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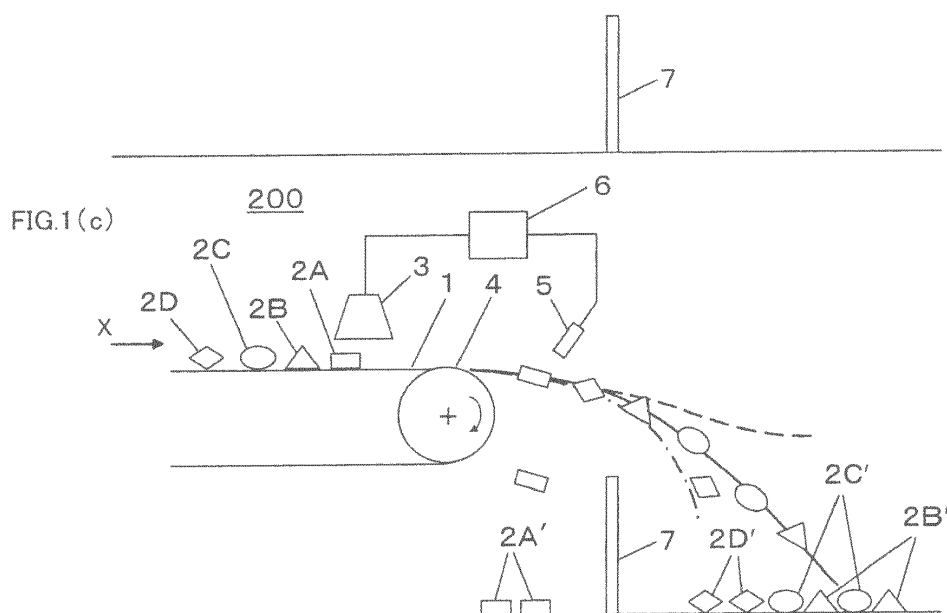
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(54) **Separation apparatus and separation method**

(57) A separation apparatus characterized by comprising:
a conveyor (1) which conveys plural separation targets (2A to 2D) having plural kinds of constituent substances (A, B);
a distinguishing device (3) which distinguishes whether the separation targets (2A to 2D) exist or not on the conveyor (1), and analyzes the constituent substances of the separation targets (2A to 2D) when the separation targets (2A to 2D) exist;
a calculation part (6) which distinguishes shape, size and

position of the separation target (2A) having the predetermined constituent substance (A), based on a distinguishing result by the distinguishing device (3), calculates a center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A), and a group of nozzles (5) recovers the separation target (2A) having the predetermined constituent substance (A) by jetting air to at least the center of gravity of the separation target (2A) having the predetermined constituent substance (A).



Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates to a separation apparatus and a separation method for separating small pieces consisting of a specific constituent substance from a group of the small pieces in which plural small pieces obtained by crushing the used household electric appliances and the like are mixed.

Related art of the Invention

[0002] In recent years, economic activities represented by mass production, mass consumption, and mass disposal have been causing environmental problems on a global scale, such as global warming and depletion of resources.

[0003] Under such circumstance, it is obliged to recycle the used air conditioners, televisions, refrigerators/freezers, and washing machines by paying attention to the recycling household electric appliances so as to build a recycling society.

[0004] The unneeded household electric appliances become small pieces by crushing and then these crushed small pieces are separated for the constituent substance by using magnetism, wind, oscillation, and the like in household electric appliance-recycling plants, so as to reuse them.

[0005] As to metal materials, the high recycling rate is realized because these small pieces are separated for the constituent substance such as iron, copper, aluminum and the like at high purity by using a specific gravity separation device or a magnetism separation device.

[0006] As to resin materials, polypropylene (hereinafter denoted as PP), which has a low specific gravity, is separated from a component having a high specific gravity through specific gravity segregation using water and thus recovered with a relatively high degree of purity.

[0007] However, in the case of the specific gravity segregation using water, an enormous amount of wastewater is produced and it is difficult to separate with high accuracy, for example, polystyrene (hereinafter denoted as PS), acrylonitrile-butadiene-styrene (hereinafter denoted as ABS) and the like, which have similar specific gravities, from each other.

[0008] Further, the separation apparatus, which can separate the resin materials at high accuracy by using a jet of air and is useful for the recycling of the resin materials, has been known (see, for example, Japanese Patent Laid-Open No.2009-279553).

[0009] In the following, such conventional separation apparatus 100 will be described, referring to Fig. 5.

[0010] Here, FIG. 5 is a schematic side view of the conventional separation apparatus 100.

[0011] In the case of the conventional separation apparatus 100, the constituent substance of the resin small piece 101 conveyed by the conveyor 104 is distinguished by the distinguishing device 106 when the resin small piece 101 passes the front of the distinguishing device 106.

[0012] According to the distinguishing result of the distinguishing device 106, air is jetted from the jetting nozzle 110 in the direction intersecting for a flight direction of the resin small piece 101 which falls from the lower end of the shooter 105, when constant time passes after the resin small piece 101 passes through a detection position of the passing detection sensor 111.

[0013] By means of this, it is decided into which side of separation board 130 the resin small piece 101 falls depending on the constituent substance, so that the resin small pieces 101 are separated each other.

SUMMARY OF THE INVENTION

[0014] The inventors of the present invention, however, have noticed that the conventional separation apparatus 100 cannot separate the resin small pieces 101 at accuracy high enough.

[0015] Then the inventors think that the cause is that the air is jetted from the jetting nozzle 110, when constant time which is decided uniformly passes after the resin small piece 101 passes through a detection position of the passing detection sensor 111.

[0016] That is to say, in the case of the conventional separation apparatus 100, many resin small pieces 101 are continuously supplied to the conveyor 104, the constituent substances of the resin small pieces 101 are distinguished, respectively, and air is jetted according to the distinguishing result.

[0017] The shapes and sizes of the resin small pieces 101 are various. When the size of the resin small piece 101 is large for the detection resolution (the minimum size of the detectable resin small piece) of the passing detection sensor 111, plural detection positions exist for the single resin small piece 101. Therefore, plural detection results corresponding to the plural detection positions, respectively, can be obtained with respect to the single resin small piece 101.

[0018] Under such a situation, in many cases, the air jetted first hits only the edge part of the resin small piece 101.

[0019] As a result, the resin small piece 101 which should be separated may not be blown off successfully, because a posture of the resin small piece 101 is changed by rotation due to the shape and size of the resin small piece 101.

[0020] Next, more concrete explanation will be described, referring to Figs. 6(a) to 6(c).

[0021] Here, Fig. 6(a) is a schematic perspective view of the other conventional separation apparatus 150. Figs. 6(b) and 6(c) are explanation views of plural distinguishing results (hereinafter referred to as the group of distinguishing results) by the distinguishing device 3 of the other conventional separation apparatus 150.

[0022] As shown in Fig. 6(a), a small piece 2A as a separation target is conveyed by the conveyor 1, and the constituent substance of the small piece 2A is distinguished when the small piece 2A passes under the distinguishing device 3.

[0023] As shown in Fig. 6(b), when the size of the small piece 2A is large for the detection resolution of the distinguishing device 3, plural distinguishing results 9 are obtained with respect to the single small piece 2A.

[0024] As shown in Fig. 6(b), the plural distinguishing results 9 denoted by black round marks are distinguishing results of the constituent substances distinguished at a constant interval when the small piece 2A passes under the distinguishing device 3, and the group of distinguishing results is formed by the plural distinguishing results 9. Further, these positions of the black round marks denote the distinguishing positions on the small piece 2A.

