

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
12 February 2004 (12.02.2004)

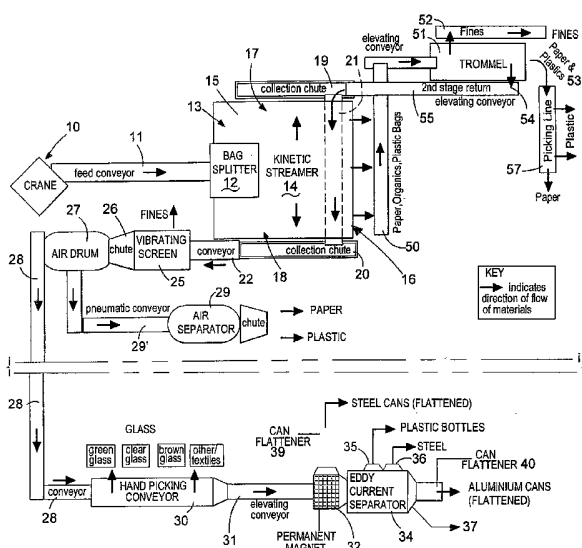
PCT

(10) International Publication Number
WO 2004/012866 A2

- (51) International Patent Classification⁷: **B03B 9/06**
- (21) International Application Number: PCT/GB2003/003324
- (22) International Filing Date: 1 August 2003 (01.08.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
0217895.2 1 August 2002 (01.08.2002) GB
- (71) Applicant (for all designated States except US): **WASTEC LIMITED** [GB/GB]; The recycling Centre, Yarm Road, Stockton on Tees, Cleveland TS18 3RU (GB).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **MOREHEAD, Gordon** [GB/GB]; c/o Wastec Limited, The Recycling Centre, Yarm Road, Stockton on Tees, Cleveland TS18 3RU (GB).
- (74) Agents: **BROWN, Fraser, Gregory, James et al.**; fJ Cleveland, 40-43 Chancery Lane, London WC2A 1JQ (GB).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— without international search report and to be republished upon receipt of that report

[Continued on next page]

(54) Title: IMPROVEMENTS TO WASTE SEPARATION



(57) Abstract: The present invention relates to an apparatus and a method for separating material, in particular waste material. Such material is normally in a co-mingled state and can consist of newspapers, cardboard, plastic bottles, glass, organic waste and other such items. According to the present invention there is provided a waste separation system for separating domestic waste comprising: means for introducing co-mingled domestic waste held in discrete bags onto a loading waste conveyor; a bag splitter into which the waste bags are conveyed and which directs a stream of waste onto; a kinetic separator comprising a generally horizontally reciprocating table which separates waste on the basis of variations in travelling response to a snatch action imparted to the table by the reciprocation, the table being formed with sloping portions which direct waste on the one hand to one or both side regions of the table and on the other hand to a distal end region of the table, a secondary waste exit means at a distal end of the table providing an exit for waste which travels the length of the table; primary waste exit means at one or both side regions of the table for waste which is directed to a side region of the table by virtue of the reciprocating motion thereof; a primary waste conveying means for transporting waste from the primary exit means of the table; a

screen separator into which is conveyed primary waste, which separator comprises one or more vibrating screens for removing relatively fine debris from the primary waste, and conveying the remaining waste; an air drum separator which receives the remaining waste, which air drum separator is adapted to entrain articles of paper or sheet plastics into an air stream and direct the entrained paper or plastics articles to an air separator for separating paper from plastics; a picking station along which is conveyed un-entrained waste from the air drum separator, which picking station permits removal of glass and textiles from the waste stream; a magnetic separator which removes magnetic metallic material from the waste stream by magnetic attraction; an eddy current separator for separating plastics articles, magnetic metallic articles and non-magnetic metallic articles one from another.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Improvements to Waste Separation

The present invention relates to an apparatus and a method for separating material, in particular waste material. Such material is normally in a co-mingled state and can consist of newspapers, cardboard, plastic bottles, glass, organic waste and other such items. With increasing environmental awareness, objections have grown to the use of landfill and incineration for disposing of domestic waste. Recycling has therefore come to be seen as an environmentally friendly way of dealing with waste. In order for recycling to be possible, the waste must be separated material by material. Hence paper, steel, aluminium, glass, textiles, plastics, organic waste and other components of waste must all be separated one from another.

Accordingly, the sorting of waste material for recycling has become a major problem. Many different systems have been developed in order to extract various components of waste. Certain elements of waste are more readily removed than others. For example magnetic or eddy current separators may be used for metallic waste, such as beverage cans. Meshes and filters may be used to remove and separate fine waste materials. Air blowers may be used to remove paper and plastic sheet. Inevitably the processes are not entirely material specific. For example non-metallic debris may be picked up with the

beverage cans during eddy removal. Paper and plastics may remain mixed after air blowing and glass and textiles may be difficult to separate by means other than hand picking.

5 The difficulties of separating domestic waste into recyclable separated quanta has led to the development of alternative waste management systems in which waste is separated by the domestic household. Local bottle and paper banks have been created where residents may deposit their glass and paper waste into discrete banks. In the home waste collection agencies may provide different
10 coloured waste bags. These are then assigned for use for paper, organic, plastics, glass or other waste. The success of these methods relies upon the co-operation of the householders. Because of the extra work that separation of waste requires within the household even the best intentioned of families find the process an inconvenient chore. Hence unless legal instruments are used to
15 enforce waste separation within the home, there is little hope for its efficacy as a separation method.

Hence efforts have continued in the development of methods for separating co-mingled domestic waste away from the household. It is possible to separate
20 certain elements of waste by, for example, relying upon the different physical properties of or dimensions of waste material. There is a requirement for a

separation system which can reasonable efficiently separate waste material into recyclable portions, with a minimum of un-recyclable end product.

WO-A-9743054 discloses a reciprocating table which is useful for separating components of waste on the basis of their inertia and differing motion response
5 to a reciprocating snatch action imparted to the table.

The present invention seeks to provide improved individual separating elements of a waste separation system, as well as an improved waste processing system
per se.

10

According to the present invention there is provided a waste separation system for separating domestic waste comprising:

means for introducing co-mingled domestic waste held in discrete bags onto a loading waste conveyor;

15 a bag splitter into which the waste bags are conveyed and which directs a stream of waste onto;

a kinetic separator comprising a generally horizontally reciprocating table which separates waste on the basis of variations in travelling response to a snatch action imparted to the table by the reciprocation, the table being formed

20 with sloping portions which direct waste on the one hand to one or both side regions of the table and on the other hand to a distal end region of the table, a

secondary waste exit means at a distal end of the table providing an exit for waste which travels the length of the table;

primary waste exit means at one or both side regions of the table for waste which is directed to a side region of the table by virtue of the reciprocating

5 motion thereof;

a primary waste conveying means for transporting waste from the primary exit means of the table;

a screen separator into which is conveyed primary waste, which separator comprises one or more vibrating screens for removing relatively fine debris

10 from the primary waste, and conveying the remaining waste;

an air drum separator which receives the remaining waste, which air drum separator is adapted to entrain articles of paper or sheet plastics into an air stream and direct the entrained paper or plastics articles to an air separator for separating paper from plastics;

15 a picking station along which is conveyed un-entrained waste from the air drum separator, which picking station permits removal of glass and textiles from the waste stream;

a magnetic separator which removes magnetic metallic material from the waste stream by magnetic attraction;

20 an eddy current separator for separating plastics articles, magnetic metallic articles and non-magnetic metallic articles one from another.

The secondary waste from the kinetic separator may be directed to a trommel separator having a first screen which removes relatively fine waste debris, a second screen which removes relatively large waste debris, and a downstream exit from which is conveyed paper and plastics articles. Preferably the waste removed by the second screen is conveyed back to the primary waste stream from the kinetic separator.

The following description relates to components of a waste separation system. According to various aspects of the present invention, the components may be provided individually, or in any combination with one another.

Means for introducing co-mingled domestic waste

This may comprise any suitable means for introducing waste such as refuse bags into the hopper. Examples of suitable devices include a grab crane, conveyor belt or screw (Archimedes) conveyor.

The bag splitter

According to this aspect of the present invention the bag splitter comprises hopper for receiving bags of mixed waste material, wherein a lower end region of the hopper is provided with a plurality of rotatably driven spindles, each spindle provided with a plurality of coaxially disposed spaced apart tearing

members, each tearing member comprising several radially extending arms.

Preferably the tearing members have a star configuration, for example six pointed stars. The tearing members on adjacent spindles may overlap so that
5 space between tearing members on one spindle is occupied by the radially extending arms of a tearing member on the adjacent spindle.

In one embodiment the spindles are arranged in two horizontally extending rows, one row above the other. Preferably the upper row is arranged so that
10 free space between spindles and tearing members of the upper row is greater than free space between the spindles and tearing members of the lower row, so that larger size particles may pass through the upper row than the lower row.
In this way waste particles may be gradually reduced in size by the bag splitter. Three or more rows may be provided if finer grading of waste material
15 is required. The decrease in free space may be achieved by providing a greater density of tearing members per spindle on the spindles of the lower rows.

In a particular embodiment there are two rows of spindles, an upper row comprising three parallel spindles and the lower row comprising for parallel
20 spindles.

Each spindle may be provided with drive means which allow for different rotational speeds or rotational directions as between spindles within a row, and/or as between spindles in different rows. The drive means may for example comprise variable speed and dual directional drive motors, each motor adapted
5 to drive a spindle.

The purpose of the "bag splitter" is to liberate the contents of the as received source material prior to presentation to the kinetic streaming equipment. The bag splitter can exist as a stand-alone unit of a particular size or can be used in
10 parallel with similar units to suit a given plant's requirements. A unit can be fed in a controlled manner in a number of ways such as by grab crane, belt feed, or screw conveyor.

