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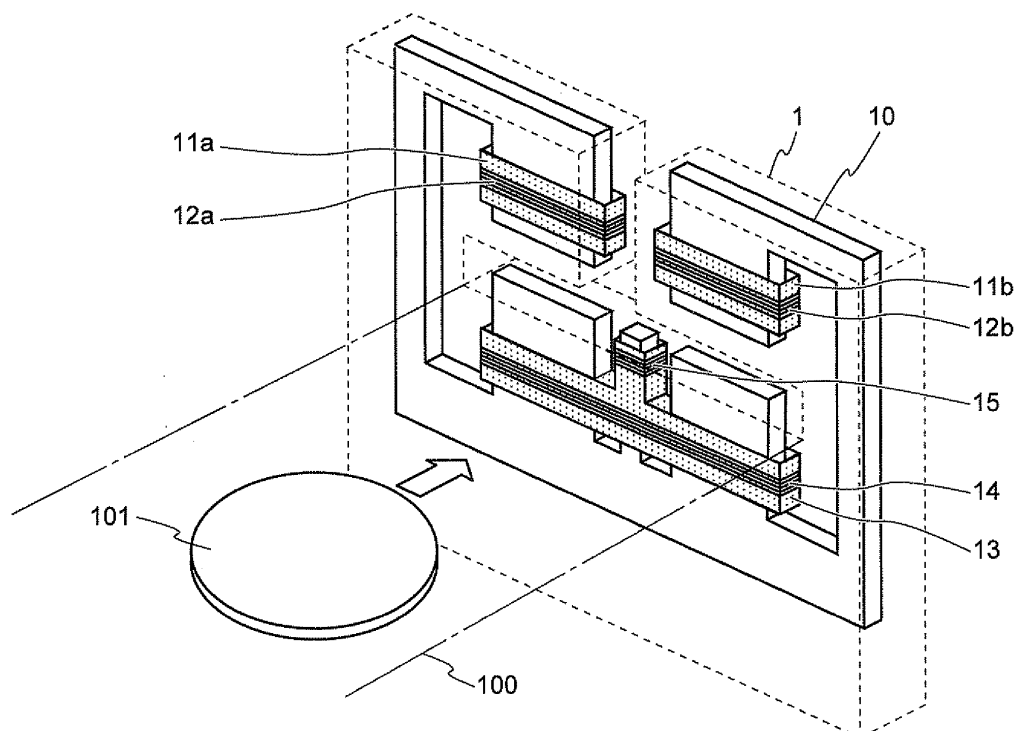
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(54) **Magnetic sensor for coin recognition**

(57) A magnetic sensor (1) for coin recognition includes a core plate (10) and a plurality of coils (12a, 12b, 14, 15). The core plate (10) has an opening for a measurement target coin to pass through, and a plurality of

convex portions jutting toward the opening. The coils (12a, 12b, 14, 15) are arranged above and below the coin when the coin passes through the opening. All the coils (12a, 12b, 14, 15) are formed around the convex portions of the core plate (10) as cores thereof.

**FIG.1**



## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a magnetic sensor for coin recognition that measures magnetic properties of coins for recognizing the coins.

### BACKGROUND ART

**[0002]** Magnetic sensors that measure magnetic properties of a coin in coin handling apparatuses that recognize and count coins are known in the art. Based on the magnetic properties of a coin measured by the magnetic sensor, the coin handling apparatus determines, for example, a thickness, a diameter, and a material of the coin, and, based on these parameters, performs recognition of a denomination and authentication of the coin.

**[0003]** For example, a transmissive magnetic sensor for coin recognition that has three coils is disclosed in Japanese Patent Application Laid-open No. H7-220133. The transmissive magnetic sensor includes one exciting coil and two detecting coils. The exciting coil is arranged below a transport path on which coins are transported, and the two detecting coils are arranged above the transport path at positions corresponding to the exciting coil. The detecting coils detect a change of a magnetic flux caused when a coin passes through a magnetic field generated from the exciting coil.

**[0004]** Japanese Patent No. 3363290 discloses a magnetic sensor for coin recognition. This magnetic sensor has five coils, and it measures changes of the magnetic fields generated from transmissive coils and reflective coils respectively. More specifically, this magnetic sensor includes a reflective exciting coil (primary coil) and a reflective detecting coil (secondary coil), two transmissive exciting coils (primary coils), and two transmissive detecting coils (secondary coils). The reflective exciting coil (primary coil) and the reflective detecting coil (secondary coil) and the two transmissive exciting coils (primary coils) are arranged below the transport path on which coins are transported. In contrast, the two transmissive detecting coils (secondary coils) are arranged above the transport path at positions corresponding to the transmissive exciting coils. In addition to detecting a change of the transmission magnetic field, the reflective detecting coils detect a change of the magnetic flux caused when an eddy current in the coin excited by the reflective exciting coil.

**[0005]** However, in the conventional technologies explained above, variability can occur in sensor properties owing to manufacturing errors in the various components of the magnetic sensor for coin recognition, or to an assembly error occurring when assembling the magnetic sensor including a plurality of coils.

**[0006]** For example, a magnetic sensor for coin recognition is assembled by arranging, inside a plastic sensor housing, a transmissive exciting coil, transmissive de-

tecting coils, a reflective exciting coil, a reflective detecting coil, and a circuit board for driving the exciting coils and processing signals obtained from the detecting coils. The position misalignment of the respective coils can be occurred owing to manufacturing errors of the respective components, or to an assembly error occurred when assembling the coils inside the sensor housing.

**[0007]** Specifically, a position misalignment can be occurred between the exciting coil and the detecting coil, between two transmissive coils arranged in a row on the transport path, and between the transmissive coils and the reflective coils, leading to variability in the sensor properties and a performance degradation of the magnetic sensor.

**[0008]** A coil is formed by winding an insulated winding wire on a core made of a magnetic material. Winding a winding wire on each of a plurality of cores to make a plurality of coils, and assembling the coils in the sensor housing to make a magnetic sensor for coin recognition is a time-consuming task. Soldering the two ends of each winding wire to the circuit board arranged inside the sensor housing is also a time-consuming task. Consequently, it is both time-consuming and costly to manufacture magnetic sensors for coin recognition.

### SUMMARY

**[0009]** The present invention is made to provide a solution to the problems in the conventional technologies. It is an object of the present invention to provide a magnetic sensor for coin recognition that can be manufactured easily and that can suppress efficiency performance degradation of the magnetic sensor caused by shifts in the positional relationships between the respective coils.

**[0010]** Advantageously, a magnetic sensor for coin recognition includes a core plate made of a magnetic material having an opening for a measurement target coin to pass through and a plurality of convex portions that jut toward the opening; and a plurality of coils arranged above and below the coin that passes through the opening. All the coils are formed around the convex portions of the core plate as cores of the coils.

**[0011]** Advantageously, in the magnetic sensor for coin recognition, at least one transmissive magnetic sensor is formed by using the coils wound around the cores thereof opposed to each other across the opening, and a magnetic circuit that includes the transmissive magnetic sensor forms a closed loop.

**[0012]** Advantageously, in the magnetic sensor for coin recognition, the core plate has two convex portions formed above and three convex portions formed below the coin that passes through the opening. The plurality of coils include two transmissive detecting coils formed by winding a winding wire on each of the two convex portions that are located above the coin, a reflective detecting coil formed by winding a winding wire on a middle convex portion from among the three convex portions

that are located below the coin, and an exciting coil formed by winding a winding wire around all the three convex portions that are located below the coin.

**[0013]** Advantageously, the magnetic sensor for coin recognition further comprises upper coil bobbins, each made of plastic and having a shape of a rectangular-pipe with a through hole. The transmissive detecting coil is formed by winding the winding wire around the upper coil bobbin in a state of that the convex portions located above the coin are inserted into the through hole.

**[0014]** Advantageously, the magnetic sensor for coin recognition further comprises a lower coil bobbin made of plastic and having through holes. The reflective detecting coil and the exciting coil are formed by winding the winding wires on the lower coil bobbin in a state of that the three convex portions located below the coin are inserted into the through holes.

**[0015]** Advantageously, in the magnetic sensor for coin recognition, the lower coil bobbin has a convex shaped lateral face, and the reflective detecting coil is formed by winding the winding wire on a middle convex member of the convex shaped lateral face, and the exciting coil is formed by winding the winding wire on the lower part of the lateral face convex shape.

**[0016]** Advantageously, in the magnetic sensor for coin recognition, the core plate is formed by a permalloy plate.

**[0017]** Advantageously, in the magnetic sensor for coin recognition, a cutout is provided in a part of the core plate so that the opening leads to an exterior of the core plate.

