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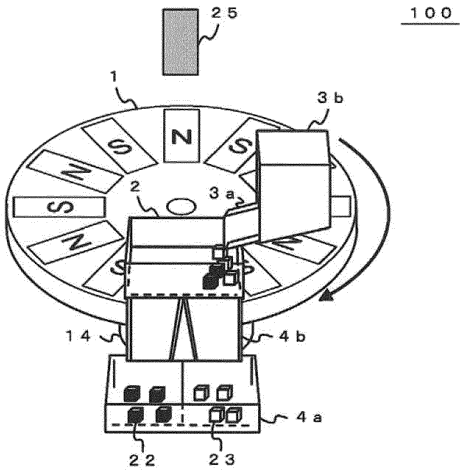
(54) EDDY CURRENT SELECTION DEVICE AND EDDY CURRENT SELECTION METHOD

(57) An eddy current separation apparatus includes: a rotating magnetic circular plate having a plurality of permanent magnets with alternating polarity, the magnets arranged in a circumferential direction; a palette arranged next to the rotating magnetic circular plate with a clearance; an actuator section having a rotating shaft fixed with the rotating magnetic circular plate; a feed section containing a product to be separated and supplying a predetermined quantity of the product to be separated to the palette; a discharge section having two containers for recycling and collecting the product to be separated supplied from the feed section to the palette in the containers for recycling; and a control unit controlling the rotating magnetic circular plate, the actuator section, the feed section and the discharge section; wherein the eddy current separation apparatus performs; a first step in which the feed section supplies a predetermined quantity of the product to be separated to the palette, a second step in which the discharged section is switched to the open position from the closed position after the first step is finished and a fixed time is passed, and a third step in which the discharged section is switched to the closed position after the second step has been finished, further wherein the eddy current separation apparatus performs from a first step to a third step again after the third step has been finished.

FIG. 2



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Description

FIELD OF THE INVENTION

[0001] This invention relates to a separation apparatus and a separation method, and more particularly, to an eddy current separation apparatus which sorts out electrically conductive materials using a rotating magnetic field.

BACKGROUND

[0002] Many methods have already been proposed for sorting out electrically conductive materials (see Patent Documents 1 to 5, for example). Among them is included a separation method which utilizes an eddy current, for example. As eddy current separation equipment, there is known a permanent magnet type in which magnets are rotated with a high speed, and an alternative current electromagnet type in which alternative current is applied to a coil in a sequential order. In the both types, an alternating magnetic field is applied to the electrically conductive material, an eddy current is generated inside of the electrically conductive material, and the conductors are sorted out by the interaction of electric current and magnetic field. Thrust forces based on the electromagnetic power are imparted to the conductors.

[0003] The permanent magnet type includes a flying distance difference sorting system by a rotating cylindrical magnet, and a rotating disk magneto system in which a rotating circular magnet disk is arranged in the lower part of a table, as representative examples. In the flying distance difference sorting system, mixture to be separated (or product to be separated) is made to move close to a rotating cylindrical magnet by a vibration table, a conveyor or the like.

[0004] The alternating magnetic field creates an eddy current in a conductive material. The conductive material receives a thrust force which is created by the eddy current and obtains a larger flying distance than that of a non-conductive material (see Patent Document 6, for example). Thereby, the conductive materials are sorted out.

[0005] On the other hand, in the rotating disk magneto system, the product to be separated is forced to move on a table. In the meantime, the rotating circular magnet disk arranged in the lower part of a table imparts a thrust force by an eddy current to a conductive material, in a direction different from the direction of the movement. Two or more magnets are fixed to the rotating circular magnet disk.

[0006] By this method, a non-conductive material, which does not generate an eddy current, moves at the end portion of a table in a linear fashion, while a conductive material moves to the side portion of a table due to the thrust force by the eddy current and shifts to the reverse end of the table. The product to be separated is segregated over a board, with making a sliding motion or a rotational motion. The divided mixtures are captured individually at the lower stream side of the table to be separated (see Patent Document 7, for example).

LIST OF CITATIONS

PATENT LITERATURE

[0007]

Patent Document 1: JP S50 - 140 953 A
Patent Document 2: JP S58 - 048 343 U
Patent Document 3: JP S59 - 032 958 A
Patent Document 4: JP H07 -163 903 A
Patent Document 5: JP 2000 - 510 764 A
Patent Document 6: JP 3 366 620 B
Patent Document 7: JP H01 - 111 459 A

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0008] By the features of the eddy current separation, the thrust force which is imparted to a conductive material in the product to be separated becomes smaller, as the conductive material becomes smaller in size. Therefore, a very small thrust force is imparted to a small sized conductive material, like a fine copper wire of some 0.2 mm to 0.6 mm in diameter. Moreover, the thrust force by an eddy current is influenced remarkably by the distance between the conductive material and the surface of a magnet. The thrust force decreases in a great degree, if the conductive material and the magnet are separated with only a distance of several millimeters.

[0009] In the flying distance difference sorting system, time when a magnet and a conductive material come in the near distance is restricted to a very small amount of time when the conductive material comes close to a rotation cylindrical magnet and starts a flight. Therefore, a conductive material of a large size to which a large thrust force is imparted can be sufficiently sorted out by a thrust force of short duration. On the contrary, a conductive material of a small size to which a relatively small thrust force is imparted is small in flying distance and difficult in sorting out.

[0010] Moreover, the conductive materials of the same kind are different in the thrust force or the movement at the start time of a flight, corresponding to a shape or a size of the materials. The conductive materials are variable in the flying distance and intermingled in the domain of non-conductive materials. Accordingly, the method is not suitable for high purity sorting.

[0011] When sorting of a conductive material of a small size is performed in the rotating disk magneto system, a small thrust force is imparted to the conductive material. The conductive material moves to the side in a small amount. The conductive material and the non-conductive material are mixed up, and sorting out in high purity cannot be performed. In the rotating disk magneto system,

it is thought to be effective to make long a time for imparting a thrust force to a conductive material, in order to enlarge the travel distance of the conductive material with a small thrust force and to raise the purity in sorting. However, it is necessary to enlarge the radius of a rotating circular magnet disk or to reduce a sending speed, if the sorting is performed by sending a mixed material in the radial direction of the rotating circular magnet disk to impart a thrust force for a long time.

[0012] If the radius of a rotating circular magnet disk is enlarged, the apparatus will become larger in size and the setting position of the apparatus will be restricted. If the sending speed in the apparatus is reduced, the throughput in the apparatus will fall. Moreover, both a conductive material and a non-conductive material move on the top of a table, for sorting out. The non-conductive material moves to a conductive material side in the process of sorting out.

[0013] The purity in sorting out falls by the intermingling of the materials. When a method is taken where the table on which the materials move is inclined to the side, in order to escape the intermingling, the movement of a conductive material to the side may be blocked crosswise.

[0014] As mentioned above, it was difficult to sort out a small sized conductive material in a high purity by the eddy current separation apparatuses, which utilize the flying distance difference sorting method, the rotating disk magneto method and the like. This invention has been made in order to solve the problem of such sorting technology. An object of this invention is to sort out a conductive material of a small size, like the shredded copper wire, in a high purity.

SOLUTION TO PROBLEM

[0015] An eddy current separation apparatus in accordance with the present invention includes:

a rotating magnetic circular plate having a plurality of permanent magnets with alternating polarity, the magnets arranged in a circumferential direction,
a palette arranged next to the rotating magnetic circular plate with a clearance,
an actuator section having a rotating shaft fixed with the rotating magnetic circular plate,
a feed section containing product to be separated and supplying a predetermined quantity of the product to be separated to the palette,
a discharge section having two containers for recycling and collecting the product to be separated supplied from the feed section to the palette into the containers for recycling,
when the state of the containers is switched from a closed position to an open position, and a control unit controlling the rotating magnetic circular plate, the actuator section, the feed section and the discharge section.

[0016] The eddy current separation apparatus is adapted to perform:

a first step in which the feed section supplies a predetermined quantity of the product to be separated to the palette,
a second step in which the discharged section is switched to the open position from the closed position after the first step is finished and a fixed time is passed, and
a third step in which the discharged section is switched to the closed position after the second step is finished, further wherein the eddy current separation apparatus performs from a first step to a third step again after the third step is finished.

ADVANTAGEOUS EFFECTS OF INVENTION

[0017] In the eddy current separation apparatus according to the present invention, which has above mentioned configurations and performs above mentioned operations, sorting out of the conductive material of a small size like the crushed copper wire can be achieved in a high purity.

BRIEF EXPLANATION OF DRAWINGS

[0018]

FIG. 1 is a sectional view for showing an eddy current separation apparatus in accordance with Embodiment 1 of the present invention.
FIG. 2 is a perspective diagram for showing the eddy current separation apparatus in accordance with Embodiment 1 of the present invention.
FIG. 3 is a top view for showing a rotating magnetic circular plate in accordance with Embodiment 1 of the present invention.
FIG. 4 is a schematic for showing the sorting operations in accordance with Embodiment 1 of the present invention.
FIG. 5 is a perspective diagram for showing the eddy current separation apparatus in accordance with Embodiment 2 of the present invention.
FIG. 6 is a perspective diagram for showing the forces which are imparted to conductive materials in accordance with Embodiment 2 of the present invention.
FIG. 7 is a perspective diagram for showing the eddy current separation apparatus in accordance with Embodiment 3 of the present invention.
FIG. 8 is a schematic for showing the eddy current separation apparatus in accordance with Embodiment 4 of the present invention.
FIG. 9 is a schematic for showing the eddy current separation apparatus in accordance with Embodiment 5 of the present invention.
FIG. 10 is a schematic for showing the eddy current

separation apparatus in accordance with Embodiment 6 of the present invention.

FIG. 11 is a schematic for showing the eddy current separation apparatus in accordance with Embodiment 7 of the present invention.

FIG. 12 is a schematic for showing the eddy current separation apparatus in accordance with Embodiment 8 of the present invention.

FIG. 13 is a schematic for showing the eddy current separation apparatus in accordance with Embodiment 9 of the present invention.

FIG. 14 is a top view for showing the eddy current separation apparatus in accordance with Embodiment 10 of the present invention.

FIG. 15 is a side view for showing the discharge section in accordance with Embodiment 10 of the present invention.

FIG. 16 is a side view for showing the eddy current separation apparatus in accordance with Embodiment 11 of the present invention.

FIG. 17 is a sectional view for showing the eddy current separation apparatus in accordance with Embodiment 12 of the present invention.

FIG. 18 is a top view for showing a palette which is on a wobbling motion.

FIG. 19 is a schematic for showing the situation where product to be separated is sorted out by the swinging of the palette.

FIG. 20 is a sectional view for showing the relation between a palette and a rotating brush.

FIG. 21 is a sectional view for showing the relation between a palette and a brush.

FIG. 22 is a sectional view for showing the relation between a palette and an air nozzle.

FIG. 23 is a fragmentary sectional view for showing the eddy current separation apparatus in accordance with Embodiment 13 of the present invention.

FIG. 24 is a perspective diagram for showing the eddy current separation apparatus in accordance with Embodiment 14 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0019] Hereinafter, an eddy current separation apparatus according to the embodiments of the present invention will be described with reference to drawings. Incidentally, the same reference numerals are given to those identical or similar to constitutional portions in respective drawings and the size and/or the scale size of the corresponding respective constitutional portions are respectively independent.

[0020] For example, when the identical constitutional portions, which are not changed, are shown, the size and/or the scale size of the identical constitutional portions may different among sectional views in which a part of the configuration is changed. Furthermore, although the configurations of the eddy current separation apparatus are further actually provided with a plurality of members, for ease of explanation, only portions necessary for explanation will be described and other portions are omitted.

Embodiment 1

[0021] FIG. 1 is a schematic view for showing the configuration of an eddy current separation apparatus in accordance with Embodiment 1 of the present invention. The eddy current separation apparatus 100 includes a rotating magnetic circular plate 1, a palette 2, a feed section 3, a discharge section 4, an actuator section 14, a detector sensor 25, a control unit 30 and the like. The actuator section 14 consists of a rotating shaft 8, shaft bearings 9, a drive motor 10, a coupling 11 and others, and is fixed to the rotating magnetic circular plate 1. Product to be separated is once held and stored in the maintenance container 3b of the feed section 3, and then, the product is injected into the palette 2 through a supply lane 3a.

[0022] The product to be separated is sorted out into a conductive material and a non-conductive material in the palette 2, and the separated materials are stored in the discharge section 4. A disk plate 6 circular in shape has concave portions. Circular joint steel plates 7 are fixed to the concave portions of the disk plate 6, and permanent magnets 5 (Neodymium Magnets) are fixed on the plates. The discharge section 4 consists of containers for recycling 4a, a discharge chute 4b, an on-off valve 4c and the like.

