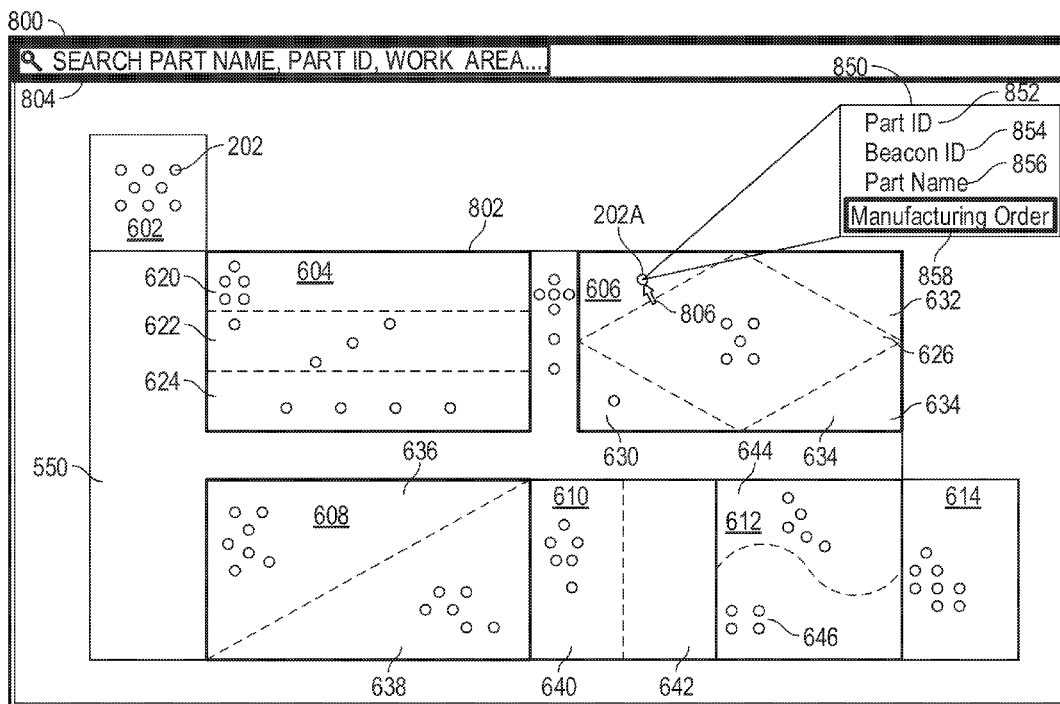




US 20170039517A1

(19) **United States**(12) **Patent Application Publication**
Amann et al.(10) **Pub. No.: US 2017/0039517 A1**(43) **Pub. Date: Feb. 9, 2017**(54) **PRESENTATION OF REAL-TIME
LOCATIONS OF PARTS IN A
MANUFACTURING OR SERVICE FACILITY**(52) **U.S. Cl.**
CPC **G06Q 10/087** (2013.01); **H04W 4/023**
(2013.01); **H04B 17/318** (2015.01)(71) Applicant: **The Weir Group PLC**, Fort Worth, TX
(US)(72) Inventors: **Andrew Amann**, Wakefield, MA (US);
Brett Gent, Rowley, MA (US)(21) Appl. No.: **15/230,383**(22) Filed: **Aug. 6, 2016****Related U.S. Application Data**(60) Provisional application No. 62/202,764, filed on Aug.
7, 2015, provisional application No. 62/202,761, filed
on Aug. 7, 2015, provisional application No. 62/202,
762, filed on Aug. 7, 2015.**Publication Classification**(51) **Int. Cl.**
G06Q 10/08 (2006.01)
H04B 17/318 (2006.01)
H04W 4/02 (2006.01)(57) **ABSTRACT**

Parts in a manufacturing or service facility are electronically tracked using wireless beacons, strategically positioned receiver devices in the facility, and a monitoring server. The wireless beacons are individually coupled to the parts in the facility and equipped with sensors that wake the wireless beacons up to wirelessly transmit location signals when sensed data indicates the parts are moving to the receiver devices. The receiver devices, in turn, transmit the location signals across a network to the monitoring server, which uses the location signals and identifiers of the receiver devices to locate the work areas of the facility in which the wireless beacons—and thus coupled parts—are located. Interactive user interfaces illustrate the real-time locations of the parts being located in the various work areas of the facility.



