transferred to and/or from the applicable location.

[005] In some material handling systems, a conveyor may form part of a movable vehicle used to transport objects to, or retrieve the objects from, the location where a transfer operation is performed. In material systems of this type, failure to rapidly and accurately determine that an object has been transferred from or to the conveyor may delay (or prevent) the vehicle from advancing to the next location.

## SUMMARY OF THE INVENTION

[006] The Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[007] The invention provides a number of aspects that may form part of a material handling system. The system may include one or more of a number of aspects of the invention as further described below.

[007a] According to an aspect, there is provided an apparatus for sorting a plurality of items, comprising: a plurality of sort destinations; a plurality of delivery vehicles for delivering items to the sort destinations, wherein each vehicle comprises: a surface for supporting items to be delivered; and an edge-detection assembly for detecting an edge of an item when the item is conveyed onto or discharged from the vehicle, wherein the edge-detection assembly comprises: an emitter for emitting a beam of light toward the surface, wherein the emitter is positioned below the surface so that the beam of light is projected transverse the surface; and a plurality of detectors for detecting the beam of light, wherein an object on the surface of the vehicle affects the beam of light received by the detectors; wherein the edge-detection assembly is positioned adjacent to, but below, a discharge end of the surface so that the emitter and the plurality of detectors form a detection plane that is transverse and orthogonal to a

plane defined by the surface; a controller for controlling the loading of an item onto one of the vehicles or the discharge of an item from the vehicle based on signals from the edge-detection assembly.

[008] According to one aspect, the invention may provide an apparatus for sorting a plurality of items. The apparatus includes a plurality of sort destinations and a plurality of delivery vehicles for delivering items to the sort destinations. A controller is provided for providing signals for controlling operation of the vehicles. A database for storing a plurality of vehicle movement profiles is also provided. In response to a characteristic determined for an item, the central controller retrieves a vehicle movement profile and the central controller controls the movement of the vehicle in response to the retrieved vehicle movement profile. The vehicle movement profile may comprise one or more of the following: acceleration, deceleration and cornering speed.

[009] According to another aspect, the invention may comprise a track system for guiding the delivery vehicles to the sort destinations.

illustrated in Figure 1;

[041] Figure 8 is a front view, in elevation, depicting an object sensing arrangement;

[042] Figure 9A depicts a linear array of photodetector elements and collimated source of optical energy mounted on a common support structure and forming part of an object sensing arrangement of the object sensing arrangement of Figure 8;

[043] Figure 9B depicts a reflecting mirror forming alignable with the common support structure of Figure 9A;

[044] Figure 10A is a front view of an object sensing arrangement detecting an optically opaque object when the object traverses a detection plane defined by propagation of collimated optical energy in a direction transverse to an object conveying path;

[045] Figure 10B is a front view of an object sensing arrangement detecting an object having at least one light refracting or reflecting portion while such object traverses a detection plane defined by propagation of collimated optical energy in a direction transverse to an object conveying path;

[046] Figure 11 is a perspective view of an alternate vehicle a material handling system;

[047] Figure 12 is an electrical schematic depicting a circuit comprising phototransistors and state sensing logic and operative to signal a change in sensing state when an object traverses the detection plane of one of the object sensing arrangements of Figures 8-11;

[047a] Figure 13 is a diagrammatic view of an output bin having multiple sort locations within the bin; and

[047b] Figure 14 is a diagrammatic view of the bin of Fig. 13 in combination with a delivery vehicle.

## Detailed Description of the Invention

[048] Some portions of the detailed description which follow are presented in terms of operations on binary digital signals stored within a memory of a specific apparatus or special purpose computing device or platform. In the context of this particular specification, the term specific apparatus or the like includes a general purpose computer once it is programmed to perform particular functions pursuant to

[0169] As discussed above, the system can control the movement of the vehicle based on detected or determined information about the item being conveyed on the vehicle. Additionally, the destination of the vehicle may be varied based on one or more characteristic(s) of an item. For instance, information regarding the physical characteristics of various items may be stored in a central data base. By scanning an item for a product identification code the system can retrieve the data regarding the physical characteristics of the item from the central data base. This data is the expected physical characteristics for the item. For example, based on the data stored for a product identification code, the item may be expected to be 5" long, 3" wide and weigh 8 ounces. If the scanning station 80 measures the item to be 8" long and/or weigh 16 ounces, the system may modify the destination for the item. Specifically, based on the scanned product code the system may direct the vehicle to deliver the item to bin "X". However, when the system detects a physical characteristic that does not match the expected characteristic the system may alter the destination bin. In the example above, if the item is scanned and weigh 16 ounces, the system may deliver the item to bin "y", which may be an alternate larger bin or may be an outsort or reject bin for receiving items that vary from the expected physical characteristic.

