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(54) Title: VERTICAL SORTER

(57) Abstract: A sorting machine includes a first hopper comprising an inlet and an outlet, a tray arranged at a declined angle and configured to receive items from the outlet of the first hopper, and an analysis system. The analysis system includes an optical sensor positioned proximal to the tray and configured to optically scan a plurality of items as they travel through the tray, and a rejector valve positioned proximal to an outlet of the tray and configured to direct a jet of air toward an item of the plurality of items to direct the item of the plurality of items into a second hopper positioned beneath the tray.

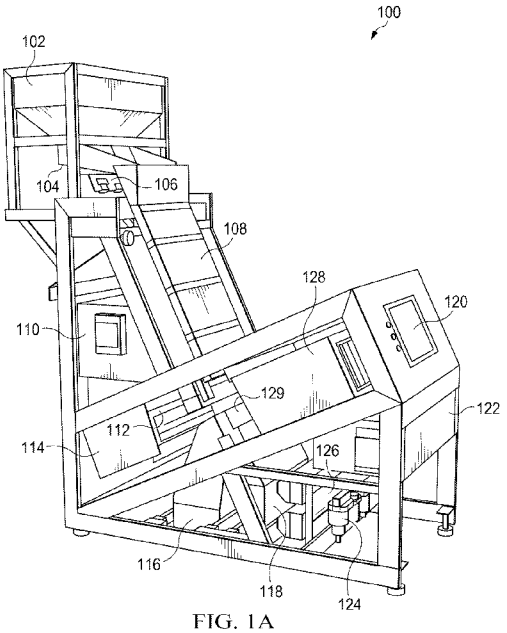

FIG. 1A

VERTICAL SORTER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from, and incorporates by reference the entire disclosure of, U.S. Provisional Application No. 63/460,483 filed on April 19, 2023.

TECHNICAL FIELD

[0002] The present disclosure relates generally to sorting machines and more particularly, but not by way of limitation, to a vertically oriented sorting machine.

BACKGROUND

[0003] This section provides background information to facilitate a better understanding of the various aspects of the disclosure. It should be understood that the statements in this section of this document are to be read in this light, and not as admissions of prior art.

[0004] Various commercial processes commonly require objects to be sorted. For example, harvested foods, such as coffee berries and olives, are often sorted into two or more categories. While this process can be done manually, manual processes are very time consuming and are not well suited to high-volume operations were hundreds or thousands of items need to be sorted in a short period of time. Various machines have been developed to speed up the sorting process. These sorting machines convey the harvested food to some component that mechanically sorts the food. Conventionally, sorting machines utilize horizontally oriented conveyers comprising rollers and motors to convey the harvested food to some component that sorts the food. These conventional sorting machines have drawbacks, such as requiring frequent adjustments/alignments, and can suffer from a lack of sorting accuracy due to variations in size, shape, weight, etc. of the food being sorted. Additional drawbacks of conventional sorting machines include the large footprint they can require, and, in some cases, the large amounts of energy required to power the sorting machines.

SUMMARY OF THE INVENTION

[0005] This summary is provided to introduce a selection of concepts that are further described below in the Detailed Description. This summary is not intended to identify key or essential

features of the claimed subject matter, nor is it to be used as an aid in limiting the scope of the claimed subject matter.

[0006] In some aspects, a sorting machine includes: a first hopper comprising an inlet and an outlet; a tray arranged at a declined angle and configured to receive items from the outlet of the first hopper; and an analysis system comprising: an optical sensor positioned proximal to the tray and configured to optically scan a plurality of items as they travel through the tray; and a rejector valve positioned proximal to an outlet of the tray and configured to direct a jet of air toward an item of the plurality of items to direct the item of the plurality of items into a second hopper positioned beneath the tray.

[0007] In some aspects, the sorting machine includes a touch screen interface configured to allow a user to control operation of the sorter.

[0008] In some aspects, the sorting machine includes an air system coupled to the rejector valve and configured to supply the rejector valve with compressed air.

[0009] In some aspects, the tray comprises a transparent window arranged to allow the optical sensor to see the plurality of items as they travel through the tray.

[0010] In some aspects, the sorting machine includes a light source positioned proximal to the tray and configured to illuminate the items as they travel through the tray.

[0011] In some aspects, the sorting machine includes a third hopper positioned beneath the tray and configured to receive items that have not been redirected by a jet of air from a rejector valve of the plurality of rejector valves.

[0012] In some aspects, the sorting machine includes a vibrator tray positioned between the first hopper and the tray, the vibrator tray configured to impart vibratory energy into the items to facilitate movement of the items from the first hopper to the tray.

[0013] In some aspects, the analysis system is configured to determine a color of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the color of each item with a threshold value for color.

[0014] In some aspects, the analysis system is configured to determine a size of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the size of each item with a threshold value for size.

[0015] In some aspects, the sorting machine includes an air jet cleaning system comprising a plurality of air jets configured to remove debris.

[0016] In some aspects, the sorting machine includes a water jet cleaning system comprising a plurality of water jets configured to remove debris.

[0017] In some aspects, a method of sorting items using a sorting machine includes: adding a plurality of items for sorting to a first hopper of the sorting machine; inspecting, by an analysis system of the sorting machine, the plurality of items with a camera of the machine; classifying, by the analysis system of the sorting machine, an attribute of each item of the plurality of items into one of a first category and a second category; and directing each item of the first category to a second hopper and each item of the second category to a third hopper, wherein the directing each item of the first category comprises not blowing each item of the first category with a jet of air and the directing each item of the second category comprising blowing each item of the second category with a jet of air.

[0018] In some aspects, the method includes supplying vibrational energy to the plurality of items to facilitate movement of the plurality of items from the first hopper to a sorting tray for the inspecting.

[0019] In some aspects, the method includes illuminating the plurality of items with a light source as the plurality of items move through a sorting tray.

[0020] In some aspects, the attribute is a color of the item.

[0021] In some aspects, the analysis system is configured to determine a color of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the color of each item with a threshold value for color.

[0022] In some aspects, the color is converted into a hex code.

[0023] In some aspects, the color is converted into an RGB value.

[0024] In some aspects, the attribute is a size of the item.

[0025] In some aspects, the analysis system is configured to determine a size of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the size of each item with a threshold value for size.

[0026] In some aspects, the analysis system includes: an optical sensor positioned proximal to the tray and configured to optically scan the plurality of items as they travel through the tray; and a rejector valve configured to direct a jet of air toward an item of the plurality of items to direct the item of the plurality of items into the second hopper.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] A more complete understanding of the subject matter of the present disclosure may be obtained by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

[0028] FIG. 1A is a perspective view of a vertical sorting machine according to aspects of the disclosure;

[0029] FIG. 1B is a detail view of the vertical sorting machine of FIG. 1A according to aspects of the disclosure.

