

[54] **REFUSE SORTING WITH SEPARATION OF GLASS AND METALS**

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[58] **Field of Search** **209/75, 111.6, 111.7, 127, 209/128, 129, 130, DIG. 3**

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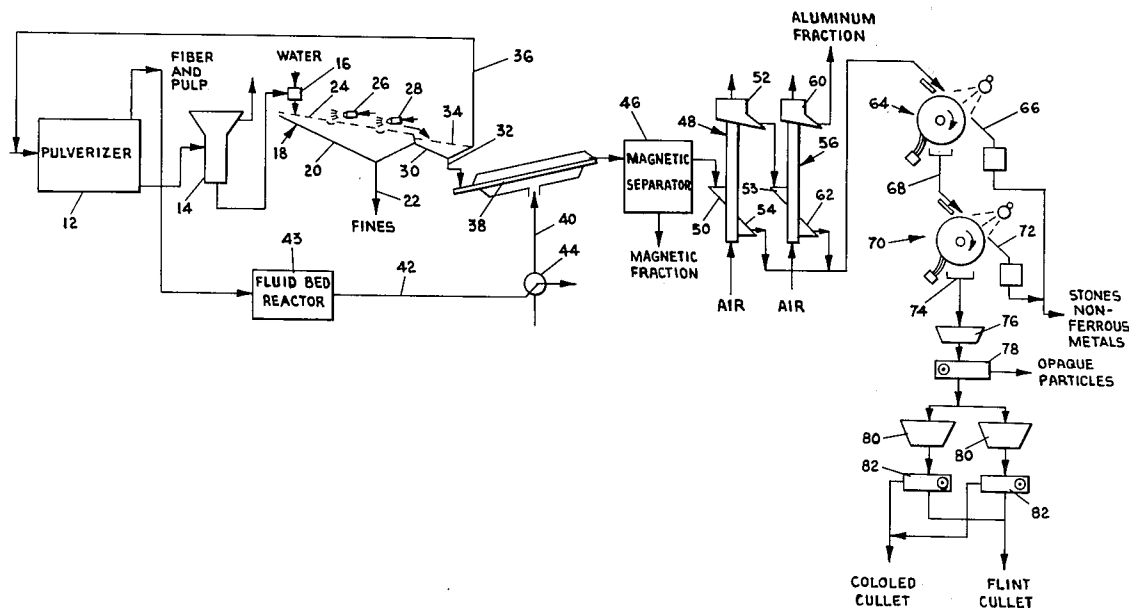
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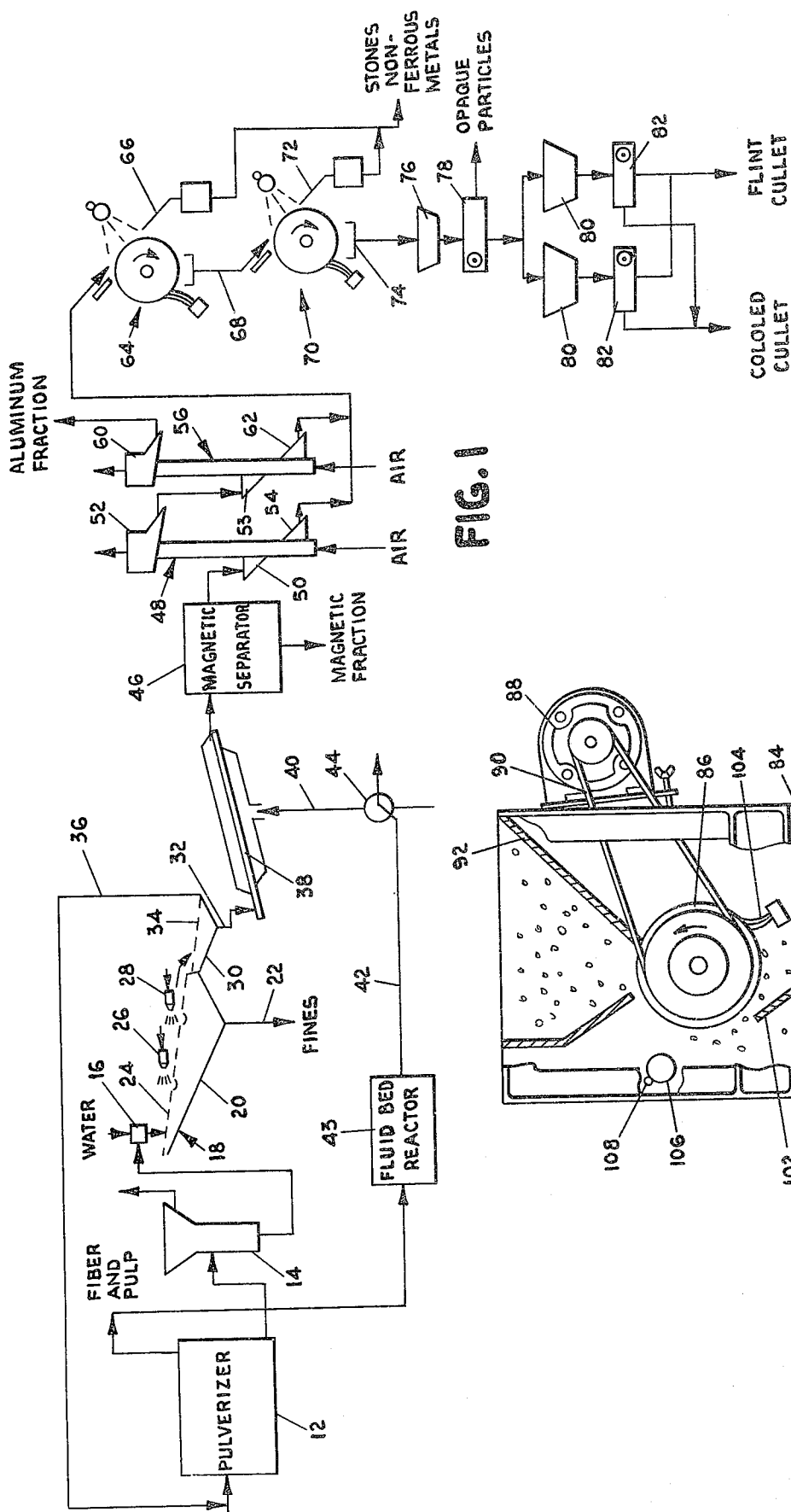
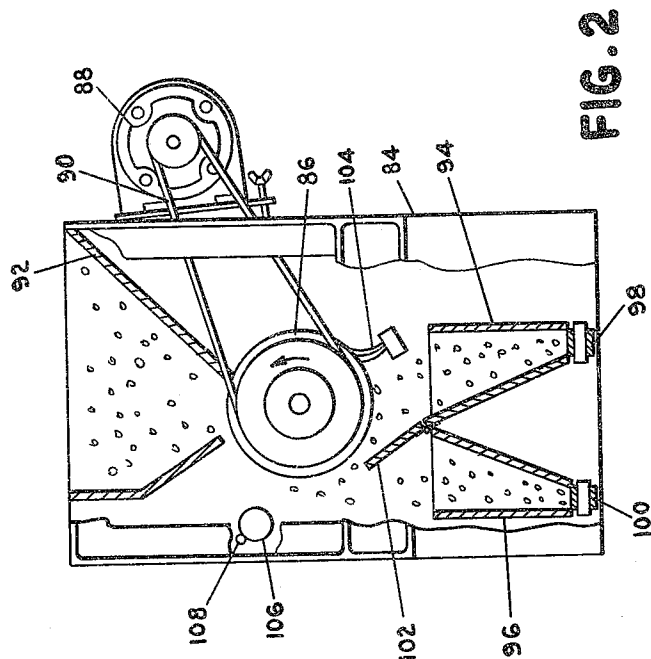
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ABSTRACT

