counts the multi-turn information of the rotary shaft SF by using the electric power supplied from the battery **32**. The counter **67** includes, for example, a CMOS logical circuit and the like. The counter **67** operates using the electric power that is supplied via a power supply terminal **6′7***p* and a ground terminal **67***g*. The power supply terminal **6′7***p* of the counter **67** is connected to the power supply line PL. The ground terminal **67***g* of the counter **67** is connected to the ground line GL. The counter **67** performs counting processing by using a voltage that is supplied via the first input terminal **67***a*, and a voltage that is supplied via the second input terminal **67***b*, as a control signal.
(68) The non-volatile memory **68** stores at least a part (for example, the multi-turn information) of the rotational position information detected by the detection unit **13** by using the electric power supplied from the battery **32** (performs a writing operation). The non-volatile memory **68** stores a result (multi-turn information) of the counting by the counter **67**, as the rotational position information detected by the detection unit **13**. A power supply terminal **68***p* of the non-volatile memory **68** is connected to the power supply line PL. A ground terminal **68***g* of the storage unit **14** is connected to the ground line GL. The storage unit **14** shown in FIG. **1** includes the non-volatile memory **68**, and can keep the information written while the electric power is supplied, even in a state where the electric power is not supplied.
(69) In the present embodiment, a capacitor **69** is provided between the rectifier stacks **61** and **62** and the regulator **63**. A first electrode **69***a* of the capacitor **69** is connected to a signal line for connecting the rectifier stacks **61** and **62** and the control terminal **63***a* of the regulator **63**. A second electrode **69***b* of the capacitor **69** is connected to the ground line GL. The capacitor **69** is a so-called smoothing capacitor, and reduces pulsation to reduce a load of the regulator. A constant of the capacitor **69** is set so that the electric power supply from the battery **32** to the detection unit **13** and the storage unit **14** is kept for a time period in which the rotational position information is detected by the detection unit **13** and the rotational position information is written into the storage unit **14**, for example.
(70) Also, the battery **32** includes, for example, a primary battery **36** such as a button-shaped battery and a rechargeable secondary battery **37**. The secondary battery **37** is electrically connected to a power supply unit MCE of the motor control unit MC. During at least a part of a time period (for example, a time period in which a main power supply is in an on state) in which the power supply unit MCE of the motor control unit MC can supply the electric power, the electric power is supplied from the power supply unit MCE to the secondary battery **37**, and the secondary battery **37** is recharged by the electric power. During a time period (for example, a time period in which a main power supply is in an off state) in which the power supply unit MCE of the motor control unit MC cannot supply the electric power, the supply of the electric power from the power supply unit MCE to the secondary battery **37** is cut off.
(71) Also, the secondary battery **37** may be electrically connected to a transmission path of the electric signals from the electric signal generation units **31**A and **31**B. In this case, the secondary battery **37** can be recharged by the electric power of the electric signals from the electric signal generation units **31**A and **31**B. For example, the secondary battery **37** is electrically connected to a circuit between the rectifier stack **61** and the regulator **63**. The secondary battery **37** can be recharged by the electric power of the electric signals that are generated from the electric signal generation units **31**A and **31**B by the rotation of the rotary shaft SF, in a state where the supply of the electric power from the power supply unit MCE is cut off. Note that the secondary battery **37** may also be recharged by the electric power of the electric signals that are generated from the electric signal generation units **31**A and **31**B as the motor M is driven to rotate the rotary shaft SF.
(72) The encoder device EC in accordance with the present embodiment selects to supply the electric power from which of the primary battery **36** and the secondary battery **37** to the position detection system **1**, in a state where the supply of the electric power from an outside is cut off. The electric power supplying system **2** includes a power supply switcher (a power supply selection unit,

a selection unit) **38**, and the power supply switcher **38** switches (selects) to supply the electric power from which of the primary battery **36** and the secondary battery **37** to the position detection system **1**. A first input terminal of the power supply switcher **38** is electrically connected to a positive electrode of the primary battery **36**, and a second input terminal of the power supply switcher **38** is electrically connected to the secondary battery **37**. An output terminal of the power supply switcher **38** is electrically connected to the input terminal **63***b* of the regulator **63**.

(73) The power supply switcher **38** selects the primary battery **36** or the secondary battery **37**, as the battery for supplying the electric power to the position detection system **1**, based on a remaining amount of the secondary battery **37**, for example. For example, when a remaining amount of the secondary battery **37** is equal to or greater than a threshold value, the power supply switcher **38** supplies the electric power from the secondary battery **37**, and does not supply the electric power from the primary battery **36**. The threshold value is set, based on electric power that is consumed in the position detection system **1**, and is set equal to or higher than the electric power that is to be supplied to the position detection system **1**, for example. For example, when the electric power that is consumed in the position detection system **1** can be covered by the electric power that from the secondary battery **37**, the power supply switcher **38** supplies the electric power from the secondary battery **37**, and does not supply the electric power from the primary battery **36**. Also, when the remaining amount of the secondary battery **37** is less than the threshold value, the power supply switcher **38** supplies the electric power from the primary battery **36**, and does not supply the electric power from the secondary battery **37**. The power supply switcher **38** may also serve as a charger for controlling the recharging of the secondary battery **37**, for example, and may determine whether the remaining amount of the secondary battery **37** is equal to or greater than the threshold value by using remaining amount information of the secondary battery **37** that is used for control of the recharging.

(74) The secondary battery **37** is used in a combined manner in this way, so that it is possible to delay the consumption of the primary battery **36**. Therefore, the encoder device EC has no maintenance (for example, replacement) of the battery **32** or the maintenance frequency is low. Note that the battery **32** may include at least one of the primary battery **36** and the secondary battery **37**. Also, in the above embodiment, the electric power is alternatively supplied from the primary battery **36** or the secondary battery **37**. However, the electric power may be supplied from both the primary battery **36** and the secondary battery **37**. For example, a processing unit to which the primary battery **36** supplies the electric power and a processing unit to which the secondary battery **37** supplies the electric power may be determined, in accordance with power consumption of each processing unit (for example, the magnetic sensor **51**, the counter **67** and the non-volatile memory **68**) of the position detection system **1**. Note that the secondary battery **37** may be recharged using at least one of the electric power that is supplied from a power supply unit EC**2** and the electric power of the electric signals that are generated from the electric signal generation units **31**A and **31**B.

(75) Subsequently, operations of the electric power supplying system **2** and the multi-turn information detection unit **3** are described. FIG. **5** is a timing chart showing operations of the multi-turn information detection unit **3** when the rotary shaft SF rotates in the counterclockwise direction (forward rotation). Since a timing chart showing operations of the multi-turn information detection unit **3** when the rotary shaft SF rotates in the counterclockwise direction (reverse rotation) is inverted to the chart of FIG. **4** over time, the descriptions thereof are omitted.

