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(54) Electrostatic separator

(57) Apparatus for separating particles based on their electrical properties and their weight using an electrical charge and gravity. The charge may either be an electrostatic charge above a platform to attract certain particles away from a platform, or may be an electrostatic charge to adhere certain particles to a platform.

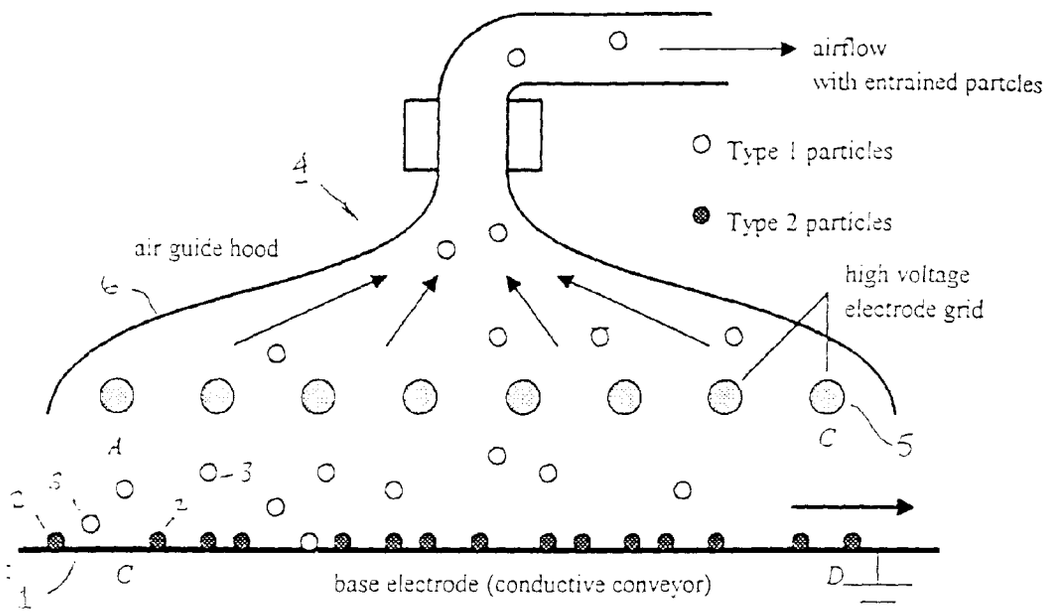

Figure 1 *An exemplary electrostatic separator employing levitation and entrainment*

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Description

The present invention relates to an apparatus and method for separation of particles.

It has recently become desirable to sort and separate waste material, for example domestic refuse, by material type. This is particularly beneficial to allow for the efficient recycling of the material. Waste material may be separated into plastics and paper materials, and may be further separated, for example by grade of plastics such as polyethylene, PVC, polycarbonate, polystyrene, or grade of paper, such as card, newspaper, tissue paper, etc.

Conventionally, waste material to be sorted is provided on a conveyor line. Trained operators standing beside the conveyor identify particular types and grades of material from the waste stream and hand pick particular materials and deposit these in bins for recycling. Different operators select different types of material This process for sorting waste material is labour intensive, yet requires highly trained personnel to correctly and rapidly identify particular types or grades of material and remove these from the waste stream.

According to a first aspect of the present invention, an apparatus for selectively separating particles comprises an electrically conductive platform arranged to receive the particles, an electrode spaced from the conductive platform, and a fluid flow path past the electrode so that, in use, a high voltage is applied between the electrode and platform to electrostatically attract predetermined particles towards the electrode depending upon the mass and electrical properties of the particles, and the attracted particles are entrained in the fluid flow to separate them from the other particles.

With this system, particular types of material can automatically be separated from the remaining particles. Preferably, the electrically conductive platform is a conveyor belt, and more preferably is an endless belt conveyor which allows a continuous supply of particles into the region where they may be attracted by the applied voltage.

