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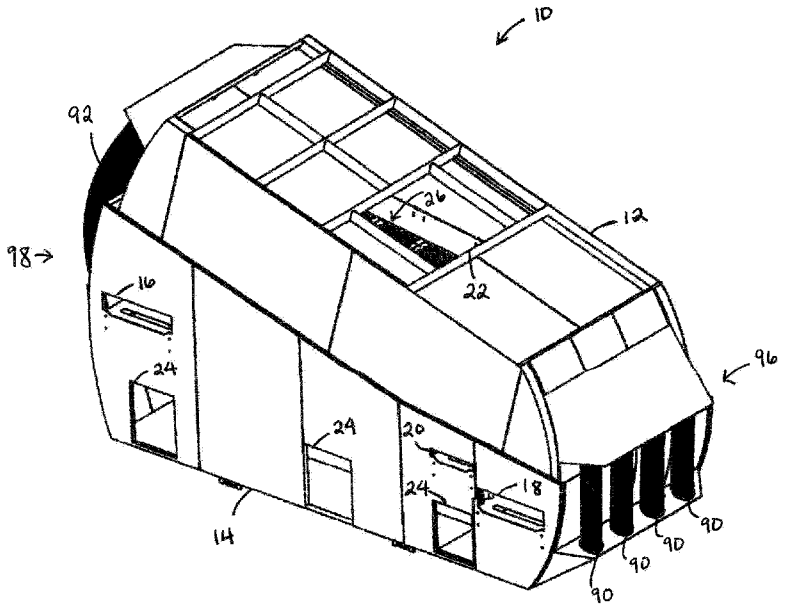


FIG. 1

[Continued on next page]

WO 2015/142937 A1

(57) Abstract: A system and method for separating mixed materials employing a primary material separation deck and a secondary modular separation pathway for further separation of a portion, e.g. a three-dimensional portion, of the mix materials.

MATERIAL SEPARATOR

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Serial No. 61/954,504 filed March 17, 2014, entitled *Material Separator*, which is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0001] The present invention relates to systems and methods for the separation of mixed materials.

BACKGROUND OF THE INVENTION

[0002] The ability to efficiently separate mixed materials, such as household recycling and construction waste, is of increasing importance and economic significance. For example, efficiently extracting and separating various types of recyclable materials from variable mixed waste streams is a critical factor when considering the economic viability of a recycling program. Material Recovery Facilities (MRFs) must be able to separate or sort mixed recyclable materials to a significantly high purity, for example 10 percent. If the final sorted and bailed product, for example similar plastic materials, does not achieve the purity required for purchase on the commodity market at a desired price, the product represents wasted resources and a financial loss for the MFR.

[0003] A critical step in the sorting or separation process is the dimensional sorting of materials. Several types of dimensional sorting equipment or separators have been developed, however, each of these known types of separators continues to suffer from significant shortcomings. Ballistic-type separators function by rotating an angled surface in a relatively small vertical circle, thereby projecting the mixed materials deposited upon the surface into the air. The materials are separated according to each materials ballistic properties and trajectory created by the movement of the surface.

[0004] These types of separators may employ a surface that is unitary or one that is divided into various portions or sections that may move in unison or separately relative to

one another. However, in order to achieve the desired motion of the surface, known separators employ a plurality of different motors. For example, different motors may be associated with each of the sides or corners of the unitary surface or with each of the various portions or sections of the surface. An obvious shortcoming of these separators is the increased maintenance associated with the calibration of the multiple motors to achieve the desired movement of the surface.

[0005] Another type of dimensional separator employs an angled surface formed of a bank of vertically rotating discs. The discs may have a roughly triangular or irregular shape and may be oriented non-symmetrically along axles or shafts. The axles rotate the discs towards an elevated side of the surface, thereby carrying certain materials up the surface while other materials fall towards the lower side of the surface. One obvious shortcoming of disc-type separators is the increased maintenance resulting from the wear associated with a surface formed of entirely moving parts, e.g. discs, axles, bearings.

[0006] Another disadvantage with disc-type separators is a propensity for materials to wrap themselves around and attach themselves to the discs and rotating spaces between the discs. These wrapped materials can lead to decreased throughput and efficiency due to the equipment's down-time required to remove the materials and increased impurities due to the effect of the wrapped materials on the migration of other materials. On disc-type systems employing multiple drive motors, required maintenance may also be undesirably high due to the need to calibrate the efforts of the different motors.

[0007] Finally, both of the above types of separator sort small materials or fines by providing voids or holes in the surface through which the fines can pass. The fines pass through the surface and ultimately into a vessel or onto a conveyor belt for transfer. However, known separators suffer from the fact that the fines must fall over equipment structure residing under the surface and above the output vessel or conveyor belt. These structures include drive motors and other moving and often sensitive attachment points of the equipment. This separation technique has the shortcoming of resulting in increased maintenance and repair due to the falling fines contaminating or damaging the components of the separator residing under the surface and above the output.

[0008] In view of the above described failures of the known dimensional separators, there exists a significant need in the art for more robust separators having increased efficiency and decreased maintenance and repair costs.

[0009] After the initial dimensional sorting of mixed materials, the MRFs typically must further sort each of the dimensionally sorted portions of the mixed materials. This secondary sorting often takes place through various separate sorting machines that each function to further sort materials based upon a different material characteristic. In order to achieve the desired level and purity of sorted materials, an MRF may have to resort to employing a variety of machines from different manufactures. This often leads to a sorting line having a relatively large foot print and a relatively complex custom sorting line design.

[0010] What is further needed in the art is a separator having a modular design that incorporates various sorting or separation points or stations for achieving secondary sorting of previously dimensionally sorted mixed materials.

OBJECTS AND SUMMARY OF THE INVENTION

[0011] The present invention provides a robust mixed material separator having increased efficiency and decreased maintenance and repair costs. These objectives are achieved in one embodiment of the present invention by providing a separator having a drive element coupled to a drive shaft, a pair of link arms coupling the drive shaft to a follower shaft, and a deck coupled to the drive shaft and the follower shaft at a point offset from an axis of rotation of the drive shaft and an axis of rotation of the follower shaft.

[0012] In another embodiment of the present invention, these objectives are achieved by providing a mixed material separator having a single drive element that is coupled to a drive shaft; and a deck that unitarily rotates vertically about an axis of rotation of the drive shaft.

[0013] In certain embodiments of the present invention, the deck may employ a screen that is statically elevated above a tray.

[0014] These objectives are also achieved by a method of the present invention including the steps of rotating a drive shaft with a drive element; transferring the rotation

of the drive shaft to a follower shaft; rotating a deck about an axis of rotation of the drive shaft and an axis of rotation of the follower shaft; depositing mixed materials upon the deck; and separating the mixed materials.

[0015] The present invention further provides a separator having a modular design that incorporates various sorting or separation points or stations for achieving secondary sorting of previously dimensionally sorted mixed materials. These objectives are achieved, in part, by providing a separator for separating mixed materials comprising: a vertically rotating horizontally oriented screen; a three-dimensional material output positioned at a first end of the screen; and a three-dimensional material separation pathway extending from the three-dimensional material output, the pathway having a plurality of different three-dimensional material separation points.

[0016] These objectives are also achieved, in part, by providing a separator for separating mixed materials comprising: a horizontally oriented deck having a plurality of material outputs; and a modular material separation pathway comprising: an extension from one of the plurality of material outputs; at least one material separation point; and a return to a material input of the separator or one of the plurality of material outputs of the deck.

[0017] These objectives are further achieved, in part, by a method for separating mixed materials comprising; separating a quantity of mixed materials through a vertical rotation of a horizontally oriented screen; collecting a three-dimensional portion of the mixed materials in a first output of the screen; transferring the three-dimensional portion of mixed materials to a three-dimensional material separation pathway; and separating different three-dimensional materials of the three-dimensional portion of the mixed materials from one another based upon different material characteristics at at least one separation point on the three-dimensional material separation pathway.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other aspects, features and advantages of which embodiments of the invention are capable of will be apparent and elucidated from the following description

of embodiments of the present invention, reference being made to the accompanying drawings, in which:

[0019] Fig. 1 is a perspective view of a separator according to one embodiment of the present invention.

