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Batch Production Tracking System and Methods

Abstract

A batch production tracking system. The batch production tracking system may include one or more transmitters, wherein each one of the one or more transmitters may be associated with a carrier; and an arrangement of one or more sensors, wherein the arrangement of one or more sensors may be provided in relation to an arrangement of one or more workstations of a batch production workflow, and wherein the one or more sensors may be configured to sense a signal from the one or more transmitters and to determine a location of the associated carrier in the batch production workflow.

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Background/Summary

RELATED APPLICATIONS [0001] This application is related and claims priority to U.S. Provisional Patent Application Nos. 63/554,365, filed on Feb. 16, 2024; and 63/696,594, filed on Sep. 20, 2024, the applications of which are incorporate herein by reference in their entireties.

TECHNICAL FIELD

[0002] The subject matter of the invention relates generally to workflow tracking systems and more particularly to a small batch production tracking system and methods including reliable case tracking.

BACKGROUND

[0003] Batch production is a method of manufacturing in which the products are made as specified groups or amounts and within a certain time frame. A batch can go through a series of steps in a large manufacturing process to make the final desired product. Batch production is used for many types of manufacturing that may need smaller amounts of production at a time to ensure specific quality standards or changes in the process. This is opposed to large mass production or continuous production methods in which the product or process does not need to be checked or changed as frequently or periodically.

[0004] In the manufacturing batch production process, the machines are in chronological order directly related to the manufacturing process. In certain cases, batch production may require less expensive equipment, thus reducing the capital cost required to set up this type of system. One drawback of batch production is that smaller batches need a great deal of planning, scheduling, process control, and data collection. Further, it is not unusual for products to be lost during the batch production process due to poor methods of tracking. Therefore, new approaches are needed with respect to improving efficiency in small batch production processes.

SUMMARY

[0005] In one embodiment, a batch production tracking system is provided. The batch production tracking system may include one or more transmitters, wherein each one of the one or more transmitters may be associated with a carrier; and an arrangement of one or more sensors, wherein the arrangement of one or more sensors may be provided in relation to an arrangement of one or more workstations of a batch production workflow, and wherein the one or more sensors may be configured to sense a signal from the one or more transmitters and to determine a location of the associated carrier in the batch production workflow. The one or more workstations each may include an interactive interface, wherein the interactive interface may be configured to allow a user to interact with and/or view an operation and/or status of one or more workstations and/or carriers. The interactive interface may include an interactive display device. The interactive display device may be configured to visually indicate a status of one or more of the carriers and/or the batch production workflow. The one or more workstations may be arranged in chronological order of steps of the batch production workflow of a product being processed. The one or more sensors may be configured to measure any one or more of acceleration, location, motion, proximity, light, orientation, force, angular velocity, magnetic field, pressure, altitude, humidity, and/or temperature. The one or more sensors may include short-range wireless low energy sensors. The arrangement of the one or more sensors may be configured such that sensing ranges of one or more of the one or more sensors overlap. Each one of the one or more transmitters may be physically coupled to a carrier. The system of claim **1**, wherein each of the one or more transmitters may include a display. Each carrier used in a particular batch production workflow may be linked in the batch production tracking system via its associated transmitter with that specific batch production workflow. The status and/or case information related to the carrier in the batch production workflow may be automatically displayed on the interactive display device of its associated workstation upon the carrier with associated transmitter entering a sensor field of a sensor of the one or more sensors associated with that workstation. The one or more transmitters may include a smart tag. The smart tag may be configured to attach to the carrier. The smart tag may include a display.

[0006] In another embodiment, a carrier for use in a batch production tracking system is provided. The carrier may include a main body portion, including a front panel, a back panel, two side panels, and a floor panel; a top lip portion, wherein the top lip portion extends upward from a top edge of the two side panels and the back panel, and wherein the top lip portion forms a wall extending from a point on one of the two side panels to a point on the other of the two side panels, the wall not extending the full length of either of the two side panels; one or more stop features formed on an outer surface of the main body portion and/or the top lip portion; and a transmitter attachment point formed on the main body portion. The one or more stop features may include one or more upper stop features and one or more lower stop features formed on each of the two side panels. The upper stop features and the lower stop features may be configured such that when the product carrier is nested within another product carrier a bottom edge of the upper stop features rest atop an upper edge of the top lip portion of the other product carrier and a bottom edge of the lower stop features rest atop an upper edge of the side panels of the other product carrier. The transmitter attachment point may include a receiving mechanism configured to receive a transmitter and secure it thereto. The transmitter may be a smart tag. The transmitter attachment point may include track rails and a locking mechanism, wherein the track rails may be configured to receive an upper portion and a lower portion of the smart tag, and the locking mechanism may be configure to secure the smart tag in place once installed in the track rails.

[0007] In another embodiment, a method of using a batch production tracking system is provided. The method may include setting up a batch production workflow in a batch production tracking system for a product to be produced; assigning one or more transmitters to the batch production workflow for the product to be processed, and associating each of the one or more transmitters with a carrier; loading the carrier with items related to producing the product; initiating the batch production workflow; moving the carrier through a series of workstations of the batch production tracking system, wherein the batch production tracking system further comprises an arrangement of sensors associated with one or more of the workstations; and tracking the carrier through the batch production workflow, wherein when the carrier is in a sensing field of one or more of the sensors data from the transmitter associated with that carrier is sensed by the one or more sensors and communicated to an associated one or more workstations. Setting up a batch production workflow for a product to be produced may include inputting details of the batch production workflow into a workflow application of the batch production tracking system. The data from the transmitter may include information related to the status and/or location of the product carrier in the batch production workflow and/or status and/or operational data of the product being produced. The workstations may include an interactive display and some or all of the sensed data may be displayed thereon. Data sensed at one workstation may be communicated to one or more other workstations.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Having thus described the subject matter of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[0009] FIG. **1** and FIG. **2** illustrate block diagrams of an example of a batch production tracking system including reliable case tracking, in accordance with an embodiment of the invention;
[0010] FIG. **3** and FIG. **4** illustrate block diagrams of other examples of workstation configurations of the batch production tracking system shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention;
[0011] FIG. **5** illustrates a perspective view of an example of an interaction display device of the batch production tracking system shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention;
[0012] FIG. **6** illustrates a perspective view of an example of beacon hardware of the batch production tracking system shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention;
[0013] FIG. **7** illustrates a block diagram of a batch production tracking system for tracking dental lab pans in a dental laboratory environment, which is an example of the batch production tracking system shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention;
[0014] FIG. **8** illustrates a perspective view of an example of a dental lab pan of the batch production tracking system shown in FIG. **7**, in accordance with an embodiment of the invention;
[0015] FIG. **9**A through FIG. **11** illustrate screenshots of examples of various display views for operating the batch production tracking system shown in FIG. **7**, in accordance with an embodiment of the invention;
[0016] FIG. **12** illustrates an example of a pan status display showing a sample snapshot from an example active batch production tracking system;
[0017] FIG. **13** illustrates an example pan status map on which the location of an example dental lab pan can be plotted.
[0018] FIG. **14** through FIG. **27** illustrate various views of another example of a dental lab pan of the batch production tracking system shown in FIG. **7**, in accordance with an embodiment of the invention;
[0019] FIG. **28** through FIG. **29**B illustrate various views of an example of a tag track of the dental lab pan shown in FIG. **14** through FIG. **27**, in accordance with an embodiment of the invention;
[0020] FIG. **30**A through FIG. **32**B illustrate various views of an example of a smart tag of the dental lab pan shown in FIG. **14** through FIG. **27**, in accordance with an embodiment of the invention; and
[0021] FIG. **33** through FIG. **46** illustrate various views of yet another example of a dental lab pan of the batch production tracking system shown in FIG. **7**, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0022] The subject matter of the invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the subject matter of the invention are shown. Like numbers refer to like elements throughout. The subject matter of the invention may 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 satisfy applicable legal requirements. Indeed, many modifications and other embodiments of the subject matter of the invention set forth herein will come to mind to one skilled in the art to which the subject matter of the invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the subject matter of the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims.
[0023] In some embodiments, the subject matter of the invention provides a small batch production tracking system and methods including reliable case tracking.
[0024] In some embodiments, the small batch production tracking system and methods may

provide mechanisms for tracking the precise geographic location of a product moving through the system.