[0023] The rotating magnetic circular plate 1 is attached to the rotating shaft 8 of the actuator section 14. The rotating shaft 8 is supported by the shaft bearings 9, and is connected to the drive motor 10 through the coupling 11 or a timing belt or the like. Rotary movements of the drive motor 10 are transmitted to the disk plate 6 through the coupling 11. The palette 2 is constituted by a thin tabular bottom plate 12, and an outer edge part 13 surrounding the bottom plate 12.

[0024] The palette 2 is arranged on the rotating magnetic circular plate 1, with a small clearance of about 1 mm to 2 mm from the surface of the permanent magnets 5. The palette 2 and the containers for recycling 4a are connected with the discharge chute 4b. Between the palette 2 and the discharge chute 4b, the on-off valve 4c is installed, and the containers for recycling 4a of the discharge section 4 are configured to set their usage state between an open position and a closed position.

[0025] The control unit 30 analyzes images detected with the detector sensor 25, and judges the degree of separation of the product to be separated. Further, the control unit 30 provides directions to the palette 2, the feed section 3, the discharge section 4, and the actuator section 14, based on the judged result, and controls their operations.

[0026] The perspective diagram of the eddy current separation apparatus 100 is shown in FIG. 2. The rotating

magnetic circular plate 1 is combined with the drive motor of the actuator section 14, and rotates in a clockwise direction, when viewed from the upper surface. The feed section 3 injects the product to be separated, in a thin volume along a straight line, intermittently to the end portion of the palette 2, in order to eliminate the overlapping of the product as much as possible. The discharge section 4 is capable of collecting all of the necessary materials on the palette.

[0027] More specifically, the discharge section accepts any type of methods for collecting the materials, like a function to make the palette 2 incline, a function to make the palette 2 vibrate for discharging, a function in which the material inside the palette are raked out, and others. The product to be separated, which is stored in the feed section 3, is injected into the palette 2 through the supply lane 3a. The injected product to be separated is classified into conductive materials 22 and non-conductive materials 23 in the palette 2, as time passes.

[0028] The product to be separated is monitored to know the situation in separation using the detector sensor 25. A fixed time is set up beforehand for sorting. If the degree of separation of the product to be separated is judged good by the control unit 30 from the image detected with the detector sensor 25, or if the fixed sorting time passes after the product is injected, the on-off valve 4c of the discharge section 4 will be in an open position.

[0029] The conductive materials 22 and the non-conductive materials 23 pass through the discharge chute 4b, and the separated materials are stored in each of the containers for recycling 4a of the discharge section 4, with maintaining the separation of the materials. Two containers for recycling 4a are provided in order to differentiate a conductive material from a non-conductive material.

[0030] FIG. 3 shows the configuration of the rotating magnetic circular plate 1. The permanent magnets 5 are arranged in a radial fashion at the concave portions of the disk plate 6 made from aluminum alloy, in such a way that the rotating magnetic circular plate has alternating polarity in a circumferential direction. The joint steel plate 7 of circular shape is fixed to the concave portion of the disk plate 6. Components which come very close to the magnets in the palette are made of non-conductive and non-magnetic material. Among them, the tabular bottom plate 12 of the palette 2 employs materials which have high rigidity, such as FRP (Fiber Reinforced Plastics).

[0031] The rotating shaft 8 is inserted in the center of the rotating magnetic circular plate 1, which is connected with the actuator section 14. The control unit 30 sends a direction for rotating to the actuator section 14, when required. The rotating magnetic circular plate 1 turns around in conjunction with the rotation of the drive motor 10. The conductive materials 22 are shown in gray and the non-conductive materials 23 are expressed in white, hereafter.

[0032] The apparatus according to the present invention has the basic configuration, as stated above. Following operations are performed in the apparatus for sorting, as shown in FIGS. 4 (FIG. 4A to FIG. 4D). First of all, the product to be separated 24, which is a mixture of conductive materials and non-conductive materials, is injected into the maintenance container 3b of the feed section 3 (see FIG. 4A, for reference). The conductive material includes crushed or segregated non-ferrous metals, which are from several mm to several dozen mm in overall size, such as crushed copper wire, small aluminum pieces and the like of about 0.2 mm or more in diameter.

[0033] The non-conductive material indicates small plastic pieces, shredded rubber solid waste, granular solid waste material, sand and others. When the supply lane 3a is opened or lowered, the predetermined quantity of the product to be separated 24 is injected, from the maintenance container 3b of the feed section 3 to one side (injection side 2a) of the palette 2. The product to be separated is arranged in a linear fashion along the radial direction of the rotating magnetic circular plate 1.

[0034] After the injection has been finished, the supply lane 3a is closed or raised (see FIG. 4B for reference). Alternating magnetic field is imparted to the injected product to be separated 24 from the rotating magnetic circular plate 1 rotating in the lower part of the palette 2. The alternating magnetic field changes the magnet polarity at a high speed. An eddy current is generated in a conductive material of the product to be separated by the alternating magnetic field. Electromagnetic power is produced between the rotating magnetic circular plates 1 and the conductive materials.

[0035] This power works as a thrust force and a conductive material travels to the opposite side (anti-injection side 2b) of the palette 2, which is the movement direction of the permanent magnet 5. Since an eddy current is not generated inside the non-conductive material, the thrust force does not take place in the non-conductive material. In this situation, the control unit 30 judges that the product to be separated is insufficiently segregated.

[0036] Only small thrust force is imparted to a conductive material of a small size. The material will move little by little inside of the palette 2 as time proceeds and will come to the opposite side (anti-injection side 2b) of the palette 2 (see FIG. 4C for reference). On the other hand, the non-conductive material does not move from the injected place, because an eddy current is not generated inside of the material. Thrust force is applied to a small sized conductive material which does not obtain great thrust force for enough time to make a sufficient separation distance where the conductive material is not intermingled with the non-conductive material.

[0037] Separation continues until the control unit 30 judges that the degree in separation is in good condition. Therefore, a conductive material and a non-conductive material are divided with a high purity in the palette 2, with the progress of time. In this situation, the control unit 30 regards the degree in separation of the product to be separated as in good order.

[0038] Next, the control unit 30 opens the on-off valve

4c, and makes the containers for recycling 4a of the discharge section 4 in an open position (see FIG. 4D, for reference). In the open position, the palette 2 and the containers for recycling 4a are connected directly with the discharge chute 4b. The conductive materials 22 and the non-conductive materials 23 pass through the discharge chute 4b, and the separated materials are stored in each of the containers for recycling 4a of the discharge section 4, with maintaining the separation of the materials.

[0039] Finally the separated conductive materials and the non-conductive materials are collected from the respective containers for recycling 4a. Then, one cycle of sorting process is completed. After that, the process returns to that of FIG. 4A. Another volume of the product to be separated is injected into the palette 2 from the feed section 3 again, and a next cycle of the sorting process starts.

[0040] As mentioned above, the thrust force can be imparted to a conductive material for a time with an arbitrarily length, by changing the duration between a time when materials are supplied to a palette and a time when the materials are discharged. Only one sheet of the bottom plate 12 of the palette 2 is provided between the conductive materials 22 and the permanent magnets 5, and the distance between them is constant.

[0041] Accordingly, even if the materials move anywhere in a palette, a thrust force comparable to the maximum thrust force in an existing apparatus can be imparted. Therefore, it is possible to apply a thrust force even to a small sized conductive material which does not obtain a great thrust force, for a time long enough to make a sufficient separation distance where the conductive materials are not mixed with the non-conductive materials.

[0042] The embodiment employs a batch type method where only a conductive material is moved, rather than a method where the product to be separated is sent to the radial direction of the rotating magnetic circular plate 1 for separation. Only conductive materials move and separation is achieved. Non-conductive materials move rarely to the conductive material side during the process of separation, and the merit of the embodiment is in rare intermingling of the materials.

[0043] From these reasons, high purity sorting of conductive materials of a small size, like fine copper wire of about 0.2 mm to 0.6 mm in diameter, from non-conductive materials, can be achieved in the embodiment effectively. It is not necessary to enlarge the size of the rotating magnetic circular plate 1 for the improvement in a throughput. The merit also exists in the embodiment that the throughput can be responded by increasing the number of the palettes 2 combined with the one rotating magnetic circular plate 1, if needed.

Embodiment 2

[0044] The eddy current separation apparatus in accordance with Embodiment 2 is explained based on FIG. 5 and FIG. 6. As shown in FIG. 5, the eddy current separation apparatus 100 includes the rotating shaft 8 which is inclined. The rotating magnetic circular plate 1 and the palette 2 are both arranged to be inclined in the same direction. The upper surface of the rotating magnetic circular plate 1 and the level plane (bottom plate 12) of the palette 2 are inclined in the direction to which the thrust force acts. If the palette 2 is installed horizontally, it is necessary for a conductive material to override a frictional force, in order to slide and move on the bottom plate of the palette 2 by the thrust force.

[0045] According to the configuration in accordance with Embodiment 2, a component of the gravity is exerted on the product to be separated in a direction to which a thrust force acts, by the inclination of the palette. As a result, as shown in FIG. 6, the frictional force which a conductive material needs to override becomes smaller apparently.

[0046] Thereby, even small sized materials to which only smaller thrust force is imparted can also be sorted out. When a non-conductive material has a larger coefficient of friction compared with a conductive material, the difference in frictional forces can also be used for sorting out, with this configuration. Higher sorting capability is expected in the embodiment.

Embodiment 3

[0047] The eddy current separation apparatus in accordance with Embodiment 3 is explained based on FIG. 7. As shown in the drawing, the eddy current separation apparatus 100 includes the rotating shaft 8 of the rotating magnetic circular plate 1 and the level plane of the palette 2, which are arranged to be inclined in the reverse direction to which the thrust force acts. At this time, the rotating shaft 8 is set at an inclined angle, where non-conductive materials slide down by the inclination of the palette 2. In the drawing, the rotating magnetic circular plate 1 is rotating in a counterclockwise direction.

[0048] According to this configuration, non-conductive materials slide or make rolling motions on the palette 2, and move to the lower part of the palette. On the contrary, conductive materials are held by a thrust force on the upper end portion of the palette 2. Accordingly, those materials are sorted out. When the non-conductive material has a smaller coefficient of friction compared with the conductive material, sorting out can be achieved also by employing the difference in a coefficient of friction. Moreover, the embodiment is also effective in the case where a non-conductive material has a shape which can easily induce more rolling compared with a conductive material.

Embodiment 4

[0049] The eddy current separation apparatus in accordance with Embodiment 4 is explained based on FIG.

8. The rotating magnetic circular plate 1 of the eddy current separation apparatus is arranged over the palette 2 in a direction where the faces of the permanent magnets 5 appear in the lower part. For this reason, the magnet side 1a of the rotating magnetic circular plate 1 faces downward, and the joint steel plate side 1b faces upward. In a usual case, a thrust force has a component of the translational direction and a component of the rotational direction, when the thrust force is produced with a single rotating magnetic circular plate 1.

[0050] According to this configuration, the direction in which a conductive material rolls on a palette by the rotational force is the same with the direction of the translational force. Those materials can be sorted out by employing the rotational force in addition to the force of the translational direction. Therefore, the embodiment is especially effective in sorting a conductive material which rolls easily.

Embodiment 5

[0051] The eddy current separation apparatus in accordance with Embodiment 5 is explained based on FIG. 9. Here, the thickness of a bottom plate starts to increase at the middle portion, from the injection side towards the anti-injection side. More specifically, the eddy current separation apparatus 100 has a palette 2, the bottom plate 12 of which is large in thickness near the outer edge part 13 of the anti-injection side, as shown in the drawing. When simultaneous separation is performed using conductive materials which have different sizes and shapes, the thrust forces which are produced in the conductive materials have considerable variation. When setting up of the apparatus is made according to the conductive material of a small thrust force, the conductive material of a large thrust force is separated simultaneously and acquires a speed larger than needed and collide with the outer edge part 13 of a palette strongly. Rebounding of the conductive materials may affect the separation of the different product to be separated.

[0052] When conductive materials pick up the pace along the palette 2, the distance from the permanent magnet 5 to a conductive material becomes larger at the domain in which the bottom plate 12 has a larger thickness, and the thrust force becomes reduced. According to this configuration, conductive material does not collide at the outer edge part strongly. After all, the embodiment here is effective in the separation of the mixture of conductive materials, which receive different thrust forces due to the variation in size and the like.

Embodiment 6

[0053] The eddy current separation apparatus in accordance with Embodiment 6 is explained based on FIG. 10. Here is provided a bottom plate, the thickness of which increases at a fixed rate from the injection side toward the anti-injection side. More specifically, there is provided the eddy current separation apparatus 100 in which the angle between the surface of the rotating magnetic circular plate 1 and the upper surface of the bottom plate 12 is on incline from a horizontal plane, as shown in the drawing.