[0030] FIG. 2 is a side view of the vertical sorting machine of FIG. 1A according to aspects of the disclosure;

[0031] FIG. 3 is a front view of the vertical sorting machine of FIG. 1A according to aspects of the disclosure;

[0032] FIG. 4 is a schematic diagram of a computer system that may be incorporated into the vertical sorting machine according to aspects of the disclosure.

DETAILED DESCRIPTION

[0033] It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the

disclosure. These are, of course, merely examples and are not intended to be limiting. The section headings used herein are for organizational purposes and are not to be construed as limiting the subject matter described. Reference will now be made to more specific embodiments of the present disclosure and data that provides support for such embodiments. However, it should be noted that the disclosure below is for illustrative purposes only and is not intended to limit the scope of the claimed subject matter in any way.

[0034] FIG. 1A is a perspective view of a vertical sorting machine 100 according to aspects of the disclosure. Machine 100 includes an upper hopper 102 into which a product for sorting may be loaded. The product may be, for example, any of a variety of foods and includes, for example, coffee berries, olives, and the like. The product may also be non-food items, such as various goods of manufacture. Upper hopper 102 includes an outlet that feeds into a vibrator tray 104. Vibrator tray 104 includes a vibration means 106 that imparts linear vibrational energy to vibrator tray 104, and consequently to food passing thereby to help the food move from upper hopper 102 into vibrator tray 104 and subsequently into a sorting or smooth tray 108. FIG. 2 illustrates an example of a vibration means in the form of a vibration motor positioned beneath and mechanically connected to vibrator tray 104 to transfer vibrational energy into vibrator tray 104. Any of a variety of vibration-inducing components may be used. For example, the vibration means may be a linear vibration motor, a rotational/eccentric vibration motor, and the like.

[0035] Smooth tray 108 is arranged at a declined angle and coupled to an outlet of vibrator tray 104. Smooth tray 108 is dimensioned with a width and a height that accommodates the food being sorted. In the aspects illustrated in FIGS. 1A, 1B, and 2-3, smooth tray 108 is designed to have a height that is slightly larger than the largest diameter of the food being sorted. The width of smooth tray 108 is a design choice and may be varied depending on the performance goals of machine 100 (e.g., the wider the width, the higher the throughput of machine 100). Implementing a height in this manner results in something like a two-dimensional array of food items that travel through smooth tray 108 (i.e., food items do not stack on top of each other on the z-axis and can only traverse through smooth tray 108 in a side-by-side fashion in a two-dimensional array in the x-y axis). Restricting the food items into this two-dimensional arrangement increases the accuracy of the sorting machine by ensuring that each food item is individually visible by a camera while passing through smooth tray 108.

[0036] Machine 100 includes an analysis system comprised of a control console 122 that includes computer and analysis electronic board (e.g., see FIG. 4 and the related discussion of exemplary aspects of a computer and analysis electronic board), a camera and illumination system console 128, a background light console 114, a touch screen interface 120, and a compressed air supply system 124. In some aspects, machine 100 includes a second control console 110 that is operable to control one or more of the background light console 114 and camera and illumination system console 128. The background light console 114 and camera and illumination system console 128 are positioned proximal to the smooth tray 108 to illuminate and scan, respectively, food as it passes through smooth tray 108. The scanning process is discussed in more detail below. In the aspects shown in FIGS. 1A, 1B, and 2-3, background light console 114 and camera and illumination console 128 are positioned near a distal end of smooth tray 108. In other aspects, background light console 114 and camera and illumination console 128 can be positioned anywhere along the length of smooth tray 108. Background light console 114 includes a light source that is configured to illuminate the food as it passes through smooth tray 108. The light source may be, for example, an incandescent light, LED light, and the like. Illumination system console 128 includes an optical sensor/camera 131 that is configured to optically and linearly scan the food as it passes through smooth tray 108. Illumination system console 128 includes a window made of a transparent material that enables the optical sensor 131 of illumination system console 128 to view the food items as they move through smooth tray 108. In some aspects, machine 100 also includes cleaning wipers 112 that clean the window to ensure that the optical sensor 131 has an unimpeded view of the food.

[0037] Control console 122 may include an analysis electronic board system comprising a processor and memory (e.g., see FIG. 4 and related discussion). A user may interact with and/or operate machine 100 via touch screen interface 120. The analysis electronic board system in control console 122 is configured to identify one or more attributes of each food item that travels through smooth tray 108 and to recognize the location of each food item along smooth tray 108. For example, the analysis electronic board system in control console 122 includes logic stored on a non-transitory storage medium that is configured to identify attributes of items, including one or more of their position, their future position based upon their location and speed, their color, their size, their shape, and the like. Attributes of the food that are

identified may include, for example, color, size, shape, and the like. The one or more attributes are used by the analysis electronic board system to classify food items. For example, the food items may be classified into a first category or a second category. The first category may be "accepted" and the second category may be "rejected". The analysis electronic board system uses the categorization and location data of each food item to sort each food item into either a first hopper 116 (e.g., "accepted") or a second hopper 118 (e.g., "rejected").

[0038] The analysis electronic board system in control console 122 sorts food items into first hopper 116 or second hopper 118 via a plurality of rejector valves/jets 129 that are arranged along an outlet of smooth tray 108. Compressed air supply system 124 may include a connection to a source of pressurized air or may include an air compressor and pressurized tank 126. Each rejector valve 129 is individually controllable by the analysis electronic board, and each rejector valve 129 includes a valve and a nozzle that are configured to selectively blow a jet of air to direct a food item toward second hopper 118. For example, when the analysis electronic board in control console 122 has identified a food item for rejection, the controller directs the appropriate valve (i.e., the valve that is aligned with the food item) to blow a jet of air at the identified food item as it exits smooth tray 108. The jet of air impacts the identified food item as the identified food item freefalls and directs the identified food item into second hopper 118. The controller allows food items that have been categorized as "accepted" to freefall from smooth tray 108, without any jets altering their course, to fall into first hopper 116. It will be appreciated that machine 100 could be configured to operate in the opposite manner in which the jets are configured to blow rejected items into first hopper 116 and accepted items into second hopper 118.