[0025] The small piece 2A which is conveyed in a conveying direction X (see Fig. 6(a)) by the conveyor 1 is thrown out the conveying end portion 4 of the conveyor 1 and flies.

[0026] The group of nozzles 5 provided in order to separate the small piece 2A, which is made from the specific constituent substance, from the flying path of the small piece 2B made from the other constituent substance is allowed to jet air according to the distinguishing results 9, and the small piece 2A made from the specific constituent substance is shot down into the side near the conveyor 1 with reference to the separation board 7, so as to be separated from the small piece 2B made from the other constituent substance.

[0027] However, it is thought that the air jetted from the group of nozzles 5 hits only an edge part 2A1 of the board-shaped small piece 2A, because the air is jetted from the group of nozzles 5, based on the distinguishing results 9 (that is, the distinguishing results 9 located in the right end in Fig. 6(b)) obtained at the first timing in the group of the distinguishing results for the small piece 2A obtained by the distinguishing device 3.

[0028] As a result, a posture of the small piece 2A is changed by rotation due to the influence of the air that has hit the edge part 2A1 of the small piece 2A.

[0029] In this case, the air is jetted continuously or intermittently based on the other distinguishing results 9 in the group of the distinguishing results, however, the air from the group of nozzles 5 does not hit the small piece 2A correctly, because the posture of the small piece 2A has been changed already.

[0030] As a result, the small piece 2A, which should be shot down into the side near the conveyor 1 with reference to the separation board 7, is not shot down into the side, flies the course denoted by the arrow, and falls to a place distant from the conveyor 1 with reference to the separation board 7 as shown in Fig. 6(a).

[0031] By the way, there is a case where erroneous decision, in which the distinguishing results which are obtained on the same small piece 2A differ, occurs. That is, as shown in Fig. 6(c), the distinguishing result 9B which should be the same as the distinguishing result 9A may be obtained as a distinguishing result which is different from the distinguishing result 9A by the erroneous decision due to an electric noise or a shape of material. Here, it is supposed that the distinguishing result 9A denotes a correct distinguishing result and the distinguishing result 9B denotes an incorrect distinguishing result.

[0032] In this case, the air is jetted based on the incorrect distinguishing result 9B. Therefore, the small piece 2A, which should be separated from the small piece 2B made from the other constituent substance, is not separated correctly, and as a result, the small piece 2A made from the specific constituent substance, which should be separated, is mixed in the group of the small piece 2B made from the other constituent substance.

[0033] An object of the present invention is, in view of the above-mentioned conventional problems, to provide a separation apparatus and a separation method, which can recover the separation target at higher accuracy.

[0034] The 1st aspect of the present invention is a separation apparatus which analyzes constituent substances of separation targets and recovers the separation target having a predetermined constituent substance, and the separation apparatus characterized by comprising:

a conveying unit (1) which conveys plural separation targets (2A, 2B, 2C, 2D) having plural kinds of constituent substances (A, B);

a distinguishing unit (3) which distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not on the conveying unit (1), and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) when the separation targets (2A, 2B, 2C, 2D) exist on the conveying unit (1); and

a recovering unit (5, 6) which distinguishes shape, size and position of the separation target (2A) having the predetermined constituent substance (A), based on a distinguishing result by the distinguishing unit (3), calculates a center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A), based on the shape,

the size and the position of the separation target (2A) having the predetermined constituent substance (A), which is distinguished, and recovers the separation target (2A) having the predetermined constituent substance (A) by jetting air or gas to at least the center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A).

[0035] The 2nd aspect of the present invention is the separation apparatus according to the 1st aspect of the present invention, wherein

the distinguishing unit (3) has lattice-like plural distinguishing points at a predetermined position for the conveying unit (1), distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not every each the distinguishing point, and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) every each the distinguishing point when the separation targets (2A, 2B, 2C, 2D) exist, and

the recovering unit (5, 6) distinguishes shape, size and position of the separation targets (2A, 2B, 2C, 2D) by analyzing an adjacency state of the distinguishing points where the separation targets (2A, 2B, 2C, 2D) exist, and specifies the separation target (2A) having the predetermined constituent substance (A), to which the air or gas is to be jetted, based on a score which is given to each of the plural kinds of constituent substances (A, B).

[0036] The 3rd aspect of the present invention is the separation apparatus according to the 1st aspect of the present invention, wherein

[0037] the distinguishing unit (3) has lattice-like plural distinguishing points at a predetermined position for the conveying unit (1), distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not every each the distinguishing point, and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) every each the distinguishing point when the separation targets (2A, 2B, 2C, 2D) exist, and

the recovering unit (5, 6) distinguishes the shape, the size and the position of the separation target (2A) having the predetermined constituent substance by analyzing an adjacency state of the distinguishing points where the constituent substances of the separation targets (2A, 2B, 2C, 2D) are the same.

[0038] The 4th aspect of the present invention is the separation apparatus according to the 1st aspect of the present invention, wherein

the distinguishing unit (3) has lattice-like plural distinguishing points at a predetermined position for the conveying unit (1), distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not every each the distinguishing point, and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) every each the distinguishing point when the separation targets (2A, 2B, 2C, 2D) exist, and

the recovering unit (5, 6) distinguishes shape, size and position of the separation targets (2A, 2B, 2C, 2D) by analyzing an adjacency state of the distinguishing points where the separation targets (2A, 2B, 2C, 2D) exist, and specifies the separation target (2A) having the predetermined constituent substance (A), to which the air or gas is to be jetted, based on the constituent substance (A, B) of each separation target (2A, 2B, 2C, 2D) on the distinguishing point which is located in a central part of each shape of the distinguished separation targets (2A, 2B, 2C, 2D).

[0039] The 5th aspect of the present invention is the separation apparatus according to any one of the 1st to 4th aspects of the present inventions,

wherein the recovering unit (5, 6) jets the air or gas to a circumference of the center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A) as well as the center of gravity (11).

[0040] The 6th aspect of the present invention is a separation method of analyzing constituent substances of the separation targets and recovering the separation target having a predetermined constituent substance, and the separation method characterized by comprising steps of:

calculating a center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A), and

jetting air or gas to at least the center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A).

Advantageous Effects of the Invention

[0041] According to the present invention, it is possible to provide a separation apparatus and a separation method, which can recover the separation target at higher accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042]

Figs. 1(a), 1(b) and 1(c) are schematic side views of a separation apparatus according to Embodiment of the present

invention;

Fig. 2 is a schematic plan view of a separation apparatus according to Embodiment of the present invention;

Figs. 3(a) and 3(b) are schematic perspective views of a separation apparatus according to Embodiment of the present invention;

Figs. 3(c) and 3(d) are explanation views of the group of distinguishing results by the distinguishing device according to Embodiment of the present invention;

Figs. 4(a), 4(b), 4(c) and 4(d) are explanation views of the groups of distinguishing results obtained by the distinguishing device of the separation apparatus according to Embodiment of the present invention;

Fig. 4(e) is an explanation view of a distinguishing application area shown in Fig. 4(d);

Fig. 5 is a schematic side view of the conventional separation apparatus;

Fig. 6(a) is a schematic perspective view of the other conventional separation apparatus; and

Figs. 6(b) and 6(c) are explanation views of group of distinguishing results by the distinguishing device of the other conventional separation apparatus.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0043] In the following, an embodiment of the present invention will be described, referring to drawings.

