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(54) **WIRELESS TAG COMMUNICATION APPARATUS, METHOD, AND STORAGE MEDIUM**

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(57) **ABSTRACT**

A wireless tag communication apparatus for communicating with one or more wireless tags attached to one or more articles placed in a placement area on a table includes multiple antennas, a driving device configured to move the multiple antennas such that the antennas draw corresponding parts of a predetermined trajectory, and a reading device configured to perform one reading operation to read information from the one or more wireless tags through the multiple antennas while controlling the driving device to move the multiple antennas along the corresponding parts of the predetermined trajectory.

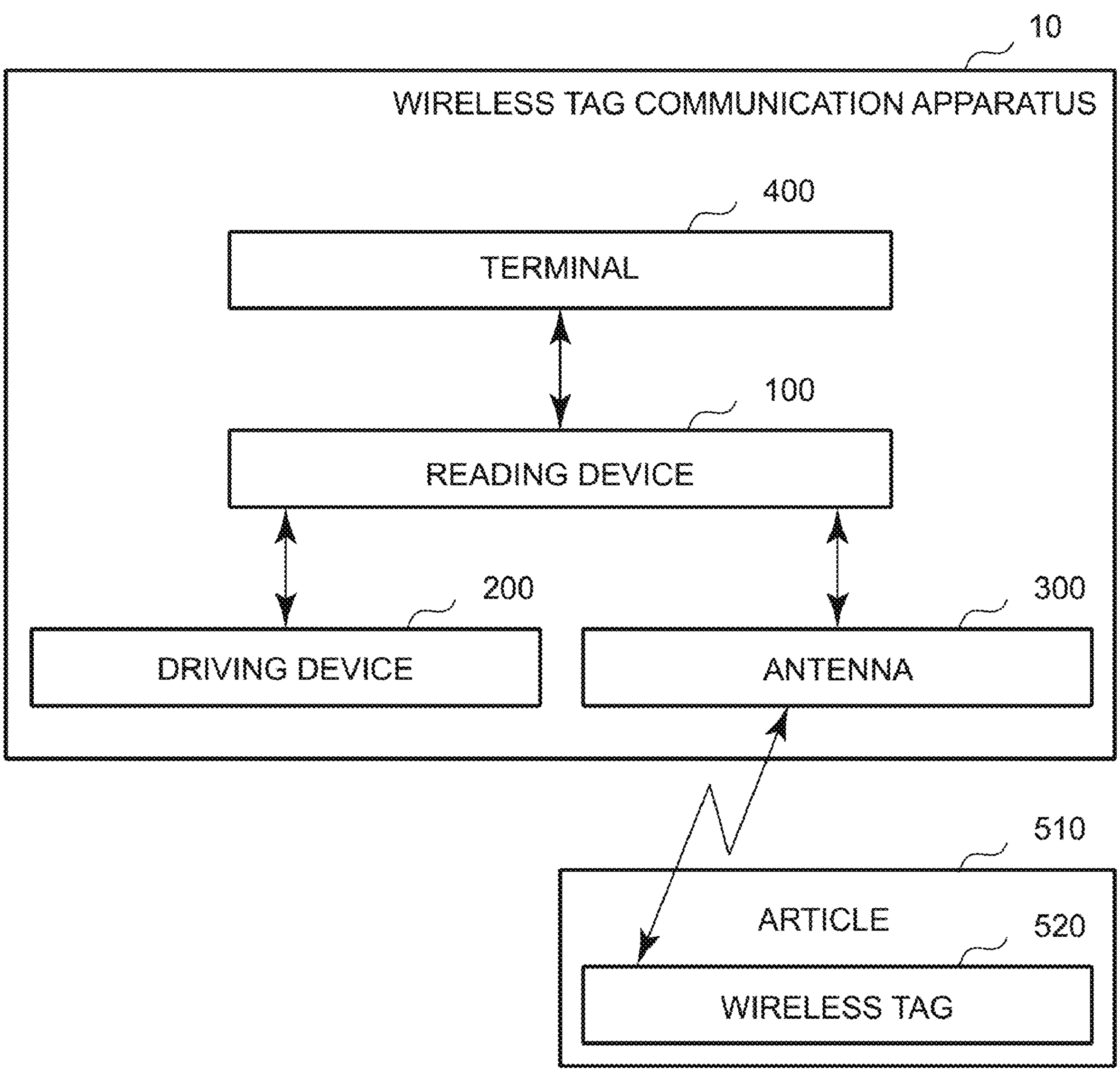


FIG. 1

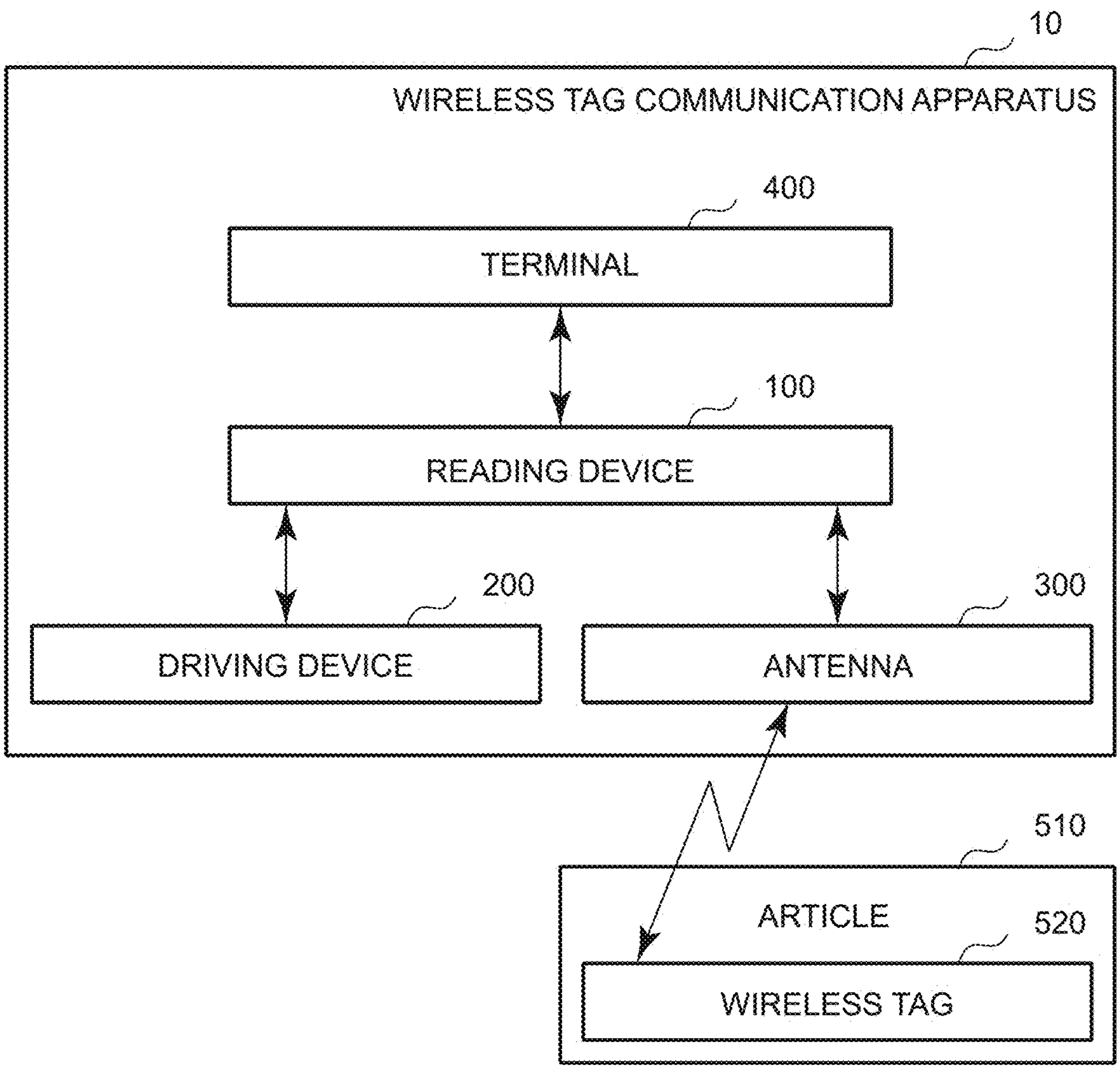

10
WIRELESS TAG COMMUNICATION APPARATUS
400
TERMINAL
100
READING DEVICE
200
DRIVING DEVICE
300
ANTENNA
510
ARTICLE
520
WIRELESS TAG