[0025] In some embodiments, the small batch production tracking system and methods may provide mechanisms that allow a user to determine the precise geographic location of a product moving through the system as well as workflow status and/or disposition.

[0026] In some embodiments, the small batch production tracking system and methods may provide any number and/or configurations of workstations and wherein the workstations may be arranged in chronological order directly related to the manufacturing process.

[0027] In some embodiments, the small batch production tracking system and methods may provide any number and/or configurations of workstations and wherein each of the workstations may include one or more interactive display devices.

[0028] In some embodiments, the small batch production tracking system and methods may provide any number and/or configurations of workstations and as well as any number and/or arrangements of sensing devices (e.g., Bluetooth low energy (BLE) beacon sensors) in close proximity to the workstations.

[0029] In some embodiments, the small batch production tracking system and methods may provide any number and/or configurations of workstations and as well as any number and/or arrangements of sensing devices (“receivers”) as well as product carriers equipped with certain hardware, e.g., beacon hardware, (“tags” or “transmitters”) and wherein bi-directional communication may exist between the sensing devices (“receivers”) and the beacon hardware (“tags” or “transmitters”) on the product carriers.

[0030] In some embodiments, the small batch production tracking system and methods may provide a workflow for administration users, another workflow for technician users, yet another workflow for shipping users, and still another workflow for manager users.

[0031] Referring now to FIG. **1** and FIG. **2** is block diagrams of one example of a batch production tracking system **100** including reliable case tracking, in accordance with an embodiment of the invention. Batch production tracking system **100** may provide mechanisms for tracking the precise geographic location of a product moving through a batch production system. Accordingly, batch production tracking system **100** allows a user to determine the precise geographic location of a product moving through the system as well as workflow status and/or disposition.

[0032] In this example, batch production tracking system **100** may include any number and/or configurations of workstations **110**. Accordingly, batch production tracking system **100** may include workstations **110-1** through **110-*n*** arranged in any configurations (e.g., see FIG. **3** and FIG. **4**). Workstations **110-1** through **110-*n*** may be any types of workstations for manufacturing any types of products in, for example, a small batch production process or environment. Further, workstations **110-1** through **110-*n*** may be arranged in chronological order directly related to the manufacturing process. That is, the types of tasks performed at each of the workstations **110-1** through **110-*n*** may be tailored to the specific product being manufactured and the specific chronological steps of manufacture.

[0033] Each of the workstations **110** may include one or more interactive display devices **112**. Interactive display devices **112** provide a means for users of batch production tracking system **100** to interact with the operation and/or status of its respective workstation **110**. For example, workstation **110-1** may include one or more interactive display devices **112-1**, workstation **110-2** may include one or more interactive display devices **112-2**, and so on. In one example, each of the interactive display devices **112** may be a tablet device, such as, but not limited to, an Apple iPad or an Android-based tablet. An example of an interactive display device **112** is shown in FIG. **5**.

[0034] Further, an arrangement of multiple sensing devices **120** may be provided in relation to the arrangement of workstations **110-1** through **110-*n***. Each of the sensing devices **120** may be, for example, a short-range wireless low energy sensor, such as a Bluetooth low energy (BLE) sensor (e.g., BLE beacon sensor). Generally, BLE beacon sensors are low-power devices for wireless detection and transmission, set up wirelessly and powered by internal batteries. BLE beacon sensors may be used to transmit sensor-related information to any other computing device. BLE beacon sensors may be capable of measuring various characteristics, such as, but not limited to, acceleration, motion, proximity, light, orientation, force, angular velocity, magnetic field, pressure, altitude, humidity, and/or temperature. Sensing devices **120** (e.g., BLE beacon sensors) are well-suited for efficiently tracking assets and collecting information within batch production tracking system **100**.

[0035] In batch production tracking system **100**, sensing devices **120** may be used to track, for example, a product carrier **130** that may be equipped with certain beacon hardware **132**. In this example, beacon hardware **132** may be the transmitter and the sensing devices **120** may be the receivers. That is, sensing devices **120** may be used to detect a signal from beacon hardware **132** of product carrier **130**.

[0036] Product carrier **130** may be loaded with product materials **136** for manufacturing and/or assembling a certain end product (not shown). Accordingly, product carrier **130** may be any device suitable for holding product materials **136**. Product carrier **130** may be moved by any means from one workstation **110** to the next and wherein a certain unique process step is performed at each respective workstation **110**. Accordingly, sensing devices **120** may be used as proximity sensors with respect to tracking the movement of product carrier **130** (via, for example, beacon hardware **132**) from one workstation **110** to the next.

[0037] Further, bidirectional communication may exist between beacon hardware **132** and sensing devices **120**. Additionally, beacon hardware **132** may emit a signal to be detected using sensing devices **120**, and may also include an integrated accelerometer. Accordingly, sensing devices **120** may be used to collect both location data and motion data from beacon hardware **132** of product carrier **130**.

[0038] Further, sensing devices **120** (i.e., the receivers) may be placed throughout the environment of workstations **110**. Therefore, the more precise location identification is required, the more sensing devices **120** are required. This also depends on the ranges of sensing devices **120** and beacon hardware **132**. In one example, FIG. **1** shows the placement of one sensing device **120** per workstation **110**. In this example, there may be a gap between any two adjacent sensing devices **120**. In another example, FIG. **2** shows the placement of multiple sensing devices **120** the arrangement of workstations **110** and providing overlapping sensing between any two adjacent sensing devices **120**. In these examples, the arrangement of sensing devices **120** shown in FIG. **2** may provide more precise location identification than that shown in FIG. **1**. Additionally, more details of other example configurations of workstations **110** and sensing devices **120** are shown below in FIG. **3** and FIG. **4**.

[0039] Referring still to FIG. **1** and FIG. **2**, batch production tracking system **100** may further include a controller **140** and a data store **150**. In one example, controller **140** and data store **150** may be running on an application server (not shown). In another example, batch production tracking system **100** may support a cloud computing environment in which controller **140** and data store **150** may be running on a cloud-based server.

[0040] Controller **140** may be used for managing the overall operations of batch production tracking system **100**. In one example, controller **140** may be a software application. In another example, controller **140** may be any controller, microcontroller, and/or microprocessor device that may provide processing capabilities, such as storing, interpreting, and/or executing software instructions. The software instructions may comprise machine readable code stored in non-transitory memory that is accessible by controller **140** for the execution of the instructions. Further, other data storage (not shown) may be built into controller **140**.

[0041] Further, with respect to managing the operations of workstations **110-1** through **110-*n***, controller **140** may include a workflow application **142** that may further include a production algorithm **144**. Workflow application **142** may be, for example, a manufacturing information system (MIS), manufacturing execution system (MES), or the like that has knowledge of the steps and locations for an item's production process.

[0042] Data store **150** may be, for example, data repositories (like databases) and/or flat files that can store data. Data store **150** may be volatile (such as random-access memory (RAM)), non-volatile (such as read-only memory (ROM), flash memory, etc.), or some combination of the two. Sensor data **152** may be stored in data store **150**. Sensor data **152** may include, for example, any information provided by sensing devices **120** and/or beacon hardware **132**. Sensing devices **120** and/or beacon hardware **132** may provide, for example, but not limited to, location data, acceleration data, motion data, proximity data, light data, orientation data, force data, angular velocity data, magnetic field data, pressure data, altitude data, humidity data, temperature data, and/or the like.