**[0018]** The above and other objects, features, advantages and the technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0019]**

FIG. 1 is a drawing for explaining how a magnetic sensor for coin recognition according to an embodiment of the present invention is used;

FIGS. 2A and 2B are a set of drawings showing a positional relationship between a transport path and the magnetic sensor for coin recognition;

FIG. 3 is a block diagram of the magnetic sensor for coin recognition;

FIG. 4 is a perspective view of an outer appearance of the magnetic sensor for coin recognition;

FIG. 5 is a drawing of components that constitute the magnetic sensor for coin recognition;

FIG. 6 is a perspective view of coils formed on a core plate;

FIG. 7 is a drawing showing how each coil is formed on the core plate;

FIGS. 8A and 8B are a set of drawings showing a shape of the core plate;

FIG. 9 is a drawing showing a positional relationship between the core plate and a transport guide; and

FIG. 10 is a drawing of a core plate of the magnetic sensor for coin recognition in a different shape.

#### DETAILED DESCRIPTION OF EMBODIMENTS

**[0020]** Exemplary embodiments of a magnetic sensor for coin recognition according to the present invention are explained in detail below with reference to the accompanying drawings. FIG. 1 is a schematic diagram for explaining how a magnetic sensor 1 for coin recognition (hereinafter, "magnetic sensor") is used in a coin handling apparatus. In FIG. 1, an outer shape of the magnetic sensor 1 is denoted by a dotted line, and a transport path 100 of coins in the coin handling apparatus leading to the magnetic sensor 1 is denoted by a dashed-dotted line.

**[0021]** The magnetic sensor 1 includes a core plate 10. The core plate 10 is made of a magnetic material and functions as a core of coils. The core plate 10 is explained in detail later. Some parts of the core plate 10 are formed as convex portion to serve as the cores for four coils, namely, two transmissive detecting coils 12a and 12b, a reflective detecting coil 15, and an exciting coil 14 that functions as a transmissive exciting coil and a reflective exciting coil. By measuring magnetic properties by means of both transmissive coils and reflective coils, a thickness, a diameter, and a material of a coin can be determined, and, based on these determined parameters, recognition of a denomination and authentication of the coin can be performed.

**[0022]** The transmissive detecting coil 12a is formed by winding a winding wire, which is an insulated copper wire, on a rectangular-pipe-shaped upper coil bobbin 11a having a through-hole. The convex portion of the core plate 10 is inserted through the through hole of the upper coil bobbin 11a. The transmissive detecting coil 12b is also formed by an upper coil bobbin 11b, around which a winding wire is wound, in a similar manner.

**[0023]** The reflective detecting coil 15 and the exciting coil 14 are formed by using a single lower coil bobbin 13. The lower coil bobbin 13 has a convex shaped lateral face that is formed by joining two rectangular-pipe on both sides of a middle rectangular-pipe to form an integrated convex shape with the bottom faces of the three rectangular-pipe aligned. All the three rectangular-pipes have through holes and the side rectangular-pipes are shorter than the middle rectangular-pipe in a direction of the through holes. The three through holes of the lower coil bobbin 13 are formed in alignment with the corresponding convex portions of the core plate 10. However, the structure according to the present embodiment is not limited to what is described above; the lower coil bobbin 13 can have any other shape provided a winding wire of the reflective detecting coil 15 can be wound on an upper part of the bobbin and a winding wire of the exciting coil

14 can be wound on a lower part of the bobbin.

**[0024]** In the lower coil bobbin 13, a wire of the reflective detecting coil 15 is wound on an upper part of the middle rectangular-pipe that forms a middle projecting part of the convex shaped lateral face, and a winding wire of the exciting coil 14 is wound on a lower part of the convex shape that includes the three through holes. The reflective detecting coil 15 and the exciting coil 14 are formed by inserting the corresponding convex portions of the core plate 10 through the three through holes of the lower coil bobbin 13.

**[0025]** The magnetic sensor 1 includes an opening formed between the lower side, on which the exciting coil 14 and the reflective detecting coil 15 are arranged, of the core plate 10 and the upper side, on which the transmissive detecting coils 12a and 12b are arranged, of the core plate 10. A coin 101 transported on the transport path 100 passes through this opening in a transport direction. Magnetic properties of the coin 101 are measured when the coin 101 passes through the opening.

**[0026]** FIGS. 2A and 2B are a set of drawings showing a positional relationship between the magnetic sensor 1 and the transport path 100. Specifically, FIG. 2A is a top view of the magnetic sensor 1, and FIG. 2B is a side view of the magnetic sensor 1. As shown in FIGS. 2A and 2B, the coin 101 is transported on the transport path 100 in the transport direction, which is indicated by an arrow, by a transport belt 102 having not shown protruding members. The magnetic sensor 1 is arranged such that a space is available above the transport path 100 to enable fitting and removal of the transport belt 102 even after the magnetic sensor 1 is installed on the transport path 100. To realize this structure, a cutout is provided in a part of the core plate 10 so that the opening for the coin 101 to pass through and the outside portion of the core plate 10 are connected, as shown in FIG. 1.

**[0027]** FIG. 3 is a functional block diagram of the magnetic sensor 1. The magnetic sensor 1 includes the core plate 10 on which a plurality of the coils is installed, and a circuit board 20. The exciting coil 14 that is an oscillating coil, and the transmissive detecting coils 12 and the reflective detecting coil 15 that are receiving coils are formed on the core plate 10.

**[0028]** As shown in FIG. 3, the circuit board 20 includes a PWM circuit 21 that generates pulse signals by synthesizing three frequency waves, a filter 22 that cuts unnecessary high frequency components from the pulse signals generated by the PWM circuit 21 to generate analog signals to be applied to the coil, and a driver 23 that amplifies the analog signals generated through the filter 22 and applies the amplified analog signals to the exciting coil 14. The circuit board 20 further includes an amplifier 24 that amplifies the signals detected by the transmissive detecting coils 12 and the reflective detecting coil 15, an A/D converter 25 that performs A/D conversion of the signals amplified by the amplifier 24, a memory 26 that stores therein digital signals outputted by the A/D converter 25, a coin recognition processing unit 27 that per-

forms coin recognition based on the signals stored in the memory 26, and a temperature sensor 28 that is connected to the coin recognition processing unit 27 and that performs correction on a measurement result based on the measured temperature. The coin recognition processing unit 27 performs processes such as FFT conversion and coin recognition. In the FFT conversion process, the signals corresponding to the frequency components of the synthesized signal generated by the PWM circuit 21 are extracted from the signals measured by the detecting coils 12 and 15. In the coin recognition process, coin recognition is performed based on the signals obtained in the FFT conversion process. Conventional technology disclosed in International Publication No. 2010/052798 can be used for these processes and hence detailed description thereof is omitted in this specification. The magnetic sensor 1 also has a function to output a signal 29 for performing the recognition of the coin 101 from the coin recognition processing unit 27 to an external device.

**[0029]** FIG. 4 is a perspective view of an outer appearance of the magnetic sensor 1. A shield plate 40, provided on one side of sensor housing components 1a and 1b of the magnetic sensor 1, reduces magnetic noise arising from a motor, solenoid, etc., arranged inside the coin handling apparatus. The magnetic sensor 1 further includes a transport guide 30 that is supported by ribs 1c arranged on the sensor housing components 1a and 1b. The magnetic sensor 1 is installed inside the coin handling apparatus such that the upper surface of the transport guide 30 forms a part of a transport surface of the transport path 100 of the coin handling apparatus.

**[0030]** The transport guide 30 has a through hole in a region on the transport surface on which the coin 101 is transported and a transparent member 30a is fitted in the through hole. A not-shown light source and a not-shown light receiver are arranged above and below the transparent member 30a. When the coin 101 that is being transported on the transport path 100 passes over the transparent member 30a, light output from the light source does not reach the light receiver; because the light is blocked by the coin 101. This timing of blocking of the light by the coin 101 is taken as the trigger to begin a coin recognition processing. If, like a Japanese 50-yen coin, a coin has a hole, the coin can be recognized by detection of the presence of the hole by the light source and the light receiver.

**[0031]** It is preferable that a hard plastic, such as, PPS (polyphenylene sulfide) plastic, be used as the material for the transport guide 30 so that it is not abraded due to the pass of the coin 101. It is further preferable that the transport guide 30 be made of a material that produces no static electricity in order that the magnetic properties of the coin 101 passing over the transport guide 30 can be accurately measured. For example, an electrically conductive hard plastic, obtained by adding electrically conductive particles to the PPS plastic, can be used as a material for the transport guide 30. A material, such as,

acrylic plastic can be used for the transparent member 30a.