(76) In “Magnetic field” of FIG. **5**, a solid line indicates a magnetic field at the position of the first electric signal generation unit **31**A, and a broken line indicates a magnetic field at the position of the second electric signal generation unit **31**B. “First electric signal generation unit”, and “Second electric signal generation unit” indicate an output of the first electric signal generation unit **31**A and an output of the second electric signal generation unit **31**B, respectively, and an output of current flowing in one direction is denoted as positive (+), and an output of current flowing in an opposite

direction thereof is denoted as negative (−). “Enable signal” indicates a potential that is applied to the control terminal **63***a* of the regulator **63** by the electric signals generated from the electric signal generation units **31**A and **31**B, and a high level is denoted as “H” and a low level is denoted as “L”. “Regulator” indicates an output of the regulator **63**, and a high level is denoted as “H” and a low level is denoted as “L”.

(77) In FIG. **5**, “Magnetic field on first magnetic sensor” and “Magnetic field on second magnetic sensor” are magnetic fields formed on the magnetic sensors **51** and **52**. The magnetic field formed by the magnet **11** is shown with a long broken line, the magnetic field formed by a bias magnet is shown with a short broken line, and a synthetic magnetic field thereof is shown with a solid line. “First magnetic sensor” and “Second magnetic sensor” each indicate outputs when the magnetic sensors **51** and **52** are constantly driven, an output from the first output terminal is shown with a broken line, and an output from the second output terminal is shown with a solid line. “First analog comparator” and “Second analog comparator” indicate outputs from the analog comparators **65** and **66**, respectively. An output when the magnetic sensor and the analog comparator are constantly driven is denoted as “constant drive”, and an output when the magnetic sensor and the analog comparator are intermittently driven is denoted as “intermittent drive”.

(78) When the rotary shaft SF rotates in the counterclockwise direction, the first electric signal generation unit **31**A outputs the current pulse flowing in the forward direction (“+” of “first electric signal generation unit”), at the angular positions of 45° and 225°. Also, the first electric signal generation unit **31**A outputs the current pulse flowing in the reverse direction (“−” of “first electric signal generation unit”), at the angular positions of 135° and 315°. The second electric signal generation unit **31**B outputs the current pulse flowing in the reverse direction (“−” of “second electric signal generation unit”), at the angular positions of 90° and 270°. Also, the second electric signal generation unit **31**B outputs the current pulse flowing in the forward direction (“−” of “second electric signal generation unit”), at the angular positions of 180° and 0° (360°. For this reason, the enable signal is switched to a high level at each of the angular positions of 45°, 90°, 135°, 180°, 225°, 270°, 315°, and 0°. Also, the regulator **63** supplies a predetermined voltage to the power supply line PL at each of the angular positions of 45°, 90°, 135°, 180°, 225°, 270°, 315°, and 0°, in a state where the enable signal is held at the high level.

(79) In the present embodiment, the output of the magnetic sensor **51** and the output of the magnetic sensor **52** have a phase difference of 90°, and the detection unit **13** detects the rotational position information by using the phase difference. The output of the magnetic sensor **51** is a positive sine wave in a range from the angular position 22.5° to the angular position 112.5°. In the angle range, the regulator **63** outputs the electric power at the angular positions of 45° and 90°. The magnetic sensor **51** and the analog comparator **65** are driven by the electric power supplied at each of the angular positions of 45° and 90°. A signal (hereinafter, referred to as “A-phase signal”) that is output from the analog comparator **65** is kept at an L-level in a state where the electric power is not supplied, and is an H-level at each of the angular positions of 45° and 90°.

(80) Also, the output of the magnetic sensor **52** is a positive sine wave in a range from the angular position of 157.5° to the angular position of 247.5°. In the angle range, the regulator **63** outputs the electric power at the angular positions of 180° and 225°. The magnetic sensor **52** and the analog comparator **66** are driven by the electric power supplied at each of the angular positions of 180° and 225°. A signal (hereinafter, referred to as “B-phase signal”) that is output from the analog comparator **66** is kept at an L-level in a state where the electric power is not supplied, and is an H-level at each of the angular positions of 180° and 225°.

(81) Herein, when the A-phase signal supplied to the counter **67** is an H-level (H) and the B-phase signal supplied to the counter **67** is an L-level, a set of the signal levels is denoted as (H, L). In FIG. **5**, a set of the signal levels at the angular position of 180° is (L, H), a set of the signal levels at the angular position of 225° is (H, H), and a set of the signal levels at the angular position of 270° is (H, L).

(82) When one or both of the detected A-phase signal and B-phase signal is an H-level, the counter **67** stores the set of the signal levels in the storage unit **14**. When one or both of the A-phase signal and B-phase signal detected next time is an H-level, the counter **67** reads out the set of the previous signal levels from the storage unit **14** and compares the set of the previous signal levels and a set of the current signal levels to determine the rotating direction of the rotary shaft SF. For example, when the set of the previous signal levels is (H, H) and the set of the current signal levels is (H, L), since the angular position in the previous detection is 225° and the angular position in the current detection is 270°, it can be seen that it is a counterclockwise direction (forward rotation). When the set of the current signal levels is (H, L) and the set of the previous signal levels is (H, H), the counter **67** supplies an up signal, which indicates that the counter will be counted up, to the storage unit **14**. When the up signal from the counter **67** is detected, the storage unit **14** updates the stored multi-turn information to a value increased by 1. In this way, the multi-turn information detection unit **3** in accordance with the present embodiment can detect the multi-turn information while determining the rotating direction of the rotary shaft SF.
(83) In this way, the encoder device EC in accordance with the present embodiment comprises the position detection system **1** (position detection unit) that detects the rotational position information of the rotary shaft SF (moving part) of the motor M (power supplying unit); the magnet **11** that rotates in conjunction with the rotary shaft SF and has a plurality of polarities along the rotating direction of the rotary shaft SF (the moving direction or the θ direction); and the electric signal generation unit **31**A (electric signal generation unit) that has the magnetosensitive member **47** (magnetosensitive part **41**A) whose magnetic characteristic is changed by the change in magnetic field associated with relative movement to the magnet **11**, and generates the electric signal, based on the magnetic characteristic of the magnetosensitive member **47**, wherein the magnetosensitive member **47** is disposed so that magnetosensitive member **47** is spaced apart from a side surface of the magnet **11** in the direction orthogonal to the rotating direction and the length direction of the magnetosensitive member **47** is orthogonal to the tangential directions of at least some of the magnetic field lines MF**2** of the magnet **11**.
(84) According to the present embodiment, a magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**A including magnetic field lines generated on the side surface of the magnet **11** is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end in the length direction of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**. For this reason, even when the magnetosensitive member **47** is disposed near the magnet **11** and the electric signal generation unit **31**A is thus made small, it is possible to effectively generate the high-output pulse (electric signal) with high reliability (stable output) by using the electric signal generation unit **31**A through the reversal of the AC magnetic field in the axial direction due to the rotation of the magnet **11**, without being affected by the unnecessary magnetic field component. Also, in a case where the encoder device EC comprises the battery **32**, it is possible to omit the maintenance (for example, replacement) of the battery **32** or to reduce the maintenance frequency of the battery **32** by using the electric signal effectively generated from the electric signal generation unit **31**A.
(85) Note that in order to suppress the effect of the magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**A, it is also considered to cover the circumference of the magnetosensitive member **47** with a magnetic body. However, when the circumference of the magnetosensitive member **47** is covered with the magnetic body, the electric signal generation unit becomes larger, which increases the cost and makes it difficult to incorporate the electric signal generation unit into the drive device. Also, a resonance point of the electric signal generation unit **31**A is lowered, so that it may become weak against vibration shock.
(86) Also, in the encoder device EC, the electric power is supplied from the battery **32** to the multi-