[0043] Various types of users may be associated with batch production tracking system **100**. For example, administrative (admin) users **102**, technician users **103**, shipping users **104**, and/or manager users **105** may be associated with batch production tracking system **100**. Accordingly, user data **154** may be stored in data store **150**. User data **154** may include, for example, any user account and/or user profile information associated with admin users **102**, technician users **103**, shipping users **104**, and/or manager users **105**.

[0044] In one example, admin users **102**, technician users **103**, shipping users **104**, and/or manager users **105** may interact with batch production tracking system **100** via interactive display devices **112** at workstations **110**. In another example, admin users **102**, technician users **103**, shipping users **104**, and/or manager users **105** may interact with batch production tracking system **100** via any computing device, such as but not limited to, a mobile device **160** (e.g., a mobile phone (or smart phone), a tablet device, a smartwatch).

[0045] In one example, a workflow mobile app **162** may be installed and running on each of the mobile devices **160**. Workflow mobile app **162** may be designed to operate on any device platform, including for example, Windows, Android, Apple, and/or the like known now or in the future. Accordingly, admin users **102**, technician users **103**, shipping users **104**, and/or manager users **105** may interact with batch production tracking system **100**, and in particular with workstations **110**, using workflow mobile app **162**. Interactive display devices **112** and/or workflow mobile app **162** may provide the user interface of batch production tracking system **100**.

[0046] To support the use of mobile devices **160**, batch production tracking system **100** may be provided in a networked computing configuration. For example, batch production tracking system **100** may be accessible via a network **170**. Network **170** may be, for example, a local area network (LAN), a wide area network (WAN), and/or a cellular network for connecting to the Internet or to an Intranet. Further, in one example, controller **140** may be in communication with workstations **110** via a wired connection. In another example, controller **140** may be in communication with workstations **110** via network **170**. Additionally, more details of a specific example of batch production tracking system **100** are shown and described below in FIG. **6** through **10**.

[0047] Referring now to FIG. **3** and FIG. **4** is block diagrams of other examples of workstation configurations of batch production tracking system **100** shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention. For example, FIG. **3** shows a 2×2 arrangement of four workstations **110** of batch production tracking system **100**. That is, a 2×2 arrangement of workstation **110-1**, workstation **110-2**, workstation **110-3**, and workstation **110-4**. In this example, a sensing device **120** may be provided at each corner (including common corners) of the four workstations **110**, for a total of nine sensing devices **120**. In this example, the sensing ranges of some adjacent sensing devices **120** may overlap while the sensing ranges of other adjacent sensing devices **120** may not overlap.

[0048] FIG. **4** shows a 2×4 arrangement of eight workstations **110** of batch production tracking system **100**. That is, a 2×4 arrangement of workstation **110-1**, workstation **110-2**, workstation **110-3**, workstation **110-4**, workstation **110-5**, workstation **110-6**, workstation **110-7**, and workstation

110-8. In this example, a line of eight sensing devices **120** may be provided at about a center portion of the 2×4 arrangement of eight workstations **110**. Further, in this example, the eight sensing devices **120** may be slightly offset or staggered in alternating fashion, as shown in FIG. **4**. Further, in this example, the sensing ranges of adjacent sensing devices **120** may overlap.

[0049] Further, unique recipe data **156** may exist in data store **150** for each product moving through batch production tracking system **100** and wherein each product has a unique CaseID. For example, recipe data **156** for each product or CaseID may include the required product materials **136** to be provided within its associated product carrier **130**. Further, recipe data **156** may include the required number and/or types of workstations **110** and the unique process steps that occur at each of the workstations **110**.

[0050] Referring now to FIG. **5** is a perspective view of an example of interactive display device **112** of batch production tracking system **100** shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention. Each of the interactive display devices **112** may be, for example, a tablet device, such as, but not limited to, an Apple iPad or an Android-based tablet. Accordingly, each of the interactive display devices **112** may have a touch screen. An interactive display device **112** may be used for both information display and system interaction.

[0051] Referring now to FIG. **6** is a perspective view of an example of beacon hardware **132** of batch production tracking system **100** shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention. Again, beacon hardware **132** may be affixed to each product carrier **130**. In one example, beacon hardware **132** may be small wireless beacon devices that incessantly transmit BLE signals (i.e., beacons) to, for example, sensing devices **120**. Beacon hardware **132** may contain a radio, processor, and batteries, continuously transmitting an identifier to sensing devices **120** for accurate tracking of each of the product carriers **130** as they move from one workstation **110** to another within batch production tracking system **100**.

[0052] Further, beacon hardware **132** may include an integrated accelerometer that allows production algorithm **144** of workflow application **142** to detect and “know” when a product carrier **130** is in motion-most likely being moved from one workstation **110** to another. Benefits of beacon hardware **132** including the integrated accelerometer may include, but are not limited to, the following. [0053] 1. On occasion when the system is “uncertain” where a product carrier **130** is located (perhaps it is equidistant between two sensing devices **120**), the system can use both the “predicted” location based on recipe data **156** as well as the motion data to increase the confidence of the calculated location. That is, if the product carrier **130** is detected as having moved, but the accelerometer shows no motion, then perhaps product carrier **130** is just located on the sensory boundary between two sensing devices **120** and the system should show no change in its location.

[0054] 2. A beacon that has been “not moving” but then “moves” a short distance into close proximity to the nearest sensing devices **120** is a candidate for “check-in/check-out” processing. This may allow the system to accurately track “in progress” CaseIDs and ultimately produce accurate “actual work time” in each step of the recipe. [0055] 3. As, for example, production algorithm **144** is optimized, the frequency that beacons of beacon hardware **132** transmit may be adjusted to potentially improve battery life. For example, when the product carrier **130** is not moving, the system can detect its location every few minutes. However, upon motion detection, it can be detected multiple times per second.

[0056] Referring still to FIG. **6**, integrated into beacon hardware **132** that may be affixed to product carrier **130** may be, for example, a display **134**, such as an e-ink display (black and white or multi-color). E-ink screens, such as those on e-readers like the Amazon Kindle, require much less power than LCD or LED screens such as those on mobile phones. However, in alternative embodiments LCD, LED, and/or other suitable screens may be used. In one non-limiting example, the size of display **134** may be about 2.9 inches diagonal and may be 296×128 (37,888) pixels.

[0057] Display **134** may be used to show minimal information due to its size and space limitations. For example, display **134** may be used to show a QR or barcode linking to the CaseID, the currently assigned or detected workstation **110** or technician user **103**, current recipe step, due date, status (e.g., “Late”, “Rush”, etc.), and the like. For example, display **134** may be updated when the case is tagged as “late” to draw attention of the technician user **103** or other personnel. Display **134** may be used to provide a “smart label” for the product carrier **130**. The “smart label” may be used as a “backup” display for critical information in the event that interactive display device **112** is not available to scan the ID of the product carrier **130**.

[0058] Referring now again to FIG. **1** through FIG. **6**, features of batch production tracking system **100** may include, but are not limited to, the following. [0059] 1. Data visualizations that can be utilized by admin users **102**, technician users **103**, and/or manager users **105**. The data visualizations may be provided using interactive display devices **112** of workstations **110** (see FIG. **5**). Further, interactive display devices **112** may be used for indicating case status (e.g., on time or late). Examples of data visualizations are shown and described below in FIG. **7** through FIG. **11**.

[0060] 2. Beacon hardware **132** and sensing devices **120**, and wherein the beacon hardware **132** may include other sensors, such as an embedded accelerometer, that may be used to help distinguish between, for example, a product carrier **130** “in motion” and “sitting on shelf.” [0061] 3. The ability to track simultaneously all of the product carriers **130** moving through batch production tracking system **100** at any given time.