The electrode is advantageously a grid electrode which gives a large area over which particles may be attracted towards the electrode, yet allows attracted particles to pass through the electrode. The spacing of the elements of the grid is preferably greater than the maximum particle size. The fluid flow, which is preferably an air flow, may be generally perpendicular to the platform to remove the attracted particles quickly. The high voltage may be applied to the electrode, in which case the conductive platform is electrically grounded.

According to a second aspect of the present invention, an apparatus for selectively separating particles comprises an electrically conductive conveyor for conveying the particles, and a means for applying an electrostatic charge to the particles so that, in use, the particles adhere electrostatically to the underside of the conveyor for a period depending on their physical and electrical properties and drop from the underside of the conveyor at a position depending upon the said properties.

This apparatus again allows for the automatic separation of particular particles, and is advantageous in that it allows the separation of more than one type of particle since all particles of a similar type will fall from the underside of the conveyor at substantially the same position. Accordingly, different types or grades of material will fall from the conveyor at different positions.

Bins may be provided below the conveyor to receive particles of particular type, or secondary conveyors may be provided to receive the particles of different type and convey them for downstream processing. The means for applying an electrostatic charge to the particles is advantageously a direct current corona discharge. This produces an ion cloud through which the particles pass and are charged.

A means for discharging the electrostatic charge on the particles is preferably provided adjacent the downstream end of the underside of the conveyor to cause all particles which have not already discharged to fall from the underside of the conveyor. The means for discharging the electrostatic charge of the particles is preferably an alternating current corona discharge. Alternatively or additionally, a brush or other barrier may be provided adjacent the downstream end of the underside of the conveyor to knock off and remove all particles remaining adhered to the conveyor. The conductive conveyor is preferably electrically grounded.

In both the first and second aspects of the present invention, the applied voltage, whether the voltage between the electrode and platform or the voltage for applying the electrostatic charqe to the particles is advantageously variable, for example to vary the initial charge applied to the particles. This facilitates the selection of the type of particle separated by the apparatus. Typically the voltage applied is between 10 and 30 kV. Alternatively or additionally, the length of time the particles are under the electrode in either aspect of the invention, which may be dependent on the conveyor speed, or the length of time the particles are above any particular collecting position in the second aspect of the invention, either by changing the length of each position at which particles are collected, or varying the speed of the conveyor may be varied. This facilitates the selection of particles. Advantageously, the conveyor speed is between 0 and 2m/s.

The separation of the particles may also advantageously be controlled by control of the ambient humidity. The charging and discharging time constants of particles may be dependent on the humidity, and accordingly varying the humidity will vary the electrostatic separation of the apparatus. Typical charge time constants for the particles range from 0.03 to 60 seconds.

According to a third aspect of the present invention, a sorting apparatus comprises a plurality of separation apparatus according to the first and/or second aspect of

the present invention. This allows a series of sequentially separations to sort the particles into different types and grades.

Particular examples of the present invention will be described in accordance with the accompanying drawings in which:-

Figure 1 shows a schematic view of a first aspect of the present invention;
Figure 2 shows a schematic embodiment according to the second aspect of the present invention; and
Figure 3 shows a schematic view of a sorting apparatus according to the third aspect of the present invention.

Figure 1 shows a schematic view of an electrostatic separator apparatus according to the first aspect of the present invention. The apparatus includes a conveyor 1 of electrically conductive material onto which particles 2,3 are deposited upstream of a separator station 4.

The separator station 4 includes an electrode grid 5 disposed above the conductive conveyor 1. The electrode grid 5 comprises conductive bars of 5mm diameter and separated by 30mm. The electrode grid is positioned between 40 and 60mm above the conveyor 1. A voltage of 10 to 30kV is applied to the electrode grid. The size of the grid 5, including the diameter and spacing of the elements, the height above the conveyor 1, and the applied voltage may all be varied depending on the particles to be separated. The conveyor 1 is electrically grounded. An air guide hood 6 is provided above the electrode grid 5. A pump (not shown) is provided to cause an airflow through the electrode grid 5 and the air guide hood 6.