[0020] Fig. 2 is a perspective view of a portion of a separator according to one embodiment of the present invention.

[0021] Fig. 3 is a perspective view of a portion of a separator according to one embodiment of the present invention.

[0022] Fig. 4 is a perspective view of a drive system of a separator according to one embodiment of the present invention.

[0023] Fig. 5 is a perspective view of a portion of a drive system of a separator according to one embodiment of the present invention.

[0024] Fig. 6 is a perspective view of a base and a drive system of a separator according to one embodiment of the present invention.

[0025] Fig. 7 is a perspective view of a separator according to one embodiment of the present invention.

[0026] Fig. 8 is a plan view of a portion of a separator according to one embodiment of the present invention.

[0027] Fig. 9 is a perspective view of a portion of a separator according to one embodiment of the present invention.

[0028] Fig. 10 is a perspective view of a portion of a separator according to one embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0029] Specific embodiments of the invention will now be described with reference to the accompanying drawings. This invention may, however, be embodied in many different

forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed description of the embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

[0030] Broadly speaking, the present invention provides a robust, economic to operate, and economic to maintain ballistic approach for the separation of mixed materials. An angled, unitary deck is connected to a system of statically interconnected counter weights driven by a single drive element. The deck is connected to the system of interconnected counter weights at connection points that are offset from the axes of rotation of the counter weights. Rotation of the system of counter weights results in a vertically circular oscillation of the deck. Oscillation of the deck, serves to separate mixed materials deposited upon the deck according to each material's ballistic properties and trajectory.

[0031] More particularly, with reference to Fig. 1, a separator 10 according to the present invention includes a cover 12, a housing 14, a first output port 16, a second output port 18, a third output port 20, and an input port 22. The input port 22 functions to receive materials for separation into the separator 10 and is located over an approximate midpoint of a deck 26 that is visible through the partially opened input port 22 shown in Fig. 1. The housing 14 may further employ one or more access ports 24 that function to allow access to various locations within the housing 14.

[0032] At a first end 96 of the separator 10 are air ducts 90 that span between the cover 12 and the housing 14. Similarly, at a second end 98 of the separator 10 are air ducts 92 that span between the cover 12 and the housing 14.

[0033] Figs. 2 and 3 are perspective views of the separator 10 with the cover 12 and certain side panels of the housing 14 and deck 26 removed for the sake of observation. The housing 14 is formed around a base 88. A drive system 42 couples the deck 26 to the base 88. The housing 14 includes, in part, a first output 28, a second output 30, and a third output 32. Located within the housing 14 below the first output 28 is a first air

chamber 100. At an opposite end of the housing 14, below the second output 30 and the third output 32 is a second air chamber 102. A pair of air ducts 94 pass along opposite longitudinal sides of the base 88 below the deck 26. The air ducts 94 connect the first air chamber 100 to the second air chamber 102, thereby forming an air passage between the first air chamber 100 and the second air chamber 102.

[0034] The second air chamber 102 includes one or more ports 104. The air ducts 90 are connected to the ports 104 at a first end and to the similar ports formed in the cover 12 at a second end, thereby forming an air passage between the second air chamber 102 and the cover 12 at the first end 96 of the separator 10. Likewise, the first air chamber 100 includes one or more ports 104. One end of the air ducts 92 is connected to the ports 104 of the first air chamber 100, and a second end of the air ducts 92 is connected to the cover 12 at the second end 98 of the separator 10.

[0035] Accordingly, a closed-loop air flow path is formed from the first air chamber 100; through air ducts 94 to the second air chamber 102; through the air ducts 90 to the cover 12; through the cover 12 over the deck 26; and through the air ducts 92 back to the first air chamber 100. Within the air flow path, for example within the first air chamber 100, one or more blowers may be employed to force air through the air flow path. The direction of flow of air within the air flow path can be either as described above, i.e. in the direction of arrow 86 shown in Figs. 2 and 3, or in the reverse direction. However, air flow in the direction of arrow 86 functions to assist in the efficient separation of certain mixed materials.

[0036] In certain embodiments of the present invention, the blower or blowers are operable to generate an air flow of approximately 8,800 cubic feet per minute. The rate of air flow may be adjusted by employing one or more adjustable blowers or by incorporating adjustable air constrictions, for example within air ducts 94. In yet another embodiment of the present invention, the air flow path, for example within the first air chamber 100, incorporates one or more air filtration systems.

[0037] In certain embodiments of the present invention, as shown in Fig. 10, an adjustable limiting panel 15 is employed in order to focus the air flow over the deck 26. The limiting panel 15 is attached to the cover 12 over or nearly over a side 50 of the screen

36 of the deck 26. The limiting panel 15 extends down from the cover 26 towards the screen 36 and angles generally toward a side 52 of the screen 36 of the deck 26. The limiting panel 15 may be attached to the cover 12 by hinges or other adjustable connectors such that the angle of the limiting panel 15 in the general direction of side 52 of the screen can be adjusted to account for a height of the deck 26 and/or adjust the extent to which the air flow is focused over the deck.

[0038] The deck 26 includes, in part, side walls 34 that extend upward longitudinally along a side 46 and a side 48 of the screen 36. The side 50 and a side 52 of the screen 36 are not bordered by side walls. The screen 36 has a plurality of holes or apertures 44 dispersed across the screen 36. The screen 36 may employ a textured upper surface having gripping elements, for example, spikes or other protrusions extending upward. The screen 36 is statically elevated above a tray 38 having a similar or identical length and width as that of the screen 36. Connected to the tray 38 is a hollow tray manifold 40 having an opening oriented above the output 32.

[0039] Figs. 4-5 are perspective views of the drive system 42 according to one embodiment of the present invention. The drive system 42 employs a drive shaft 56 and a follower shaft 58 that pass through and are attached to a frame 54 by bearing assemblies 60 at end 106 and an end 108 of the frame 54, respectively. The end 108 of the frame 54 is pivotally attached to an end 110 of the base 88. An opposite end 106 of the frame 54 is attached to an end 112 of the base 88 by one or more adjusting elements 114. The adjusting element 114 may, for example be a hydraulic cylinder or threaded shaft. In certain embodiments of the present invention, the adjusting element 114 functions to allow for adjustment of an angle of the screen 36 of the deck 26 while the deck 26 is in operation or oscillating.

[0040] In other words, during operation of the separator 10, the adjustment element 114 allows the operator to elevate or lower the end 106 of the frame 54 relative to the fixed location or elevation of the end 108 of the frame 54. Hence, the side 52 of the screen 36, which is statically coupled to the end 106 of the frame 54, is elevated or lowered relative to the side 50 of the screen 36, which is statically coupled to the end 108 of the frame 54.

[0041] A counter weight 62 is attached to each end 64 of the drive shaft 54 and to each end 66 of the follower shaft 58. For clarity, only one end 64 of the drive shaft 54 and only one end 66 of the follower shaft 58 are shown in Fig. 5. The second, opposite end 64 of the drive shaft 54 and the second, opposite end 66 of the follower shaft 58 are obscured within the counter weights 62 shown in Fig. 5.

[0042] A link shaft 70 is attached to the counter weight 62 a hole 78 and projects from the counter weight 62 in a direction away from the frame 54. A first end of a link arm 68 is attached via a bearing assembly to the link shaft 70 of counter weight 62 of the drive shaft 56 and a second end of the link arm 68 is attached via a bearing assembly to the link shaft 70 of the counter weights 62 of the follower shaft 58 that is positioned on the same side of the frame 54. Similarly, a second link arm 68 is attached to the link shafts 58 of the counter balances 62 and the link shaft 70 of the counter weights 62 of the follower shaft 58 positioned on the opposite side of the frame 54, as shown in Fig. 4. As shown in Fig. 5, the holes 78 are formed into or through the respective count weight 62 so as to be offset from the axes of rotation of the counter weights 62 about the drive shaft 56 and follower shaft 58.