Sorting of refuse into its components wherein the refuse is comminuted into a particulate mass, and a glass concentrate fraction consisting substantially of glass particles and a minor portion of residual non-glass particles, including metal particles, is sorted from a substantially non-glass fraction and is electrostatically sorted to remove the metal particles therefrom. The resulting glass concentrate fraction is then sorted according to color. In the electrostatic sorting process, the glass concentrate fraction is deposited onto an upper surface of a slowly moving grounded drum and a high tension electrostatic field is applied to the particles as they rotate from the upper portion to the lower portion of the drum. Further, a discharge of electricity is applied to the particles on the drum and the particles are separated in accordance with their conductivities. The high tension electrostatic field is applied from a side of the drum slightly above the horizontal centerline by a high tension electrode, and the current is discharged from substantially behind the electrode. The particles have an average mean diameter in the range of one-fourth to three-fourth inch and the ratio of largest to smallest particle size is about 2 to 1.

13 Claims, 2 Drawing Figures





REFUSE SORTING WITH SEPARATION OF GLASS AND METALS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to sorting of refuse into its components. In one of its aspects, the invention relates to removal of minor parts of aluminum and other metals from a glass-rich concentrate fraction having a mean average particle size in the range of one-fourth to three-fourth inch.

2. State of the Prior Art

In U.S. Pat. No. 3,650,396 to Gillespie et al., there is disclosed and claimed a method and system for sorting refuse into its components wherein a glass-rich fraction is photometrically sorted according to color. In my co-pending U.S. Pat. application Ser. No. 347,184 entitled REFUSE SORTING AND TRANSPARENCY SORTING, there is disclosed and claimed a method and system for sorting refuse into its components wherein a glass-rich fraction is sorted according to color and wherein the glass particles are first sorted according to their transparency to remove crockery, bone, and other opaque types of particles.

It has been discovered that small amounts of metal particles, principally aluminum, remain in the glass concentrate despite the various separation processes. Such amounts are generally below 10 percent and usually below 2 percent. These metal particles may not effectively be sorted in the transparency sorting step because of the thinness of the metal diameters. These metal particles, if undetected, interfere with the color sorting and may report with the flint cullet. It therefore becomes necessary to remove these small amounts of metal particles prior to the color sorting step.

This metal removal problem is of some consequence because the particles have already been run through more conventional separation processes and only a small percentage of metal particles remain. The glass particles are generally required to be in a range of about one-fourth to three-fourth inch for an effective color sort.

SUMMARY OF THE INVENTION

It has been found, quite surprisingly, that these small amounts of metal can effectively be removed from the glass concentrate by a special electrostatic sorting process. The particles to be sorted have a mean average diameter in the range of one-fourth to three-fourth inch and have a ratio of largest to smallest particles of about 2 to 1. The glass-rich concentrate, having the metal particles sorted therefrom, is thereafter sorted according to transparency to remove the opaque particles, and thereafter sorted according to color.

The electrostatic sorting process includes the depositing of the particles in a thin layer on the top surface of a slowly revolving grounded drum. An electrostatic field is applied by an electrode positioned slightly above the horizontal centerline and spaced from the surface of the drum. The drum revolves toward the electrode. Further, a discharge of electricity is provided by a small electrode in contact with the high tension electrode, with the discharge electrode being positioned behind the high tension electrode with respect to the rotating drum. A charge of 20 kilovolts or

greater is applied to the electrode to establish the electrostatic field.

The effective high tension electrostatic sorting is highly surprising in view of the fact that such electrostatic processes have heretofore been used almost exclusively to sort very fine materials, for example, materials less than 20 mesh (less than 0.0328 in.). Although there is disclosure of the separation of coke from clinker in sizes up to about 1 inch in diameter in very special types of electrostatic separators (see U.S. Pat. No. 1,551,397 to Johnson), electrostatic sorting of this type has not been effective in sizes above about 20 mesh.

