

DESCRIPTION
COIN PROCESSING DEVICE

Technical Field

5 [0001]

The present invention relates to a coin processing device that is mounted to a vending machine, a money changer, a fare adjustment machine, a ticket-vending machine, or a servicing apparatus (hereinafter, referred to as a "vending machine or the
10 like"), and particularly to a coin processing device provided with an outer diameter detection sensor that detects an outer diameter of a coin.

Background Art

15 [0002]

A coin processing device, which determines genuineness of inserted coins and sorts and stores coins determined as genuine coins for each denomination, is mounted inside a vending machine or the like. Such a coin processing device is provided with a coin
20 sorting unit that determines the genuineness of the inserted coins and sorts out the coins for each denomination.

[0003]

The coin sorting unit is provided with an outer diameter detection sensor that mainly detects an outer diameter of a coin
25 and a material detection sensor that mainly detects a material of the coin. The outer diameter detection sensor includes a coil provided in a coin passage through which the inserted coin passes and is connected to an oscillation circuit. The material detection sensor is configured in the same manner. The oscillation circuit
30 oscillates at an oscillation frequency depending on an inductance of the coil. This oscillation frequency is set to a frequency at which an electromagnetic field caused by oscillation is easily affected by the coin. As the electromagnetic field is affected by the coin, an amplitude of an oscillation signal also changes.
35 Therefore, it is possible to detect the outer diameter and the material of the coin based on the oscillation frequency and the

voltage. Accordingly, it is possible to perform genuineness determination and type determination of the coin.

[0004]

Meanwhile, there is a coin processing device configured to
5 determine genuineness of a plurality types of coins including a
bimetal coin. The bimetal coin is a coin having different
materials between a central core section and a ring section that
surrounds the core section. For example, a two-dollar coin in
Canada is known as the bimetal coin. In order to accurately
10 detect an outer diameter of such a bimetal coin, a technique of
using a ring-shaped outer diameter detection sensor having a
space at the central section is known (see Patent Literature 1).

[0005]

In the ring-shaped outer diameter detection sensor, a core
15 section of the bimetal coin and the space of the outer diameter
detection sensor overlap each other, and thus, an electromagnetic
field (magnetic flux density) at the core section of the bimetal coin
at this time is sufficiently smaller than an electromagnetic field at
a ring section. Accordingly, it is possible to detect an outer
20 diameter of the bimetal coin with high accuracy by mainly
reflecting influence of the ring section at the outer circumference
of the bimetal coin.

Citation List

25 Patent Literature

[0006]

Patent Literature 1: Japanese Patent No. 4126668

Summary of Invention

30 Technical Problem

[0007]

However, when the above-described conventional outer
diameter detection sensor is used, the vicinity of an outer
circumference of a small coin (for example, a Canadian ten-cent
35 coin) CO other than the bimetal coin overlaps a space OP1 of an
outer diameter detection sensor 4X as illustrated in FIG. 13.

Thus, an oscillation frequency and the outer diameter have a relationship that is not proportional in a range RX where the outer diameter of the coin is small as illustrated in FIG. 14. Therefore, there is a possibility of making a mistake in the genuineness determination and type determination without accurately detecting the outer diameter of the small coin.

[0008]

The present invention has been made in consideration of such points, and an object thereof is to provide a coin processing device that is capable of improving accuracy of detection of each outer diameter of plural types of coins.

Solution to Problem

[0009]

A coin processing device according to an aspect of the present invention includes: a coin passage through which an inserted coin passes; a material detection sensor which includes a first coil and a second coil facing each other with the coin passage interposed therebetween; an outer diameter detection sensor which includes a ring-shaped third coil that surrounds the first coil and a ring-shaped fourth coil that surrounds the second coil, the third coil and the fourth coil facing each other with the coin passage interposed therebetween; a first oscillation circuit which is connected to the material detection sensor and oscillates a first oscillation signal in an individual connection state, and is connected to the material detection sensor and the outer diameter detection sensor that are connected in series and oscillates the first oscillation signal in a series connection state; a second oscillation circuit which is connected to the outer diameter detection sensor and oscillates a second oscillation signal in the individual connection state; a switching unit which switches the individual connection state and the series connection state; and a coin identification unit which detects an outer diameter of the coin using the second oscillation signal in the individual connection state or the first oscillation signal in the series connection state and identifies the coin based on the outer diameter.

Advantageous Effects of Invention

[0010]

According to the present invention, it is possible to improve
5 the accuracy in the detection of each outer diameter of plural
types of coins.

Brief Description of Drawings

[0011]

10 FIG. 1 is a diagram illustrating a part of a schematic
configuration of a coin processing device according to an
embodiment.

FIG. 2(a) is a side view illustrating one side surface of an
identification sensor, FIG. 2(b) is a side view illustrating another
15 side surface of the identification sensor, and FIG. 2(c) is a
cross-sectional view of a coin passage and the identification
sensor.