[0054] Moreover, three containers for recycling 4a are installed. According to this configuration, a thrust force becomes smaller as the distance from the surface of the permanent magnets 5 to the conductive materials becomes larger. Thereby, the thrust force becomes smaller gradually, as the conductive material moves along the inside of a palette.

[0055] Therefore, while a material of a large size or of a large electrical conductivity travels a longer distance along the palette, a material of a small size or of a small electrical conductivity travels a shorter distance along the palette. By collecting these materials in the discharge section 4 which has two or more outlets, the product to be separated can be sorted out on two or more classes by the magnitude relation in the electrical conductivity, the size or the like of the materials.

Embodiment 7

[0056] The eddy current separation apparatus in accordance with Embodiment 7 is explained based on FIG. 11. The eddy current separation apparatus 100 applies vibration to the palette 2, as shown in the drawing. More specifically, micro vibration is applied towards the out of plane direction of the palette using an ultrasonic transducer 20, as long as the product to be separated exists in the palette. Or relatively big vibration is applied intermittently by a motor with an eccentrically clamped weight. According to this configuration, the product to be separated in a former case touches the palette 2 in a reduced period, and the frictional force becomes smaller.

[0057] A conductive material of a small size, to which only a smaller thrust force is imparted, can also be sorted out. In the latter case, there seems to be a situation where a conductive material stays ahead of a non-conductive material and the movement of the non-conductive material is blocked. Even in that case, it is possible to continue the separation by shifting the spatial relationship of both materials.

Embodiment 8

[0058] The eddy current separation apparatus in accordance with Embodiment 8 is explained based on FIG. 12. The eddy current separation apparatus 100 includes a lid 21, which is attached to the palette, as shown in the drawing, and shields the inside and outside of the palette at the time of sorting out. This lid 21 will open, only when the product to be separated is injected from the supply section, and when the separation of the product is finished and materials are delivered to the discharge section. The lid 21 employs such a structure which shall not block those operations, when the product to be separated

is supplied or ejected.

[0059] According to this configuration, the product to be separated does not jump out of the palette during the separation. The aerial current which is generated by the rotation of the rotating magnetic circular plate arranged at the lower part of the palette may influence the separation of the mixture. Moreover, such disturbance, which is given to the product to be separated from the outside of the palette, can be reduced in the embodiment.

Embodiment 9

[0060] The eddy current separation apparatus in accordance with Embodiment 9 is explained based on FIG. 13. The rotating magnetic circular plate 1 is arranged at the lower part of the palette 2, and an auxiliary rotating magnetic circular plate 17 is arranged at the upper part of the palette 2. The auxiliary rotating magnetic circular plate 17 is arranged over the palette, with the magnet side 1a facing downward. At this time, it is preferable to connect the rotating magnetic circular plates at the upper part and at the lower part with the same rotating shaft 8. The rotating magnetic circular plates rotate synchronously, in such a way that the permanent magnets 5, which always encounter at the upper and lower sides, may have reversed polarity.

[0061] In other words, the auxiliary rotating magnetic circular plate 17 shares the rotating shaft 8 with the rotating magnetic circular plate 1, and permanent magnets facing each other are in reversed polarity. According to the configuration, there is an advantage that the magnetic flux density in a palette becomes higher, and the thrust force of the translational direction becomes larger, compared with the case where a single rotating magnetic circular plate is used.

Embodiment 10

[0062] The eddy current separation apparatus in accordance with Embodiment 10 is explained based on FIG. 14 and FIG. 15. The eddy current separation apparatus 100 includes two or more palettes 2, which are arranged with respect to one set of rotating magnetic circular plates 1, a feed section 3, and a discharge section 4, as shown in FIG. 14. In this example, six palettes 2 are connected with the palette drive ring 18 through the palette inclination axles 19, and arranged neatly in a torus manner. The product to be separated is supplied to the palette 2 which is in an injection position, through the supply lane 3a from the feed section 3.

[0063] In the drawing, the palette which is at 5 o'clock direction is in an injection position. The palette in the injection position overlaps with the supply lane 3a. By rotating the palette drive ring 18 using the palette drive motor 15, the palettes 2 rotate at a low speed on the upper part of the rotating magnetic circular plate 1. Any other methods for driving the palette are accepted, where two or more palettes move at the same time. Among them, is includes a method where a cam follower is attached to the palettes and the palettes move on the top of a rail.

[0064] The control unit 30 decides the degrees in the separation of the product to be separated on two or more palettes. When any one of the palettes is judged good in the degree of separation of the product to be separated, or when a fixed time has passed for sorting, the control unit 30 directs an open position to the discharge section, if the palette arrives at a discharge position. At the discharge position, the discharge section 4 and the palette 2 overlap together. In the drawing, a rightmost palette, which is in 3 o'clock direction, has arrived at the discharge position.

[0065] The discharge section 4 according to this configuration is exemplary shown in FIG. 15. Although the palette 2 is kept on the level at the time of sorting, the palette is on incline at the time of discharge, with the palette inclination axle 19 on the center. When the palette is on incline, the use state of the containers for recycling 4a is in an open position. The palette is in a closed position at the time when the palette is on the level. The separated product of conductive materials and non-conductive materials are discharged to the discharge section 4 through the discharge chute 4b.

[0066] The method suitable for this situation includes a case where the palette 2 is made to rotate intermittently or a case where the discharge chute 4b is given a wobbling motion according to the motion of the palette 2, with the palette 2 rotating at a fixed speed. According to this configuration, the magnetic flux density which is produced from the magnets in the rotating magnetic circular plate can be used in an efficient manner by increasing the number of the palette 2. Moreover, by reducing the number of the feed sections 3 and the discharge sections 4 with respect to the number of the palettes 2, the operating rates of the feed section 3 and the discharge section 4 can be improved.

[0067] Therefore, it is possible to increase the throughput of the apparatus, without increasing the number of the rotating magnetic circular plates 1, the feed sections 3, and the discharge sections 4, so as to match the increase in the palettes 2. As a result, the increase in the area occupied by the apparatus and in the cost for producing the apparatus can be suppressed in a small quantity.

[0068] By adjusting the rotational speed of the palette 2, time need for sorting can be easily adjusted, taking into account the magnitude of an eddy current action on the product to be separated. To be more precise, the rotational speed is raised at the time of sorting a conductive material which is big in size and receives a comparatively big thrust force.

[0069] The separation can be performed in a short time, and a throughput in sorting can be increased. On the contrary, the rotational speed is reduced at the time of sorting a conductive material which is small in size and receives a small thrust force. The separation is performed

for a more prolonged time for sorting and the sorting in a high purity can be performed.

Embodiment 11

[0070] The eddy current separation apparatus in accordance with Embodiment 11 is explained based on FIG. 16. The eddy current separation apparatus 100 includes two or more rotating magnetic circular plates 1, which are combined with s single rotating shaft 8. Accordingly, the rotating magnetic circular plates 1 share the rotating shaft 8. In the drawing, three rotating magnetic circular plates 1 are exemplarily shown, which are fixed to the single rotating shaft 8.

[0071] In this configuration, the number of the drive motor 10 is kept in one and a channel is divided into three at the feed section 3. Parallel processing is performed, by achieving the same sorting in each combination of a rotating magnetic circular plate 1 and a palette 2. The throughput can be increased 3 times in the present embodiment.

[0072] Moreover, by utilizing a vertical space effectively, a throughput in sorting out can be increased without increasing the area occupied by apparatus largely. Furthermore, in each rotating magnetic circular plate, the apparatus may be arranged in such a way that the magnetic flux density imparted to a work is set up to become larger from the top step by step. By connecting each discharge section to the following feed section in series, sorting is performed at each rotating magnetic circular plate in a stepwise manner.

[0073] Selection of the flow on the rotating magnetic circular plates can be achieved. For example, sorting of a conductive material with a large size is performed at the top rotating magnetic circular plate. Remained conductive materials with a small size and non-conductive materials are sorted out at a 2nd rotating magnetic circular plate and at a 3rd rotating magnetic circular plate respectively, so sorting of the product can be performed in a parallel flow.

Embodiment 12

[0074] The eddy current separation apparatus in accordance with Embodiment 12 is explained based on FIG. 17. The eddy current separation apparatus 100 contains the rotating magnetic circular plate 1, the palette 2, the feed section 3, the discharge section 4, the actuator section 14, a wobbling mechanism 26, the control unit 30, and the like. The actuator section 14 consists of the rotating shaft 8, the shaft bearing 9, the drive motor 10, the coupling 11 and others, and is fixed to the rotating magnetic circular plate 1. After the product to be separated is once held and stored in the maintenance container 3b of the feed section 3, the product is injected to the palette 2 through the supply lane 3a.

[0075] Then, the product to be separated is sorted out from a conductive material to a non-conductive material in the palette 2, and the segregated are stored in the discharge section 4. The disk plate 6 in a circular shape has concave portions. The joint steel plates 7 in a circular shape are fixed to the concave portions of the disk plate 6, and permanent magnets 5 (Neodymium Magnets) are fixed on the joint steel plates. The discharge section 4 consists of the containers for recycling 4a, the discharge chute 4b, the discharge mechanism 4d and others.

[0076] The rotating magnetic circular plate 1 is attached to the rotating shaft 8 of the actuator section 14. The rotating shaft 8 is supported by the shaft bearings 9, and is connected to the drive motor 10 through the coupling 11 or a timing belt or the like. Rotary movements of the drive motor 10 are transmitted to the disk plate 6 through the coupling 11. The rotational speed of the rotating magnetic circular plate 1 is controlled by the control unit 30.

[0077] The palette 2 consists of the bottom plate 12 of a thin tabular shape and an outer edge part 13 surrounding the bottom plate 12. The palette 2 is arranged above the rotating magnetic circular plate 1, with keeping a small clearance of about 1 mm to 2 mm with respect to the surface of the permanent magnets 5. Although the palette 2 is kept on level with the rotating magnetic circular plate 1 at the time of sorting out, the palette is on incline if the discharge mechanism 4d is on an operational mode and the discharge section 4 is on an open position (see FIG. 15, for reference).

[0078] Components which come very close to the magnet in the palette consist of non-conductive and non-magnetic materials. Among them, the bottom plate 12 utilizes materials having the features like non-conductivity, non-magnetism and high rigidity, such as alumina, FRP (Fiber Reinforced Plastics) and others.

[0079] The rotating magnetic circular plate 1 is combined with the drive motor of the actuator section 14 and rotates in a clockwise direction, when viewed from the upper surface. The feed section 3 injects the product to be separated intermittently to the end portion of the palette 2 in a thin and linear arrangement, in order that the mixtures of the product may escape from overlapping together as much as possible. The discharge section 4 has the function to collect all of the materials separated on the palette in order that respective materials may not be mixed up.

[0080] The product to be separated stored in the feed section 3 is supplied to the palette 2 through the supply lane 3a. The supplied product to be separated is divided into the conductive materials 22 and the non-conductive materials 23 in the palette 2, as time proceeds. Time from the injection to the palette 2 to the adequate separation of the mixtures depends on the characteristics of the product to be separated.

[0081] The magnitude of the thrust force, which is produced in the product to be separated by the action of an eddy current, is dependent on the electrical conductivity, the mass, the shape, the size and others of the product. High purity separation can be attained by setting up the

sorting time from an injection to discharge beforehand corresponding to the product to be separated. After the sorting time has passed, the conductive materials 22 and the non-conductive materials 23, which have been separated, are taken out from the palette 2 respectively.

[0082] The product to be separated passes through the discharge chute 4b by the discharge mechanism 4d, and the product are stored at the containers for recycling 4a in a state where they are separated. Two containers for recycling 4a are arranged in order to maintain the separation of conductive materials and non-conductive materials.

[0083] Sorting by this apparatus is performed on the following principles. At first, the control unit 30 injects the product to be separated 24 which is a mixture of a conductive material and a non-conductive material to the maintenance container 3b of the feed section 3, with always rotating the rotating magnetic circular plate 1 (see FIG. 4A, for reference). The conductive materials include crushed or segregated non-ferrous metals, which are from several mm to several dozen mm in overall size, such as crushed copper wire, small aluminum pieces and the like of about 0.2 mm or more in diameter.

[0084] The non-conductive materials include small plastic pieces, shredded rubber solid waste, granular solid waste material, sand, etc. When the supply lane 3a is opened or lowered, the predetermined quantity of the product to be separated 24 is injected, from the maintenance container 3b of the feed section 3, to one side (injection side 2a) of the palette 2. The product to be separated has been arranged in a linear manner along the radial direction of the rotating magnetic circular plate 1.