FIG. 2

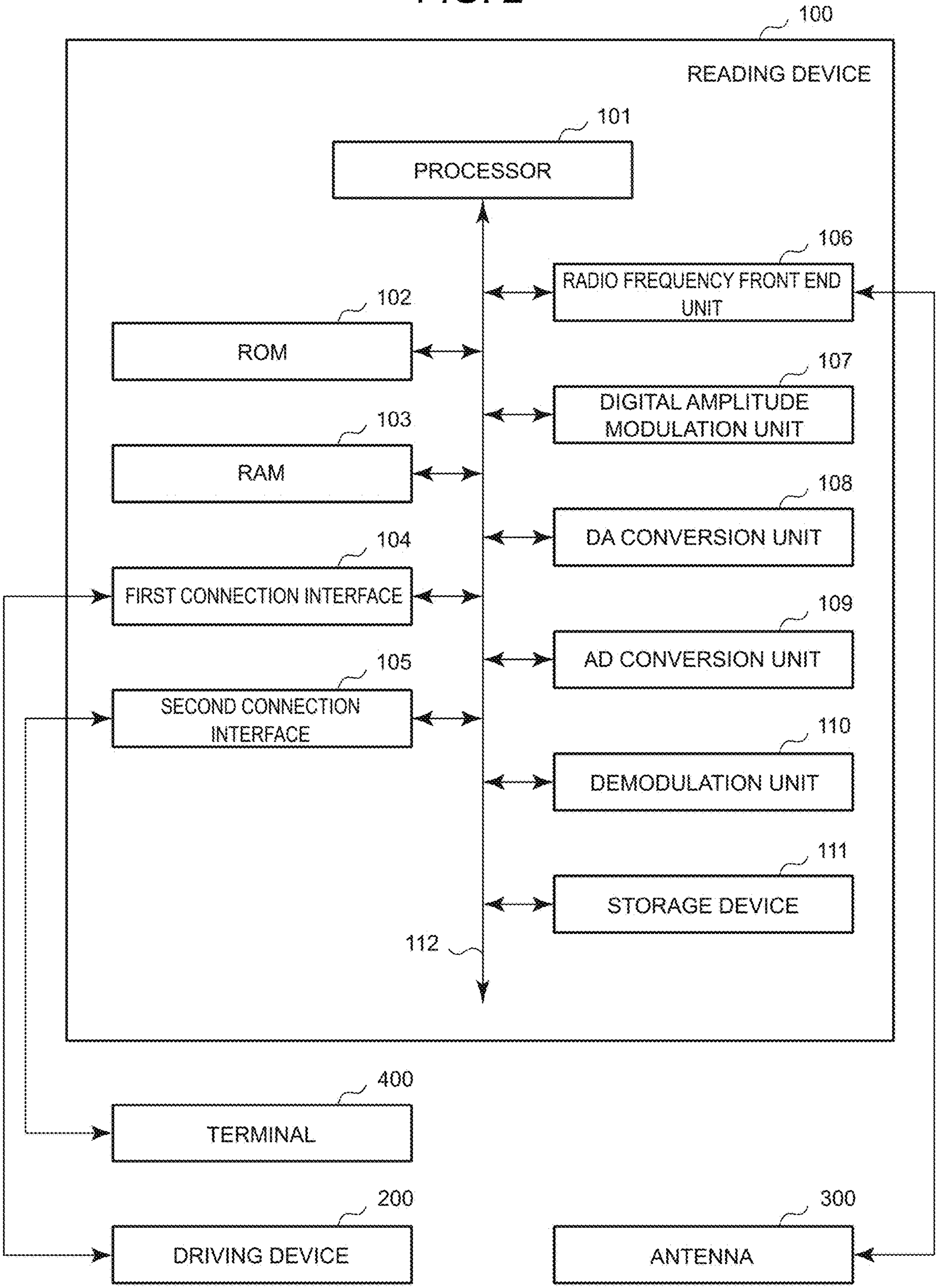

100
READING DEVICE
101
PROCESSOR
106
RADIO FREQUENCY FRONT END UNIT
102
ROM
107
DIGITAL AMPLITUDE MODULATION UNIT
103
RAM
108
DA CONVERSION UNIT
104
FIRST CONNECTION INTERFACE
109
AD CONVERSION UNIT
105
SECOND CONNECTION INTERFACE
110
DEMODULATION UNIT
111
STORAGE DEVICE
112
400
TERMINAL
200
DRIVING DEVICE
300
ANTENNA