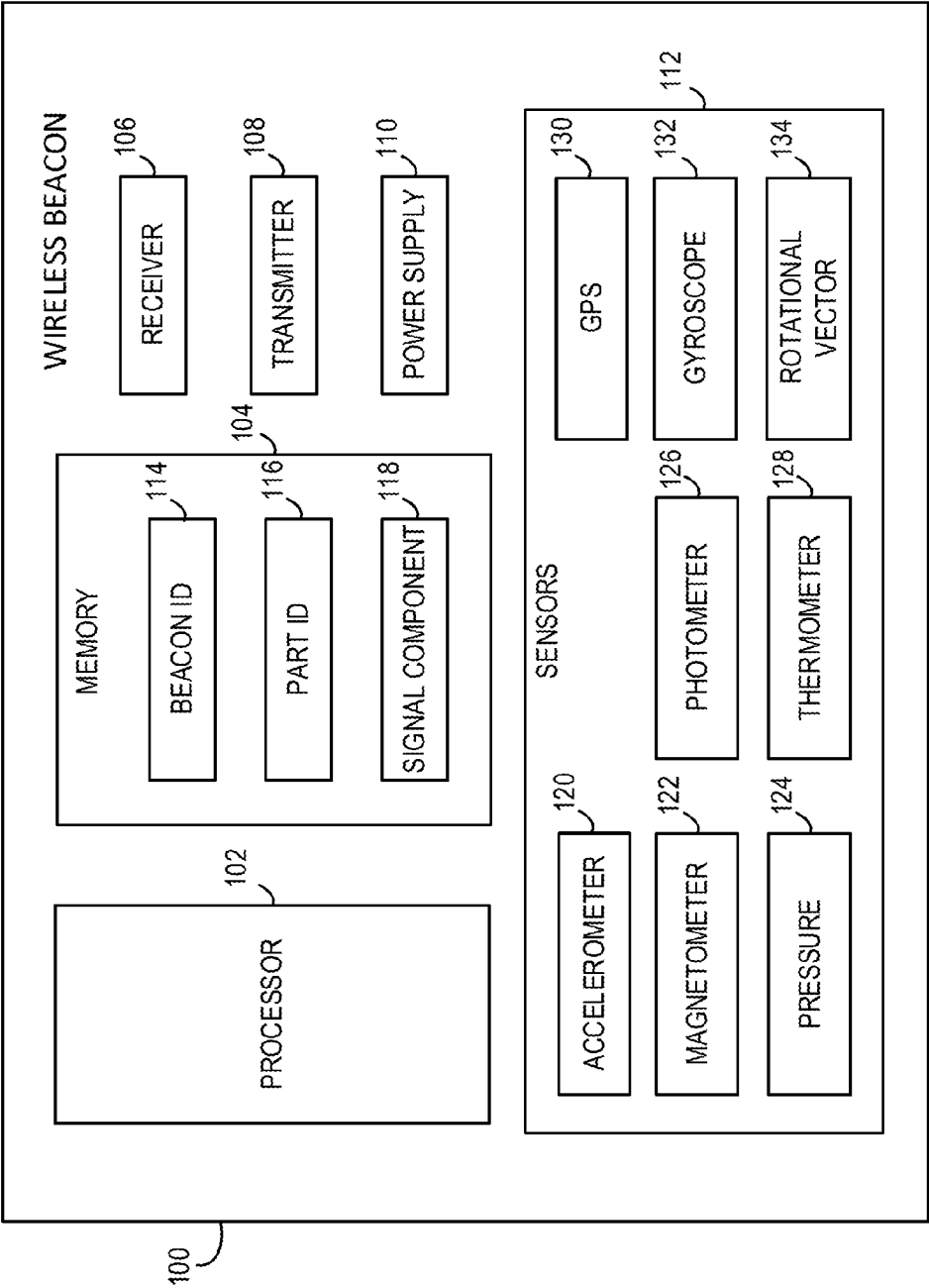


FIG.1

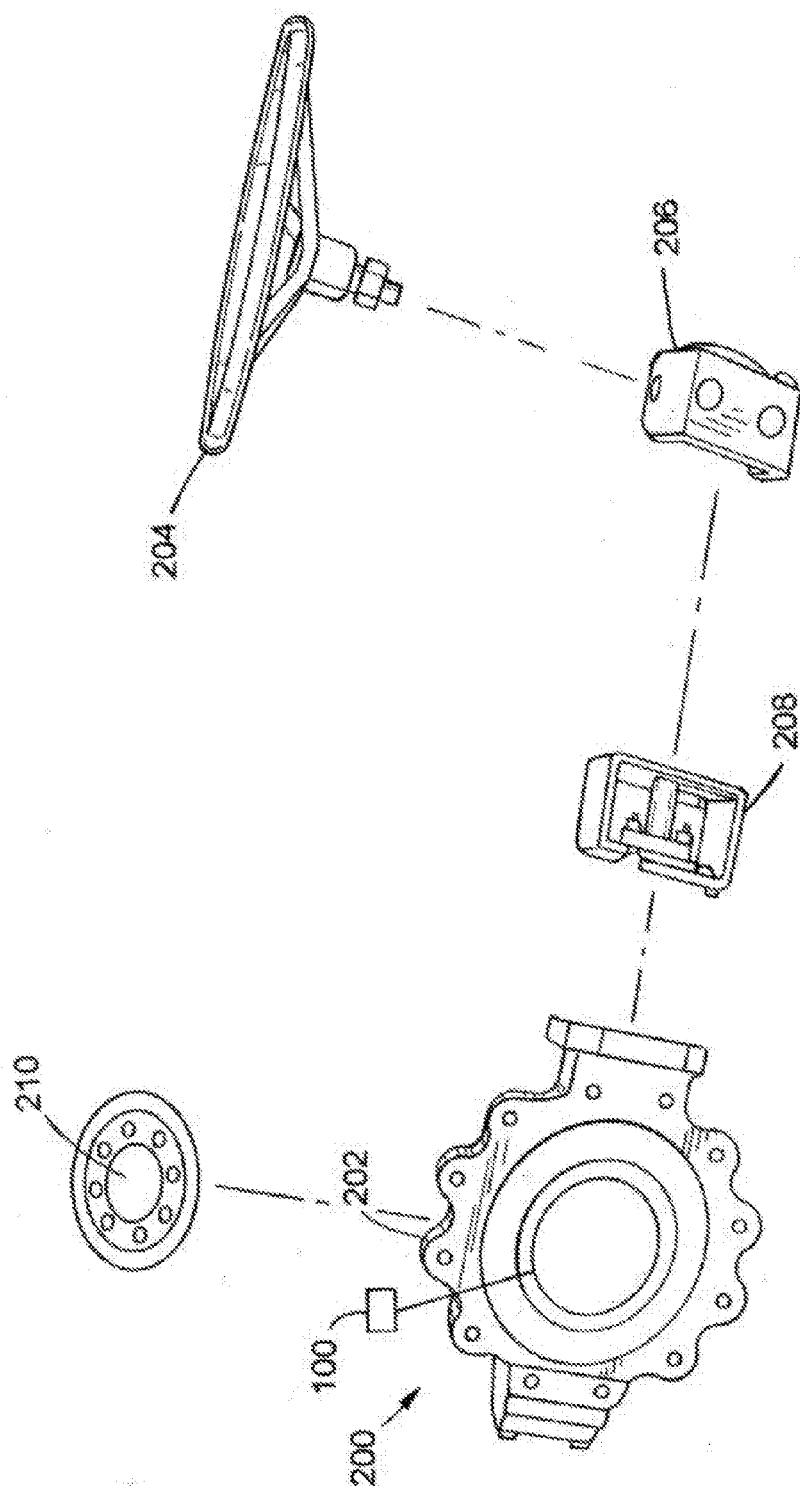


FIG.2A

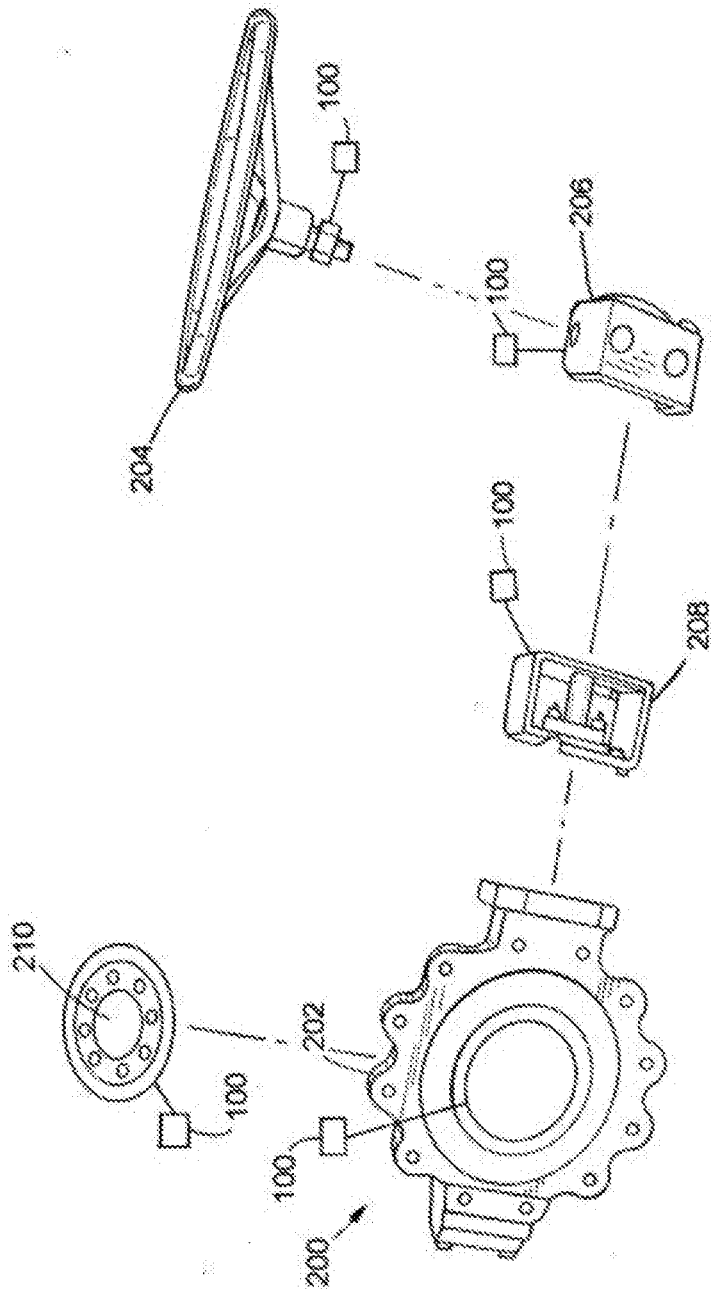


FIG.2B

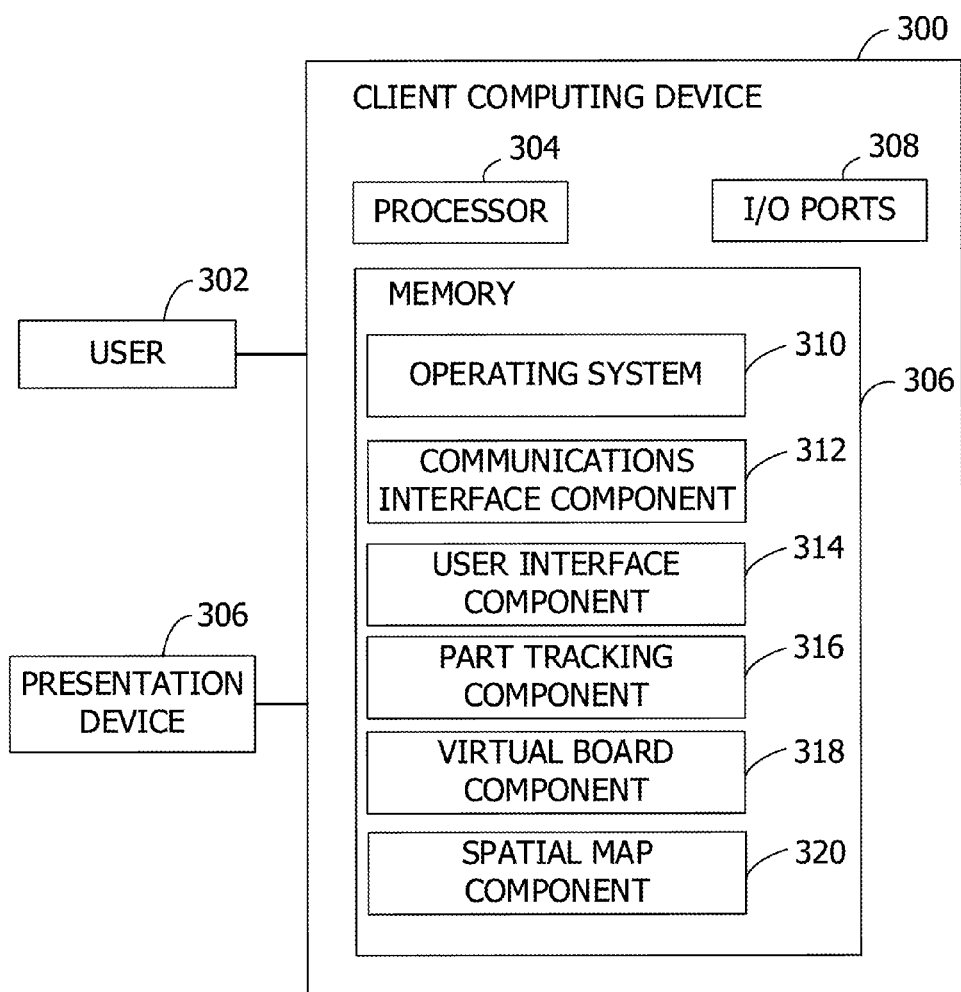


FIG.3