[0062] Additionally, batch production tracking system **100** may provide mechanisms for the initial assignment of a Case to a product carrier **130**. Further, batch production tracking system **100** may be used to facilitate “check-out” (or “clock-in”) and “check-in” (or “clock-out”) steps when a product carrier **130** is being actively worked on by a technician user **103**.

[0063] Additionally, batch production tracking system **100** may provide mechanisms for determining product carriers **130** that are “late” according to the system of record. Then, using interactive display devices **112**, may visually indicate the “late” status to both technician users **103** and manager users **105**. Then, may remove the “late” indication if the product carriers **130** is no longer flagged as such by the system of record. Additionally, batch production tracking system **100** may provide mechanisms to correctly prioritize work items for technician users **103** in an automated way, eliminating guesswork and endpoint decision making by the technician users **103**.

[0064] Further, in batch production tracking system **100**, a certain workflow may be defined for admin users **102**. Another workflow may be defined for technician users **103**. Yet another workflow may be defined for shipping users **104**. Still another workflow may be defined for manager users **105**.

[0065] Referring now to FIG. **7** is a block diagram of an example batch production tracking system **200** for tracking, for example, dental lab pans in a dental laboratory environment, which is an example of the batch production tracking system **100** shown in FIG. **1** and FIG. **2**, in accordance with an embodiment of the invention. In batch production tracking system **200**, the product being manufactured may be, in non-limiting examples, dental prosthetics, implant retained hybrid products, dental surgical products, crown and bridge products, dentures, digital nightguards, implants, and/or any other small batch production type products.

[0066] Batch production tracking system **200** may be substantially the same as batch production tracking system **100** except that workstations **110** are replaced with workstations **210**. Workstations **210** are any workstations, for example but not limited to, workstations tailored for producing dental products in a dental laboratory environment. Accordingly, in batch production tracking system **200**, lab pan **230** is an example of product carrier **130** and dental case materials **236**, e.g., dental case materials, is an example of product materials **136**.

[0067] Further, in this example, batch production tracking system **200** may include a workflow mobile app **262** running on each of the mobile devices **160**. Workflow mobile app **262** is specifically designed for tracking lab pans **230** in, for example, a dental laboratory environment.

[0068] Referring now to FIG. **8** is a perspective view of an example of lab pan **230** of batch production tracking system **200** shown in FIG. **7**, which is an example of product carrier **130**. In this example, lab pan **230** may include the beacon hardware **132** shown in FIG. **6** that may also include display **134**. Further, each lab pan **230** of batch production tracking system **200** may have a unique Pan ID. In one example, the Pan ID may be available as a label on the physical lab pan **230**.

[0069] Referring now to FIG. **9**A through FIG. **11** are screenshots of various example display views for operating the batch production tracking system **200** shown in FIG. **7**, in accordance with an embodiment of the invention. Further, the display views shown in FIG. **9**A through FIG. **11** may be displayed to the user via any one of the interactive display devices **112** and/or via workflow mobile app **262**.

[0070] FIG. **9**A, FIG. **9**B, FIG. **9**C, and FIG. **9**D are screenshots showing an example workflow associated with admin users **102**. For example, the goal for the admin user **102** is to start the tracking process of a Case (i.e., a particular patient case), as shown in display view **250** of FIG. **9**A. This may involve putting the dental case materials **236** and associated information into a selected lab pan **230** and linking the Case Number to the Pan ID. Display view **252** of FIG. **9**B shows an example of linking the Case Number to the Pan ID. Display view **254** of FIG. **9**C shows an example of scanning the Pan ID. This relationship may be used by batch production tracking system **200** to report the location of the lab pan **230** during the manufacturing process. Batch production tracking system **200** must ensure the linkage of the Case Number to the Pan ID is correct. Display view **256** of FIG. **9**D shows an example of the admin user **102** checking on the status of a certain Pan ID and Case Number.

[0071] Further to the example, a workflow associated with admin users **102** may include, but is not limited to, the following steps. The workflow may be facilitated using workflow application **142** at controller **140** and interactive display devices **112** at workstations **210**.

[0072] At one step, an admin user **102** may enter the details of the Case into workflow application **142**.

[0073] At a next step, the admin user **102** may enter the Pan ID assigned to this case (i.e., the Pan ID of the physical lab pan **230**).

[0074] At a next step, the admin user **102** may save the case in workflow application **142**, which establishes a case number (e.g., 2023-#####).

[0075] At a next step, the admin user **102** may add case details (e.g., scanned documents, such as, for example, Rx).

[0076] Using an interactive display device **112**, an admin user **102** may log in using username/password, which may also set user type and location (e.g., Admin).

[0077] Next, the interactive display device **112** may display user information (such as, for example, Name and Role) to confirm successful login, as well as an activity feed appropriate to the Role.

[0078] Next, the admin user **102** may start the tracking process by selecting “Check Pan ID” using, for example, the touch screen of the interactive display device **112**.

[0079] Next, a front camera of the interactive display device **112** may turn on and the resulting feed may be displayed on the device screen.

[0080] Next, the admin user **102** may scan the PanID (QR Code etched onto the beacon) using, for example, the camera of the interactive display device **112**.

[0081] Next, upon successful scan, the linked Case Number may be displayed and the admin user **102** may be prompted to confirm that it is the correct (linked) Case Number and Pan ID.

[0082] Next, the admin user **102** may select (e.g., press) a “confirm” button to verify the relationship.

[0083] Next, if NOT matched, the admin user **102** may be able to CHANGE the linked Case Number by keying in the correct Case Number, and then may be asked to repeat the “Check” process.

[0084] Next, if an error occurs, the admin user **102** may be informed of the type of error and the required next action (such as repeating the scan process). An example of an error scenario may be a Pan ID that was not “released” from a previous Case Number.

[0085] FIG. **10**A, FIG. **10**B, FIG. **10**C, and FIG. **10**D are screenshots showing an example workflow associated with technician users **103** and shipping users **104**. To complete the case, a series of tasks must be performed. The technician user **103** may perform these tasks. When a lab pan **230** is moved very close to a sensing device **120**, the lab pan **230** may be said to be "in-focus." Bringing a lab pan **230** in-focus may be used to change the state of the lab pan **230**. In one embodiment, a lab pan **230** may be defined to be in one of three states: [0086] 1. Pan Unassigned—A lab pan **230** is not assigned unless the lab pan **230** has been placed in-focus (in range of sensing device **120**) at a given workstation **110**. A lab pan **230** can be located at a workstation **110** but still not assigned, e.g., not in-focus. [0087] 2. Pan Assigned—A lab pan **230** may be assigned to a given workstation **110** when the lab pan **230** is brought in-focus (in range of sensing device **120**) at the workstation **110**. [0088] 3. Pan In-progress—A lab pan **230** may be said to be in-progress when a task is currently being performed on the pan's case by the technician user **103**.
[0089] Display view **258** of FIG. **10**A shows an example of the Pan IDs assigned to a certain technician user **103**. Display view **260** of FIG. **10**B shows an example of a case in progress. Display view **262** of FIG. **10**C shows an example of Case images associated with a certain patient and Pan ID. Display view **264** of FIG. **10**D shows an example of a magnified view of one specific Case image shown in display view **262** of FIG. **10**C.
[0090] Further to the example, an example workflow associated with technician users **103** may include, but is not limited to, the following steps. The workflow may be facilitated using workflow application **142** at controller **140** and interactive display devices **112** at workstations **210**. Again, the lab pan **230** may be defined to be in one of three states: Pan Unassigned, Pan Assigned, or Pan In-progress.
[0091] Using an interactive display device **112**, the technician user **103** may log in using, for example, username/password, which may also set user type and location (Technician).
[0092] Next, the default view for a technician user **103** may be displayed at interactive display device **112**. For example, the default view for a technician user **103** may include a Current Work Queue, prioritized as follows: [0093] LATE RUSH, by number of days late [0094] LATE, by number of days late [0095] RUSH by days until due date [0096] Other by days until due date
[0097] Next, by selecting a CASE (e.g., touching the "card" on the tablet screen), the technician user **103** may view case details, including Case images. Tapping a Case image may enlarge from "thumbnail" view to full-screen view or 100% of image size, depending on image resolution. "Pinch to zoom" may be enabled for image viewing.
[0098] Next, moving the physical lab pan **230** into close proximity to a sensing device **120** and holding it there for a period of time (e.g., approximately 1 second) toggles the lab pan **230** to "in-focus" state.
[0099] Next, if a lab pan **230** is Unassigned and becomes in-focus, it may be assigned to the technician user **103**.
[0100] However, if a lab pan **230** is Assigned to another technician user **103** and becomes in-focus at a new location, it may be assigned to the new technician user **103**. Further, if the lab pan **230** is also "In Progress", it may be made no longer In Progress. This may be a "check-out" action.
[0101] However, if a lab pan **230** is Assigned to the current technician user **103** and becomes in-focus, it may be made "In Progress." This may be a "check-in" action.
[0102] However, if a lab pan **230** is Assigned to the current technician user **103** and is also In Progress, it may be toggled to no longer In Progress. This may be a "check-out" action.
[0103] The shipping user **104** may provide a specialized role with the function of "releasing" the Pan ID (i.e., a given lab pan **230**) so that it is free to be linked to a new Case ID. A workflow associated with shipping users **104** may include, but is not limited to, the following steps. The workflow may be facilitated using workflow application **142** at controller **140** and interactive display devices **112** at workstations **210**.
[0104] Using an interactive display device **112**, the shipping user **104** may log in using, for