[0039] Camera and illumination system console 128 scans and tracks each food item as it travels through smooth tray 108. In some aspects, optical sensor 131 of camera and illumination system console 128 scans each food item to detect a color of the food item. Optical sensor 131 registers the color of the food item as a digital value (e.g., as a hex code such as #008000, as an RGB code such as RGB(0, 128, 0), or the like). The digital value of a particular food item is compared against a stored threshold value to categorize the food item based upon its detected color. For example, a coffee berry typically varies in color from shades of green when it is not yet ripe to shades of red as the berry ripens. Camera and illumination system console 128 uses a pre-set threshold value to compare to the detected digital value of the food item. The pre-set

threshold value may be a value set by a user and can be adjusted to sort the food item as desired. This comparison results in a determination that the food item either satisfies the minimal value for acceptance (i.e., the food item is sufficiently ripe) or fails the minimal value for acceptance (i.e., the food item is not sufficiently ripe). Food items that are determined to be acceptable are allowed to fall unimpeded into accepted hopper 116.

[0040] Food items that are determined to be unacceptable are diverted into rejected hopper 118 by a jet of air from one of the rejector valves 129. In order to accurately time the jet of air from rejector valves 129, camera and illumination system console 128 uses data from optical sensor 131 to track each food item's path as it moves through smooth tray 108. For example, the speed of the food item as it moves through smooth tray 108 and the horizontal position along the x-axis of smooth tray 108 are tracked by camera and illumination system console 128. These two parameters enable camera and illumination system console 128 to calculate the position of each food item as it travels through smooth tray 108 and its projected path as it exits smooth tray 108. The timing of rejector valve 129 can then be calculated so that the rejected food item can be accurately diverted into rejected hopper 118 by the jet of air. This process is managed simultaneously for each food item that moves through smooth tray 108.

[0041] FIG. 1B is a detail view of vertical sorting machine 100 that illustrates an air jet cleaning system with jets 130, 132, and a water jet cleaning system with jets 134, 136 and. Jets 130, 132 are configured to remove debris etc. from rejector jets 129 to insure proper operation of jets 129. Jets 134, 136 are configured to apply pressurized water to flush out debris from rejector jets 129. For example, in some aspects, jets 132, 134 may be used to flush debris, and jets 130, 132 may then be used to flush out water/debris from rejector jets 129.

[0042] FIG. 3 is a front view of vertical sorting machine 100. FIG. 3 illustrates various controls that may be used to control operation of vertical sorting machine 100, including touch screen interface 120, a power button 140 (to allow a user to power on/off the system), a CPU light 142 (to indicate proper system operation/no errors), power supply light 144 (to indicate proper uninterruptable power supply operation), a control cabinet latch 146 (to lock access to the control cabinet), an hour meter 148 (to keep track of how many hours the machine has run), and a cabinet door latch 150 (to prove access to the cabinet).

[0043] The above discussion of the scanning process was discussed relative to a color of the items. It will be appreciated that other attributes of the items could be used for sorting instead, such as size, shape, and the like.

[0044] FIG. 4 illustrates an example of a computer system 300 that, in some cases, can be representative, for example, of analysis electronic board in control console 122 for characterizing and sorting items using the vertical sorting machines described herein. Computer system 300 includes an application 314 operable to execute on computer resources 302. Application 314 can be, for example, an interface for operating computer system 300. In other embodiments, application 314 can be, for example, an interface for operating and/or accessing all engines and datastores of computer system 300. In particular embodiments, computer system 300 may perform one or more steps of one or more methods described or illustrated herein. In particular embodiments, one or more computer systems may provide functionality described or illustrated herein. In particular embodiments, encoded software running on one or more computer systems may perform one or more steps of one or more methods described or illustrated herein or provide functionality described or illustrated herein.

[0045] The components of computer system 300 may comprise any suitable physical form, configuration, number, type and/or layout. As an example, and not by way of limitation, computer system 300 may comprise an embedded computer system, a system-on-chip (SOC), a single-board computer system (SBC) (such as, for example, a computer-on-module (COM) or system-on-module (SOM)), a desktop computer system, a laptop or notebook computer system, an interactive kiosk, a mainframe, a mesh of computer systems, a mobile telephone, a personal digital assistant (PDA), a wearable or body-borne computer, a server, or a combination of two or more of these. Where appropriate, computer system 300 may include one or more computer systems; be unitary or distributed; span multiple locations; span multiple machines; or reside in a cloud, which may include one or more cloud components in one or more networks.

[0046] In the depicted embodiment, computer system 300 includes a processor 308, memory 312, storage 310, a display 316, interface 306, and bus 304. Although a particular computer system is depicted having a particular number of particular components in a particular

arrangement, this disclosure contemplates any suitable computer system having any suitable number of any suitable components in any suitable arrangement.

[0047] Processor 308 may be a microprocessor, controller, or any other suitable computing device, resource, or combination of hardware, software and/or encoded logic operable to execute, either alone or in conjunction with other components, (e.g., memory 312), the application 314. Such functionality may include providing various features discussed herein. In particular embodiments, processor 308 may include hardware for executing instructions, such as those making up the application 314. As an example, and not by way of limitation, to execute instructions, processor 308 may retrieve (or fetch) instructions from an internal register, an internal cache, memory 312, or storage 310; decode and execute them; and then write one or more results to an internal register, an internal cache, memory 312, or storage 310. Display 316 is configured to display information to a user (e.g., route guidance information). In some aspects, display 316 may be a touchscreen display that receives input from a user (e.g., origin and our destination information). In some aspects, display 316 may be integrated into computer system 300 (i.e., when computer system 300 is a mobile, stand-alone unit). In some aspects, display 316 may be integrated into a vehicle (i.e., a part of the infotainment and/or navigation system of an automobile in which computer system 300 is installed).

[0048] In particular embodiments, processor 308 may include one or more internal caches for data, instructions, or addresses. This disclosure contemplates processor 308 including any suitable number of any suitable internal caches, where appropriate. As an example, and not by way of limitation, processor 308 may include one or more instruction caches, one or more data caches, and one or more translation lookaside buffers (TLBs). Instructions in the instruction caches may be copies of instructions in memory 312 or storage 310 and the instruction caches may speed up retrieval of those instructions by processor 308. Data in the data caches may be copies of data in memory 312 or storage 310 for instructions executing at processor 308 to operate on; the results of previous instructions executed at processor 308 for access by subsequent instructions executing at processor 308, or for writing to memory 312, or storage 310; or other suitable data. The data caches may speed up read or write operations by processor 308. The TLBs may speed up virtual-address translations for processor 308. In particular embodiments, processor 308 may include one or more internal registers for data, instructions, or addresses. Depending on the embodiment, processor 308 may include any suitable number

of any suitable internal registers, where appropriate. Where appropriate, processor 308 may include one or more arithmetic logic units (ALUs); be a multi-core processor; include one or more processors 308; or any other suitable processor.