[0085] After the injection has been finished, the supply lane 3a is closed or raised (see FIG. 4B, for reference). The injected product to be separated 24 is applied with alternating magnetic field from the rotating magnetic circular plate 1, rotating in the lower part of the palette 2. The alternating magnetic field changes magnet polarity at a high speed. An eddy current is generated in a conductive material of the product to be separated by the alternating magnetic field.

[0086] Electromagnetic force is induced between the rotating magnetic circular plates 1 and the conductive materials. This force works as a thrust force and a conductive material moves to the opposite side (anti-injection side 2b) of the palette 2, which is the move direction of the permanent magnet 5. Since the eddy current is not generated inside the non-conductive material, the thrust force is not generated in the non-conductive material.

[0087] It is difficult to move a conductive material in a situation where a non-conductive material stays ahead of the conductive material to block the movement. In the present embodiment, the wobbling mechanism 26 carries out rocking movement of the palette 2 at the time of sorting, keeping the magneto surface and the palette surface parallel near the rotating magnets, as shown in FIG. 18. According to this configuration, the direction of the thrust force which a conductor receives is not constant with respect to the direction of a palette. The movement trajectory of a conductive material changes according to the rocking movement of the palette. The trajectory of the material changes in a zig-zag manner, as shown in FIG. 19. A conductive material can move without the prevention by the non-conductive material at the front, and sorting out can be continued. The wobbling mechanism may employ a linkage mechanism or a cam mechanism or others, as a mechanism of the rocking movement. The control unit 30 changes the angle and cycle of the rocking movement, according to the product to be separated.

[0088] If a conductive material, which is small in size and to which only a small thrust force is imparted, spends many hours in sorting, the conductive material will move little by little inside of the palette 2, and will come to the opposite side (anti-injection side 2b) of the palette 2 (see FIG. 4C for reference). On the other hand, an eddy current is not produced inside a non-conductive material.

[0089] Thereby, the non-conductive material does not move from the injected place. A thrust force is applied even to the conductive material which is small in size and receives not so large thrust force, for a time long enough to make a sufficient difference in distance between the non-conductive material and the conductive material and prevent the intermingling of them.

[0090] Time necessary to make the sufficient difference in distance is dependent on the product to be separated. Materials are injected into the palette 2 experimentally beforehand to grasp a time to make the sufficient difference in distance. The time is set as a sorting time in the control unit 30. The control unit 30 will change the discharge section 4 into an open position from a closed position, when the materials are injected into the palette and the set upped and fixed sorting time passes. In the present embodiment, the discharge mechanism 4d actuates to make the palette 2 to incline.

[0091] The product to be separated is discharged from the palette 2 into the containers for recycling 4a, (see FIG. 17, for reference). When the palette 2 is inclined, the separated conductive and non-conductive materials pass along the discharge chute 4b and stored in the containers for recycling 4a, with keeping the separated state of the materials (see FIG. 4D, for reference). Thereafter, in order to return the discharge section 4 to a closed position, the discharge mechanism 4d is changed into a halt condition (or a normal position), and the palette 2 is made in parallel.

[0092] The discharge mechanism 4d includes any kind of systems which employ a mechanism, such as a mechanism which rakes out the internal materials of a palette with the rotating brush 31 (see FIG. 20, for reference), a mechanism which drives the brush 32 by the linkage mechanism or a cam mechanism, and rakes out the internal materials of a palette with this brush (see FIG. 21, for reference), a mechanism which sends compressed air from the air nozzle 33, and flies the materials into the air for the separation (see FIG. 22, for reference) and

others.

[0093] The convex part 2a is provided in order to prevent the discharge of the product to be separated into the containers for recycling 4a, when the discharge mechanism 4d is in a closed position (or a halt condition). As the processes mentioned above proceed, one cycle of sorting is completed.

[0094] If new product to be separated is injected into the palette 2 from the feed section 3 again, the following cycle for sorting will start (see FIG. 4A, for reference). By repeating these cycles, the product to be separated stored in the feed section is separated into conductive materials and non-conductive materials one by one, and the separated materials are stored in the containers for recycling 4a.

[0095] As mentioned above, time for applying a thrust force to a conductive material can be arbitrarily adjusted, by changing the time from the injection of a material into a palette to the discharge of the material. There is provided only a single bottom plate 12 of the palette 2 between the conductive materials 22 and the permanent magnets 5, and the distance between the plate and the magnets is constant.

[0096] Even if the materials move anywhere in the palette, a thrust force as large as the maximum thrust force in an existing apparatus can be imparted to the materials. Therefore, a thrust force can be applied to a small sized conductive material which does not obtain a large thrust force, for a time long enough to make a sufficient difference in distance where the conductive material is not mixed up with the non-conductive material.

Embodiment 13

[0097] The eddy current separation apparatus in accordance with Embodiment 13 is explained based on drawings. FIG. 23 is a drawing for showing the configuration of the eddy current separation apparatus according to the embodiment of the present invention. There are provided three containers for recycling 4a in the eddy current separation apparatus 100. The product to be separated is supposed to be injected into the central part of the palette 2. Conductive materials include a conductive material 22a whose shape is likely to roll over, and a conductive material 22b whose shape is not likely to roll over and those materials are mixed up.

[0098] A thrust force has a component of the translational direction and a component of the rotational direction, when the thrust force is given to the product to be separated with one rotating magnetic circular plate 1. Therefore, a material whose shape is likely to roll over is subject to the force of the rotational direction exceeding the force of the translational direction and moves to the right side of the drawing.

[0099] A material, whose shape is not likely to roll over, slides and moves to the left side of the drawing, by the force of the translational direction. Even in the case where the product to be separated includes the material which is likely to roll over in shape and the material which is not likely to roll over in shape, sorting out can be performed by collecting the separated materials along the move direction, according to this configuration.

Embodiment 14

[0100] The eddy current separation apparatus in accordance with Embodiment 14 is explained based on drawings. FIG. 24 is a drawing for showing the configuration of the eddy current separation apparatus in accordance with the embodiment of the present invention. The eddy current separation apparatus 100 consists of the proximity sensor 27 of the guide type which grasps a sorting situation of the product to be separated inside a palette. The proximity sensor 27 will respond, if sorting advances and the conductive material 22 comes closer.

[0101] The sorting situation is transmitted to the control unit 30. The proximity sensor 27 can be substituted with a temperature sensor which detects the conductor heated by the eddy current. The control unit 30 gives a direction to a discharge section to teach the timing for collecting the materials on a palette, and the discharge section which receives the direction collects the materials on a palette. If the collection is completed, the control unit will send a direction to a feed section for injecting new materials on the palette.

[0102] According to this method, the sorting time from the injection of the materials into a palette to the discharge of the materials is judged and changed in each cycle. Even in a case where the product to be separated has large variations in size and changes in the material quality or the like, a throughput cannot be reduced on lessening the vainness in sorting time as much as possible. The purity in sorting can be maintained.

[0103] The eddy current separation apparatus according to the present invention which has the configuration and performs above mentioned operations has the following effects. On the features of the eddy current sorting, the generated thrust force becomes smaller, as the size of a conductive material in the product to be separated becomes smaller. Time required for separating a conductive material from a non-conductive material in an adequate quantity and for achieving the separation in a sufficient purity becomes longer.

[0104] According to this invention, changed is the time from the injection of the materials into the inside of a palette to the discharge of the materials. The time for applying a thrust force can be easily set up long, taking into account the conductivity of the material in concern for sorting,

[0105] There is provided only a single palette between the conductive material and the surface of the magnets, and the distance in between is small and constant. Accordingly, even if a material moves to anyplace inside the palette, the thrust force compatible with a maximum thrust force in an existing apparatuses can be imparted to the material. Moreover, only a conductive material

moves on the palette, while sorting out is performed.

[0106] Compared with the systems in the conventional rotating disk magneto method where both a conductive material and a non-conductive material move for sorting out, a non-conductive material seldom moves to the conductive material side during the process of sorting, and the intermingling of the materials is rare.

[0107] According to the above-mentioned effects, the high purity sorting can be attained also to a conductive material of a small size, like the fine copper wire of some 0.2 mm to 0.6 mm in diameter. Moreover, sorting out is performed at the injected position on the palette, unlike the existing technology system in which a mixture of shredder residue is sent to the radial direction of a rotating disk magnet for separation.

[0108] Accordingly, the rotating magnet does not need a length in the radial direction for sorting. Therefore, it is not necessary to enlarge the radius of the rotation magnet for the improvement in a throughput. The improvement in the throughput is supported by increasing the count of the palettes combined with one rotating magnet, if in need.

[0109] It should be noted that each embodiment of the present invention may be freely combined, or appropriately modified or features may be omitted within the spirit and scope of the invention.

Explanation of Numerals and Symbols

[0110]

1	Rotating Magnetic Circular Plate
1a	Magnet Side ; 1b Joint Steel Plate Side
2	Palette
2a	Injection Side
2b	Anti-injection Side
3	Feed Section
3a	Supply Lane
3b	Maintenance Container
4	Discharge Section
4a	Container For Recycling
4b	Discharge Chute
4c	On-off Valve
5	Permanent Magnet
6	Disk Plate
7	Joint Steel Plate
8	Rotating Shaft
9	Shaft Bearing
10	Drive Motor
11	Coupling
12	Bottom Plate
13	Outer Edge Part
14	Actuator Section
15	Palette Drive Motor
17	Auxiliary Rotating Magnetic Circular Plate
18	Palette Drive Ring
19	Palette Inclination Axis
20	Ultrasonic Transducer
21	Lid
22	Conductive Material
23	Non-conductive Material
24	Product To Be Separated
25	Detector Sensor
30	Control Unit
100	Eddy Current Separation Apparatus

Claims

1. An eddy current separation apparatus comprising;

- a rotating magnetic circular plate having a plurality of permanent magnets with alternating polarity, the magnets arranged in a circumferential direction,
- a palette arranged next to the rotating magnetic circular plate with a clearance,
- an actuator section having a rotating shaft fixed with the rotating magnetic circular plate,
- a feed section containing product to be separated and supplying a predetermined quantity of the product to be separated to the palette,
- a discharge section having two containers for recycling and collecting the product to be separated supplied from the feed section to the palette into the containers for recycling, when the state of the containers is switched from a closed position to an open position, and
- a control unit for controlling the rotating magnetic circular plate, the actuator section, the feed section and the discharge section;

wherein the eddy current separation apparatus is adapted to perform:

- a first step in which the feed section supplies a predetermined quantity of the product to be separated to the palette,
- a second step in which the discharged section is switched to the open position from the closed position after the first step is finished and a fixed time is passed, and
- a third step in which the discharged section is switched to the closed position after the second step is finished,

further wherein the eddy current separation apparatus is adapted to perform from a first step to a third step again after the third step has been finished.

2. The eddy current separation apparatus as set forth in claim 1,
wherein the rotating magnetic circular plate is arranged with the magnet side facing upward, and
the palette is arranged above the rotating magnetic circular plate.

3. The eddy current separation apparatus as set forth in claim 2,
wherein the rotating magnetic circular plate and the palette are on incline toward the same direction.

4. The eddy current separation apparatus as set forth in claim 3,
wherein the rotating magnetic circular plate rotates in a clockwise direction when viewed from the upper face.

5. The eddy current separation apparatus as set forth in claim 3,
wherein the rotating magnetic circular plate rotates in an anti-clockwise direction when viewed from the upper face.

6. The eddy current separation apparatus as set forth in claim 1,
wherein the rotating magnetic circular plate is arranged with the magnet side facing downward, and the palette is arranged under the rotating magnetic circular plate.

7. The eddy current separation apparatus as set forth in claim 2,
wherein the palette has a bottom plate, the thickness of which starts to increase at the middle portion, from the injection side towards the anti-injection side.

8. The eddy current separation apparatus as set forth in claim 2,
wherein the palette has a bottom plate, the thickness of which is on increases at a fixed rate, from the injection side towards the anti-injection side.

9. The eddy current separation apparatus as set forth in claim 8,
wherein the discharge section has three containers for recycling.

10. The eddy current separation apparatus as set forth in claim 2,
further comprising a ultrasonic transducer for vibrating the palette up and down.

11. The eddy current separation apparatus as set forth in claim 2,
further comprising an auxiliary rotating magnetic circular plate having a plurality of permanent magnets, the magnets arranged in a circumferential direction with alternating polarity,
wherein the auxiliary rotating magnetic circular plate is arranged above the palette with the magnet side facing downward.

12. The eddy current separation apparatus as set forth in claim 12,
wherein the auxiliary rotating magnetic circular plate shares the rotating shaft with the rotating magnetic circular plate, and
the permanent magnets facing each other are in reverse polarity.

13. The eddy current separation apparatus as set forth in claim 1,
wherein the palette is arranged on level when the discharge section is in a closed position and on incline when the discharge section is in an open position.

