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~~ disclosure 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, the present disclosure refers to 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 an on-board motor for driving the vehicle; an input station comprising a qualification station for analyzing items to detect a first characteristic of the item indicative of the sort destination to which the item is to be sorted and a second characteristic indicative of a physical characteristic of the item; a conveyor for conveying items from the qualification station to a loading station wherein items are loaded onto the vehicle at the loading station; a track for guiding the delivery vehicles to the sort

destinations, wherein the track is adjacent the sort locations and comprises a plurality of generally vertical rail sections forming a row of columns and a plurality of generally horizontal rail sections interconnecting the columns forming a vertical loop; a recirculation conveyor extending transverse the loop and toward the input station wherein the recirculation conveyor is configured to convey items away from the track toward the input station; a controller for providing signals for controlling operation of the vehicles, wherein in response to signals received from the scanning station for an item that is loaded onto one of the vehicles, the controller selectively provides one or more signals to direct the vehicle to an entrance to the recirculation conveyor and to discharge the item onto the recirculation conveyor wherein the recirculation conveyor is operable to convey the item back toward the input station for re-processing at the qualification station.

[007b] According to another aspect, the present disclosure refers to an apparatus for sorting a plurality of items, comprising: a first group of sort destinations positioned along a first track; a second group of sort destinations positioned along a second track, wherein the second track is spaced apart from the first track to form an aisle between the first and second track; a plurality of delivery vehicles vertically and horizontally displaceable within the aisle for delivering items to the sort destinations; an input station comprising a qualification station configured to analyze an item to detect a first characteristic of the item indicative of the sort destination to which the item is to be sorted and a second characteristic of the item; a conveyor for conveying items from the qualification station to a loading station where items are loaded onto the delivery vehicles; a recirculation path providing a path along which the item can be transported back toward the input station, wherein the recirculation path has a first end positioned vertically higher than at least a portion of the conveyor; a reject area positioned adjacent the loading station; a controller for controlling operation of the vehicles, wherein the controller is configured to selectively direct items to one of the three locations in response to a combination of the first and second characteristics, wherein the three locations comprise the reject bin, the recirculation path and one of the sort destinations.

[007c] According to another aspect, the present disclosure refers to a method for

sorting a plurality of items to a plurality of sort locations, comprising the steps of: conveying items to from an input area to a loading area; scanning the items between the input area and the loading area to detect a first characteristic of the items; scanning the items between the input area and the loading area to detect a second characteristic of the items; loading each item on an independently operable vehicle that moves along vertical loop of track in an aisle between a first set of sort locations and a second set of sort locations; selectively operating the vehicles to direct items to a reject area in response to the step of scanning the items to detect a first characteristic or the step of scanning the items to detect a second characteristic; selectively operating one of the vehicles to raise an item above the height of the input area in response to the step of scanning the item to detect a first characteristic; selectively operating the one vehicle to convey the item to a recirculation path after the step of selectively operating the vehicles to raise the item, wherein the step of selectively operating the vehicles to convey the item to a recirculation path in in response to failing to detect a second characteristic for the item; selectively operating the vehicle to convey the item to one of the sort destinations in response to detecting the first characteristic and the second characteristic; and conveying the item along the recirculation path toward the input area if the item is conveyed to the recirculation path.

[008]According to one ~~aspect~~example, the ~~invention~~ disclosure may provide an apparatus for sorting a plurality of items is provided. The apparatus includes a plurality of sort destinations and a plurality of 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~~example, the ~~invention~~ disclosure may comprise a track system for guiding the delivery vehicles to the sort destinations.

[010] According to another ~~aspect~~example, the ~~invention~~ disclosure may comprise a scanner for scanning an item to detect a characteristic of each item, wherein the detected characteristic is the characteristic determined for an item that the controller uses to retrieve a vehicle movement profile. The detected characteristic may be a product identification code for the item.

[011] According to yet another ~~aspect~~example, the detected characteristic may be one of the length, width, height, weight or shape of the item.