[0043] To each of the link shafts 70 projecting from each of the counter weights 62 is attached, via a bearing assembly, a cam arm 72. Opposite the ends of the cam arms 72 attached to the link shafts 70 are output shafts 74. The output shafts 74 protrude from the cam arms 72 in a direction away from the frame 52. For clarity, the opposite side's drive assembly including the counter weights 62 and the associated link shafts 70, cam arms 72, output shaft 74, and link arm 68, have been omitted from Fig. 5.

[0044] Each of the output shafts 74 are, in turn, connected to the deck 26 by bearing assemblies incorporated into or otherwise attached to a deck bracket 76, shown in Fig. 3. The deck 26 employs one deck bracket 76 on each longitudinal side of the deck 26. One end of each deck bracket 76 is attached to the output shaft 74 associated with the drive shaft 56 and an opposite end of each deck bracket 76 is attached to the output shafts 74 associated with the follower shaft 58.

[0045] In certain embodiments of the present invention, a dimension of the travel or a diameter of the oscillation of the deck 26 is adjustable through adjustment or rotation of

the individual cam arms 72 about the link shaft 74 and/or through interchanging cam arms 72 having different lengths. The dimension of travel or the diameter of the rotation of the deck 26 is up to eight inches or greater, for example 12 inches. The dimension of travel or diameter of rotation of the deck 26 is a function of a dimension of the offset of the axes of the output shafts 74 coupled to the drive shaft 56 from the axis of rotation of the drive shaft 56, and similarly, is a function of a dimension of offset of the axes of the output shafts 74 coupled to the follower shaft 58 from the axis of rotation of the follower shaft 58. This dimension of offset is directly proportional to the dimension of travel or a diameter of the rotation of the deck 26, however, as rotational speed of the deck increases, this proportional relationship may vary due to inherent flex in the system.

[0046] In certain embodiments of the present invention, adjustment of the dimension of travel or the diameter of the rotation of the deck 26 is possible through adjustment members, for example hydraulic cylinders, that link ends of the cam arms 72 attached to the deck brackets 72 to a point on the counter weights 62 apart from the link shafts 70. Such adjustment members are operated in unison and allow for adjustment of the dimension of travel or the diameter of the rotation of the deck 26 during operation of the separator 10.

[0047] The drive system 42 further includes a drive element 80. The drive element 80 may, for example, be a combustion, a hydraulic, an electric or other form of motor or a combination thereof. The drive element 80 is associated with a drive gear 84 which, in turn, is associated with the drive shaft 56. The drive element 80 may, for example, directly engage and drive the rotation of the drive gear 84 through rotation of a gear that is in direct contact with the drive gear 84. Alternatively, a chain or drive belt may be employed to communicate an output rotation from the drive element 80to the drive gear 84.

[0048] While the present figures and disclosure shows and describes only one drive element 80 that drives or is otherwise associated with the drive gear 84 and the drive shaft 56, it is contemplated that a plurality of drive elements 80 may drive or otherwise be associated with the drive gear 84 and the drive shaft 56.

[0049] In certain embodiments of the present invention, a gear box 82 may be employed between the drive element 80 and the drive gear 84. The gear box 82 may but

need not necessarily employ a clutch system. The gear box 82 may be associated with the drive element 80 and the drive gear 84 through, for example, direct engagement or through a drive belt or a chain.

[0050] In operation, activation of the drive element 80 functions to rotate the drive gear 84 which, in turn, rotates the drive shaft 56 and the counter weights 62 attached to each end of the drive shaft 56. The rotation of the counter weights 62 associated with the drive shaft 56 is communicated through the link arms 68 to the counter weights 62 associated with the follower shaft 58, thereby resulting in a synchronized rotation of all of the counter weights 62. The synchronized rotation of the counter weights 62 is, in turn, communicated to the deck 26 through the rotation of the link shafts 70, the cam shafts 72, and the output shafts 74 and through the coupling of the output shafts 74 to the deck brackets 76. A vertically circular rotation of the deck 26 is achieved due to the offset orientation of the link shafts 70 relative to the axes of rotation of the drive shaft 56 and the follower shaft 58.

[0051] As shown in Figs. 1-3, the screen 36 of the deck 26 is angled relative to the housing 14. The side 52 of the screen 36 is elevated higher than the side 50 of the screen 36. While the figure show the screen 36 of the deck 26 as angled in only one axis it is contemplated that the screen 36 may, in certain embodiments, be angled in a second axis, for example, such that one of the sides 46 and 48 is elevated above the other. From the perspective of Figs. 1-3, the direction of rotation of the deck 26 is clockwise, as indicated by arrow 86.

[0052] As mixed materials are deposited through the input 22 onto the screen 36 of the deck 26, the oscillating motion of the deck 26 functions to separate the mixed materials into at least three distinct types. Relatively light materials, for example, two-dimensional materials such as fibers, films, and certain flattened materials migrate towards the side 52 of the screen 36 and into the first output 28. Relatively heavy materials, for example, three-dimensional materials such as plastic, metal and certain large dimensional fibers migrate towards the side 50 of the screen 36 and into the second output 30. Finally, materials of a relatively small dimension or fines, for example, crushed glass, shredded paper, and certain organic materials fall through the apertures 44 of the screen, onto the

tray 38. Due to the orientation and motion of the tray 38, the small dimensional materials migrate towards and through the tray manifold 40 and into the third output 32.

[0053] The separated materials are transferred out from the first output 28, the second output 30, and the third output 32 through the first output port 16, the second output port 18, and the third output port 20, respectively. In certain embodiments, the transfer is facilitated by conveyor systems or other similar transfer systems.

[0054] The separator 10 of the present invention provides numerous advantages over existing separators. For example, the separator 10 of the present invention is operable to achieve an adjustable oscillation or travel of up to approximately ten inches or greater, for example 12 inches; roughly twice the travel achieved by known separators. This increased travel, in turn, provides increased throughput capacity over known separators. Furthermore, the lower profile of the separator 10 relative to known separators allows for operation of the separator 10 in building having relatively low ceilings. Due to the presence of fewer components that are prone to wear, that are exposed to falling fines, and that require calibration, the separator of the present invention also requires less maintenance and thereby achieves lower operating cost relative to known separators that employ discs or multiple motors or drive elements.

[0055] The separator 10 according to the present invention also advantageously incorporates an adjustable, closed or semi-closed air flow path over the materials being sorted. When the air flow is in the direction of arrow 83 shown in Figs. 2 and 3, the air flow enhances the migration of two-dimensional materials, such as certain fibers, up the deck 26 towards the output 28. In other words, the air flow through the closed or semi-closed air flow path enhances the separation efficiency of the separator 10. Additionally, when an air filtration system is employed within the air flow path of the separator 10, the resulting sorted materials contain reduced contaminates, thereby increasing efficiency of the separation process. Furthermore, due to the air filtration system within the air flow path, the separator 10 experiences reduced contamination and wear from airborne particulates, thereby decreasing maintenance and repair costs.

[0056] Finally, the separator 10 according to the present invention advantageously allows an operator to adjust the angle of the screen 36 of the deck 26 without stopping

operation of the separator 10. The separator 10 allows for fine or infinite adjustment of the screen 26 so as to optimize separation of varying streams of mixed materials. Known separators, if operable for adjustment of the screen or separation surface angle, must be stopped in order to facilitate such adjustment. Accordingly, the present invention provides increased separation efficiency by allowing for adjustment of the separator 10 without having to actually stop the separation process.

[0057] In another embodiment of the present invention, generally speaking, a separator employs additional separation mechanisms and material pathways that facilitate further or secondary separation of previously dimensionally separated materials, for example, three-dimensional materials such as plastic, metal and certain large dimensional fibers.