(Embodiment 1)

[0044] A configuration and operation of a separation apparatus 200 according to the present Embodiment 1 will be described, mainly referring to Figs. 1(a) to 1(c) and Fig. 2.

[0045] Here, Figs. 1(a), 1(b) and 1(c) are schematic side views of a separation apparatus 200 according to the present Embodiment 1 of the present invention. Fig. 2 is a schematic plan view of the separation apparatus 200 according to the present Embodiment 1 of the present invention.

[0046] By the way, the following Embodiment is merely one example of the present invention, and the present invention is not limited to the Embodiment.

[0047] In this Embodiment 1, one example of the separation method according to the present invention will also be described, while describing the operation of the separation apparatus 200.

[0048] According to the present Embodiment 1, since the constituent substances of small pieces 2A, 2B, 2C and 2D are analyzed by a distinguishing device 3 having an optical device which analyzes the constituent substances of the small pieces 2A to 2D, based on the distributions of intensity of reflected light which are detected by irradiating the small pieces 2A to 2D with light, it is possible to separate the small pieces 2A to 2D consisting of the resin material, which cannot be separated by the conventional specific gravity separation device.

[0049] The optical device of the distinguishing device 3 has plural light emitting/light receiving elements (not shown) which are disposed in the direction perpendicular to the conveyance direction X of the conveyor 1 (see Fig. 2). In this Embodiment, since the conveyor 1 is allowed to have another distribution of intensity of reflected light that is different from each of the unique distributions of intensity of reflected light of the resin materials, it becomes possible to distinguish whether the small pieces 2A to 2D exist or not and analyze the constituent substances thereof as described below.

[0050] More specifically, the distinguishing device 3 analyzes the constituent substances of the small pieces 2A to 2D as the separation targets which are conveyed by the conveyor 1, and the analyzed small piece 2A made from the specific constituent substance is separated from the flying paths of the other small pieces 2B to 2D which are thrown out the conveying end portion 4 of the conveyor 1.

[0051] That is, the separation apparatus 200 specifies the small piece 2A which should be separated, based on information about the constituent substances analyzed by the distinguishing device 3, determines the timing at which air is allowed to jet pulsingly from nozzles which are disposed above or below the flying path, and blows off the small piece 2A made from the specific constituent substance by jetting the air pulsingly based on the timing in order to separate the small piece 2A from the other small pieces 2B to 2D.

[0052] In this Embodiment, as described below, the air is jetted at least to a position of a center of gravity of the small piece 2A.

[0053] In Figs. 1(a) to 1(c), the small pieces 2A, 2B, 2C and 2D denote the small pieces before passing under the distinguishing device 3, and the small pieces 2A', 2B', 2C' and 2D' denote the small pieces after passing under the distinguishing device 3. Here, the small pieces 2A' to 2D' are the same as the small pieces 2A to 2D, respectively.

[0054] First, a configuration of a separation apparatus 200 according to Embodiment 1 will be described more concretely, referring to Fig. 1(a) and Fig. 2.

[0055] A group of nozzles 5 is provided with plural nozzles which jet air in order to separate the small piece 2A made from the specific constituent substance from the flying path of the small pieces 2A to 2D as separation targets which are conveyed and are thrown out the conveying end portion 4 of the conveyor 1, and the plural nozzles are disposed in

a width direction of the conveyor 1.

[0056] A calculation part 6 specifies the small piece 2A which should be separated, based on information about the constituent substances analyzed by the distinguishing device 3, and determines the timing at which the air is allowed to jet pulsingly from the group of nozzles 5.

[0057] A separation board 7 is a member which is disposed so as to separate the small piece 2A made from the specific constituent substance, which has been separated from the flying paths of the other small pieces 2B to 2D.

[0058] Each size of the small pieces 2A to 2D is about 10 to 100 mm with respect to a lengthwise direction and a lateral direction, and is about 0.5 to 2 mm with respect to a thickness direction.

[0059] A conveyance speed of the conveyor 1 is about 2 to 3 m/sec.

[0060] The interval between the nozzles of the group of nozzles 5, which are disposed in the direction perpendicular to the conveyance direction X of the conveyor 1, is about 5 to 10 mm.

[0061] Next, operation of the separation apparatus 200 according to Embodiment 1 will be described more concretely, referring to Figs. 1(a) to 1(c).

[0062] As shown in Fig. 1(b), the distinguishing device 3 distinguishes whether the small piece 2A' as one of the separation targets, which passed under the distinguishing device 3, exists or not, and analyzes the constituent substance of the small piece 2A' when the distinguishing device 3 judges that the small piece 2A' exists.

[0063] As shown in Fig. 1(c), the small pieces 2A' to 2D' which have been distinguished by the distinguishing device 3 are thrown out the conveying end portion 4 of the conveyor 1.

[0064] When the small piece 2A' made from the specific constituent substance, which should be separated, passes under the group of nozzles 5, the air is jetted pulsingly from the nozzle corresponding to the position of the small piece 2A'.

[0065] Then, the small piece 2A' made from the specific constituent substance, which should be separated, is blown off and separated from the flying paths of the other small pieces 2B' to 2D'.

[0066] The typical flying paths of the small pieces 2B' to 2D' which have been thrown out the conveying end portion 4 of the conveyor 1 are indicated by a solid line, a dotted line and a chain line.

[0067] Next, it will be described more concretely how the small piece 2A made from the specific constituent substance, which should be separated, is specified, based on information about the constituent substances analyzed by the distinguishing device 3, and how the timing, at which the air is allowed to jet pulsingly from the group of nozzles 5, is determined.

[0068] When the small pieces 2A to 2D as the separation targets which are conveyed by the conveyor 1 pass under the distinguishing device 3, the distinguishing device 3 distinguishes whether the small pieces 2A to 2D exist or not and analyzes the constituent substances thereof.

[0069] That is, the distinguishing device 3 distinguishes whether the small pieces 2A to 2D exist or not and analyzes the constituent substances thereof at a constant cycle or a constant interval with respect to the parallel and perpendicular directions with reference to the conveyance direction X of the conveyor 1.

[0070] Therefore, for example, when the size of the small piece 2A is large for the detection resolution of the distinguishing device 3, plural distinguishing results are obtained for the single small piece 2A.

[0071] As for this point, more concrete explanation will be described as follows, referring to Fig. 3(a) and Fig. 3(b).

[0072] Here, Fig. 3(a) and Fig. 3(b) are schematic perspective views of the separation apparatus 200 according to Embodiment of the present invention. Fig. 3(c) and Fig. 3(d) are explanation views of the groups of distinguishing results by the distinguishing device 3 of the separation apparatus 200 according to Embodiment of the present invention.

[0073] As shown in Fig. 3(a), for example, as for the small piece 2A conveyed by the conveyor 1, the constituent substances corresponding to the distinguishing positions 8C to 8E are analyzed, respectively.

[0074] Since the small piece 2A does not exist at the distinguishing positions 8A, 8B, 8F and 8G, data indicating that small piece 2A does not exist is obtained. Here, the distinguishing positions 8A, 8B, 8C, 8D, 8E, 8F and 8G denote the positions where the distinguishing device 3 distinguishes whether the small pieces exist or not and analyzes the constituent substances thereof by using the plural light emitting/light receiving elements which the distinguishing device 3 is provided with.