With the invention sorts of about 70 percent efficiency have been experienced with the result that substantially all metal particles are removed from the glass concentrate.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a schematic representation of a sorting system and method according to the invention;

FIG. 2 is a schematic side elevational view in section of a high tension sorting apparatus used in the method and system according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and to FIG. 1 in particular, there is shown a system for sorting refuse into its various components and having as one end product a glass fraction comprising substantially only flint glass and a glass fraction comprising substantially only colored glass.

Domestic trash or other suitable refuse is fed to a pulverizer unit 12 which pulverizes or comminutes the feed, producing a fiber and pulp fraction and a concentrated solids fraction. A suitable pulverizer is a Black Clawson Hydrapulper manufactured by the Black Clawson Company of Middletown, Ohio. The solids fraction is passed to a cyclone separator 14 which removes a water and fiber fraction from an upper portion and a more concentrated solids fraction from a bottom portion.

The dewatered solids fraction is passed by a suitable conveyor to a washer and distributor 16 where water is added thereto. The watered fraction is distributed onto a screening and washing machine 18 having a hopper 20 with an outlet 22 at the bottom thereof and a screen 24 across the top. The screen 24 has vibratory motion imparted thereto to move the solids fraction along the top of the screen 24 where it is subjected to a further water wash from a pair of nozzles 26 and 28 positioned above the screen. A suitable screen has ¼-inch openings to permit particles of one-fourth inch or less to pass therethrough into hopper 20. Those particles larger than one-fourth inch then move to the lower end of the screening and washing machine 18 and onto a second screen 34. Vibratory motion is imparted to this screen also. This screen 34 preferably has openings of three-fourths of an inch to permit particles smaller than three-fourths of an inch to pass therethrough. The larger particles move to the bottom end of screen 34 where they are removed and passed through a recycle line 36 back to the pulverizer 12. The recycle line can be a pneumatic conveyor or any suitable means for returning the oversized particles back to the pulverizer.

For example, the oversize particles can even be carted back to the pulverizer in a truck. The particles collected in the hopper 30 will have a mean average diameter predominately between one-fourth and three-fourth inch. A suitable screening and washing device is manufactured by Derrick Manufacturing Company of Buffalo, N.Y.

The particles are removed from the bottom of the hopper 30 through an outlet 32 and passed to a fluidized bed conveyor and dryer 38. As the particles are passed through this fluidized bed dryer 38, air is directed upwardly therethrough to remove the water therefrom. The air is heated and supplied through a line 40.

The pulp and fibrous fraction from the pulverizer 12 can be passed to a fluid bed reactor 43 after suitable water removal steps (not shown) and incinerated in the reactor 43. Excess heat in the form of hot air, suitably scrubbed clean of noxious elements, may be bled from the fluid bed reactor 43, either directly or through a heat exchanger 44 through line 42. Alternatively, the dryer may have its own provision for heat generation. Suitable machines are manufactured by the Door Oliver Company of Stamford, Conn. (reactor), and the Jeffry Manufacturing Company of Columbus, Ohio (dryer). The dryer may include a cooling stage if required. Alternatively, the hot gases may be used to convey the material directly through a pneumatic conveyor such as that manufactured by the Meyer Machine Company of San Antonio, Tex.

The dried particles are removed from an upper end of the dryer 38 and passed to a magnetic separator 46. Any suitable magnetic separator can be used. An example of such a separator is a Rotating Drum Type Magnetic Separator, manufactured by the Dings Magnetic Company of Milwaukee, Wis.