turn information detection unit **3** in a short time after the electric signal is generated from the electric signal generation unit **31**A, so that the multi-turn information detection unit **3** is dynamically driven (intermittently driven). After the detection and writing of the multi-turn information are over, the power delivery to the multi-turn information detection unit **3** is cut off but the counted value is kept because it is stored in the storage unit **14**. The sequence is repeated each time the predetermined position on the magnet **11** passes near the electric signal generation unit **31**A, even in a state where the supply of the electric power from the outside is cut off. Also, the multi-turn information stored in the storage unit **14** is read by the motor control unit MC and the like when the motor M starts next time, and is used to calculate an initial position of the rotary shaft SF, and the like. In the encoder device EC, the battery **32** supplies at least a part of the electric power that is consumed in the position detection system **1**, in accordance with the electric signal generated from the electric signal generation unit **31**A. Therefore, it is possible to increase the lifetime of the battery **32**. For this reason, it is possible to omit the maintenance (for example, replacement) of the battery **32** or to reduce the maintenance frequency of the battery **32**. For example, when the lifetime of the battery **32** is longer than other parts of the encoder device EC, it may be unnecessary to replace the battery **32**.

(87) In the meantime, when a magnetosensitive wire such as a Wiegand wire is used, the pulse current (electric signal) is obtained from the electric signal generation unit **31**A even though the magnet **11** is rotated at extremely low speed. For this reason, for example, in the state where the electric power is not supplied to the motor M, even though the rotary shaft SF (magnet **11**) is rotated at extremely low speed, the output of the electric signal generation unit **31**A can be used as the electric signal. Note that as the magnetosensitive wire (first magnetosensitive part **41**A), an amorphous magnetostrictive wire and the like can also be used. In this case, for example, the encoder device EC may perform full-wave rectification on the electric signal (current) generated from the electric signal generation unit (for example, **31**A and **31**B) by using the rectifier stack (for example, a rectifier), and to supply the rectified electric power to the multi-turn information detection unit **3** and the like.

(88) Also, in the present embodiment, as shown in FIG. **3**A, since the tip end portions of the first and second magnetic bodies **45**A and **46**A of the electric signal generation unit **31**A are disposed near the parts whose polarities are different from each other at the same angular positions on the front surface (N pole **16**A to the S pole **16**D) and back surface (S pole **17**A to the N pole **17**D) of the magnet **11**, the electric signal generation unit **31**A can be made further smaller. Note that like an electric signal generation unit **31**C of a modified embodiment shown in FIGS. **3**D and **3**E, a tip end portion of a first magnetic body **45**C on one end-side of the magnetosensitive member **47** may be disposed near a part (for example, the N pole **16**A, the S pole **16**B or the like) having any polarity on the front surface of the magnet **11**, and a tip end portion of a second magnetic body **46**C on the other end-side of the magnetosensitive member **47** may be disposed near a part (for example, the S pole **16**D, the N pole **16**A or the like) having different polarity on the front surface of the magnet **11**. In this case, the first and second magnetic bodies **45**C and **46**C guide the magnetic field lines from the two parts (for example, the N pole **16**A and the S pole **16**D) of the magnet **11**, which are located at different positions in the rotating direction and have polarities different from each other, to the length direction of the magnetosensitive member **47**. Also in the electric signal generation unit **31**C, a magnetic circuit MC**2** is formed from the magnet **11** so as to pass the first magnetic body **45**C, the magnetosensitive member **47** and the second magnetic body **46**C. Therefore, the magnetosensitive member **47** can effectively output the stable pulse by the reversal of the AC magnetic field due to the rotation of the magnet **11**, without being affected by the unnecessary magnetic field on the side surface of the magnet **11**.

(89) In the above embodiment, the two electric signal generation units **31**A and **31**B are provided. However, the encoder device EC may comprise only one electric signal generation unit **31**A. Also, the encoder device EC may comprise three or more electric signal generation units. Also, in other

embodiments and modified embodiments thereof to be described later, one electric signal generation unit will be described. However, a plurality of electric signal generation units may be provided.

Second Embodiment

(90) A second embodiment is described with reference to FIGS. **6**A to **6**E. Note that in FIGS. **6**A to **6**D, the parts corresponding to FIGS. **3**A to **3**C are denoted with the same reference signs, and the detailed descriptions thereof are omitted. FIG. **6**A is a plan view showing a magnet **11**A and an electric signal generation unit **31**D of an encoder device in accordance with the present embodiment, FIG. **6**B is a side view of FIG. **6**A, and FIG. **6**C is an enlarged view showing a part of FIG. **6**A. In FIGS. **6**A and **6**B, the magnet **11**A is configured so that the direction and strength of the magnetic field in a radial direction (or the diametrical direction, or a radiation direction) AD**2** with respect to the rotary shaft SF are changed by rotation. The magnet **11**A is, for example, an annular member that is coaxial with the rotary shaft SF. The main surfaces (front surface and back surface) of the magnet **11**A are substantially perpendicular to the rotary shaft SF, respectively.

(91) The magnet **11**A includes an annular magnet on an outer periphery-side where an N pole **16**E and an S pole **16**F are alternately disposed in the rotating direction or the circumferential direction (**0** direction) of the rotary shaft SF and an annular magnet on an inner periphery-side where an S pole **17**E and an N pole **17**F are alternately disposed in the θ direction. Phases of the annular magnet on the outer periphery-side and the annular magnet on the inner periphery-side are offset by 180°. In the magnet **11**A, a boundary between the S pole **17**E and the N pole **17**F on the inner periphery-side substantially matches a boundary between the N pole **16**E and the S pole **16**F on the outer periphery-side, with respect to the angular position in the θ direction. The magnet **11**A has a flat plate shape along the θ direction, and a plurality of polarities (the N pole **16**E, the S pole **16**F and the like) along the θ direction. Also, in the magnet **11**A, a direction orthogonal to the rotating direction (moving direction), i.e., in the present embodiment, the radial direction AD**2** with respect to the rotary shaft SF is regarded as a width direction of the magnet **11**A. The magnet **11**A has polarities (the N pole **16**E, the S pole **17**E and the like) different from each other in the width direction (radial direction AD**2**) orthogonal to the θ direction, on the front surface or back surface. The magnet **11**A is a permanent magnet magnetized to have a plurality of pairs of polarities (for example, 12 pairs) in the θ direction. In the present embodiment, a magnetization direction (orientation direction) of the magnet **11**A is the radial direction AD**2**.