**[0032]** FIG. 5 is a drawing of components that constitute the magnetic sensor 1. As shown in FIG. 5, the core plate 10, explained in FIGS. 1 and 3, and the circuit board 20, explained in FIG. 3, are included inside the sensor housing components 1a and 1b.

**[0033]** The core plate 10 with the transport guide 30 assembled thereto is assembled to the sensor housing component 1a. The circuit board 20 is arranged inside the sensor housing component 1a so as to cover the core plate 10. The circuit board 20 is fixed to the sensor housing component 1a with a screw 20e. The other sensor housing component 1b is assembled so as to cover the sensor housing component 1a and is fixed with a screw 1d. Finally, the shield plate 40 is assembled to the sensor housing component 1a on the outside thereof.

**[0034]** It is preferable that a hard plastic, such as, PPS plastic, be used as the material for the sensor housing components 1a and 1b. As a material for the core plate 10, it is preferable that a magnetic material alloy that has a large initial permeability but a small magnetic coercivity, such as, permalloy, a PC2 type alloy standardized by JIS standard, JIS-C-2531, be used. The core plate 10 can be a few-millimeter thick single layer plate or a multi-layered plate formed by bonding a plurality of thin plates.

**[0035]** FIG. 6 is a perspective view of the coils formed on the core plate 10 shown in FIG. 5. When assembling the magnetic sensor 1 as shown in FIG. 5, the upper coil bobbins 11a and 11b and the lower coil bobbin 13 are assembled to the core plate 10 in advance, as shown in FIG. 6.

**[0036]** FIG. 7 is a drawing of an assemblage of the core plate 10, the upper coil bobbins 11a and 11b, and the lower coil bobbin 13 shown in FIG. 6. The upper coil bobbin 11a includes two pins 51a and 52a. The transmissive detecting coil 12a is formed by winding the winding wire first on the pin 51a, then around the upper coil bobbin 11a, and finally on the pin 52a. In this manner, the upper coil bobbin 11a is assembled to the core plate 10 with one end of the winding wire wound on and fixed to the pin 51a and the other end wound on and fixed to the pin 52a. The upper coil bobbin 11b is also similarly assembled to the core plate 10 with one end of the winding wire wound on and fixed to a pin 51b and the other end wound on and fixed to a pin 52b.

**[0037]** The lower coil bobbin 13 includes two pins 53 and 54 for use by the exciting coil 14 and two pins 55 and 56 for use by the reflective detecting coil 15. The exciting coil 14 is formed by winding the winding wire first on the pin 53, then around the lower coil bobbin 13, and finally on the pin 54. The reflective detecting coil 15 is also similarly formed by winding the winding wire first on the pin 55, then around the lower coil bobbin 13, and finally on the pin 56. In this manner, the lower coil bobbin 13 is assembled to the core plate 10 with the ends of the winding wire of the exciting coil 14 wound on and fixed to the pins 53 and 54, and the ends of the winding wire

of the reflective detecting coil 15 wound on and fixed to the pins 55 and 56.

**[0038]** An electric wire with a surface thereof insulated, such as, enameled copper wire, for example, polyurethane copper wire, etc., is used as the winding wire. The diameter or the number of windings of the winding wire need not be the same for all the coils. For example, a thicker winding wire and fewer windings can be used for the exciting coil 14 compared with the winding wires used in the transmissive detecting coils 12a and 12b and the reflective detecting coil 15.

**[0039]** It is preferable that a hard plastic that does not deform due to stress during the winding of the winding wire be used as a material for the upper coil bobbins 11a and 11b and the lower coil bobbin 13. For example, PPS plastic used for the sensor housing components 1a and 1b can be used for the upper coil bobbins 11a and 11b and the lower coil bobbin 13. An electrically conductive metal material can be used as a material for the pins 51 to 56.

**[0040]** As shown in FIG. 5, through holes 20a to 20d are provided on the circuit board 20 through which the pins 51 to 56 of the upper coil bobbins 11a and 11b and the lower coil bobbin 13 pass. Each of the through holes 20a to 20d is made of an electrically conductive metal material, such as, copper with gold plating done thereon, and is connected to the corresponding circuit on the circuit board 20.

**[0041]** Specifically, the through holes 20a, through which the pins 51a and 52a on which the ends of the winding wire of the transmissive detecting coil 12a are fixed, and the through holes 20b, through which the pins 51b and 52b on which the ends of the winding wire of the transmissive detecting coil 12b are fixed, are connected to the amplifier 24 shown in FIG. 3. The through holes 20c, through which the pins 55 and 56 on which the ends of the winding wire of the reflective detecting coil 15 are fixed, are also connected to the amplifier 24. The through holes 20d, through which the pins 53 and 54 on which the ends of the winding wire of the exciting coil 14 are fixed, are connected to the driver 23 shown in FIG. 3.

**[0042]** In the magnetic sensor 1, when the core plate 10 and the circuit board 20 are assembled to the sensor housing component 1a, the pins 51 to 56 jut from a surface of the circuit board 20 toward the sensor housing component 1b, as shown in FIG. 5. The winding wires that form each of the coils and that are fixed to the pins 51 to 56 are insulated electric wires of which surface is insulated. However, during a soldering operation of each of the through holes 20a to 20d of the circuit board 20 and each of the pins 51 to 56 jutting from the through holes 20a to 20d, the covering material of the insulated electric wire melts due to the heat, causing electrical continuity between each of the pins 51 to 56 and the winding wire. Consequently, with one soldering operation for a pin, the pin, the winding wire fixed to the pin and the corresponding circuit formed on the circuit board can be simultaneously electrically connected.

**[0043]** In this manner, the soldering operation of each winding wire forming the coil to the circuit board 20 can be easily performed with the pins 51 to 56 provided on the bobbins and the through holes 20a to 20d provided on the circuit board 20. Furthermore, the soldering operation can be easily automated by performing the soldering operation by using the pin which is made of a harder material compared to the winding wire.

**[0044]** The upper coil bobbins 11a and 11b and the lower coil bobbin 13 are assembled to the core plate 10 as shown in FIG. 7. Specifically, the upper coil bobbin 11a, with the winding wire wound previously thereon, is assembled such that an upper convex portion 10a of the core plate 10 is inserted through the through hole of the upper coil bobbin 11a. Similarly, the upper coil bobbin 11b, with the winding wire wound previously thereon, is assembled such that an upper convex portion 10b of the core plate 10 is inserted through the through hole of the upper coil bobbin 11b. The lower coil bobbin 13, with the winding wires wound previously thereon, is assembled such that a lower middle convex portion 10d of the core plate 10 is inserted through the middle through hole, and lower two convex portions 10c and 10e of the core plate 10 on the two sides of the middle convex portion 10d are inserted through the corresponding through holes of the lower coil bobbin 13.

**[0045]** Consequently, the convex portion 10a of the core plate 10 serves as the core for the transmissive detecting coil 12a and the convex portion 10b of the core plate 10 serves as the core for the transmissive detecting coil 12b. The upper region of the convex portion 10d of the core plate 10 serves as the core for the reflective detecting coil 15.

**[0046]** The convex portions 10c to 10e of the core plate 10 serve as a core for the exciting coil 14. The three convex portions 10c to 10e are arranged inside of the winding wire of the exciting coil 14. That is, the exciting coil 14, instead of having a separate winding wire wound on each of the convex portions 10c to 10e, has a common winding wire wound on all the three convex portions 10c to 10e.

**[0047]** In the magnetic sensor 1, the magnetic fields to be used by the three detecting coils can be generated from a single exciting coil 14. Specifically, by driving the exciting coil 14, the magnetic field to be used by the transmissive detecting coil 12a is generated from the convex portion 10c of the core plate 10, the magnetic field to be used by the transmissive detecting coil 12b is generated from the convex portion 10e of the core plate 10, and the magnetic field to be used by the reflective detecting coil 15 is generated from the convex portion 10d of the core plate 10.

**[0048]** FIGS. 8A and 8B are a set of drawings showing a relationship between a shape of the core plate and a diameter of a measurement target coin. As shown in FIG. 8A, the core plate 10 has a chamfered corner 10f on a periphery thereof. The chamfered corner 10f enables easy identification of the front and back, top and bottom,

and left side and right side of the core plate 10, thereby allowing easy automation of an assemblage operation of the upper coil bobbins 11a and 11b and the lower coil bobbin 13 to the core plate 10 as shown in FIG. 7 and an assemblage operation of the magnetic sensor 1 as shown in FIG. 5.