FIG. 3

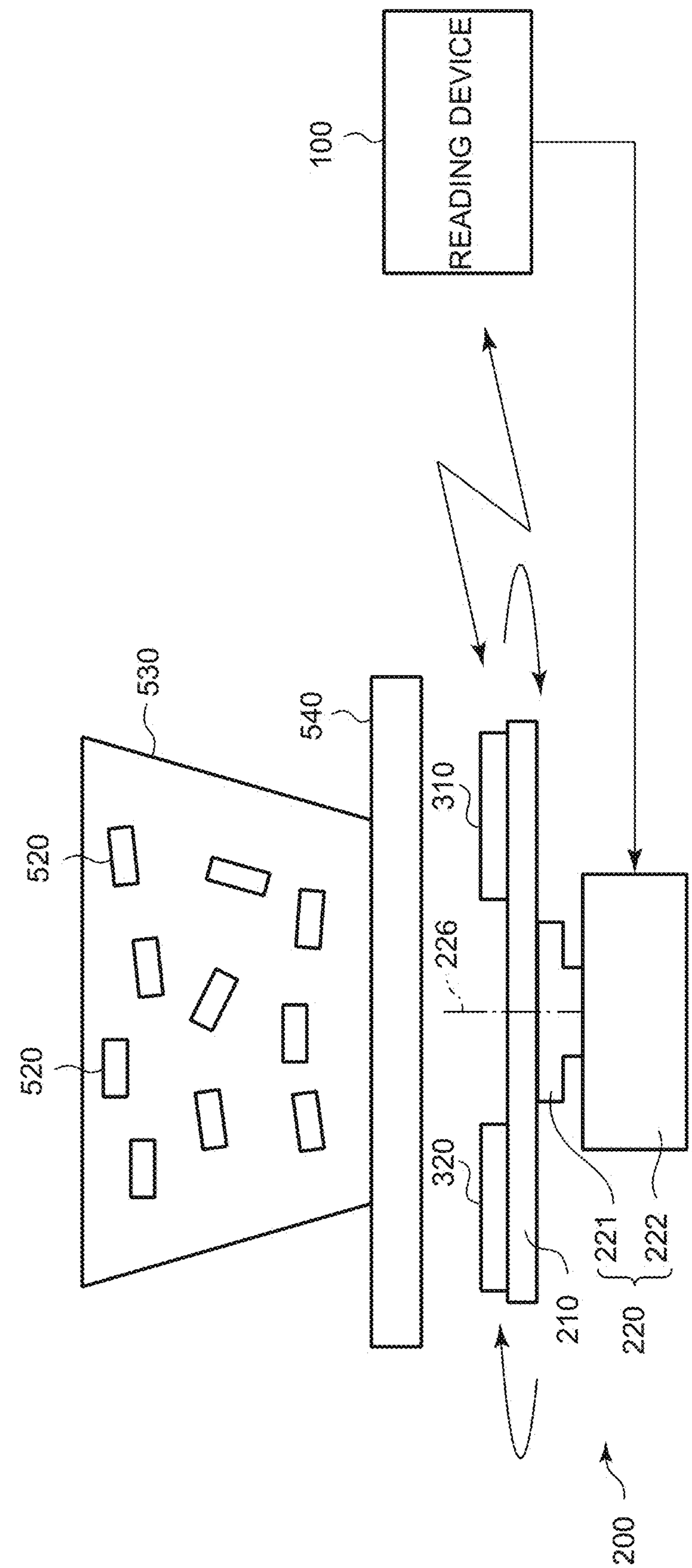

READING DEVICE
100
530
540
520
520
310
320
226
221
222
210
220
200

FIG. 4

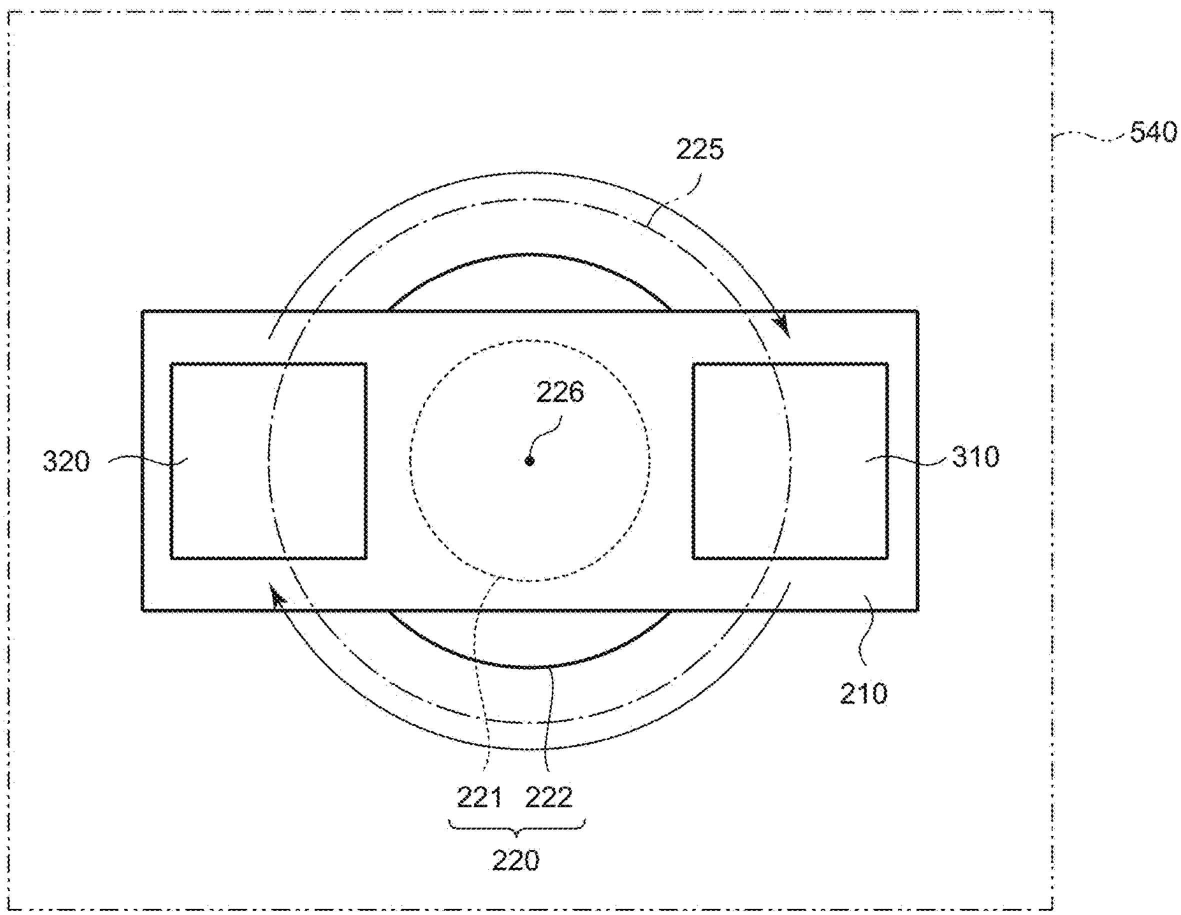


FIG. 5

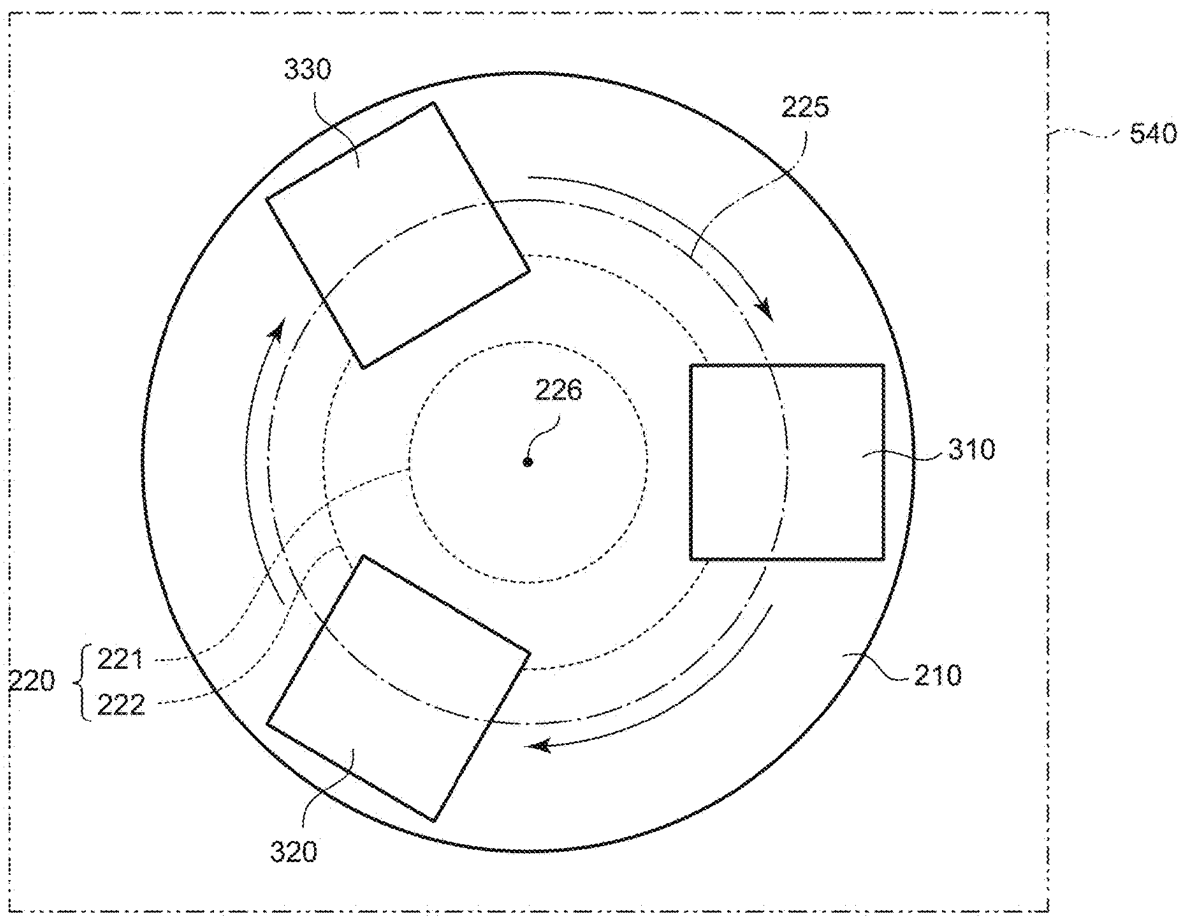


FIG. 6

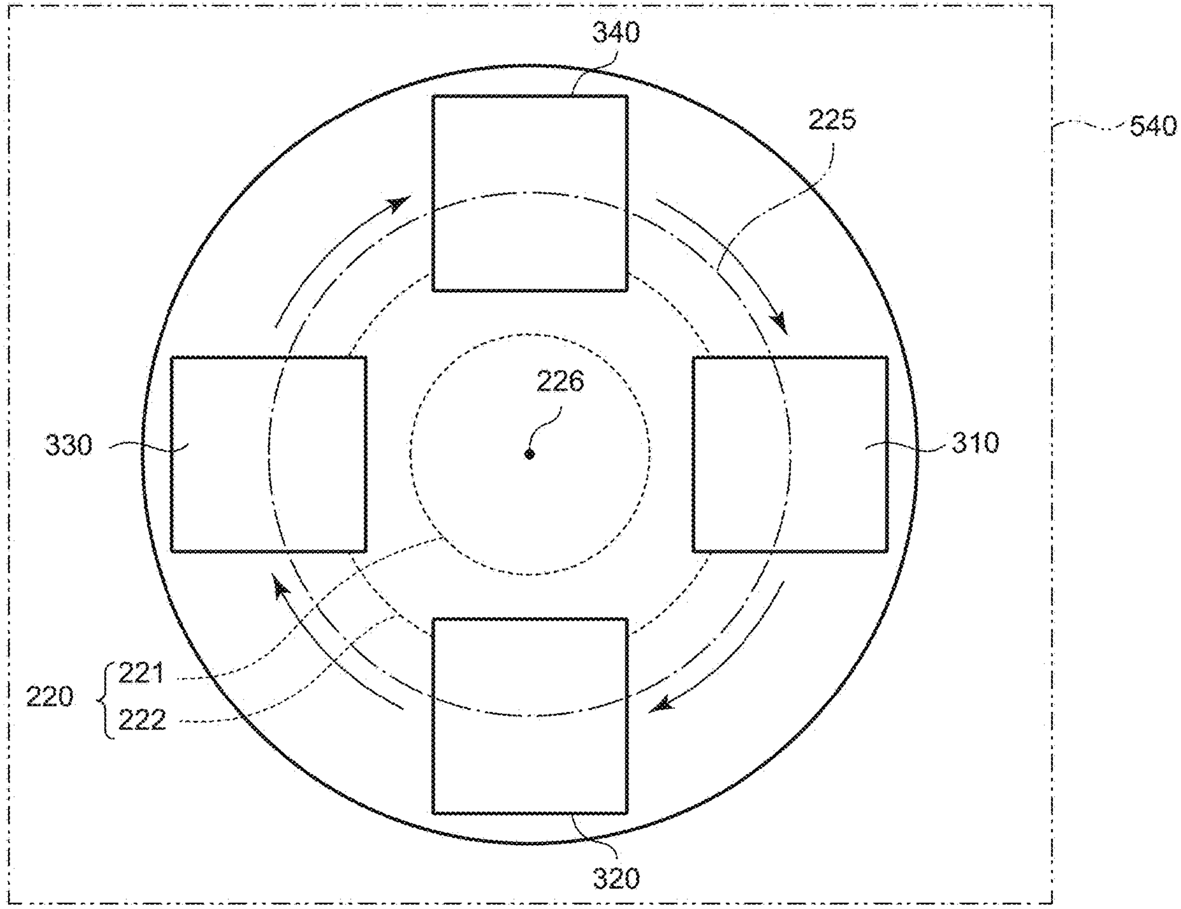
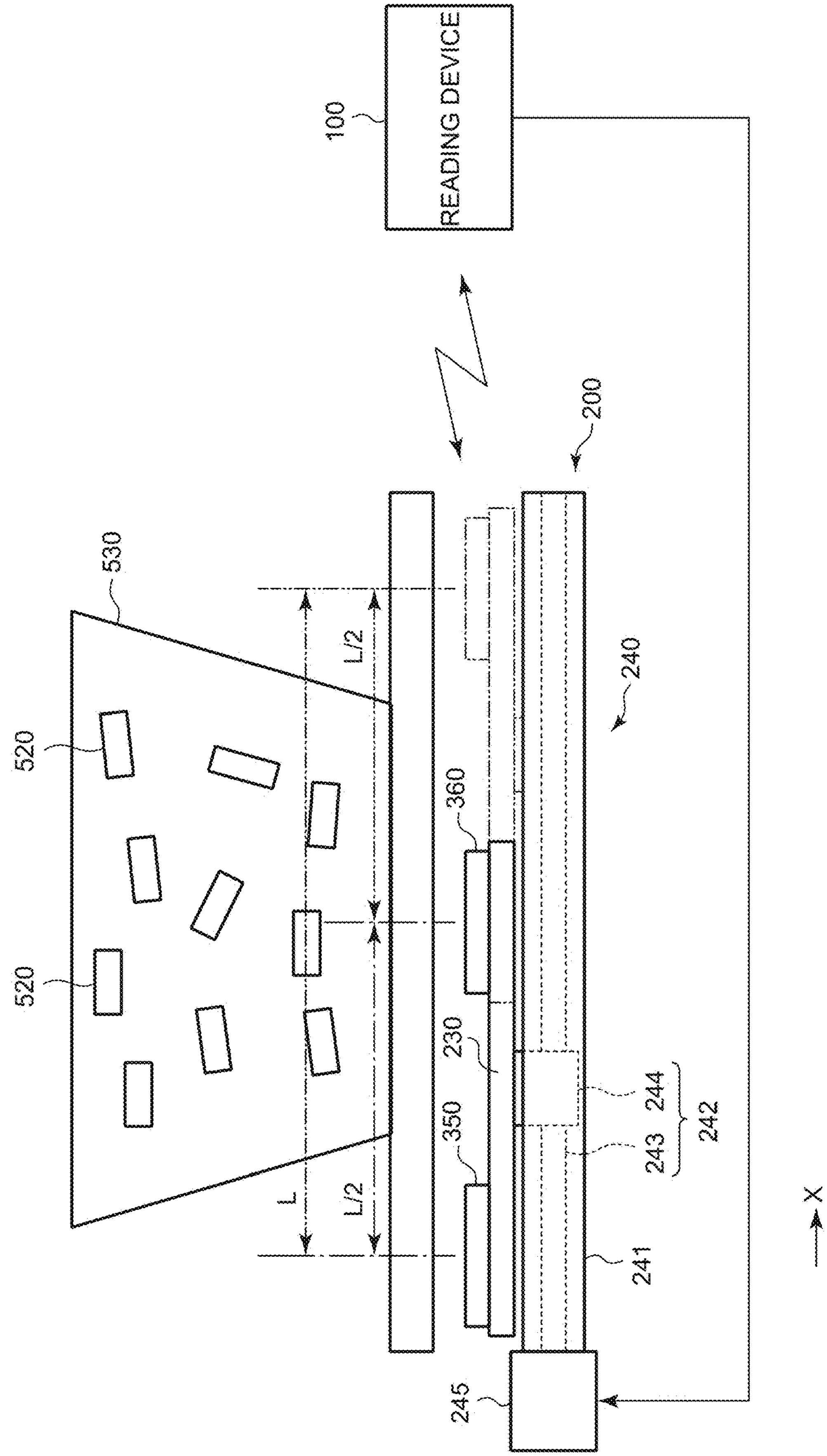
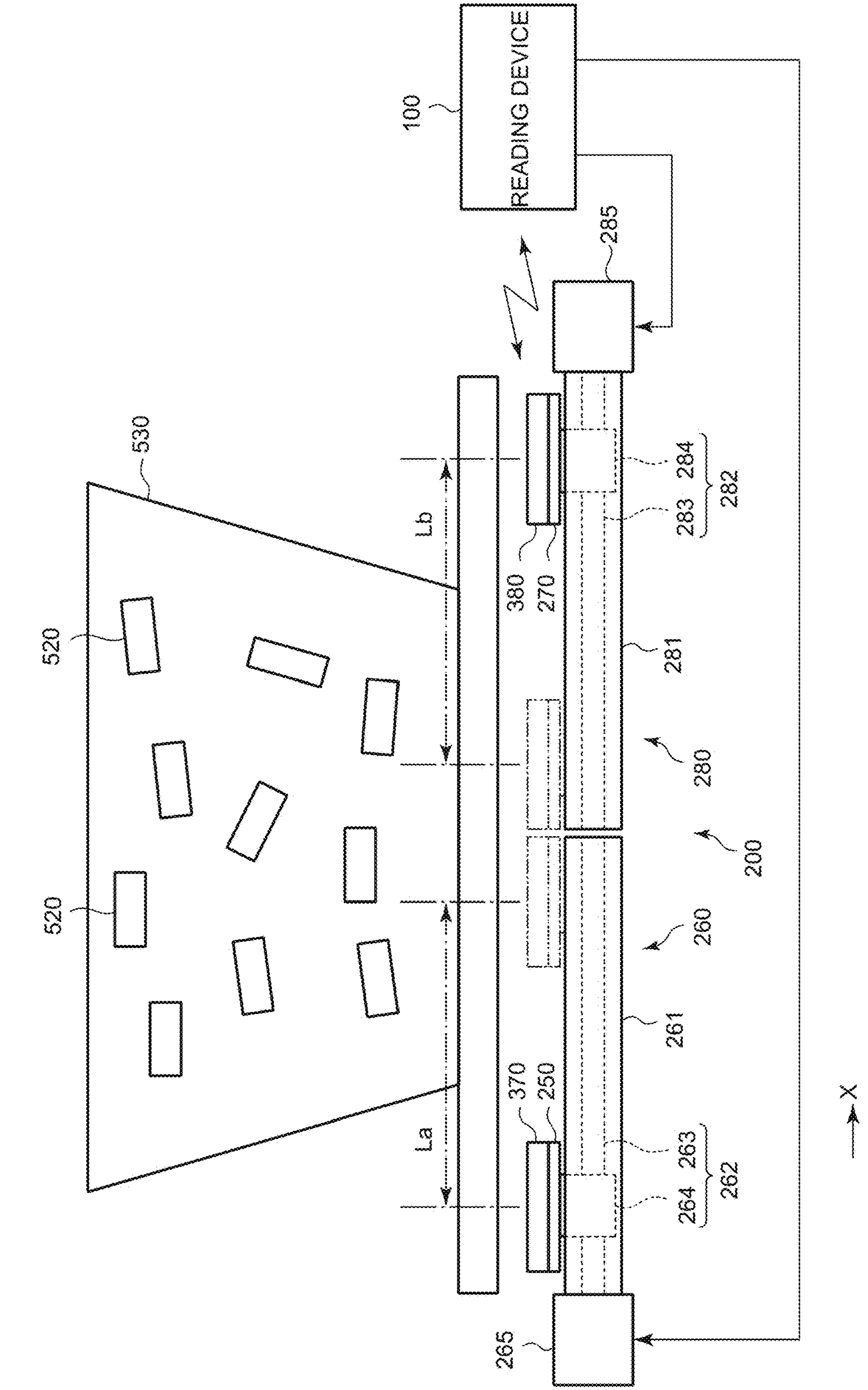


FIG. 7



READING DEVICE
100
200
530
520
520
L
L/2
L/2
360
230
350
240
244
243
242
241
245
X

FIG. 8



READING DEVICE
100
285
530
520
520
Lb
La
380
270
284
283
282
281
280
200
260
261
370
250
263
262
264
265
X

WIRELESS TAG COMMUNICATION APPARATUS, METHOD, AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2024-023734, filed Feb. 20, 2024, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to a wireless tag communication apparatus, a method, and a storage medium.

BACKGROUND

[0003] In recent years, wireless tags have been increasingly used in place of bar codes that have been used in the past for payment processes.

[0004] In a system using wireless tags, each wireless tag is attached to an article, the wireless tag is detected by a wireless tag communication apparatus, and information is read from the wireless tag. When receiving an electromagnetic wave, the wireless tag transmits an electromagnetic wave in response to the received electromagnetic wave. The wireless tag communication apparatus moves an antenna that transmits an electromagnetic wave, receives an electromagnetic wave transmitted from a wireless tag in response to the transmitted electromagnetic wave, thereby detects the wireless tag, and reads information from the wireless tag.

[0005] A wireless tag communication apparatus is preferably capable of quickly reading information from wireless tags.

SUMMARY OF THE INVENTION

[0006] Embodiments of the present disclosure provide a wireless tag communication apparatus, a method, and a storage medium that make it possible to quickly read information from wireless tags.

[0007] An aspect of the present disclosure provides a wireless tag communication apparatus for communicating with one or more wireless tags attached to one or more articles placed in a placement area on a table. The communication apparatus comprises: multiple antennas; a driving device configured to move the multiple antennas such that the antennas draw corresponding parts of a predetermined trajectory; and a reading device configured to perform one reading operation to read information from the one or more wireless tags through the multiple antennas while controlling the driving device to move the multiple antennas along the corresponding parts of the predetermined trajectory.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a block diagram illustrating an example of a configuration of a wireless tag communication apparatus according to an embodiment.