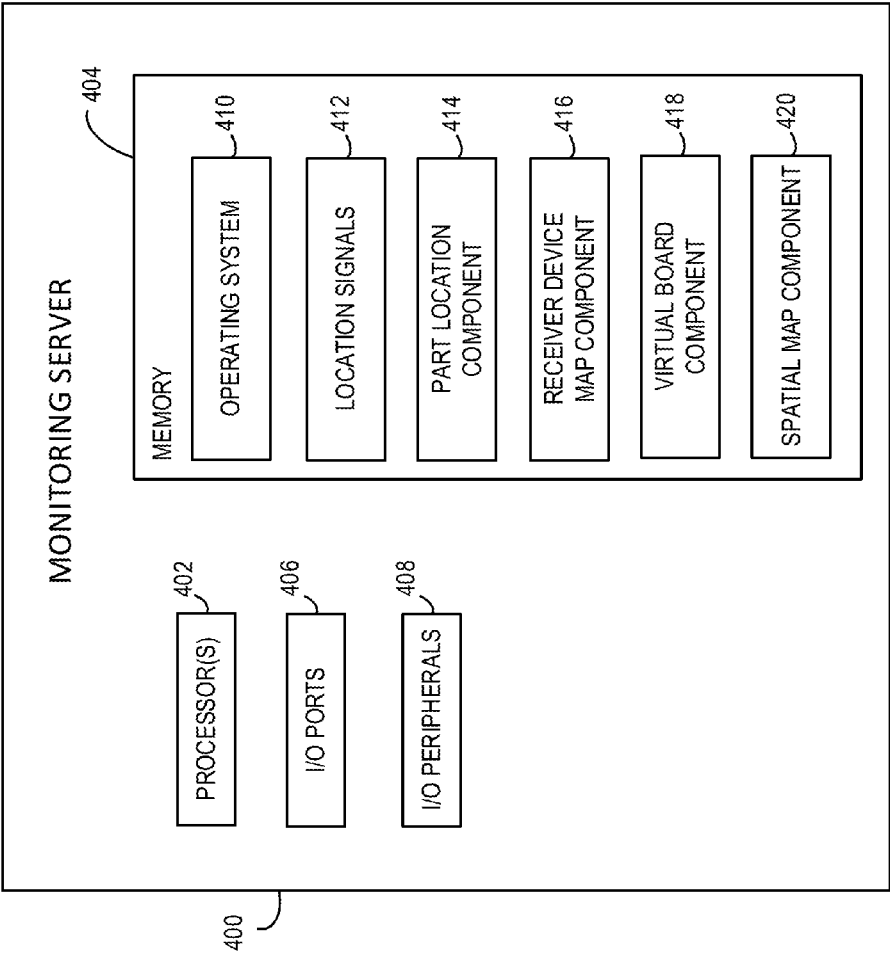


FIG.4

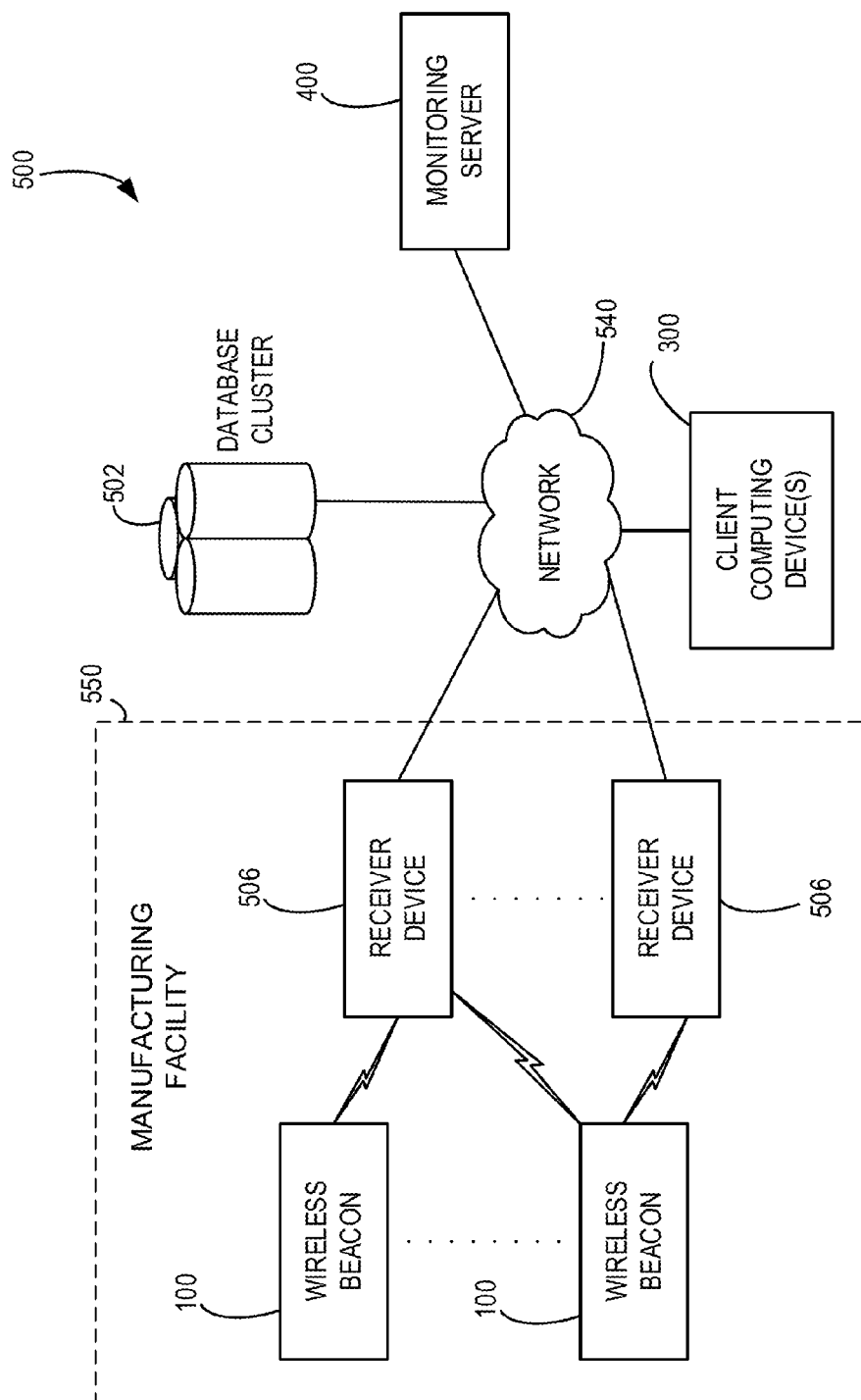


FIG.5

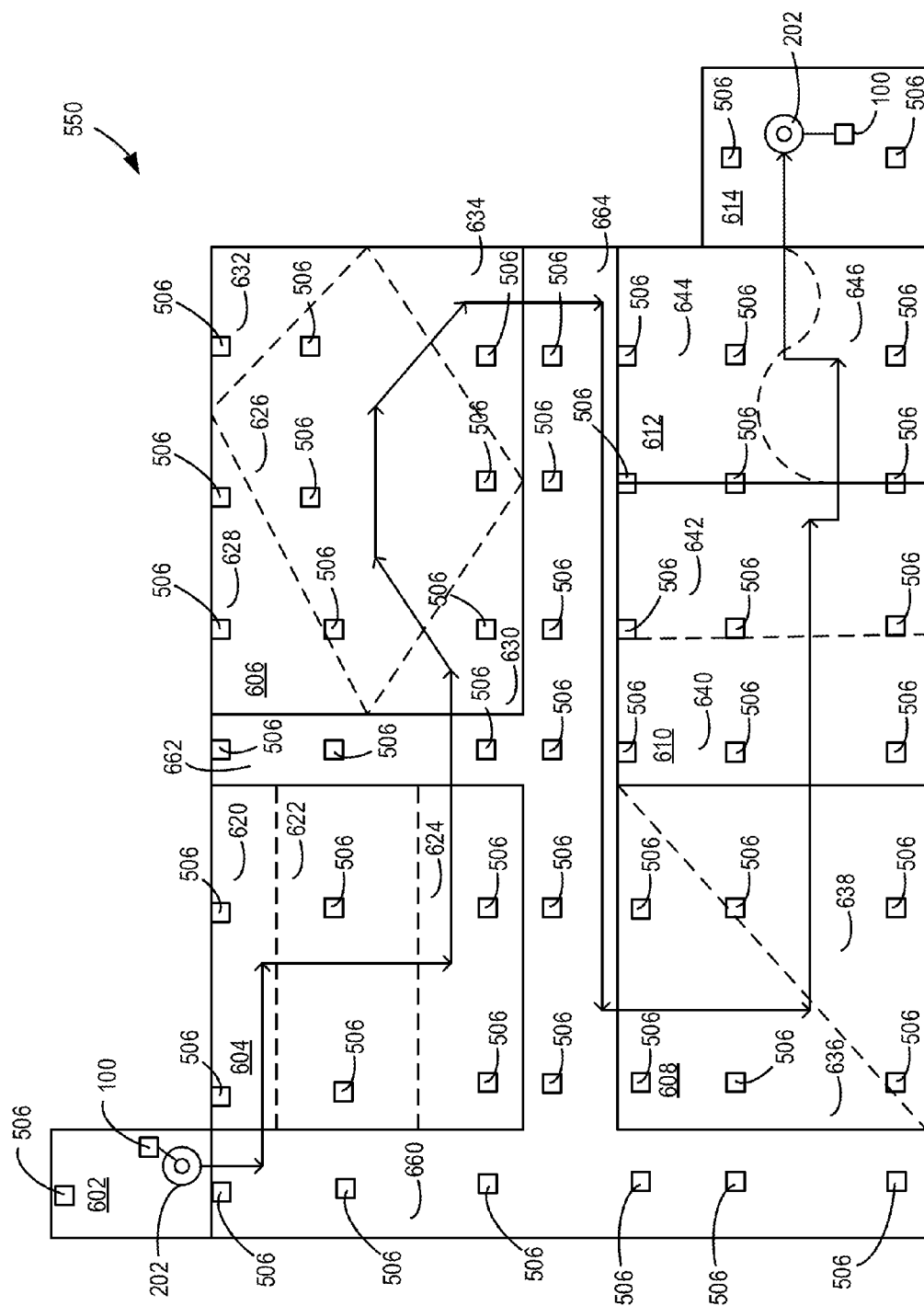
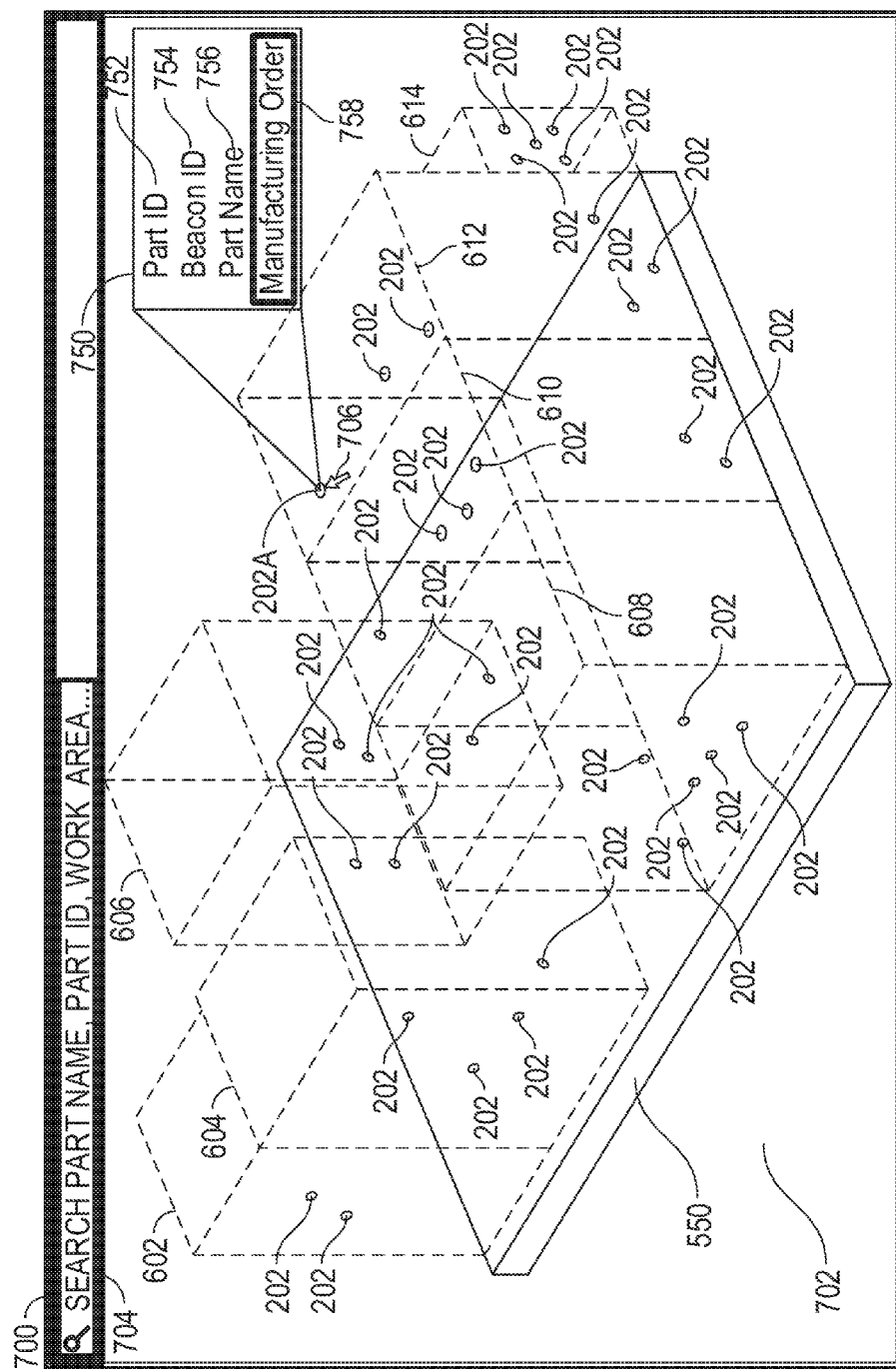
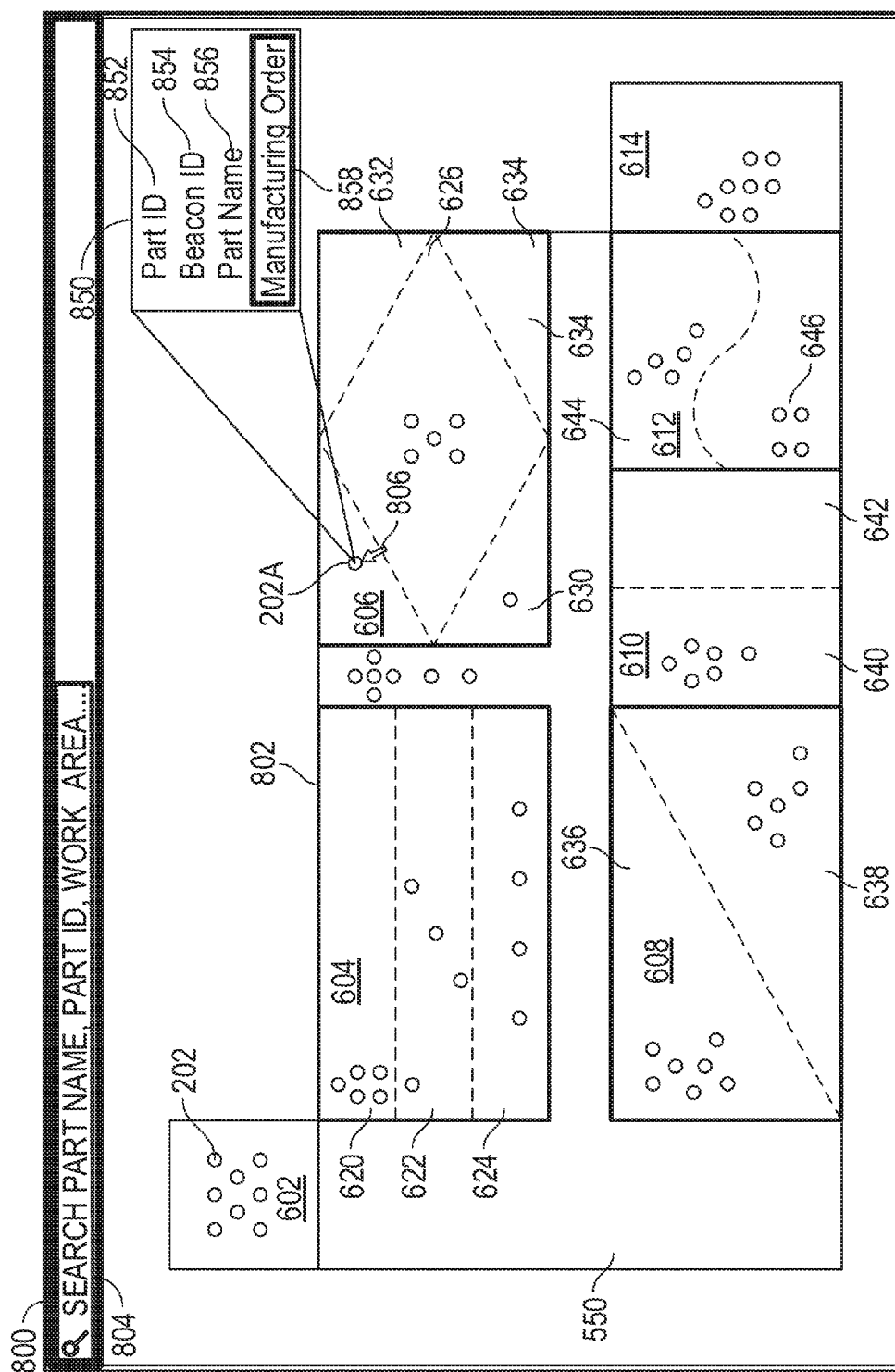