(92) In the present embodiment, the magnetosensitive member **47** of the electric signal generation unit **31**D is disposed so that the length direction LD**2** is orthogonal to the front surface of the magnet **11**A having a flat plate shape, in the vicinity of an outer surface of the magnet **11**A. Also, the length direction LD**2** of the magnetosensitive member **47** in the electric signal generation unit **31**D is disposed to be orthogonal to the radial direction AD**2** with being spaced in the diametrical direction (for example, the radial direction) of the magnet **11**A orthogonal to the rotary shaft SF or in a direction parallel to the diametrical direction. In this case, the length direction LD**2** is parallel to the axial direction of the rotary shaft SF. In other words, in the present embodiment, the length direction LD**2** of the magnetosensitive member **47** is substantially orthogonal to the radial direction AD**2** that is the magnetization direction of the magnet **11**A, and is also substantially orthogonal to the θ direction (circumferential direction). Also, a tip end portion of a first magnetic body **45**D on one end-side of the magnetosensitive member **47** is disposed near an outer surface of a part of one polarity (for example, the N pole **16**E) on the outer periphery-side of the magnet **11**A, and a tip end portion of a second magnetic body **46**D on the other end-side of the magnetosensitive member **47** is disposed near an outer surface of a part (for example, the S pole **16**F) of the other polarity (polarity different from the one polarity) on the outer periphery-side of the magnet **11**A. In other words, the first and second magnetic bodies **45**D and **46**D guide the magnetic field lines from the two parts (for example, the N pole **16**E and the S pole **16**F) of the magnet **11**A, which are located at different positions in the θ direction and have polarities different from each other, to the length

direction LD2 of the magnetosensitive member **47**. The other configurations are similar to the first embodiment.
(93) Also in the present embodiment, a magnetic circuit MC**3** is formed from the magnet **11**A so as to pass the first magnetic body **45**D, the magnetosensitive member **47**, and the second magnetic body **46**D. Also, as shown in FIG. **6**C, the length direction of the magnetosensitive member **47** is disposed so as to be substantially orthogonal to a tangential direction (herein, the θ direction) of the magnetic field line MF**2**, which passes through a substantial center in the length direction of the magnetosensitive member **47**, of the magnetic field lines generated on the side surface of the magnet **11**A.
(94) A magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**D including magnetic field lines generated on the side surface of the magnet **11**A is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**A. For this reason, even when the magnetosensitive member **47** is disposed near the magnet **11**A and the electric signal generation unit **31**D is thus made small, it is possible to effectively generate the high-output pulse (electric signal) by using the electric signal generation unit **31**D through the reversal of the AC magnetic field in the radial direction AD**2** due to the rotation of the magnet **11**A, without being affected by the unnecessary magnetic field component. Also, in a case where the encoder device comprises the battery **32**, it is possible to omit the maintenance (for example, replacement) of the battery **32** or to reduce the maintenance frequency of the battery **32** by using the electric signal effectively generated from the electric signal generation unit **31**D.
(95) Note that in the present embodiment, like an electric signal generation unit **31**E of a modified embodiment shown in FIGS. **6**D and **6**E, a tip end portion of a first magnetic body **45**E on one end-side of the magnetosensitive member **47** may be disposed near a part (for example, the N pole **16**E, the S pole **16**F or the like) of one polarity on the outer periphery-side of the magnet **11**A, and a tip end portion of a second magnetic body **46**E on the other end-side of the magnetosensitive member **47** may be disposed near a part (for example, the S pole **17**E, the N pole **17**F or the like) of different polarity on the inner periphery-side of the magnet **11**A. In this case, the first and second magnetic bodies **45**E and **46**E guide the magnetic field lines from the two parts (for example, the N pole **16**E and the S pole **17**E) of the magnet **11**A, which are located at different positions in the width direction (radial direction AD**2**) of the magnet **11**A and have polarities different from each other, to the length direction of the magnetosensitive member **47**. Also in the electric signal generation unit **31**E, a magnetic circuit MC**4** is formed from the magnet **11**A so as to pass the first magnetic body **45**E, the magnetosensitive member **47**, and the second magnetic body **46**E. Therefore, the magnetosensitive member **47** can effectively output the stable pulse by the reversal of the AC magnetic field due to the rotation of the magnet **11**A, without being affected by the unnecessary magnetic field on the side surface of the magnet **11**A.
Third Embodiment
(96) A third embodiment is described with reference to FIGS. **7**A to **7**C. Note that in FIGS. **7**A to **7**C, the parts corresponding to FIGS. **6**A to **6**C are denoted with the same reference signs, and the detailed descriptions thereof are omitted. FIG. **7**A is a plan view showing a magnet **11**A and an electric signal generation unit **31**F of an encoder device in accordance with the present embodiment, and FIG. **7**B is a side view showing the magnet **11**A shown in FIG. **7**A, as a sectional view. In FIGS. **7**A and **7**B, the magnet **11**A is configured so that the direction and strength of the magnetic field in the radial direction AD**2** with respect to the rotary shaft SF are changed by rotation.
(97) In the present embodiment, the magnetosensitive member **47** of the electric signal generation unit **31**F is disposed in a space K so that the length direction LD**2** is orthogonal to the front surface

of the magnet **11**A having a flat plate shape, in the vicinity of an inner surface of the magnet **11**A having the space K inside. Also, the length direction LD**2** of the magnetosensitive member **47** in the electric signal generation unit **31**F is disposed to be orthogonal to the radial direction AD**2** with being spaced in a diametrical direction (for example, the radial direction) of the magnet **11**A orthogonal to the rotary shaft SF or in a direction parallel to the diametrical direction. In the present embodiment, the length direction LD**2** of the magnetosensitive member **47** is substantially orthogonal to the radial direction AD**2** that is the magnetization direction of the magnet **11**A, and is also substantially parallel to the axial direction of the rotary shaft SF. Also, a tip end portion of a first magnetic body **45**F on one end-side of the magnetosensitive member **47** is disposed near an inner surface of a part of one polarity (for example, the N pole **17**F) on the inner periphery-side of the magnet **11**A, and a tip end portion of a second magnetic body **46**F on the other end-side of the magnetosensitive member **47** is disposed near an inner surface of a part (for example, the S pole **17**E) of the other polarity on the inner periphery-side of the magnet **11**A. In other words, the first and second magnetic bodies **45**F and **46**F guide the magnetic field lines from the two parts (for example, the N pole **17**F and the S pole **17**E) of the magnet **11**A, which are located at different positions in the θ direction and have polarities different from each other, to the length direction LD**2** of the magnetosensitive member **47**. The other configurations are similar to the first embodiment.