[0075] Next, as shown in Fig. 3(b), when a certain period of time passes and the small piece 2A is further conveyed in the conveyance direction X by the conveyor 1, the constituent substances at the distinguishing positions 8B to 8F are analyzed, respectively.

[0076] Since the small piece 2A does not exist at the distinguishing positions 8A and 8G, data indicating that small piece 2A does not exist is obtained.

[0077] Thus, as shown in Fig. 3(c), distinguishing operation at the distinguishing positions 8A to 8G is repeated at a constant interval, and plural distinguishing results 9 are obtained with respect to the single small piece 2A.

[0078] That is, the distinguishing device 3 has the plural light emitting/light receiving elements as an optical device disposed one-dimensionally, which correspond to the distinguishing positions 8A to 8G, and repeats the distinguishing operation with respect to the conveyance direction X of the conveyor 1. Thus, the lattice-like plural distinguishing results 9 which are arranged two-dimensionally for the conveyor 1 are obtained.

[0079] By the way, the distinguishing device 3 may have an optical device which, for example, has plural light emit-

ting/light receiving elements arranged two-dimensionally, and may collectively obtain many distinguishing results arranged two-dimensionally.

[0080] When the constituent substance is distinguished continuously with respect to the parallel or perpendicular direction with reference to the conveyance direction X, the calculation part 6 judges that the small piece 2A exists as a single lump on a figure which is formed by the distinguishing positions 8A to 8G.

[0081] That is, the calculation part 6 analyzes an adjacency state of the plural distinguishing results 9, and judges that the plural distinguishing results 9, which correspond to the distinguishing positions on the same figure, are the distinguishing results that should be dealt with as distinguishing results with respect to the single small piece 2A.

[0082] Here, when the adjacency state of the plural distinguishing results 9 is analyzed by the calculation part 6, the adjacency state is analyzed by distinguishing whether the small piece exists or not at the distinguishing positions 8A to 8G without taking the constituent substance of the small piece into consideration.

[0083] Further, when the calculation part 6 judges that the small piece 2A which should be blown off and be separated exists on the figure described above, the calculation part 6 performs quadrature and calculates the position of the center of gravity of the figure.

[0084] For example, as shown in Fig. 3(d), a solid line 10 which encloses plural distinguishing results 9 is created, the quadrature is performed for the figure which is formed by the solid line 10 and considered the shape of the small piece 2A, and the position of the center of gravity 11 of the figure is calculated.

[0085] Then, when the center of gravity 11 passes under the group of nozzles 5, air is jetted from the corresponding nozzle which corresponds to the position of the center of gravity 11, so that the small piece 2A' is blown off and separated.

[0086] By the way, one nozzle that is the nearest to the position of the center of gravity 11 may be used as the corresponding nozzle, or two or more nozzles around the position of the center of gravity 11 may be used as the corresponding nozzles, according to the size of the small piece 2A.

[0087] The length of an air injection period may be adjusted according to the size of the small piece 2A. More concretely, when the weight of the small piece 2A and/or the conveyance speed of the conveyor 1 are large, the air may be jetted not only at the timing when the center of gravity 11 passes under the group of nozzles 5 but also continually or intermittently at least until the center of gravity 11 passes under the group of nozzles 5 from the upper stream side of the position of the group of nozzles 5.

[0088] Accordingly, even when the weight of the small piece 2A and/or the conveyance speed of the conveyor 1 are large, the small piece 2A can be separated correctly from the small pieces 2B to 2D, because the air also hits a front side portion of the small piece 2A, which is away from the center of gravity 11 by a desired distance with respect to the conveyance direction X of the conveyor 1.

[0089] By the way, also in this embodiment, erroneous decision resulting from an electric noise, a shape of material, and the like may occur.

[0090] That is, as described above, since the optical device is used in the distinguishing device 3, the erroneous decision due to the shape of the material, the surface condition of the material, and the like may occur.

[0091] For example, when the small piece 2A of PS should be separated, there is a case where the distinguishing results 9 which show that PS exists in the small piece 2B of PP are obtained. If the air is jetted according to such distinguishing results 9, the small piece 2B of PP may be separated.

[0092] Next, more concrete explanation will be described, referring to Figs. 4(a) to 4(e).

[0093] Figs. 4(a), 4(b), 4(c) and 4(d) are the explanation views of the groups of distinguishing results obtained by the distinguishing device 3 of the separation apparatus 200 according to Embodiment of the present invention, respectively, and Fig. 4(e) is the explanation view of the distinguishing application area shown in Fig. 4(d).

[0094] There is a case where the group of distinguishing results with respect to the single small piece 2A which should be separated, as shown in Fig. 4(a), has been formed only by the distinguishing result 9A which indicates the constituent substance A of the small piece 2A correctly. And also, there is a case where the group of distinguishing results with respect to the single small piece 2A which should be separated, as shown in Fig. 4(b), has been formed by the distinguishing result 9A which indicates the constituent substance A of the small piece 2A correctly and the distinguishing result 9B which indicates the constituent substance B rather than the constituent substance A of the small piece 2A incorrectly.

[0095] Further, as shown in Fig. 4(c), there is a case where it is judged that the two overlapping small pieces 2A and 2B exist as a single lump.

[0096] Therefore, it may be determined whether the jetting of air is carried out or not, by simply ignoring the distinguishing results except the distinguishing result 9A being a large majority, or it may be determined whether the jetting of air is carried out, by using an evaluation function, based on a score which is given to each of the plural kinds of constituent substances.

[0097] Here, an example, in which it is determined by using evaluation functions whether the jetting of air is carried out or not, will be described. That is, the evaluation functions are expressed by the following (Expression 1) and (Expression 2). A determination value J_{OK} which denotes a permission degree of blowing off is defined by the (Expression

1) and a determination value J_{NG} which denotes a disapproval degree of blowing off is defined by the (Expression 2). According to this example, in the case of $J_{OK} < J_{NG}$, the jetting of air is not carried out, and in the case of $J_{OK} \geq J_{NG}$, the jetting of air is carried out.

(Expression 1)

$$J_{OK} = p(A)q(A)\alpha_{OK}(A) + p(B)q(B)\alpha_{OK}(B).$$

(Expression 2)

$$J_{NG} = p(A)q(A)\alpha_{NG}(A) + p(B)q(B)\alpha_{NG}(B).$$

Here, $p(A)$ is a constant showing the probability of a distinguishing result with respect to the constituent substance A, and

$p(B)$ is a constant showing the probability of a distinguishing result with respect to the constituent substance B.

[0098] For example, if it is known beforehand that the erroneous decision about the constituent substance A occurs easily, $p(A)$ is set smallish.

[0099] Next, $q(A)$ is an area ratio (%) about the constituent substance A, and

[0100] $q(B)$ is an area ratio (%) about the constituent substance B.

[0101] For example, $q(A)$ is a numerical value which is obtained by dividing the number of the distinguishing result 9A, which correctly indicates the constituent substance A about a figure which is considered a shape of the small piece 2A, by the summation of the number of all the distinguishing results 9A, 9B and the like about the same figure.

[0102] As shown in Fig. 4(c), when the number of the distinguishing result 9A, which indicates the constituent substance A, is 15, and the summation of the number of all the distinguishing results 9A and 9B is 23 (=15+8), $q(A)$ is about 65%.