**[0049]** A gap size b of the opening shown in FIG. 8A through which the coin 101 passes is determined based on a thickness of the coin 101 having the maximum thickness from among a plurality of the coins 101 whose magnetic properties are to be measured by the magnetic sensor 1 and a thickness t of a corresponding part of the sensor housing component 1a which houses the core plate 10 therein. For example, if the thickness of the corresponding part of the sensor housing component 1a that lies above and below the coin 101 is t (mm (millimeters)) each, and the maximum coin thickness is a (mm), it is preferable that the gap size b of the core plate 10 be about 1 mm bigger than  $tx2+a$  (mm). Specifically, if the thickness t of the corresponding part of the sensor housing component 1a is 0.5 mm, the maximum coin thickness a is 2.5 mm, the gap size should preferably be about 4 to 5 mm.

**[0050]** With regard to the shape of the core plate 10, for accurate measurement of the magnetic properties of the coin 101, dimensions of the parts of the core plate 10 are so set that the two outer edges of the cores of the coils in left and right directions (coin diameter direction) in FIGS. 8A and 8B are not used. The accuracy in the measurement of the magnetic properties is compromised because a sensitivity of the sensor drops at the core edges. Specifically, as shown in FIG. 8A, dimensions c and d, which are the distances from the left and right outer edges of the convex portions 10c and 10e to the corresponding edges of a circumference, in a diameter direction, of the coin 101 having the maximum diameter from among the measurement target coins 101, are set so as to be greater than or equal to 1 mm each. For example, if the maximum diameter of the coin 101 is 26.5 mm, a distance W1 between the outer edges of the convex portions 10c and 10e of the core plate 10 in the coin diameter direction is set to be greater than or equal to 28.5 mm ( $=26.5+2.0$ ).

**[0051]** Furthermore, as shown in FIG. 8B, dimensions e and f, which are the distances from the left and right inner edges (in the coin diameter direction which is perpendicular to the transport direction) of the convex portions 10c and 10e of the core plate 10 to the corresponding edges of a circumference, in the diameter direction, of the coin 101 having the minimum diameter from among the measurement target coins 101, are also similarly set so as to be greater than or equal to 1 mm each. Specifically, if the minimum diameter of the coin 101 is 20.0 mm, given that the distance W1 shown in FIG. 8A is 28.5 mm, dimensions W2 and W3 of the convex portions 10c and 10d, respectively, shown in FIG. 8B, are set to be greater than or equal to 9.5 mm each ( $=(28.5-20.0+1.0)$ ). The dimensions W2 and W3, for example, can be set to

be 10 mm each.

**[0052]** A position of the coin 101 in the left and right direction of FIGS. 8A and 8b while being transported varies according to its transportation status. Therefore, it is desirable that the transport position of the coin 101 when passing through the core plate 10 be adjusted.

**[0053]** FIG. 9 is a drawing showing a positional relationship between the convex portions 10a to 10e of the core plate 10 and the transport guide 30 when the transport position of the coin 101 is limited. The position of the coin 101 in the left and right directions of FIG. 9 while passing through the opening of the core plate 10 is limited by the transport guide 30, as shown in FIG. 9. Specifically, dimensions c and d, which are the distances from the outer edges of the convex portions 10c and 10e of the core plate 10 in the left and right directions to the corresponding side walls of the transport guide 30 that limits the coin position, are set to be greater than or equal to 1 mm each. By limiting the transport position of the coin 101 in this manner, the measurement of the magnetic properties of the coin 101 by the core edges that have low sensitivity can be avoided.

**[0054]** With regard to the shape of the core plate 10, the outer edges in the left and right directions of FIGS. 8A and 8B of the convex portions 10a and 10b that serve as the cores for the transmissive detecting coils 12a and 12b, respectively, are in alignment with the outer edges of the convex portions 10c and 10e on the exciting coil 14, as shown in FIG. 8A. Furthermore, on the edges facing the coin 101, the inner edges in the left and right directions of FIGS. 8A and 8B of the convex portions 10a and 10b are similarly aligned with the inner edges of the convex portions 10c and 10e, as shown in FIG. 8B.

**[0055]** In the present embodiment, a cutout is provided on the topside of the core plate 10 to facilitate replacement of the transport belt 102; however, the shape of the core plate 10 is not limited to this. Specifically, as shown in FIG. 10, the core plate 10 can be a rectangular plate with an unbroken periphery and with convex portions for forming the coils with the opening provided for the coin 101 to pass through. With this structure, position misalignment between the cores is prevented. In addition, a high-sensitivity transmissive magnetic sensor can be realized because of the formation of a closed magnetic circuit by the exciting coil 14 and the transmissive detecting coils 12a and 12b.

**[0056]** Thus, according to the present embodiment, a plurality of the convex portions 10a to 10e is formed in a single piece of the core plate 10 to serve as cores for a plurality of the coils. Consequently, position misalignment between the coils is prevented, and variability in the performance of the magnetic sensor 1 caused by assembly error of the coils can be suppressed. Furthermore, coils with the convex portions 10a to 10e of the core plate 10 as the cores thereof can be easily formed by assembling the bobbins with the winding wires wound thereon to the core plate 10. With this structure, the number of components, cost, and assembly time can be

reduced compared to a case where the coils are formed using separate cores.

**[0057]** Moreover, a single exciting coil 14 is used for exciting the magnetic fields of a plurality of detecting coils, and the bobbins used for the exciting coil 14 and the reflective detecting coil 15 are integrated into a single lower coil bobbin 13. Consequently, the number of components, cost, and assembly time can be reduced.

**[0058]** Thus, the present invention provides a magnetic sensor for coin recognition that is used for coin recognition and that measures magnetic properties of a coin by using a plurality of coils formed by winding winding wires on cores. The present invention is useful in reducing variability in the performance of the sensor caused by assembly error, etc., of the coils.

**[0059]** According to an aspect of the present invention, all cores used in the detection of magnetic properties of a coin are integrated in a single core plate as convex portions. Consequently, position misalignment of the cores that significantly affects sensor properties can be avoided.

**[0060]** According to another aspect of the present invention, a transmissive magnetic sensor is formed by using coils of which cores are the convex portions opposing each other across a gap in the integrated core plate. Consequently, a uniform gap can be maintained between an exciting coil and detecting coils even if a plurality of the transmissive magnetic sensors is to be formed. As a result, uniform sensor sensitivity can be maintained. Furthermore, because a single core plate is used for the cores, a closed loop circuit is formed by a magnetic circuit that includes the transmissive magnetic sensor. Consequently, variation of a magnetic flux due to a pass of a coin can be detected with high sensitivity.

**[0061]** According to still another aspect of the present invention, two transmissive magnetic sensors and one reflective magnetic sensor can be formed by using a single core plate without position misalignment occurring between the coils forming the various sensors.

**[0062]** According to still another aspect of the present invention, the transmissive detecting coils are formed by using upper coil bobbins. Consequently, the coils can be easily assembled by assembling the upper coil bobbins, with winding wires wound previously thereon, to the core plate.

**[0063]** According to still another aspect of the present invention, a reflective detecting coil and an exciting coil for exciting magnetic fields to be used by the transmissive detecting coils and the reflective detecting coil are formed by using a single lower coil bobbin. Consequently, the number of parts can be reduced. Furthermore, the lower coil bobbin, with the winding wires of the respective coils wound previously thereon, can be easily assembled to the core plate.

**[0064]** According to still another aspect of the present invention, the lower coil bobbin has a convex shaped lateral face; the winding wire of the exciting coil is wound on a lower part of the lower coil bobbin and the winding

wire of the reflective detecting coil is wound on a middle convex member of the lower coil bobbin. Consequently, reflective magnetic properties can be accurately measured by the reflective detecting coil while the magnetic fields to be used by the transmissive detecting coil and the reflective detecting coil are excited by one exciting coil.

**[0065]** According to still another aspect of the present invention, permalloy is used in the core plate. Consequently, a high-performance magnetic sensor for coin recognition can be realized.

**[0066]** According to still another aspect of the present invention, the core plate has a cutout so that the opening leads to an exterior of the core plate. Consequently, even after the magnetic sensor for coin recognition is installed on a transport path, a transport belt used to transport the coin can be easily replaced.

**[0067]** Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching of the claims.

## Claims

1. A magnetic sensor (1) for coin recognition comprising:

a core plate (10) made of a magnetic material and shaped like a plate, and having an opening for a measurement target coin to pass through and a plurality of convex portions that jut toward the opening; and

a plurality of coils (12a, 12b, 14, 15) arranged above and below the coin that passes through the opening, wherein all the coils (12a, 12b, 14, 15) are formed around the convex portions of the core plate (10) as cores thereof.

2. The magnetic sensor (1) for coin recognition according to Claim 1, wherein at least one transmissive magnetic sensor is formed by using the coils (12a, 12b, 14) wound around the cores thereof opposed to each other across the opening, and a magnetic circuit that includes the transmissive magnetic sensor (1) forms a closed loop.