14. The eddy current separation apparatus as set forth in claim 1,
wherein the palette is adapted to perform wobbling motions.

15. The eddy current separation apparatus as set forth in claim 1,
wherein the discharge section has a brush, a rotating brush or an air nozzle.

16. The eddy current separation apparatus as set forth in claim 1,
wherein the discharge section has three containers for recycling and
the feed section is adapted to supply the product to be separated to the central part of the palette.

17. The eddy current separation apparatus as set forth in claim 1,
wherein a plurality of the palettes which are adapted to rotate in a circumferential direction of the rotating magnetic circular plate are arranged in a circular manner.

18. The eddy current separation apparatus as set forth in claim 1,
wherein the rotating magnetic circular plates and the palettes are arranged longitudinally one after another.

19. An eddy current separation apparatus comprising;

- a rotating magnetic circular plate having a plurality of permanent magnets with alternating polarity, the magnets arranged in a circumferential direction,
- a palette arranged next to the rotating magnetic circular plate with a clearance,
- a detector sensor for detecting an image of the product to be separated which includes conductive material and non-conductive material and is supplied to the palette,
- a control unit for judging the degree of separation of the product to be separated based on the image detected with the detector sensor,

- an actuator section having a rotating shaft fixed with the rotating magnetic circular plate and adapted for rotating the rotating magnetic circular plate according to a direction from the control unit,
- a feed section containing product to be separated and adapted for supplying a predetermined quantity of the product to be separated to the injection side of the palette according to a direction from the control unit, and
- a discharge section having two containers for recycling and switching the state of the containers for recycling between a closed position and an open position according a direction from the control unit,

wherein the control unit is adapted to perform

- a first step to send a direction to the feed section in supplying the product to be separated,
- a second step to send a direction for setting a closed position to the discharged section and send a direction for rotating the rotating magnetic circular plate to the actuator section, and
- a third step to acquire the image of the product to be separated from the detector sensor and judge the degree of separation of the product to be separated from the image, and
- a fourth step to send a direction to the discharge section in setting an open position when the degree of the separation of the product to be separated is judged good,

further wherein the control unit is adapted to perform from a first step to a fourth step again after the fourth step has been finished.

20. An eddy current separation method in an eddy current separation apparatus which comprises;

- a rotating magnetic circular plate having a plurality of permanent magnets with alternating polarity, the magnets arranged in a circumferential direction,
- a palette arranged next to the rotating magnetic circular plate with a clearance,
- an actuator section having a rotating shaft fixed with the rotating magnetic circular plate,
- a feed section containing product to be separated and supplying a predetermined quantity of the product to be separated to the palette,
- a discharge section having two containers for recycling and collecting the product to be separated supplied from the feed section to the palette into the containers for recycling, when the state of the containers is switched from a closed position to an open position, and
- a control unit controlling the rotating magnetic circular plate, the actuator section, the feed section and the discharge section;

wherein the eddy current separation method includes

- a first step in which the feed section supplies a predetermined quantity of the product to be separated to the palette,
- a second step in which the discharged section is switched to the open position from the closed position after the first step is finished and a fixed time has passed, and
- a third step in which the discharged section is switched to the closed position after the second step has been finished,

further wherein the eddy current separation method includes a step to perform from a first step to a third step again after the third step has been finished.

FIG. 1

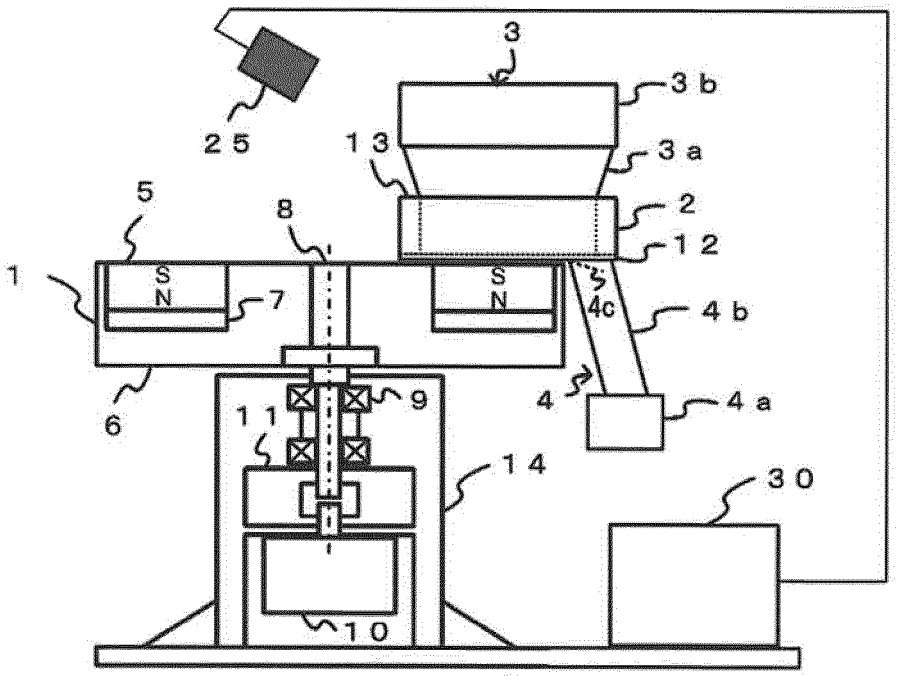


FIG. 2

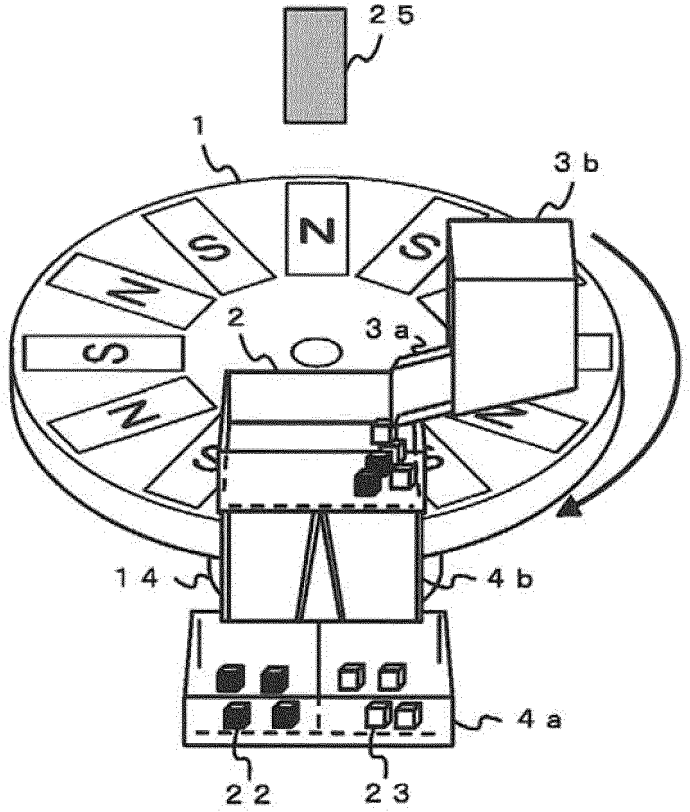
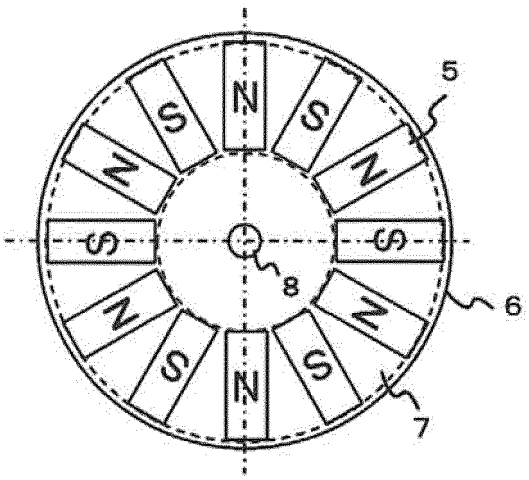


FIG. 3



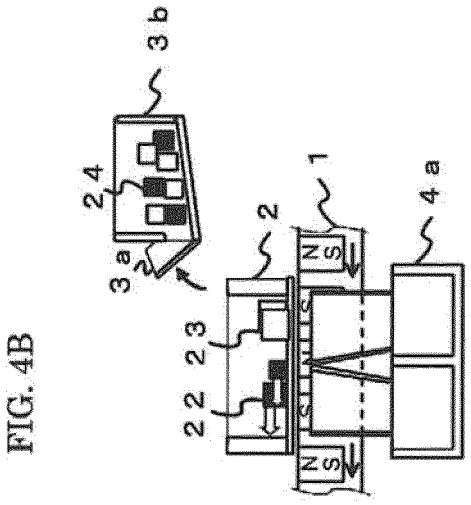


FIG. 4B

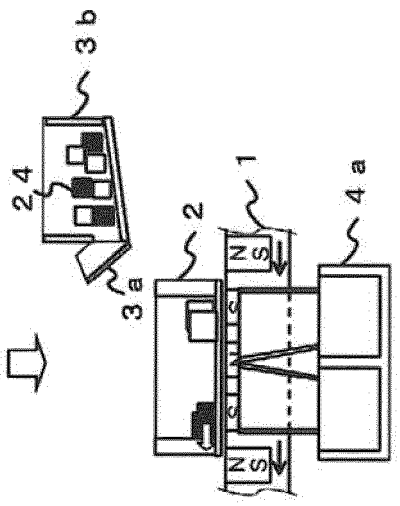


FIG. 4C

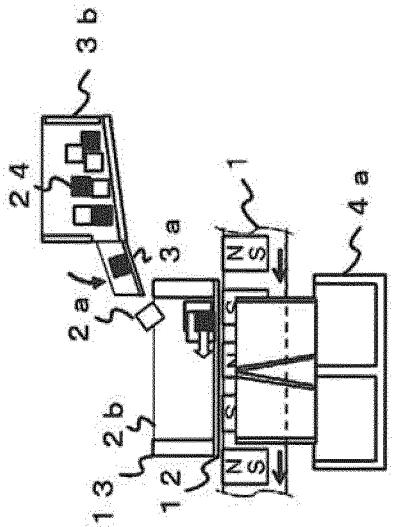


FIG. 4A

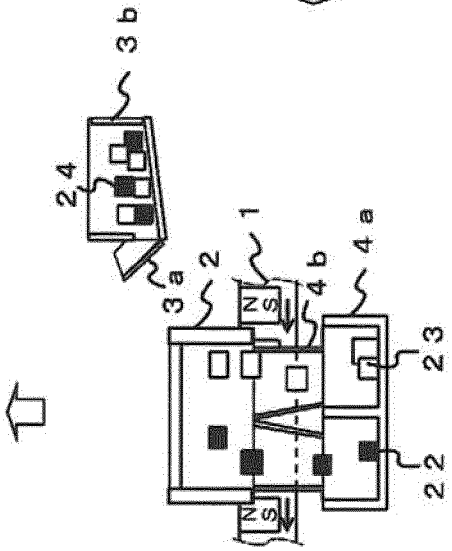
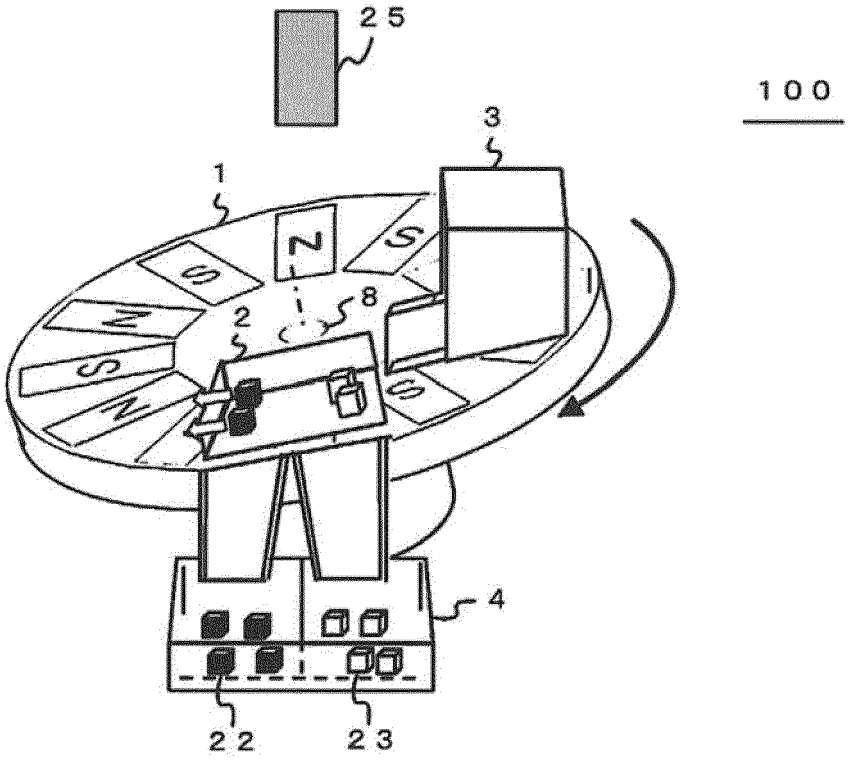