A magnetic fraction is separated from a nonmagnetic fraction in the separator 46. The nonmagnetic fraction is passed to a first pneumatic separator 48. The separator 48 has an inlet 50, a light fraction outlet 52, and a heavy fraction outlet 54. Air is supplied to a bottom portion of the separator and passed upwardly therethrough to entrain particles of lighter specific gravity. The particles of lower specific gravity are removed through outlet 52 and passed to the inlet 58 of a second pneumatic separator 56. This separator 56 has outlet 62 for a heavy fraction and an outlet 60 for a light fraction. Air is passed upwardly through the separator 56 to separate particles of lower specific gravity from particles of higher specific gravity. The lower specific gravity particles are removed through outlet 60. The flow of air through separators 48 and 56 is regulated to entrain those particles whose specific gravity is lighter than glass and to permit glass particles to settle to the bottom of the separator for removal. This lighter fraction contains predominately light weight materials such as aluminum, stones, ceramics, bones, wood, rubber and plastics. This lighter fraction can be passed to an aluminum concentrating apparatus where an aluminum rich fraction can be recovered for reuse. The separation is achieved by regulation of the upward air velocity to split the feed according to the different settling velocities of its particulate components. This differential is a function of article shape as well as specific gravity. The split can be made in free or hindered settling conditions. A suitable air separator is manufactured by Sortex Company of North America, Inc., Lowell, Mich.

The heavier fractions separated from separators 48 and 56 comprises essentially glass and some residual stones and ceramic, and some balled up aluminum particles and other metals. Typically, these heavy glass fractions comprise about 75 percent glass, about 5.6 percent magnetic material, about 2 percent aluminum, about 2 percent ceramics, less than 1 percent non-magnetic materials, less than 1 percent plastics, and the remainder, bones, seeds, stones, and sand. This fraction is passed to a first high tension electrostatic separator 64 wherein more conductive materials are separated from less conductive materials. A more conductive fraction is removed through line 66 and the less conductive fraction is collected at the bottom of the first electrostatic separator 64. The less conductive fraction is passed to a second high tension electrostatic separator 70. In a similar manner, a more conductive fraction is removed through line 72 and combined with the fraction removed through line 66. A less conductive fraction is concentrated at the bottom of the second electrostatic separator 70 and removed through line 74. These less conductive fractions collected in line 74 comprise mostly glass and some non-conductive materials such as ceramics, plastics, bone, seeds, stones and sand.

The glass concentrate in line 74 is passed to a hopper dispenser 26 which dispenses the particles one at a time to a transparency sorting apparatus 78 wherein the particles are separated according to their ability to pass light. The opaque particles, such as the stones, crockery, and other ceramics, wood, hard rubber, bone, clinker, etc., are separated out and the resulting glass fraction is passed to a pair of hopper dispensers 80 which dispense the particles one at a time to a photometric sorting apparatus 87. A more complete description of the transparency sorting apparatus is disclosed and claimed in my copending U.S. Pat. application Ser. No. 347,184 filed Apr. 2, 1973 entitled REFUSE SORTING AND TRANSPARENCY SORTING.

The glass particles are separated according to color in the photometric sorting apparatus 82 producing a colored cullet and a flint cullet. The flint cullet, which may be in some instances worth more than the colored cullet, can be remelted and used for making clear bottles or other types of clear glassware. The colored fraction can be either further separated by other photometric sensing means (not shown) into different colors, or can be used as a melt for brown bottles.

A more detailed discussion of the color sorting apparatus is disclosed in U.S. Pat. No. 3,650,396 which is incorporated herein by reference. Also disclosed in said U.S. Pat. No. 3,650,396 is another method of sorting refuse to obtain the glass fraction which contains a minor amount of opaque particles. The system disclosed above for obtaining the glass fraction with the undesirable opaque particles is only illustrative and other systems can be employed.

Reference is now made to FIG. 2 for a more detailed description of the electrostatic sorting apparatus. A frame 84 rotatably supports an electrically grounded drum 86 which is driven in the direction of the arrow through a motor 88 and pulley belt 90. A hopper 92 receives the heavier fractions from separators 48 and 56 and distributes these fractions evenly onto the surface of the drum 86. A glass concentrate bin 94 is positioned substantially beneath the drum 86. A metal concentrate bin 96 is positioned to the left side of the roller as

illustrated in FIG. 2 to catch particles which are lifted from the drum 86 as it rotates in the direction of the arrow. A conveyor belt 98 is positioned at the bottom of the glass concentrate bin 94 to remove the products collecting therein, and a conveyor belt 100 is positioned at the bottom of the metal concentrate bin 96 to remove products as they are deposited therein.