3. The magnetic sensor (1) for coin recognition according to Claim 1 or 2, wherein the core plate (10) has two convex portions formed above and three convex portions formed below the coin that passes through the opening, and the plurality of coils include two transmissive detecting coils (12a, 12b) formed

by winding a winding wire on each of the two convex portions that are located above the coin, a reflective detecting coil (15) formed by winding a winding wire on a middle convex portion from among the three convex portions that are located below the coin, and an exciting coil (14) formed by winding a winding wire around all the three convex portions that are located below the coin.

4. The magnetic sensor (1) for coin recognition according to Claim 3, further comprising upper coil bobbins (11a, 11b), each made of plastic and having a shape of a rectangular-pipe with a through hole, wherein the transmissive detecting coil (12a, 12b) is formed by winding the winding wire around the upper coil bobbin (11a, 11b) in a state of that the convex portions located above the coin are inserted into the through hole.

5. The magnetic sensor (1) for coin recognition according to any of Claims 1 to 3, further comprising a lower coil bobbin (13) made of plastic and having through holes, wherein the reflective detecting coil (15) and the exciting coil (14) are formed by winding the winding wires around the lower coil bobbin (13) in a state of that the three convex portions located below the coin are inserted into the through holes.

6. The magnetic sensor (1) for coin recognition according to Claim 5, wherein the lower coil bobbin (13) has a convex shaped lateral face, and the reflective detecting coil (15) is formed by winding the winding wire on a middle convex member of the convex shaped lateral face, and the exciting coil (14) is formed by winding the winding wire on the lower part of the lateral face convex shape.

7. The magnetic sensor (1) for coin recognition according to any one of Claims 1 to 6, wherein the core plate (10) is formed by a permalloy plate.

8. The magnetic sensor (1) for coin recognition according to any one of Claims 1 to 7, wherein a cutout is provided in a part of the core plate (10) so that the opening leads to an exterior of the core plate (10).