In use, the mixed particles 2,3 are conveyed to the separating station 4 along the conductive conveyor 1. The high voltage applied to the electrode grid 5 causes an electrostatic field between the conveyor 1 and grid 5 which causes particles with particular physical and electrical properties to be levitated and drawn towards the electrode grid 5. Particles with a high conductivity and short charging time constant will become charged by conduction. When the charge increases above a certain level, the attractive force of the electric field overcomes the gravitational force holding the particles on the conveyor, and causes the particles to levitate. Less conductive particles with a longer charging time constant take longer to build sufficient charge to levitate towards the high voltage electrode, and thereby allows separation of the particles 2,3. The air flow through the electrode grid 5 and into the air guide hood 6 entrains particles 3 levitated by the electrostatic force and thereby separates these from the particles 2 which remain on the conveyor 1 and are taken from the active area.

By controlling one or more of the voltage applied to the electrode grid 5, the rate at which particles 2,3 pass through the separating station 4, which is determined by the speed of the conveyor 1, and the ambient humidity particles of particular properties can be separated. With this system, it is possible to separate conductive particles by weight, particles having different charging time constants, and particles having different electric conductivities.

Figure 2 shows an embodiment of an electrostatic separator according to a second aspect of the present invention. The apparatus includes an endless belt conveyor 11 which runs around a pair of opposed rollers 14,15. The endless belt 11 is of a conductive material, and is electrically grounded. Particles 16,17,18,19 are fed from a sample feeder onto the upper surface of the conductive belt. The particles 16,17,18,19 pass through an ion cloud generated by a DC corona discharge. As the particles 16,17,18,19 pass through the ion cloud, they are electrostatically charged. The charge on the particles causes them to electrostatically adhere to the conductive belt 11. As the particles cling to the underside of the conductive belt 11, they will remain held on the belt until the gravitational force acting on the particles exceeds the electrostatic force holding the particles onto the conductive belt 11. Accordingly, heavy particles 18, such as paper clips and staples will fall from the conductive belt 11 immediately as the gravitational forces will immediately be greater than the electrostatic forces. Lighter weight conductive particles 16 with a short discharge time constant discharge quickly so that the gravitational force will overcome the electrostatic force quickly. Accordingly, these particles will drop into bin B as shown in Figure 2. Particles having a longer discharge time, such as the intermediate particles 17, retain their electrostatic force for a longer period, and therefore remain electrostatically adhered to the conductive belt 11 for longer than the conductive particles 16. Accordingly, the intermediate particles 17 fall from the conductive belt 11 at a later time than the conductive particle 16 and so fall into bin C. An AC corona discharge 13 is provided above bin D. All particles which retain an electrostatic charge, such as insulating particles 19 having a long discharge time constant are discharged by the bi-polar ion cloud produced by the AC corona discharge 13, and accordingly fall into bin D. A brush 20 contacting the downstream end of the underside of the conveyor 11 ensure all particles are knocked from the belt 11 into bin D.

As with the apparatus according to the first aspect of the present invention, by increasing the electrostatic charge, for example by increasing the electric field and intensity of the ion cloud produced by the DC corona discharge source 12, the electrostatic forces between the particles 16,17,18,19 and the conductive belt 11 will be controlled, and will cause different types of particles to fall at particular positions and be separated. Further, by increasing the speed of the conductive belt 11, or by reducing the longitudinal dimension of the bins into which the particles fall, different types of particles can be separated.

If the charging and discharging time constants are

dependent on the ambient humidity, the separation of particles may also be controlled by changing the ambient humidity.

Apparatus according to either the first or second aspect of the present invention may be provided in a series of stages to further separate the particles. An example of this is shown in Figure 3 in which each of the separator stages comprises a separating station according to the first or second aspect of the present invention. Although Figure 3 shows each separator stage having only two outputs, where a separator according to the second aspect of the present invention is used, additional outputs may be provided. As shown in Figure 3, the output streams of two or more separator stages may be combined as the input for a subsequent stage, such as the output of separator stages C and E, or may be combined into a single bin, as the outputs of separator stages D and F.

Where the separator stages are in accordance with the second aspect of the present invention, the bins A, B, C and D may be replaced by conveyors which convey the sorted particles to the subsequent stage.