FIG. 4D

FIG. 5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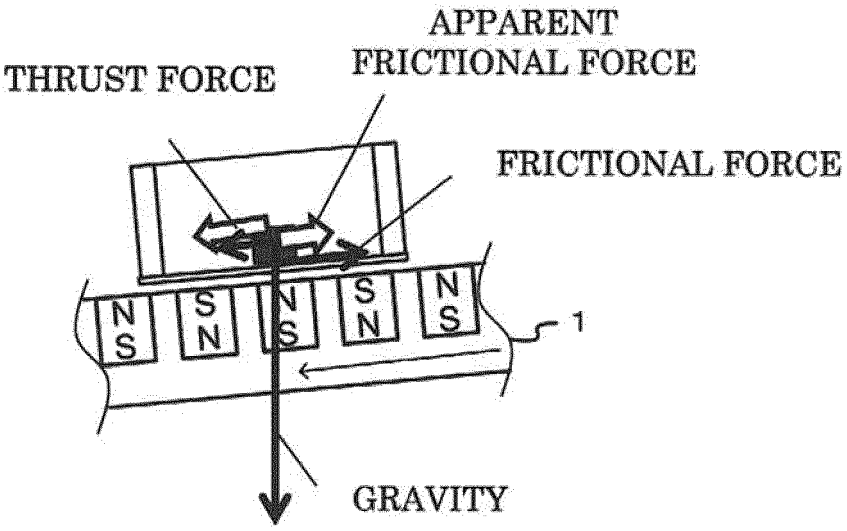
23

FIG. 6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FRICTIONAL FORCE
THRUST FORCE
FRICTIONAL FORCE
N
S
S
N
N
S
S
N
N
S
1
GRAVITY

FIG. 7

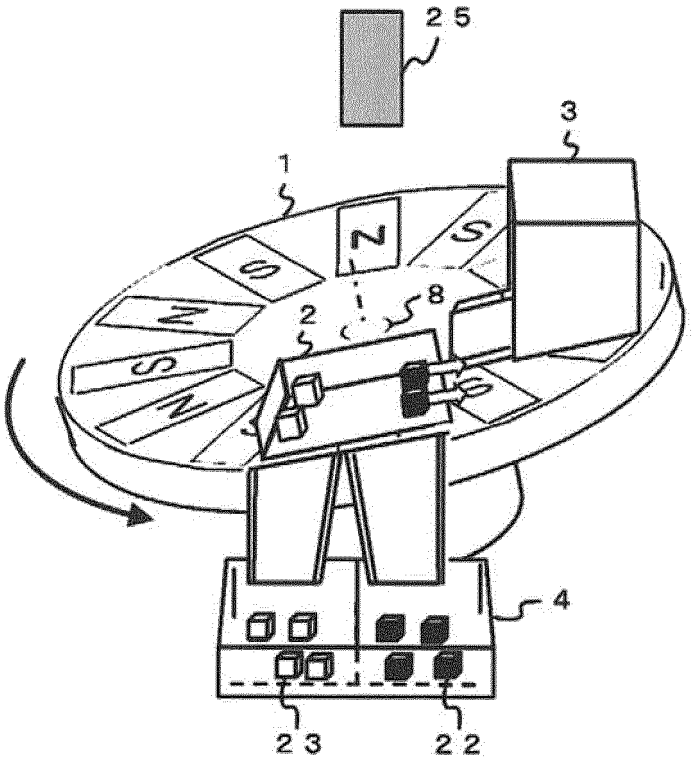


FIG. 8

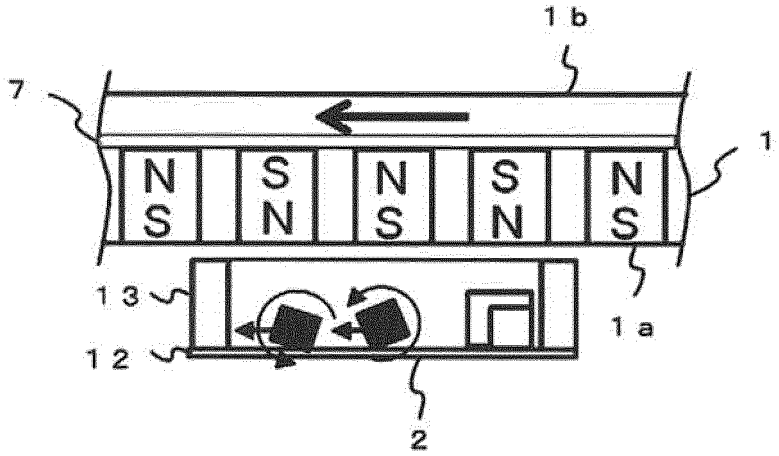


FIG. 9

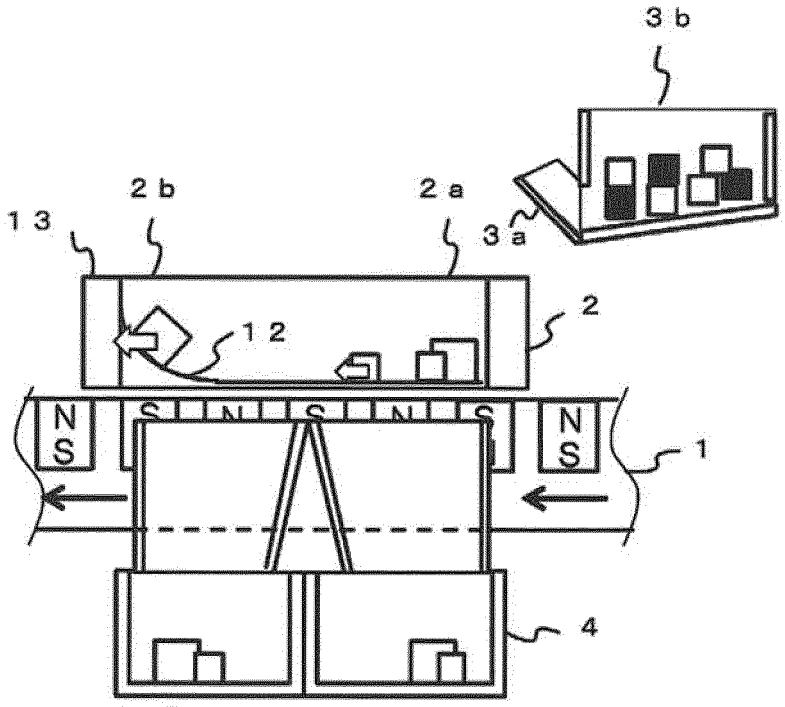
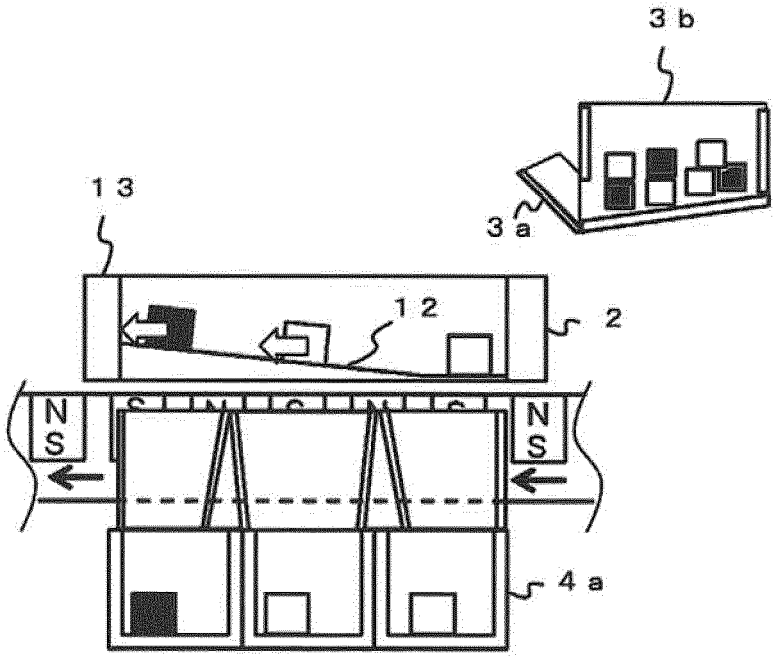