[0103] Further, $\alpha_{OK}(A)$ is a predetermined constant about the constituent substance A, which shows the degree of promoting the blowing off of the small piece,

$\alpha_{OK}(B)$ is a predetermined constant about the constituent substance B, which shows the degree of promoting the blowing off of the small piece,

$\alpha_{NG}(A)$ is a predetermined constant about the constituent substance A, which shows the degree of suppressing the blowing off of the small piece, and

$\alpha_{NG}(B)$ is a predetermined constant about the constituent substance B, which shows the degree of suppressing the blowing off of the small piece.

[0104] Regarding the constituent substance A, for example, in a case where importance thereof is high and then an increase in recovering quantity of the constituent substance A is desired, $\alpha_{OK}(A)$ is set largish, and for example, in a case where the accuracy of separation thereof is required and mixing reduction of the constituent substance B is desired, $\alpha_{NG}(A)$ is set largish.

[0105] Regarding the constituent substance B, for example, in a case where importance thereof is high and then an increase in recovering quantity of the constituent substance B is desired, $\alpha_{NG}(B)$ is set largish, and for example, in a case where the accuracy of separation thereof is required and mixing reduction of the constituent substance A is desired, $\alpha_{OK}(B)$ is set largish.

[0106] Incidentally, in this case, the constituent substance A is recovered by carrying out the jetting of air, and the constituent substance B is recovered by not carrying out the jetting of air.

[0107] Regarding the constituent substance A, for example, in a case where, although the importance thereof is high, the accuracy of separation thereof is not required so much, the constants indicated by the following (Expression 3) are set.

(Expression 3)

$$\alpha_{OK}(A)=0.7, \alpha_{NG}(A)=0.3.$$

[0108] Further, regarding the constituent substance A, for example, in a case where, although the importance thereof is not so high, the accuracy of separation thereof is required, the constants indicated by the following (Expression 4) are set.

(Expression 4)

$$\alpha_{OK}(A)=0.5, \alpha_{NG}(A)=0.5.$$

[0109] Similarly, regarding the constituent substance B, for example, in a case where, although the importance thereof

is high, the accuracy of separation thereof is not required so much, the constants indicated by the following (Expression 5) are set.

$$\begin{aligned} & \text{(Expression 5)} \\ & \alpha_{OK}(B)=0.5, \alpha_{NG}(B)=0.5. \end{aligned}$$

[0110] Further, regarding the constituent substance B, for example, in a case where, although the importance thereof is not so high, the accuracy of separation thereof is required, the constants indicated by the following (Expression 6) are set.

$$\begin{aligned} & \text{(Expression 6)} \\ & \alpha_{OK}(B)=0.7, \alpha_{NG}(B)=0.3. \end{aligned}$$

[0111] From the above, for example, in a case where, although the importance of the constituent substance A is high, the accuracy of separation thereof is not required so much and, although the importance of the constituent substance B is not so high, the accuracy of separation thereof is required, the constants indicated by the (Expression 3) and (Expression 6), respectively, are adopted.

[0112] By the way, if it is known beforehand that the erroneous decision occurs easily near the edge part of the small piece 2A, it may be determined whether the jetting of air is carried out or not, based on the distinguishing results in the center portion of the small piece 2A.

[0113] As shown in Fig. 4(d), if it is known beforehand that the erroneous decision occurs easily near the edge part 2A1 of the small piece 2A, it may be determined whether the jetting of air is carried out or not, by applying the above-mentioned evaluation function to the distinguishing results 9 which exist in a distinguishing application area 12 in the center portion of the small piece 2A except the neighborhood of the edge part 2A1.

[0114] Here, the distinguishing application area 12 is an area which is constituted only by the below-mentioned distinguishing positions Pc, as shown in Fig. 4(e). That is, when the data of four distinguishing results which indicate the existence of the small piece 2A is obtained at the four distinguishing positions Pu, Pd, Ps1 and Ps2, which exist around the distinguishing position Pc, the distinguishing application area 12 is set up. As shown in Fig. 4(e), the distinguishing position Pc is between the distinguishing positions Pu and Pd with reference to an arrow direction Y perpendicular to the conveyance direction X of the conveyor 1, and the distinguishing position Pc is between the distinguishing positions Ps1 and Ps2 with reference to an arrow direction X' parallel to the conveyance direction X of the conveyor 1.

[0115] By means of this, the bad influence resulting from the erroneous decision becomes small. As a result, the phenomenon, in which the material which should be separated cannot be separated, decreases more, and the phenomenon, in which the material which should not be separated is separated, decreases more.

[0116] By the way, the conveyor 1 of the present Embodiment is one example of a conveying unit of the present invention. The distinguishing device 3 of the present Embodiment is one example of a distinguishing unit of the present invention. The constitution which includes the group of nozzles 5 and the calculation part 6 is one example of a recovering unit of the present invention. Each of the small pieces 2A to 2D of the present Embodiment is one example of separation targets of the present invention. And the air is one example of air or gas of the present invention.

[0117] For example, a part of the function of the distinguishing device 3 may be carried out by the calculation part 6, and a part of the function of the calculation part 6 may be carried out by the distinguishing device 3.

[0118] The calculation part 6 may distinguish the shape, size and position of the small piece 2A by analyzing the adjacency state of the plural distinguishing results 9 in which the constituent substances of the small pieces 2A to 2D are the same rather than, as described above, by distinguishing whether the small piece exists or not at the distinguishing positions 8A to 8G without taking the constituent substance of the small piece into consideration, to analyze the adjacency state of the plural distinguishing results 9 (see Figs. 4(a) to 4(e)).

[0119] For example, the adjacency state of all the plural distinguishing results 9 may be analyzed first, while disregarding the constituent substances of the small pieces 2A to 2D, and after that, the constituent substances of the small pieces 2A to 2D may be analyzed. By contrast, the constituent substances of the small pieces 2A to 2D may be analyzed first, and after that, the adjacency state of the plural distinguishing results 9 may be analyzed for every constituent substance.

[0120] In the latter case where the constituent substances of the small pieces 2A to 2D are analyzed first, and after that, the adjacency state of the plural distinguishing results 9 is analyzed for every constituent substance, there are few bad influences resulting from the erroneous decision because the constituent substances of the small pieces 2A to 2D are analyzed first.

[0121] Accordingly, since the extremely high separation precision and separation efficiency are realized and the separation purity and recovering yield of the small piece made from the constituent substance which should be separated can be raised, the range of the separation target products for recycling is enlarged and the small pieces of the specific

constituent substances included in the general wastes can be recycled. As a result, improvement of the recycling quality and productivity can be expected, and also the resources circulation can be promoted.

INDUSTRIAL APPLICABILITY

[0122] A separation apparatus and a separation method of the present invention, with which it is possible to recover the separation target in higher separation precision, are useful for utilizing as a separation apparatus and a separation method, for example, for separating small pieces consisting of a specific constituent substance from a group of the small pieces in which plural small pieces obtained by crushing the used household electric appliances and the like are mixed.

Reference Signs List

[0123]

1	Conveyor
2A, 2B, 2C, 2D, 2A', 2B', 2C', 2D'	Small piece
3	Distinguishing device
4	Conveying end portion
5	Group of nozzles
6	Calculation part
7	Separation board
200	Separation apparatus

Claims

1. A separation apparatus which analyzes constituent substances of separation targets and recovers the separation target having a predetermined constituent substance, and the separation apparatus **characterized by** comprising:

a conveying unit (1) which conveys plural separation targets (2A, 2B, 2C, 2D) having plural kinds of constituent substances (A, B);

a distinguishing unit (3) which distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not on the conveying unit (1), and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) when the separation targets (2A, 2B, 2C, 2D) exist on the conveying unit (1); and

a recovering unit (5, 6) which distinguishes shape, size and position of the separation target (2A) having the predetermined constituent substance (A), based on a distinguishing result by the distinguishing unit (3), calculates a center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A), based on the shape, the size and the position of the separation target (2A) having the predetermined constituent substance (A), which is distinguished, and recovers the separation target (2A) having the predetermined constituent substance (A) by jetting air or gas to at least the center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A).