In one embodiment, the bag splitter itself may consist of rows of parallel
15 rotating shafts each containing a number of "star-wheels" over their length. The shafts, wheels, and distance between the rows can be set at pre-determined distances from one another depending upon the particular application. The speed and direction of rotation of these shafts may be variable one with respect to another in order to modify and enhance the release effect.

20

Source material enters the bag splitter from above and falls onto the upper row

of star-wheels. These wheels then force apart compacted items within the waste and tear open any bags or containers releasing their contents. Released material is then free to fall through gaps between individual wheels and onto the next row. Each row of wheels will have a reduced fall-through gap, thus gradually
5 reducing the average product size into a suitable size for streaming purposes.

Upon exit from the splitter the material, can be either directly loaded onto a single kinetic streamer or fed to numerous streamers at pre-determined constant feed rates by means of screw conveyors, or other conveyors.

10

Trommel Separator

According to this aspect of the invention, there is provided a trommel separator comprises a rotatably driven drum which drum is provided on an internal surface thereof with an upstanding internally directed helical rib or ribs so that
15 channels are formed between adjacent ribs, and wherein the cylindrical drum is formed with a plurality of filter holes, whereby in use rotation of the drum and helical rib or ribs acts to direct waster material along the channels between the ribs, from one end of the drum to the other, and wherein the filter holes allow waste material smaller than the hole dimensions to fall under gravity out from
20 the drum.

The drum may be maintained at an incline so that an entrance end is raised with respect to an exit end. In this way the travel of large material particles along the drum is encouraged.

5 The holes may be of varying size. Typically the holes will be relatively small towards the entrance end of the drum, and relatively large towards the exit end. In this way fine material is removed first, followed by fine and larger particles released by a tumbling motion induced by the drum rotation.

10 In a particular aspect of the invention, the holes may be provided by a series of large orifices formed in the drum located along the channels, which orifices may be provided with a mesh overlay. The grading of the mesh may be varied along the length of the channels so as to provide a varying particle size separation.

15

Waste falling from the trommel may be collected and transported away by means of a belt conveyor axially located beneath the drum.

In one embodiment, the 'trommel' consists of a driven cylindrical vessel which
20 is used to separate material received from the kinetic streamer(s) into separate material groups which can then be more readily processed. The main groups

that are retrieved are organic fine particles in a number of separate grades, and a mixed group of other material which is separable by size.

The operating principle relies upon material being fed into an inclined rotating cylinder which has raised internal transfer spirals. The raised spiral effect carries larger objects through the trommel in a tumbling motion passing then out of the exit end of the spiral. This tumbling motion frees up entrapped smaller products, such as organic fines and cans etc., which when released fall onto the outer surface of the cylinder wall. Still trapped within the spiral, these items are removed from the trommel through varying sizes of exit holes depending upon the nature of material requiring removal. Typically these exit holes will be smaller at a front end getting larger towards an exit end. Material falls by gravity from the trommel into separate bunds or onto conveyors so as to be removed for further use or processing. The material that is carried through the trommel passes out of the exit end and usually consists of various larger items including paper and plastic film which can then be separated by other means such as an air drum and picking line chosen according to the degree of separation required.

20 Air drum separator

According to yet another aspect of the invention there is provided a separator

comprising a generally cylindrical drum formed with a plurality of holes which provide air communication between an interior of the cylinder and an exterior of the cylinder, vacuum means for generating a relatively low pressure region interior of the cylinder, drive means for rotating the drum, whereby waste
5 directed onto an outside surface of the drum may be held by the vacuum action to the drum, or may pass through the drum surface via the holes for collection under the drum.

Means may be provided to detach waste held against the drum by the vacuum.
10 Such means may be a scraper for lifting the waste from the exterior surface so that the waste may fall away from the drum.

However, according to a preferred embodiment of the invention, the detachment means may comprise a selective sleeve fixed proximal to an
15 interior region of the drum, so that at as the drum rotates relative to the sleeve, the drum holes become occluded by the sleeve, so that the interior low pressure of the drum is no longer able to communicate with the outside of the drum, and the low pressure is released from the drum in the region of the sleeve so that the waste may fall from the drum.

20

The sleeve preferably comprises a truncated cylindrical member, corresponding

to an arc of the cylinder which defines a portion of cylindrical surface. The truncated cylindrical member is preferably oriented so that the sleeve occupies one side or half of the drum.

- 5 The drum separator is useful for separating flexible planar materials such as plastics sheet, paper, textiles or the like. The material is drawn from the waste stream onto the drum by the vacuum action and held until removed by the detachment means. The detachment means may comprise a scraper which lifts the material from the drum surface, or a roller.

10

- The air drum separator is a device designed to extract paper and non-rigid plastic film from the process material flow. It comprises a drum, the surface of which is constructed using a mesh of a grade specific to the particular material stream received. The drum is rotated at a speed dictated by the nature of process material. Air extraction by driven fan evacuates the core area of the drum, causing air to be drawn in through the apertures in the surface mesh and create the necessary suction effect. An air release screen segment provided internal to the drum ensures that only a part of the drum's surface is exposed to suction.

20

The suction is created through the surface mesh allows paper and film passing

over the drum to adhere to it and be separated from the remaining material flow, which, with a higher mass falls from the drum unaffected. Paper and film remain held to the surface of the drum until it passes over the fixed air release segment where the suction effect is eliminated, allowing the paper to fall into
5 the conveyor zone to be removed by conveyor or further processing.

A counter-rotating mult-finned roller positioned at the material off-take area of the air drum removes any unwanted over size items that may be held on to the drum surface by the suction. These items together with the remaining waste are
10 then passed to a conveyor and on for further processing.

Kinetic Streamer

A suitable kinetic streamer is a material-separating table of the type disclosed in WO-A-9743054, the disclosure of which is incorporated herein by reference.
15 This document discloses a separating table which is sloped and profiled in a generally convex manner so that material tends to fall off the table in response reciprocating movement of the table in a forward and backward sense. The severity of the return motion at the extremes of table motion may be used to induce travel of material across the table. The rate of travel depends upon
20 various factors such as particle mass, shape and size. However, by fine-tuning it is possible to ensure that like waste falls from the table at different locations

along the table.

Alternatively, and according to another aspect of this invention, there is provided an improved material separator comprising:

- 5 a table formed with generally convex upper surface, the surface following a sloping profile of gradually reducing fall from a rear end of the table to a front end, which sloping profile promotes transport of material on the table by gravity feed to side regions of the table and the front end of the table, wherein the table is provided with a reciprocal drive mechanism which acts to
- 10 induce a reciprocal motion of the table in front/rear directions, characterised in that the drive mechanism is an hydraulic mechanism comprising at least one hydraulic actuator drives the table, which is provided with a positional feedback device for monitoring actuator positions, and an actuator controller in communication with the feedback device, which controller is capable of
- 15 logging actuator stroke as a function of time, thereby permitting calculation of table speed and acceleration during each stroke, wherein the controller is programmable so that stroke dynamics may be adjusted, to vary the separating effect of the table during reciprocation.
- 20 The critical period of the stroke for creating a discriminatory separation effect is the extremes at which the table changes direction. By varying the harshness

of the change in direction, the waste matter may be induced to travel along the table at one direction change, and across the table towards the side at the other direction change. The amount of lateral or longitudinal travel is dependent on the characteristics of the individual particles of waste matter, but generally speaking items of the same material, having the same shape, will respond in the same way. In addition different material/shape combinations will respond to a different extent, so that different material types will develop distinct streams of travel across the table. In this way some particle types will fall off the table early in their travel as they tend to go directly to the sides of the table.

Whereas others may travel longitudinally along the table to the front.

The separator may be provided with one or more ancillary actuators which act to enhance or dampen the harshness of the main actuator stroke motion. Hence the ancillary actuators may provide a harsh kickback on the out or front stroke, followed by a smooth return stroke. Preferably there are one or more front ancillary actuators and one or more rear ancillary actuators. In this way a high degree of material discrimination and tuning may be achieved by means of the controller.

The ancillary actuators are may be hydraulic. However, preferably the ancillary actuators are gas driven, so that a high acceleration may be imparted to the

ancillary actuators.

The timing of the reversal of the main actuator should coincide with application of an ancillary actuation effect which will counteract the severity of a return (to provide damping) or add to the severity to provide a kickback effect.

Preferably there is at least one feed chute for delivering material to the table surface. One or more of the feed chutes may be vibrated during use. If there are two or more feed chutes, then gaps can be provided between successive feed chutes so that some material is extracted before reaching the carrier surface.

Vibrating screen

The waste separation system may include a vibrating screen device. The vibrating screen device comprises a grille which may be formed from an array of parallel elongate rods mounted over a collection hopper. The grille provided with reciprocal drive means and is longitudinally oriented so that the rods are aligned with the reciprocal travel directions. The reciprocal drive promotes movement of particles too large to fall between the grill, along the grill. The grill is preferably provided with an incline so that the grilles is inclined

downwards towards a waste egress end of the grill. A further, finer vibrating screen may be provided downstream of the first grille, so as to provide further sifting of the waste received by the hopper under the first screen.

- 5 The double grille reduces the risk of contamination of the organic product being extracted and can also be used to grade the organics to suit a particular application.

- 10 All parameters of the machine characteristics and operation are variable to suit the material being processed, including the design, inclination and orientation of the grilles together with the frequency and amplitude of vibration.

- 15 The vibrating screen is particularly effective at extracting fine organic material from the waste material flow. Smaller and less rigid waste material falls between the rods of the grill, while larger material is conveyed onwards in the stream.