3. Vehicle Delivery Control

[0170] The system may also control how an item is discharged or delivered at an output bin 190 based on the determined or detected physical characteristics of an item. If an item is fragile, the system may control the vehicle so that the conveyor belts rotate more slowly to discharge the item into the output bin more slowly. Additionally or alternatively, the position of the vehicle relative to the output bin may be varied based on the detected or determined characteristic. For example, if an item is fragile, the system may stop the vehicle lower relative to the bin so that the item is closer to the bottom of the bin and therefore has less of a vertical fall when the item is discharged into the bin.

[0171] Referring now to Fig. 13 and 14, when multiple items are to be delivered to the same output bin 190, the system may control the position of the vehicle 200 relative

to the output bin 190 to reduce the distance that the items must fall when being discharged and to reduce the likelihood of the items causing a jam as the items stack on top of one another. The control of the position of the vehicle during delivery may be varied depending on the detected or determined characteristic(s) of one or more of the items being sorted to the delivery bin.

[0172] As shown in Fig. 13 and 14 when multiple items are to be delivered to a single bin, the system may divide the single output bin into three virtual sort destinations. The system then sorts the three items to the three virtual sort locations. For instance, as shown in Fig. 13, when viewed from the front, the output bin 190 may be segmented into three virtual sort locations: location 1, location 2, and location 3. In Fig. 13 the single output bin is divided into three virtual locations having equal height. However, the size of each virtual location may be varied based on one or more characteristic determined or detected for an item. Additionally, the virtual locations can be prioritized based on the determined or detected characteristic(s) of the items. For instance, if a plurality of items are to be delivered to an output bin and one of the items is fragile and one of the items is heavy and/or dense, the system may prioritize the virtual locations by prioritizing the heavy item to be delivered into the bin first and the fragile item is delivered into the bin second to minimize the likelihood of damage. In order to prioritize the order of delivery, the system may control the flow of vehicles to stage or delay the vehicle transporting the fragile item.

[0173] Similarly, rather than virtually split a single output bin into a plurality of sort locations, the system may virtually merge a plurality of bins into a single virtual bin based on the characteristics determined or detected for multiple items in an order. For instance, if multiple items are to be delivered to a single output bin, but the physical attributes of the different items dictates the order in which the items should be placed into the bin, the system may deliver the items to two or more bins (preferably adjacent bins). The items are then sorted to the different bins. Returning again to the example of a first item that is fragile and a second item that is heavy, when the system detects or determines these features, the system may dynamically reassign the delivery of the items to two separate output bins rather than a single bin if the fragile item is delivered

to the output bin before the vehicle with the second item reaches the output bin. After the two items are delivered to two separate bins, the system provides a signal to the operator indicating that the items in the two separate bins should be withdrawn together and treated as a single order rather than being two separate orders.

[0174] When an output bin is separated into multiple sort locations as shown in Fig. 13, the system may control the operation of the vehicles to vary the position of the vehicle relative to the output bin. For instance, referring to Fig. 14, when the vehicle carrying the first item to the output bin arrives at the output bin, the system controls the vehicle to advance the vehicle into alignment with the lowest location for the output bin (e.g. Location 1 in Fig. 14) and the item is ejected into the bin so that the first item is on the bottom of the bin. The vehicle carrying the second item to be delivered to the output bin is then advanced so that the vehicle is aligned with the next lowest location of the output bin (i.e. Location 2) and the vehicle ejects the item into the bin so that the second item is placed onto the first item. Finally, the vehicle carrying the third item to be delivered to the output bin is then advanced so that the vehicle is aligned with the highest location of the output bin (i.e. Location 3) so that the third item is ejected on the first and second items.