(98) Also in the present embodiment, a magnetic circuit MC**5** is formed from the magnet **11**A so as to pass the first magnetic body **45**F, the magnetosensitive member **47**, and the second magnetic body **46**F. Also, the length direction of the magnetosensitive member **47** is disposed so as to be substantially orthogonal to a tangential direction (herein, the θ direction) of the magnetic field line, which passes through a substantial center in the length direction LD**2** of the magnetosensitive member **47**, of the magnetic field lines generated on the inner surface of the magnet **11**A. A magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**F including magnetic field lines generated on the inner surface of the magnet **11**A is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**A. For this reason, even when the magnetosensitive member **47** is disposed on the inner surface of the magnet **11**A and the electric signal generation unit **31**F is thus made small, it is possible to effectively generate the high-output pulse (electric signal) by using the electric signal generation unit **31**F through the reversal of the AC magnetic field in the radial direction AD**2** due to the rotation of the magnet **11**A, without being affected by the unnecessary magnetic field component. The other effects are similar to the above-described embodiments.

(99) Note that in the present embodiment, like an electric signal generation unit of a modified embodiment shown in FIG. **7**C, the magnetosensitive member **47** may be disposed on an outer surface of the magnet **11**A so that the length direction of the magnetosensitive member **47** is substantially perpendicular to the outer surface. In this case, a tip end portion of a magnetic body **45**F**1** on one end-side of the magnetosensitive member **47** is disposed near a part (for example, the N pole **16**E, the S pole **16**F or the like) of one polarity on the outer periphery-side of the magnet **11**A, and the other end of the magnetosensitive member **47** is disposed near a part (for example, the S pole **16**F, the N pole **16**E or the like) of different polarity on the outer periphery-side of the magnet **11**A. In this case, one end of the magnetic body **45**F**1** is disposed near one end-side of the magnetosensitive member **47**, and the other end of the magnetic body **45**F**1** is disposed near the part of one polarity on the outer periphery-side of the magnet **11**A. In other words, in the present modified embodiment, the other magnetic body (the first magnetic body or the second magnetic body) is omitted. In the present modified embodiment, the length direction of the magnetosensitive member **47** is substantially parallel to the radial direction that is the magnetization direction of the

magnet **11**A, and is also substantially orthogonal to the θ direction (circumferential direction).
(100) In the present modified embodiment, a magnetic circuit MC**51** is formed from the magnet **11**A so as to pass the magnetic body **45**F**1** and the magnetosensitive member **47**. Therefore, the magnetosensitive member **47** can effectively output the stable pulse by the reversal of the AC magnetic field due to the rotation of the magnet **11**A, without being affected by the unnecessary magnetic field on the side surface of the magnet **11**A.
Fourth Embodiment
(101) A fourth embodiment is described with reference to FIGS. **8**A to **8**E. Note that in FIGS. **8**A to **8**E, the parts corresponding to FIGS. **3**A to **3**C are denoted with the same reference signs, and the detailed descriptions thereof are omitted.
(102) FIG. **8**A is a plan view showing a magnet **11** and an electric signal generation unit **31**G of an encoder device in accordance with the present embodiment, and FIGS. **8**B and **8**C are side views showing the magnet **11** shown in FIG. **8**A, as sectional views. In FIGS. **8**A and **8**B, the magnet **11** is configured so that the direction and strength of the magnetic field in the axial direction AD**1** parallel to the rotary shaft SF are changed by rotation. The magnet **11** has a plurality of polarities (for example, the N pole **16**A and the S pole **16**B) in the θ direction, and also has parts (for example, the N pole **16**A and the S pole **17**A) of two polarities different from each other in the thickness direction (radial direction AD**2**) orthogonal to the θ direction. The magnetization direction of the magnet **11** is the axial direction AD**1**.
(103) In the present embodiment, the magnetosensitive member **47** of the electric signal generation unit **31**G is disposed so that the length direction LD**3** of the magnetosensitive member **47** is parallel to the front surface of the magnet **11** having a flat plate shape and the length direction LD**3** is perpendicular to the outer surface of the magnet **11**, in the vicinity of the outer surface of the magnet **11**. Also, the length direction LD**3** of the magnetosensitive member **47** in the electric signal generation unit **31**G is disposed to be orthogonal to the axial direction AD**1** with being spaced in the diametrical direction (for example, the radial direction) of the magnet **11** orthogonal to the rotary shaft SF or in a direction parallel to the diametrical direction. In the present embodiment, the length direction LD**3** of the magnetosensitive member **47** is substantially orthogonal to the axial direction AD**1** that is the magnetization direction of the magnet **11**, is substantially parallel to the radial direction of the rotary shaft SF, and is substantially orthogonal to the θ direction (circumferential direction). Also, a tip end portion of a first magnetic body **45**G on one end-side of the magnetosensitive member **47** is disposed near a part of one polarity (for example, the N pole **16**A) on the front surface-side of the magnet **11**, and a tip end portion of a second magnetic body **46**G on the other end-side of the magnetosensitive member **47** is disposed near a part (for example, the S pole **17**A) of the other polarity on the back surface-side of the magnet **11**. In other words, the first and second magnetic bodies **45**G and **46**G guide the magnetic field lines from the two parts (for example, the N pole **16**A and the S pole **17**A) of the magnet **11**, which are located at same angular position in the θ direction and have polarities different from each other, to the length direction LD**3** of the magnetosensitive member **47**. The other configurations are similar to the first embodiment.
(104) Also in the present embodiment, a magnetic circuit MC**6** is formed from the magnet **11** so as to pass the first magnetic body **45**G, the magnetosensitive member **47**, and the second magnetic body **46**G. Also, as shown in FIG. **8**C, the length direction LD**3** of the magnetosensitive member **47** is disposed so as to be substantially orthogonal to a tangential direction MD**3** (herein, parallel to the axial direction AD**1**) of the magnetic field line MF**3**, which passes through a substantial center in the length direction LD**3** of the magnetosensitive member **47**, of the magnetic field lines generated on the side surface of the magnet **11**.
(105) A magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**G including magnetic field lines generated on the side surface of the magnet **11** is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary

magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**. For this reason, even when the magnetosensitive member **47** is disposed near the magnet **11** and the electric signal generation unit **31**G is thus made small, it is possible to effectively generate the high-output pulse (electric signal) by using the electric signal generation unit **31**G through the reversal of the AC magnetic field in the axial direction AD**1** due to the rotation of the magnet **11**, without being affected by the unnecessary magnetic field component. The other effects are similar to the first embodiment.

(106) Note that in the present embodiment, like an electric signal generation unit **31**H of a modified embodiment shown in FIGS. **8**D and **8**E, a tip end portion of a first magnetic body **45**H on one end-side of the magnetosensitive member **47** may be disposed near a part (for example, the N pole **16**A, the S pole **16**B or the like) of one polarity on the front surface-side of the magnet **11**, and a tip end portion of a second magnetic body **46**H on the other end-side of the magnetosensitive member **47** may be disposed near a part (for example, the S pole **16**D, the N pole **16**A or the like) of different polarity on the front surface-side of the magnet **11**. In this case, the first and second magnetic bodies **45**H and **46**H guide the magnetic field lines from the two parts of the magnet **11** (for example, the N pole **16**A and the S pole **16**D), which are located at different positions in the θ direction of the magnet **11** and have polarities different from each other, to the length direction of the magnetosensitive member **47**. Also in the electric signal generation unit **31**H, a magnetic circuit MC**7** is formed from the magnet **11** so as to pass the first magnetic body **45**H, the magnetosensitive member **47**, and the second magnetic body **46**H, and the magnetosensitive member **47** can effectively output the stable pulse by the reversal of the AC magnetic field due to the rotation of the magnet **11**, without being affected by the unnecessary magnetic field on the side surface of the magnet **11**.