[0058] More particularly, with reference to Figs. 7-9, a separator 200 is similar to the above described separator 10 with the exception that the separator 200 further employs a three-dimensional material pathway 202, shown generally in Figs. 8 and 9. For the sake of observation, certain side panels of the housing 14 and the deck 26 of the separator 200 shown in Figs. 8 and 9 are removed.

[0059] In operation, as mixed materials are deposited through the input 22 onto the screen 36 of the deck 26, the oscillating motion of the deck 26 functions to separate the mixed materials into at least three distinct types. Relatively heavy materials, for example, three-dimensional materials such as plastic, metal and certain large dimensional fibers migrate towards the side 50 of the screen 36 and into the second output 30. From second output 30 the materials enter the material pathway 202. The arrows on the line 202 indicated as the materials pathway 202 show the flow of the various types of three-dimensional materials.

[0060] For example, at a first separation point 204 ferrous materials are removed from the mixed, three-dimensional materials by employing, for example, a magnet. The ferrous materials are captured and removed from the stream of mixed, three-dimensional materials at an output 206. The remaining mixed, three-dimensional materials are transferred along portion 208 of the pathway 202 to second separation point 210. The second separation point 210 employs, for example, an eddy current for removal or capture

of materials such as aluminum. The aluminum materials removed from the stream of mixed, three-dimensional materials at an output 212.

[0061] The remaining mixed, three-dimensional materials are transferred along portion 214 of the pathway 202 to a third separation point 216. The third separation point 216 employs, for example, an optical recognition system and/or a three-dimensional laser scanning technique in cooperation with robotics for the identification and capture of materials such as plastics. The plastics are removed from the stream of three-dimensional materials at an output 218. Any remaining materials that were not removed via separation points 204, 210, and 216 enter portion 220 of pathway 202 and are recirculated back into the input 22 and/or into output 30. Accordingly, any unsorted three-dimensional materials will continue to pass through the separation points 204, 210, and 216 of pathway 202 until identified and removed from the material pathway 202 at separation points 204, 210, and 216 or are otherwise manually removed.

[0062] The portions 208, 214, and 220 of the materials pathway 202 may, for example, employ conveyor systems or other similar transfer systems in order to transfer the three-dimensional materials to separation points 204, 210, and 216. The separator 200 may be employed in a modular fashion. In other words, the separator 200 need not include each of separation points 204, 210, and 216 but rather only those separation points desired by the separation facility.

[0063] The separator 200 is advantageous in that it provides for increased separation of materials in a single piece of equipment or separator. The separator 200 is also advantageous in that the modular design of the separator provides the separation facility with the flexibility of adding or subtracting various types of material separation techniques.

[0064] Although the invention has been described in terms of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or exceeding the scope of the claimed invention. Accordingly, it is to be understood that the drawings and descriptions herein are proffered by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

What is claimed is:

1. A separator for separating mixed materials comprising:

a vertically rotating horizontally oriented screen;

a three-dimensional material output positioned at a first end of the screen; and

a three-dimensional material separation pathway extending from the three-dimensional material output, the pathway having a plurality of different three-dimensional material separation points.

2. The separator of claim 1 wherein the three-dimensional material output is positioned at the first end of the screen that is lower than an opposite second end of the screen.

3. The separator of claim 1 wherein the three-dimensional material separation pathway comprises a series of conveyor belts linking together each of the plurality of different three-dimensional material separation points.

4. The separator of claim 1 wherein the three-dimensional material separation pathway extends from the three-dimensional material output and returns to a material input of the separator.

5. The separator of claim 1 wherein the three-dimensional material separation pathway is incorporated into the structure of the separator.

6. The separator of claim 1 wherein the plurality of different three-dimensional material separation points comprises at least three different three-dimensional material separation points.

7. The separator of claim 1 wherein each separation point of the plurality of different three-dimensional material separation points comprises a different material separation technique.

8. The separator of claim 1 wherein one of the separation points of the plurality of different three-dimensional material separation points comprises a magnet.

9. The separator of claim 1 wherein one of the separation points of the plurality of different three-dimensional material separation points comprises an eddy current.

10. The separator of claim 1 wherein one of the separation points of the plurality of different three-dimensional material separation points comprises an optical recognition system.

11. A separator for separating mixed materials comprising:

a horizontally oriented deck having a plurality of material outputs; and

a modular material separation pathway comprising:

an extension from one of the plurality of material outputs;

at least one material separation point; and

a return to a material input of the separator or one of the plurality of material outputs of the deck.

12. The separator of claim 11 wherein the modular material separation pathway comprises a series of three separation points.

13. The separator of claim 11 wherein the at least one material separation point comprises a magnet.

14. The separator of claim 11 wherein the at least one material separation point comprises an eddy current.

15. The separator of claim 11 wherein the at least one material separation point comprises an optical recognition system.

16. The separator of claim 11 wherein the modular material separation pathway is incorporated within the separator.

17. A method for separating mixed materials comprising;

separating a quantity of mixed materials through a vertical rotation of a horizontally oriented screen;

collecting a three-dimensional portion of the mixed materials in a first output of the screen;

transferring the three-dimensional portion of mixed materials to a three-dimensional material separation pathway; and

separating different three-dimensional materials of the three-dimensional portion of the mixed materials from one another based upon different material characteristics at at least one separation point on the three-dimensional material separation pathway.

18. The method of claim 17 wherein the step of transferring the three-dimensional portion of mixed materials to a three-dimensional material separation pathway comprises employing a system of conveyor belts.

19. The method of claim 17 wherein the step of separating different three-dimensional materials of the three-dimensional portion of the mixed materials from one another based upon different material characteristics at at least one separation point on the three-dimensional material separation pathway comprises separating the different three-dimensional materials based upon a materials magnetism.

20. The method of claim 17 wherein the at least one separation point on the three-dimensional material separation pathway is incorporated into a mixed material separator.