Picking line

- 20 The waste separation system may comprise a manual picking line which may be a horizontal conveyor provided with one or more personnel platforms for workers to access the waste stream on the conveyor. Workers visually select

types of waste such as aluminium, steel, rigid plastic and glass or textiles.

These are manually retrieved and conveyed to sorting bins. This is particularly useful for material which is not otherwise susceptible of automatic separation using the methods provided.

5

The picking line comprises an enclosed horizontal conveyor, with a personnel platform provided on one side, and a series of off-take chutes on the opposite side. Material is fed onto the conveyor at one end, and any undesired material is removed by hand and thrown onto chutes for further processing or disposal.

10 As the material progresses along the conveyor, any glass present is removed by hand and sorted by colour. The remaining aluminium, steel and rigid plastics are then fed to an exit conveyor for further processing.

Ferrous material separator

15 The waste separating system may include a ferrous material separator, such as are known in the art. These apply a magnetic field to a moving stream of waste, so that ferrous material (such as drink or food cans) is continuously entrained in the magnetic field and drawn away from the stream of waste. The magnetic field means may be provided on a moving conveyor so that entrained
20 ferrous material is continuously conveyed away from the waste stream. The conveyor should operate in a travelling direction orthogonal, or substantially

orthogonal to the direction of waste stream travel.

Brief Description of the Drawings

Following is a description with reference to the figures of the drawings, and by
5 way of example only, of embodiments of the present invention.

In the drawings:

Figure 1 is a schematic plan view of a separating system according to the
present invention.

10

Figure 2 is a top view of a bag splitter according to one aspect of the present
invention.

15

Figure 3 is a cut away side view of the bag splitter, showing spindles end-on.

Figure 4 is a cut away side view of the bag splitter, showing spindles side-on.

20

Figure 5 is a perspective rendition of a waste separation surface according to
another aspect of the invention.

Figure 6 is a side view of a trommel according to the present invention.

Figure 7 is an end-on view of the trommel.

Figure 8 is an enlarged view of filter mesh incorporated in the trommel.

- 5 Figure 9 is a plan view of a vibrating screen separator forming a component of the waste separation system.

Figure 10 is a side view of the screen.

- 10 Figure 11 is a front end view of the screen separator.

Figure 12 is an end on view along arrow A in figure 13 of a drum separator according to a further aspect of the present invention.

- 15 Figure 13 is a sectional side view of the drum separator.

Figure 14 is an end-on view along arrow B in figure 13 of the drum separator.

- Figure 15 is a sectional side view of a picking station forming a component of
20 the present invention.

Figure 16 is an end-on view from the exit end of the picking station.

Figure 17 is a side view of a ferrous metal separator forming a component of the present invention.

5

Figure 18 is an end-on view of the separator.

Waste material separating system

Figure 1 is a schematic representation in plan view of a waste material separation system according to the present invention. The general separation process and components are described immediately hereafter. A detailed description of apparatus elements forming part of the system is provided afterwards, under the distinct headings for each component.

10 Municipal solid waste comprising domestic waste contained in bags and loose form is delivered to the base of a crane 10. The crane is provided with a depending grab claws with which to grasp and lift waste. By means of the crane, waste is deposited on a feed conveyor belt 11. The conveyor belt is angled upwardly from the depositing region to an upper end region of a bag splitter 12. The bag splitter comprises a hopper into which the waste is conveyed. A lower region of the hopper is provided with plural rotating

15

20

spindles, each of which is provided with coaxially mounted and radially extending spikes in the form of stars. These tear into the waste bags to liberate the bag contents. The contents and torn bags drop from the hopper onto a lead end region 13 of a kinetic streamer 14.

5

The streamer comprises a generally horizontally reciprocating table 15 with a separating surface 14. The table reciprocates back and forth in along a single axis between the lead end region 13 and a distal end region 16. The table changes direction at each end of its travel. On the basis of the differing responses of waste articles and debris to a snatch return stroke imparted to the table waste moves over the table in a way which effectively separates material having different shape, size configuration or density. The table is formed with downwardly tapering portions which lead toward side regions 17 and 18 of the table. Relatively dense, small matter and articles falls toward the side regions of the table. This matter drops from the edge of the table through collection chutes 19, 20. A first collection chute 19 opens onto an ancillary conveyor 21. The ancillary conveyor passes underneath the table 15 to the other side region 18. The ancillary conveyor deposits waste from the side region 17 into second collection chute 20 where it joins waste from the side region 18. This waste from chute 20 is allowed to fall onto a primary conveyor 22 which conveys side region originating waste to a vibrating screen station 25.

20

The vibrating screen station is of a type described in more detail hereinafter.

The screens have a mesh which allows relatively fine objects and debris to pass there through. The screen vibrates to ensure that the waste agitated. This ensures that fine matter is not masked by other larger matter and prevented
5 from passing through the mesh. A downstream exit from the screen station directs the waste stream into a chute 26. The chute directs waste into a drum separator 27.

The drum separator comprises a cylindrical main housing, and a mesh internal
10 cylinder. A vacuum pump communicates with an interior region of the internal cylinder. The cylinder is rotated above the waste stream. By virtue of the low pressure zone created by the vacuum pump inside the internal cylinder, large sheets an object are drawn onto an exterior surface of the cylindrical mesh. Typically plastic sheet, paper and clothing are drawn onto the cylinder. This
15 lifted material is continually peeled away from the cylinder exterior surface by a scraper. This peeled sheet matter is conveyed by a pneumatic conveyor 29' to an air separator 29. This separator uses differential air entrainment properties of the sheet material to separate paper from plastics material.

20 Waste not drawn onto the drum separator 27 passes unaffected from the drum and to a conveyor 28. This conveyor transports the remaining waste to a hand

picking station 30. The hand picking station requires the use of manual labour to identify and remove green glass, colourless glass, brown glass, textiles and other substantial articles which would not otherwise be removed by the downstream stations.

5

From the hand picking station 30, the waste is conveyed by conveyor 31 past a magnetic separator 32. The magnetic separator is of a type described hereafter. It comprises a permanent magnet 33 which is disposed above the waste stream. The magnet removes magnet-responsive material, typically steel beverage cans.

10 The steel beverage cans are delivered to a flattener 39.

Waste passing the magnetic separator is directed through an eddy current separator 34, of a type common in the art, and not described in further detail herein. The separator provides an exit 35 for low-density plastics articles such as bottles, an exit 36 for steel articles not removed by the magnet 33, and a downstream exit 37 for low-density aluminium articles such as beverage cans. The cans are delivered to a can flattener 40.

Returning now to the kinetic streamer, waste which travels along the full length of the reciprocating table 15 to the distal end region drops onto a secondary conveyor belt 50. Such waste is typically low-density material such as organic

20

food matter, paper, card, plastics material bags and packaging. The conveyor
50 delivers the waste to a trommel separator 51. The trommel separator action
is described hereinafter. It separates fine material and delivers it from a first
exit 52, it separates relatively large plastic and paper articles which are
5 delivered from a downstream end 53 of the trommel, it also separates more
general waste from a second exit 54. Waste from the second exit is conveyed
by a return conveyor 55 to the side collection chute 18 of the kinetic streamer.
In this way waste appropriate for further separation is returned to the main
waste stream. The downstream end of the trommel is provided with a chute
10 which directs the waste to a hand picking station 57 for separation of paper and
plastics.

The configuration of individual components of the system will be described in
the following.

15

Bag splitter

The bag splitter 12 shown in figure 1 is shown in figures 2 to 4. The splitter
comprises a conventional square tapered hopper 100. The hopper is located
over an orthogonal frame 101 of upstanding legs and cross members. The
20 frame carries two rows 102, 103 of spindles. The upper row of spindles 102
comprises three horizontally spaced parallel spindles. The spindles each carry a

plurality of six-pointed star shaped tearing wheels 104.

The lower row 103 comprises four horizontally spaced parallel spindles. Each spindle carries a plurality of six-pointed star shaped tearing wheels 105. The
5 density of wheels on the lower spindles (i.e. number of wheels per spindle) is greater on the lower spindles than the on the upper spindles. For example, as shown in figure 4, each upper spindle carries seven wheels, whereas each lower spindle carries fifteen wheels.

10 In addition, the lower wheels are smaller than the upper wheels. As there are more spindles in the lower row 103 than the upper row, and as each spindle carries more wheels on the lower row, the free space between wheels on the lower row is less than on the upper row. Thus two grades of particle size reduction are provided. A relatively coarse first grade corresponding to the
15 upper row, and a relatively fine grade corresponding to the second row.

Each spindle is driven by a unique variable speed bi-directional electric motor 107. The motors are provided with a controller allowing user adjustment of spindle rotation speed and direction. Differential directions and speeds as
20 between adjacent spindles can provide enhanced shearing and tearing action.

Bags of waste dropped into the hopper are torn and sheared by the upper wheels. The free material falls under gravity to the next layer of wheels, for further shearing by the wheels.

- 5 Once the waste is sufficiently fine to fall through the free space in the lower row, it falls onto the kinetic streamer surface 14.

Kinetic Streamer

- The kinetic streamer 15 shown in figure 1 is has a surface and drive
10 mechanism shown schematically in figure 5. The table surface 14 is represented in figure 5 with a magnified vertical axis, so that the form of the table is emphasised more than would otherwise be the case with a scale representation. In practice the form of the table, and the degree of shaping will be arrived at by routine trial and error, provided that Figure 5 provides
15 guidance as to the kind of shaping that will be suitable to provide a waste separation effect for domestic refuse.

- The table is formed by machining to have a lateral profile which tapers gradually away from the middle region 200 of the table and then more steeply
20 from the edge regions 201 of the table. The table has a longitudinal profile which tapers from a waste-receiving end 202 down to a waste exit end 203.