FIG. 3 is a block diagram illustrating a configuration which
relates to genuineness determination and type determination of
20 the coin processing device of FIG. 1.

FIG. 4 is a circuit diagram illustrating connection of a
switching unit in an individual connection state.

FIG. 5 is a circuit diagram illustrating connection of the
switching unit in a series connection state.

25 FIG. 6(a) is a view illustrating a positional relationship
between a bimetal coin and the identification sensor, FIG. 6(b) is
a graph illustrating each temporal change of a frequency and a
voltage of an outer diameter detection sensor corresponding to
FIG. 6(a), FIG. 6(c) is a view illustrating a positional relationship
30 between a coin other than the bimetal coin and the identification
sensor, and FIG. 6(d) is a graph illustrating each temporal change
of a frequency and a voltage of the outer diameter detection
sensor corresponding to FIG. 6(c).

FIG. 7(a) is a view illustrating a positional relationship
35 between the bimetal coin and the identification sensor, FIG. 7(b)
is a graph illustrating each temporal change of a frequency and a

voltage of a material detection sensor corresponding to FIG. 7(a),
FIG. 7(c) is a view illustrating a positional relationship between
the coin other than the bimetal coin and the identification sensor,
and FIG. 7(d) is a graph illustrating each temporal change of a
5 frequency and a voltage of the material detection sensor
corresponding to FIG. 7(c).

FIG. 8(a) is a view illustrating a positional relationship
between the bimetal coin and the identification sensor, FIG. 8(b)
is a graph illustrating each temporal change of a frequency and a
10 voltage of an outer diameter and material detection sensor
corresponding to FIG. 8(a), FIG. 8(c) is a view illustrating a
positional relationship between the coin other than the bimetal
coin and the identification sensor, and FIG. 8(d) is a graph
illustrating each temporal change of a frequency and a voltage of
15 the outer diameter and material detection sensor corresponding
to FIG. 8(c).

FIG. 9 is a flowchart illustrating a genuineness
determination and type determination process of the coin
processing device.

20 FIG. 10 is a graph illustrating a data collection period.

FIG. 11 is a graph illustrating a relationship between the
outer diameter of the coin other than the bimetal coin and the
frequency detected by the identification unit in the series
connection state according to the embodiment.

25 FIG. 12 is a graph illustrating a relationship between a
frequency and a voltage of a coin having a clad structure
according to the embodiment.

FIG. 13 is a view illustrating a positional relationship
between a conventional outer diameter detection sensor and a
30 small coin.

FIG. 14 is a graph illustrating a relationship between an
outer diameter of a coin other than a conventional bimetal coin
and a frequency.

35 Description of Embodiments
[0012]

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. The embodiment does not limit the present invention.

[0013]

5 FIG. 1 is a diagram illustrating a part of a schematic configuration of a coin processing device 1 according to an embodiment. As illustrated in FIG. 1, the coin processing device 1 is provided with an insertion opening 2 to which a coin is inserted, a coin passage 3 which is provided to be inclined below
10 the insertion opening 2 and through which the inserted coin passes, and an identification sensor 4 which is provided on a sidewall of the coin passage 3. The sidewall of the coin passage 3 is not illustrated.

[0014]

15 The coin inserted from the insertion opening 2 rolls along the coin passage 3 by its own weight and passes through the identification sensor 4. Accordingly, genuineness determination and type determination of the coin is performed as described below.

20 [0015]

 FIG. 2(a) is a side view illustrating one side surface of the identification sensor 4 and FIG. 2(b) is a side view illustrating another side surface of the identification sensor 4. FIG. 2(c) is a cross-sectional view obtained by cutting the coin passage 3 and
25 the identification sensor 4 of FIG. 1 along a plane which is vertical to a passing direction of a coin CO.

[0016]

 The identification sensor 4 includes a material detection sensor 4a and an outer diameter detection sensor 4b.

30 [0017]

 The material detection sensor 4a includes a first coil L1 and a second coil L2 which face each other with the coin passage 3 interposed therebetween. The first coil L1 and the second coil L2 are circular and planar coils. That is, the coin can pass through
35 the inside of the material detection sensor 4a.