[012] According to another example~~aspect~~, the ~~invention~~ disclosure provides an apparatus for sorting a plurality of items to a plurality of sort destinations and a plurality of delivery vehicles for delivering items to the sort destinations. The apparatus may include a controller for providing signals for controlling operation of one of the vehicle carrying one of the items to one of the sort destinations. In response to a characteristic determined for an item the central controller may control the operation of the vehicle so that the position of the vehicle relative to the sort destination varies in response to the determined characteristic.

[013] According to a further example~~aspect~~, the ~~invention~~ disclosure provides sort destination in the form of an output bin having a rearward end through which the item is discharged into the output bin.

[014] According to another example~~aspect of the invention~~ an output bin for a material handling system may comprise an open rearward end.

[015] According to another example~~aspect of the invention~~ an output bin for a material handling system may comprise a displaceable or collapsible rearward wall.

[016] According to another example~~aspect of the invention~~ a method is provided for sorting a plurality of items. The method may include the step of loading an item onto a vehicle to be delivered to an output bin and driving the vehicle to the output bin. The method may further include the steps of discharging the item from the vehicle into the output bin and monitoring the position of the item on the vehicle. The method may also include the step of controlling operation of the vehicle based on the step of monitoring

the position of the item, wherein the step of controlling operation of the vehicle comprises controlling the vehicle to attempt to move the item to a desired location on the vehicle.

[017] According to a further exampleaspect, the invention disclosure provides a method including the step of driving a vehicle along a guide. The guide may comprise a surface and the vehicle may comprises a rotatable element, so that the step of driving a vehicle along a guide comprises driving the rotatable element along the surface of the guide. The step of driving the vehicle may comprise driving the vehicle in a vertical direction.

[018] According to another exampleaspect, the invention disclosure includes a method for sorting items using a plurality of vehicles, including the step of controlling the acceleration or deceleration of a vehicle to control the position of an item on the vehicle.

[019] According to a further exampleaspect of the invention, a method for sorting items using vehicles includes the step of driving a conveyor belt of the vehicle to displace the item on the vehicle while the vehicle is moving along a track.

[020] According to another exampleaspect, the invention disclosure provides a method for sorting items using a plurality of vehicles including the step continuously monitoring the position of an item on a vehicle as the vehicle travels to the output bin.

[021] In another exampleaspect, the invention disclosure provides an apparatus for sorting a plurality of items that includes a plurality of delivery vehicles guided by a track to deliver items to one or more destination. The apparatus may include a loading station for loading items onto the vehicles. The items may be analyzed to detect a first characteristic before the items are loaded onto a vehicle. A recirculation system may be provided for recirculating items to an input station from a point along the track.

[022] In another exampleaspect, the invention disclosure provides an apparatus for sorting a plurality of items that includes a plurality of delivery vehicles guided by a track to deliver items to one or more destination and the apparatus having a qualification station for detecting first and second characteristics of items to be delivered by the vehicles before the items are loaded onto the vehicles at a loading station. The system may include a

recirculation path providing a path along which the items can be transported along the track. The recirculation path may have a first end and a second end and the first end may be positioned vertically higher than the second end. The second end may be positioned adjacent the input station so that items placed on the first end of the recirculation pathway tend to move downwardly toward the second end adjacent the input station.

[023] According to another exampleaspect, the invention disclosure provides an apparatus for sorting a plurality of items and the apparatus may include a reject area positioned vertically lower than a first end of a recirculation path. The recirculation path may be a roller bed. The recirculation path may be a chute or slide. The recirculation path may comprise a conveyor including one or more moveable belts or belt links.

[024]According to a further exampleaspect, the invention disclosure provides a sorting apparatus having a controller for controlling operation of delivery vehicles, wherein in response to signals received from by a scanning station regarding a first characteristic for an item, a vehicle is directed to an entrance to a recirculation path where the controller controls the vehicle to discharge the item onto the recirculation path. The recirculation path may convey the item back to an input station. At the input station the item may be re-processed at a qualification station. Additionally, in response to signals from the scanning station regarding a second characteristic the item is directed to a reject area.