2. The separation apparatus according to claim 1, wherein the distinguishing unit (3) has lattice-like plural distinguishing points at a predetermined position for the conveying unit (1), distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not every each the distinguishing point, and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) every each the distinguishing point when the separation targets (2A, 2B, 2C, 2D) exist, and the recovering unit (5, 6) distinguishes shape, size and position of the separation targets (2A, 2B, 2C, 2D) by analyzing an adjacency state of the distinguishing points where the separation targets (2A, 2B, 2C, 2D) exist, and specifies the separation target (2A) having the predetermined constituent substance (A), to which the air or gas is to be jetted, based on a score which is given to each of the plural kinds of constituent substances (A, B).

3. The separation apparatus according to claim 1, wherein the distinguishing unit (3) has lattice-like plural distinguishing points at a predetermined position for the conveying unit (1), distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not every each the distinguishing point, and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) every each the distinguishing point when the separation targets (2A, 2B, 2C, 2D) exist, and the recovering unit (5, 6) distinguishes the shape, the size and the position of the separation target (2A) having the

predetermined constituent substance by analyzing an adjacency state of the distinguishing points where the constituent substances of the separation targets (2A, 2B, 2C, 2D) are the same.

4. The separation apparatus according to claim 1, wherein

the distinguishing unit (3) has lattice-like plural distinguishing points at a predetermined position for the conveying unit (1), distinguishes whether the separation targets (2A, 2B, 2C, 2D) exist or not every each the distinguishing point, and analyzes the constituent substances of the separation targets (2A, 2B, 2C, 2D) every each the distinguishing point when the separation targets (2A, 2B, 2C, 2D) exist, and the recovering unit (5, 6) distinguishes shape, size and position of the separation targets (2A, 2B, 2C, 2D) by analyzing an adjacency state of the distinguishing points where the separation targets (2A, 2B, 2C, 2D) exist, and specifies the separation target (2A) having the predetermined constituent substance (A), to which the air or gas is to be jetted, based on the constituent substance (A, B) of each separation target (2A, 2B, 2C, 2D) on the distinguishing point which is located in a central part of each shape of the distinguished separation targets (2A, 2B, 2C, 2D).

5. The separation apparatus according to any one of claims 1 to 4,

wherein the recovering unit (5, 6) jets the air or gas to a circumference of the center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A) as well as the center of gravity (11).

6. A separation method of analyzing constituent substances of the separation targets and recovering the separation target having a predetermined constituent substance, and the separation method **characterized by** comprising steps of:

calculating a center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A), and

jetting air or gas to at least the center of gravity (11) of the separation target (2A) having the predetermined constituent substance (A).

FIG.1(a)

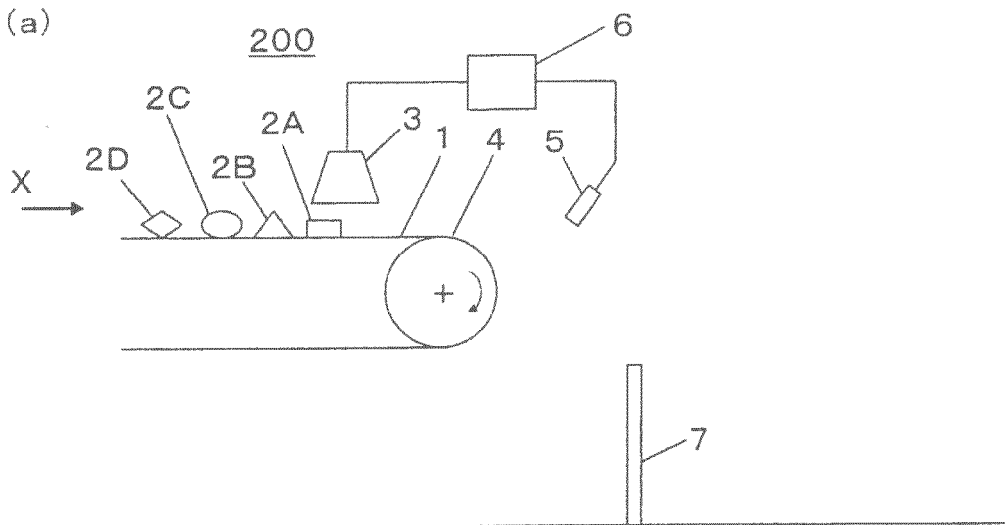


FIG.1(b)

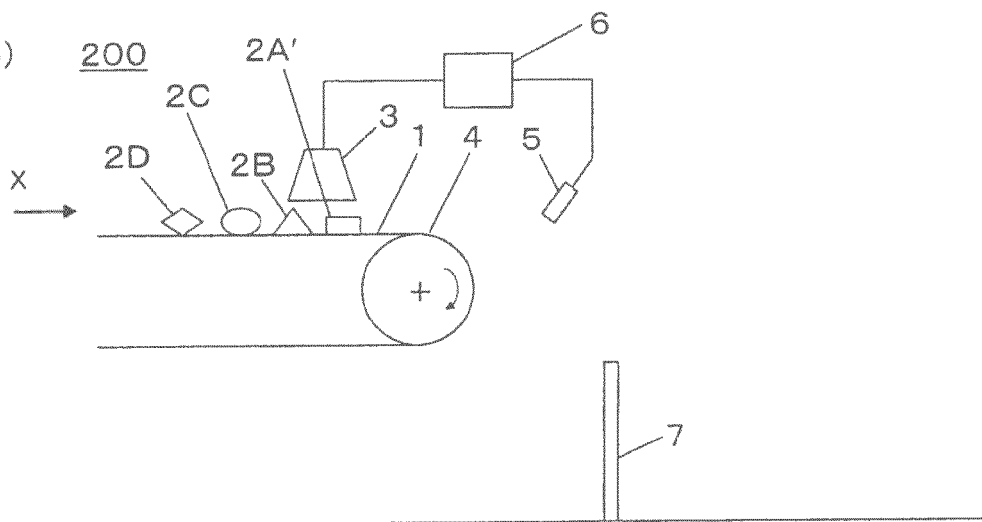


FIG.1(c)