FIG. 10



CONDUCTIVITY	L	M	S
SIZE	L	M	S

FIG. 11

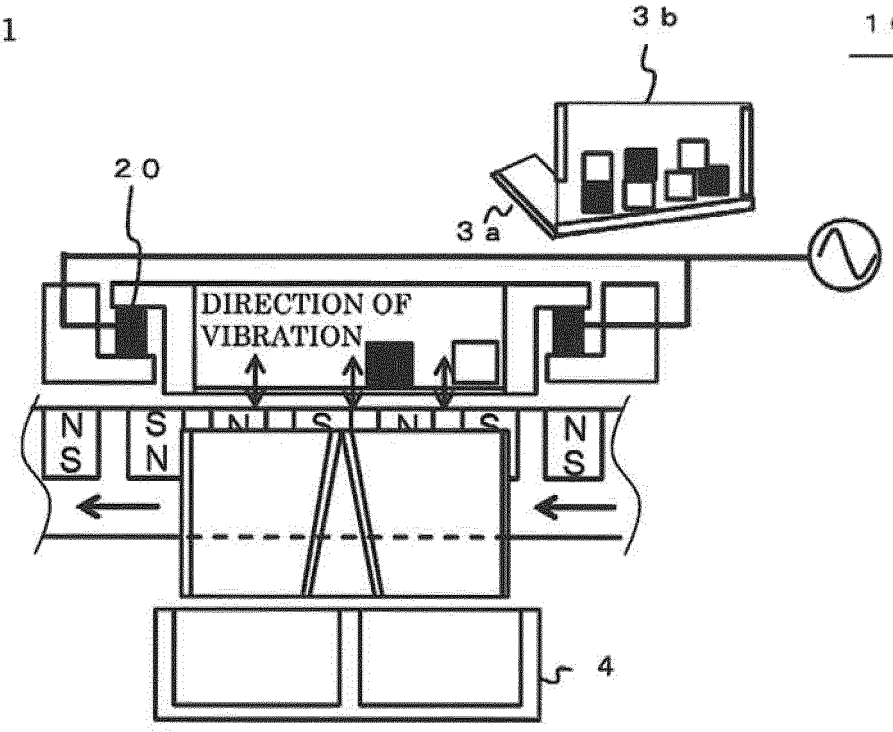


FIG. 12

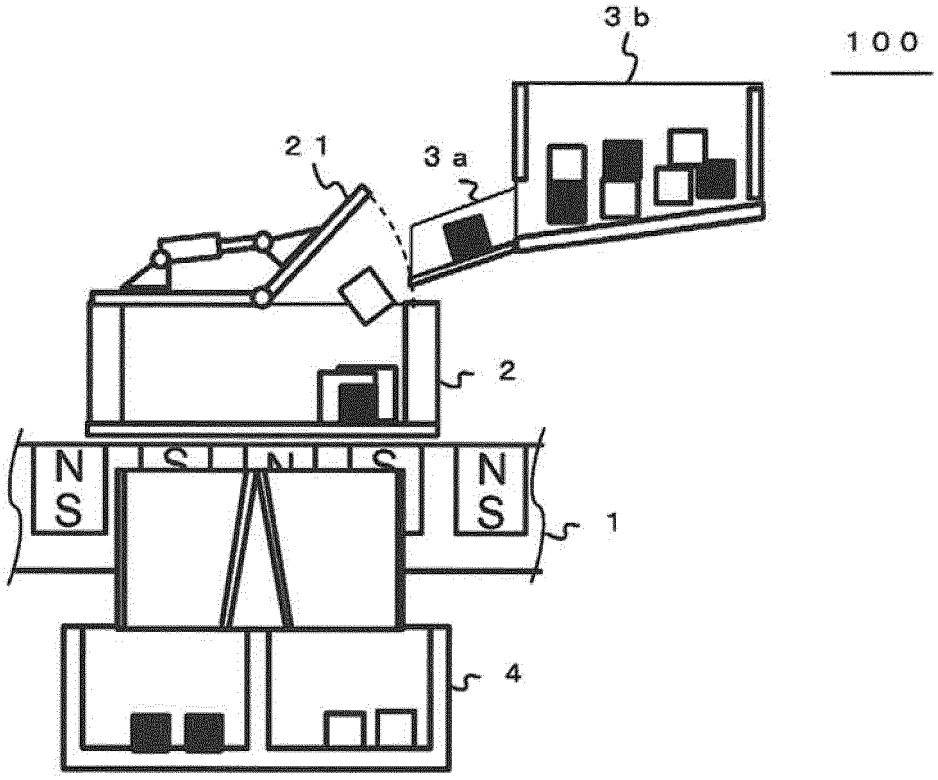


FIG. 13

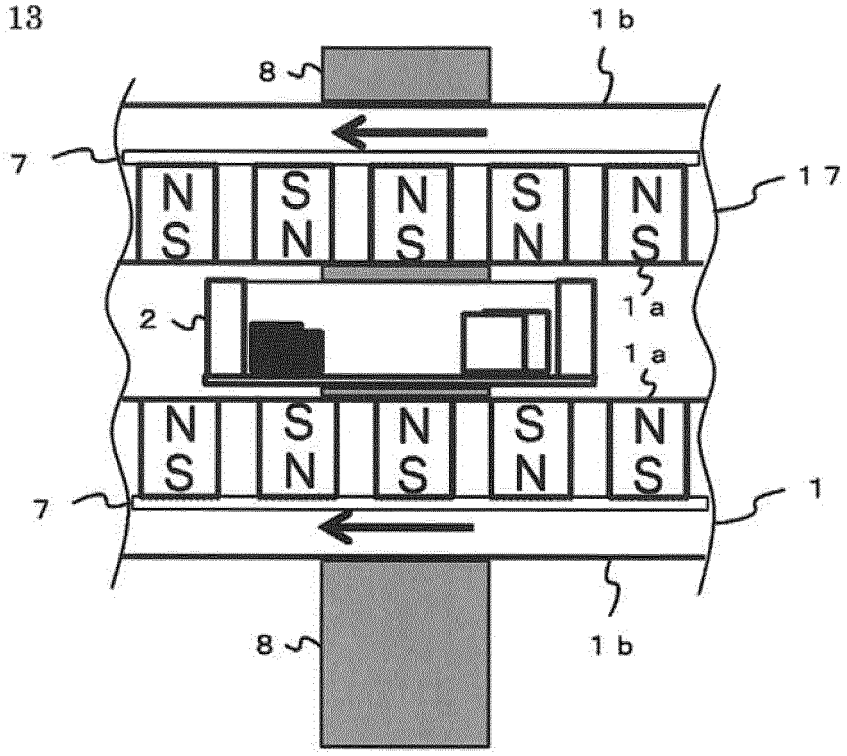


FIG. 14

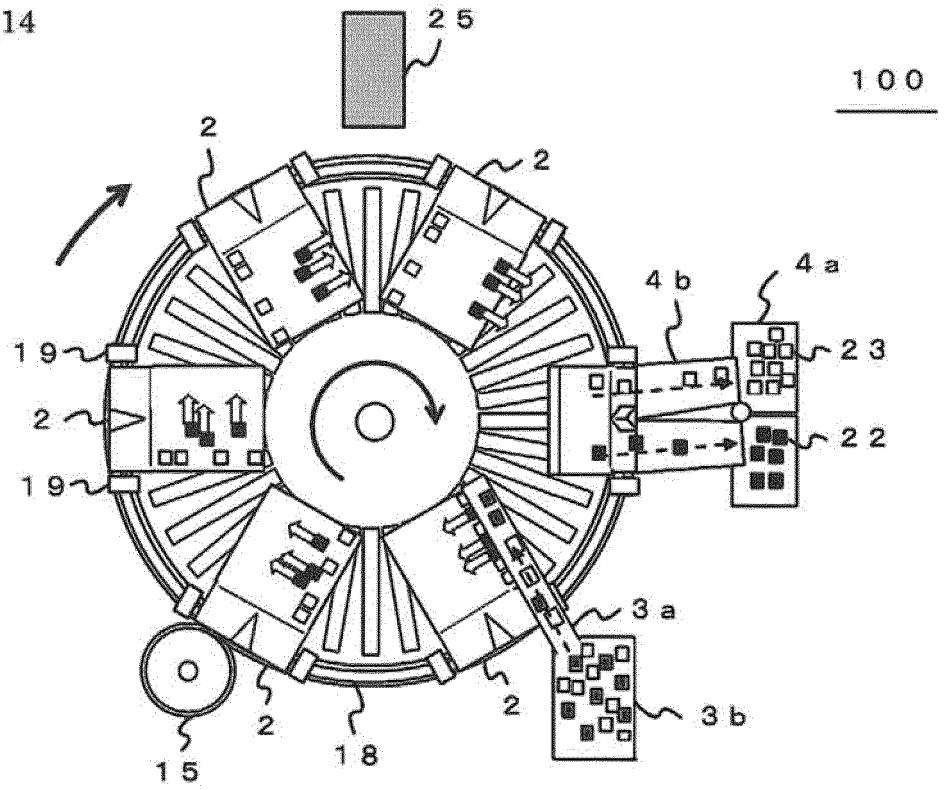


FIG. 15

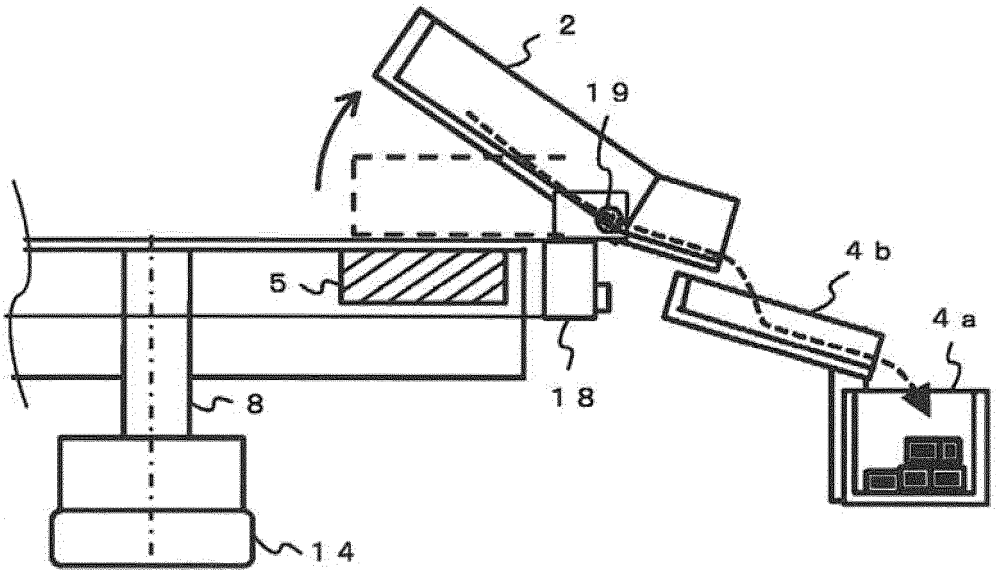


FIG. 16

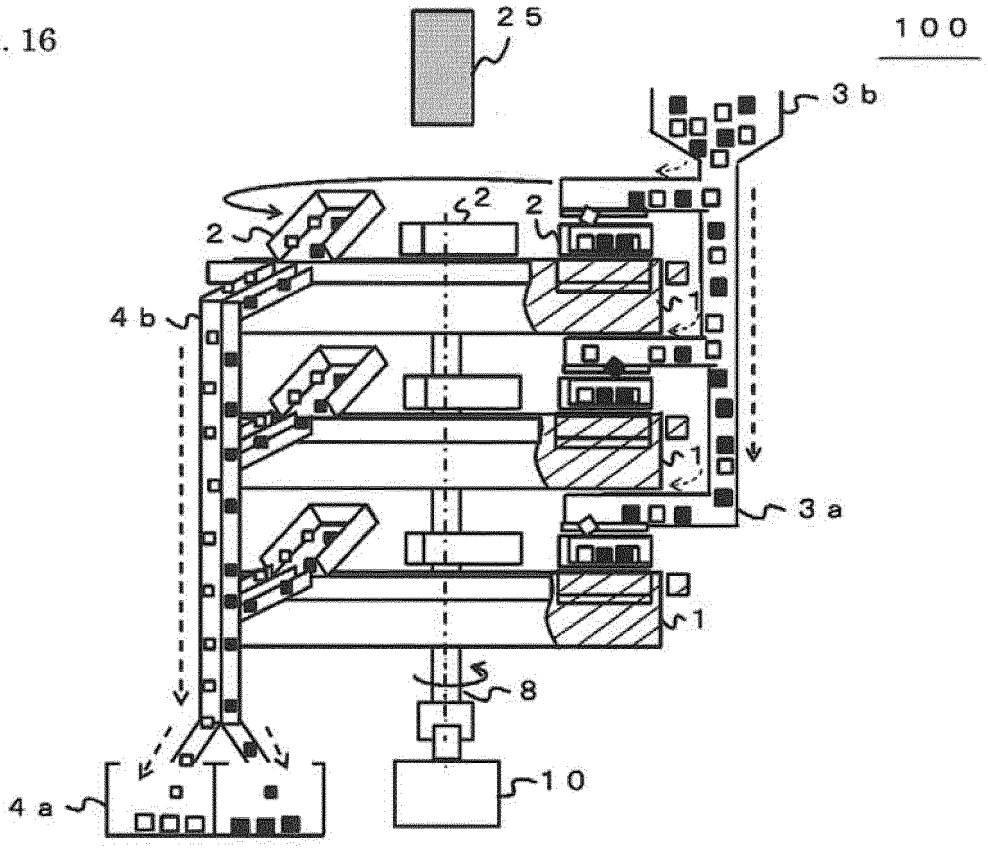


FIG. 17

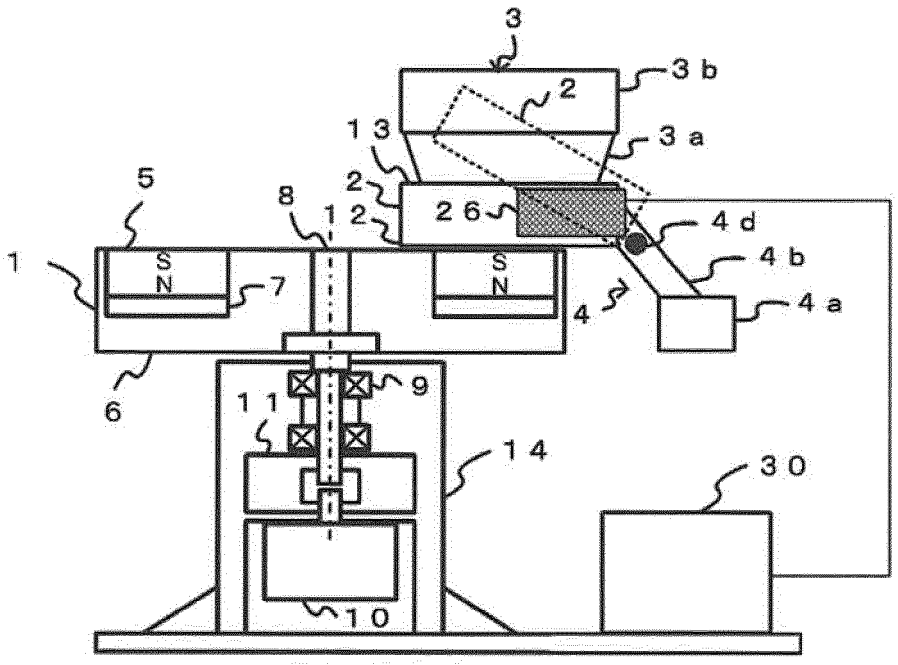
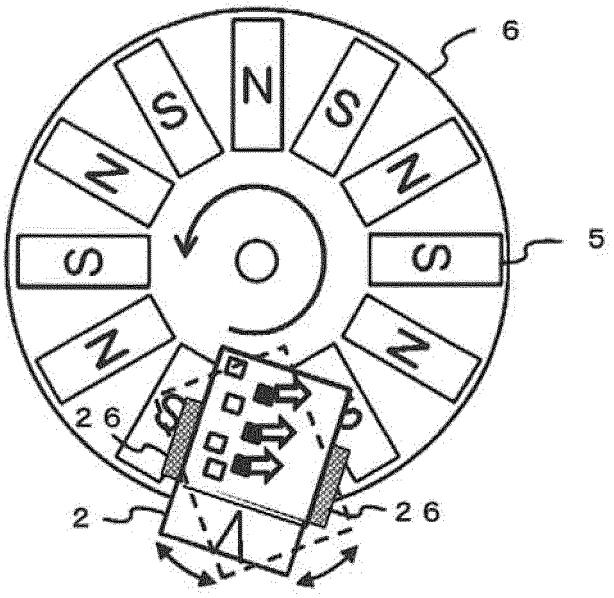