The table 15 is mounted on bearings (not shown) which permit low friction fore-aft motion of the table, as indicated by the motion arrows AA' in figure 5.

The table is attached at a rear end to a hydraulic actuator 204. An hydraulic power unit 205 drives the actuator. The hydraulic activator provides a fore-aft
5 (longitudinal) reciprocating action on the table.

The sloping profiled reciprocating table is driven by a hydraulic power unit 205. The table travels upon fixed guide rails, and the table separates a mixed waste stream into a number of separate streams each containing similar
10 materials.

The table motion is critical to creating these differing waste streams and it is the rate of change in direction coupled with the speed of travel that govern how the materials behave during operation.

15

An hydraulic power unit drives, through various control elements and the use of a proportional valve, a main reciprocating actuator 204 which is coupled to the table. The actuator is fitted with a positional feedback device which interfaces with a PLC (Programmable Logic Controller) based operating
20 system. System operating parameters, such as speed, stroke etc. are inputted via an HMI (Human Machine Interface) panel which is also capable of displaying

real time position monitoring and system alarms.

Although the action of the table is simply that of a back and forth motion, the change in direction that is encountered at the extremes of the stroke is

5 controlled in such a manner as to impart forward momentum into the waste at an "out" stroke and a sideways impetus at an "in" stroke. By varying the degree of harshness of the change in direction, along with the rate of travel, the waste material will behave in different ways thus giving control over the streaming effect.

10

Gas damper cylinder pairs 206 and 207, front and back respectively, are utilised to create this 'kick-back' as required by the waste stream on the out stroke and to 'dampen' the impact on the return stroke. The control positions at which the damper cylinders and the hydraulic drive system interact with each other is critical to the performance of the 'kinetic streamer' as the compression of the damper cylinders aids in the rate of change of direction of the machine. The timing of the reversal of the hydraulic drive should be at a point that will correspond to the extent of resistance met by the damper cylinders.

20 **Trommel**

Figure 6 shows a trommel 51 of the waste management system. The trommel

comprises a cylindrical screening member 300. The screening member is formed with an internal helical spine 301 (shown in dashed lines in figure 6) which upstands from the screening member. The screening member is supported at each end region thereof by rectilinear frame members 302 and 303. The frame members include annular bearings (not shown) which permit rotation of the cylinder. A variable speed motor drive 304 drives a rear end region 305 of the cylinder via a roller 306. The cylinder is inclined downwardly from the front end 306 to the rear 305. This provides a gravity assisted feed of matter in the trommel.

10

The spine 301 defines a U-section channel which spirals through the inside surface of the cylindrical member. A series of large screening holes 308 provided along the channel, through the cylindrical member. Each large hole is provided with a relatively fine mesh 309 of round holes to provide fine screening.

15

A fixed speed conveyor 310 runs under the cylindrical member and collects fine material (such as organic matter) which falls through the fine mesh 309. Larger particles are drawn through the cylindrical member in the manner of an Archimedes screw, and deposited from the rear end 306 onto a further conveyor 311. This material is typically plastics film, paper etc.

20

Vibrating screen

Figure 9 is a plan view of the screen separator 25 shown in figure 1. The screen separator comprises a planar screen 400 which comprises a plurality of elongate rods 401. The rods are supported on four horizontal cross members
5 402.

The screen is mounted on a chassis 403 via pivots 404 at a front end region of the screen, and return arms 405 at a rear end region. The chassis is attached to an under frame 406 via four coil springs 407. Two vibration actuators 408 act
10 between the chassis and frame (linkage not shown) to induce vibration of the screen. The screen is mounted at an angle leading downwards from the pivots 404 to the return arms 405. The rods 401 are aligned longitudinally to facilitate travel of particles under the influence of vibration and gravity along the screen. Particles which are small enough, or which are broken into smaller pieces by
15 the vibration action, fall between the rods and may be collected separately. Larger particles are expelled from the screen at the rear end thereof.

Air drum separator

The air drum separator 27 is shown in figures 12, 13 and 14. The separator has
20 a hopper 500 which receives waste from the vibrating screen described hereinbefore. The separator comprises a rectilinear housing 501 which is

formed at a lower end region thereof with a waste collection bin 502 for collecting small particles which fall through the drum separator 503 mounted above. The drum separator comprises a cylindrical screened component 514 having a cylindrical circumferential surface 504 and front end 505 and open rear end 506. The cylinder is mounted for rotation about an axle 507 which is supported at each end thereof by bearings 508, 509. Radial spokes 510 support the cylinder on the axle. The axle is belt drive by an electric motor 511.

A shield member 515 is a segment of a cylinder which is located internally of the cylindrical screen 514. The segment member corresponds to about half the cylindrical screen 514, so that it shields the about half the internal surface of the cylindrical screen at any one time. The segment 514 is fixed in the position shown in figures 12 and 13 and does not rotate with the screen 514.

An air extractor 520 comprises a fan (not shown) that operates to create a low-pressure region within an extractor chamber 521. Two extractor ducts 522 extend vertically from the chamber to expel air drawn into the extractor chamber. Air is drawn by the fan through the front side of the screen cylinder in the direction shown by arrow A in figure 13. In this way a low-pressure region is created inside the cylinder.

In use, waste material is directed onto an upper side of the drum separator as shown in figure 12. The drum is rotated continuously so that waste material is conveyed around the outside of the cylinder. Small particles pass through the drum screen and are collected in the bin 502. Larger matter remains on the outside of the screen. As the screen rotates, planar flexible material such as paper, plastics sheeting and textiles is held on the screen by the pressure differential between the outside of the drum and the inside. Particles or shapes which are not capable of being drawn and held onto the screen fall away from the screen as the screen rotates. These are then conveyed towards the hand picking station by the belt conveyor 28 shown in figure 1.

The planar material is held onto the screen and until the segment shield masks the screen so that the suction of the inside of the drum is released. Thus as the screen passes the fixed segment shield, the planar material falls away (with the aid of a scraper (not shown) if necessary. The fallen paper is gathered in the bin 502 and conveyed to an air separator 29 (in figure 1). The air separator is one common in the art and is not therefore described in detail herein. It acts to separate plastics material from paper material.

Hand picking station

Figures 15 and 16 show the picking station 30 forming part of the system of

figure 1. The hand picking station comprises a belt conveyor 600 which receives material from the air drum separator 27. Alongside the belt conveyor is a raised platform 601 which provides access to the belt conveyor for personnel tasked with waste picking. On an opposite side of the conveyor to the platform are four collection bins 602, each having an associated chute 603 to collect material picked and discarded by the picking personnel. The pickers take material which is difficult to separate other than by human intervention, and unwanted material which has passed through the other separation steps without being selected. Typically, glass is one such material.

10

Ferrous metal separator

A ferrous metal separator 32 used in the system of the present invention is shown in figures 17 and 18. The separator comprises a belt 700 of magnetic material. The conveyor is driven by an electric motor 701. The motor and belt conveyor are supported by a frame 702. The belt is aligned across an inclined waste material conveyor 31. As material passes under the magnetic conveyor, ferrous material such as steel or iron is entrained in the magnetic field and drawn onto the magnetic conveyor. The conveyor transfers the material around to a discharge side 703 where the ferrous material is ejected, by for example a belt scraper (not shown), or by locally depleting the magnetic field.

20

Non-magnetic metals may be removed by the use of an eddy current separator

34.

Magnetic (eddy current) separator

An eddy current separator is shown as 34 in figure 1. Eddy current separators
5 are well known in the field of waste processing, and are typically used to
separate non-ferrous metals, such as aluminium cans, from non-metallic waste.
The separators use magnetic circuits to produce strong eddy current forces,
which allows separation based upon the varying response of different materials
to the applied eddy current.

10

In an eddy current separator, a rotor comprised of magnet blocks, either
standard ferrite ceramic or the more powerful rare earth magnets depending on
application, are spun at high revolutions (over 3000 rpm) to produce an 'eddy
current'. This eddy current reacts with different metals, according to their
15 specific mass and resistivity, creating a repelling force on the charged particle.
If a metal is light, yet conductive such as aluminium, it is easily levitated and
ejected from the normal flow of the product stream making separation possible.
Separation of stainless steel is also possible depending on the grade of material.
As such separators are well known in the art a detailed description of the
20 implementation used in the system of the present invention is not given herein.

Claims

1. A waste separation system for separating domestic waste comprising:
means for introducing co-mingled domestic waste held in discrete bags onto a
5 loading waste conveyor;
a bag splitter into which the waste bags are conveyed and which directs a
stream of waste onto;
a kinetic separator comprising a generally horizontally reciprocating table
which separates waste on the basis of variations in travelling response to a
10 snatch action imparted to the table by the reciprocation, the table being formed
with sloping portions which direct waste on the one hand to one or both side
regions of the table and on the other hand to a distal end region of the table, a
secondary waste exit means at a distal end of the table providing an exit for
waste which travels the length of the table;
15 primary waste exit means at one or both side regions of the table for waste
which is directed to a side region of the table by virtue of the reciprocating
motion thereof;
a primary waste conveying means for transporting waste from the primary exit
means of the table;
20 a screen separator into which is conveyed primary waste, which separator
comprises one or more vibrating screens for removing relatively fine debris

from the primary waste, and conveying the remaining waste;
an air drum separator which receives the remaining waste, which air drum separator is adapted to entrain articles of paper or sheet plastics into an air stream and direct the entrained paper or plastics articles to an air separator for
5 separating paper from plastics;
a picking station along which is conveyed un-entrained waste from the air drum separator, which picking station permits removal of glass and textiles from the waste stream;
a magnetic separator which removes magnetic metallic material from the waste
10 stream by magnetic attraction;
an eddy current separator for separating plastics articles, magnetic metallic articles and non-magnetic metallic articles one from another.