[0175] As shown in Fig. 14, the rear wall of the output bin 190 may be open so that the vehicles can discharge items through the back of the output bin at varying heights along the height of the output bin. However, it should be appreciated that rather than having an open back wall, the back wall may be displaceable or collapsible to allow the vehicles to stop at varying positions along the height of the output bin and discharge items into the bin.

[0176] As described above, various parameters of how an item is delivered to an output bin may be varied based on the physical characteristic(s) determined or detected for an item. Additionally, the system may include additional elements that are optionally used during delivery based on the determined or detected characteristics for the items. For example, the vehicles may include a separate extendable belt or the conveyor belts 212 may be mounted onto a carriage that can be displaced relative to the wheels of the

**CLAIMS**

1. An apparatus for sorting a plurality of items, comprising:
a plurality of sort destinations;
a plurality of delivery vehicles for delivering items to the sort destinations, wherein each vehicle comprises:
a surface for supporting items to be delivered; and
an edge-detection assembly for detecting an edge of an item when the item is conveyed onto or discharged from the vehicle, wherein the edge-detection assembly comprises:
an emitter for emitting a beam of light toward the surface, wherein the emitter is positioned below the surface so that the beam of light is projected transverse the surface; and
a plurality of detectors for detecting the beam of light, wherein an object on the surface of the vehicle affects the beam of light received by the detectors;
wherein the edge-detection assembly is positioned adjacent to, but below, a discharge end of the surface so that the emitter and the plurality of detectors form a detection plane that is transverse and orthogonal to a plane defined by the surface;
a controller for controlling the loading of an item onto one of the vehicles or the discharge of an item from the vehicle based on signals from the edge-detection assembly.

2. The apparatus of claim 1 comprising a track for guiding the vehicles to the sort destinations.

3. The apparatus of claim 1 wherein the plurality of detectors comprises a linear array of aligned detectors.

4. The apparatus of any of claims 1-3 comprising a mirror wherein the emitter emits the beam of light toward the mirror and the mirror reflects the beam of light toward the plurality of detectors.

5. The apparatus of claim 4 wherein the emitter and the plurality of detectors are mounted on a first support element and the mirror is mounted on a second support element spaced apart from the first support element.

6. The apparatus of any of claims 1-5 wherein the edge-detection assembly is configured to detect elements on the surface having a thickness of as thin as approximately 0.05 mm.

7. The apparatus of any of claims 1-6 wherein the edge-detection assembly is configured to detect elements on the surface having a thickness of as thin as approximately 0.5 mm.

8. The apparatus of any of claims 1-7 wherein the edge-detection assembly is configured to detect elements on the surface having a thickness of as thin as approximately 1.0 mm.

9. The apparatus of any of claims 1-8 wherein the edge-detection assembly is configured to detect elements on the surface having a thickness of as thin as approximately 2.0 mm.

10. The apparatus of any of claims 1-9 wherein the edge-detection assembly is configured to detect elements on the surface having a thickness of as thin as approximately 3.0 mm.

11. The apparatus of any of claims 1-10 wherein the emitter comprises a laser.

12. The apparatus of any of claims 1-11 wherein the emitter comprises a lens for dispersing the light to create a beam of light having sufficient height to impinge on each of the detectors.

13. The apparatus of any of claims 1-12 wherein the edge-detection assembly is mounted adjacent an end of the surface of the vehicle.

14. The apparatus of claim 5 wherein the first support element is mounted adjacent a first edge of the surface and the second support element is mounted adjacent a second edge of the surface so that the first and second support are on opposite sides of the vehicle.

15. The apparatus of any of claims 1 to 14, wherein the detectors are photodiodes or photo transistors.

16. The apparatus of any of claims 1 to 15 wherein the controller is adapted to register a first change in logic state when a leading surface of an object moving in a first direction crosses the detection plane formed by the beam of light.

17. The apparatus of claim 16 wherein the controller is further adapted to register a second change in logic state when a trailing surface of an object moving in the first direction crosses the object detection plane.

18. The apparatus of claim 1 comprising a lens system dimensioned and arranged to receive optical energy from the emitter and to collimate the received optical energy into a line aligned with the plurality of detectors, wherein optical energy of the line is received by each detector of the plurality of detectors unless an amount of optical energy above a sensitivity threshold is absorbed, reflected or refracted by an object intersecting the detection plane.