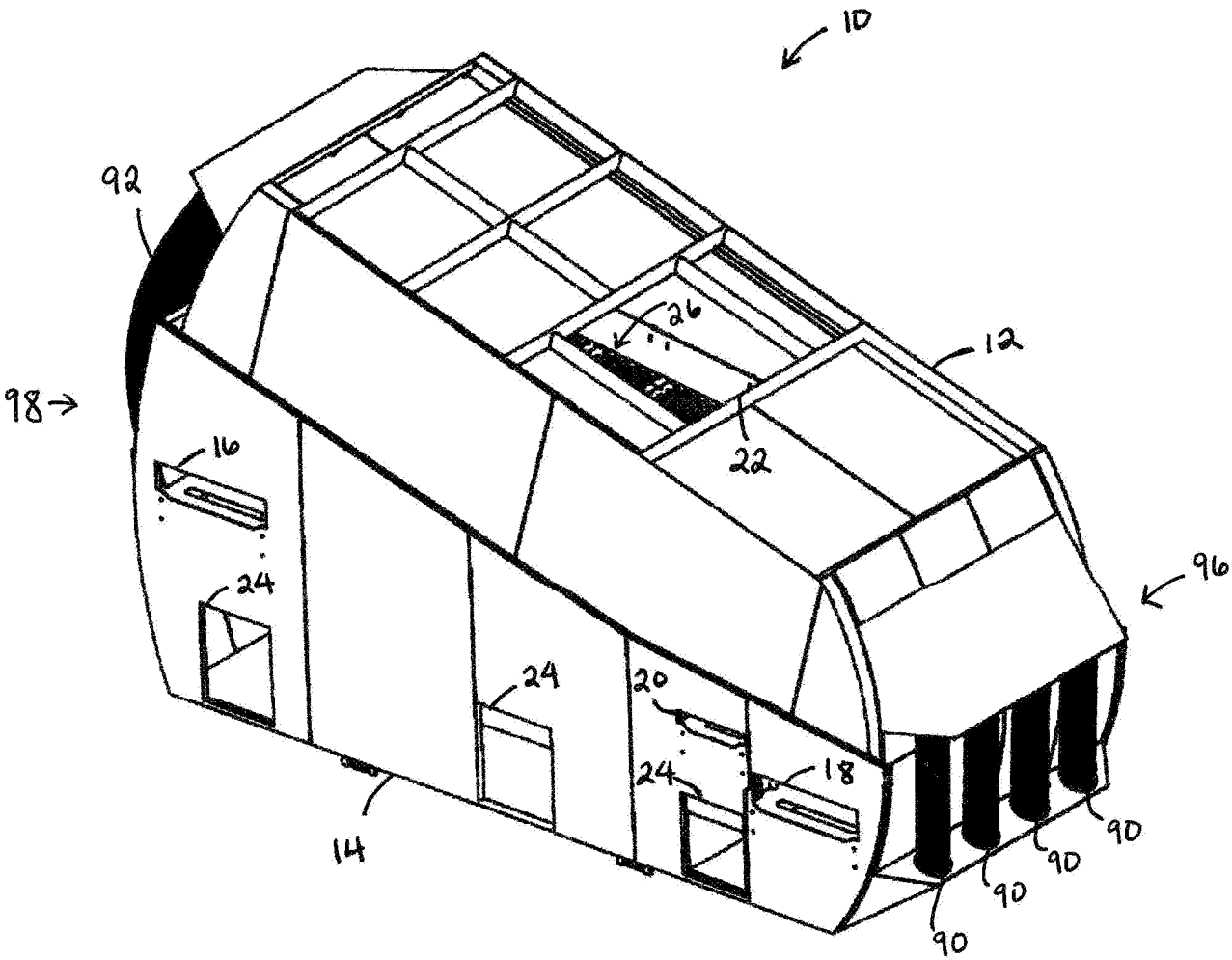


FIG. 1

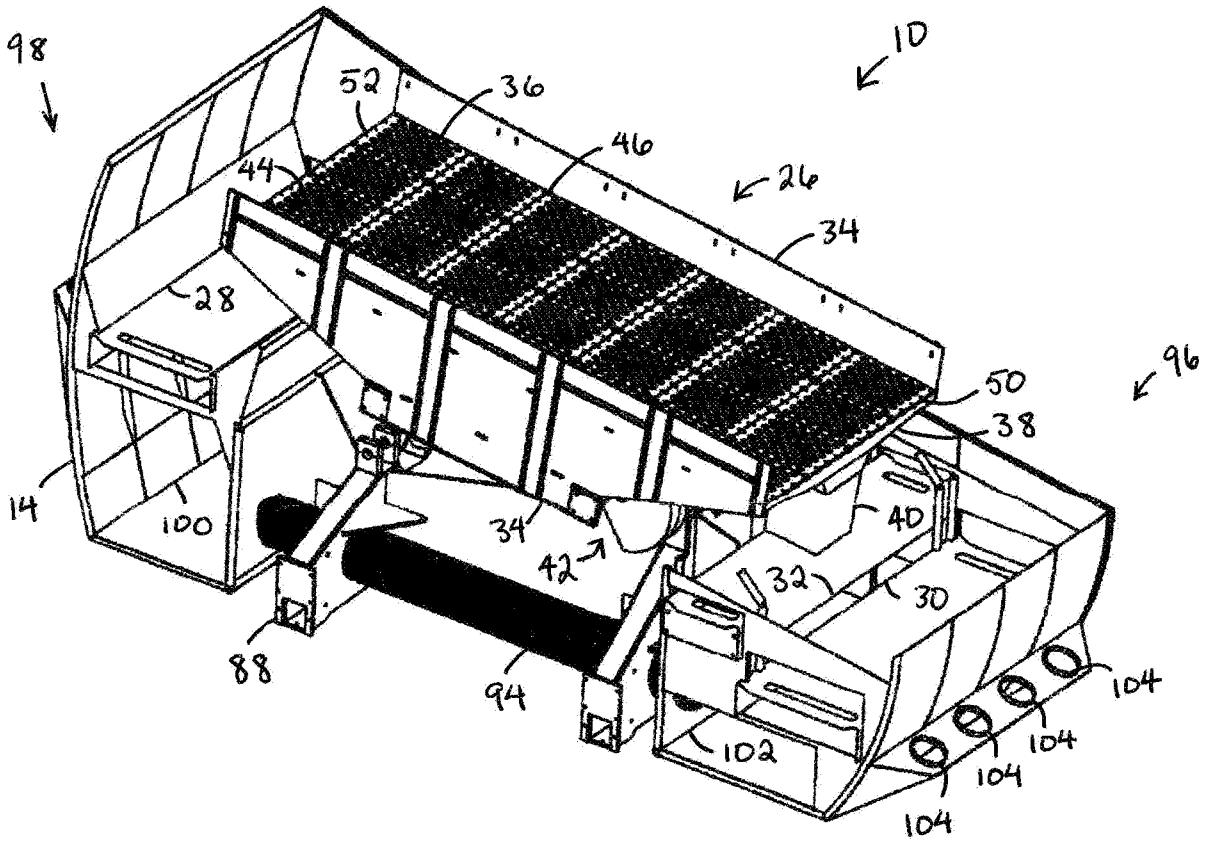

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FIG. 2

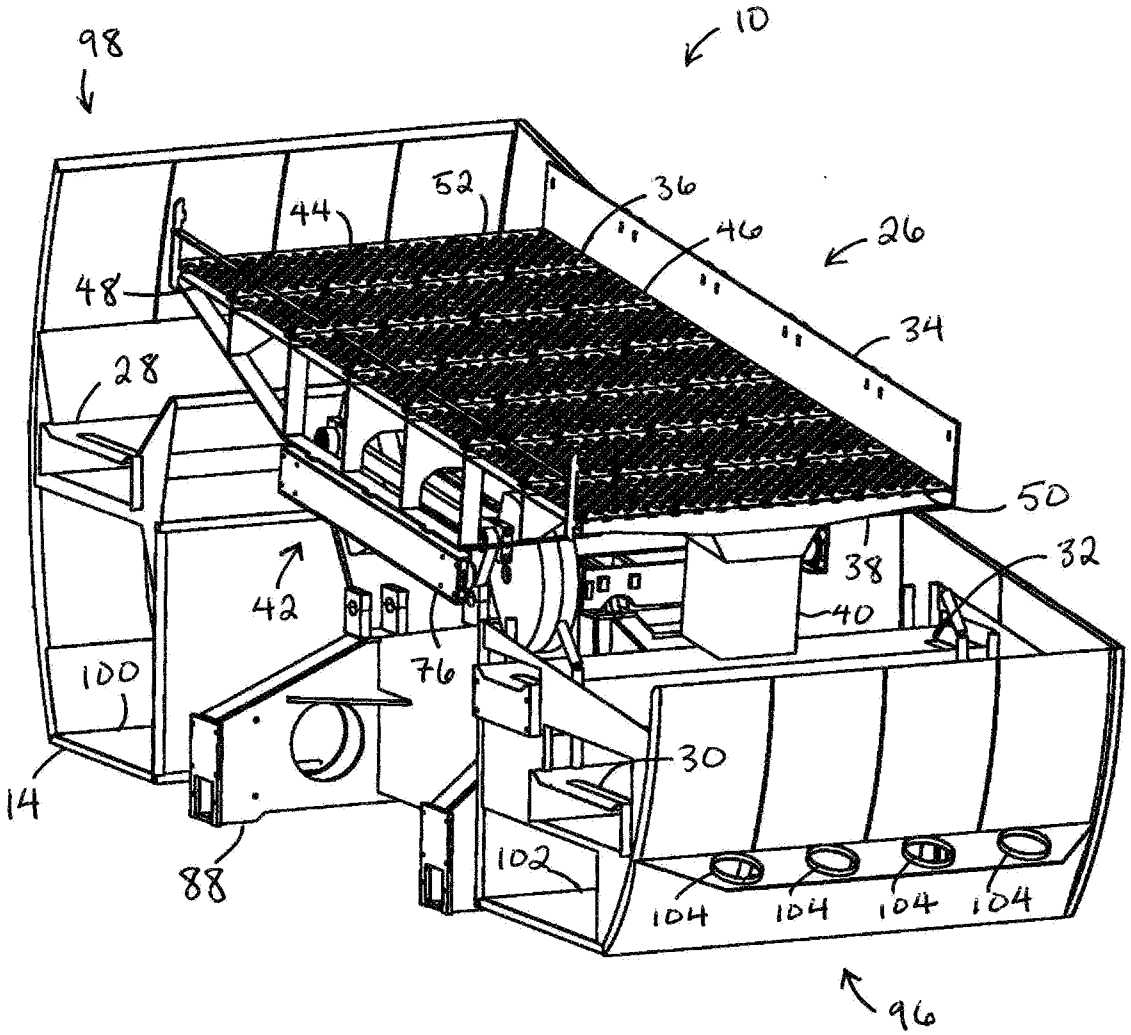

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FIG. 3

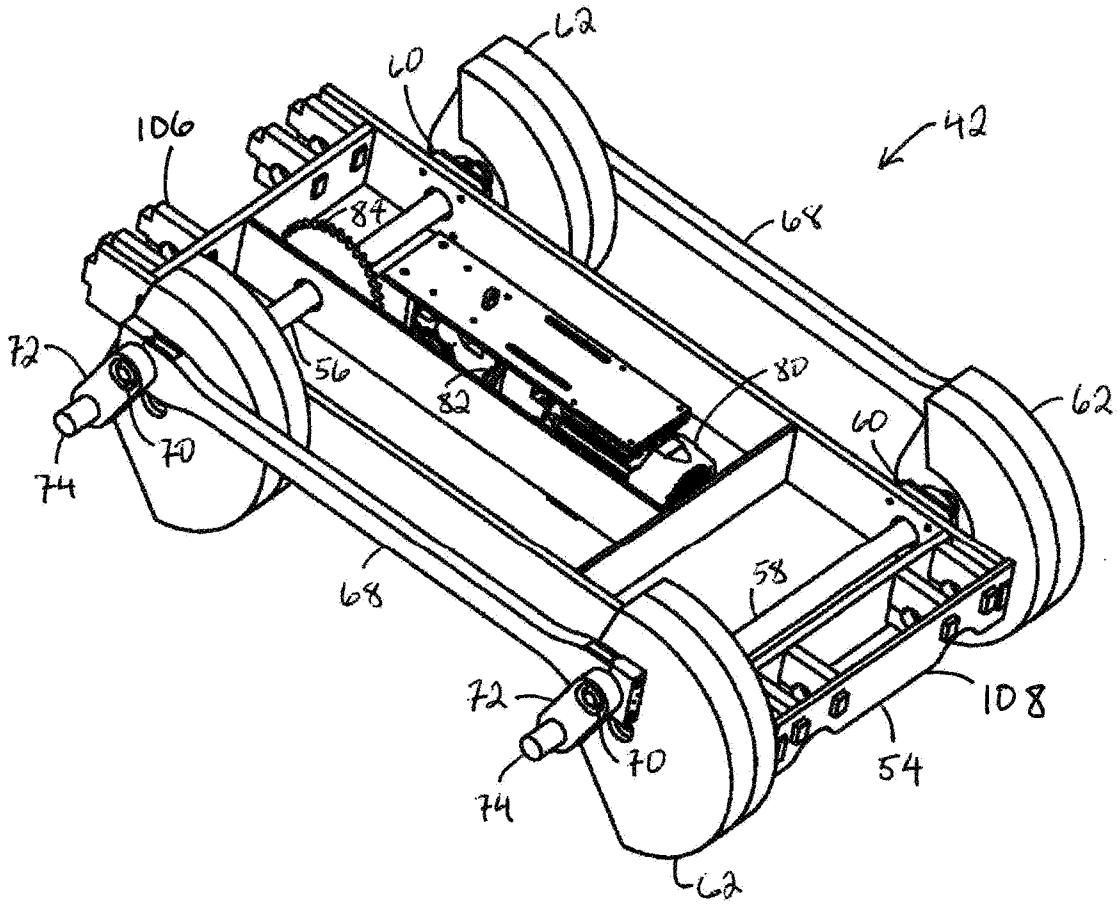


FIG. 4

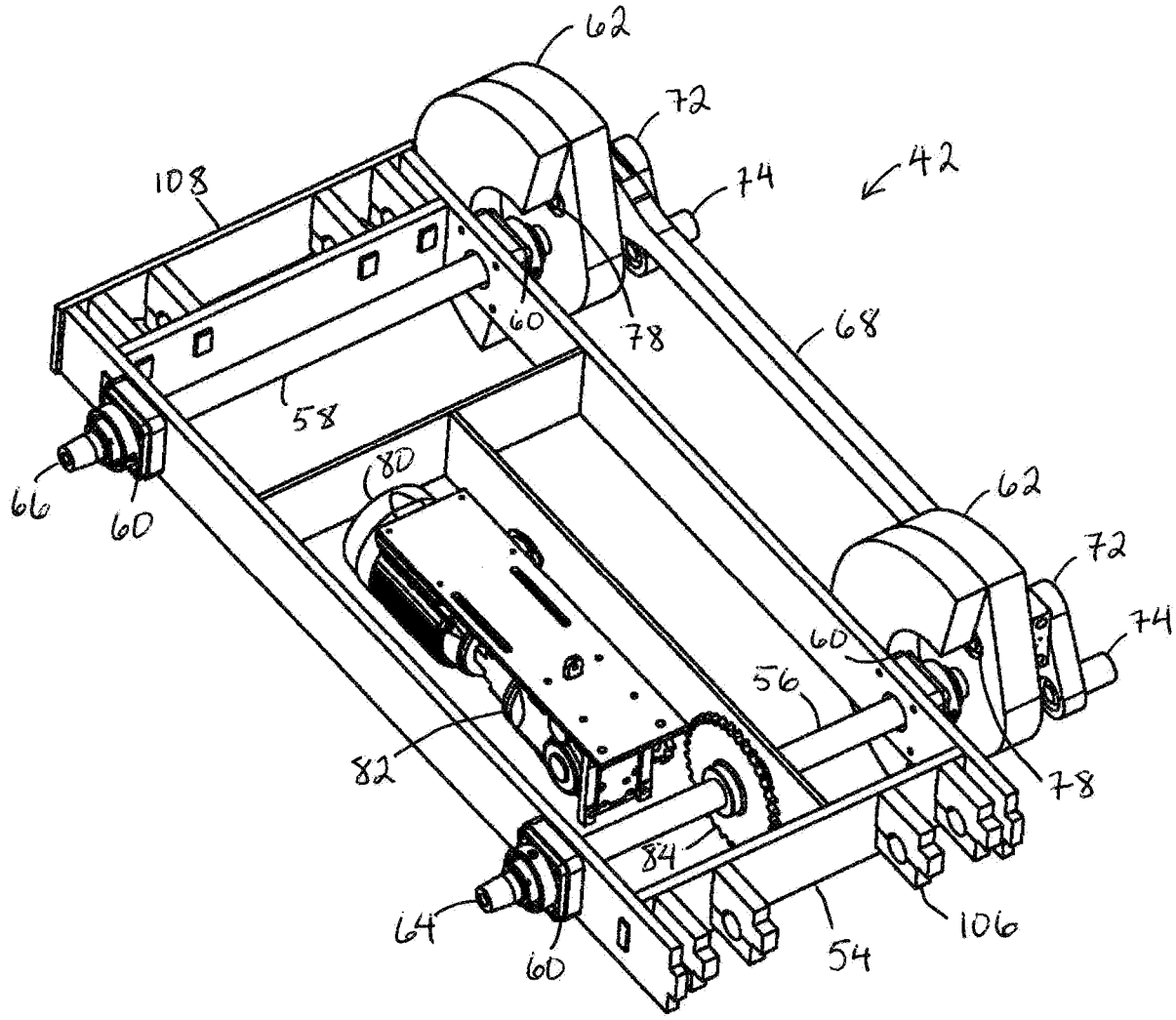

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FIG. 5

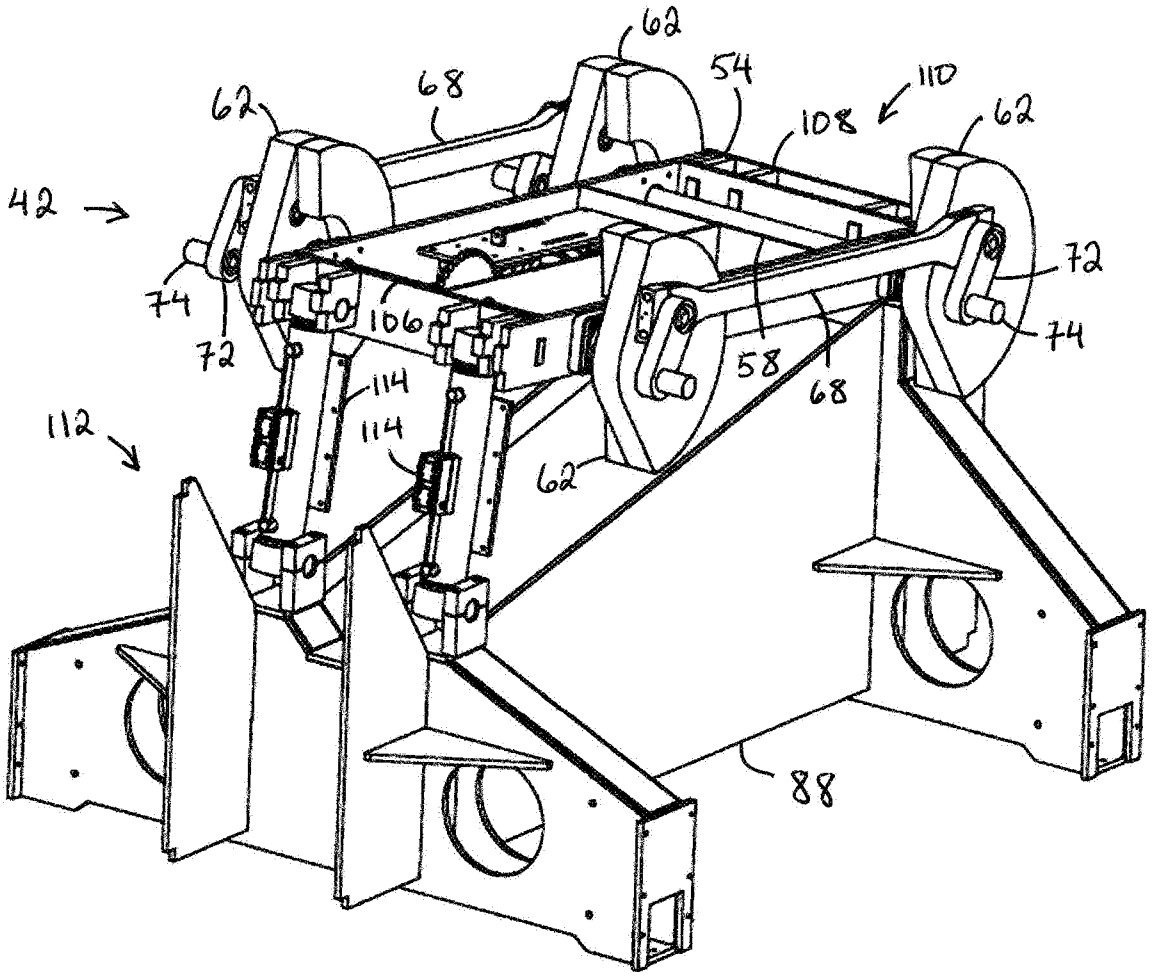


FIG. 6