FIG. 6



7
G
E



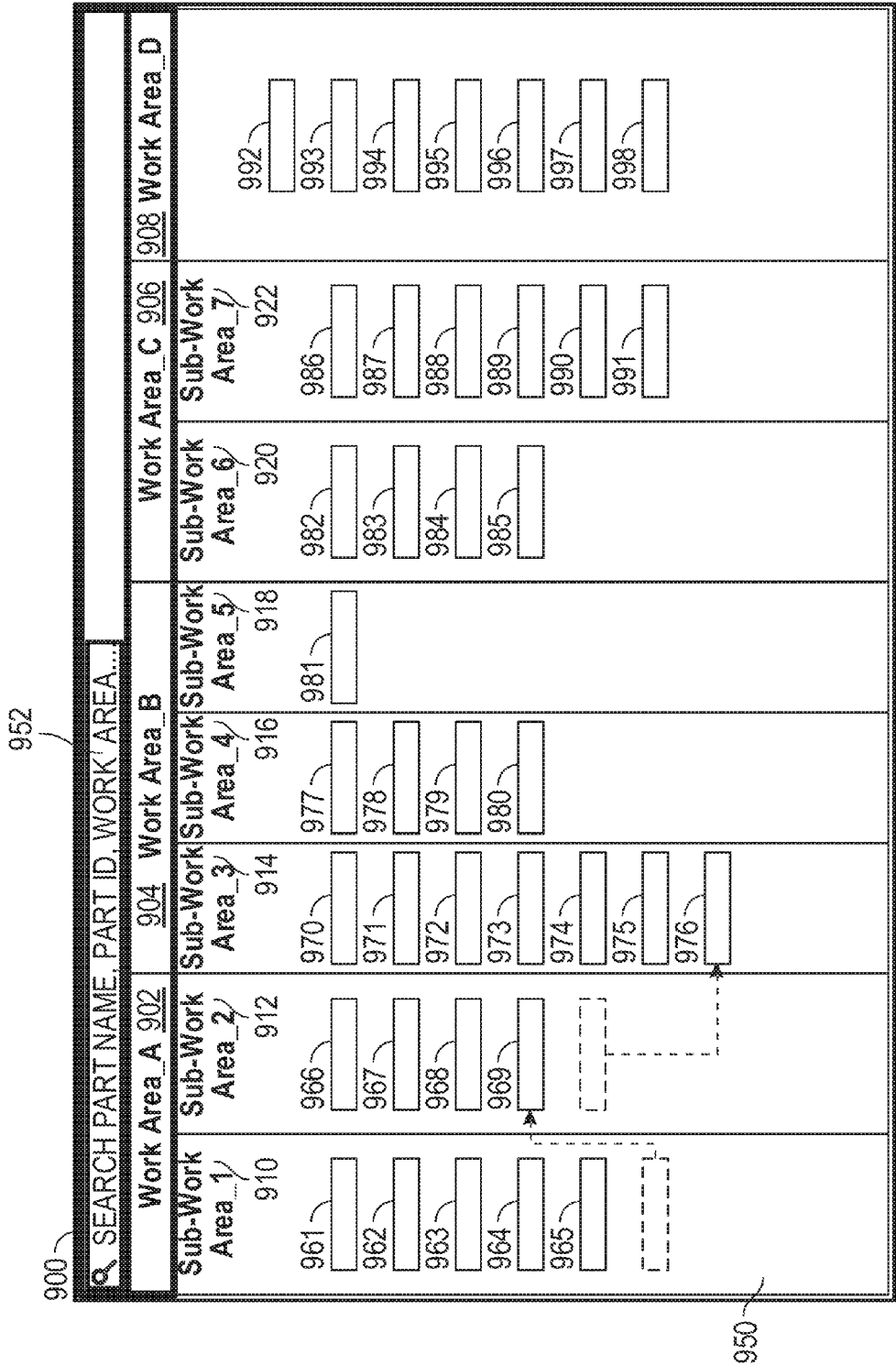


FIG. 9

1000						MANUFACTURING ORDER		1004	
1002						COMMERCIAL			
						MO No: 0010724		1006	
						CO No: 0010000204 - 130		1008	
Date Required		Date Printed		Facility		Staff		Order qty	
062714				100		TBUCKLEY		4.00 EA	
Product No: BTOT06ASGEN003 TRI BF 006-150 WCB LG GEAR ROTORK									
1014 Drawing No: APP-PV41-ZOD-108 1010 Rev: Spec. & Grade: A216 WCB NDE: 1012									
1016 Prod. Control: Q.C:									
1018 C of C / CMTR Quantity (Issued)									
Heat No		Date Issued		PO No		Serial		Vendor	
References and Procedures									
1020 1. Magnetic Particle Insp:					2. Liquid Penetrant Insp:				
3. Weld:					4. Hardfacing:				
5. Min-Wall:					6. Weld End Drawing:				
OPER		Wrk ctr				Run time		Date	
		Name						Empl. Init	
PV-41 PACKAGE									
DATA SHEET APP-PV41-ZOD-108									
DRAWING APP-PV41-ZOD-108 LATEST REVISION									
TEST PROCEDURE 321-54571 LATEST REVISION									
CLEANING PROCEDURE 501-55106 LATEST REVISION									
PACKAGING PROCEDURE 512-54646 LATEST REVISION									
PAINT PROCEDURE 502-54751 LATEST REVISION (ZONE 3)									
1		MOF OFFSET MATERIAL FOR ASSEMBLY				061614			
		ASSEMBLY ORDER - WVC IPSWICH							
10		MFG MFG - CREATE ROUTING - IPSWICH				10.00		061614	
		ADD ROUTING							
20		IAS ASSEMBLY				3.32		061714	
		ASSEMBLE PER DWG							
ASSEMBLE AND TORQUE FASTENERS PER DRAWING APP-PV41-ZOD-105									
-REFERENCE ASSEMBLY PROCEDURE CP-E-10									
30		IAS ASSEMBLY				4.50		061714	
		TEST							
DESCRIPTION: TEST PER PROCEDURE 321-54751									
CHECK CLAMP RING NUT TORQUE AFTER TEST									
50		IOU QUICK TURN CELL				4.50		061814	
		DRILL & PIN DISK TO DRIVESHAFT							
DRILL AND PINION DISC TO DRIVE SHAFT									
PER PROCEDURE CP-E-05 LATEST REVISION									
70		V61 BC INDUSTRIES - SUBCONTRACT				061914			
		PAINTING SERVICES							
1026 SUPPLIER TO PROVIDE SERVICES TO PAINT									
VALVE, HANDWHEEL, AND ACTUAOR									
VALVE IS WCB CARBON STEEL									