[0018]

The outer diameter detection sensor 4b includes a ring-shaped third coil L3 which surrounds the first coil L1 and a ring-shaped fourth coil L4 which surrounds the second coil L2. The third coil L3 and the fourth coil L4 face each other with the coin passage 3 interposed therebetween. That is, the coin can pass through the inside of the outer diameter detection sensor 4b. [0019]

In this manner, the outer diameter detection sensor 4b is provided in a ring shape to surround the material detection sensor 4a. [0020]

The first coil L1 and the third coil L3 are spiral coils each of which is provided in a planar shape on a first printed board. The second coil L2 and the fourth coil L4 are spiral coils each of which is provided in a planar shape on a second printed board. It is possible to easily and accurately set relative positions of the material detection sensor 4a and the outer diameter detection sensor 4b by employing the spiral coil. [0021]

FIG. 3 is a block diagram illustrating a configuration which relates to genuineness determination and type determination of the coin processing device 1 of FIG. 1. The coin processing device 1 is provided with a first oscillation circuit 11 which oscillates a first oscillation signal OSC1, a second oscillation circuit 12 which oscillates a second oscillation signal OSC2, envelope detection circuits 13 and 14, a switching unit 15, a coin identification unit 16, and a storage unit (memory) 17. [0022]

The first oscillation circuit 11 includes capacitive elements C1 and C2 and an amplifier IC1. One end of the capacitive element C1 is connected to one end of the first coil L1 and an input terminal of the amplifier IC1. The other end of the capacitive element C1 is connected to one end of the capacitive element C2 and is grounded. The other end of the capacitive element C2 is connected to one end of the second coil L2 and an output terminal of the amplifier IC1. A signal of the input terminal of the

amplifier IC1 is the first oscillation signal OSC1. A frequency of the first oscillation signal OSC1 in a case where there is no coin is set depending on an inductance connected between the input and output terminals of the amplifier IC1 and capacitance values of the capacitive elements C1 and C2.

[0023]

The other end of the first coil L1 is connected to a switch S1 of the switching unit 15. The other end of the second coil L2 is connected to a switch S2 of the switching unit 15.

[0024]

The second oscillation circuit 12 includes capacitive elements C3 and C4 and an amplifier IC2. One end of the capacitive element C3 is connected to a switch S4 of the switching unit 15 and an input terminal of the amplifier IC2. The other end of the capacitive element C3 is connected to one end of the capacitive element C4 and is grounded. The other end of the capacitive element C4 is connected to the switch S3 of the switching unit 15 and an output terminal of the amplifier IC2. The other end of the third coil L3 is connected to the other end of the fourth coil L4. A signal of the input terminal of the amplifier IC2 is the second oscillation signal OSC2. A frequency of the second oscillation signal OSC2 in the case where there is no coin is set depending on an inductance connected between the input and output terminals of the amplifier IC2 and capacitance values of the capacitive elements C3 and C4.

[0025]

The first oscillation signal OSC1 is supplied to the envelope detection circuit 13 and the coin identification unit 16. The envelope detection circuit 13 performs envelope detection of the first oscillation signal OSC1 and outputs a voltage of the first oscillation signal OSC1.

[0026]

The second oscillation signal OSC2 is supplied to the envelope detection circuit 14 and the coin identification unit 16. The envelope detection circuit 14 performs envelope detection of the second oscillation signal OSC2 and outputs a voltage of the

second oscillation signal OSC2.

[0027]

The switching unit 15 includes the switches S1 to S4 and performs switching between an individual connection state and a series connection state. In the individual connection state, the first oscillation circuit 11 is connected to the material detection sensor 4a, and the second oscillation circuit 12 is connected to the outer diameter detection sensor 4b. In the series connection state, the first oscillation circuit 11 is connected to the material detection sensor 4a and the outer diameter detection sensor 4b which are connected in series, and the second oscillation circuit 12 is not connected to the material detection sensor 4a or the outer diameter detection sensor 4b.

[0028]

The coin identification unit 16 includes, for example, an AD converter, a CPU (Central Processing Unit), and the like and detects each frequency of the first oscillation signal OSC1 and the second oscillation signal OSC2. In addition, the coin identification unit 16 controls the switching unit 15.

[0029]

The storage unit 17 includes, for example, a RAM (Random Access Memory), a non-volatile memory, and the like and stores the voltage and the frequency of the first oscillation signal OSC1 and the voltage and the frequency of the second oscillation signal OSC2 supplied from the coin identification unit 16.

[0030]

The coin identification unit 16 detects a feature amount (an outer diameter and a material) of a coin based on the first oscillation signal OSC1 and the second oscillation signal OSC2 using values stored in the storage unit 17 and identifies the coin based on the detected feature amount. A specific process will be described later.

[0031]

FIG. 4 is a circuit diagram illustrating connection of the switching unit 15 in the individual connection state. As illustrated in FIG. 4, the switches S1 and S2 connect the other end

of the first coil L1 and the other end of the second coil L2 in the individual connection state. The switch S3 connects one end of the third coil L3 and the output terminal of the amplifier IC2. The switch S4 connects one end of the fourth coil L4 and the input terminal of the amplifier IC2. Accordingly, the first coil L1 and the second coil L2 are connected in series between the input and output terminals of the amplifier IC1, and the third coil L3 and the fourth coil L4 are connected in series between the input and output terminals of the amplifier IC2.