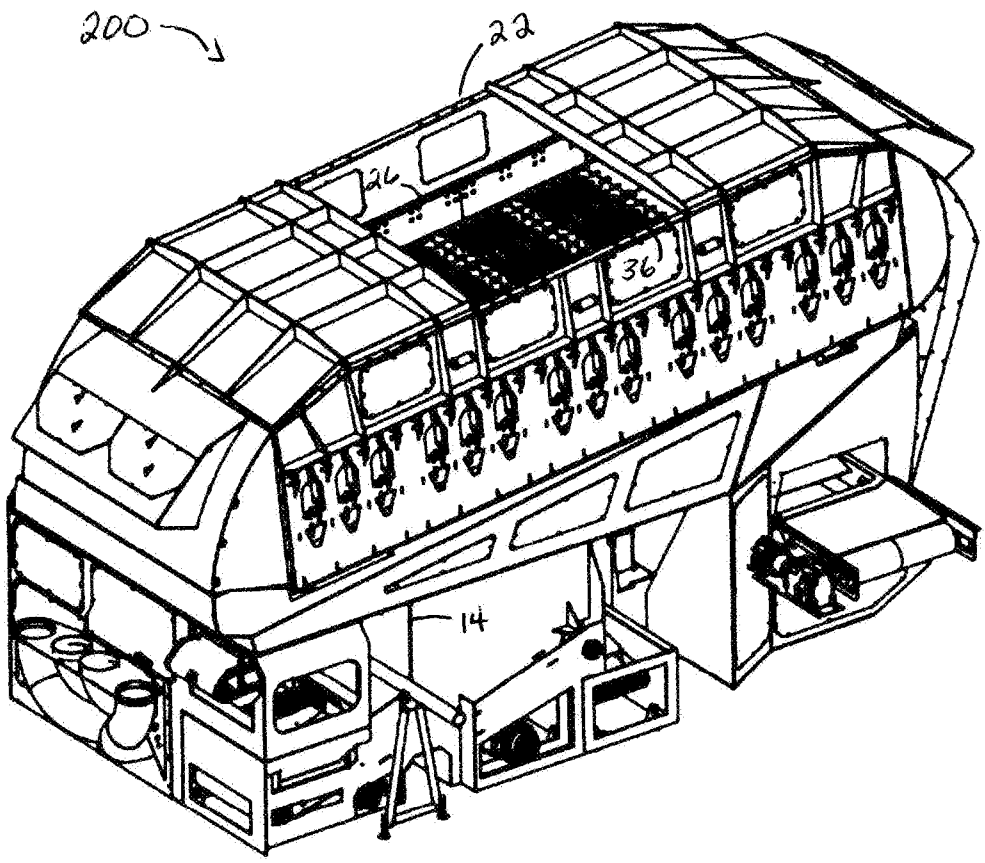


FIG. 7

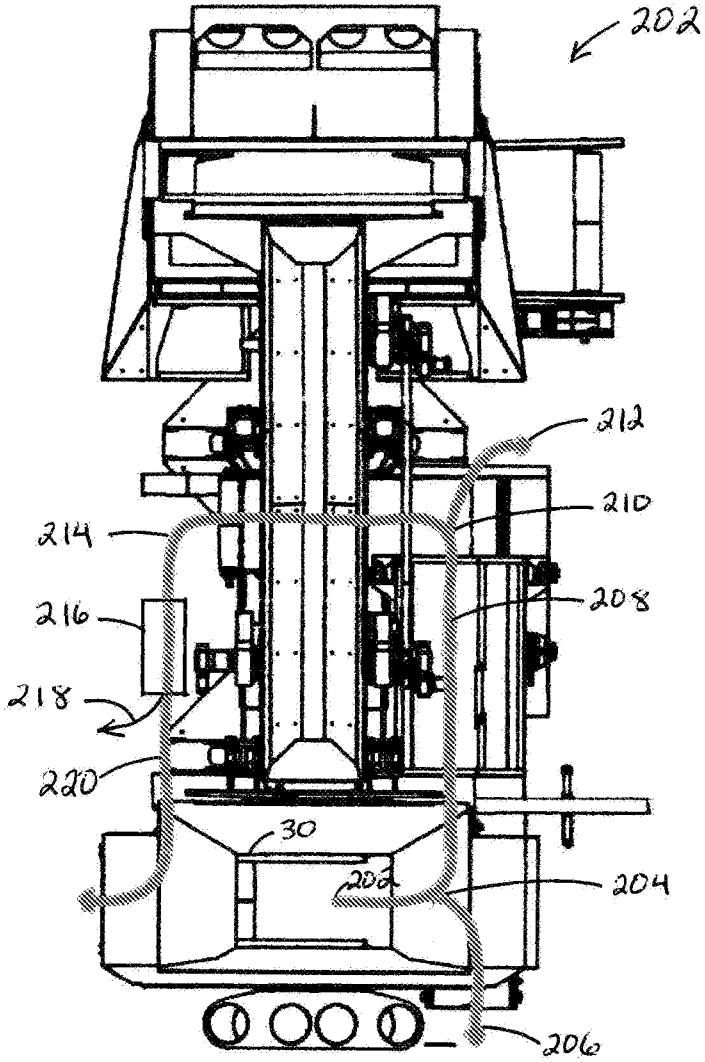


FIG. 8

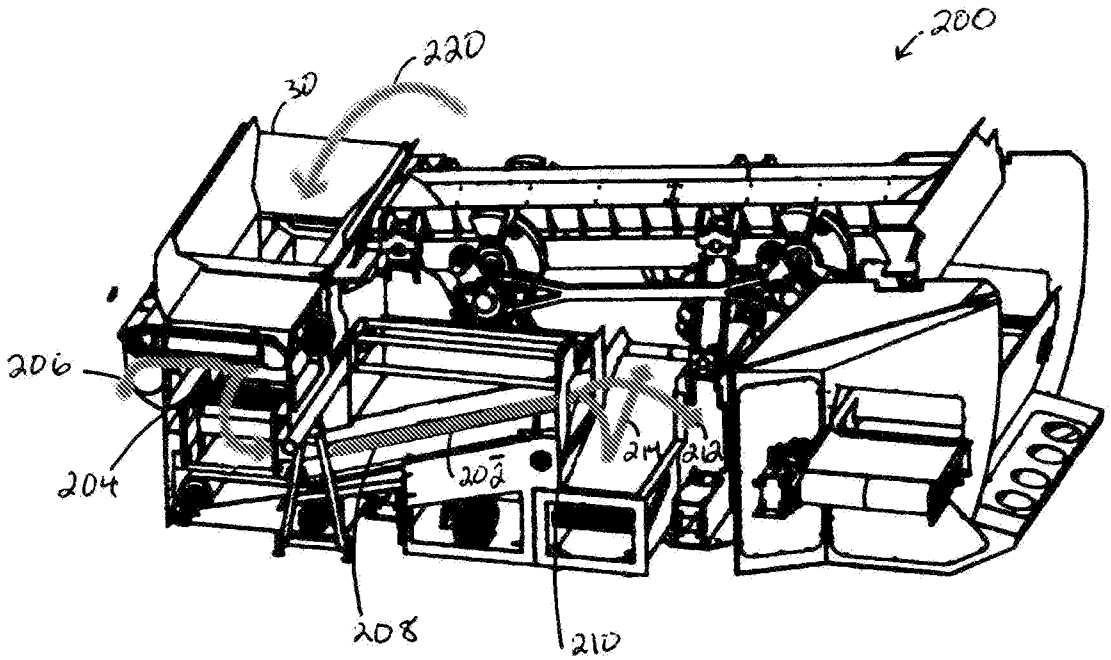


FIG. 9

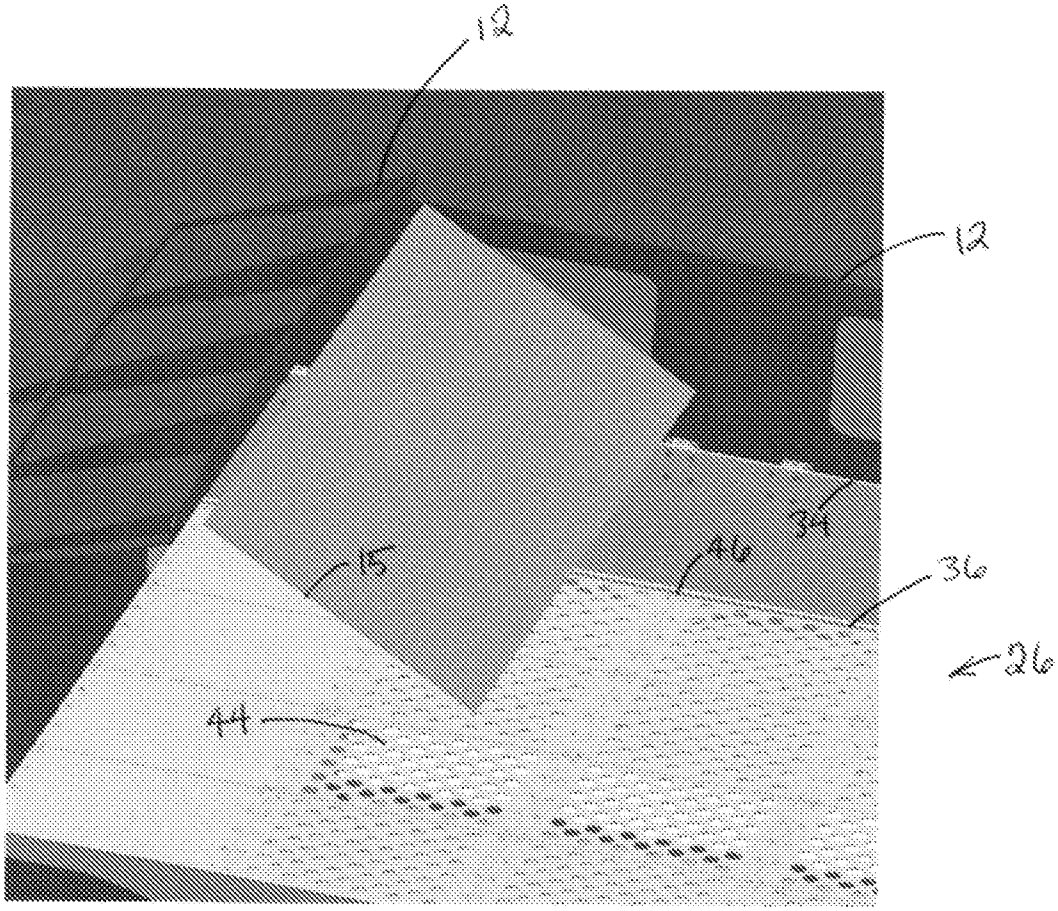


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/021083

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B07B 13/16 (2015.01)
CPC - B07B 13/16 (2015.05)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B03B 4/00, 4/02; B07B 1/00, 1/12, 1/28, 1/42, 1/46, 4/00, 4/02, 4/08, 9/00, 13/14, 13/16 (2015.01)
CPC - B03B 4/00, 4/02; B07B 1/005, 1/12, 1/42, 1/46, 4/02, 4/08, 9/00, 13/14, 13/16 (2015.05) (keyword delimited)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 209/12.1, 44, 44.2, 365.1, 366, 366.5, 396, 413, 420, 467, 674

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

PatBase, Google Patent, Google, Google Scholar, YouTube
search terms used: material, separator, recycling, mixed, screen, output, return

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 6,199,702 B1 (BUER) 13 March 2001 (13.03.2001) entire document	11-14, 16 ---------- 1-10, 15, 17-20
Y	US 2,928,545 A (FORSBERG) 15 March 1960 (15.03.1960) entire document	1-10, 17-20
Y	US 6,003,681 A (WILBUR et al) 21 December 1999 (21.12.1999) entire document	10, 15
A	US 3,016,203 A (SEARS et al) 09 January 1962 (09.01.1962) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 May 2015	18 JUN 2015

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774