[0049] Memory 312 may be any form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, random access memory (RAM), read-only memory (ROM), flash memory, removable media, or any other suitable local or remote memory component or components. In particular embodiments, memory 312 may include random access memory (RAM). This RAM may be volatile memory, where appropriate. Where appropriate, this RAM may be dynamic RAM (DRAM) or static RAM (SRAM). Moreover, where appropriate, this RAM may be single-ported or multi-ported RAM, or any other suitable type of RAM or memory. Memory 312 may include one or more memories 312, where appropriate. Memory 312 may store any suitable data or information utilized by computer system 300, including software embedded in a computer readable medium, and/or encoded logic incorporated in hardware or otherwise stored (e.g., firmware). In particular embodiments, memory 312 may include main memory for storing instructions for processor 308 to execute or data for processor 308 to operate on. In particular embodiments, one or more memory management units (MMUs) may reside between processor 308 and memory 312 and facilitate accesses to memory 312 requested by processor 308.

[0050] As an example, and not by way of limitation, computer system 300 may load instructions from storage 310 or another source (such as, for example, another computer system) to memory 312. Processor 308 may then load the instructions from memory 312 to an internal register or internal cache. To execute the instructions, processor 308 may retrieve the instructions from the internal register or internal cache and decode them. During or after execution of the instructions, processor 308 may write one or more results (which may be intermediate or final results) to the internal register or internal cache. Processor 308 may then write one or more of those results to memory 312. In particular embodiments, processor 308 may execute only instructions in one or more internal registers or internal caches or in memory 312 (as opposed to storage 310 or elsewhere) and may operate only on data in one or more internal registers or internal caches or in memory 312 (as opposed to storage 310 or elsewhere).

[0051] In particular embodiments, storage 310 may include mass storage for data or instructions. As an example, and not by way of limitation, storage 310 may include a hard disk drive (HDD), a floppy disk drive, flash memory, an optical disc, a magneto-optical disc, magnetic tape, or a Universal Serial Bus (USB) drive or a combination of two or more of these. Storage 310 may include removable or non-removable (or fixed) media, where appropriate. Storage 310 may be internal or external to computer system 300, where appropriate. In particular embodiments, storage 310 may be non-volatile, solid-state memory. In particular embodiments, storage 310 may include read-only memory (ROM). Where appropriate, this ROM may be mask-programmed ROM, programmable ROM (PROM), erasable PROM (EPROM), electrically erasable PROM (EEPROM), electrically alterable ROM (EAROM), or flash memory or a combination of two or more of these. Storage 310 may take any suitable physical form and may comprise any suitable number or type of storage. Storage 310 may include one or more storage control units facilitating communication between processor 308 and storage 310, where appropriate.

[0052] In particular embodiments, interface 306 may include hardware, encoded software, or both providing one or more interfaces for communication (such as, for example, packet-based communication) among any networks, any network devices, and/or any other computer systems. As an example, and not by way of limitation, communication interface 306 may include a network interface controller (NIC) or network adapter for communicating with an Ethernet or other wire-based network and/or a wireless NIC (WNIC) or wireless adapter for communicating with a wireless network.

[0053] Depending on the embodiment, interface 306 may be any type of interface suitable for any type of network for which computer system 300 is used. As an example, and not by way of limitation, computer system 300 can include (or communicate with) an ad-hoc network, a personal area network (PAN), a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), or one or more portions of the Internet or a combination of two or more of these. One or more portions of one or more of these networks may be wired or wireless. As an example, computer system 300 can include (or communicate with) a wireless PAN (WPAN) (such as, for example, a BLUETOOTH WPAN), a WI-FI network, a WI-MAX network, an LTE network, an LTE-A network, a cellular telephone network (such as, for example, a Global System for Mobile Communications (GSM) network), or any other suitable

wireless network or a combination of two or more of these. computer system 300 may include any suitable interface 306 for any one or more of these networks, where appropriate.

[0054] In some embodiments, interface 306 may include one or more interfaces for one or more I/O devices. One or more of these I/O devices may enable communication between a person and computer system 300. As an example, and not by way of limitation, an I/O device may include a keyboard, keypad, microphone, monitor, mouse, printer, scanner, speaker, still camera, stylus, tablet, touchscreen, trackball, video camera, another suitable I/O device or a combination of two or more of these. An I/O device may include one or more sensors. Particular embodiments may include any suitable type and/or number of I/O devices and any suitable type and/or number of interfaces 306 for them. Where appropriate, interface 306 may include one or more drivers enabling processor 308 to drive one or more of these I/O devices. Interface 306 may include one or more interfaces 306, where appropriate.

[0055] Bus 304 may include any combination of hardware, software embedded in a computer readable medium, and/or encoded logic incorporated in hardware or otherwise stored (e.g., firmware) to couple components of computer system 300 to each other. As an example and not by way of limitation, bus 304 may include an Accelerated Graphics Port (AGP) or other graphics bus, an Enhanced Industry Standard Architecture (EISA) bus, a front-side bus (FSB), a HYPERTRANSPORT (HT) interconnect, an Industry Standard Architecture (ISA) bus, an INFINIBAND interconnect, a low-pin-count (LPC) bus, a memory bus, a Micro Channel Architecture (MCA) bus, a Peripheral Component Interconnect (PCI) bus, a PCI-Express (PCI-X) bus, a serial advanced technology attachment (SATA) bus, a Video Electronics Standards Association local (VLB) bus, or any other suitable bus or a combination of two or more of these. Bus 304 may include any number, type, and/or configuration of buses 304, where appropriate. In particular embodiments, one or more buses 304 (which may each include an address bus and a data bus) may couple processor 308 to memory 312. Bus 304 may include one or more memory buses.

[0056] Herein, reference to a computer-readable storage medium encompasses one or more tangible computer-readable storage media possessing structures. As an example and not by way of limitation, a computer-readable storage medium may include a semiconductor-based or other integrated circuit (IC) (such, as for example, a field-programmable gate array (FPGA) or

an application-specific IC (ASIC)), a hard disk, an HDD, a hybrid hard drive (HHD), an optical disc, an optical disc drive (ODD), a magneto-optical disc, a magneto-optical drive, a floppy disk, a floppy disk drive (FDD), magnetic tape, a holographic storage medium, a solid-state drive (SSD), a RAM-drive, a SECURE DIGITAL card, a SECURE DIGITAL drive, a flash memory card, a flash memory drive, or any other suitable tangible computer-readable storage medium or a combination of two or more of these, where appropriate.

[0057] Particular embodiments may include one or more computer-readable storage media implementing any suitable storage. In particular embodiments, a computer-readable storage medium implements one or more portions of processor 308 (such as, for example, one or more internal registers or caches), one or more portions of memory 312, one or more portions of storage 310, or a combination of these, where appropriate. In particular embodiments, a computer-readable storage medium implements RAM or ROM. In particular embodiments, a computer-readable storage medium implements volatile or persistent memory. In particular embodiments, one or more computer-readable storage media embody encoded software.