10 [0032]

In this manner, the first oscillation circuit 11 is connected to the material detection sensor 4a and oscillates the first oscillation signal OSC1 in the individual connection state. The second oscillation circuit 12 is connected to the outer diameter detection sensor 4b and oscillates the second oscillation signal OSC2 in the individual connection state.

15 [0033]

FIG. 5 is a circuit diagram illustrating connection of the switching unit 15 in the series connection state. As illustrated in FIG. 5, the switches S1 and S3 connect the other end of the first coil L1 and the one end of the third coil L3 in the series connection state. The switches S2 and S4 connect the other end of the second coil L2 and the one end of the fourth coil L4. Accordingly, the first coil L1, the third coil L3, the fourth coil L4, and the second coil L2 are connected in series between the input and output terminals of the amplifier IC1.

20 [0034]

In this manner, the first oscillation circuit 11 is connected to the material detection sensor 4a and the outer diameter detection sensor 4b, which are connected in series, and oscillates the first oscillation signal OSC1 in the series connection state.

30 [0035]

Next, a description will be given regarding examples of frequencies and voltages of the respective sensors when the coin passes through the identification sensor 4.

35 [0036]

(Outer Diameter Detection Sensor 4b in Individual Connection State)

FIG. 6(a) is a view illustrating a positional relationship between a bimetal coin BCO and the identification sensor 4, and
5 FIG. 6(b) is a graph illustrating each temporal change of a frequency and a voltage of an outer diameter detection sensor 4b corresponding to FIG. 6(a). The frequency and the voltage of the outer diameter detection sensor 4b indicate the frequency and the voltage of the second oscillation signal OSC2 in the individual
10 connection state.
[0037]

FIG. 6(c) is a view illustrating a positional relationship between the coin CO other than the bimetal coin and the identification sensor 4, and FIG. 6(d) is a graph illustrating each
15 temporal change of a frequency and a voltage of the outer diameter detection sensor 4b corresponding to FIG. 6(c).
[0038]

As illustrated in FIG. 6(a), the bimetal coin BCO does not reach the outer diameter detection sensor 4b when the bimetal
20 coin BCO is positioned at a point P1. Therefore, the frequency and the voltage of the outer diameter detection sensor 4b are substantially the same values as those of a standby state where no coin is inserted as illustrated in FIG. 6(b).
[0039]

25 An end portion of the bimetal coin BCO reaches an end portion of the outer diameter detection sensor 4b at a next point P2. Therefore, the frequency and the voltage of the outer diameter detection sensor 4b begin to decrease from the values of the standby state.

30 [0040]

The bimetal coin BCO overlaps the entire outer diameter detection sensor 4b at a next point P3. The frequency and the voltage of the outer diameter detection sensor 4b at this time are the minimum values.

35 [0041]

Thereafter, the overlapping area between the bimetal coin

BCO and the outer diameter detection sensor 4b decreases more and more, and accordingly, the frequency and the voltage of the outer diameter detection sensor 4b increase more and more up to the values of the standby state.

5 [0042]

As illustrated in FIGS. 6(c) and 6(d), the frequency and the voltage of the outer diameter detection sensor 4b show the same change as that in the case of the bimetal coin BCO when the coin CO other than the bimetal coin is positioned at each of points P1a, P2a and P3a.

10

[0043]

(Material Detection Sensor 4a in Individual Connection State)

FIG. 7(a) is a view illustrating a positional relationship between the bimetal coin BCO and the identification sensor 4, and FIG. 7(b) is a graph illustrating each temporal change of a frequency and a voltage of a material detection sensor 4a corresponding to FIG. 7(a). The frequency and the voltage of the material detection sensor 4a indicate the frequency and the voltage of the first oscillation signal OSC1 in the individual connection state.

20

[0044]

FIG. 7(c) is a view illustrating a positional relationship between the coin CO other than the bimetal coin and the identification sensor 4, and FIG. 7(d) is a graph illustrating each temporal change of a frequency and a voltage of the material detection sensor 4a corresponding to FIG. 7(c).

25

[0045]

As illustrated in FIG. 7(a), the bimetal coin BCO does not reach the material detection sensor 4a when the bimetal coin BCO is positioned at the point P1. Therefore, the frequency and the voltage of the material detection sensor 4a are substantially the same values as those of the standby state as illustrated in FIG. 7(b).

35

[0046]

A ring section BCO1 of the bimetal coin BCO reaches an end

portion of the material detection sensor 4a at the next point P2. Accordingly, the frequency of the material detection sensor 4a changes and the voltage thereof decreases as compared to the values of the standby state.

5 [0047]

A core section BCO2 of the bimetal coin BCO reaches the end portion of the material detection sensor 4a at the next point P3. Accordingly, the frequency of the material detection sensor 4a changes from the value at the point P2, and the voltage thereof
10 increases from the value of the point P2 and then decreases. That is, a voltage waveform has a peak (unevenness) 20 near the point P3.