A brush 104 is provided at the outside edge of bin 94 and scrapes particles from the drum 86 as it passes the top of bin 94. The particles thus scraped from the drum 86 will fall into the bin 94. A splitter plate 102 is provided beneath the drum to direct the particles into bin 94 or 96 as desired. The splitter plate 102 is desirably adjustably mounted by means (not shown) to adjust the fractions which fall into the respective bins.

A large electrode 106 is positioned at an acute angular distance in the direction of rotation of the drum 86 from the discharge point of the hopper 92. A small wire 108 is electrically and mechanically connected to the large electrode 106. The large electrode 106 assumes a position of about 10 o'clock with respect to the roller 86, and the small wire 108 assumes a position of about 11 o'clock with respect to the large electrode 106. Thus, the large electrode is slightly above the horizontal centerline of the drum 86 and the small discharge wire 108 is partially shielded behind the large electrode 106. These unusual positions of the electrode 106 and discharge wire 108 have been found to be quite important in achieving a satisfactory sort for the large particle feed. A high tension charge is applied to the electrodes 106 and 108. The large electrode 106 tends to have a short, dense, non-discharging field. The wire 108 generally has a very small diameter, for example 10/1000 of an inch or less. This small wire creates a corona discharge onto the surface of drum 86 as it passes thereby. The combination of the large diameter electrode 106 and the wire 108 creates a very strong discharge pattern which is "beamed" in the direction of the drum 86 and is concentrated in a very narrow arc.

In the operation of the high tension electrostatic separator illustrated in FIG. 2, the particles having a mean average diameter in the range of one-fourth to three-fourth of an inch are distributed on the surface of the drum 86 as it rotates in a counterclockwise direction as viewed in FIG. 2. The speed of the roller is desirably slow, for example, 10 rpm, or slower for a roller of about 8 inches in diameter. As the particles pass by the electrode 106 and wire 108, they are subject to an electrical discharge and a very strong electrostatic field. The less conductive materials such as glass, are "pinned" to the surface of the drum 86 and are retained on the roller until they drop into the bin 94. At the bottom side of the roller, they either drop or are removed from the roller by brush 104. The glass particles, as well as any other relatively non-conductive particles, thus are concentrated in bin 94. On the other hand, the more conducting material, such as aluminum, other metals, and any other relatively conductive materials are "lifted" from the surface by the effect of the field created by the large electrode 106. Any charge given to the particles is quickly discharged on the grounded roller 86. Thus, the metal and other relatively conductive materials are lifted from the surface of roller 86 and fall into the bin 96. The fraction falling into bins 94 and 96 can be adjusted by movement of the splitter plate 102.

A more complete discussion of the art of electrostatic separation of minerals is found in the *Journal of the Electro-Chemical Society*, Vol. 116, No. 2, Feb. 1969, pages 576-600, in an article entitled "State of the Art of Electrostatic Separation of Minerals" by James E. Lawyer. This article is incorporated herein by reference.

In separating the glass and metal particles according to the invention, the sizes of the particles should be closely controlled so that the ratio of the largest to smallest particles is about 2:1. For optimum sorting according to color, the particles should have a mean average diameter in the range of one-fourth to three-fourth inch.

In the operation of the high tension sorter illustrated in FIG. 2, the potential applied to the electrode 106 and wire 108 is constant at about 30 KV and the speed of the drum roller 86 is about 10 rpms. Under these conditions, the sorting efficiency of the separator has been found to be very satisfactory.

The method and system according to the invention provide for the substantially complete removal of aluminum and other conductive materials from glass so that the glass can be separated according to color to produce saleable products. The conductive materials can be further separated into saleable products. The high tension electrostatic separation provides an effective means for separating the glass particles from aluminum and other conductive materials after a substantial concentration of glass has been achieved. Although high tension electrostatic separation has been used for many minerals, this type of high tension electrostatic sorting has been heretofore unknown in particle sizes in the range of one-fourth to three-fourth of an inch. The ability of the separation to take place with the larger particle sizes is believed to be related to the plate-like nature of the aluminum and other metal particles. The thin geometry of the metals gives a larger surface for exposure to charge for a given mass than a round particle of similar size.