example, username/password, which may also set user type and location (Shipping).

[0105] Next, interactive display device **112** may display user information (such as Name and Role) to confirm successful login, as well as an activity feed appropriate to the Role.

[0106] Next, the shipping user **104** may start the process by, for example, tapping a “Release Pan” navigation item.

[0107] Next, the front camera of the interactive display device **112** may be activated (turned on) and the resulting feed may be displayed on the device screen.

[0108] Next, the shipping user **104** may scan the PanID (QR Code etched onto the beacon) using the camera of the interactive display device **112**.

[0109] Next, upon successful scan, the linked Case Number may be displayed and the shipping user **104** may be prompted to confirm the desire to unlink and release the Pan.

[0110] Next, the shipping user **104** may activate (press) a “confirm” button to verify the action.

[0111] FIG. **11** is a screenshot showing an example of a workflow associated with manager users **105**. Manager users **105** may have access rights and an interface similar to both admin users **102** and technician users **103**. For example, the manager user **105** may be able to Find a Case using the system (based on location detected of the Pan ID), view Case Details, and/or potentially override some system data (e.g., the assigned technician user **103**).

[0112] A workflow associated with manager users **105** may include, but is not limited to, the following steps. The workflow may be facilitated using workflow application **142** at controller **140** and interactive display devices **112** at workstations **210**.

[0113] Using an interactive display device **112**, the manager user **105** may log in using, for example, username/password, which may also set user type and location (Manager).

[0114] Next, the default view for a manager user **105** may be displayed at interactive display device **112**. For example, the default view for a manager user **105** may include a Current Work Queue for all technician users **103**, which may, for example, be prioritized as follows: [0115] LATE RUSH, by number of days late [0116] LATE, by number of days late [0117] RUSH by days until due date [0118] Other by days until due date

[0119] Additionally, the default view for the manager user **105** may include technician assignments (to assist with locating Cases), highlight Cases in the system that DO NOT match the expected location, and/or other information.

[0120] Referring now again to FIG. **7** through FIG. **11**, batch production tracking system **200** may provide certain core functions, such as, but not limited to, the following: [0121] “Switch User” function-simply logout/login; [0122] Search/locate function-Search/locate a lab pan **230**; and [0123] Reports and notifications function; [0124] “Smart Label” function; and [0125] Beacon programming function.

[0126] Further, batch production tracking system **200** may provide certain manager functions, such as, but not limited to, the following: [0127] Re-assign case/pans; [0128] Multi-technician work queue monitoring; and [0129] Multi-technician work queue monitoring.

[0130] Further, batch production tracking system **200** may provide certain technician functions, such as, but not limited to, the following: [0131] “In-focus” function that enables “in progress” status toggle; [0132] “In-focus” function for “check in/check out” status toggle; [0133] Case details view; and [0134] Work priority and logic view.

[0135] Further, batch production tracking system **200** may provide certain shipping functions, such as, but not limited to, the following:

Release Pan ID

[0136] Further, the functions described above may be generally applied to batch production tracking system **100** shown and described in FIG. **1** through FIG. **6**.

[0137] In summary and referring now to FIG. **1** through FIG. **11**, batch production tracking system **100**, **200** may receive an order from a customer for a given product. At time of order entry (input), each order may be assigned a “tag” (a transmitter, e.g., beacon hardware **132** with display **134**) which may then be physically attached to the order. This information may be automatically communicated to workflow application **142** and/or production algorithm **144** of batch production tracking system **100**, **200**. This tag remains with the order until time of shipment (e.g., when the order leaves the manufacturing facility).

[0138] Throughout the batch production facility, sensing devices **120** ("receivers") may be placed. The more precise location identification is required, the more sensing devices **120** may be required. In one example, for broad/general location, that is, location of order is in a given room or space, may require one sensing device **120** per room. In another example, for precise/exact location, that is, location of order is in a given room, on a specific side of the room, at a specific workspace/desk, etc., may require multiple sensors, potentially one or more for each workspace/desk.

[0139] Then, as the order flows/moves through batch production tracking system **100**, **200** and the manufacturing process, the beacon hardware **132** ("tags" or "transmitters") and sensing devices **120** ("receivers") continuously communicate location of each individual order/tag.

[0140] This information may then be provided/available via a location report print out and/or a visual display map indicator which consist of a visual representation of the facility layout and the location of each order as it relates to the map using, for example, interactive display devices **112** and/or workflow mobile app **162**, **262**.

[0141] Workflow application **142** and/or production algorithm **144** may use the location identification of each order paired with production scheduling software to determine whether an order is in a wrong location and/or whether an order is behind schedule/late according to the production schedule of each given order.

[0142] Further, batch production tracking system **100**, **200** may visually indicate on the printed report and/or display, amongst other things, the "location map", and as well as on the "tag" itself, that a given order is in the wrong location, or behind schedule.

[0143] Further, batch production tracking system **100**, **200** may provide the ability to use the beacon hardware **132** ("tags" or "transmitters") and sensing devices **120** ("receivers") to "log" a workspace and/or person in and/or out of a given task/step within the production scheduling software, allowing for instant date time stamp of when each scheduled task is started and/or completed and by whom. This allows for a historical track of each order.

[0144] Referring now again to FIG. **7** through FIG. **13**, batch production tracking system **200** may be used for tracking lab pans **230** in a dental laboratory environment, according to the following example. Further, this method may be generally applied to the operation of batch production tracking system **100** described in FIG. **1** through FIG. **6**.

[0145] There are two primary hardware components of batch production tracking system **200** that may be used for tracking lab pans **230**. First, is the signaling device, which is beacon hardware **132**. The second is the sensor, which is sensing device **120**. In this example, beacon hardware **132** may be attached to the lab pan **230** and transmits beacons via Bluetooth Low Energy (BLE). There may be two different types of beacons transmitted by beacon hardware **132**. For example, beacon hardware **132** may have an accelerometer that detects motion; when motion of the lab pan **230** is detected, beacon hardware **132** may transmit a specific set of beacons at about 500 millisecond intervals, or other suitable intervals. However, when it is detected that the lab pan **230** is stopped, then beacon hardware **132** may transmit a different set of beacons at about 5 second intervals, or other suitable intervals.