[0058] Herein, reference to encoded software may encompass one or more applications, bytecode, one or more computer programs, one or more executables, one or more instructions, logic, machine code, one or more scripts, or source code, and vice versa, where appropriate, that have been stored or encoded in a computer-readable storage medium. In particular embodiments, encoded software includes one or more application programming interfaces (APIs) stored or encoded in a computer-readable storage medium. Particular embodiments may use any suitable encoded software written or otherwise expressed in any suitable programming language or combination of programming languages stored or encoded in any suitable type or number of computer-readable storage media. In particular embodiments, encoded software may be expressed as source code or object code. In particular embodiments, encoded software is expressed in a higher-level programming language, such as, for example, C, Perl, or a suitable extension thereof. In particular embodiments, encoded software is expressed in a lower-level programming language, such as assembly language (or machine code). In particular embodiments, encoded software is expressed in JAVA. In particular embodiments, encoded software is expressed in Hyper Text Markup Language (HTML), Extensible Markup Language (XML), or other suitable markup language.

[0059] Additional examples of the system and method of use thereof can be found in Appendix A, attached herewith.

[0060] Although various embodiments of the present disclosure have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the present disclosure is not limited to the embodiments disclosed herein, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the disclosure as set forth herein.

[0061] The term "substantially" is defined as largely but not necessarily wholly what is specified, as understood by a person of ordinary skill in the art. In any disclosed embodiment, the terms "substantially", "approximately", "generally", and "about" may be substituted with "within [a percentage] of" what is specified, where the percentage includes 0.1, 1, 5, and 10 percent.

[0062] The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the disclosure. Those skilled in the art should appreciate that they may readily use the disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the disclosure. The scope of the invention should be determined only by the language of the claims that follow. The term "comprising" within the claims is intended to mean "including at least" such that the recited listing of elements in a claim are an open group. The terms "a", "an", and other singular terms are intended to include the plural forms thereof unless specifically excluded.

[0063] Depending on the embodiment, certain acts, events, or functions of any of the algorithms described herein can be performed in a different sequence, can be added, merged, or left out altogether (e.g., not all described acts or events are necessary for the practice of the algorithms). Moreover, in certain embodiments, acts or events can be performed concurrently, e.g., through multi-threaded processing, interrupt processing, or multiple processors or processor cores or on other parallel architectures, rather than sequentially. Although certain

computer-implemented tasks are described as being performed by a particular entity, other embodiments are possible in which these tasks are performed by a different entity.

[0064] Conditional language used herein, such as, among others, "can", "might", "may", "e.g.", and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

[0065] While the above detailed description has shown, described, and pointed out novel features as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the devices or algorithms illustrated can be made without departing from the spirit of the disclosure. As will be recognized, the processes described herein can be embodied within a form that does not provide all of the features and benefits set forth herein, as some features can be used or practiced separately from others. The scope of protection is defined by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

[0066] Although various embodiments of the method and apparatus of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the invention as set forth herein.

CLAIMS

What is claimed is:

1. A sorting machine comprising:

a first hopper comprising an inlet and an outlet;

a tray arranged at a declined angle and configured to receive items from the outlet of the first hopper; and

an analysis system comprising:

an optical sensor positioned proximal to the tray and configured to optically scan a plurality of items as they travel through the tray; and

a rejector valve positioned proximal to an outlet of the tray and configured to direct a jet of air toward an item of the plurality of items to direct the item of the plurality of items into a second hopper positioned beneath the tray.

2. The sorting machine of claim 1, further comprising a touch screen interface configured to allow a user to control operation of the sorter.

3. The sorting machine of claim 1, further comprising an air system coupled to the rejector valve and configured to supply the rejector valve with compressed air.

4. The sorting machine of claim 1, wherein the tray comprises a transparent window arranged to allow the optical sensor to see the plurality of items as they travel through the tray.

5. The sorting machine of claim 1, further comprising a light source positioned proximal to the tray and configured to illuminate the items as they travel through the tray.

6. The sorting machine of claim 1, further comprising a third hopper positioned beneath the tray and configured to receive items that have not been redirected by a jet of air from a rejector valve of the plurality of rejector valves.

7. The sorting machine of claim 1, further comprising a vibrator tray positioned between the first hopper and the tray, the vibrator tray configured to impart vibratory energy into the items to facilitate movement of the items from the first hopper to the tray.

8. The sorting machine of claim 1, wherein the analysis system is configured to determine a color of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the color of each item with a threshold value for color.

9. The sorting machine of claim 1, wherein the analysis system is configured to determine a size of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the size of each item with a threshold value for size.

10. The sorting machine of claim 1, further comprising an air jet cleaning system comprising a plurality of air jets configured to remove debris.

11. The sorting machine of claim 1, further comprising a water jet cleaning system comprising a plurality of water jets configured to remove debris.

12. A method of sorting items using a sorting machine, the method comprising:

adding a plurality of items for sorting to a first hopper of the sorting machine;

inspecting, by an analysis system of the sorting machine, the plurality of items with a camera of the machine;

classifying, by the analysis system of the sorting machine, an attribute of each item of the plurality of items into one of a first category and a second category; and

directing each item of the first category to a second hopper and each item of the second category to a third hopper, wherein the directing each item of the first category comprises not blowing each item of the first category with a jet of air and the directing each item of the second category comprising blowing each item of the second category with a jet of air.

13. The method of claim 12, further comprising supplying vibrational energy to the plurality of items to facilitate movement of the plurality of items from the first hopper to a sorting tray for the inspecting.

14. The method of claim 12, further comprising illuminating the plurality of items with a light source as the plurality of items move through a sorting tray.

15. The method of claim 12, wherein the attribute is a color of the item.

16. The method of claim 15, wherein the analysis system is configured to determine a color of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the color of each item with a threshold value for color.

16. The method of claim 15, wherein the color is converted into a hex code.

17. The method of claim 15, wherein the color is converted into an RGB value.

18. The method of claim 12, wherein the attribute is a size of the item.

19. The method of claim 12, wherein the analysis system is configured to determine a size of each item of the plurality of items as they pass through the tray and to characterize each item as accepted or rejected relative to a comparison of the size of each item with a threshold value for size.

20. The method of claim 12, wherein the analysis system comprises:

an optical sensor positioned proximal to the tray and configured to optically scan the plurality of items as they travel through the tray; and

a rejector valve configured to direct a jet of air toward an item of the plurality of items to direct the item of the plurality of items into the second hopper.