[0048]

This is because the bimetal coin BCO uses different
15 materials between the core section BCO2 and the ring section BCO1 so that an electromagnetic field receives different levels of influence between the case where the ring section BCO1 reaches the material detection sensor 4a and the case where the core section BCO2 reaches the material detection sensor 4a.

20 [0049]

The entire material detection sensor 4a is overlapped by the core section BCO2 of the bimetal coin BCO at the next point P4. The overlapping area between the bimetal coin BCO and the material detection sensor 4a is substantially constant before and
25 after the point P4. The frequency and the voltage of the material detection sensor 4a are substantially constant in a range.

[0050]

Thereafter, when the overlapping area between the bimetal coin BCO and the material detection sensor 4a decreases, the
30 frequency and the voltage of the material detection sensor 4a increase more and more up to the values of the standby state along with the decrease of the area. A voltage waveform at this time also has a peak.

[0051]

35 Meanwhile, when the coin CO other than the bimetal coin reaches the point P2a, an end portion of the coin CO reaches the

end portion of the material detection sensor 4a. Accordingly, the frequency of the material detection sensor 4a changes and the voltage thereof decreases as compared to the values of the standby state.

5 [0052]

The area of the coin CO overlapping the material detection sensor 4a increases at the next point P3a. Accordingly, the frequency of the material detection sensor 4a changes from the value at the point P2a, and the voltage thereof decreases from the value of the point P2a.

10 [0053]

Thereafter, the frequency and the voltage of the material detection sensor 4a are substantially constant in a range where the overlapping area between the coin CO and the material detection sensor 4a is substantially constant before and after the point P4a.

15 [0054]

Thereafter, when the overlapping area between the coin CO and the material detection sensor 4a decreases, the frequency and the voltage of the material detection sensor 4a increase more and more up to the values of the standby state along with the decrease of the area.

20 [0055]

In this manner, the coin CO other than the bimetal coin uses one type of material, and thus, the voltage waveform of the material detection sensor 4a does not have the peak.

25 [0056]

(Series Connection State)

FIG. 8(a) is a view illustrating a positional relationship between the bimetal coin BCO and the identification sensor 4, and FIG. 8(b) is a graph illustrating each temporal change of a frequency and a voltage of an outer diameter and material detection sensor corresponding to FIG. 8(a). The outer diameter and material detection sensor indicates the outer diameter detection sensor 4b and the material detection sensor 4a which are connected in series. The frequency and the voltage of the

outer diameter and material detection sensor indicate the frequency and the voltage of the first oscillation signal OSC1 in the series connection state.

[0057]

5 FIG. 8(c) is a view illustrating a positional relationship between the coin CO other than the bimetal coin and the identification sensor 4, and FIG. 8(d) is a graph illustrating each temporal change of a frequency and a voltage of the outer diameter and material detection sensor corresponding to FIG. 8(c).

10 [0058]

 When the bimetal coin BCO is positioned at the point P1 as illustrated in FIG. 8(a), the frequency and the voltage of the outer diameter and material detection sensor are substantially the same values as those in the standby state where no coin is inserted as illustrated in FIG. 8(b).

15 [0059]

 The end portion of the bimetal coin BCO reaches the end portion of the outer diameter detection sensor 4b at the next point P2. Therefore, the frequency and the voltage of the outer diameter and material detection sensor decrease from the values of the standby state.

20 [0060]

 The core section BCO2 of the bimetal coin BCO reaches the end portion of the material detection sensor 4a at the next point P3. Accordingly, the frequency and the voltage of the outer diameter and material detection sensor decrease from the values at the point P2.

25 [0061]

30 The entire material detection sensor 4a is overlapped by the core section BCO2 of the bimetal coin BCO at the next point P4. The frequency and the voltage of the outer diameter detection sensor 4b at this time are the minimum values.

 [0062]

35 Thereafter, the overlapping area between the bimetal coin BCO and the outer diameter and material detection sensor

decreases more and more, and accordingly, the frequency and the voltage of the outer diameter and material detection sensor increase more and more up to the values of the standby state.

[0063]

5 As illustrated in FIGS. 8(c) and 8(d), the frequency of the outer diameter and material detection sensor changes, and the voltage thereof decreases more and more when the position of the coin CO other than the bimetal coin changes from the point P1a to P2a and P3a. The overlapping area between the coin CO and the
10 outer diameter and material detection sensor are constant at the points P3a and P4a, the frequency and the voltage of the outer diameter and material detection sensor are constant.

[0064]

Next, a genuineness determination and type determination
15 process will be described with reference to FIGS. 9 and 10.

FIG. 9 is a flowchart illustrating the genuineness determination and type determination process of the coin processing device 1. The process of FIG. 9 is performed by control of the coin identification unit 16. FIG. 10 is a graph
20 illustrating a data collection period and corresponds to the above-described FIGS. 6(b) and 6(d).