100
3
3b
2
13
3a
5
2
8
12
26
4d
1
S
N
7
S
N
4b
4
4a
6
11
9
14
30
10

FIG. 18


6
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N
N
S
S
5
N
N
26
2
26

FIG. 19

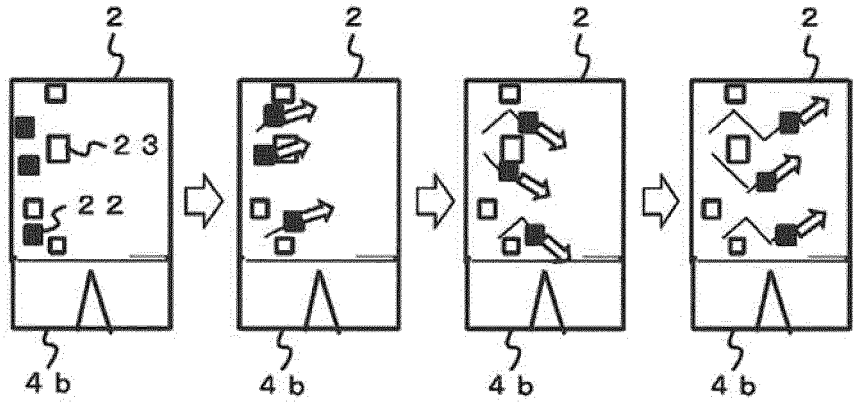


FIG. 20

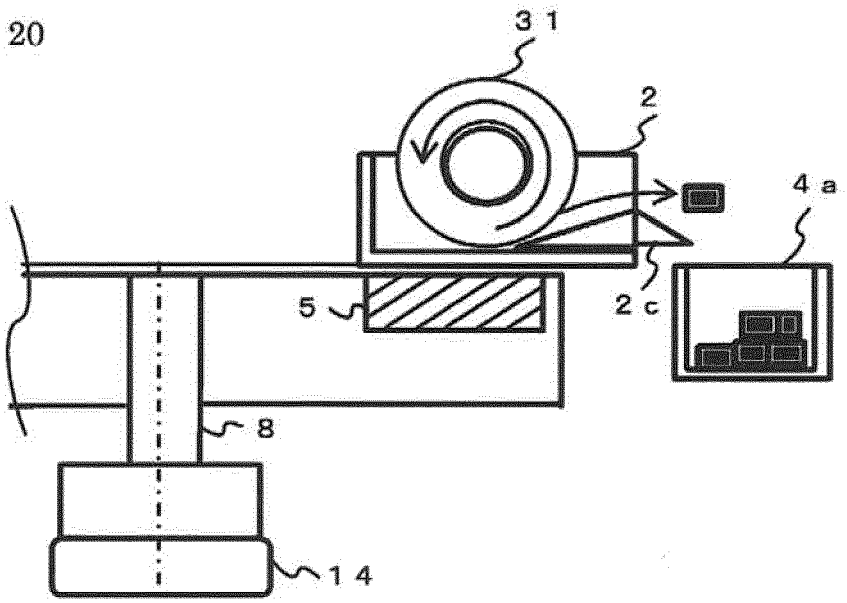


FIG. 21

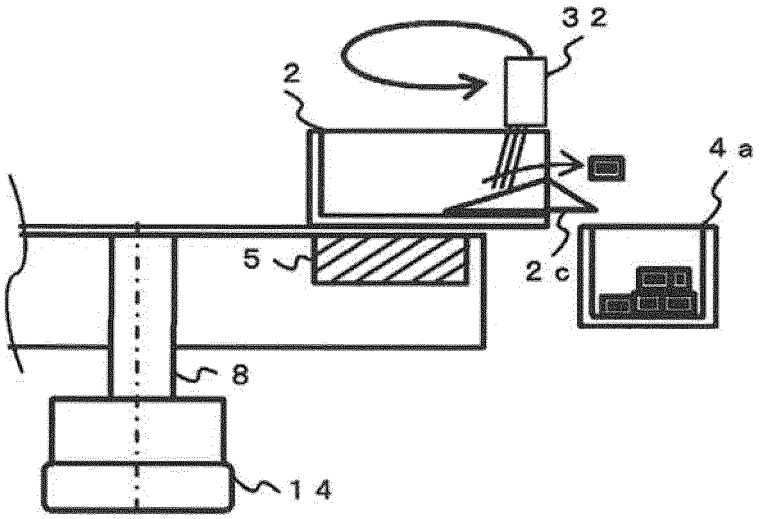


FIG. 22

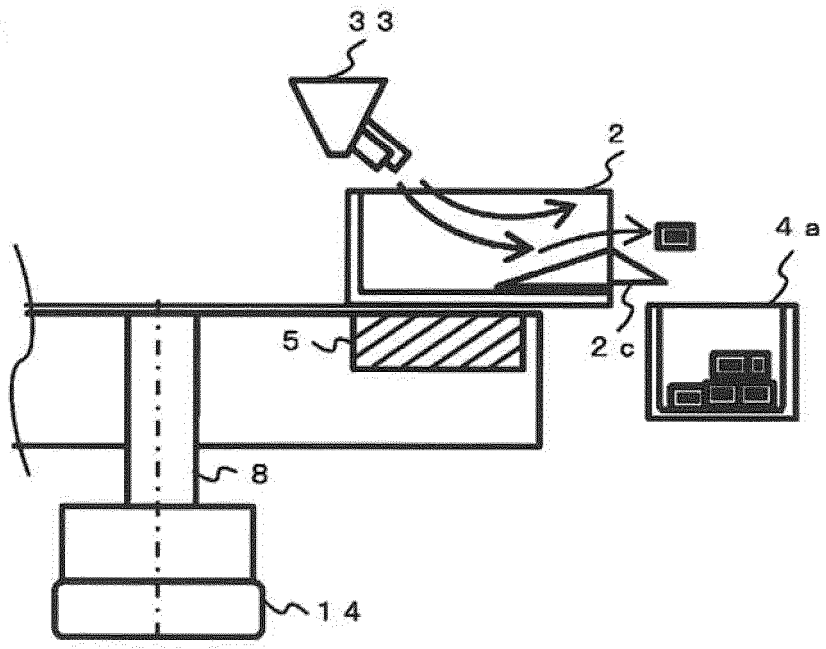


FIG. 23

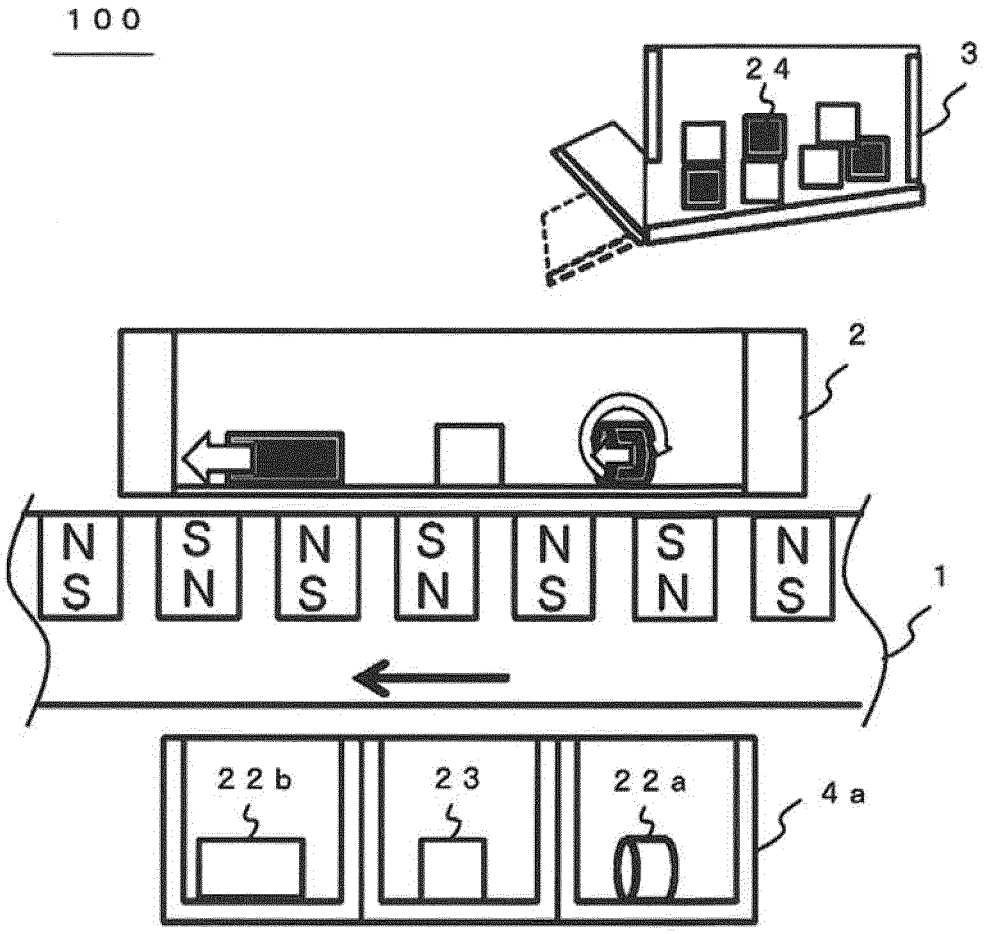
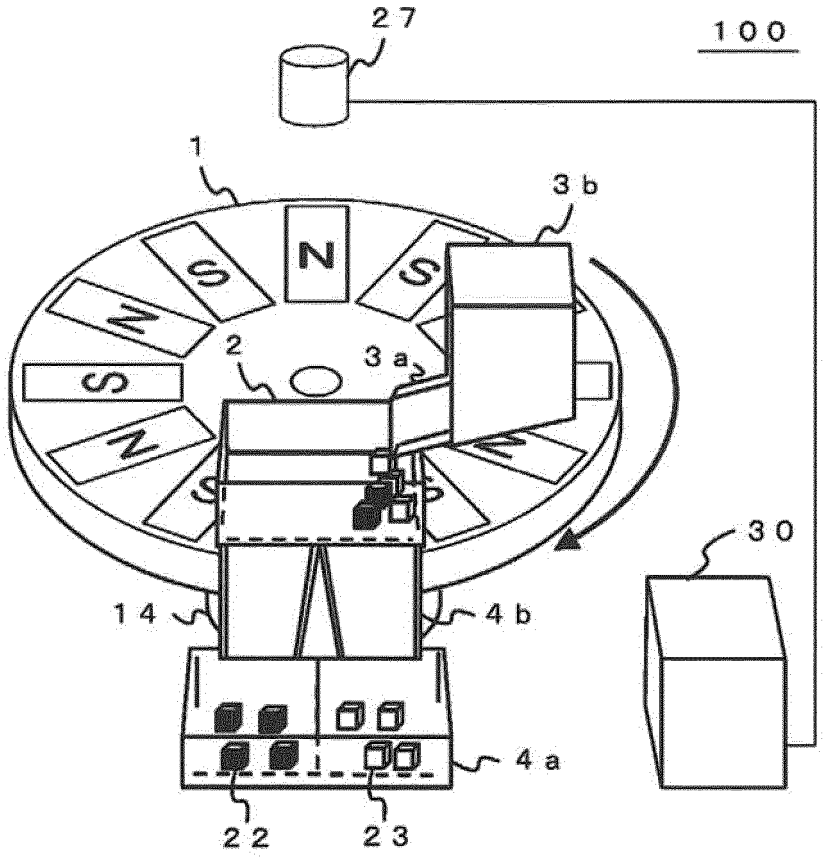


FIG. 24



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/056456

A. CLASSIFICATION OF SUBJECT MATTER
B07C5/344(2006.01)i, *B03C1/23*(2006.01)i, *B03C1/24*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B07C5/344, B03C1/23, B03C1/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 1998/03266 A1 (WESTER TONBERGBAU KG), 29 January 1998 (29.01.1998), entire text; all drawings & DE 19629110 C1 & EP 912248 B1 & AU 3768397 A	1-20
A	DE 19737161 A1 (HAMOS GMBH RECYCLING- UND SEPARATIONSTECHNIK), 22 April 1999 (22.04.1999), entire text; all drawings (Family: none)	1-20
A	JP 2003-103195 A (Kenzo TAKAHASHI), 08 April 2003 (08.04.2003), entire text; all drawings (Family: none)	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2015 (22.05.15)	02 June 2015 (02.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

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Patent documents cited in the description

- JP S50140953 A **[0007]**
- JP S58048343 U **[0007]**
- JP S59032958 A **[0007]**
- JP H07163903 A **[0007]**
- JP 2000510764 A **[0007]**
- JP 3366620 B **[0007]**
- JP H01111459 A **[0007]**