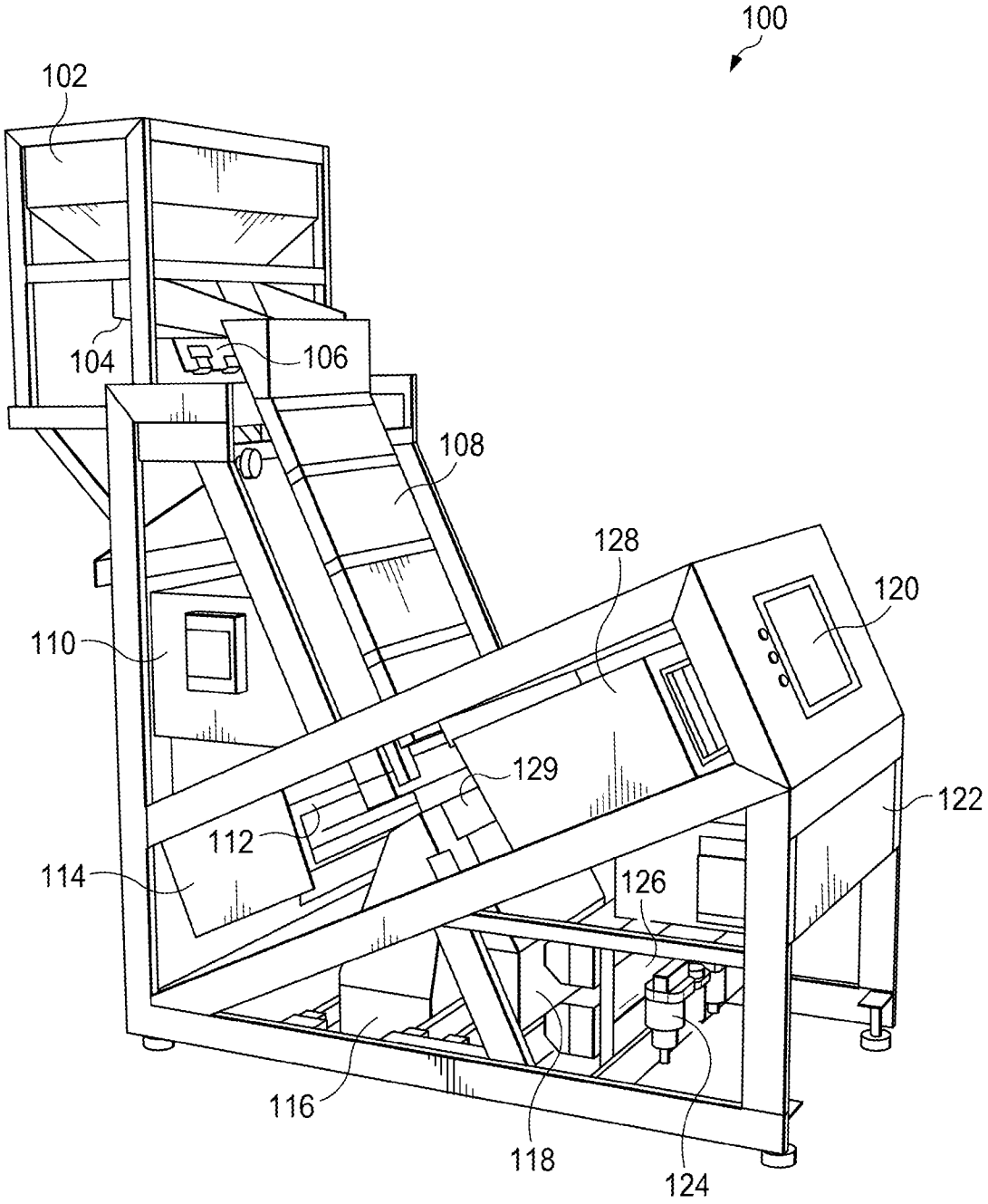

FIG. 1A

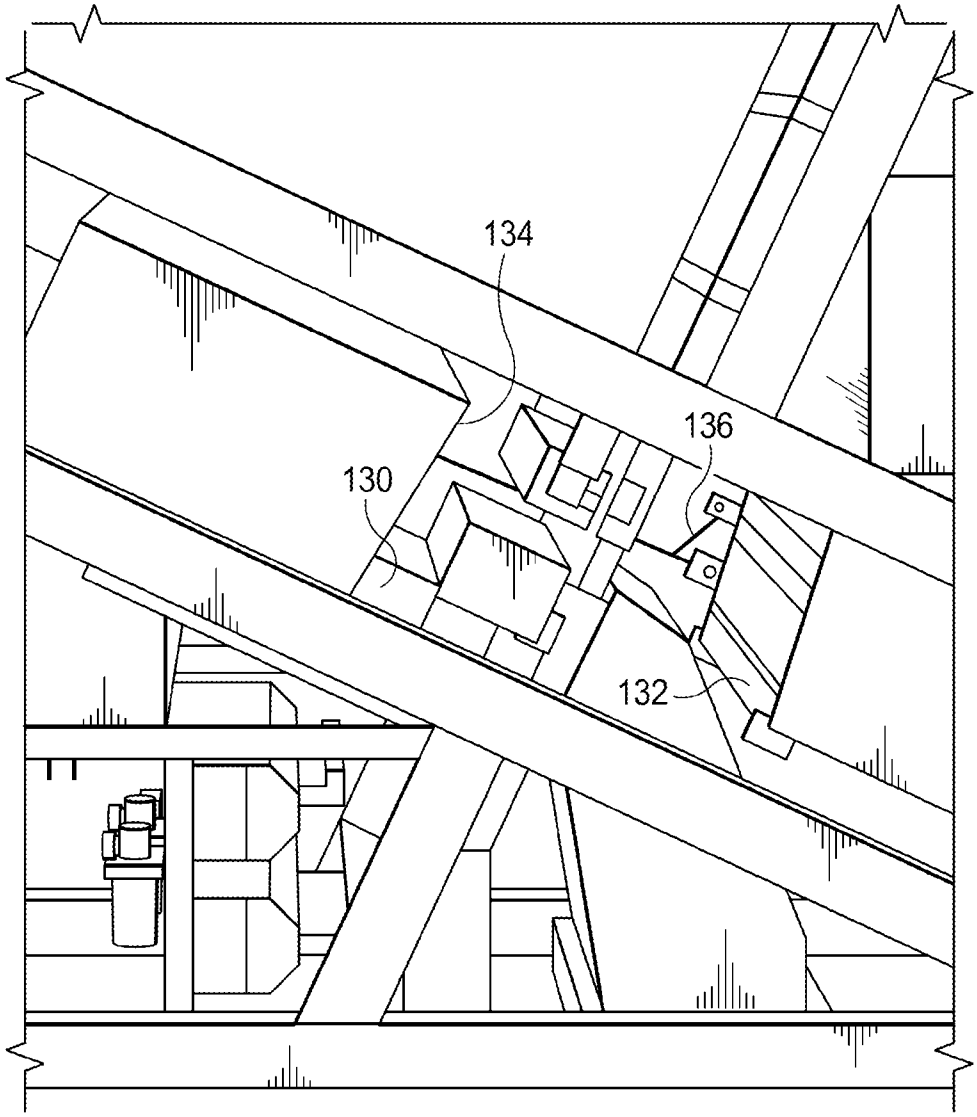

FIG. 1B

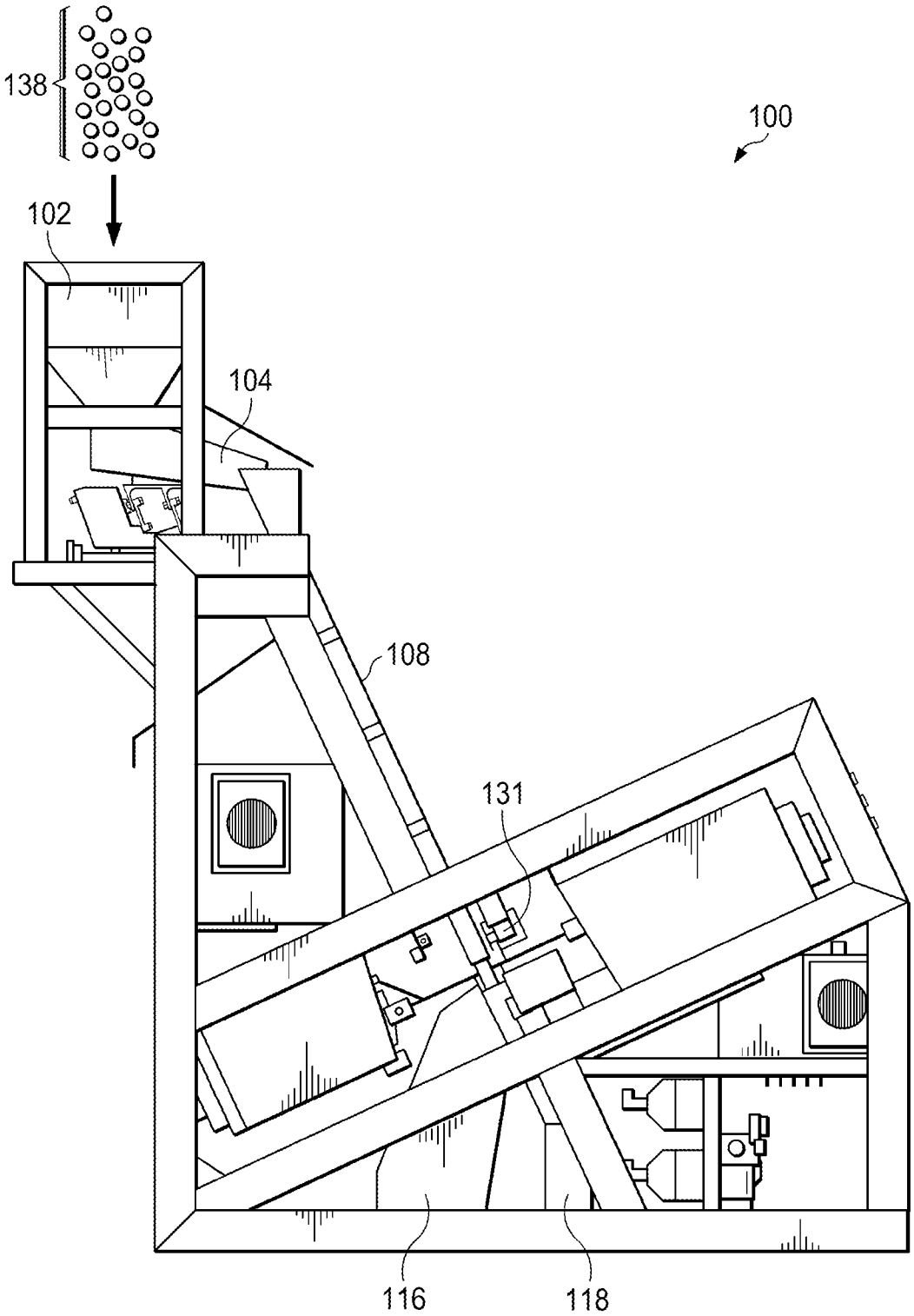

FIG. 2

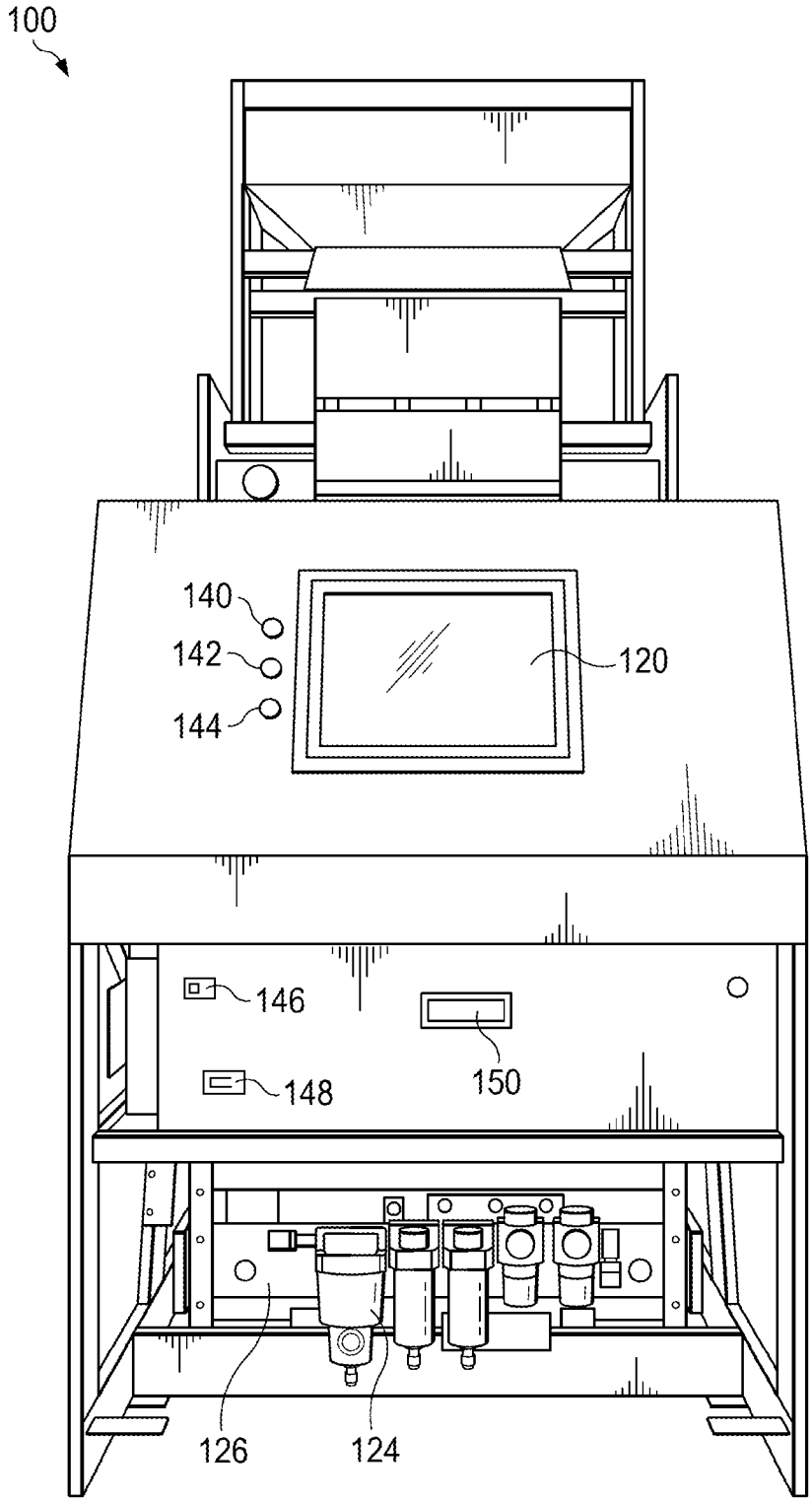

FIG. 3

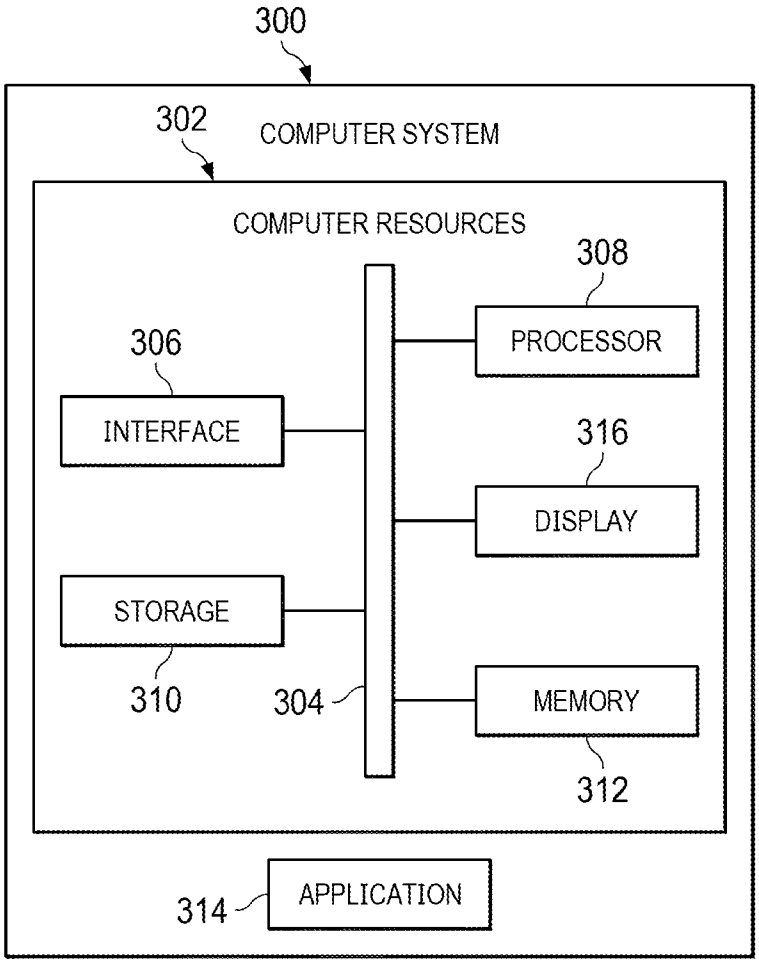
300
302
COMPUTER SYSTEM
COMPUTER RESOURCES
308
PROCESSOR
306
INTERFACE
316
DISPLAY
STORAGE
310
304
MEMORY
312
314
APPLICATION

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 24/25300

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B07C 5/342, B07C 5/36 (2024.01)
ADD. B07C 5/00, B07C 5/04, B07C 5/08, B07C 5/10, B07C 5/34, B07C 5/38 (2024.01)

CPC - INV. B07C 5/342, B07C 5/366
ADD. B07C 5/34, B07C 5/3422, B07C 5/3425, B07C 5/36, B07C 5/363, B07C 5/365, B07C 5/367