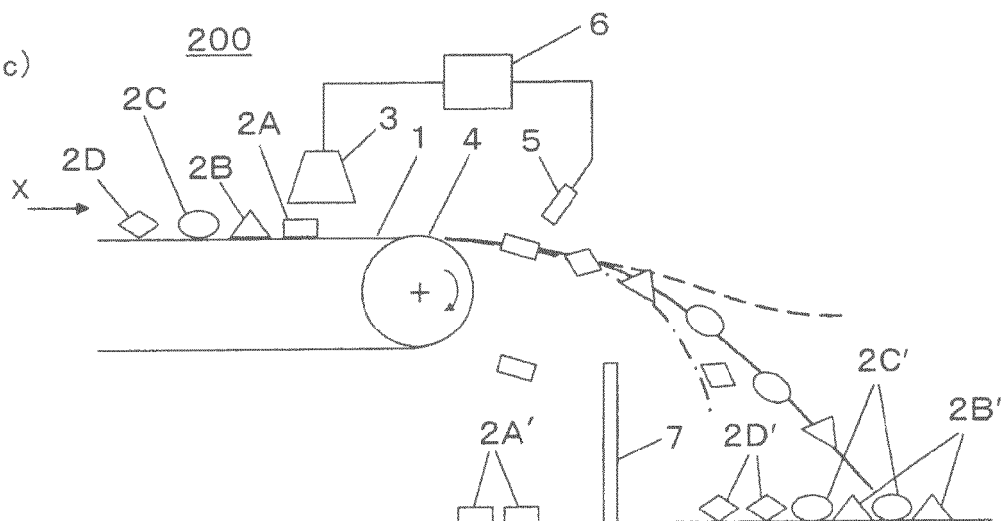


FIG.2

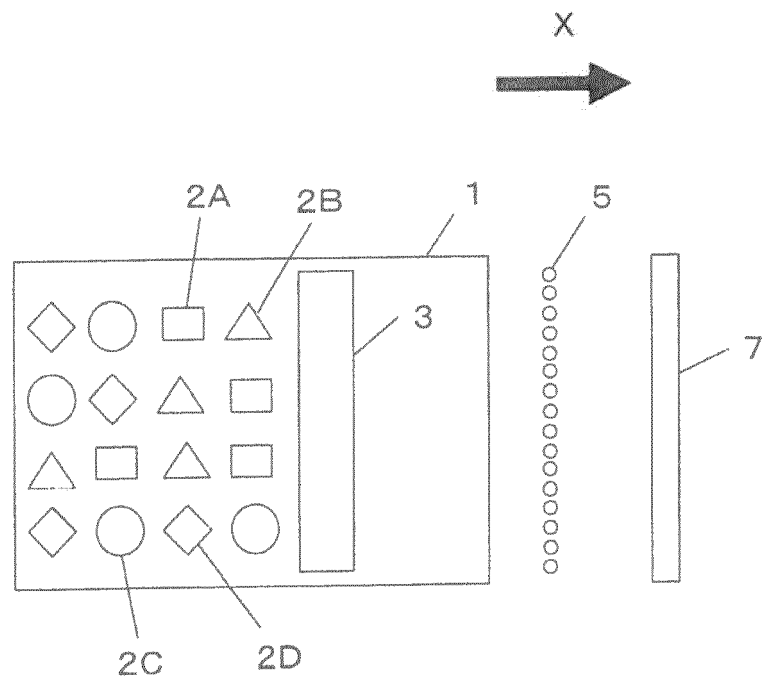


FIG.3(a)

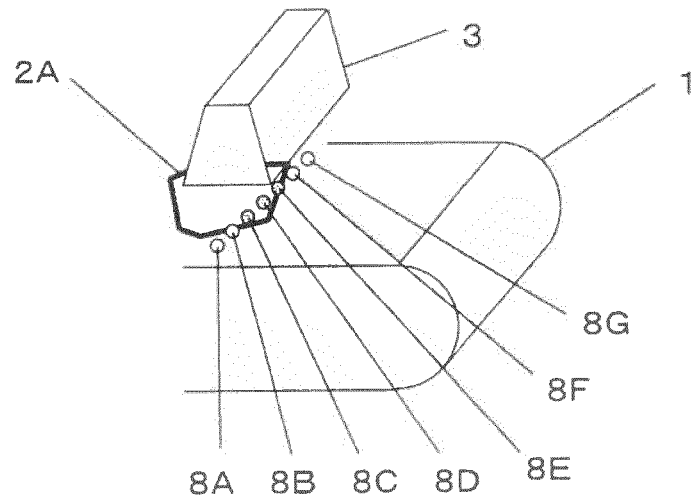


FIG.3(b)

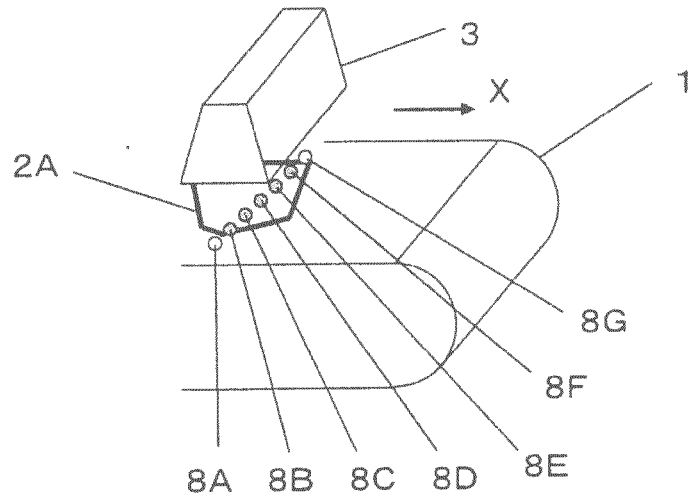


FIG.3(c)

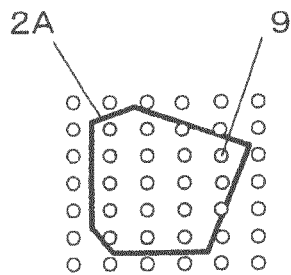


FIG.3(d)

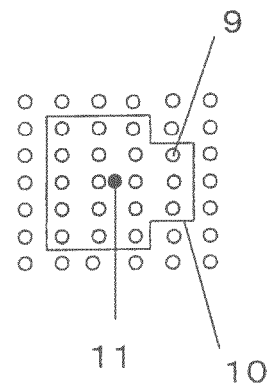


FIG.4(a)

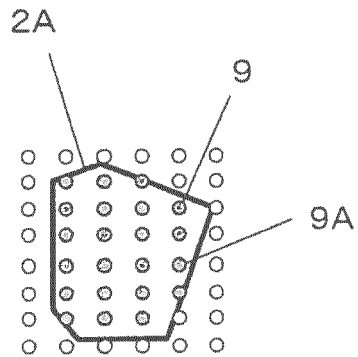


FIG.4(b)

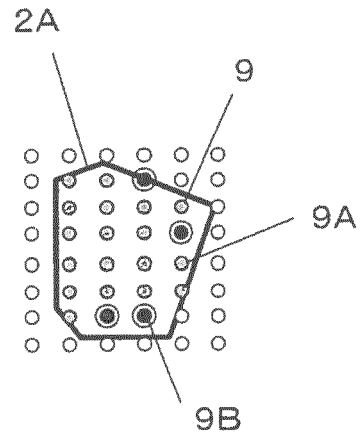


FIG.4(c)

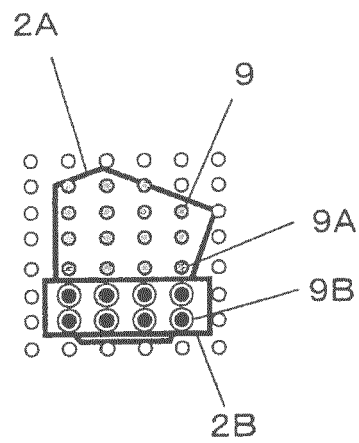


FIG.4(d)