Fifth Embodiment

(107) A fifth embodiment is described with reference to FIGS. **9**A and **9**B. Note that in FIGS. **9**A and **9**B, the parts corresponding to FIGS. **3**A to **3**C are denoted with the same reference signs, and the detailed descriptions thereof are omitted. FIG. **9**A is a plan view showing a magnet **11**B, magnetic sensors **51** and **52** (magnetism detection unit **12**), and an electric signal generation unit **31**A of an encoder device in accordance with the present embodiment, and FIG. **9**B is a side view showing the magnet **11**B of FIG. **9**A, as a sectional view. In FIGS. **9**A and **9**B, the magnet **11**B includes an annular magnet on the outer periphery-side where an N pole **16**G and an S pole **16**H each having an opening angle of 180° and a fan shape are disposed in the rotating direction (θ direction) of the rotary shaft SF and an annular magnet on the inner periphery-side where an S pole **16**J and an N pole **16**I each having an opening angle of 180° and a fan shape are disposed in the θ direction. Also, on back surfaces of the N pole **16**G and the S pole **16**H on the outer periphery-side, an S pole **17**G and an N pole **17**H having the same shape and different polarity are bonded, and on back surfaces of the N pole **16**I and the S pole **16**J on the inner periphery-side, an S pole **17**I and an N pole **17**J having the same shape and different polarity are bonded. As such, phases of the annular magnet on the outer periphery-side of the magnet **11**B and the annular magnet on the inner periphery-side are offset by 180°. Also, the magnet **11**B has two polarities different from each other in the thickness direction (axial direction AD**1**). In the magnet **11**B, a boundary between the S pole **16**J and the N pole **16**I on the inner periphery-side substantially matches a boundary between the N pole **16**G and the S pole **16**H on the outer periphery-side, with respect to the angular position in the θ direction.

(108) In the present embodiment, the magnetosensitive member **47** of the electric signal generation unit **31**A is disposed so that the length direction of the magnetosensitive member **47** is parallel to the front surface of the magnet **11**B having a flat plate shape and the length direction is parallel to the rotating direction (**0** direction) of the rotary shaft SF, in the vicinity of the outer surface of the magnet **11**B. Also, the tip end portion of the first magnetic body **45**A on one end-side of the

magnetosensitive member **47** is disposed near a part of one polarity (for example, the S pole **16**H) on the front surface-side of the magnet **11**B, and the tip end portion of the second magnetic body **46**A on the other end-side of the magnetosensitive member **47** is disposed near a part (for example, the N pole **17**H) of the other polarity on the back surface-side of the magnet **11**B. In other words, the first and second magnetic bodies **45**A and **46**A guide the magnetic field lines from the two parts (for example, the S pole **16**H and the N pole **17**H) of the magnet **11**B, which are located at same angular position in the θ direction and have polarities different from each other, to the length direction of the magnetosensitive member **47**.

(109) Also, the magnetic sensors **51** and **52** are disposed so as to overlap a boundary part between the annular magnet on the inner periphery-side and the annular magnet on the outer periphery-side, in the vicinity of the front surface of the magnet **11**B. An angle between the magnetic sensors **51** and **52** is, for example, about 90°. The other configurations are similar to the first embodiment. In the present embodiment, the magnetization direction of the magnet **11**B with respect to the electric signal generation unit **31**A is the axial direction AD**1**, and the magnetization direction with respect to the magnetic sensors **51** and **52** is the radial direction. Also, the length direction of the magnetosensitive member **47** is substantially orthogonal to the axial direction AD**1** that is the magnetization direction of the magnet **11**B, and is substantially parallel to the θ direction (circumferential direction). Also in the present embodiment, the magnetic circuit MC**1** is formed from the magnet **11**B so as to pass the first magnetic body **45**A, the magnetosensitive member **47**, and the second magnetic body **46**A. Also, the length direction of the magnetosensitive member **47** is disposed so as to be substantially orthogonal to a tangential direction (herein, parallel to the axial direction AD**1**) of the magnetic field line, which passes through a substantial center in the length direction of the magnetosensitive member **47**, of the magnetic field lines generated on the side surface of the magnet **11**B.

(110) A magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**A including magnetic field lines generated on the side surface of the magnet **11**B is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**B. For this reason, even when the magnetosensitive member **47** is disposed near the magnet **11**B and the electric signal generation unit **31**A is thus made small, it is possible to effectively generate the high-output pulse (electric signal) by using the electric signal generation unit **31**A through the reversal of the AC magnetic field in the axial direction AD**1** due to the rotation of the magnet **11**B, without being affected by the unnecessary magnetic field component. Also, each of the magnetic sensors **51** and **52** can detect a change in magnetic field including a magnetic field line MF**4** that is generated between the annular magnet on the inner periphery-side of the magnet **11**B and the annular magnet on the outer periphery-side. The encoder device of the present embodiment can obtain the angle and multi-turn information of the rotary shaft SF by using detection results of the magnetic sensors **51** and **52**. The other effects are similar to the first embodiment.

Sixth Embodiment

(111) A sixth embodiment is described with reference to FIGS. **10**A and **10**B. Note that in FIGS. **10**A and **10**B, the parts corresponding to FIGS. **9**A and **9**B are denoted with the same reference signs, and the detailed descriptions thereof are omitted.

(112) FIG. **10**A is a plan view showing a rotational disc **11**D for optical sensor, magnetic sensors **51** and **52**, an optical sensor **21**A, and an electric signal generation unit **31**A of an encoder device in accordance with the present embodiment, and FIG. **10**B is a side view showing a magnet **11**B of FIG. **10**A, as a sectional view. In FIGS. **10**A and **10**B, the annular rotational disc **11**D (which is actually provided with an opening (not shown) through which the rotary shaft SF passes) is fixed to the front surface of the magnet **11**B. The rotational disc **11**D and the magnet **11**B rotate in the θ

direction in conjunction with the rotary shaft SF. An incremental scale **11**Da and an absolute scale **11**Db are formed concentrically on a front surface of the rotational disc **11**D. Also, the rotational disc **11**D is disposed between the tip end portion of the first magnetic body **45**A of the electric signal generation unit **31**A and the front surface of the magnet **11**B. The magnetic circuit MC**1** of the electric signal generation unit **31**A is formed to pass through the rotational disc **11**D.