Claims

1. An apparatus for selectively separating particles (2,3) comprising an electrically conductive platform (1) arranged to receive the particles (2,3), an electrode (5) spaced from the conductive platform (1), and a fluid flow path past the electrode (5) so that, in use, a high voltage is applied between the electrode (5) and platform (1) to electrostatically attract predetermined particles (3) towards the electrode (5) depending upon the mass and electrical properties of the particles (3), so the attracted particles (3) are entrained in the fluid flow to separate them from the other particles (2).

2. An apparatus according to claim 1, in which the electrically conductive platform (1) is a conveyor belt.

3. An apparatus according to claim 2, in which the platform (1) is an endless belt conveyor which allows a continuous supply of particles (2,3) into the applied voltage region.

4. An apparatus according to any one of the preceding claims in which the electrode (5) is a grid electrode.

5. An apparatus according to claim 4, in which the spacing of the elements of the grid is greater than the maximum particle size.

6. An apparatus according to any one of the preceding claims, in which the fluid flow is generally perpendicular to the platform (1).

7. An apparatus according to any one of the preceding claims, in which the high voltage is applied to the electrode (5), and in which the conductive platform (1) is electrically grounded.

8. An apparatus for selectively separating particles (16,17,18,19) comprising an electrically conductive conveyor (11) for conveying the particles (16, 17, 18, 19), and a means (12) for applying an electrostatic charge to the particles (16,17,18,19) so that, in use, the particles (16,17,18,19) adhere electrostatically to the underside of the conveyor (11) for a period depending on their physical and electrical properties and drop from the underside of the conveyor (11) at a position depending upon the said properties.

9. An apparatus according to claim 8, in which bins are provided below the conveyor (11) to receive particles (16,17,18,19) of particular type.

10. An apparatus according to claim 8, in which secondary conveyors are provided below the conveyor (11) to receive the particles (16,17,18,19) of different type and convey them for downstream processing.

11. An apparatus according to any one of claims 8 to 10, in which the means for applying the electrostatic charge to the particles (16,17,18,19) is a direct current corona discharge (12).

12. An apparatus according to any one of claims 9 to 11, further comprising a means (13) for discharging the electrostatic charge on the particles (16, 17, 18, 19) provided substantially adjacent the downstream end of the underside of the conveyor (11).

13. An apparatus according to claim 12, in which the means for discharging the electrostatic charge of the particles is an alternating current corona discharge.

14. An apparatus according to any one of claims 9 to 13, further comprising a brush (20) or other barrier adjacent the downstream end of the underside of the conveyor (11).