FIG. 10

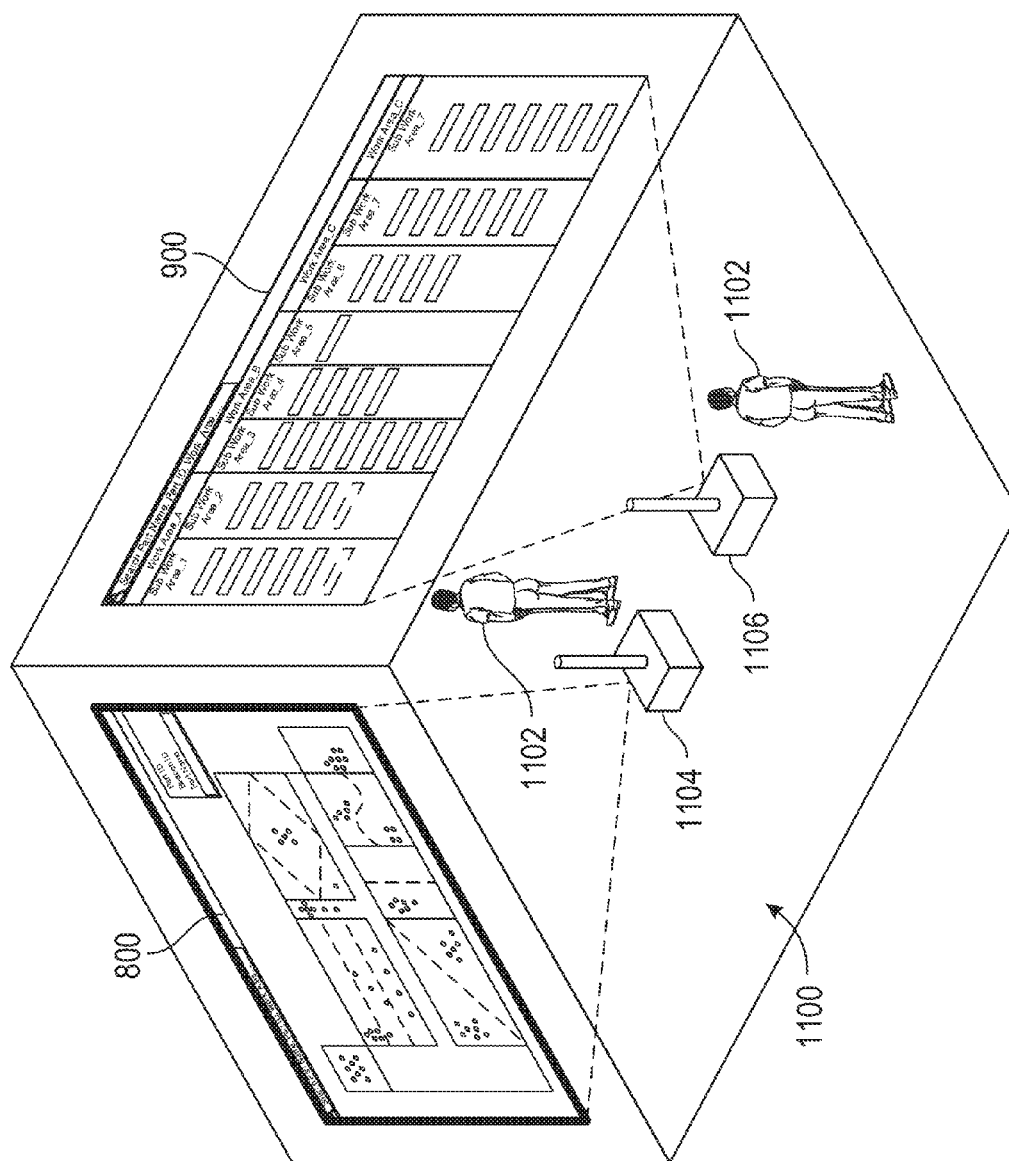


FIG. 11

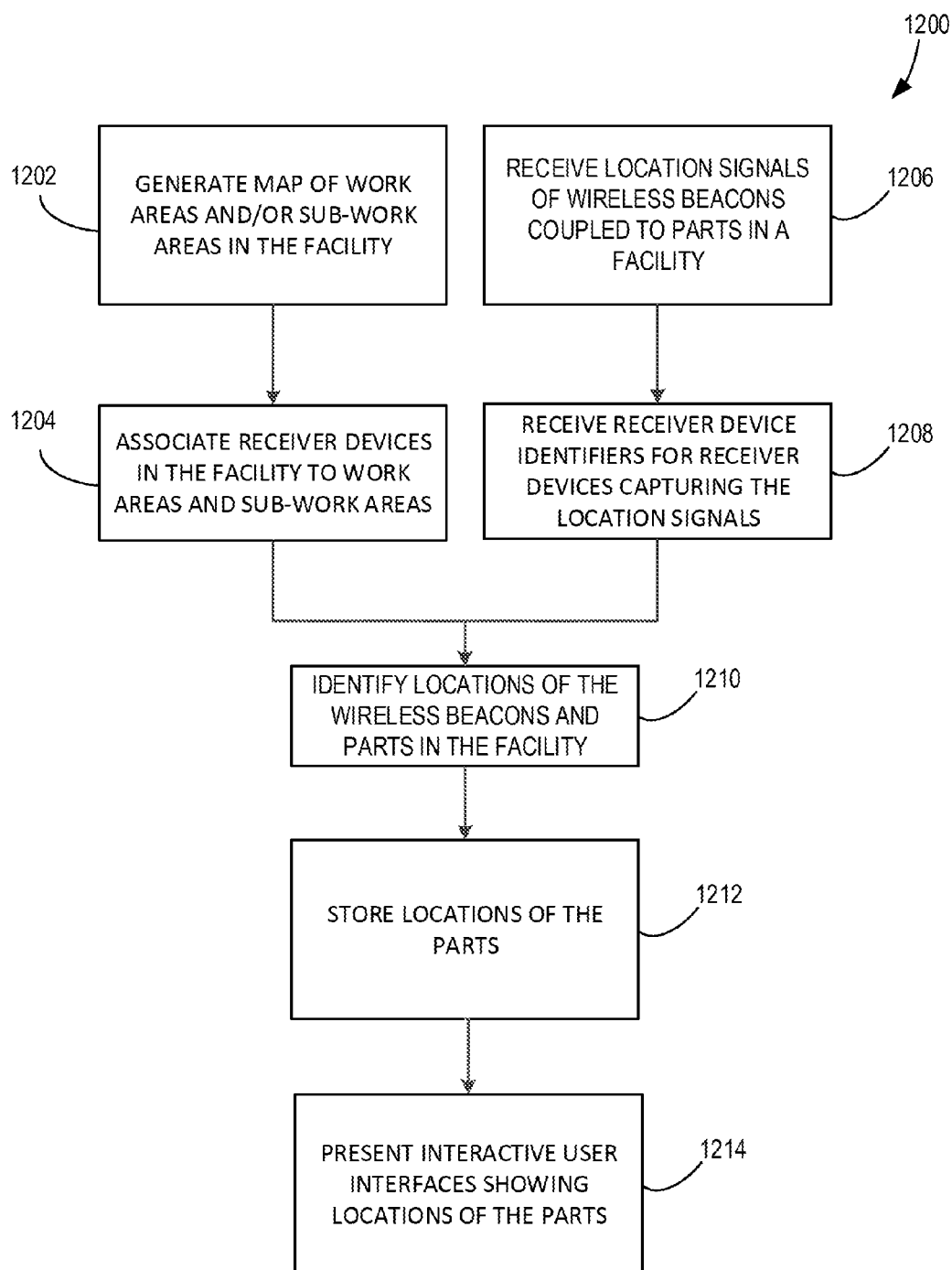


FIG. 12

PRESENTATION OF REAL-TIME LOCATIONS OF PARTS IN A MANUFACTURING OR SERVICE FACILITY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 62/202,761 filed on Aug. 7, 2015 and entitled “MONITORING PARTS IN A FACILITY”; U.S. Provisional Application Ser. No. 62/202,762 filed on Aug. 7, 2015 and entitled “TRACKING PARTS IN MANUFACTURING AND SERVICE FACILITIES”; and U.S. Provisional Application Ser. No. 62/202,764 filed on Aug. 7, 2015 and entitled “PRESENTATION OF REAL-TIME LOCATIONS OF PARTS IN A MANUFACTURING OR SERVICE FACILITY.” These three provisional patent applications are hereby incorporated by reference in their entirety for all intents and purposes.

TECHNICAL FIELD

[0002] This disclosure generally relates to tracking parts in a manufacturing or service facility and, more specifically, to presenting the tracked parts in interactive user interfaces (UIs) and displaying the real-time locations of the parts in work areas of the manufacturing or service facility.

BACKGROUND

[0003] To function efficiently, manufacturing and service facilities depend on getting the right component part to the right worker at the right time. Modern facilities are typically divided into different work areas (e.g., receiving, welding, assembly, shipping, etc.), and parts are brought to specialized workers in those areas to perform a job function. Many inefficiencies result from the logistics involved with moving parts around a facility floor. If the correct part is not in the appropriate work area at the right time, a worker wastes time tracking the part down in the facility.

[0004] Many of today's manufacturing and service facilities use paperwork to detail job tasks needing to be performed to build or service a particular part. Using paperwork to track part manufacturing and service tasks is cumbersome, inaccurate, and often requires more time finding and keeping the paperwork up to date than manufacturing or servicing the part. A worker typically has to locate the appropriate paperwork, update it correctly when a specific job task is finished, and then ensure it stays with the part as the part travels to the next work area. Such a process is only as good as the workers who maintain the accuracy of the paperwork, and even the best workers typically cannot ensure the appropriate paperwork always follows all parts in the facility. Countless man hours are wasted tracking such paperwork and keeping it up to date. And the typical reaction of management to improve the efficiency of the process is to add additional paperwork or perform additional administrative tasks, most of which further complicate things.

[0005] The paperwork includes manufacturing drawings for the various stages of production. The manufacturing drawings are printed in large format and include tolerances for the part. Oftentimes the manufacturing drawings are updated by the engineering team while the part is currently out on the shop floor. The updated manufacturing drawings then need to be placed with the part on the shop floor so the part can be manufactured according to the updated drawing

parameters. If the part has already been machined beyond the updated tolerances, then the part may need to be scrapped resulting in a complete loss of the part and machining costs. Moreover, if the updated drawings do not end up being placed with the proper part, the part is not machined properly, which could result in failure or even catastrophic failure during operation as many of the parts manufactured are in hazardous operational conditions (high pressure, flooding, nuclear environments).

[0006] Even worse, worker productivity is drastically reduced when workers must search for parts that are not in the correct work areas or must hunt down corresponding paperwork detailing tasks that need to be completed on the part. Welders hunting for paperwork or parts in a shop or manufacturing facility spend less time actually welding. The end goal of any manufacturing or service facility is to maximize the amount of time specialized workers spend performing their specialized job tasks. Miring workers down with administrative paper tasks or part-hunting expeditions reduces the time spent actually manufacturing or servicing parts.

SUMMARY

[0007] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features or essential features of the claimed subject matter. Nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0008] One embodiment includes an apparatus for presenting a user interface that illustrates real-time locations of parts in a facility. The apparatus includes memory configured to store: (1) location signals of wireless beacons coupled to parts in the facility, and (2) a virtual board component. The apparatus also includes one or more processors that are programmed to determine the real-time locations of the parts based on the location signals of the wireless beacons and to execute the virtual board component to generate a virtual board user interface presenting the locations of the real-time locations of the parts.

[0009] In one embodiment, the apparatus includes a receiver for receiving the location signals from one or more receiver devices over a public or private network.

[0010] In one embodiment, the apparatus includes a receiver for receiving the location signals from a monitoring server over a public or private network.

[0011] In one embodiment, the wireless beacons are configured to wirelessly transmit the location signals to one or more receiver devices using a Bluetooth low energy (LE) wireless connection. In one embodiment, the virtual board user interface includes a virtual board user interface area displaying a plurality of work areas in the facility and showing at least some of the parts as being located in the plurality of work areas.

[0012] In one embodiment, the work areas are displayed indicating at least one member of a group including a welding work area, a machining work area, an assembly work area, a shipping work area, and a receiving work area.

[0013] In one embodiment, the virtual board user interface includes a virtual board user interface area displaying a plurality of sub-work areas in the facility and showing at least some of the parts being located in the plurality of sub-work areas. In one embodiment, the sub-work areas are displayed indicating at least one member of a group includ-

ing a holding sub-work area, an inspection sub-work area, and a completion sub-work area.

[0014] In one embodiment, the apparatus includes a presentation device configured to display the virtual board user interface. In one embodiment, the presentation device includes a projector. In one embodiment, the presentation device includes a computer monitor. In one embodiment, the presentation device includes a television. In one embodiment, the presentation device includes a mobile tablet. In one embodiment, the presentation device includes a smart phone.

[0015] In one embodiment, the memory is configured to store a spatial map component, and the one or more processors are programmed to execute the spatial map component to generate a two- or three-dimensional spatial user interface indicative of the real-time locations of the parts based on the location signals.

[0016] In one embodiment, the two- or three-dimensional spatial user interface presents part representations of the parts in one or more work areas of the facility. In one embodiment, the work areas include at least one member of a group including a welding work area, a machining work area, an assembly work area, a shipping work area, and a receiving work area.

[0017] In one embodiment, the two- or three-dimensional spatial user interface presents part representations of the parts in one or more sub-work areas of the facility. In one embodiment, the sub-work areas are displayed indicating at least one member of a group including a holding sub-work area, an inspection sub-work area, and a completion sub-work area.

[0018] In one embodiment, the one or more processors are programmed to update the real-time locations of the parts in the virtual board user interface based on the location signals.

[0019] In one embodiment, the parts include at least one member of a group including: a fluid end, a swivel, a joint, a valve, a hose, a conduit, a manifold trailer, safety iron, a safety hammer, a dart valve, a plug valve, a clapper check valve, a pressure relief valve, an emergency unloading valve, a gate valve, a subsea dosage valve, a hydraulic valve, a valve seat, a butterfly valve, a steadseal valve, a hyperseal valve, a Polytetrafluoroethylene-lined valve, a swingthrough valve, a rubber-sealing valve, a rubber-line valve, a fire safe valve, a swing and lift check valve, a T-pattern globe valve, a Y-pattern globe valve, a three-way globe valve, a compressor check valve, a cold reheat check valve, a cold heat check valve, a testable check valve, a reverse current valve, a parallel slide valve, a gate valve, a safety valve, a safety relief valve, an isolation valve, a relief valve, a mounted-ball valve, a ball valve, a diaphragm valve, a butterfly valve, a gate and globe valve, a check valve, a lift check valve, a swing check valve, a steam isolation valve, a feedwater isolation valve, an integrated safety valve, a single-stage turbine, a multi-stage turbine, a hydraulic turbine, a pump turbine, a quad-runner turbine, a gear operator, a pneumatic actuator, a pressure control panel, a lifting clamp, a flow line safety restraint, a choke, a drop ball injector, a pump, a blowout preventer, a gas separator, an overshot connector, a wellhead, a frac pump, a positive displacement pump, a hydrocyclone, a dewatering pump, a vortex pump, a trailer, a manifold system, a fluid end system, a slurry pump, a water pump, a subsea pump, a premix tank, a frac tree, a swellable packer, a manifold skid, a tubing head, a wellhead, a rod rotator, a stuffing box, a casing head, a tubing head, a

conveyor, a screening machine, a material handling machine, a communiton machine, a feeder, a crusher, a modular plant, a barge, and a control valve.