[0009] FIG. **2** is a block diagram illustrating an example of a configuration of a reading device illustrated in FIG. **1**.

[0010] FIG. **3** is a side view schematically illustrating an example of a configuration of a wireless tag communication apparatus according to a first embodiment.

[0011] FIG. **4** is a plan view schematically illustrating an example of a configuration of the wireless tag communication apparatus according to the first embodiment.

[0012] FIG. **5** is a plan view schematically illustrating an example of a configuration of a wireless tag communication apparatus according to a first variation of the first embodiment.

[0013] FIG. **6** is a plan view schematically illustrating an example of a configuration of a wireless tag communication apparatus according to a second variation of the first embodiment.

[0014] FIG. **7** is a side view schematically illustrating an example of a configuration of a wireless tag communication apparatus according to a second embodiment.

[0015] FIG. **8** is a side view schematically illustrating an example of a configuration of a wireless tag communication apparatus according to a third embodiment.

DETAILED DESCRIPTION

[0016] Hereinafter, embodiments will be described in detail with reference to the drawings. The present invention is not limited to the embodiments described below.

Wireless Tag Communication Apparatus

[0017] First, a wireless tag communication apparatus **10** according to an embodiment will be described with reference to FIG. **1**. FIG. **1** is a block diagram illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the embodiment.

[0018] The wireless tag communication apparatus **10** determines whether a wireless tag **520** attached to an article **510**, such as a commodity, is within a predetermined range, reads information from the wireless tag **520** that is within the predetermined range, and processes the read information.

[0019] FIG. **1** shows one article **510** and one wireless tag **520** for convenience. However, there may be any number of articles **510** and any number of wireless tags **520**. One wireless tag **520** is attached to each article **510**.

[0020] The wireless tag communication apparatus **10** includes a reading device **100**, a driving device **200**, an antenna **300**, and a terminal **400**.

[0021] The reading device **100** controls the driving device **200** and the antenna **300** to read information from the wireless tag **520**. An example of a configuration of the reading device **100** will be described later.

[0022] The driving device **200** moves the antenna **300**. An example of a configuration of the driving device **200** will be described later.

[0023] The antenna **300** communicates with the wireless tag **520**. The antenna **300** emits an electromagnetic wave. Also, the antenna **300** receives an electromagnetic wave that is transmitted from the wireless tag **520** in response to the emitted electromagnetic wave. The antenna **300** converts the electromagnetic wave received from the wireless tag **520** into a radio frequency signal, and outputs the radio frequency signal to the reading device **100**.

[0024] The terminal **400** processes information read from the wireless tag **520** by the reading device **100**. The terminal **400** is, for example, a personal computer (PC). However, the terminal **400** is not limited to a PC but may be any device that can process information.

[0025] The wireless tag **520** is typically a radio frequency identification (RFID) tag. The wireless tag **520** may be another type of wireless tag. The wireless tag **520** is a passive wireless tag that operates using a radio wave transmitted from the antenna **300** as an energy source. The wireless tag **520** performs backscatter modulation on an unmodulated signal, thereby transmitting a signal including information stored in the wireless tag **520**. For example, the information stored in the wireless tag **520** includes unique identification information. For example, the information stored in the wireless tag **520** includes information about the article **510** to which the wireless tag **520** is attached.

Reading Device

[0026] Next, the reading device **100** will be described with reference to FIG. **2**. FIG. **2** is a block diagram illustrating an example of a configuration of the reading device **100**.

[0027] The reading device **100** includes a processor **101**, a read-only memory (ROM) **102**, a random-access memory (RAM) **103**, a first connection interface **104**, a second connection interface **105**, a radio frequency front end unit **106**, a digital amplitude modulation unit **107**, a digital-to-analog (DA) conversion unit **108**, an analog-to-digital (AD) conversion unit **109**, a demodulation unit **110**, and a storage device **111**. These components of the reading device **100** can communicate with each other via a bus **112**.

[0028] The processor **101** corresponds to a central part of a computer that performs, for example, calculation processes and control processes necessary for the operations of the reading device **100**. The processor **101** loads various programs stored in the ROM **102**, the storage device **111**, or the like into the RAM **103**. The processor **101** implements various functions necessary for the operations of the reading device **100** by executing the programs loaded into the RAM **103**.

[0029] The processor **101** may be a central processing unit (CPU), a micro processing unit (MPU), a system-on-chip (SoC), a digital signal processor (DSP), a graphics processing unit (GPU), an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field-programmable gate array (FPGA), or a combination of these devices.

[0030] The ROM **102** corresponds to a main storage device of a computer having the processor **101** as a central part. The ROM **102** is a non-volatile read-only memory. The ROM **102** stores programs for causing the processor **101** to implement various functions. The ROM **102** stores, for example, data and various setting values used by the processor **101** to perform various processes.

[0031] The RAM **103** corresponds to a main storage device of a computer having the processor **101** as a central part. Data can be read from and written to the RAM **103**. The RAM **103** is a work area that temporarily stores data used by the processor **101** to perform various processes.

[0032] The first connection interface **104** is used by the reading device **100** to communicate with the driving device **200**.

[0033] The second connection interface **105** is used by the reading device **100** to communicate with the terminal **400**.

[0034] The radio frequency front end unit **106** outputs a radio frequency signal to the antenna **300**. In addition, the radio frequency front end unit **106** receives a radio frequency signal from the antenna **300**.

[0035] The digital amplitude modulation unit **107** adds information to a carrier wave to be transmitted to the wireless tag **520**.

[0036] The DA conversion unit **108** converts a digital signal modulated by the digital amplitude modulation unit **107** into an analog signal. The DA conversion unit **108** outputs a radio frequency signal to the antenna **300** via the radio frequency front end unit **106**.

[0037] The AD conversion unit **109** converts a radio frequency signal input from the antenna **300** via the radio frequency front end unit **106** into a digital signal.

[0038] The demodulation unit **110** extracts various kinds of information from a radio wave received from the wireless tag **520**. For example, the demodulation unit **110** extracts a unique identification code stored in the wireless tag **520** from a digital signal obtained by the AD conversion unit **109**. Also, when a radio wave is received from the wireless tag **520** via the antenna **300**, the demodulation unit **110** extracts, according to known technology, tag data of the wireless tag **520** in time series from the digital signal obtained by the AD conversion unit **109**. The tag data is time-series data based on a radio wave received from the wireless tag **520** by the antenna **300**. The tag data includes phase data. The phase data indicates the phase of the radio wave received from the wireless tag **520**. The tag data includes a received signal strength indicator (RSSI). The RSSI indicates the reception intensity of the radio wave received from the wireless tag **520**. The tag data may include both of the phase data and the RSSI.

[0039] The storage device **111** is a non-volatile memory that stores data, programs, and the like. The storage device **111** may be, but is not limited to, a hard disk drive (HDD) or a solid state drive (SSD). The storage device **111** stores programs for causing the processor **101** to implement various functions. The storage device **111** also stores data used by the processor **101** to perform various processes.

[0040] The processor **101** implements various functions of the reading device **100** by executing programs stored in the ROM **102** or the storage device **111**. Here, each of the ROM **102** and the storage device **111** is an example of a non-transitory computer-readable storage medium that stores a program for causing the processor **101** to perform a process. Functions of the reading device **100** include, for example, controlling the movement of the antenna **300** by the driving device **200**, controlling communication via the antenna **300**, determining the position of the wireless tag **520**, reading information from the wireless tag **520**, and outputting information to the terminal **400**.

First Embodiment

[0041] Next, a wireless tag communication apparatus **10** according to a first embodiment will be described with reference to FIG. **3** and FIG. **4**. FIG. **3** is a side view schematically illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the first embodiment. FIG. **4** is a plan view schematically illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the first embodiment.

[0042] The wireless tag communication apparatus **10** according to the first embodiment includes two antennas **310** and **320**. The two antennas **310** and **320** are movably held by the driving device **200**. The driving device **200** is disposed under a table **540** on which articles **510** (for example, commodities), to which wireless tags **520** are attached, are placed. That is, the two antennas **310** and **320** are movably disposed under the table **540**.

[0043] In FIG. **3**, the articles **510** are not illustrated, and only the wireless tags **520** are illustrated. Also, the articles **510** and the wireless tags **520** are not shown in FIG. **4**.

[0044] The table **540** is a plate-like member that is held horizontally. A placement area for the articles **510**, such as commodities, is set on the table **540**. The articles **510** are recommended to be placed in the placement area. For example, the articles **510** are placed in a basket **530** (e.g., a shopping basket), and the basket **530** is placed in the placement area on the table **540**.

[0045] The wireless tag communication apparatus **10** reads information from the wireless tags **520** attached to the articles **510**. Specifically, the wireless tag communication apparatus **10** reads information from target wireless tags **520** located within the placement area. However, the wireless tag communication apparatus **10** may also read information from non-target wireless tags **520** located outside of the placement area on the table **540**. In particular, when non-target wireless tags **520** are located near the placement area, it is highly likely that the wireless tag communication apparatus **10** erroneously reads information from the non-target wireless tags **520**.