(113) Also, the optical sensor **21**A includes a light-emitting element **21**Aa that generates illumination light, and light-receiving sensors **21**Ab and **21**Ac that receive the illumination light generated from the light-emitting element **21**Aa and reflected on the incremental scale **11**Da and the absolute scale **11**Db. The encoder device of the present embodiment can obtain the rotating angle integrated each time the rotary shaft SF rotates by a predetermined angle from a predetermined reference angle, and an absolute angular position within one-turn of the rotary shaft SF by processing detection signals of the light-receiving sensors **21**Ab and **21**Ac in a detection unit (not shown) similar to the detection unit **23** of FIG. **1**. Also, it is possible to obtain the multi-turn information of the rotary shaft SF by performing one counting each time a relative angular position exceeds 360°.

(114) Similarly, the encoder device of the present embodiment can obtain the rotating angle and multi-turn information of the rotary shaft SF by using detection results of the magnetic sensors **51** and **52**. Also, a magnetic field component unnecessary for pulse generation in the electric signal generation unit **31**A including magnetic field lines generated on the side surface of the magnet **11**B is orthogonal to the length direction of the magnetosensitive member **47**, and the unnecessary magnetic field component does not adversely affect the generation of the magnetic domain wall from one end toward the other end of the magnetosensitive member **47** caused by the reversal of the AC magnetic field due to the rotation of the magnet **11**B. For this reason, even when the magnetosensitive member **47** is disposed near the magnet **11**B and the electric signal generation unit **31**A is thus made small, it is possible to effectively generate the high-output pulse (electric signal) by using the electric signal generation unit **31**A through the reversal of the AC magnetic field in the axial direction AD**1** due to the rotation of the magnet **11**B, without being affected by the unnecessary magnetic field component. The other effects are similar to the first embodiment.

(115) Note that when the plurality of electric signal generation units is provided, like the embodiments and modified embodiments, the electric power that is output from the electric signal generation unit **31**A may also be used as a detection signal for detecting the multi-turn information or may be used for supply to a detection system and the like. Note that in the first embodiment, the magnet **11** is an eight-pole magnet having four poles in the circumferential direction and two poles in the thickness direction. However, the present invention is not limited thereto, and can be changed as appropriate. For example, the number of poles of the magnet **11** in the circumferential direction may be two or four or more.

(116) Note that in the above embodiments, the position detection system **1** detects the rotational position information of the rotary shaft SF (moving part), as the position information but may also detect at least one of a position in a predetermined direction, a speed and an acceleration, as the position information. The encoder device EC may comprises a rotary encoder or a linear encoder. Also, the encoder device EC may have a configuration where the electric power generation part and the detection unit are provided on the rotary shaft SF and the magnet **11** is provided outside the moving body (for example, the rotary shaft SF), so that the relative positions of the magnet and the detection unit are changed with movement of the moving part. Also, the position detection system **1** may not detect the multi-turn information of the rotary shaft SF, and may detect the multi-turn information by an external processing unit of the position detection system **1**.

(117) In the above embodiments, the electric signal generation units **31**A and **31**B generate the electric power (electric signal) when a predetermined positional relation with the magnet **11** is satisfied. The position detection system **1** may also detect (count) the position information (for example, the rotational position information including the multi-turn information or the angular

position information) of the moving part (for example, the rotary shaft SF) by using, as the detection signal, the change in electric power (signal) generated from the electric signal generation units **31**A and **31**B. For example, the electric signal generation units **31**A and **31**B may be used as sensors (position sensors), and the position detection system **1** may detect the position information of the moving part by the electric signal generation units **31**A and **31**B and one or more sensors (for example, the magnetic sensor and the light-receiving sensor). Also, when the number of the electric signal generation units is two or more, the position detection system **1** may detect the position information by using the two or more electric signal generation units, as sensors. For example, the position detection system **1** may detect the position information of the moving part by using the two or more electric signal generation units, as sensors, without using the magnetic sensors, or may detect the position information of the moving part without using the light-receiving sensor. Also, similarly to the magnetic sensor, the position detection system **1** may determine the rotating direction of the rotary shaft SF by using the two or more electric signal generation units, as sensors, based on two or more electric signals.

(118) Also, the electric signal generation units **31**A and **31**B may supply at least a part of electric power that is consumed in the position detection system **1**. For example, the electric signal generation units **31**A and **31**B may supply the electric power to a processing unit of the position detection system **1**, which has relatively small power consumption. Also, the electric power supply system **2** may not supply the electric power to some of the position detection system **1**. For example, the electric power supplying system **2** may intermittently supply the electric power to the detection unit **13** and may not supply the electric power to the storage unit **14**. In this case, the electric power may be supplied intermittently or continuously to the storage unit **14** from a power supply, a battery and the like provided outside the electric power supplying system **2**. The electric power generation part may generate the electric power by a phenomenon other than the large Barkhausen jump, and for example, may not supply the electric power to the moving part (for example, the rotary shaft SF) and some of the position detection system **1**. For example, the electric power supplying system **2** may intermittently supply the electric power to the detection unit **13** and may not supply the electric power to the storage unit **14**. In this case, the electric power may be supplied intermittently or continuously to the storage unit **14** from a power supply, a battery and the like provided outside the electric power supplying system **2**. The electric power generation part may generate the electric power by a phenomenon other than the large Barkhausen jump, and for example, may generate the electric power by electromagnetic induction associated with the change in magnetic field due to movement of the moving part (for example, the rotary shaft SF). The storage unit in which the detection result of the detection unit is stored may be provided outside the position detection system **1** or may be provided outside the encoder device EC.

(119) [Drive Device]

(120) An example of the drive device is described. FIG. **11** shows an example of a drive device MTR. In descriptions below, the constitutional parts that are the same as or equivalent to the above embodiments are denoted with the same reference signs for omitting or simplifying the descriptions. The drive device MTR is a motor device including an electric motor. The drive device MTR comprises the rotary shaft SF, a main body part (drive part) BD that rotates the rotary shaft SF, and the encoder device EC that detects the rotational position information of the rotary shaft SF.

(121) The rotary shaft SF has a load-side end portion SFa, and an anti-load-side end portion SFb. The load-side end portion SFa is connected to another power transmission mechanism such as a decelerator. A scale S is fixed to the anti-load-side end portion SFb via a fixing part. The scale S is fixed, and the encoder device EC is attached. The encoder device EC is an encoder device in accordance with the embodiments, the modified embodiments or combinations thereof.

(122) In the drive device MTR, the motor control unit MC shown in FIG. **1** controls the main body part BD by using a detection result of the encoder device EC. Since the replacement of the battery

of the encoder device EC is not required or is less required, the drive device MTR can reduce the maintenance cost. Note that the drive device MTR is not limited to the motor device, and may also be another drive device having a shaft part that rotates by using a hydraulic pressure or pneumatic pressure.

(123) [Stage Device]

(124) An example of a stage device is described. FIG. **12** shows a stage device STG. The stage device STG has such a configuration that a rotational table (moving object) TB is attached to the load-side end portion SFa of the rotary shaft SF of the drive device MTR shown in FIG. **11**. In descriptions below, the constitutional parts that are the same as or equivalent to the above embodiments are denoted with the same reference signs for omitting or simplifying the descriptions.