[0020] Another embodiment is directed toward one or more computer-storage media with stored computer-executable instructions configured to cause one or processors to display a user interface displaying real-time locations of parts in a manufacturing facility. The user interface includes: a first user interface area displaying a first set of parts currently located in a first work area of the manufacturing facility, and a second user interface area displaying a second set of parts currently located in a second work area of the manufacturing facility.

[0021] In one embodiment, the first user interface area is configured to remove display of at least one part from the first user interface area and display an indication of the at least one of part in the second user interface area upon sensed movement of the at least one part in the manufacturing facility from the first work the second work area.

[0022] In one embodiment, the real-time locations of the parts are determined by a monitoring server or a client computing device based on location signals of wireless beacons coupled to the parts.

[0023] In one embodiment, the user interface includes a third user interface area for receiving search query terms for identifying parts or work areas in the user interface. In one embodiment, the user interface is configured to highlight at least a portion of the first user interface area when search query terms received by the third user interface area indicate that at least one part in the manufacturing facility is located in the first work area, and highlight at least a portion of the second user interface area when search query terms received by the third user interface area indicate that at least one part in the manufacturing facility is located in the second work area.

[0024] In one embodiment, the first user interface and the second user interface are displayed in a three-dimensional view.

[0025] Another embodiment is directed to a method for presenting a user interface indicating the real-time locations of parts in a manufacturing facility; wherein, the parts are coupled to wireless beacons configured to wirelessly transmit location signals. The method includes: receiving the location signals; determining locations of the parts in the manufacturing facility based on the location signals; and presenting a user interface having a first user interface area showing a first set of the parts being located in a first work area, and a second user interface area showing a second set of the parts being located in a second work area.

[0026] In one embodiment, the user interface shows at least one part moving from the first work area to the second work area as the location signals associated with the at least one part indicate movement to the second work area.

[0027] In one embodiment, the user interface includes a virtual board user interface showing the real-time locations of the parts in a plurality of work areas.

[0028] In one embodiment, the user interface includes a virtual board user interface showing the real-time locations of the parts in a plurality of sub-work areas.

[0029] In one embodiment, the user interface includes a spatial map user interface showing the real-time locations of the parts in a plurality of work areas.

[0030] In one embodiment, the user interface includes a spatial map user interface showing the real-time locations of the parts in a plurality of sub-work areas.

[0031] In one embodiment, the method includes receiving a user selection of at least one part, retrieving a manufacturing or service order associated with the at least one part, and presenting the manufacturing or service order.

[0032] Another embodiment is directed to one or more computer storage media embodying computer-executable components for causing a computing device to present a user interface indicative of the real-time locations of parts in a facility. The media includes: a communications interface component configured to receive location signals associated with wireless beacons coupled to the parts in the facility, a part location component configured to determine the real-time locations of the parts in the facility based on the location signals, and a virtual board component configured to present a virtual board user interface showing the real-time locations of the parts in relation to one or more work areas of the facility.

[0033] Another embodiment is directed to one or more computer storage media embodying computer-executable components executable for causing a computing device to present a user interface indicative of the real-time locations of parts in a facility. The media includes: a communications interface component configured to receive location signals associated with wireless beacons coupled to the part in the facility, a part location component configured to determine real-time locations of the parts in the facility based on the location signals, and a spatial map component configured to present a spatial user interface showing the real-time locations of the parts in relation to one or more work areas of the facility.

DESCRIPTION OF DRAWINGS

[0034] The accompanying drawings facilitate an understanding of the various embodiments.

[0035] FIG. 1 illustrates a block diagram of a wireless beacon for implementing some of the disclosed embodiments.

[0036] FIGS. 2A-2B are exploded-view diagrams of valves with wireless beacons for implementing some of the disclosed embodiments.

[0037] FIG. 3 is a client computing device configured to present interactive UIs showing the locations of parts in a manufacturing facility in accordance with some of the disclosed embodiments.

[0038] FIG. 4 illustrates a block diagram of a monitoring server configured to track parts in a manufacturing facility and provide interactive UIs in accordance with some of the disclosed embodiments.

[0039] FIG. 5 is a block diagram of a networking environment for implementing some of the disclosed embodiments.

[0040] FIG. 6 is diagram of a manufacturing facility with strategically positioned receiver devices in accordance with some of the disclosed embodiments.

[0041] FIG. 7 is a UI diagram illustrating an example of a three-dimensional spatial UI showing real-time locations of parts in a manufacturing facility in accordance with some of the disclosed embodiments.

[0042] FIG. 8 is a UI diagram illustrating an example of a two-dimensional spatial UI showing real-time locations of parts in a manufacturing facility in accordance with some of the disclosed embodiments.

[0043] FIG. 9 is a UI diagram illustrating an example of a virtual board UI showing real-time locations of parts in a manufacturing facility in accordance with some of the disclosed embodiments.

[0044] FIG. 10 illustrates a diagram of a digitally presented manufacturing order, according to one embodiment.

[0045] FIG. 11 is a three-dimensional diagram of a facility room in which a spatial UI and a virtual board UI showing real-time locations of parts in a manufacturing facility are being displayed in accordance with some of the embodiments disclosed herein.

[0046] FIG. 12 is a flow chart diagram illustrating a work flow for locating parts in a manufacturing facility and presenting user interfaces showing the real-time locations of the parts in accordance with some of the disclosed embodiments.

DETAILED DESCRIPTION

[0047] Embodiments disclosed herein generally relate to systems, methods, devices, and computer storage media for presenting the locations of parts being wirelessly tracked throughout a manufacturing or service facility. Interactive UIs provide the real-time locations of the parts in the manufacturing or service facility and track the parts traveling through different work and sub-work areas of the facility. Some embodiments illustrate the locations of the tracked parts in a two- or three-dimensional “spatial” UI of the facility floor. Other embodiments provide a “virtual board” UI that displays the real-time locations of the parts organized according to the various work and/or sub-work areas of the facility.

[0048] The different UI views disclosed herein are interactive, in some embodiments, such that a user can interact with displayed representations of the individual parts to retrieve part-specific or order-specific information about the parts. Some embodiments link various work, manufacturing, and service orders to displayed representations of the parts in the different work or sub-work areas of the facility, providing an easy way for users to access specific details and job tasks related to the parts. For example, users may click on a UI element representing a specific part in a certain work or sub-work area to retrieve part identifiers, wireless beacon identifiers (discussed in more detail below), manufacturing or service orders, manufacturing or servicing tasks, or the like. Thus, the disclosed UIs provide workers with an integrated solution for seeing the current locations of parts in manufacturing or servicing facilities and relevant information for each part.

[0049] Parts may be tracked throughout the facility using the techniques, systems, methods, and computer-storage disclosed in the provisional patent application concurrently filed on Aug. 7, 2015, entitled “TRACKING PARTS IN MANUFACTURING AND SERVICE FACILITIES,” filed by the Applicant, and having the same inventor as this application. Additionally, some embodiments may use attached location tags to determine locations of parts, as disclosed the provisional patent application concurrently filed on Aug. 7, 2015, entitled “MONITORING PARTS IN A FACILITY,” filed by the Applicant, and having one joint inventor in common with this application. Both concurrently

filed provisional applications are incorporated herein by reference in their entirety for all purposes and are referenced herein collectively as the “Concurrently Filed Applications.”

[0050] One embodiment identifies and tracks parts in a facility using wireless beacons coupled to the parts. The wireless beacons transmit location signals as the parts move throughout the facility. Such an embodiment uses receiver devices strategically positioned in the facility and configured to wirelessly capture the location signals from the wireless beacons. The receiver devices transmit the received location signals over a network (e.g., the Internet or private network) to a server or client computing device that determines the real-time location of the parts in the facility.

[0051] The locations of the parts may be determined by the monitoring server or client computing device using the strengths of the location signals relayed by the receiver devices. Parts may be located in the various work areas and sub-work areas in the facility. One embodiment determines the work or sub-work area location of a particular part based on the receiver device—or multiple receiver devices—in the facility that captured the strongest signal(s) from a wireless beacon coupled to the part. Parts may be tracked through the facility by analyzing location signals subsequently transmitted by the wireless beacons—either periodically or upon detection of certain events (e.g., motion, acceleration, pressure, temperature, light, global positioning, rotation, rotational vector, or the like)—and relayed by the receiver devices to the monitoring server or client computing device.

[0052] Additionally, the historical locations of parts may be stored and analyzed to better understand the operational inefficiencies of a manufacturing or service facility, or to ascertain inefficiencies of individual workers. Some embodiments integrate the systems and techniques described herein with their electronic staffing record systems to determine how efficiently specialized workers are performing job tasks. The number of parts still needing to pass through various work areas may be used to forecast shipment completion dates, current work capacities, staffing productivity, and/or staffing needs. The amount of time parts stays in a welding working area may be tracked and associated with a welder's overall efficiency at welding a particular part.

[0053] The embodiments discussed herein may be implemented in various manufacturing, service, wholesale, and retail facilities. In one example, a manufacturing facility may use the various embodiments herein to track parts being assembled therein. In another example, a service facility may use embodiments disclosed herein to track parts being fixed, inspected, or otherwise serviced. In other examples, retail facilities may use the disclosed embodiments to track goods being stored or displayed. For the sake of clarity, instead of having to constantly mention all of the possible facilities throughout this disclosure, embodiments are discussed in a manufacturing facility to aid the reader with the understanding that such embodiments may equally be used in other types of facilities as well. Thus, the embodiments disclosed in a manufacturing facility may be used in a servicing facility, retail facility, wholesale facility, or other facility.

[0054] The manufacturing facilities discussed herein have separate work areas, and each work area may include one or more sub-work areas. As referred to herein, a “work area” is an area in a manufacturing facility in which a particular work operation is performed. Examples of work areas

include, without limitation, an intake area, a welding area, a machining area, an assembly area, a curing area, a painting area, a molding area, a programming area, a testing area, an inspection area, a shipping area, or any other area used to manufacture a completed part.

[0055] Work areas themselves may include one or more sub-work areas. For example, a welding area may include a holding sub-work area where parts needing to be welded are held, a welding sub-work area where welding is performed, an inspection sub-work area where welds are inspected, and an outtake sub-work area where welded parts are placed before moving to other areas. In another example, an assembly work area may include intake and outtake sub-work areas and several assembly sub-work areas where parts are attached along a manufacturing line. For instance, a first rotor may be moved to a first assembly sub-work area, the rotor is later fastened to a stator in a second assembly sub-work area, a second rotor is moved to a third sub-work area, and so forth. Additional examples of work areas and sub-work areas are too numerous to list here, and need not be exhaustively provided to understand the various embodiments disclosed. But it should at least be noted that embodiments may monitor the sub-work areas and the work areas to understand when parts are moving in and out of both.

[0056] Some of the embodiments disclosed herein track parts in a facility by their real-time locations in the various work areas and/or sub-work areas of a manufacturing facility. Additionally or alternatively, the historic locations of parts in various work areas and sub-work areas of a manufacturing facility may also be tracked. For example, one embodiment may track every work area and sub-work area through which a part has passed, and this historical location data about the part may be analyzed to determine specific bottlenecks in the manufacturing process, estimate delivery times of orders, forecast facility capacity, or determine other useful metrics related to the manufacturing or servicing facility.