[0046] In order to avoid such erroneous reading, the wireless tag communication apparatus **10** determines whether the wireless tags **520** are within the placement area, sets only the wireless tags **520** within the placement area as target wireless tags **520**, and reads information only from the target wireless tags **520**.

[0047] For example, the wireless tag communication apparatus **10** measures the phase of each wireless tag **520** by moving the antennas **310** and **320** and determines whether the wireless tag **520** is within the placement area based on a phase difference indicating the amount of change in the phase. In another example, the wireless tag communication apparatus **10** moves the antennas **310** and **320** to obtain the tag data of the wireless tag **520** at multiple positions and determines whether the wireless tag **520** is within the placement area by using a trained model that is generated by machine learning using the tag data as input.

[0048] For this purpose, the driving device **200** moves the antennas **310** and **320**. The driving device **200** includes a stage **210** that holds the antennas **310** and **320** and a moving mechanism **220** that moves the stage **210**.

[0049] The stage **210** holds the antennas **310** and **320** apart from each other such that the emitting surfaces of the antennas **310** and **320** face the table **540**. For example, the stage **210** is a rectangular plate-like member.

[0050] The moving mechanism **220** is a rotation mechanism that rotates the stage **210** around a rotation center axis **226**. The moving mechanism **220** includes a holder **221** and a motor **222**.

[0051] The holder **221** holds the stage **210** horizontally. That is, the holder **221** holds the stage **210** in parallel with the table **540**. The holder **221** is fixed to the rotation shaft of the motor **222**.

[0052] The motor **222** rotates the holder **221** around the rotation center axis **226**. The rotation center axis **226** is perpendicular to the horizontal plane. That is, the rotation center axis **226** is parallel to the vertical axis. The rotation center axis **226** passes through the midpoint between the two antennas **310** and **320**. That is, the rotation center axis **226** passes through the bisection point of a line segment connecting the centers of the two antennas **310** and **320**. In other words, the two antennas **310** and **320** are arranged point-symmetrically with respect to the rotation center axis **226** of the motor **222**. That is, the two antennas **310** and **320** are arranged at equal angles with respect to the rotation center axis **226** along the circumference of a circle **225** centered on the rotation center axis **226** of the motor **222**. In still other words, the two antennas **310** and **320** are arranged at 180-degree intervals around the rotation center axis **226**.

[0053] The moving mechanism **220** rotates the stage **210** around the rotation center axis **226**. As a result, the two antennas **310** and **320** move along the circumference of the same circle **225**.

[0054] The driving device **200** operates as described below under the control of the reading device **100**. In other words, the reading device **100** controls the driving device **200** such that the driving device **200** operates as described below.

[0055] The driving device **200** rotates the stage **210** by 180 degrees during each measurement (or one reading operation of reading information from the wireless tags **520** within the placement area). As a result, the antenna **310** moves along the circumference of the circle **225** to a position where the antenna **320** was located before the measurement. The antenna **320** moves along the circumference of the circle **225** to a position where the antenna **310** was located before the measurement. That is, the driving device **200** moves the two antennas **310** and **320** such that the two antennas **310** and **320** draw the corresponding parts of the entire trajectory that needs to be drawn by the two antennas **310** and **320** to perform one reading operation of reading information from the wireless tags **520** within the placement area.

[0056] Therefore, it is possible to draw a trajectory corresponding to one round of the circle **225**, which needs to be drawn by the antennas **310** and **320** in one measurement, by moving each of the antennas **310** and **320** by a half circumference of the circle **225**. That is, with the wireless tag communication apparatus **10** according to the first embodiment, the time required for measurement is half the time required by a wireless tag communication apparatus that performs measurement with one antenna. Accordingly, the wireless tag communication apparatus **10** according to the first embodiment can perform measurement in half the time required by a wireless tag communication apparatus that performs measurement using one antenna. Thus, the present embodiment provides the wireless tag communication apparatus **10** that can quickly read information from the wireless tags **520**.

First Variation

[0057] Next, a wireless tag communication apparatus **10** according to a first variation of the first embodiment will be described with reference to FIG. **5**. FIG. **5** is a plan view schematically illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the first variation of the first embodiment. The view of FIG. **5** corresponds to the view of FIG. **4**. In FIG. **5**, as in FIG. **4**, the articles **510** and the wireless tags **520** are not shown.

[0058] The wireless tag communication apparatus **10** according to the present variation includes three antennas **310**, **320**, and **330**. The three antennas **310**, **320**, **330** are movably held by a driving device **200** located under the table **540**.

[0059] The driving device **200** includes a stage **210** that holds the antennas **310**, **320**, and **330**, and a moving mechanism **220** that moves the stage **210**.

[0060] The stage **210** holds the antennas **310**, **320**, and **330** apart from each other such that the emission surfaces of the antennas **310**, **320**, and **330** face the table **540**. For example, the stage **210** is a circular plate-like member.

[0061] The moving mechanism **220** is a rotation mechanism that rotates the stage **210** around the rotation center axis **226**. The configuration of the moving mechanism **220** is described above.

[0062] The three antennas **310**, **320**, and **330** are arranged along the circumference of the circle **225** centered on the rotation center axis **226** of the motor **222** at equal angles with respect to the rotation center axis **226**. That is, the three antennas **310**, **320**, and **330** are arranged at 120-degree intervals around the rotation center axis **226**.

[0063] The moving mechanism **220** rotates the stage **210** around the rotation center axis **226**. As a result, the three antennas **310**, **320**, and **330** move along the circumference of the same circle **225**.

[0064] The driving device **200** operates as described below under the control of the reading device **100**. In other words, the reading device **100** controls the driving device **200** such that the driving device **200** operates as described below.

[0065] The driving device **200** rotates the stage **210** by 120 degrees during each measurement. As a result, the antenna **310** moves along the circumference of the circle **225** to a position where the antenna **320** was located before the measurement. The antenna **320** moves along the circumference of the circle **225** to a position where the antenna **330** was located before the measurement. The antenna **330** moves along the circumference of the circle **225** to a position where the antenna **310** was located before the measurement. That is, the driving device **200** moves the three antennas **310**, **320**, and **330** such that the three antennas **310**, **320**, and **330** draw the corresponding parts of the entire trajectory that needs to be drawn by the three antennas **310**, **320**, and **330** to perform one reading operation of reading information from the wireless tags **520** within the placement area.

[0066] Therefore, it is possible to draw a trajectory corresponding to one round of the circle **225**, which needs to be drawn by the antennas **310**, **320**, and **330** in one measurement, by moving each of the three antennas **310**, **320**, and **330** by one third of the circumference of the circle **225**. That is, with the wireless tag communication apparatus **10** according to the present variation, the time required for measurement is only one third of the time required by a wireless tag communication apparatus that performs measurement with one antenna. Accordingly, the wireless tag communication apparatus **10** according to the present variation can perform measurement in one third of the time required by a wireless tag communication apparatus that performs measurement using one antenna. Thus, the present variation provides the wireless tag communication apparatus **10** that can quickly read information from the wireless tags **520**.

[0067] In the present variation, the three antennas **310**, **320**, and **330** do not necessarily have to be arranged along the circumference of the circle **225** at equal angles with respect to the rotation center axis **226**. The angle formed by a pair of the three antennas **310**, **320**, and **330** with respect to the rotation center axis **226** may be different from the angle formed by another pair of the three antennas **310**, **320**, and **330**.

[0068] For example, the three antennas **310**, **320**, and **330** may be arranged along the circumference of the circle **225** such that the antennas **310** and **320** form an angle of 90 degrees, the antennas **320** and **330** form an angle of 120 degrees, and the antennas **330** and **310** form an angle of 150 degrees with respect to the rotation center axis **226**. In this case, the driving device **200** rotates the stage **210** around the rotation center axis **226** by 150 degrees such that the three antennas **310**, **320**, and **330** draw the corresponding parts of the entire trajectory that needs to be drawn by the three antennas **310**, **320**, and **330** to perform one reading operation of reading information from the wireless tags **520** within the placement area. In other words, the antennas **310**, **320**, and **330** may be arranged at different angles around the rotation center axis **226**, and the driving device **200** may move each of the antennas **310**, **320**, and **330** by the largest one of the different angles around the rotation center axis **226**.

Second Variation

[0069] Next, a wireless tag communication apparatus **10** according to a second variation of the first embodiment will be described with reference to FIG. **6**. FIG. **6** is a plan view schematically illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the second variation of the first embodiment. The view of FIG. **6** corresponds the view of FIG. **4**. In FIG. **6**, as in FIG. **4**, the articles **510** and the wireless tags **520** are not shown.

[0070] The wireless tag communication apparatus **10** according to the present variation includes four antennas **310**, **320**, **330**, and **340**. The four antennas **310**, **320**, **330**, **340** are movably held by a driving device **200** located under the table **540**.

[0071] The driving device **200** includes a stage **210** that holds the antennas **310**, **320**, **330**, and **340**, and a moving mechanism **220** that moves the stage **210**.