[0146] A sensing device **120** may be placed at each workstation **210** location to detect the presence of a lab pan **230**. Sensing devices **120** may have a protocol to synchronize the time between all of the sensing devices **120**. The beacons of each lab pan **230** may be detected by many sensing devices **120**. All the sensing devices **120** report the beacons received at a configurable rate to a centralized server (e.g., controller **140** and data store **150** at an application server) on the same interval. For example, data collected by workflow application **142** and/or production algorithm **144** of controller **140** may include the unique ID of the beacon hardware **132** and the Received Signal

Strength Indicator (RSSI). The RSSI values may typically be in a range from about −20 dBm to about −100 dBm, or other suitable range. Note: a −20 dBm may be considered a very strong signal and a −100 dBm may be considered a very weak signal. Controller **140** may take a snapshot that collects all the values reported for the beacon hardware **132** of any given lab pan **230** from all of the reporting sensing devices **120**. This may be done for each of the lab pans **230** being tracked. For example, if **100** lab pans **230** are being tracked, there will be 100 snapshots processed at controller **140**. These snapshots may currently be taken every one minute unless there is pan movement. If the lab pan **230** is in motion, a motion snapshot is taken within a second.

[0147] Once controller **140** has a given snapshot for a pan's beacons, workflow application **142** and/or production algorithm **144** may be used to analyze the data received from all sensing devices **120** and determine the location of a given lab pan **230**. For the distance calculation, the following formula is used to calculate the distance in meters:

[00001] $\text{Distance} = 10^{(\text{MeasuredPower - InstantRSSI}) / (10 \times N)}$

[0148] "Measured Power" is the measured RSSI value when the beacon is exactly a defined distance (e.g., 1 meter) from the sensor. This gives a baseline measurement.

[0149] "Instant RSSI" is the measured value reported by the sensor in a snapshot.

[0150] "Variable (N)" is called the Loss Path Gradient and ranges between a defined range (e.g., 2 and 4). In ideal conditions with no obstructions the Gradient may be low (e.g., close to 2). In an area with lots of walls, people, or other obstructions, the Gradient may be larger.

[0151] The Loss Path Gradient is calculated by using the following formula:

[00002] $N = (\text{MeasuredRSSI - InstantRSSI}) / (10. * \log(\text{InstantDistance} / \text{MeasuredDistance}))$

[0152] In our example pan tracking case, controller **140** will default to using a Gradient value of N (e.g., N=3). Lab pans **230** that are located in different rooms may be reported at a greater distance than what is actual. This may be because the walls may cause the gradient to be a higher value. For example, production algorithm **144** may be programmed to classify these sensing devices **120** as more distant and may ignore selected results when determining the location of the lab pan **230**.

[0153] When a lab pan **230** is placed very close to the sensing device **120** and the RSSI improves to a level of, for example, −35 dBm or better (less negative), the lab pan **230** may be classified as "in-focus". When a lab pan **230** is "in-focus" at a location, the controller **140** is near 100% certain of the location and special actions can be taken for this lab pan **230**. For example, it could mean this lab pan **230** is being "checked-in" to this location. Depending on the function performed at this location the "in-focus" state could trigger different actions in batch production tracking system **200**.

Example

[0154] To calculate the distance of an "in-focus" lab pan **230**:

[00003] $\text{MeasurePower} = (\text{-53})\text{dB}m, N = 3(\text{noisyenvironment}), \text{InstantRSSI} = (\text{-35})$
$\text{Distance} = 10^{(\text{-53}) - (\text{-35})) / 30} = 10^{(\text{-0.6})} \text{orDistance} = 0.25\text{meters}(.25\text{metersis}9.8\text{inches})$

[0155] In our example case, this shows the lab pan **230** as being "in focus" at about 10 inches of distance from the sensing device **120**. Because the Gradient condition may vary between sensing devices **120**, the "in-focus" level will be configurable per sensing device **120**. For example, if the sensing device **120** is mounted below a table or work surface, a lower RSSI (e.g., worse than −35 dBm) might be seen when the lab pan **230** is at, for example, 10 inches, which means the "in focus" threshold will need to be lower (for example, −40 dBm) than an unobstructed sensing device **120**.

[0156] It should be noted the RSSI signals vary for many different reasons. To help ensure accuracy within batch production tracking system **200**, a moving average is maintained by the sensing device **120** to smooth out false and high variance data from the beacon hardware **132**. Also, batch production tracking system **200** takes advantage of the integrated accelerometer to "lock" the lab pan **230** at a given location if no movement is detected.

[0157] Referring now to FIG. **12** is an example of an example pan status display **300** showing an example sample snapshot from an active batch production tracking system **200**. Pan status display **300** shows the location of one example lab pan **230** in an example batch production tracking

system **200**. This lab pan **230** is showing the nearest location of "RM 5B-Finish."
[0158] Because, for example, production algorithm **144** of controller **140** knows the latitude and longitude of the sensing device **120**, e.g., "RM 5B-Finish," the physical location of the lab pan **230** can be plotted on a map of, for example, a production facility, such as, a dental lab. For example, FIG. **13** shows an example of a pan status map **305** on which the location of the lab pan **230** can be plotted. Further, all data collected in this method of tracking lab pans **230** using batch production tracking system **200** may be stored in sensor data **152** at data store **150**.
[0159] In one example, sensing devices **120** may be positioned to be about four (4) or more feet apart to help with the proximity locating of the lab pans **230** and to avoid proximity issues in reading the beacon hardware **132** sensor.
[0160] Referring now to FIG. **14** through FIG. **27** is various views of a lab pan **400**, which is another example of the lab pan **230** of the batch production tracking system **200** shown in FIG. **7**, in accordance with an embodiment of the invention.
[0161] FIG. **14** shows a perspective view of the lab pan **400**. In this example, lab pan **400** may include a main body **410**, and may include a top lip portion **420** on the upper edge of the main body **410**. The main body **410** may include a front panel **412**, a back panel **414**, two side panels **416**, and a floor panel **418**, all arranged as shown in FIG. **14**.
[0162] The top lip portion **420** may provide additional vertical space. In one non-limiting example, top lip portion **420** may provide about an additional 32 millimeters (mm) of vertical space. Unlike most traditional lab pans, this additional vertical and horizontal enclosure further protects and prevents small or fragile items from becoming damaged or falling out of the pan as they are transported between locations.
[0163] Arranged on the outside of each side of the lab pan **400** may be upper stop features **422** and may further include one or more lower stop features **423**. In one example, there may be two upper stop features **422** and one stop feature **423** on each side. The stop features are used for facilitating stacking multiple lab pans **400**, as shown, for example, in FIG. **25**, FIG. **26**, and FIG. **27**. Additionally, a tag track **424** is provided on the outside of, for example, the front panel **412** of the lab pan **400**. The tag track **424** may be used for receiving and holding a smart tag **440**. Generally, the lab pan **400** may be formed of any rigid, lightweight, durable, and cleanable material, such as, but not limited to, molded plastic, aluminum, and/or the like.
[0164] FIG. **15**A shows an example of more details of the tag track **424**. In this example, the tag track **424** may include a pair of track rails **426**, a tag lock bar **428**, and a track label area **430**, all arranged in one example as shown. The tag track **424** is sized to substantially correspond to the size of the smart tag **440**. FIG. **15**B shows an example of more details of the smart tag **440**. In this example, the smart tag **440** may include a tag display **442**, a display frame **444**, and a tag grip portion **446** for fitting into the track rails **426** of the tag track **424**. Yet more details of the tag track **424** and the smart tag **440** are shown and described below in FIG. **28** through FIG. **32**B.
[0165] FIG. **16**, FIG. **17**, FIG. **18**, and FIG. **19** show a front view, a side view, a top view, and a bottom view, respectively, of the lab pan **400** shown in FIG. **14**.
[0166] FIG. **20**, FIG. **21**, FIG. **22**, FIG. **23**, and FIG. **24** show a front view, a side view, a cross-sectional view (taken front to back), a top view, and a bottom view, respectively, of the lab pan **400** shown in FIG. **14**. By way of example, FIG. **20**, FIG. **21**, FIG. **22**, FIG. **23**, and FIG. **24** indicate non-limiting example dimensions (in millimeters (mm)) of the lab pan **400** shown in FIG. **14**. Other dimensions of the lab pan **400** are contemplated and may be greater or less than those shown.
[0167] FIG. **16** through FIG. **24** all show the lab pan **400** with the smart tag **440** installed in the tag track **424**. In one example, the design of the tag track **424** on the front panel **412** of the main body **410** is such that with the smart tag **440** installed, the smart tag **440** may be substantially centered on the front panel **412**.
[0168] FIG. **25**, FIG. **26**, and FIG. **27** show a perspective view, a front view, and a side view, respectively, of multiple lab pans **400** stacked together. In this example, three lab pans **400** stacked