[0057] Work areas and sub-work areas may all be contained within one facility (in some embodiments) or may be contained within multiple structures (in other embodiments). Even when contained in a single facility, the work areas may be included on different floors, in different rooms, or in various separated areas of the structures. For example, welding and assembly of parts may take place on a large shop floor. Whereas, parts may be received at an intake area in a separate room of the facility, or in an entirely other building structure of the facility. In another example that tracks parts across multiple structures, assembly and welding of a part may occur in a facility in Fort Worth, Tex., but the part may be programmed in another facility in Ipswich, Mass. The tracking techniques used herein may be configured to monitor the part in both facilities. Thus, embodiments disclosed herein may be used to track parts through a single structure, at different structures, or through separate rooms and floors of structures.

[0058] Any part in a manufacturing, service, wholesale, or service facility may be tracked using the various techniques and devices disclosed herein. Some specific embodiments focus on the tracking of parts in the oil-and-gas, power, mineral-extraction, and similar industries of manufacturing. Example parts that may be tracked in a manufacturing facility using the embodiments disclosed herein include, without limitation: fluid ends, swivels, joints, manifold trailers, valves, hoses, conduits, safety iron, safety hammers,

dart valves, plug valves, clapper check valves, pressure relief valves, emergency unloading valves, gate valves, subsea dosage valves, hydraulic valves, valve seats, butterfly valves, steadseal valves, hyperseal valves, Polytetrafluoroethylene-lined valves, swingthrough valves, rubber-sealing and rubber-line valves, fire safe valves, swing and lift check valves, T-pattern globe valves, Y-pattern globe valves, three-way globe valves, compressor check valves, cold reheat check valves, cold heat check valves, testable check valves, reverse current valves, parallel slide valves, gate valves, safety valves, safety relief valves, isolation valves, relief valves, mounted-ball valves, ball valves, diaphragm valves, butterfly valves, gate and globe valves, check valves, lift check valves, swing check valves, steam isolation valves, feedwater isolation valves, integrated safety valves, single-stage turbines, multi-stage turbines, hydraulic turbines, pump turbines, quad-runner turbines, gear operators, pneumatic actuators, pressure control panels, lifting clamps, flow line safety restraints, chokes, drop ball injectors, pumps, blowout preventers, gas separators, overshot connectors, wellheads, frac pumps, manifold systems, fluid end systems, slurry pumps, water pumps, subsea pumps, premix tanks, frac trees, swellable packers, manifold skids, tubing heads, wellheads, rod rotators, stuffing boxes, casing heads, tubing heads, control valves, positive displacement pumps, hydrocyclones, dewatering pumps, vortex pumps, trailers, conveyors, screening machines, material handling machines, communiton machines, feeders, crushers, modular plants, barges, and any other additional manufactured or serviced parts. A part as listed herein can refer to individual parts or components of an assembled product. For example, a part may be a larger assembly or parts therefore; for example, but not limitation, a pump, a machine, a plant, means the larger assembly or the individual parts comprising the larger assembly. Though such a list is lengthy, it is not exhaustive. Other parts in manufacturing facilities may alternatively be tracked using the embodiments disclosed herein.

[0059] To aid the reader, a running example is discussed throughout this disclosure of wireless beacons being coupled to a “valve body,” which is one constituent part of a valve that, when combined with other constituent valve parts (e.g., a disc, a hand wheel, an actuator, a shaft, a cover, etc.) forms an assembled valve. Other parts—including those previously stated, equivalents thereof, or other manufactured or serviced parts—may be tracked in a manufacturing facility using the systems and techniques described herein. For the sake of clarity, however, an exemplary valve body is referred to throughout this disclosure as a part to further illuminate some of the disclosed embodiments.

[0060] Embodiments disclosed herein may generally be described in the context of computer-executable instructions, such as program modules, executed by one or more computing devices in software, firmware, hardware, or a combination thereof. The computer-executable instructions may be organized into one or more computer-executable components or modules. Generally, program components and modules include, but are not limited to, routines, programs, objects, components, and data structures that perform particular tasks or implement particular abstract data types. Aspects of the disclosure may be implemented with any number and organization of such components or modules. For example, aspects of the disclosure are not limited to the specific computer-executable instructions or the specific components or modules illustrated in the figures and

described herein. Other examples of the disclosure may include different computer-executable instructions or components having more or less functionality than illustrated and described herein. Moreover, in examples involving a general-purpose computer, aspects of the disclosure transform the general-purpose computer into a special-purpose computing device when configured to execute the instructions described herein.

[0061] Having briefly described an overview of some of the disclosed embodiments and generally defined various terminology used throughout this disclosure, the accompanying figures and corresponding disclosure below describe additional aspects of some of the embodiments disclosed herein. The following figures are provided merely to illustrate aspects of some of the disclosed embodiments and are not meant to limit all embodiments to any particular configuration of sequence of steps. Also, technically equivalent configurations, facilities, and work flows will be readily apparent to those skilled in the art in light of this disclosure. Such equivalent designs are fully contemplated by this disclosure.

[0062] FIG. 1 illustrates a block diagram of a wireless beacon 100, according to one embodiment. The wireless beacon 100 includes a processor 102, memory 104, a receiver 106, a transmitter 108, a power supply 110, and one or more sensors 112 that collectively function to transmit wireless location signals for use in identifying a particular part's location. The illustrated components of wireless beacons 100 may be encapsulated in a casing made of plastic, rubber, metal, or other type of material that protect the electronic components of the wireless beacon 100 from damage inside the manufacturing facility. Although the various blocks of FIG. 1 are shown with lines for the sake of clarity, in reality, delineating various components is not so clear, and metaphorically, the lines would more accurately be blurry. For example, processor 102 may have internal memory. The inventors hereof recognize that such is the nature of the art and reiterate that the diagram of FIG. 1 is merely illustrative of an exemplary wireless beacon that can be used in connection with one or more of the disclosed embodiments. Moreover, alternative embodiments may include additional components or may not include some of the illustrated components, and equivalents of the various components will be readily apparent to those of skill in the art.

[0063] Processor 102 may include one or more microprocessors, microcontrollers, arithmetic logic units (ALUs), integrated circuits (ICs), application-specific ICs (ASICs) or chips, systems on chip (SoC), or other processing units configured to instruct transmission of wireless location signals according to the techniques and methods disclosed herein. In one embodiment, processor 102 comprises a Bluetooth-branded chip or circuit (e.g., a Bluetooth low energy (LE) or other Bluetooth Smart version chip) capable of selectively broadcasting low-powered wireless signals based on data detected by various sensors 112.

[0064] The wireless beacon 100 transmits location signals to receiver devices using the transmitter 108. In one embodiment, the transmitter 108 comprises a Bluetooth-branded transmitter capable of transmitting controlled-range wireless transmissions. Such a transmitter may specifically use a Bluetooth LE (e.g., Bluetooth version 4.x) or a Bluetooth Smart transmitter capable of transmitting wireless signals at further piconet distances and at lower peak, average, and

idle mode power consumption than legacy Bluetooth transmitters. Other embodiments may use legacy Bluetooth transmitters (e.g., Bluetooth versions 1.x, 2.x, 3.x, etc.).

[0065] When using Bluetooth for wireless transmissions, transmitter **108** may use a Bluetooth antenna to transmit location signals, or other messages, on a radio channel that regularly changes frequency (i.e., hops) according to a predetermined code. For example, transmitter **108** may include a Bluetooth transmitter that transmits in the unlicensed industrial, scientific, and medical (ISM) band at or about at 2.4 to 2.485 GHz, using a spread-spectrum frequency-hopping full-duplex signal at a nominal rate at or about 1600 hops/sec. Frequency hopping may occur across about 79 frequencies at or about at 1 MHz intervals, in some embodiments. Other embodiments may use various other adaptive frequency hopping (AFH) techniques.

[0066] Receiver devices, which are disclosed in more detail in the Concurrently Filed Application, may be configured to receive signals along the same frequencies as those used by the transmitter **108**. For example, a receiver device may tune to the same transmission frequencies and hopping schemes being used by the transmitter **108**, enabling the receiver device to listen to the appropriate frequency at the appropriate time to receive data packets of location signals.

[0067] In other embodiments, the transmitter **108** comprises a Zigbee-branded transmitter to wirelessly transmit location signals to receiver devices. In such embodiments, the transmitter **108** operates on the physical radio specification of the Institute of Electrical and Electronics Engineers (IEEE) 802.15.4 standard and transmits in the unlicensed bands at or about at 2.4 GHz, 900 MHz, and 868 MHz. In other embodiments, the transmitter **108** wirelessly transmits location signals according to the IEEE 802.11 Wi-Fi standard. In such embodiments, the transmitter **108** operates on or about on the 2.4 GHz or 5 GHz ISM radio frequency bands. The transmitter **108** may alternatively be configured to transmit location signals using various other wireless protocols, e.g., without limitation, WirelessHD, WiGig, Z-Wave, and the like. Receiver devices may be tuned accordingly to listen for data packets along corresponding frequency bands used by the aforesaid communications protocols.

[0068] Additionally or alternatively, transmitter **108** may take the form of active or semi-passive radio frequency identification (RFID) transmitters, in some embodiments. Using active or semi-active RFID transmitters, transmitter **108** may wirelessly broadcast at a variety of frequencies, e.g., without limitation, at low frequency bands of or about 125/135 kHz, relatively high frequency bands (when compared to the low frequency band) of or about 13.56 MHz, and relatively ultra-high frequency bands (when compared to the low and high frequency bands) of or about 850-950 MHz. Receiver devices may be tuned accordingly to listen for data packets along corresponding frequency bands used by the aforesaid communications protocols.

[0069] The receiver **106** is capable of receiving data, either wirelessly through any of the aforementioned wireless communication protocols or through a wired connection. In one embodiment, the receiver **106** receives a part identifier (ID) **116** for the part coupled to the wireless beacon **100**, allowing the wireless beacon **100** to locally store the part ID **116** in memory **104**. Locally storing the part identifier (ID) **116** in memory **104** allows the wireless beacon to include the part

identifier in location signals that are wirelessly transmitted to receiver devices. Not all embodiments will communicate part identifiers **116** in location signals, however. Some embodiments will instead broadcast location signals that include a standard data value or code word, an identifier of the wireless beacon (beacon ID **114**) stored in memory **104**, or a combination thereof—either with or without the part (ID) identifier **116**.

[0070] In one embodiment, wireless beacon **100** is programmed with the part ID **116** at a programming work station in the facility. Parts may be paired with wireless beacons using programming devices that communicate the part IDs **116** to the wireless beacons **100** for storage thereon. When the part leaves the facility, the wireless beacon **100** may be removed from the part and returned to a storage container until the wireless beacon is paired again with another part by being programmed with that part's part ID **116**. In this sense, the wireless beacons **100** are reusable and can be repeatedly be used to track different parts coming through the facility.

[0071] Wireless beacon **100** includes a variety of computer-readable media, which are represented in FIG. 1 as memory **104**. Computer-readable media include computer-storage memory and communication media. By way of example, and not limitation, computer-storage memory may comprise Random Access Memory (RAM); Read Only Memory (ROM); Electronically Erasable Programmable Read Only Memory (EEPROM); flash memory or other memory technologies; solid-state memory; hard drives; compact disks (CDs); digital versatile disks (DVDs) and other optical or holographic media; magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices; or any other memory that can be used to encode desired information and be accessed by wireless beacon **100**.

[0072] Computer-storage media may include volatile, nonvolatile, removable, and non-removable computer-storage memory implemented in any method or technology for storage of information including, without limitation, computer-readable instructions, data structures, program modules, data types, dynamic link libraries (DLLs), application programming interfaces (APIs), or other data. Computer-storage media are tangible, mutually exclusive to communication media, and exclude carrier waves and propagated signals. For purposes of this disclosure, computer-storage media are not signals per se. In contrast, communication media typically embody computer readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism and include any information delivery media.