[0072] The stage **210** holds the antennas **310**, **320**, **330**, and **340** such that the emission surfaces of the antennas **310**, **320**, **330**, and **340** face the table **540**. For example, the stage **210** is a circular plate-like member.

[0073] The moving mechanism **220** is a rotation mechanism that rotates the stage **210** around the rotation center axis **226**. The configuration of the moving mechanism **220** is described above.

[0074] The four antennas **310**, **320**, **330**, and **340** are arranged along the circumference of the circle **225** centered on the rotation center axis **226** of the motor **222** at equal angles with respect to the rotation center axis **226**. That is, the four antennas **310**, **320**, **330**, and **340** are arranged at 90-degree intervals around the rotation center axis **226**.

[0075] The moving mechanism **220** rotates the stage **210** around the rotation center axis **226**. As a result, the four antennas **310**, **320**, **330**, and **340** move along the circumference of the same circle **225**.

[0076] The driving device **200** operates as described below under the control of the reading device **100**. In other words, the reading device **100** controls the driving device **200** such that the driving device **200** operates as described below.

[0077] The driving device **200** rotates the stage **210** by 90 degrees during each measurement. As a result, the antenna **310** moves along the circumference of the circle **225** to a position where the antenna **320** was located before the measurement. The antenna **320** moves along the circumference of the circle **225** to a position where the antenna **330**

was located before the measurement. The antenna **330** moves along the circumference of the circle **225** to a position where the antenna **340** was located before the measurement. The antenna **340** moves along the circumference of the circle **225** to a position where the antenna **310** was located before the measurement. That is, the driving device **200** moves the four antennas **310**, **320**, **330**, and **340** such that the four antennas **310**, **320**, **330**, and **340** draw the corresponding parts of the entire trajectory that needs to be drawn by the four antennas **310**, **320**, **330**, and **340** to perform one reading operation of reading information from the wireless tags **520** within the placement area.

[0078] Therefore, it is possible to draw a trajectory corresponding to one round of the circle **225**, which needs to be drawn by the antennas **310**, **320**, **330**, and **340** in one measurement, by moving the four antennas **310**, **320**, **330**, and **340** by one fourth of the circumference of the circle **225**. That is, with the wireless tag communication apparatus **10** according to the present variation, the time required for measurement is one-fourth of the time required by a wireless tag communication apparatus that performs measurement with one antenna. Accordingly, the wireless tag communication apparatus **10** according to the present variation can perform measurement in one-fourth of the time required by a wireless tag communication apparatus that performs measurement with one antenna. Thus, the present variation provides the wireless tag communication apparatus **10** that can quickly read information from the wireless tags **520**.

[0079] In the present variation, the four antennas **310**, **320**, **330**, and **340** do not necessarily have to be arranged along the circumference of the circle **225** at equal angles with respect to the rotation center axis **226**. The angle formed by an adjacent pair of the four antennas **310**, **320**, **330**, and **340** with respect to the rotation center axis **226** may be different from the angle formed by another adjacent pair of the four antennas **310**, **320**, **330**, and **340**. This configuration is similar to that of the second variation, and the detailed description of this configuration is omitted.

Second Embodiment

[0080] Next, a wireless tag communication apparatus **10** according to a second embodiment will be described with reference to FIG. **7**. FIG. **7** is a side view schematically illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the second embodiment. The view of FIG. **7** corresponds to the view of FIG. **3**. In FIG. **7**, as in FIG. **3**, the articles **510** are not shown. Below, differences from the first embodiment are mainly described.

[0081] The wireless tag communication apparatus **10** according to the second embodiment includes two antennas **350** and **360**. The two antennas **350** and **360** are movably held by a driving device **200** located below the table **540**.

[0082] The driving device **200** includes a stage **230** that holds the antennas **350** and **360**, and a moving mechanism **240** that moves the stage **230**.

[0083] The stage **230** holds the antennas **350** and **360** such that the emission surfaces of the antennas **350** and **360** face the table **540**. For example, the stage **230** is a rectangular plate-like member. The stage **230** holds the antennas **350** and **360** such that the antennas **350** and **360** are spaced apart from each other by a distance L/2 in the X-axis direction in FIG. **7**. Here, L/2 is the distance between the centers of the two antennas **350** and **360**, and is equal to the stroke of the moving mechanism **240**, that is, the distance by which the antennas **350** and **360** are moved by the moving mechanism **240**.

[0084] The moving mechanism **240** is a linear motion mechanism that linearly moves the stage **230**. The moving mechanism **240** includes a guide rail **241** and a motor **245**. The guide rail **241** holds the stage **230** such that the guide rail **241** is linearly movable. The moving direction of the stage **230** corresponds to the direction in which the antennas **350** and **360** are separated from each other, that is, the X-axis direction. For example, the guide rail **241** includes a ball screw **242**. The ball screw **242** includes a rotatable screw shaft **243** and a nut **244** that is movable along the screw shaft **243** as the screw shaft **243** rotates. The nut **244** holds the stage **230**. The motor **245** rotates the screw shaft **243**. The rotational movement of the screw shaft **243** is converted into a linear movement of the nut **244**.

[0085] Therefore, when the motor **245** is rotated, the stage **230** is linearly moved in the horizontal direction (X-axis direction). For example, when the motor **245** is rotated in the forward direction, the stage **230** is linearly moved in the +X direction; and when the motor **245** is rotated in the reverse direction, the stage **230** is linearly moved in the −X direction. That is, the stage **230** is reciprocated in the X-axis direction by changing the rotation direction of the shaft of the motor **245**.

[0086] The driving device **200** operates as described below under the control of the reading device **100**. In other words, the reading device **100** controls the driving device **200** such that the driving device **200** operates as described below.

[0087] The driving device **200** moves the stage **230** along the X-axis by the distance L/2 during each measurement. In the example of FIG. **7**, the driving device **200** moves the stage **230** in the +X-direction by the distance L/2. In the next measurement, the driving device **200** moves the stage **230** in the −X direction by the distance L/2.

[0088] In the example of FIG. **7**, the antenna **350** moves to a position where the antenna **360** was located before the measurement. That is, the driving device **200** moves the two antennas **350** and **360** such that the two antennas **350** and **360** draw the corresponding parts of the entire trajectory that needs to be drawn by the two antennas **350** and **360** to perform one reading operation of reading information from the wireless tags **520** within the placement area.

[0089] Therefore, it is possible to draw a trajectory with a distance L, which needs to be drawn by the antennas **350** and **360** in one measurement, by moving the two antennas **350** and **360** by the distance L/2. That is, with the wireless tag communication apparatus **10** according to the second embodiment, the time required for measurement is half the time required by a wireless tag communication apparatus that performs measurement using one antenna. Accordingly, the wireless tag communication apparatus **10** according to the second embodiment can perform measurement in half the time required by a wireless tag communication apparatus that performs measurement using one antenna. Thus, the present embodiment provides the wireless tag communication apparatus **10** that can quickly read information from the wireless tags **520**.

[0090] In the present embodiment, the driving device **200** includes two antennas **350** and **360**. However, the driving device **200** may include three or more antennas. In such a case, the stroke can be shortened and the time required for one measurement can be shortened as the number of antennas increases.

Third Embodiment

[0091] Next, a wireless tag communication apparatus **10** according to a third embodiment will be described with reference to FIG. **8**. FIG. **8** is a side view schematically illustrating an example of a configuration of the wireless tag communication apparatus **10** according to the third embodiment. The view of FIG. **8** corresponds to the view of FIG. **7**. In FIG. **8**, as in FIG. **7**, the articles **510** are not shown. Below, differences from the second embodiment are mainly described.

[0092] The wireless tag communication apparatus **10** according to the third embodiment includes two antennas **370** and **380**. The two antennas **370** and **380** are movably held by a driving device **200** located below the table **540**.

[0093] The driving device **200** includes a stage **250** that holds the antenna **370**, a moving mechanism **260** that moves the stage **250**, a stage **270** that holds the antenna **380**, and a moving mechanism **280** that moves the stage **270**. The antennas **370** and **380** are examples of first and second antennas, the stages **250** and **270** are examples of first and second stages, and the moving mechanisms **260** and **280** are examples of first and second moving mechanisms.

[0094] The stage **250** holds the antenna **370** such that the emission surface of the antenna **370** faces the table **540**. The stage **270** holds the antenna **380** such that the emission surface of the antenna **380** faces the table **540**. For example, the stages **250** and **270** are rectangular plate-like members.

[0095] The moving mechanisms **260** and **280** are linear motion mechanisms that linearly move the stages **250** and **270**, respectively. The configuration of each of the moving mechanisms **260** and **280** is the same as that of the moving mechanism **240** in the second embodiment.

[0096] That is, the moving mechanism **260** includes a guide rail **261** and a motor **265**. The guide rail **261** holds the stage **250** such that the stage **250** is linearly movable. The guide rail **261** includes a ball screw **262**. The ball screw **262** includes a screw shaft **263** and a nut **264**. The nut **264** holds the stage **250**. The motor **265** rotates the screw shaft **263**. The rotational movement of the screw shaft **263** is converted into a linear movement of the nut **264**.