2. A system as claimed in claim 1 wherein the secondary waste from the
15 kinetic separator is directed to a trommel separator having a first screen which removes relatively fine waste debris, and a downstream exit from which is unscreened matter.

3. A system as claimed in claim 1 or claim 2 wherein the means for
20 introducing co-mingled domestic waste comprises a grab crane, a conveyor belt or a screw (Archimedes) conveyor.

4. A bag splitter for use in the waste management system comprising a hopper for receiving bags of mixed waste material, wherein a lower end region of the hopper is provided with a plurality of rotatably driven spindles, each spindle provided with a plurality of coaxially disposed spaced apart tearing members, each tearing member comprising several radially extending arms.
5. A splitter as claimed in claim 4 wherein the tearing members have a star configuration, for example six pointed stars.
- 10 6. A splitter as claimed in claim 5 wherein the tearing members on adjacent spindles overlap so that space between tearing members on one spindle is occupied by the radially extending arms of a tearing member on the adjacent spindle.
- 15 7. A splitter as claimed in any of claims 4 to 6 wherein the spindles are arranged in two horizontally extending rows, one row above the other.
8. A splitter as claimed in claim 7 wherein the upper row is arranged so that free space between spindles and tearing members of the upper row is
- 20 greater than free space between the spindles and tearing members of the lower row, so that larger size particles may pass through the upper row than the

lower row.

9. A splitter as claimed in claim 8 wherein the free space is achieved by providing a greater density of tearing members per spindle on the spindles of
5 the lower rows.

10. A splitter as claimed in any of claims 4 to 9 wherein each spindle is provided with drive means which allow for different rotational speeds or rotational directions as between spindles within a row, and/or as between
10 spindles in different rows.

11. A trommel separator for use in the waste separating system comprising a rotatably driven drum which drum is provided on an internal surface thereof with an upstanding internally directed helical rib or ribs so that channels are
15 formed between adjacent ribs, and wherein the cylindrical drum is formed with a plurality of filter holes, whereby in use rotation of the drum and helical rib or ribs acts to direct waster material along the channels between the ribs, from one end of the drum to the other, and wherein the filter holes allow waste material smaller than the hole dimensions to fall under gravity out from the
20 drum.

12. A trommel separator as claimed in claim 11 wherein the drum is maintained at an incline so that an entrance end is raised with respect to an exit end. In this way the travel of large material particles along the drum is encouraged.

5

13. A trommel separator as claimed in claim 11 or claim 12 wherein the filter holes may be of varying size, typically the holes will be relatively small towards an entrance end of the drum, and relatively large towards an exit end.

10 14. An air drum separator for use in the waste separating system comprising a generally cylindrical drum formed with a plurality of holes which provide air communication between an interior of the cylinder and an exterior of the cylinder, vacuum means for generating a relatively low pressure region interior of the cylinder, drive means for rotating the drum, whereby waste directed onto
15 an outside surface of the drum may be held by the vacuum action to the drum, or may pass through the drum surface via the holes for collection under the drum.

15. A drum separator as claimed in claim 14 wherein the detachment means
20 comprises a selective sleeve fixed proximal to an interior region of the drum, so that at as the drum rotates relative to the sleeve, the drum holes become

occluded by the sleeve, so that the interior low pressure of the drum is no longer able to communicate with the outside of the drum, and the low pressure is released from the drum in the region of the sleeve so that the waste may fall from the drum.

5

16. A drum separator as claimed in claim 15 wherein the sleeve comprises a truncated cylindrical member, corresponding to an arc of the cylinder which defines a portion of cylindrical surface.

10

17. A reciprocating table separator for use in the waste separating system comprising a table formed with generally convex upper surface, the surface following a sloping profile of gradually reducing fall from a rear end of the table to a front end, which sloping profile promotes transport of material on the table by gravity feed to side regions of the table and the front end of the table, wherein the table is provided with a reciprocal drive mechanism which acts to induce a reciprocal motion of the table in front/rear directions, characterised in that the drive mechanism is an hydraulic mechanism comprising at least one hydraulic actuator drives the table, which is provided with a positional feedback device for monitoring actuator positions, and an actuator controller in communication with the feedback device, which controller is capable of logging actuator stroke as a function of time, thereby permitting calculation of

15
20

table speed and acceleration during each stroke, wherein the controller is programmable so that stroke dynamics may be adjusted, to vary the separating effect of the table during reciprocation.

- 5 18. A reciprocating separator as claimed in claim 17 wherein the separator may be provided with one or more ancillary actuators which act to enhance or dampen the harshness of the main actuator stroke motion whereby the ancillary actuators may provide a harsh kickback on the out or front stroke, followed by a smooth return stroke.

10

19. A reciprocating separator as claimed in claim 19 wherein the ancillary actuators are gas driven, so that a high acceleration may be imparted to the ancillary actuators.

- 15 20. A vibrating screen separator for use with the waste separating system, which separator comprises a grill of parallel elongate rods mounted over a collection hopper, which rods are arranged on a frame which is attached to vibrating drive means.

- 20 21. A waste separating system as hereinbefore described with reference to the figures of the drawings.