[0065]

First, the individual connection state is set after turning on power (Step S1).

25 Next, a voltage of the outer diameter detection sensor 4b (a standby voltage V_s in FIG. 10) is stored in the storage unit 17 (Step S2).

Next, the voltage of the outer diameter detection sensor 4b is measured (Step S3).

30 [0066]

Next, when the voltage of the outer diameter detection sensor 4b has not changed to 80% of the standby voltage V_s (No in Step S4), the process returns to the processing in Step S3 since the coin does not reach near the outer diameter detection sensor
35 4b.

[0067]

When the voltage of the outer diameter detection sensor 4b has changed to 80% of the standby voltage V_s (Yes in Step S4, time t_1 in FIG. 10), the voltage and the frequency of the outer diameter detection sensor 4b are stored in the storage unit 17 since the coin reaches near the outer diameter detection sensor 4b (Step S5). This time t_1 becomes a data collection start point. [0068]

Next, the voltage and the frequency of the material detection sensor 4a are stored in the storage unit 17 (Step S6).
 10 Next, the state is switched to the series connection state (Step S7).
 [0069]

Next, the voltage and the frequency of the outer diameter and material detection sensory are stored in the storage unit 17 (Step S8).
 15

Next, the state is switched to the individual connection state (Step S9).
 [0070]

Next, when the voltage of the outer diameter detection sensor 4b has not returned to 85% of the standby voltage V_s (No in Step S10), the process returns to the processing in Step S5. In this manner, the switching unit 15 alternately switches the individual connection state and the series connection state.
 20
 [0071]

When the voltage of the outer diameter detection sensor 4b has returned to 85% of the standby voltage V_s (Yes in Step S10, time t_2 in FIG. 7), whether the coin is the bimetal coin is determined based on the voltage waveform of the material detection sensor 4a stored in the storage unit 17 (Step S11).
 25
 30 That is, the time t_2 in FIG. 7 becomes a data collection end point, and a period between the time t_1 and t_2 becomes the data collection period.
 [0072]

In the present embodiment, for example, the coin identification unit 16 determines whether the coin is the bimetal coin depending on the voltage of the first oscillation signal OSC1
 35

in the individual connection state during passing of the coin through a portion (the material detection sensor 4a) between the first coil L1 and the second coil L2, and either the second oscillation signal OSC2 in the individual connection state or the first oscillation signal OSC1 in the series connection state is selected. That is, whether the coin is bimetal coin is determined using the above-described difference in the voltage waveform of the material detection sensor 4a (FIGS. 7(b) and 7(d)).

[0073]

10 To be specific, the coin identification unit 16 determines that a coin is the bimetal coin when the peak is present in the voltage waveform of the first oscillation signal OSC1 in a determination period set in advance during the passing of the coin through the portion between the first coil L1 and the second coil
15 L2, and selects the second oscillation signal OSC2 in the individual connection state.

[0074]

In addition, the coin identification unit 16 determines that a coin is the coin other than the bimetal coin when there is no peak
20 in the voltage waveform of the first oscillation signal OSC1 in the above-described determination period and selects the first oscillation signal OSC1 in the series connection state.

[0075]

The determination period is a period from the point P1 to
25 the point P3 of FIG. 7(b) and a period of FIG. 7(d) which corresponding thereto, for example.

[0076]

When the coin is the bimetal coin (Yes in Step S11), the outer diameter is detected using the frequency of the outer
30 diameter detection sensor 4b (the selected second oscillation signal OSC2) stored in the storage unit 17, and the coin is identified based on the outer diameter (Step S12). For example, the outer diameter may be determined depending on a comparison result obtained by comparing the minimum value of
35 the frequency and a frequency determination threshold value.

[0077]

Next, the material is detected using the voltage of the outer diameter detection sensor 4b, the frequency and the voltage of the material detection sensor 4a, and the voltage of the outer diameter and material detection sensor stored in the storage unit 17, and the coin is identified based on the material (Step S13). For example, the material may be detected using comparison results obtained by comparing the minimum value of the voltage and a voltage determination threshold value and comparing the minimum value of the frequency and the frequency determination threshold value. The voltage determination threshold value and the frequency determination threshold value are stored in the storage unit 17 in advance.

[0078]

Incidentally, the material may be detected in Step S13 using at least any of the voltage of the outer diameter detection sensor 4b, the frequency of the material detection sensor 4a, the voltage of the material detection sensor 4a, and the voltage of the outer diameter and material detection sensor.

[0079]

On the other hand, when the coin is not the bimetal coin (No in Step S11), the outer diameter is detected using the frequency of the outer diameter and material detection sensor (the selected first oscillation signal OSC1) stored in the storage unit 17, and the coin is identified based on the outer diameter (Step S14). For example, the outer diameter may be determined depending on the comparison result obtained by comparing the frequency minimum value and determination threshold value.