[0097] Similarly, the moving mechanism **280** includes a guide rail **281** and a motor **285**. The guide rail **281** holds the stage **270** such that the stage **270** is linearly movable. The guide rail **281** includes a ball screw **282**. The ball screw **282** includes a screw shaft **283** and a nut **284**. The nut **284** holds the stage **270**. The motor **285** rotates the screw shaft **283**. The rotational movement of the screw shaft **283** is converted into a linear movement of the nut **264**.

[0098] For example, the moving mechanisms **260** and **280** are arranged such that the rotation center axes of the screw shafts **263** and **283** coincide with each other, and the movement directions of the stages **250** and **270** coincide with each other. Also, the moving mechanisms **260** and **280** are disposed such that the motors **265** and **285** are located outside of the table **540**. Furthermore, the moving mechanisms **260** and **280** are arranged such that the ends of the guide rails **261** and **281** are located as close as possible to each other.

[0099] La indicates the stroke of the moving mechanism **260**, i.e., the distance by which the antenna **370** is moved by the moving mechanism **260**. Lb indicates the stroke of the moving mechanism **280**, i.e., the distance by which the antenna **380** is moved by the moving mechanism **280**. For example, La and Lb are equal to each other. La and Lb may be different from each other.

[0100] The moving mechanisms **260** and **280** move the antennas **370** and **380** in synchronization with each other. For example, the moving mechanisms **260** and **280** move the antennas **370** and **380** from outside to inside and from inside to outside. Also, the moving mechanisms **260** and **280** may move the antennas **370** and **380** from right to left and from left to right.

[0101] The driving device **200** operates as described below under the control of the reading device **100**. In other words, the reading device **100** controls the driving device **200** such that the driving device **200** operates as described below.

[0102] In the driving device **200**, the moving mechanisms **260** and **280** move the stages **250** and **270** in synchronism with each other along the X-axis during each measurement. As a result, the antennas **370** and **380** move in synchronization with each other. In the example of FIG. **8**, the driving device **200** moves the antennas **370** and **380** from outside to inside. Also, during the next measurement, the driving device **200** moves the antennas **370** and **380** from inside to outside.

[0103] That is, the driving device **200** moves the two antennas **370** and **380** such that the two antennas **370** and **380** draw the corresponding parts of the entire trajectory that needs to be drawn by the two antennas **370** and **380** to perform one reading operation of reading information from the wireless tags **520** within the placement area.

[0104] Therefore, it is possible to draw a trajectory with a distance La+Lb, which needs to be drawn by the antennas **370** and **380** in one measurement, by moving the antennas **370** and **380** by the distances La and Lb, respectively. That is, with the wireless tag communication apparatus **10** according to the third embodiment, the time required for measurement is almost half the time required by a wireless tag communication apparatus that performs measurement using one antenna. Accordingly, the wireless tag communication apparatus **10** according to the third embodiment can perform measurement in approximately half the time required by a wireless tag communication apparatus that performs measurement using one antenna. Thus, the present embodiment provides the wireless tag communication apparatus **10** that can quickly read information from the wireless tags **520**.

[0105] In the present embodiment, the driving device **200** moves the antennas **370** and **380** such that the antennas **370** and **380** move toward and away from each other. However, the driving device **200** may move the antennas **370** and **380** from right to left and from left to right while keeping the antennas **370** and **380** at a constant distance from each other.

[0106] The present disclosure may also be applied to a method performed by the processor **101** of the wireless tag communication apparatus **10** and a non-transitory computer-readable storage medium storing a program for causing the processor **101** of the wireless tag communication apparatus **10** to perform a process. For example, the processor **101** controls antennas to communicate with the wireless tags **520** to read information from the wireless tags **520** and controls the driving device **200** to move the antennas.

[0107] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosure. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the disclosure. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosure.

What is claimed is:

1. A wireless tag communication apparatus for communicating with one or more wireless tags attached to one or more articles placed in a placement area on a table, the communication apparatus comprising:

multiple antennas;

a driving device configured to move the multiple antennas such that the antennas draw corresponding parts of a predetermined trajectory; and

a reading device configured to perform one reading operation to read information from the one or more wireless tags through the multiple antennas while controlling the driving device to move the multiple antennas along the corresponding parts of the predetermined trajectory.

2. The wireless tag communication apparatus according to claim **1**, wherein the driving device moves the antennas along a circumference of a same circle.

3. The wireless tag communication apparatus according to claim **2**, wherein

the antennas are arranged at equal angles around a center of the circle; and

when N, which is an integer greater than or equal to two, indicates a number of the antennas, the driving device moves each of the antennas by 360/N degrees around the center of the circle.

4. The wireless tag communication apparatus according to claim **2**, wherein

the antennas are arranged at different angles around a center of the circle; and

the driving device moves each of the antennas by a largest one of the different angles around the center of the circle.

5. The wireless tag communication apparatus according to claim **1**, wherein

the antennas are arranged along one straight line; and

the driving device moves the antennas such that one of the antennas is moved to a previous position of another one of the antennas.

6. The wireless tag communication apparatus according to claim **1**, wherein

the antennas are arranged along one straight line; and

the driving device moves each of the antennas along a corresponding part of the straight line at once.

7. The wireless tag communication apparatus according to claim **1**, wherein the driving device includes a stage that holds the antennas and a moving mechanism that moves the stage.

8. The wireless tag communication apparatus according to claim **7**, wherein

the stage is a rectangular plate-like member that is rotatable around a rotation center axis;

the antennas include two antennas arranged on the stage at 180-degree intervals around the rotation center axis; and

the moving mechanism rotates the stage by 180 degrees around the rotation center axis during the one reading operation.

9. The wireless tag communication apparatus according to claim **7**, wherein

the stage is a circular plate-like member that is rotatable around a rotation center axis;

the antennas include three antennas arranged on the stage at 120-degree intervals around the rotation center axis; and

the moving mechanism rotates the stage by 120 degrees around the rotation center axis during the one reading operation.

10. The wireless tag communication apparatus according to claim **7**, wherein

the stage is a circular plate-like member that is rotatable around a rotation center axis;

the antennas include four antennas arranged on the stage at 90-degree intervals around the rotation center axis; and

the moving mechanism rotates the stage by 90 degrees around the rotation center axis during the one reading operation.

11. The wireless tag communication apparatus according to claim **7**, wherein the moving mechanism includes a holder that holds the stage and a motor that rotates the holder around a rotation center axis.

12. The wireless tag communication apparatus according to claim **7**, wherein

the stage is a rectangular plate-like member;

the antennas consist of two antennas that are arranged on the stage and spaced apart from each other by a distance L/2, L indicating a distance of the predetermined trajectory; and

the moving mechanism moves the stage by the distance L/2 during the one reading operation.

13. The wireless tag communication apparatus according to claim **12**, wherein the moving mechanism includes a guide rail that holds the stage such that the stage is linearly movable and a motor that moves the stage along the guide rail.

14. The wireless tag communication apparatus according to claim **13**, wherein

the guide rail includes a ball screw including a rotatable screw shaft and a nut that holds the stage and is movable along the screw shaft as the screw shaft rotates; and

the motor rotates the screw shaft.

15. The wireless tag communication apparatus according to claim **1**, wherein

the antennas include a first antenna and a second antenna; and

the driving device includes

a first stage that holds the first antenna,

a second stage that holds the second antenna,

a first moving mechanism that moves the first stage, and

a second moving mechanism that moves the second stage.

16. The wireless tag communication apparatus according to claim **15**, wherein each of the first stage and the second stage is a rectangular plate-like member; and

the first moving mechanism and the second moving mechanism, respectively, move the first stage and the second stage by a same distance in synchronization with each other.

17. The wireless tag communication apparatus according to claim **16**, wherein

the first moving mechanism includes a first guide rail that holds the first stage such that the first stage is linearly movable and a first motor that moves the first stage along the first guide rail; and

the second moving mechanism includes a second guide rail that holds the second stage such that the second stage is linearly movable and a second motor that moves the second stage along the first guide rail.

18. The wireless tag communication apparatus according to claim **17**, wherein

the first guide rail includes a first ball screw including a rotatable first screw shaft and a first nut that holds the first stage and is movable along the first screw shaft as the first screw shaft rotates;

the second guide rail includes a second ball screw including a rotatable second screw shaft and a second nut that holds the second stage and is movable along the second screw shaft as the second screw shaft rotates; and

the first moving mechanism and the second moving mechanism are arranged such that a rotation center axis of the first screw shaft coincides with a rotation center axis of the second screw shaft.

19. A method performed by a wireless tag communication apparatus including multiple antennas and a driving device configured to move the multiple antennas such that the antennas draw corresponding parts of a predetermined trajectory, the method comprising:

performing one reading operation to read information from one or more wireless tags attached to one or more articles placed in a placement area on a table through the multiple antennas while controlling the driving device to move the multiple antennas along the corresponding parts of the predetermined trajectory.

20. A non-transitory computer-readable storage medium storing a program for causing a processor to perform a process comprising:

performing one reading operation to read information from one or more wireless tags attached to one or more articles placed in a placement area on a table through multiple antennas while controlling a driving device to move the multiple antennas along corresponding parts of a predetermined trajectory.

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