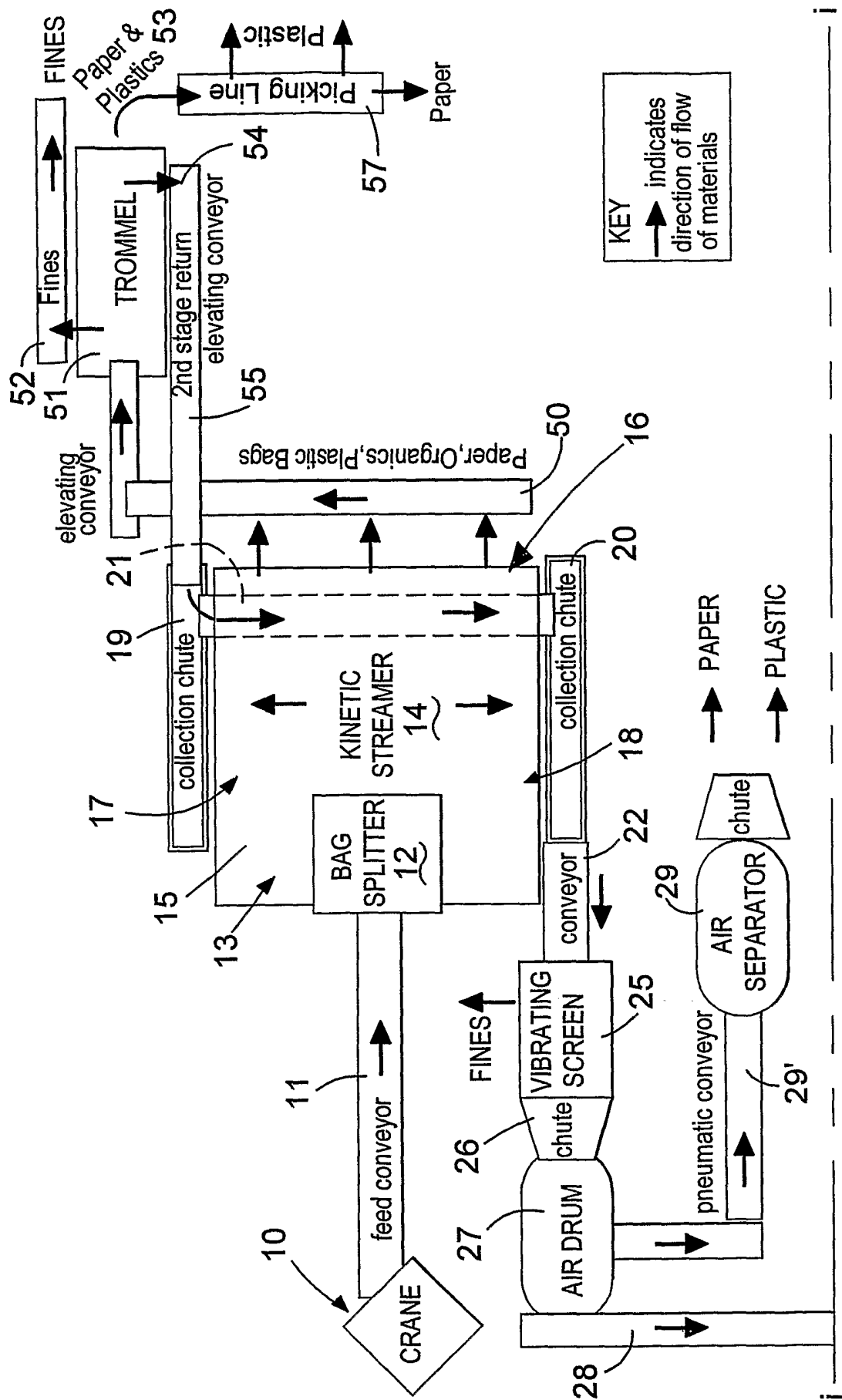


FIG.1

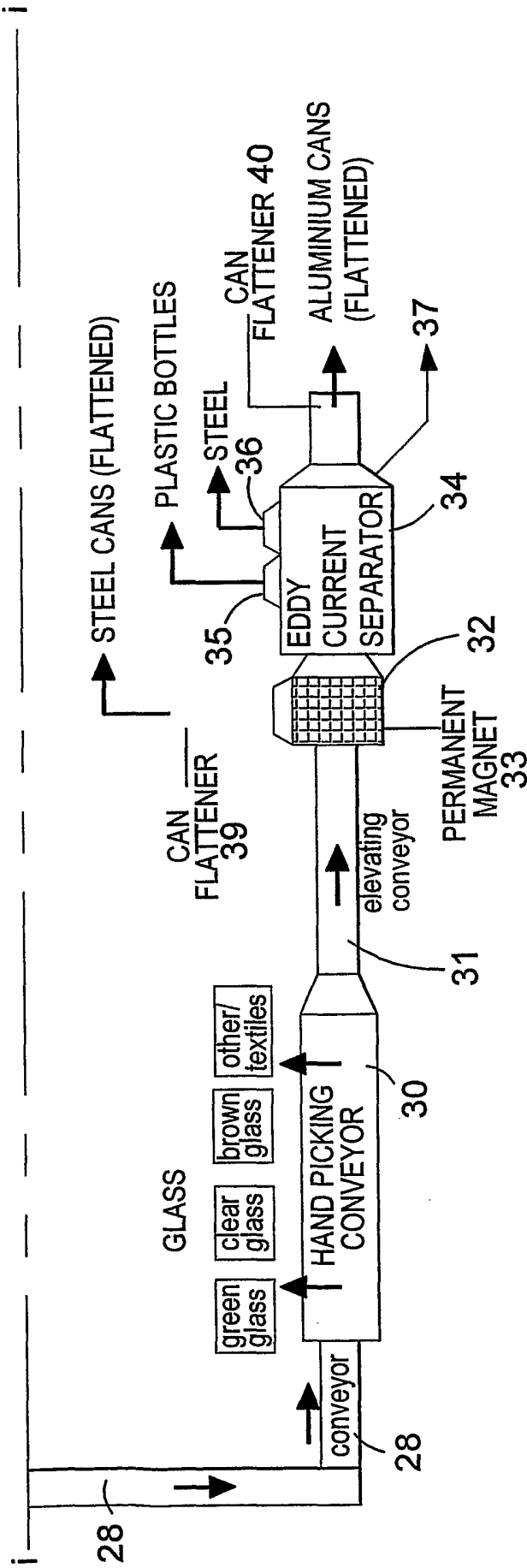


FIG.1
(continued)