together, but any number of the lab pans **400** can be stacked. Here, the purpose of the upper stop features **422** and the lower stop features **423** is depicted. That is, when stacking one lab pan **400** atop another, the upper stop features **422** of the upper lab pan **400** come to rest atop the upper edge of the top lip portion **420** of the lower lab pan **400**. Similarly, the lower stop features **423** of the upper lab pan **400** come to rest atop the upper edge of the main body **410** of the lower lab pan **400**.

[0169] Multiple lab pans **400** may be easily stackable due to the carefully placed upper stop features **422** and lower stop features **423** on the outer walls. The upper stop features **422** and lower stop features **423** prevent stacked pans from colliding with or damaging the smart tags **440** belonging to neighboring lab pans **400**. Enabling each lab pan **400** to safely sit above each smart tag **440**, keeping them intact and maximizing readability. More specifically, the placement of the upper stop features **422** and lower stop features **423** causes each pan to stack into each other at a very specific height. In one non-limiting example, the upper stop features **422** and lower stop features **423** are positioned such that the smart tags **440** of each lab pan **400** may sit about 1.5 mm above each other.

[0170] Referring now to FIG. **28** through FIG. **29**B is various views of an example of the tag track **424** of the lab pan **400** shown in FIG. **14** through FIG. **27**, in accordance with an embodiment of the invention.

[0171] FIG. **28** shows a perspective view of the tag track **424** only of the lab pan **400**. Again, the tag track **424** may include the pair of track rails **426**, the tag lock bar **428**, and the track label area **430**, all arranged as shown. The track rails **426** and the tag lock bar **428** are provided for engaging with and holding the tag track **424**. The tag track **424** with the track rails **426** is designed to slide and lock the smart tag **440** onto the lab pan **400**.

[0172] FIG. **29**A and FIG. **29**B show front views of the tag track **424** of the lab pan **400**. FIG. **29**B indicates non-limiting example dimensions (in millimeters (mm)) of the tag track **424**.

[0173] Referring now to FIG. **30**A through FIG. **32**B is various views of an example of the tag track **424** of the lab pan **400** shown in FIG. **14** through FIG. **27**, in accordance with an embodiment of the invention.

[0174] FIG. **30**A, FIG. **30**B, and FIG. **30**C show a front view, a back view, and a side view, respectively, of an example of the smart tag **440** of the lab pan **400**. Again, the smart tag **440** may include the tag display **442**, the display frame **444**, and the tag grip portion **446** for fitting into the track rails **426** of the tag track **424**. FIG. **30**A, FIG. **30**B, and FIG. **30**C indicate non-limiting example dimensions (in millimeters (mm)) of the smart tag **440**.

[0175] In one example, the smart tag **440** may be a multifunctional small E-ink low power display device. The tag display **442** of the smart tag **440** may be a customizable display screen that can be programmed and updated freely to display any types of information.

[0176] FIG. **31** is a perspective view showing an example action of sliding the smart tag **440** into the tag track **424** of the lab pan **400**. The track rails **426** of the tag track **424** are specifically designed to tightly grab the tag grip portion **446** of the smart tag **440**. The tag lock bar **428** of the tag track **424** prevents an installed smart tag **440** from easily being removed. Meaning each smart tag **440** may be permanently or semi-permanently associated with a certain individual lab pan **400**. The track label area **430** of the tag track **424** may be about a 1-inch-wide flat section that allows additional labels, notes, QR codes, and the like to be attached to each individual lab pan **400**.

[0177] FIG. **32**A is an end view showing the tag track **424** of the lab pan **400** without the smart tag **440** installed. FIG. **32**B is an end view showing the tag track **424** of the lab pan **400** with the smart tag **440** installed. FIG. **32**A and FIG. **32**B indicate certain non-limiting dimensions (in millimeters (mm)) of the tag track **424** and the smart tag **440**.

[0178] Referring now to FIG. **33** through FIG. **46** is various views of a lab pan **405**, which is yet another example of the lab pan **230** of the batch production tracking system **200** shown in FIG. **7**, in accordance with an embodiment of the invention.

[0179] The lab pan **405** may be substantially the same as the lab pan **400** described above in FIG.

14 through FIG. **27** except for its size. More specifically, the lab pan **405** may be larger than the lap pan **400**.

[0180] FIG. **33** shows a perspective view of the lab pan **405**. Like the lab pan **400**, the lab pan **405** may include the main body **410** and the top lip portion **420** on the upper edge of the main body **410**. The main body **410** may include the front panel **412**, the back panel **414**, two side panels **416**, and the floor panel **418**, all arranged as shown in FIG. **33**. Likewise, the lab pan **405** includes an arrangement of upper stop features **422** and lower stop features **423**. Likewise, the tag track **424** is provided on the outside of the front panel **412** for receiving and holding the smart tag **440**. Generally, the lab pan **405** may be formed of any rigid, lightweight, durable, and cleanable material, such as, but not limited to, molded plastic, aluminum, and/or the like.

[0181] FIG. **34**A is another perspective view showing the action of sliding the smart tag **440** into the tag track **424** of the lab pan **405**. Like the lab pan **400**, with the smart tag **440** installed, the smart tag **440** is substantially centered on the front panel **412** of the lab pan **405**. FIG. **34**B is an end view showing the tag track **424** of the lab pan **405** without the smart tag **440** installed.

[0182] FIG. **35**, FIG. **36**, FIG. **37**, and FIG. **38** show a front view, a side view, a top view, and a bottom view, respectively, of the lab pan **405** shown in FIG. **33**.

[0183] FIG. **39**, FIG. **40**, FIG. **41**, FIG. **42**, and FIG. **43** show a front view, a side view, a cross-sectional view (taken front to back), a top view, and a bottom view, respectively, of the lab pan **405** shown in FIG. **33**. More specifically, FIG. **39**, FIG. **40**, FIG. **41**, FIG. **42**, and FIG. **43** indicate non-limiting example dimensions (in millimeters (mm)) of the lab pan **405** shown in FIG. **33**. Other dimensions of the lab pan **400** are contemplated and may be greater or less than those shown.

[0184] FIG. **33** through FIG. **43** show the lab pan **405** with the smart tag **440** installed in the tag track **424**. The tag track **424** may be positioned on the front panel **412** of the main body **410**, such that when installed the smart tag **440** may be substantially centered on the front panel **412** of the lab pan **405**.

[0185] FIG. **44**, FIG. **45**, and FIG. **46** show a perspective view, a front view, and a side view, respectively, of multiple lab pans **405** stacked together. In this example, three lab pans **405** stacked together, but any number of the lab pans **405** can be stacked. Here, the purpose of the upper stop features **422** and the lower stop features **423** is depicted. That is, when stacking one lab pan **405** atop another, the upper stop features **422** of the upper lab pan **405** come to rest atop the upper edge of the top lip portion **420** of the lower lab pan **405**. Similarly, the lower stop features **423** of the upper lab pan **405** come to rest atop the upper edge of the main body **410** of the lower lab pan **405**.