15. A sorting apparatus comprising a plurality of separation apparatus according to any one of the preceding claims.

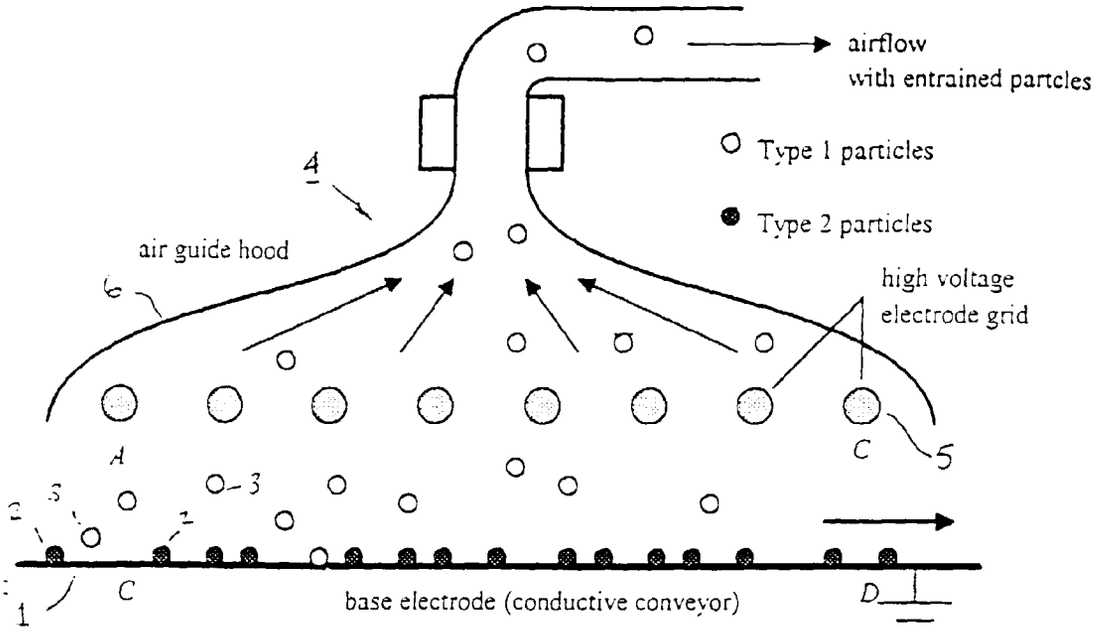

Figure 1 *An exemplary electrostatic separator employing levitation and entrainment*