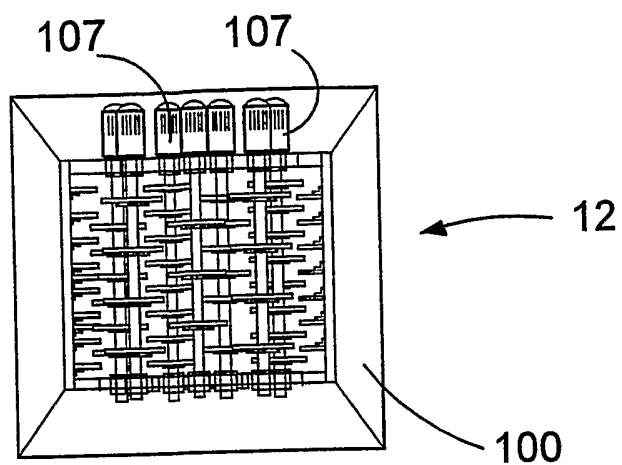


FIG. 2

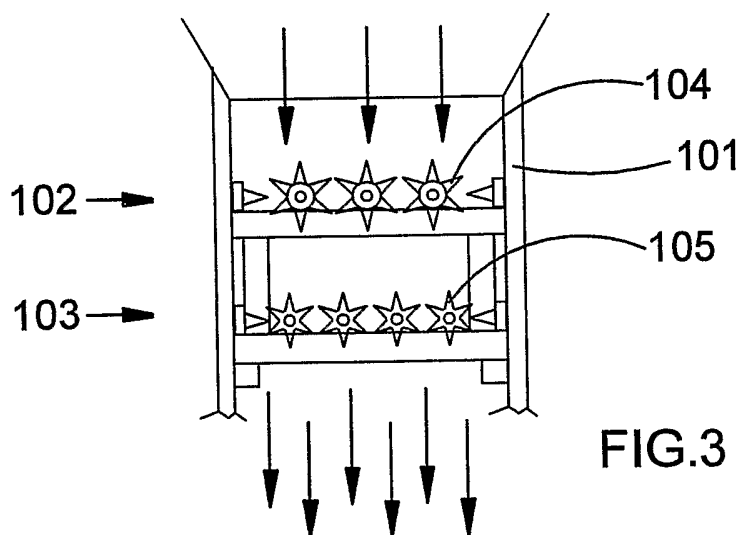


FIG. 3

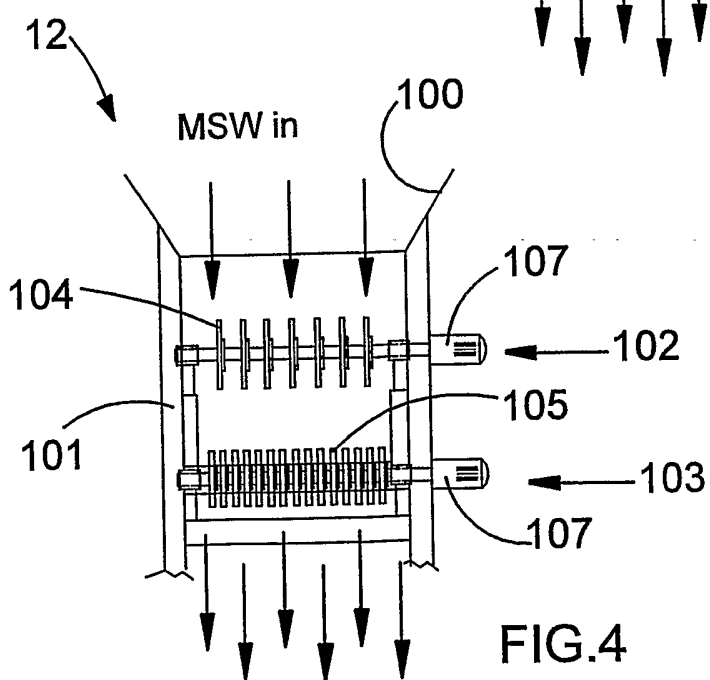


FIG. 4

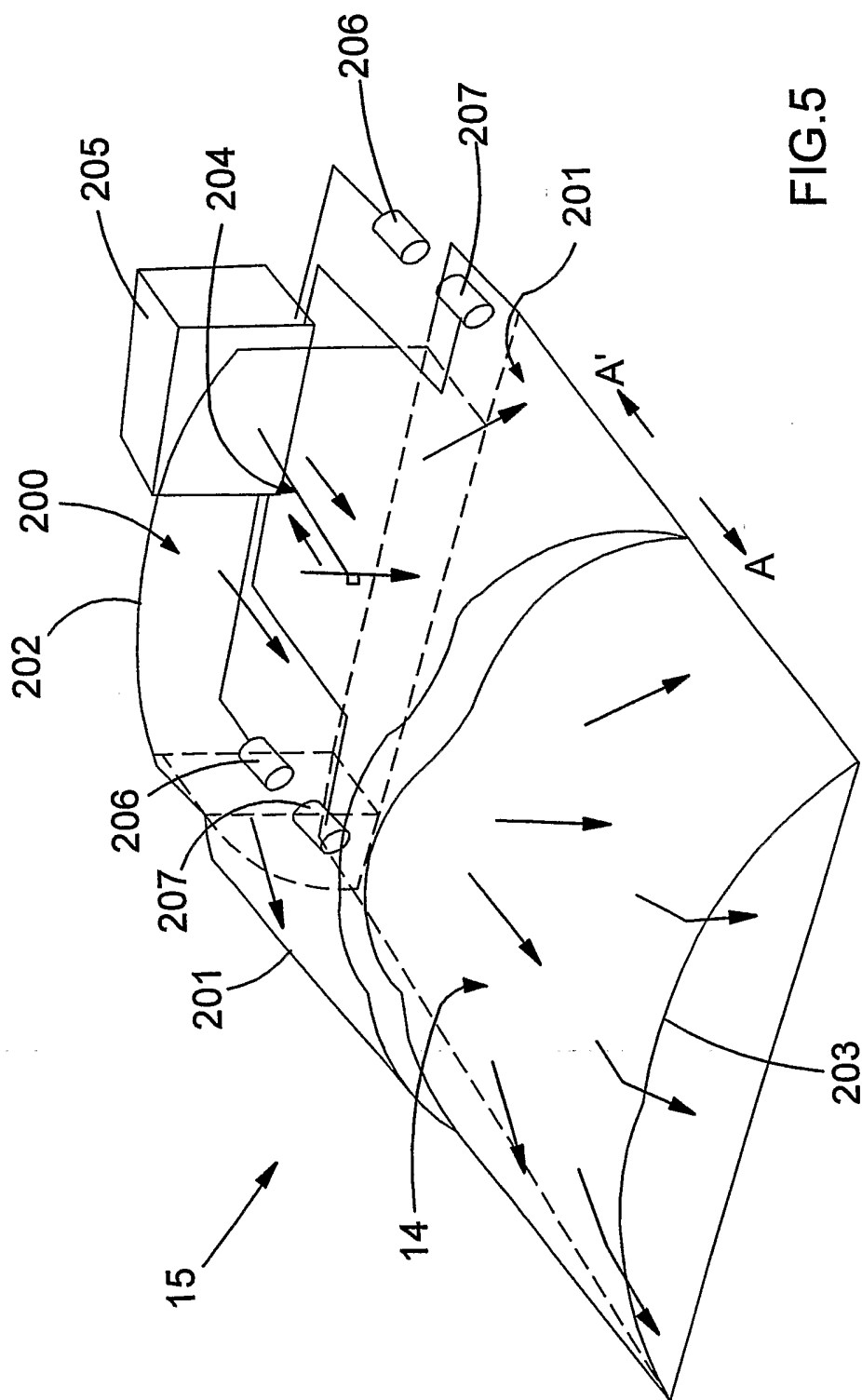


FIG. 5

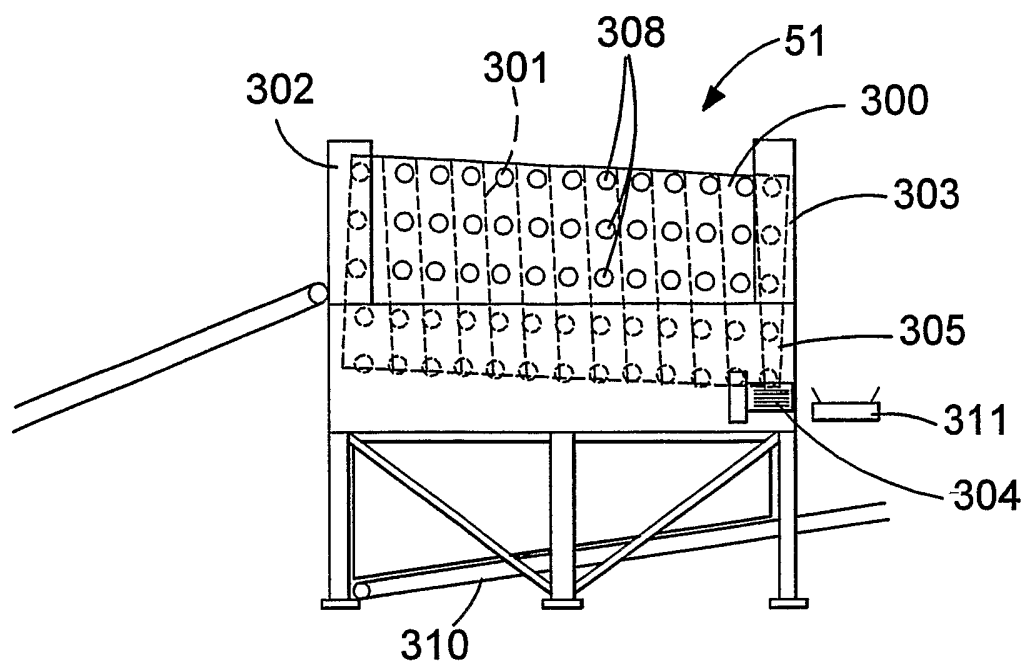


FIG.6

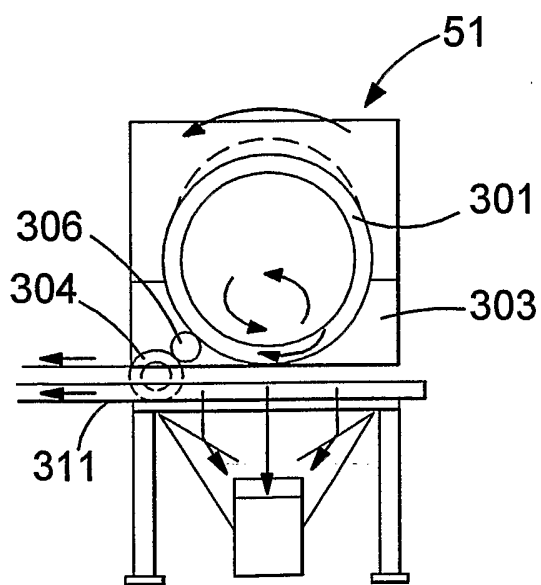


FIG.7

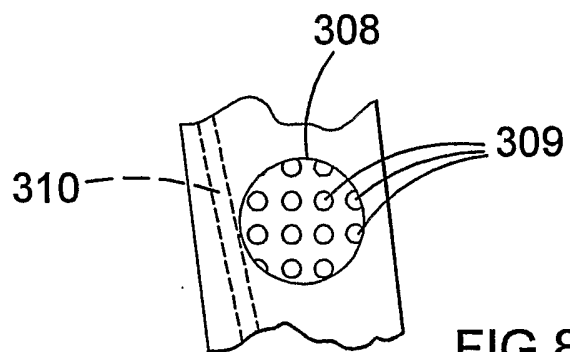


FIG.8