[0080]

Next, the material is detected using the voltage of the outer diameter detection sensor 4b, the frequency and the voltage of the material detection sensor 4a, and the voltage of the outer diameter and material detection sensor stored in the storage unit 17, and the coin is identified based on the material (Step S15). For example, the material may be detected using comparison results obtained by comparing the minimum value of the voltage and the voltage determination threshold value and comparing the

minimum value of the frequency and the frequency determination threshold value.

[0081]

Incidentally, the material may be detected in Step S15
5 using at least any of the voltage of the outer diameter detection sensor 4b, the frequency of the material detection sensor 4a, the voltage of the material detection sensor 4a, and the voltage of the outer diameter and material detection sensor.

[0082]

10 In this manner, the coin identification unit 16 detects the outer diameter of the coin using the second oscillation signal OSC2 in the individual connection state or the first oscillation signal OSC1 in the series connection state.

[0083]

15 In addition, the coin identification unit 16 detects the material of the coin using at least any of the first oscillation signal OSC1 in the individual connection state, the second oscillation signal OSC2 in the individual connection state, and the first oscillation signal OSC1 in the series connection state.

20 [0084]

FIG. 11 is a graph illustrating a relationship between the outer diameter of the coin other than the bimetal coin and the frequency detected by the coin identification unit 16 in the series connection state according to the embodiment. Since the entire
25 coin is affected by the electromagnetic field regardless of the outer diameter in the series connection state, the frequency to be detected by the coin identification unit 16 decreases in proportional to a size of the outer diameter as illustrated in FIG. 11. Therefore, it is possible to detect the outer diameter with
30 high accuracy even if the coin is small.

[0085]

FIG. 12 is a graph illustrating a relationship between a frequency and a voltage of a coin having a clad structure according to the embodiment. The frequency of the material
35 detection sensor 4a in the individual connection state is denoted by f_{org} , and the frequency thereof in the series connection state

is denoted by Flow. The inductance in the series connection state becomes larger than the inductance of the material detection sensor 4a, and thus, the frequency Flow is lower than the frequency Forg in the state where there is no coin.

5 [0086]

In this manner, it is possible to detect the material at two skin depths using the two frequencies Forg and Flow. Therefore, it is possible to detect the material for each layer with respect to a coin such as a plated coin or a clad coin, which is configured
10 using a multi-layer member, other than the bimetal coin. Accordingly, it is possible to improve the detection accuracy of the material.

[0087]

In the example of FIG. 12, a material of a test coin having
15 the clad structure, which has a core material and a surface layer material covering the core material, is detected. In the case of the frequency Forg, the electromagnetic field is mainly affected by the surface layer material, and thus, the surface layer material can be detected. In the case of the frequency Flow, the
20 electromagnetic field is mainly affected by the core material, and thus, the core material can be detected. In this example, the frequency Flow is substantially equal to the frequency Forg due to the influence of the coin.

[0088]

25 As illustrated in FIG. 12, the voltage becomes high in the case of the frequency Forg in the individual connection state, and the voltage becomes low in the case of the frequency Flow in the series connection state. In this manner, the voltages different from each other between the two connection states are obtained,
30 and thus, it is possible to detect that the coin has the core material and the surface layer material made of the materials different from each other.

[0089]

Although not illustrated, it is possible to detect a material
35 for each layer of the multi-layer member using three frequencies when the voltage of the outer diameter detection sensor 4b, the

frequency and the voltage of the material detection sensor 4a, and the voltage of the outer diameter and material detection sensor are used as described above.

[0090]

5 In this manner, whether the coin is bimetal coin is detected depending on whether the peak is present in the voltage waveform of the material detection sensor 4a during the passing of the coin serving as a detection target by providing the material
10 detection sensor 4a and the ring-shaped outer diameter detection sensor 4b that surrounds the material detection sensor 4a according to the present embodiment.

[0091]

 Further, when the coin is determined as the coin other than the bimetal coin, it is configured such that the outer diameter is
15 detected using the frequency of the outer diameter and material detection sensor obtained by connecting the material detection sensor 4a and the outer diameter detection sensor 4b in series. Accordingly, the entire surface of the coin is affected by the
20 electromagnetic field from the material detection sensor 4a and the outer diameter detection sensor 4b even if the coin has a small outer diameter. Accordingly, the outer diameter and the
 frequency are proportional to each other regardless of the outer diameter, and thus, it is possible to detect the outer diameter with high accuracy.

25 [0092]

 On the other hand, when the coin is determined as the bimetal coin, the outer diameter is detected using the frequency of the ring-shaped outer diameter detection sensor 4b, and thus, it is possible to detect the outer diameter with high accuracy by
30 reflecting the ring section at the outer circumference of the bimetal coin.

[0093]

 Therefore, it is possible to improve the detection accuracy of the outer diameter of plural types of coins.