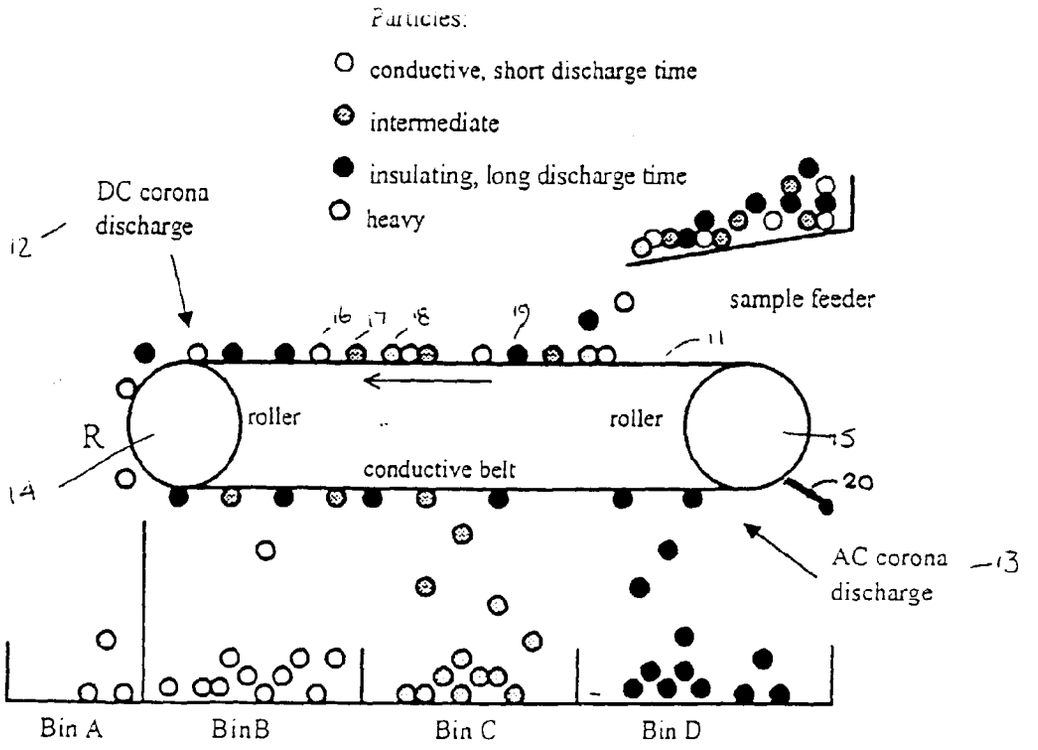

Figure 2 *An exemplary electrostatic separator employing a conductive conveyor*

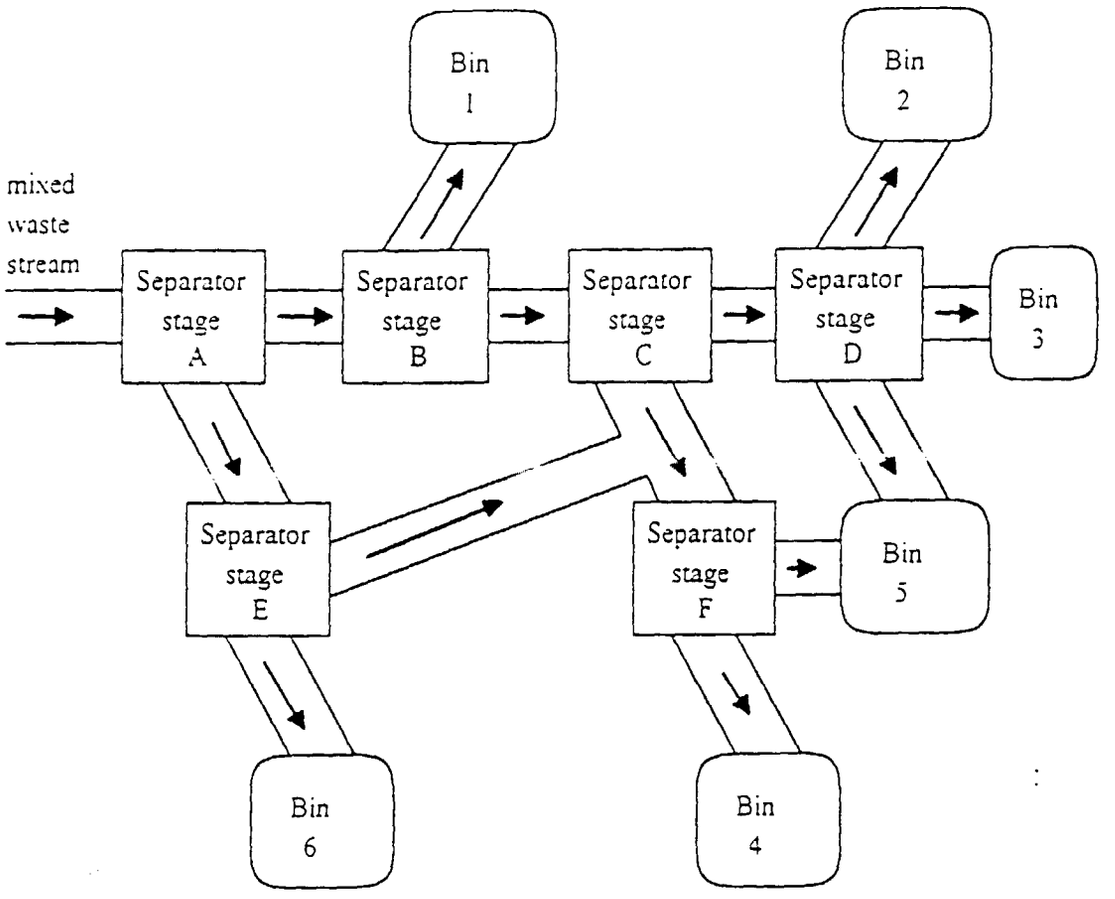
mixed
waste
stream
Separator stage A
Separator stage B
Separator stage C
Separator stage D
Separator stage E
Separator stage F
Bin 1
Bin 2
Bin 3
Bin 4
Bin 5
Bin 6

Fig 3

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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 2479

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	US 3 402 814 A (MOREL ROGER CLAUDIUS MARIUS ET AL) 24 September 1968 * column 2, line 62 - column 3, line 72 * * column 5, line 42 - line 67; claims 1-7; figures 1,5 *	1,6,8,9, 12,14 4,5	B03C7/00 B03C7/04 B03C7/08
X A	DE 12 29 022 B (N.DOLGOPOLOV) 24 November 1966 * the whole document *	1,4,6 2,5,8,9, 11,14	
A	DE 42 32 123 A (KOOPMANN LUDGER) 31 March 1994 * column 2, line 34 - line 61; claims 1,2,5; figure 1 *	1-3,7	
X A	NL 7 810 038 A (SIMCO NEDERLAND) 9 April 1980 * page 2, line 22 - page 3, line 30; claims 1-3,5; figure 1 *	8,9,12 11,13,14	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	31 July 1997	Decanniere, L

CATEGORY OF CITED DOCUMENTS

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