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)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

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

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 4,271,966 A (CROWLEY) 09 June 1981 (09.06.1981) entire document, especially Fig. 1, 3; col. 2, ll. 45-55, 67-68; col. 3, ll. 1-30	1, 6, 7 --- 2, 10-13, 20
X --- Y	US 2023/0031481 A1 (KAWAMURA) 02 February 2023 (02.02.2023) entire document, especially Fig. 1, 2; para [0001], [0065]-[0066], [0070], [0073], [0074], [0078], [0085], [0106], [0108]-[0109]	1, 3, 5, 8, 12, 14-15, 16A --- 4, 9, 12, 13, 16B, 17-20
Y	US 2002/0144458 A1 (HUNTER et al.) 10 October 2002 (10.10.2002) entire document, especially para [0110], [0170], [0199], [0203]	2, 10
Y	US 4,426,005 A (SATAKE) 17 January 1984 (17.01.1984) entire document, especially Fig. 5; col. 5, ll. 5-60	4
Y	US 2012/0165973 A1 (EARLAM) 28 June 2012 (28.06.2012) entire document, especially para [0030]-[0031]	9, 16B, 17-19
Y	US 2021/0061588 A1 (LUKKA et al.) 04 March 2021 (04.03.2021) entire document, especially para [0144]	11
A	US 4,697,709 A (CODDING) 06 October 1987 (06.10.1987) entire document	1-15, 16A, 16B, 17-20
A	US 5,271,505 A (LOW) 21 December 1993 (21.12.1993) entire document	1-15, 16A, 16B, 17-20
A	US 2007/0256959 A1 (DEEHOLTS) 08 November 2007 (08.11.2007) entire document	1-15, 16A, 16B, 17-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"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
26 June 2024	AUG 0 8 2024
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300