[025]According to another exampleaspect of the invention a sorting apparatus is provided in which in response to signals from a qualification station a controller controls a vehicle to direct the vehicle to the one of the destination areas.

[026]According to another exampleaspect, the invention disclosure provides a method for sorting a plurality of items that includes scanning items and selectively elevating items above an input area based on scanned characteristics. The method may also include the step of selectively conveying items down a re-circulation path to the input area after the step of selectively elevating items. The method may include the step of selectively sorting items after the step of selectively elevating items.

[027] According to another exampleaspect, the method may include the step of moving

items to the input area. The method may also include the step of scanning the items to detect a first characteristic of the item. Optionally, the system may include the step of scanning the item to detect a second characteristic of the item. The system may include the step of selectively directing items to a reject area based on the step of scanning the items to detect a first characteristic or the step of scanning the items to detect a second characteristic.

[028] According to another exampleaspect, the step of selectively elevating items may be based on the step of scanning the items to detect a first characteristic or the step of scanning the items to detect a second characteristic. Optionally, the step of selectively conveying items down a re-circulation path may be based on the step of scanning the items to detect a first characteristic or the step of scanning the items to detect a second characteristic. Additionally, the step of selectively sorting the items to one or more destinations may be based on the step of scanning the items to detect a first characteristic and the step of scanning the items to detect a second characteristic.

[029] Systems and methods are described for aiding in the reliable and accurate sensing of an object boundary such, for example, as the leading and/or trailing edge surface(s) of an object relative to an underlying conveyor surface. According to one or more examplesembodiments, a sensing arrangement for sensing an object boundary location relative to an underlying object support surface comprises a plurality of photodetector elements disposed in a linear array; a laser light source; and a lens system dimensioned and arranged to receive optical energy from the laser light source and to collimate the received optical energy into a line aligned with the plurality of photodetector elements. Optical energy of the line is received by each photodetector element of the plurality of photodetector elements unless an amount of optical energy above a sensitivity threshold is absorbed, reflected or refracted by an object disposed on the underlying support surface.

[030] In another exampleembodiment, a system for conveying objects along a conveying path defines an object support surface and includes an object transfer mechanism operative to move an object, supported by the object support surface, in at least one

object transfer direction; and a sensing arrangement for sensing an intersection between an object and a detection plane transverse and a detection plane, the sensing arrangement including a plurality of photodetector elements disposed in a linear array; a laser light source; and a lens system dimensioned and arranged to receive optical energy from the laser light source and to collimate the received optical energy into a line aligned with the plurality of photodetector elements, wherein optical energy of the line is received by each photodetector element of the plurality of photodetector elements unless an amount of optical energy above a sensitivity threshold is absorbed, reflected or refracted by an object disposed on the object support surface.

[031] In yet another example~~embodiment~~, a vehicle for conveying objects along a conveying path in a material handling system comprises first and second shafts extending in a direction transverse and orthogonal to an object transfer direction; a conveyor belt supported by the pair of shafts, the conveyor belt defining an object support surface; an electric motor for driving at least one of the shafts and causing movement of the conveyor belt and any object disposed on the object support surface following movement of the vehicle along the conveying path to an object transfer location; a sensing arrangement for sensing an object boundary location relative to the object support surface, the sensing arrangement including a plurality of photodetector elements disposed in a linear array; a laser light source; and a lens system dimensioned and arranged to receive optical energy from the laser light source and to collimate the received optical energy into a line aligned with the plurality of photodetector elements. Optical energy of the line is received by each photodetector element of the plurality of photodetector elements unless an amount of optical energy above a sensitivity threshold is absorbed, reflected or refracted by an object disposed on the object support surface.

[032] In some examples~~embodiments~~, a vehicle for conveying objects along a conveying path in a material handling system comprises a pair of shafts comprising a first shaft and a second shaft extending in a direction transverse to an object transfer direction; a conveyor belt supported by the pair of shafts, the conveyor belt defining an object support surface; an electric motor for driving at least one of the shafts and causing