FIG.1

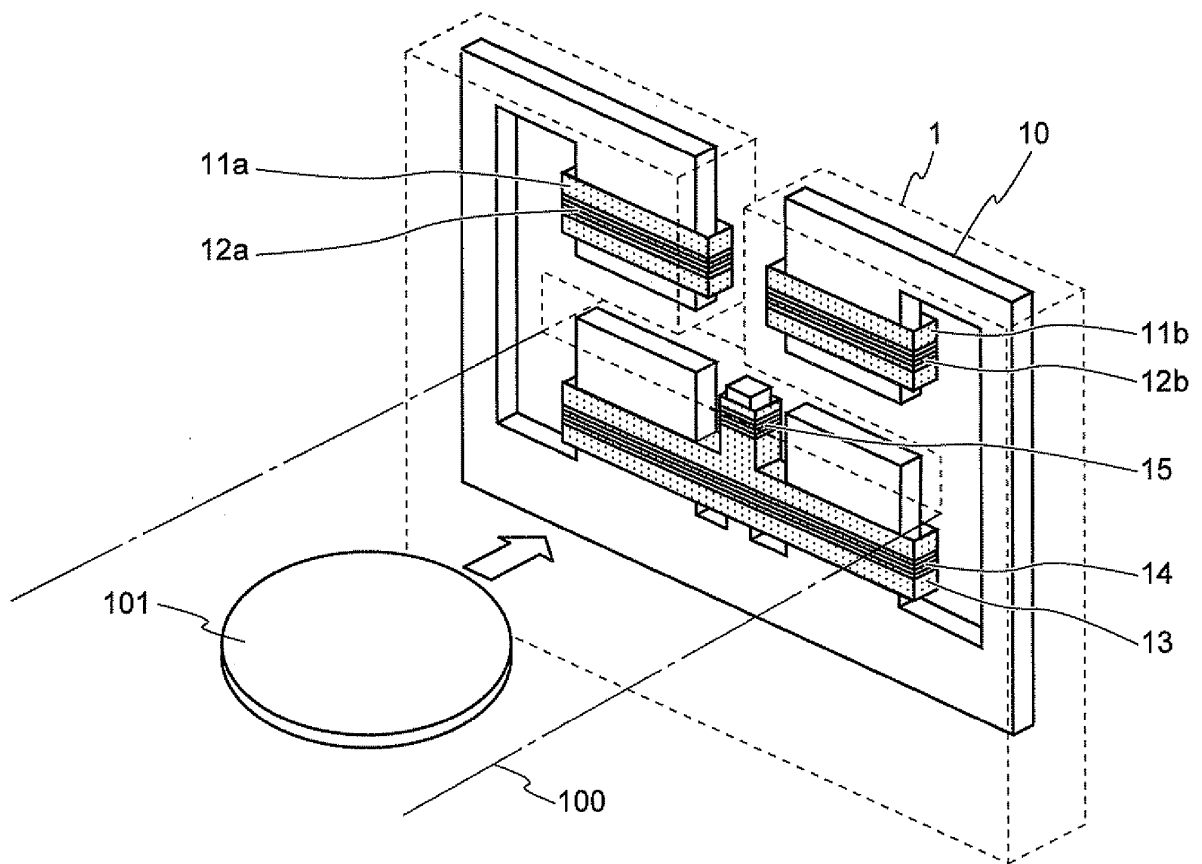


FIG.2A

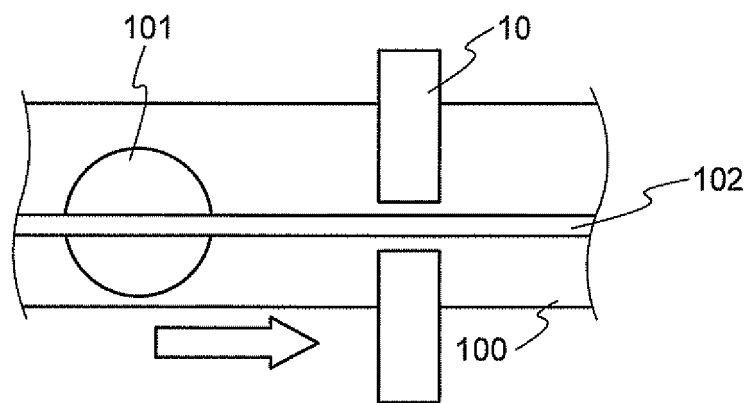


FIG.2B

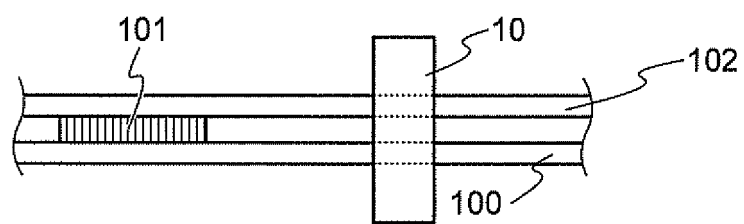


FIG.3

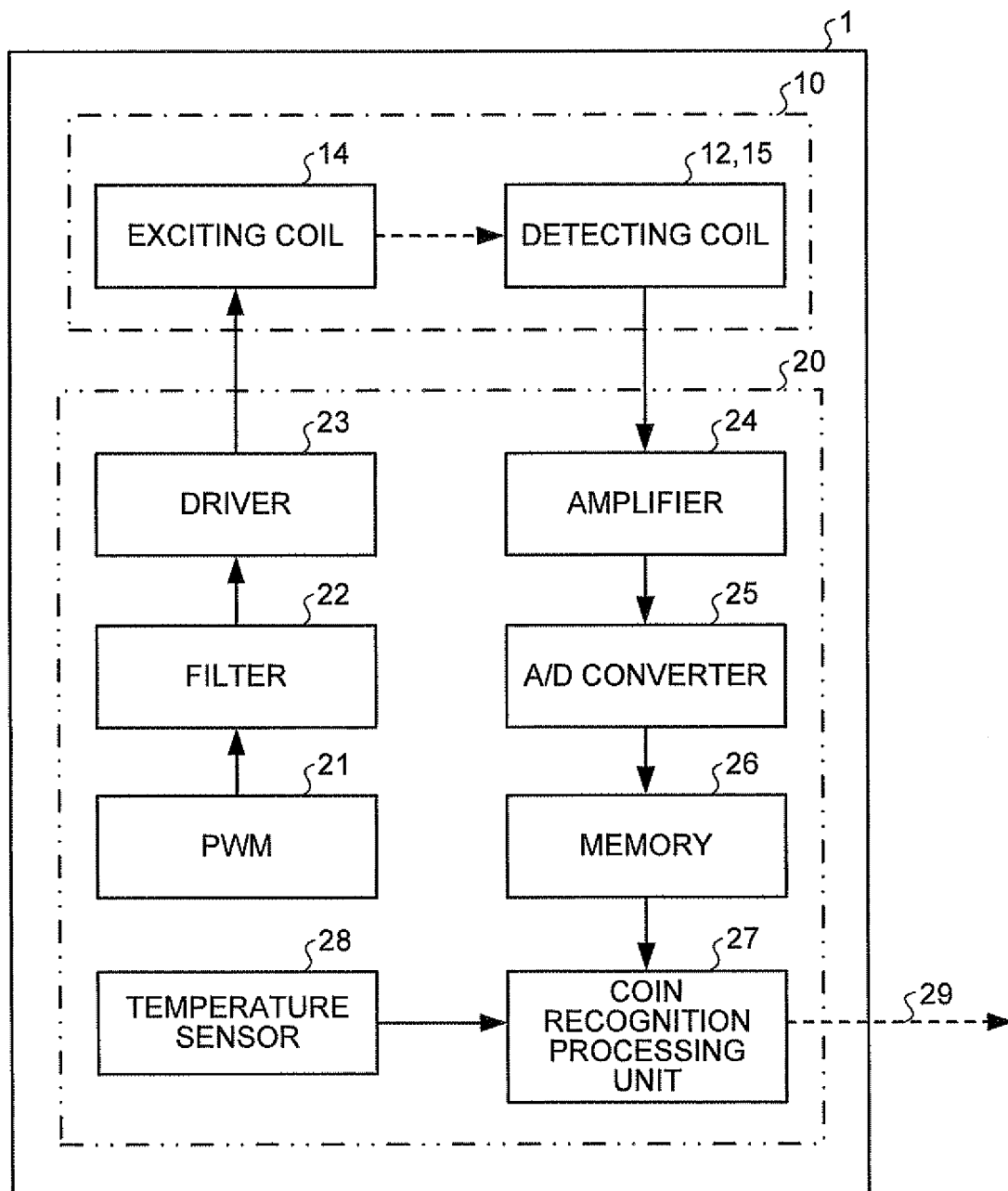
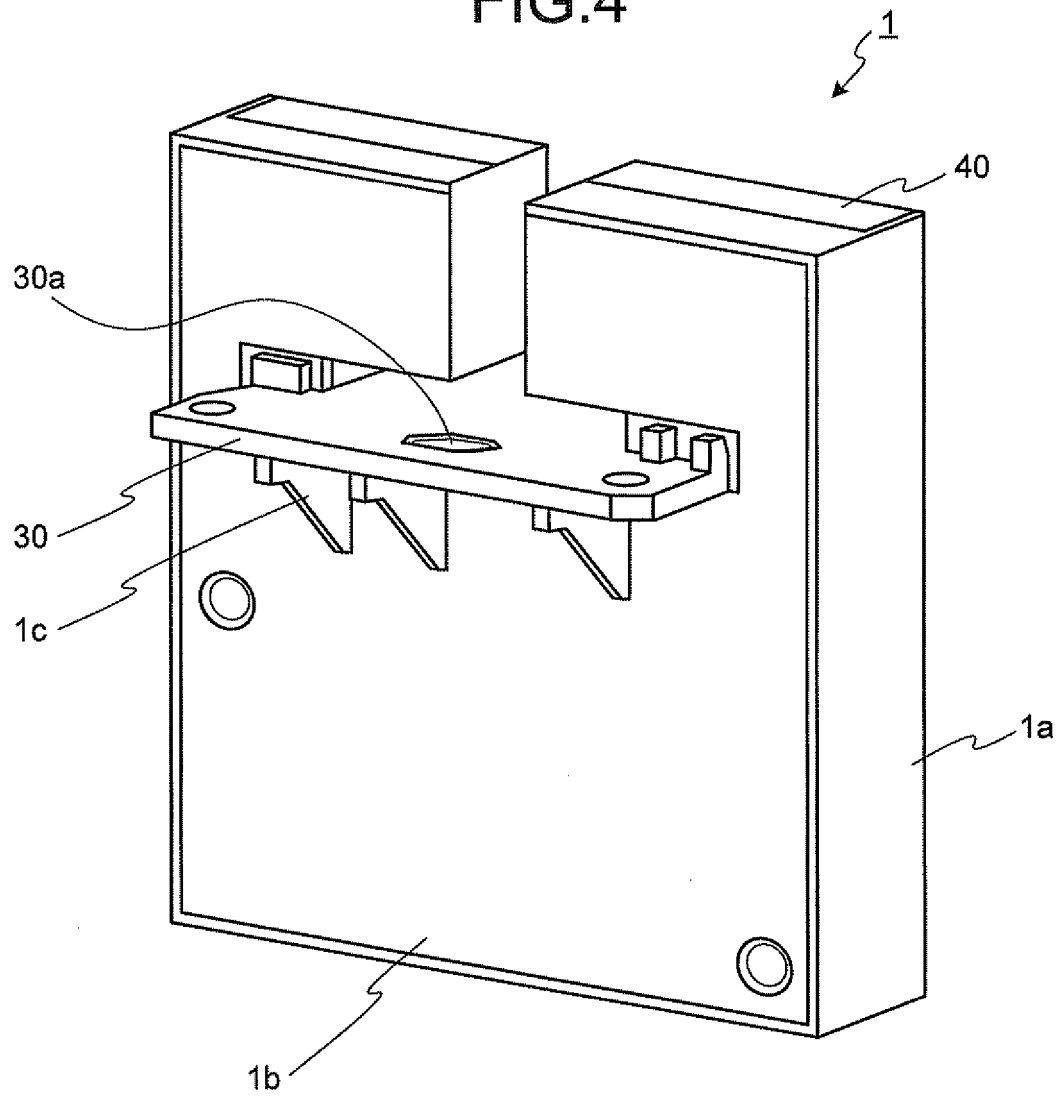