(125) In the stage device STG, when the drive device MTR is driven to rotate the rotary shaft SF, the rotation is transmitted to the rotational table TB. At this time, the encoder device EC detects the angular position of the rotary shaft SF, and the like. Therefore, it is possible to detect an angular position of the rotational table TB by using an output from the encoder device EC. Note that a decelerator and the like may be disposed between the load-side end portion SFa of the drive device MTR and the rotational table TB. Since the replacement of the battery of the encoder device EC is not required or is less required, the stage device STG can reduce the maintenance cost. Note that the stage device STG can be applied to a rotational table provided in a machine tool such as a lathe, for example.

(126) [Robot Device]

(127) An example of a robot device is described. FIG. **13** is a perspective view showing a robot device RBT. Note that FIG. **13** pictorially shows a part (joint part) of the robot device RBT. In descriptions below, the constitutional parts that are the same as or equivalent to the above embodiments are denoted with the same reference signs for omitting or simplifying the descriptions. The robot device RBT comprises a first arm AR**1**, a second arm AR**2**, and a joint part JT. The first arm AR**1** is connected to the second arm AR**2** via the joint part JT.

(128) The first arm AR**1** includes an arm part **101**, a bearing **101***a*, and a bearing **101***b*. The second arm AR**2** includes an arm part **102** and a connection part **102***a*. The connection part **102***a* is disposed between the bearing **101***a* and the bearing **101***b* at the joint part JT. The connection part **102***a* is provided integrally with the rotary shaft SF**2**. The rotary shaft SF**2** is inserted into both the bearing **101***a* and the bearing **101***b* at the joint part JT. An end portion on a side of the rotary shaft SF**2**, which is inserted into the bearing **101***b*, is connected to a decelerator RG through the bearing **101***b*.

(129) The decelerator RG is connected to the drive device MTR, and decelerates rotation of the drive device MTR to 1/100 or the like, for example, and transmits the same to the rotary shaft SF**2**. Although not shown and described in FIG. **13**, the load-side end portion SFa of the rotary shaft SF of the drive device MTR is connected to the decelerator RG. Also, the scale S of the encoder device EC is attached to the anti-load-side end portion SFb of the rotary shaft SF of the drive device MTR.

(130) In the robot device RBT, when the drive device MTR is driven to rotate the rotary shaft SF, the rotation is transmitted to the rotary shaft SF**2** via the decelerator RG. The connection part **102***a* is integrally rotated by the rotation of the rotary shaft SF**2**, so that the second arm AR**2** rotates with respect to the first arm AR**1**. At this time, the encoder device EC detects an angular position of the rotary shaft SF, and the like. Therefore, it is possible to detect an angular position of the second arm AR**2** by using an output from the encoder device EC.

(131) Since the replacement of the battery of the encoder device EC is not required or is less required, the robot device RBT can reduce the maintenance cost. Note that the robot device RBT is not limited to the above configuration, and the drive device MTR can be applied to a variety of robot devices having a joint.

Claims

1. An encoder device comprising: a position detection unit for detecting rotational position information of a rotary shaft configured to rotate around a first axis as a center; a magnet configured to rotate around the first axis as the center in conjunction with the rotary shaft and provided with two kinds of polarities alternating along a circumferential direction of a rotation with the first axis as the center; and an electric signal generation unit for generating an electric signal based on a magnetic characteristic of a magnetosensitive part, wherein the electric signal generation unit includes: the magnetosensitive part in which the magnetic characteristic changes by a change in magnetic field caused by the rotation of the magnet; a first magnetic body, wherein a first end of the first magnetic body is positioned near the magnet in a direction parallel to the first axis, and a second end of the first magnetic body is connected to a first end of the magnetosensitive part; and a second magnetic body, wherein a first end of the second magnetic body is positioned near the magnet in the direction parallel to the first axis, and a second end of the second magnetic body is connected to a second end of the magnetosensitive part, and the magnetosensitive part is disposed along a plane that is orthogonal to the first axis and spaced apart from the magnet in a radial direction of the rotation around the first axis as the center.
2. The encoder device according to claim 1, wherein a polarity of the magnet near which the first end of the first magnetic body is positioned and a polarity of the magnet near which the first end of the second magnetic body is positioned are different from each other.
3. The encoder device according to claim 1, wherein the first magnetic body and the second magnetic body guide a magnetic field line of the magnet in a length direction of the magnetosensitive part.
4. The encoder device according to claim 1, wherein the magnet has polarities different from each other also in a thickness direction orthogonal to the circumferential direction.
5. The encoder device according to claim 4, wherein the first magnetic body and the second magnetic body guide magnetic field lines from two parts of the magnet, which are located at the same position in the circumferential direction and have polarities different from each other, to a length direction of the magnetosensitive part.
6. The encoder device according to claim 4, wherein the first magnetic body and the second magnetic body guide magnetic field lines from two parts of the magnet, which are located at different positions in the circumferential direction and have polarities different from each other, to a length direction of the magnetosensitive part.
7. The encoder device according to claim 1, wherein the magnetosensitive part generates large Barkhausen jump by the change in the magnetic field associated with a rotation of the magnet.
8. The encoder device according to claim 1, wherein the electric signal generation unit generates pulsed electric power by a rotation of the rotary shaft.
9. The encoder device according to claim 1, further comprising a battery for supplying at least a part of electric power that is consumed in the position detection unit in accordance with the electric signal generated by the electric signal generation unit.
10. The encoder device according to claim 9, further comprising a switching unit for switching whether to supply electric power from the battery to the position detection unit in accordance with the electric signal generated by the electric signal generation unit.
11. The encoder device according to claim 9, wherein the battery includes a primary battery or a secondary battery.
12. The encoder device according to claim 9, wherein the position detection unit (i) includes a magnet for detecting positions and a magnetism detection unit, mutual relative positions of the magnet for detecting positions and the magnetism detection unit being changed by a rotation of the rotary shaft, and (ii) detects the rotational position information based on a magnetic field formed by

the magnet for detecting positions, and the magnetism detection unit detects the magnetic field formed by the magnet for detecting positions by using electric power supplied from the battery.
13. The encoder device according to claim 12, wherein the magnet that causes the change in the magnetic field for the electric signal generation unit to generate the electric signal also serves as the magnet for detecting positions.
14. The encoder device according to claim 1, wherein the position detection unit includes: a scale that rotates in conjunction with the rotary shaft; an irradiation unit for irradiating the scale with light; and a light detection unit for detecting light from the scale.
15. The encoder device according to claim 1, wherein the magnet has a ring shape, and the magnetosensitive part is disposed outside of an outer surface of the magnet or inside of an inner surface of the magnet.
16. The encoder device according to claim 1, wherein the position detection unit includes: an angle detection unit for detecting angular position information within one-turn of the rotary shaft; and a multi-turn information detection unit for detecting, as the rotational position information, multi-turn information of the rotary shaft.
17. A drive device comprising: the encoder device according to claim 1; and a power supplying unit for supplying power to the rotary shaft.
18. A stage device comprising: a moving object; and the drive device according to claim 17 for moving the moving object.
19. A robot device comprising: the drive device according to claim 18; and an arm configured to be relatively moved by the drive device.