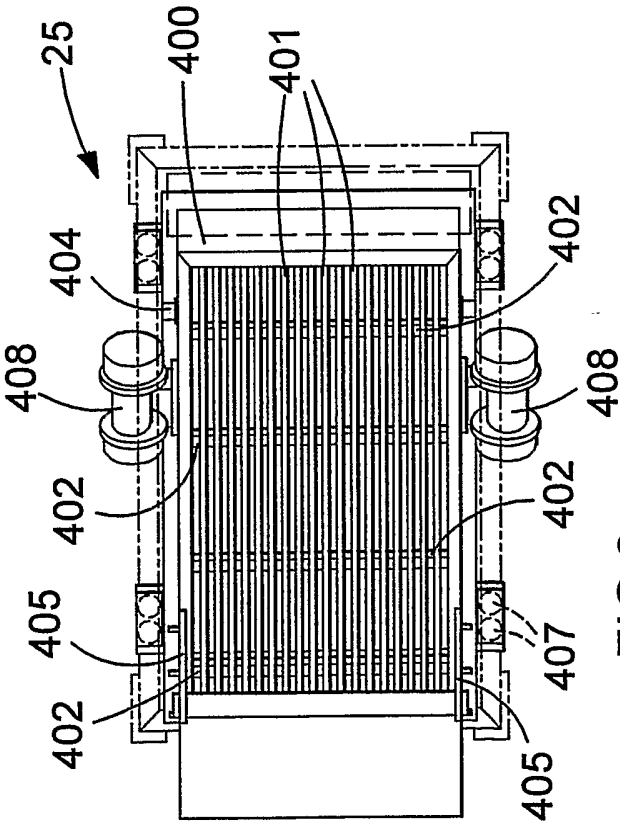


FIG. 9

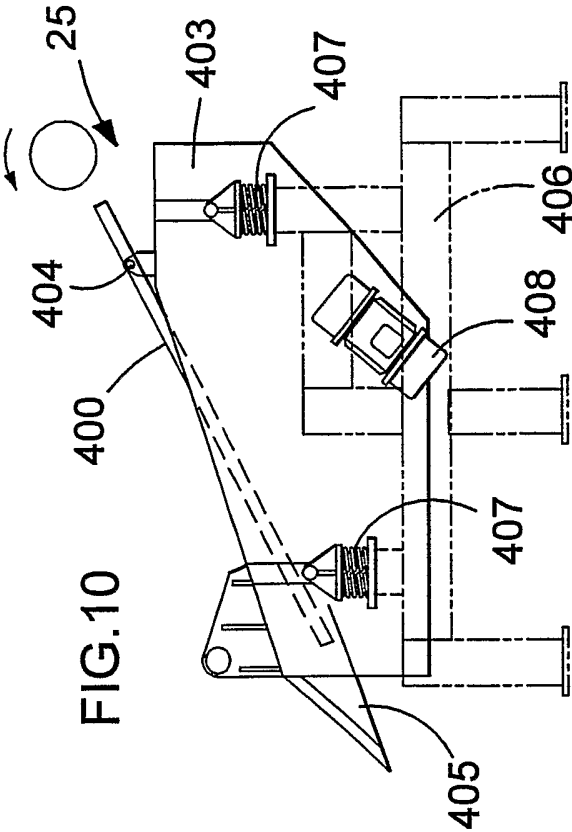


FIG. 10

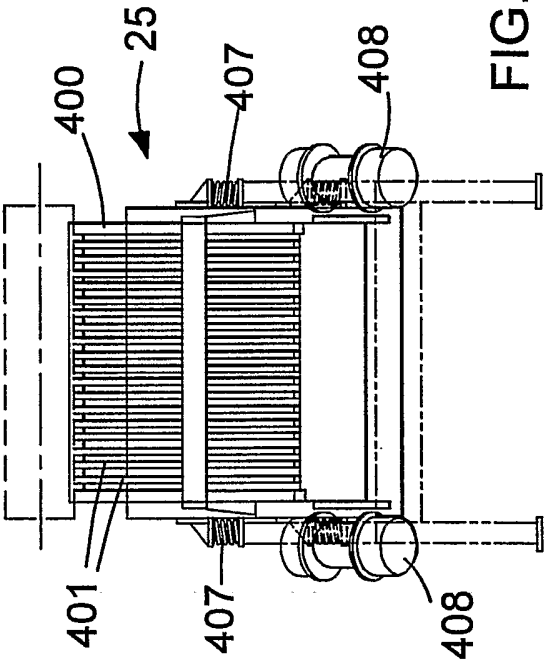
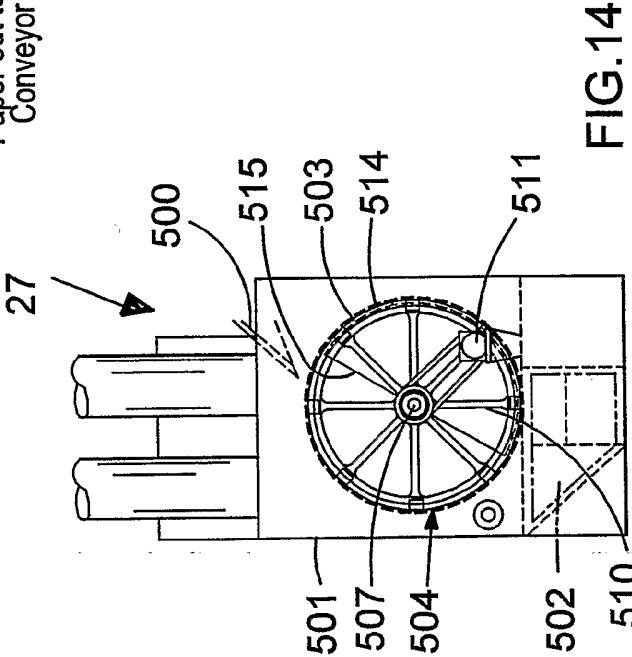
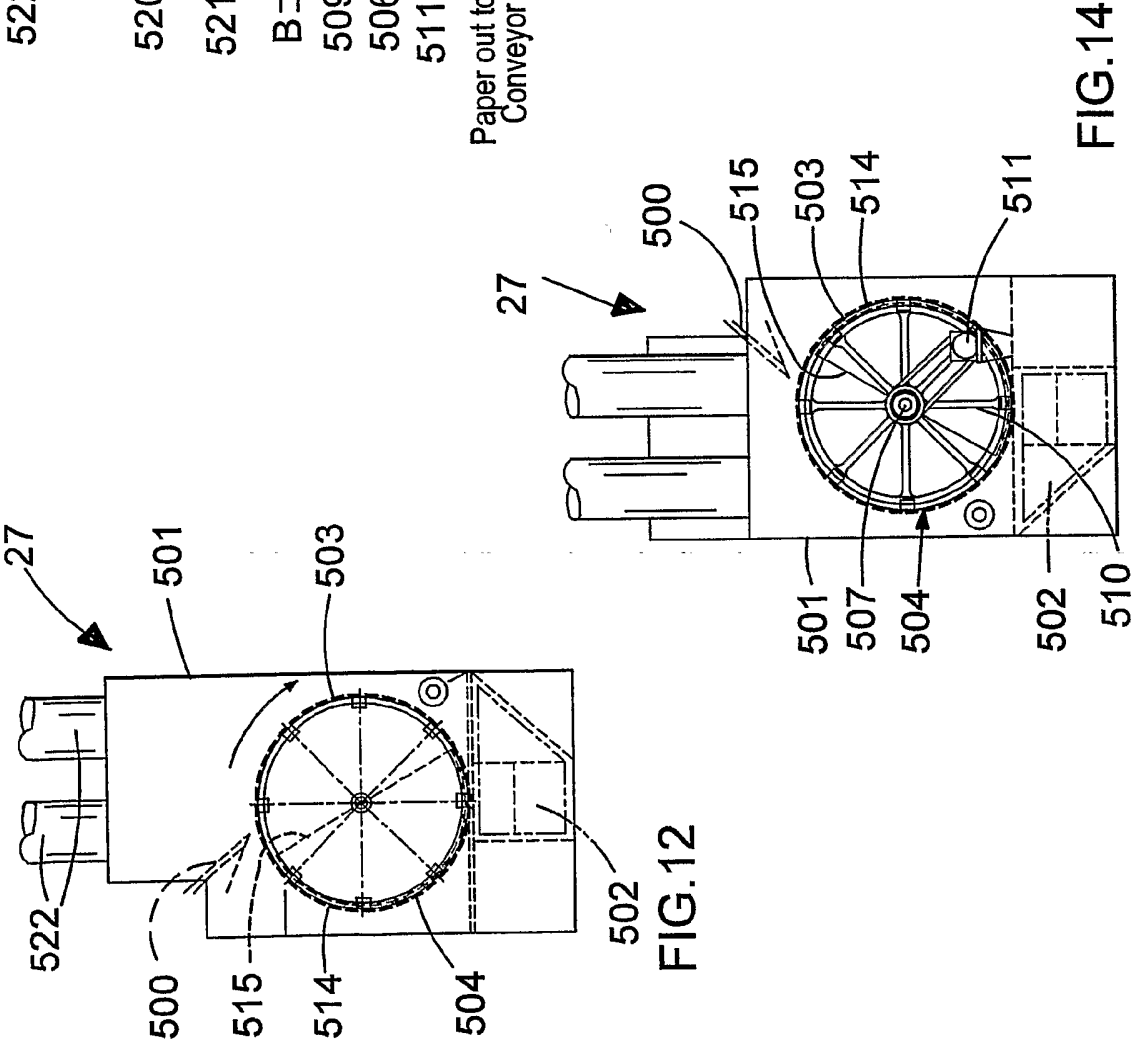
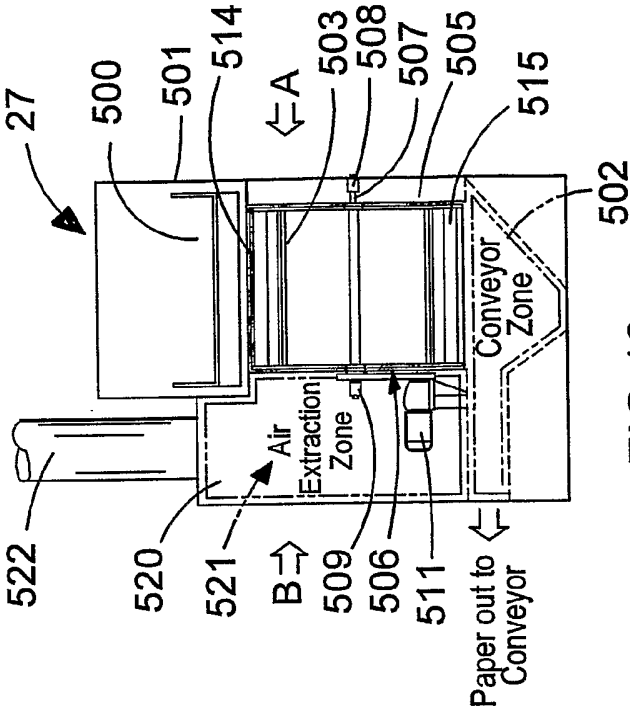


FIG. 11



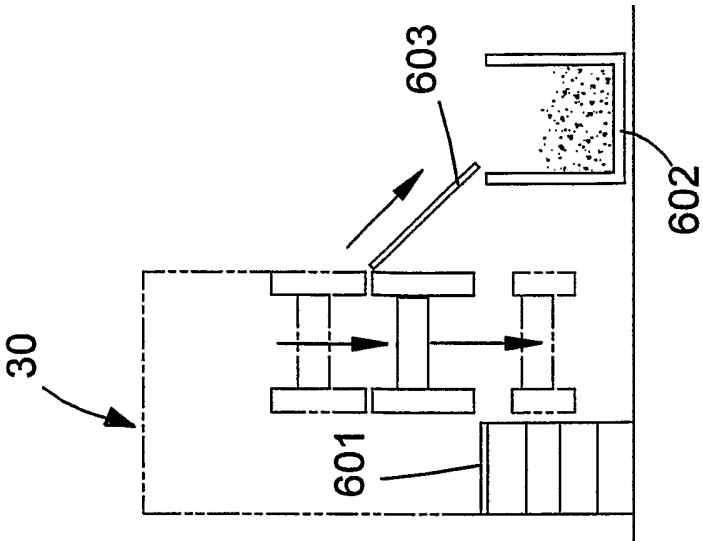


FIG. 16

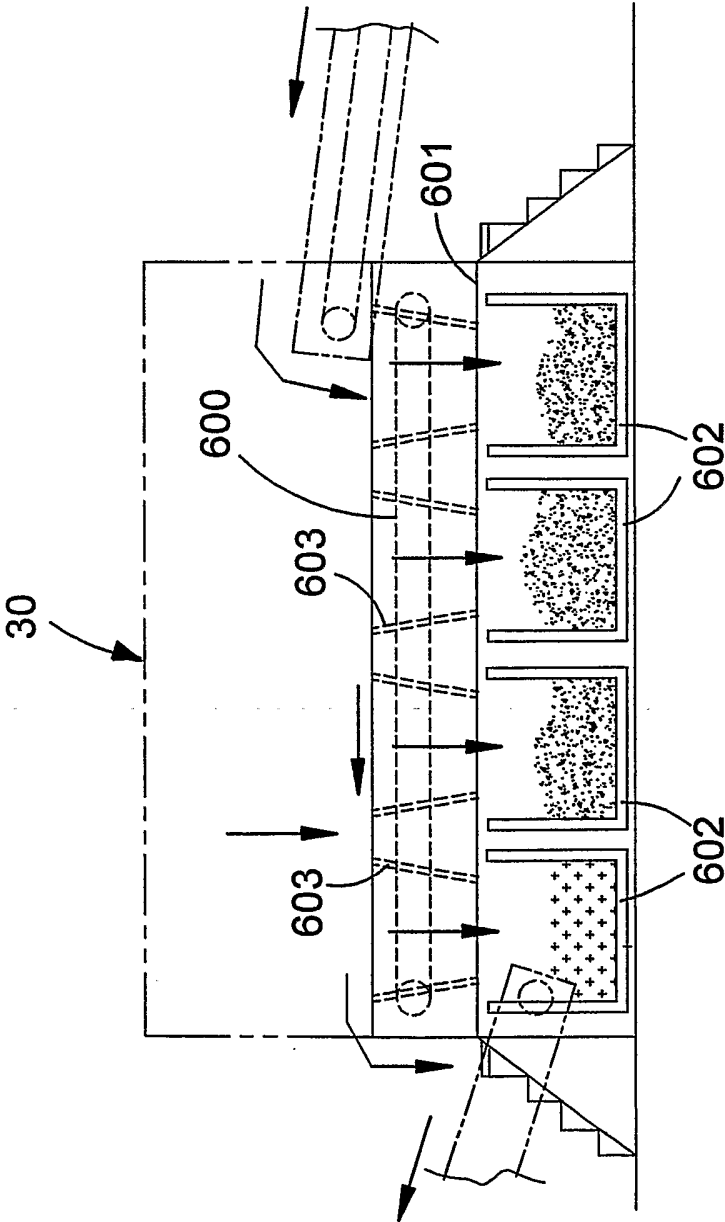


FIG. 15