FIG.4



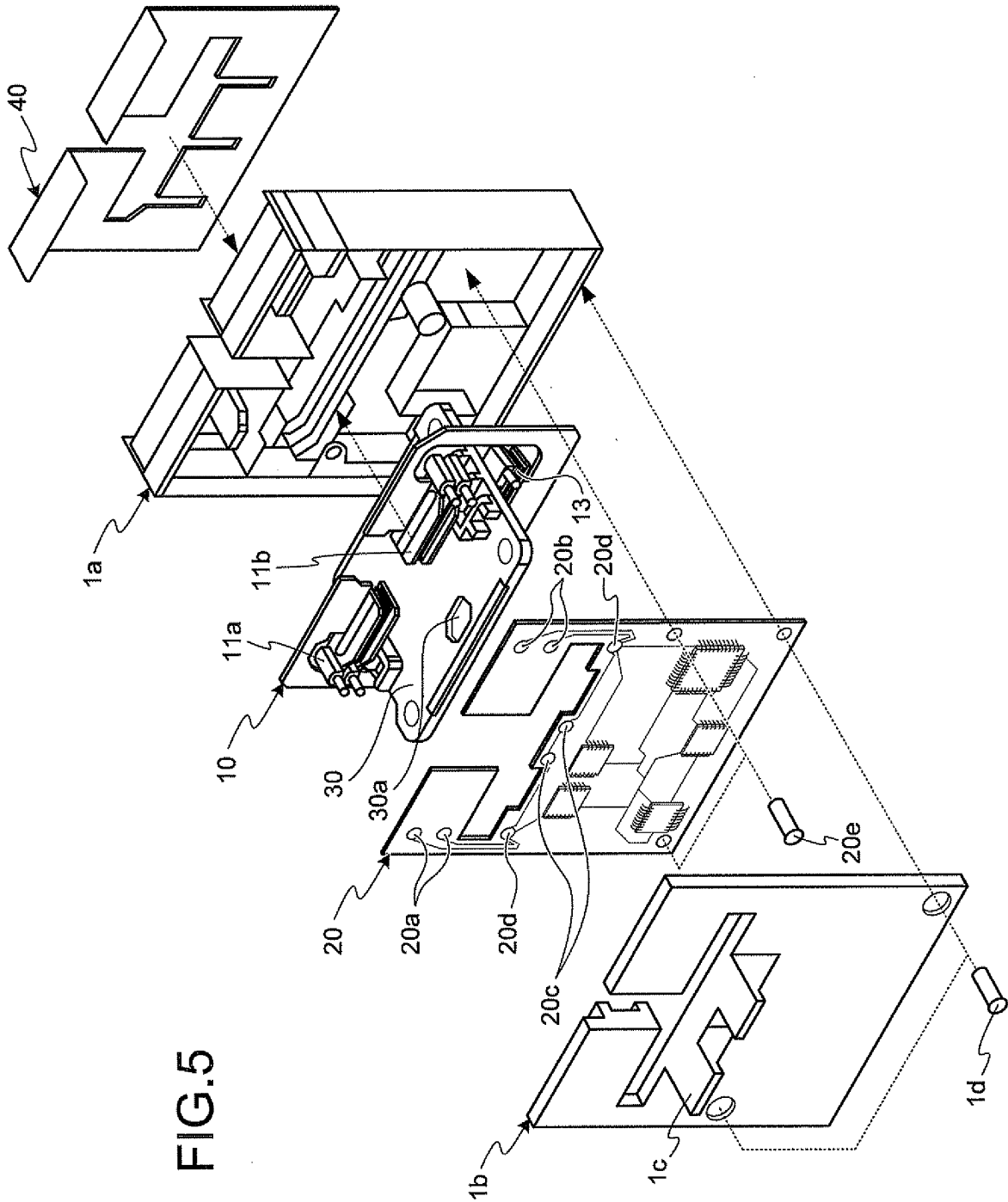


FIG.5

FIG.6

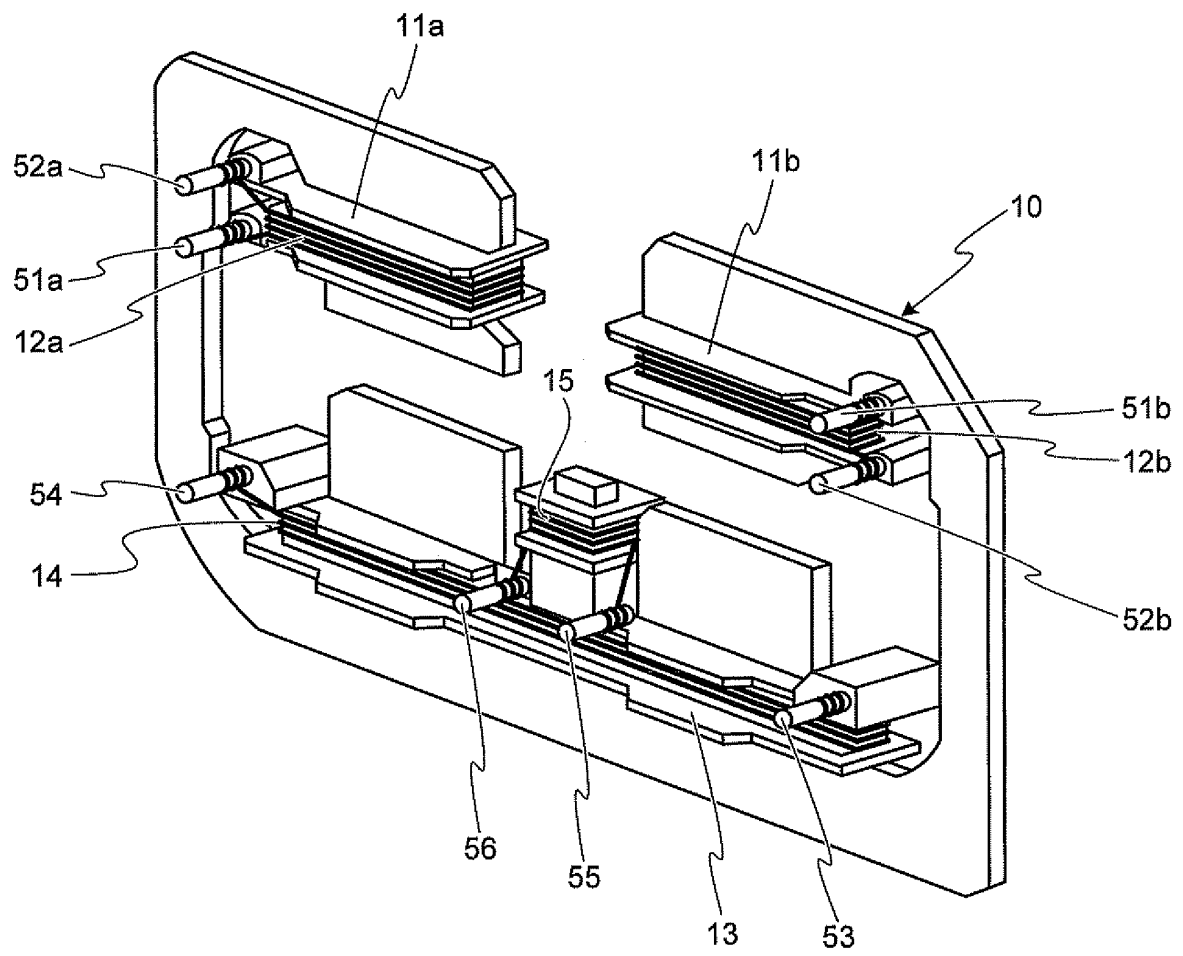


FIG. 7

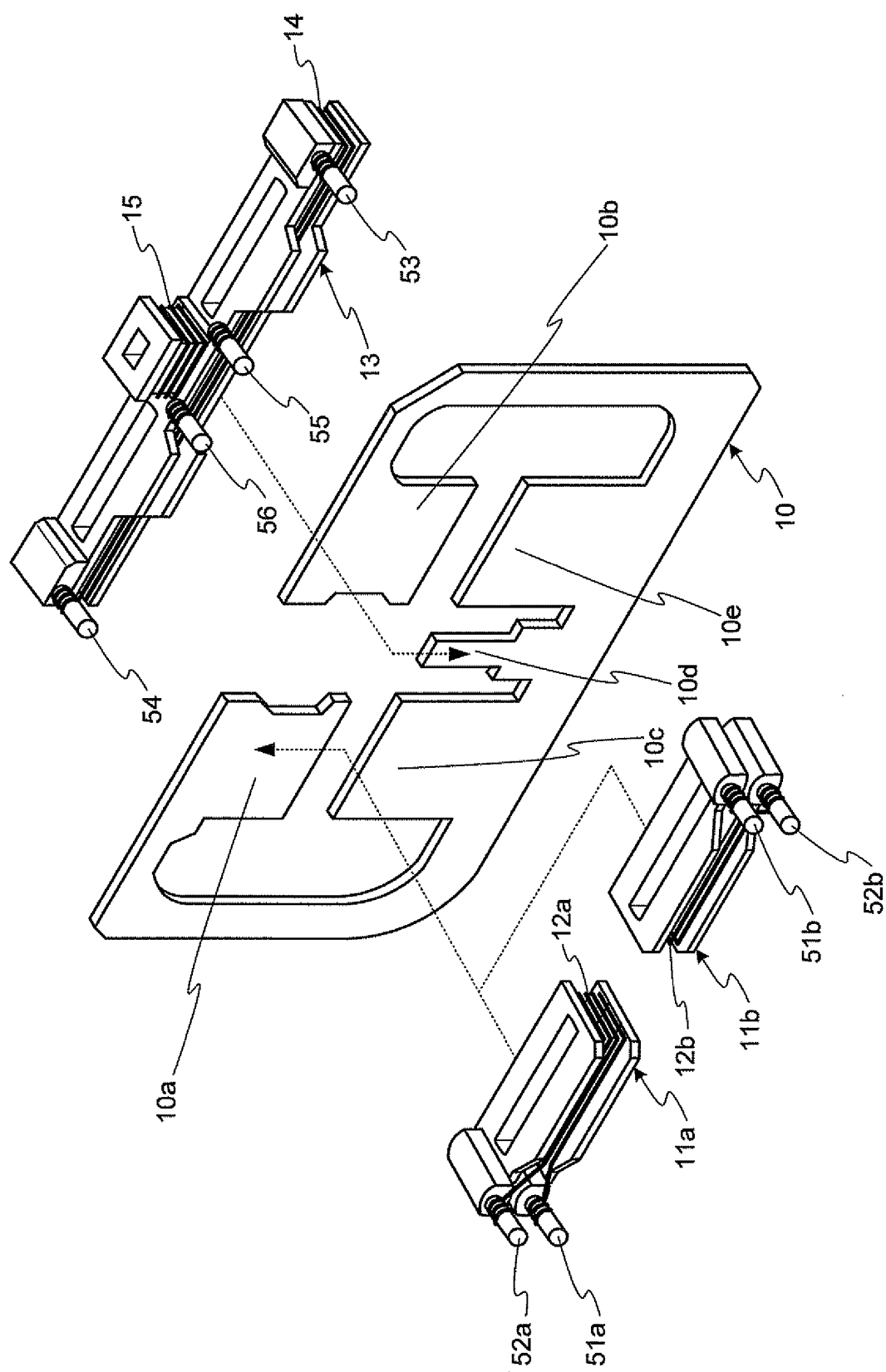


FIG.8A

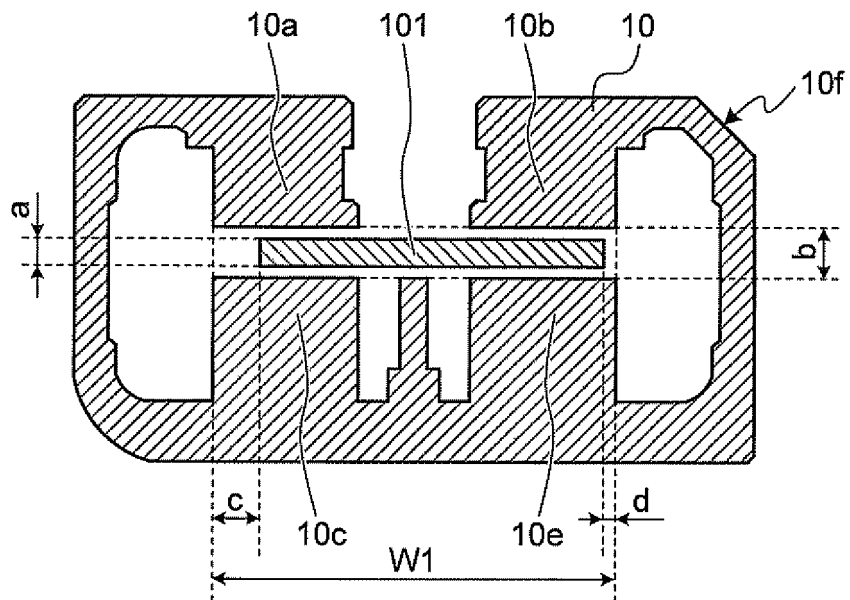


FIG.8B

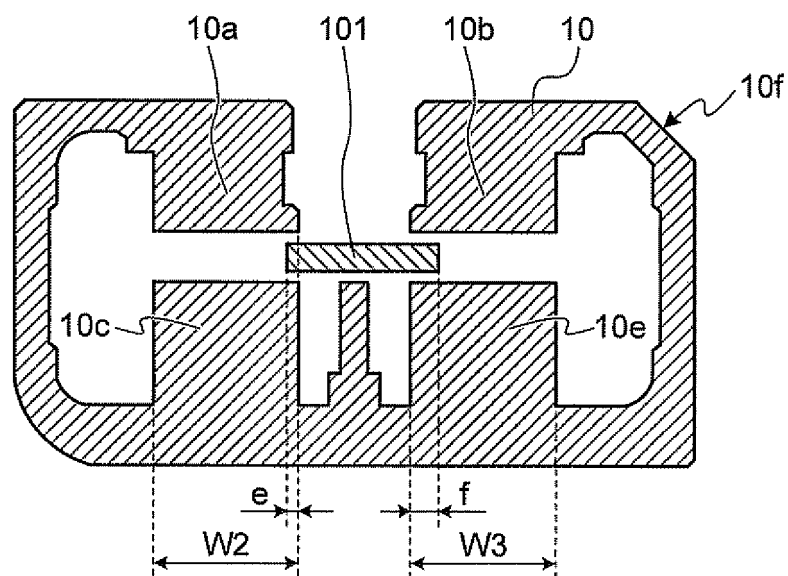


FIG.9

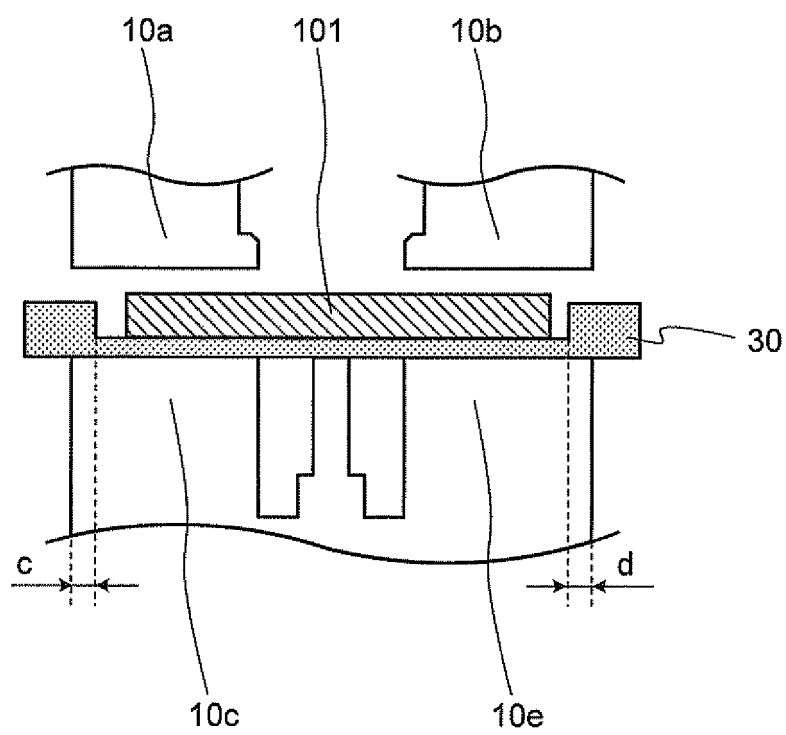
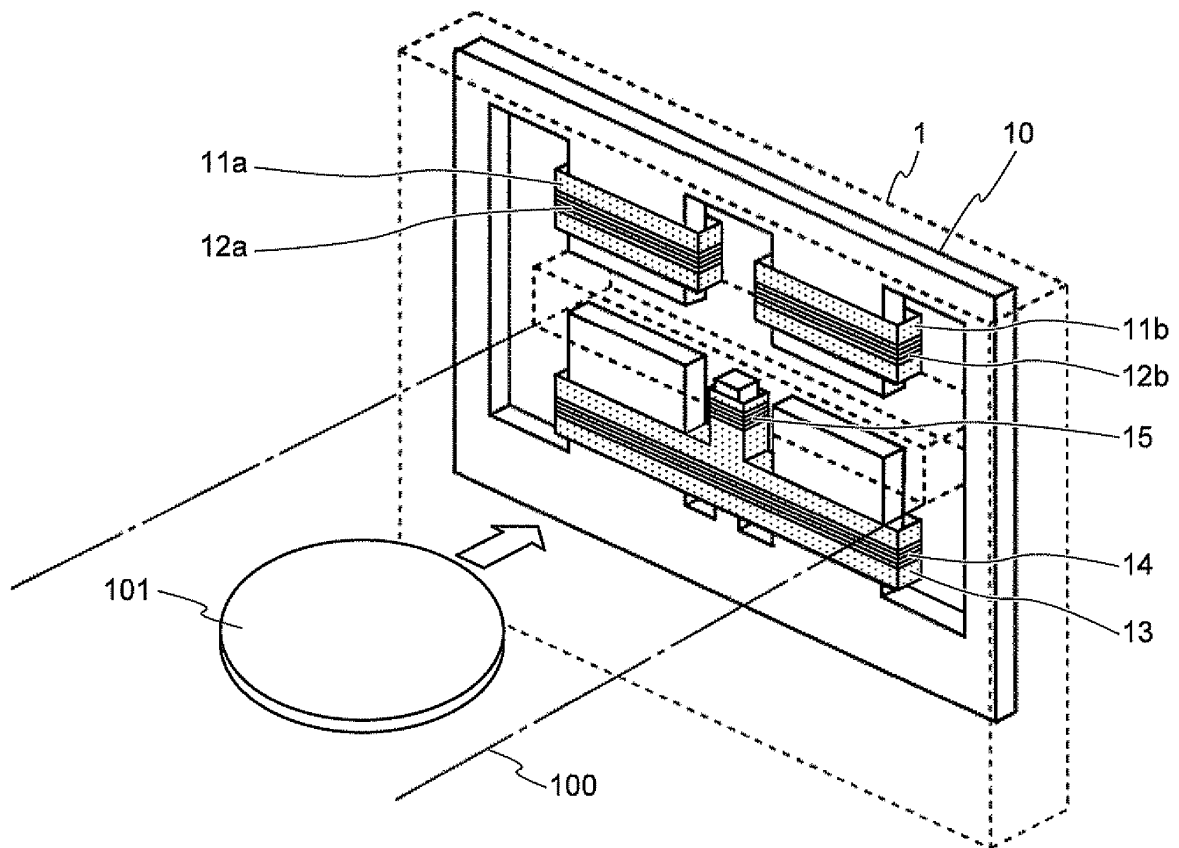


FIG.10





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Application Number  
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| The Hague                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                              | 18 April 2013                    | Neville, David                          |
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