[0186] Following long-standing patent law convention, the terms “a,” “an,” and “the” refer to “one or more” when used in this application, including the claims. Thus, for example, reference to “a subject” includes a plurality of subjects, unless the context clearly is to the contrary (e.g., a plurality of subjects), and so forth.

[0187] The terms “comprise,” “comprises,” “comprising,” “include,” “includes,” and “including,” are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that may be substituted or added to the listed items.

[0188] Terms like “preferably,” “commonly,” and “typically” are not utilized herein to limit the scope of the claimed embodiments or to imply that certain features are critical or essential to the structure or function of the claimed embodiments. These terms are intended to highlight alternative or additional features that may or may not be utilized in a particular embodiment of the present invention.

[0189] The term “substantially” is utilized herein to represent the inherent degree of uncertainty that may be attributed to any quantitative comparison, value, measurement, or other representation and to represent the degree by which a quantitative representation may vary from a stated reference without resulting in a change in the basic function of the subject matter at issue.

[0190] Various modifications and variations of the disclosed methods, compositions and uses of the invention will be apparent to the skilled person without departing from the scope and spirit of the invention. Although the subject matter has been disclosed in connection with specific preferred aspects or embodiments, it should be understood that the subject matter as claimed should not be unduly limited to such specific aspects or embodiments.

[0191] The subject matter may be implemented using hardware, software, or a combination thereof and may be implemented in one or more computer systems or other processing systems. In one aspect, the subject matter is directed toward one or more computer systems capable of carrying out the functionality described herein.

[0192] For the purposes of this specification and appended claims, unless otherwise indicated, all numbers expressing amounts, sizes, dimensions, proportions, shapes, formulations, parameters, percentages, quantities, characteristics, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about” even though the term “about” may not expressly appear with the value, amount or range. Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are not and need not be exact, but may be approximate and/or larger or smaller as desired, reflecting tolerances, conversion factors, rounding off, measurement error and the like, and other factors known to those of skill in the art depending on the desired properties sought to be obtained by the presently disclosed subject matter. For example, the term “about,” when referring to a value can be meant to encompass variations of, in some embodiments±100%, in some embodiments±50%, in some embodiments±20%, in some embodiments±10%, in some embodiments±5%, in some embodiments±1%, in some embodiments±0.5%, and in some embodiments±0.1% from the specified amount, as such variations are appropriate to perform the disclosed methods or employ the disclosed compositions.

[0193] Further, the term “about” when used in connection with one or more numbers or numerical ranges, should be understood to refer to all such numbers, including all numbers in a range and modifies that range by extending the boundaries above and below the numerical values set forth. The recitation of numerical ranges by endpoints includes all numbers, e.g., whole integers, including fractions thereof, subsumed within that range (for example, the recitation of 1 to 5 includes 1, 2, 3, 4, and 5, as well as fractions thereof, e.g., 1.5, 2.25, 3.75, 4.1, and the like) and any range within that range.

[0194] Although the foregoing subject matter has been described in some detail by way of illustration and example for purposes of clarity of understanding, it will be understood by those skilled in the art that certain changes and modifications can be practiced within the scope of the appended claims.

Claims

1. A batch production tracking system, comprising: a. one or more transmitters, wherein each one of the one or more transmitters is associated with a carrier; and b. an arrangement of one or more sensors, wherein the arrangement of one or more sensors is provided in relation to an arrangement of one or more workstations of a batch production workflow, and wherein the one or more sensors are configured to sense a signal from the one or more transmitters and to determine a location of its associated carrier in the batch production workflow.

2. The system of claim 1, wherein the one or more workstations each comprise an interactive interface, wherein the interactive interface is configured to allow a user to interact with and/or view an operation and/or status of one or more workstations and/or carriers.

3. The system of claim 2, wherein the interactive interface comprises an interactive display device.

4. The system of claim 3, wherein the interactive display device is configured to visually indicate a status of one or more of the carriers and/or the batch production workflow.

5. The system of claim 1, wherein the one or more workstations are arranged in chronological order of steps of the batch production workflow of a product being processed.

6. The system of claim 1, wherein the one or more sensors are configured to measure any one or more of acceleration, location, motion, proximity, light, orientation, force, angular velocity, magnetic field, pressure, altitude, humidity, and/or temperature.
7. The system of claim 1, wherein the one or more sensors comprise short-range wireless low energy sensors.
8. The system of claim 1, wherein the arrangement of the one or more sensors is configured such that sensing ranges of one or more of the one or more sensors overlap.
9. The system of claim 1, wherein each one of the one or more transmitters is physically coupled to a carrier.
10. The system of claim 1, wherein each of the one or more transmitters include a display.
11. The system of claim 1, wherein each carrier used in a particular batch production workflow is linked in the batch production tracking system via its associated transmitter with that specific batch production workflow.
12. The system of claim 3, wherein status and/or case information related to the carrier in the batch production workflow is automatically displayed on the interactive display device of its associated workstation upon the carrier with associated transmitter entering a sensor field of a sensor of the one or more sensors associated with that workstation.
13. The system of claim 1, wherein the one or more transmitters comprise a smart tag.
14. The system of claim 13, wherein the smart tag is configured to attach to the carrier.
15. The system of claim 13, wherein the smart tag includes a display.
16. A carrier, comprising: a. a main body portion, including a front panel, a back panel, two side panels, and a floor panel; b. a top lip portion, wherein the top lip portion extends upward from a top edge of the two side panels and the back panel, and wherein the top lip portion forms a wall extending from a point on one of the two side panels to a point on the other of the two side panels, the wall not extending the full length of either of the two side panels; c. one or more stop features formed on an outer surface of the main body portion and/or the top lip portion; and d. a transmitter attachment point formed on the main body portion.
17. The carrier of claim 16, wherein the one or more stop features comprise one or more upper stop features and one or more lower stop features formed on each of the two side panels.
18. The carrier of claim 17, wherein the upper stop features and the lower stop features are configured such that when the product carrier is nested within another product carrier a bottom edge of the upper stop features rest atop an upper edge of the top lip portion of the other product carrier and a bottom edge of the lower stop features rest atop an upper edge of the side panels of the other product carrier.
19. The carrier of claim 16, wherein the transmitter attachment point comprises a receiving mechanism configured to receive a transmitter and secure it thereto.
20. The carrier of claim 16, wherein the transmitter comprises a smart tag.
21. The carrier of claim 20, wherein the transmitter attachment point comprises track rails and a locking mechanism, wherein the track rails are configured to receive an upper portion and a lower portion of the smart tag and the locking mechanism is configure to secure the smart tag in place once installed in the track rails.
22. A method of using a batch production tracking system, the method comprising: a. setting up a batch production workflow for a product to be produced; b. assigning one or more transmitters to the batch production workflow for the product to be processed, and associating each of the one or more transmitters with a carrier; c. loading the carrier with items related to producing the product; d. initiating the batch production workflow; e. moving the carrier through a series of workstations of the batch production tracking system, wherein the batch production tracking system further comprises an arrangement of sensors associated with one or more of the workstations; and f. tracking the carrier through the batch production workflow, wherein when the carrier is in a sensing field of one or more of the sensors data from the transmitter associated with that carrier is sensed

by the one or more sensors and communicated to an associated one or more workstations.

23. The method of claim 22, wherein setting up a batch production workflow for a product to be produced comprises inputting details of the batch production workflow into a workflow application of the batch production tracking system.

24. The method of claim 22, wherein the data from the transmitter includes information related to the status and/or location of the product carrier in the batch production workflow and/or status and/or operational data of the product being produced.

25. The method of claim 22, wherein the workstations comprise an interactive display and some or all of the sensed data may be displayed thereon.

26. The method of claim 22, wherein data sensed at one workstation is communicated to one or more other workstations.