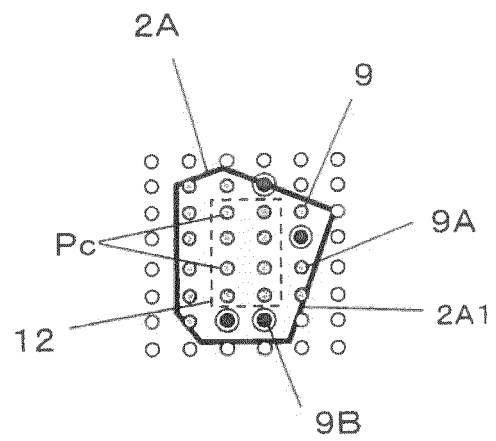


FIG.4(e)

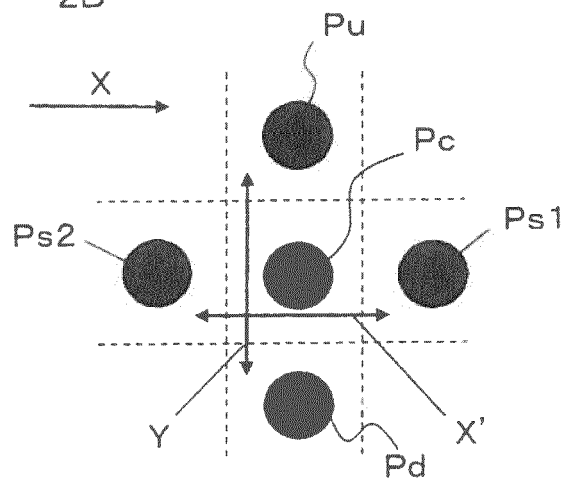


FIG.5

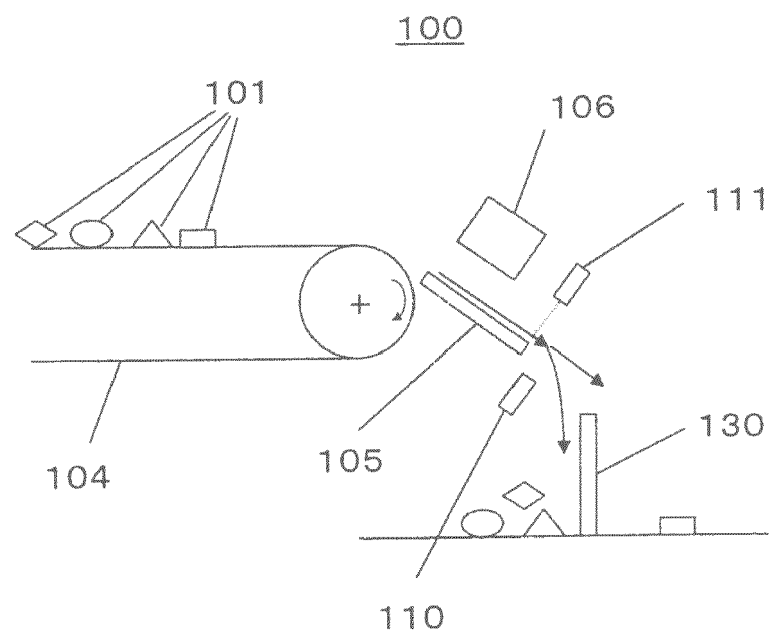


FIG.6(a)

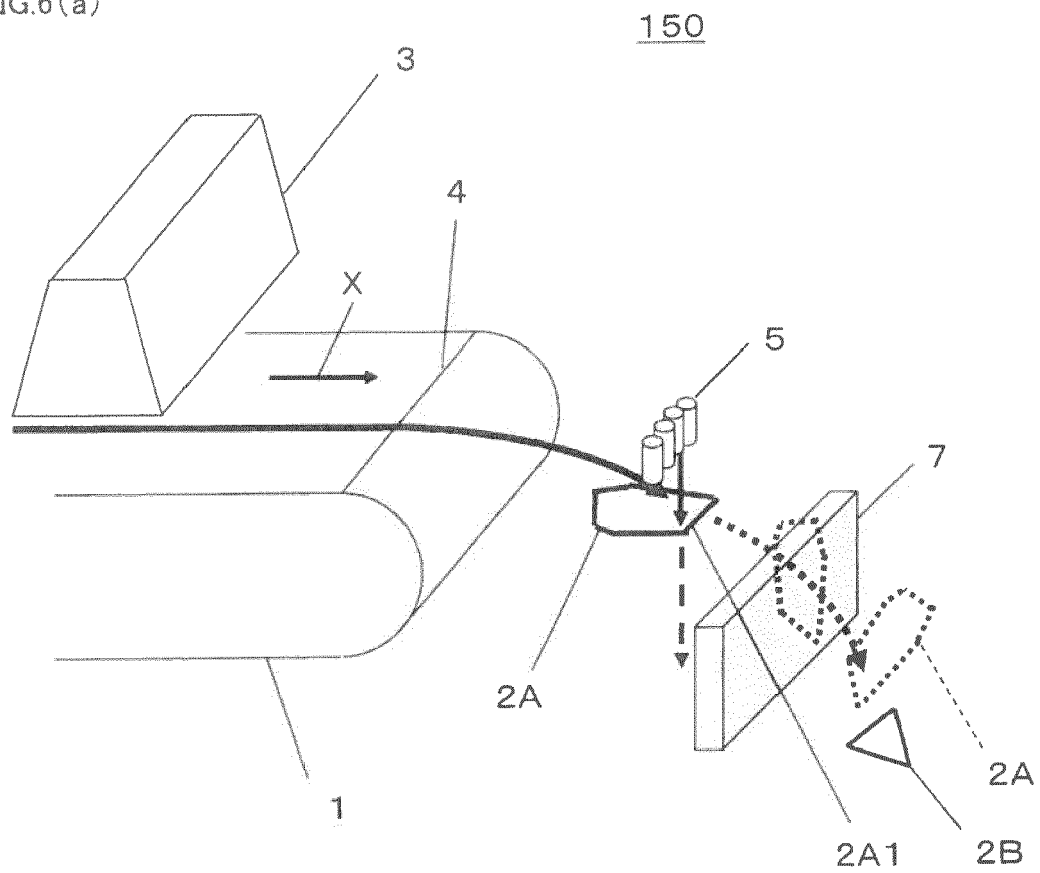


FIG.6(b)

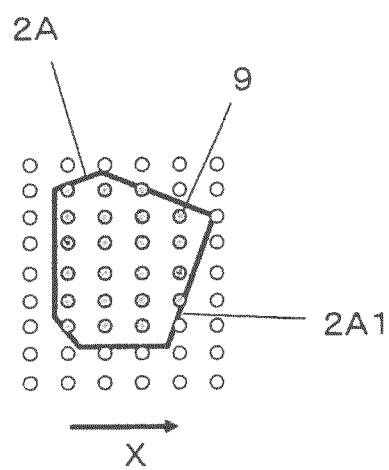
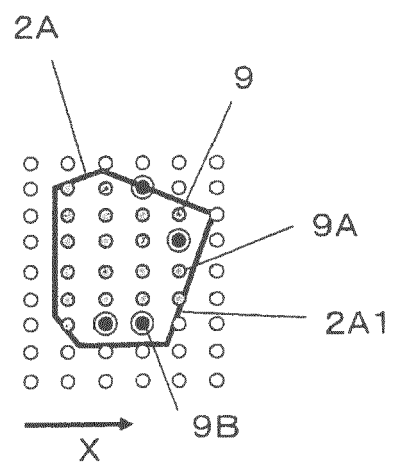


FIG.6(c)





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