35 [0094]

 In addition, it is configured such that the material is

detected using the voltage of the outer diameter detection sensor 4b, the frequency and the voltage of the material detection sensor 4a, and the voltage of the outer diameter and material detection sensor regardless of the type of the coin.

5 [0095]

Accordingly, it is possible to use the three types of frequencies, and thus, the information that can be obtained increases. That is, a depth that the electromagnetic field reaches differs depending on a frequency, and thus, a material on a
10 surface and a material of an inner portion can be distinguished and detected depending on the frequency even in the case of the clad coin or the plated coin configured using the multi-layer member.

[0096]

15 Therefore, it is possible to improve the detection accuracy of the material of plural types of coins.

[0097]

Incidentally, the first coil L1 to the fourth coil L4 may be formed by winding a conducting wire around a core such as a
20 ferrite material.

[0098]

In addition, the description has been given regarding the example where the voltage and the frequency are stored by alternately switching the individual connection state and the
25 series connection state and whether the coin is the bimetal coin is determined after the data collection period ends, but the invention is not limited thereto. For example, whether the coin is the bimetal coin may be determined at substantially the same timing as the point P3 in FIG. 7(b), and thereafter, the outer diameter
30 and the material may be determined using a voltage and a frequency thus obtained by fixing the state to any one of the individual connection state and the series connection state depending on a result of the determination.

[0099]

35 Although several embodiments of the present invention have been described as above, the embodiments are given as

examples and have no intention to limit the scope of the invention. These embodiments can be implemented in various other modes, and various omissions, substitutions, and alterations can be made within a scope without departing from a gist of the invention.

- 5 The accompanying claims and their equivalents are intended to cover these embodiments and modifications thereof as would fall within the scope and the gist of the invention.

Reference Signs List

- 10 [0100]
- 1 coin processing device
 - 2 insertion opening
 - 3 coin passage
 - 4 identification sensor
 - 15 4a material detection sensor
 - 4b outer diameter detection sensor
 - L1 first coil
 - L2 second coil
 - L3 third coil
 - 20 L4 fourth coil
 - 11 first oscillation circuit
 - 12 second oscillation circuit
 - 13, 14 envelope detection circuit
 - 15 switching unit
 - 25 16 coin identification unit
 - 17 storage unit

CLAIMS

1. A coin processing device comprising:
 - a coin passage through which an inserted coin passes;
 - a material detection sensor which includes a first coil and a second coil facing each other with the coin passage interposed therebetween;
 - an outer diameter detection sensor which includes a ring-shaped third coil that surrounds the first coil and a ring-shaped fourth coil that surrounds the second coil, the third coil and the fourth coil facing each other with the coin passage interposed therebetween;
 - a first oscillation circuit which is connected to the material detection sensor and oscillates a first oscillation signal in an individual connection state, and is connected to the material detection sensor and the outer diameter detection sensor that are connected in series and oscillates the first oscillation signal in a series connection state;
 - a second oscillation circuit which is connected to the outer diameter detection sensor and oscillates a second oscillation signal in the individual connection state;
 - a switching unit which switches the individual connection state and the series connection state; and
 - a coin identification unit which detects an outer diameter of the coin using the second oscillation signal in the individual connection state or the first oscillation signal in the series connection state and identifies the coin based on the outer diameter.
2. The coin processing device according to claim 1, wherein the coin identification unit selects any of the second oscillation signal in the individual connection state and the first oscillation signal in the series connection state depending on the first oscillation signal in the individual connection state during passing of the coin through a portion between the first coil and the second coil, and detects the outer diameter of the coin using the

selected first oscillation signal or second oscillation signal.

3. The coin processing device according to claim 2, wherein the coin identification unit selects the second oscillation signal in the individual connection state when a peak is present in a voltage waveform of the first oscillation signal in a determination period set in advance during passing of the coin through a portion between the first coil and the second coil, and selects the first oscillation signal in the series connection state when there is no peak in the voltage waveform of the first oscillation signal in the determination period.

4. The coin processing device according to any one of claims 1 to 3, wherein the coin identification unit detects a material of the coin using the first oscillation signal in the individual connection state and identifies the coin based on the material and the outer diameter.

5. The coin processing device according to claim 4, wherein the coin identification unit detects the material of the coin using the first oscillation signal in the individual connection state and the first oscillation signal in the series connection state.

6. The coin processing device according to any one of claims 1 to 5, further comprising a storage unit which stores a voltage and a frequency of the first oscillation signal and a voltage and a frequency of the second oscillation signal, wherein the switching unit alternately switches the individual connection state and the series connection state, and the coin identification unit identifies the coin using a value stored in the storage unit.

7. The coin processing device according to any one of claims 1 to 6, wherein

the first coil and the third coil are spiral coils each of which is provided on a first substrate in a planar shape, and

the second coil and the fourth coil are spiral coils each of which is provided on a second substrate in a planar shape.