The electrostatic sorting process according to the invention is believed to be related to the differences in conductivities of the particles being separated. However, the sorting may also be related to the different affinity which the particles have for surface charge.

The electrostatic sorting apparatus illustrated in FIG. 2 is illustrative of the type of apparatus which can be used in the invention. Such a sorting apparatus is sold by Carpco Research and Engineering Company, Inc. of Jacksonville, Fla.

Whereas the invention has been described with reference to a grounded drum, it is conceivable that the sorting operation can take place by reversing the polarities, i.e., by applying the potential to the drum and by grounding the electrodes.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, the drawings, and the appended claims without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a method of sorting refuse into its components wherein said refuse is comminuted into a particulate mass, and a glass concentrate fraction consisting substantially of glass particles and a minor portion of residual non-glass particles, including metal particles, are

sorted from a substantially non-glass fraction and said glass concentrate fraction is photoelectrically sorted according to color, the improvement which comprises:

passing said glass concentrate fraction through a high-tension electrostatic sorting zone prior to said photoelectric sorting step, and in said electrostatic sorting zone, electrostatically sorting said particles according to the electrical conductivities thereof, and

recovering the less conductive glass fraction.

2. A method of sorting refuse according to claim 1 wherein said particles have a size in the range of one-fourth to three-fourth inch.

3. A method of sorting refuse according to claim 2 wherein said particles are deposited onto the surface of a rotating drum in said electrostatic sorting zone and said electrostatic sorting step comprises applying an electrical potential of at least 20 kilovolts to said particles on said rotating drum.

4. A method of sorting refuse according to claim 3 wherein said drum rotates at a speed of about 10 rpm. or slower.

5. A method of sorting refuse according to claim 2 wherein said electrostatic potential is applied at an angle to said drum slightly above the horizontal centerline thereof.

6. A method of sorting refuse according to claim 5 and further comprising the step of applying a discharge of electricity to said particles on said drum.

7. A method of sorting refuse according to claim 6 wherein said discharge of electricity is applied to said particles at an angle to said drum slightly above the centerline thereof.

8. A method of sorting refuse according to claim 1 wherein said less conductive fraction is further sorted according to the transparency thereof prior to said color sorting step.

9. In a system for sorting refuse wherein said refuse is comminuted into a particulate mass and a glass concentrate fraction consisting substantially of glass particles and a small portion of residual non-glass particles

including metals is sorted from a substantially non-glass fraction, and said glass concentrate fraction is sorted according to color, the improvement which comprises:

means for sorting particles according to the conductivities and/or affinity for surface charge thereof,

means for passing said glass concentrate fraction to said conductivity/surface charge affinity sorting means wherein conductive particles in said glass concentrate fraction are removed therefrom, leaving a substantially metal-free glass concentrate fraction; and

means for recovering said metal-free glass concentrate fraction for sorting according to color.

10. A system for sorting refuse according to claim 9 wherein said conductivity sorting means includes:

an electrically grounded drum;

means for rotating said drum about its axis;

a high tension electrode spaced from said drum;

means for applying a potential to said electrode; and an electrical discharge electrode in electrical contact with said high-tension electrode.

11. A system for sorting refuse according to claim 10 and further comprising means mounting said high-tension electrode and said electrical discharge electrode so that said high-tension electrode assumes a position slightly above the horizontal centerline of said drum and said electrical discharge electrode is substantially behind said high-tension electrode.

12. A system for sorting refuse according to claim 11 and further comprising means for separating from said glass concentrate fraction those particles having a mean average diameter greater than three-fourth inch and less than one-fourth inch upstream of said conductivity/surface charge sorting means.

13. A system for sorting refuse according to claim 9 and further comprising means for sorting from said glass concentrate fraction those particles having a mean average diameter greater than three-fourth inch and less than one-fourth inch upstream of said conductivity/surface charge sorting means.

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