[0073] Computer-storage memory **104** represents computer-storage media on the wireless beacon **100**. In operation, the processor **102** reads data and/or executes computer-executable instructions stored in memory **104**. Memory **104** may also store a beacon identifier (ID) **114** indicative of the wireless beacon **100** and a part ID **116** indicative of the part to which the wireless beacon **100** is attached, affixed, paired, or coupled. The beacon ID **114** is a unique alphanumeric value, e.g., a codeword, beacon number, a media access control address (MAC), or other type of identifier unique to the wireless beacon **100**. The part ID **116** is also a unique alphanumeric value that may include a part number, PO

number, customer identifier, shipping number, part description, MAC address, or other type of identification of the coupled part.

[0074] Memory 104 stores a signal component 118 that comprises executable instructions dictating when to transmit location signals from the wireless beacons 100 using the transmitter 108. In one embodiment, signal component 118 selectively instructs the processor 102 to transmit location signals upon detected incidents or events, as sensed by one or more hardware or software sensors 112 on the wireless beacon 100. In another embodiment, signal component 118 instructs the processor 102 to periodically transmit location signals at specific time periods (e.g., every 25 milliseconds, 30 seconds, 5 minutes, 1 hour, etc.); at certain times of the day (8:00 am, noon, 2:00 pm, etc.); on particular days (e.g., Monday, Thursday, etc.); or a combination thereof. In still another embodiment, the wireless beacon 100 may be equipped with a user-interface (e.g., physical button, keypad, etc., joystick, etc.) that allows a user to prompt the transmission of location signals. For instance, a detected specific user interaction (e.g., pushing of a button) by the signal component 118 prompts transmission of location signals. The signal component 118 may be configured to transmit location signals based on input from any of the illustrated sensors 112 or from a combination of signals from the sensors 112. Along these lines, some embodiments may only include one or some combination of the illustrated sensors 112.

[0075] Sensors may include an accelerometer 120, a magnetometer 122, a pressure sensor 124, a photometer 126, a thermometer 128, a GPS sensor 130, a gyroscope 132, a rotational vector sensor 134, additional sensors, or a combination thereof. Some of the sensors 112 may be combined into a single sensor chip. For example, the accelerometer 120 may be combined with the magnetometer 122, the pressure sensor 124 may be combined with the thermometer 128, the gyroscope 132 may be combined with the rotational vector 134, etc. Predicating location-signal transmissions on the sensed inputs can drastically reduce overall power consumption because the wireless beacons 100 only transmit signals—and thus wake up—at particular detected events. In such embodiments, an operating system of the wireless beacon is kept inactive (i.e., sleeps) until a sensor detects a particular threshold event (e.g., movement, acceleration, temperature, light, pressure, rotation, GPS, etc.), at which time the operating system is woken up and location signals are transmitted. This saves considerable battery power in the wireless beacons 100. Wireless beacons 100 can mostly stay in a disabled state until being woken up by a sensor 112 sensing a particular threshold, event, or incident requiring transmission of a location signal.

[0076] Looking at the sensors 112 depicted, the accelerometer 120 captures the acceleration force of the wireless beacon 100 in the x, y, and/or z directions. In one embodiment, signal component 118 is configured to transmit location signals upon the detection of any sensed acceleration. Transmitting in such a manner may consume significant power resources, however, because the wireless beacon 100 and its coupled part may be stored in a container that is frequently jostled, bumped into, or otherwise moved at times when the part is not being transferred throughout the manufacturing facility. Therefore, some embodiments will wait until the accelerometer 120 measures a certain threshold of acceleration or movement before transmitting the location

signals. For example, movement of 1 ft/s² or 0.3 m/s² may need to be reached before the signal component 118 instructs location signals to be transmitted.

[0077] Additionally, the direction of acceleration or movement detected by the accelerometer 120 may also be taken into account by the signal component 118 when determining when to transmit location signals. Acceleration or movement in one or more directions (e.g., x, y, or z direction, or a combination thereof) may be weighted by the signal component 118 in order to give more or less deference to a particular direction, or directions, as conditions used to base transmissions of location signals. For example, acceleration in the z direction may be weighted differently than acceleration in the x or y directions, because the z direction may be more likely to indicate that a part is being lifted out of a bin in one work area or sub-work area and will likely be transferred to another. In another example, movement in the z direction may be discounted when compared to movement in the x and y directions, as movement up and down may likely be inconsequential as an indicator of whether a part is moving to a different work area or sub-work area. Any of the directions (x, y, or z) may be weighted account for different parts, movements, or facilities.

[0078] The magnetometer 122 may take the form of a low-powered vector or total-field magnetic sensor capable of detecting magnetic fields either in aggregate or in two or three dimensions. Examples of magnetic sensors that may be used include, without limitation, a Hall effect sensor, a giant magnetoresistance (GMR) sensor, a magnetic tunneling junction (MTJ) sensor, an anisotropic magnetoresistance (AMR) sensor, and a Lorentz force sensor. In operation, the signal component 118 may be configured to transmit location signals when the magnetometer 122 senses a threshold magnetic field, either in the aggregate or in particular directions, thereby indicating the wireless beacon 100 is within a particular proximity (e.g., 0.5, 1, 3, etc. feet or meters) to a specific magnetic structure (e.g., metallic beam) or electromagnetic device (e.g., receiver device).

[0079] The threshold level of sensed magnetism necessary for the signal component 118 to transmit location signals may be correlated to the distance such structures or receiver devices are from the wireless beacon 100. For example, the signal component 118 may only transmit location signals when a field of more than 4 Gauss is sensed, because a 4 Gauss field correlates to a particular distance of a specific structure or device in the manufacturing facility. Alternatively, to avoid false positives when the part is moving, a time element may be factored when using readings from the magnetometer 122 such that a threshold level of magnetism must be detected for threshold period of time (e.g., 5 seconds, 1 minute, 1 hour, etc.) to trigger the transmission of location signals.

[0080] The pressure sensor 124 detects pressures, and the thermometer 128 detects temperature. In particular, the pressure sensor 124 may take the form of a transducer, a capacitance-type sensor, micromachine silicon (MMS) sensor, microelectromechanical system (MEMS) sensor, a chemical vapor deposition (CVD) sensor, or other type of sensor capable of detecting pressure. Pressure and temperature may differ in various work and sub-work areas. For instance, welding and curing work areas may be relatively hotter than assembly areas. So the signal component 118

may be configured to transmit location signals based on sensed temperature and/or pressure being or temperature/pressure changes.

[0081] A photometer 126 may be used to detect light intensity or other optics. Photometer 126 may include one or more photoresistors, photodiodes, photomultipliers, or other types photo-voltaic components capable of measuring one or more light properties, including, for example but without limitation: light illuminance, irradiance, absorption, scattering, reflection, fluorescence, phosphorescence, luminescence. In one embodiment, the signal component 118 transmits location signals based one or more detected light properties. In one specific embodiment, different light sources or signs having particular light reflective properties may be positioned throughout the manufacturing facility in an attempt to delineate different work or sub-work areas. The photometer 126 may be configured to continually or periodically detect light properties, and provide detected light properties to the signal component 118 for evaluation.

[0082] A GPS sensor 130 may be used to detect the location and movement of the wireless beacon 100. The GPS sensor 130 may include its own integrated antenna along with various filters, radio frequency shields, and internal processor. In operation, the GPS sensor 130 detects x and y coordinates, and the signal component 118 can, in turn, use such coordinates to locate and track movement of the wireless beacon 100.

[0083] A gyroscope 132 may be used to detect movement through gyroscopic rotation (e.g., roll, pitch, and yaw) and the speed of movement. The gyroscope 132 may work alone or in conjunction with the accelerometer 120 to determine the acceleration or speed of movement of the wireless beacon 100. Acceleration and speed of movement may be considered by the signal component 118 when determining when to transmit location signals.

[0084] The orientation and location of the wireless beacon 100 may alternatively or additionally be sensed using a rotational vector sensor 134. The rotational vector sensor 134 may be configured to detect rotational vector components along the x, y, and/or z axes, calculating the orientation of the wireless beacon 100 as a combination of an angle (θ) around an axis (x, y, z). For example, the rotational vector components may be calculated in the following manner:

$$\text{Vector}(x)=x*\sin(\theta/2)$$

$$\text{Vector}(y)=y*\sin(\theta/2)$$

$$\text{Vector}(z)=z*\sin(\theta/2)$$

Where the magnitude of the rotation vector is equal to $\sin(\theta/2)$, and the direction of the rotation vector is equal to the direction of the axis of rotation. These three vector components may be used by the rotational vector sensor 134 to determine the orientation and location of the wireless beacon 100, and the signal component 118 may use the determined orientation and location of the wireless beacon 100 to determine when to transmit location signals.

[0085] In one embodiment, the signal component 118, when executed by the processor 102, additionally or alternatively adds sensor data to the location signals that are wirelessly broadcast. For example, direction or acceleration information from the accelerometer 120, magnetic field data from the magnetometer 122, pressure readings from the pressure sensor 124, light data from the photometer 126, temperature readings from the thermometer 128, GPS coordinates

from the GPS sensor 130, gyroscopic rotation from the gyroscope 132, and rotational vector magnitudes from the rotational vector sensor 134 may be included in the location signals from the wireless beacon 100. The wireless beacon 100 may transmit various sensor data—either collected at the time the wireless beacon 100 is woken up, historically, or periodically—along with the beacon ID 114, part ID 116, or a combination thereof to the receiver devices discussed below.

[0086] The power supply 110 may take the form of a battery, which is either rechargeable or not. Some embodiments may include power monitoring circuitry or software that, when executed by the processor 102, determines the power level of the power supply. Indications of such power levels may be wirelessly communicated from the transmitter 108 using any of the aforementioned wireless communication protocols and techniques to either a receiver device, a client computing device, or a server.

[0087] To preserve power supply 110, embodiments may selectively transmit location signals from the wireless beacon 100 only when certain events are detected by one or more sensors 112. Embodiments may include only one of the illustrate sensors 120-134 or a combination thereof. The processor 102 may be programmed to process data sensed by the various sensors 112 and consequently initiate the broadcasting or transmitting of location signals when particular conditions are sensed. Location signals may be transmitted either synchronously according to an internal clock (e.g., at a time frequency of or about 60 Hz) or asynchronously.

[0088] FIG. 2A is an exploded-view diagram of a valve 200 with a wireless beacon 100 coupled to one of the valve's constituent parts, according to one embodiment. Valve 200 comprises a valve body 202, an hand wheel 204, an actuator 206, a shaft 208, and a valve disc 210. The valve body 202, hand wheel 204, actuator 206, shaft 208, and valve disc 210 are machined, welded, and assembled in a manufacturing facility into valve 200. The wireless beacon 100 may be coupled to the valve body 202 in any number of ways. For example, the wireless beacon 100 may be tied to the valve body 202; affixed with an adhesive; attached with bands (e.g., plastic, metallic, rubber, etc.), ties, ropes, strings, clasps, hooks, Velcro, magnets, clips, fasteners; placed in a container, bag, pocket, bin, or other receptacle that travels with the valve body 202 throughout the manufacturing facility; or otherwise coupled to the valve body 202.

[0089] The illustrated valve 200 is only shown with one constituent part—the valve body 202—having a coupled wireless beacon 100. As shown in FIG. 2B, wireless beacons 100 may be coupled to all the constituent parts of the valve 200, i.e., the valve body 202, the hand wheel 204, the actuator 206, the shaft 208, the valve disc 210, or any particular constituent parts needing to be tracked.

[0090] FIG. 3 is a client computing device 300 configured to present locations of parts in a manufacturing facility, according to one embodiment. The client computing device 300 is associated with one or more users 302 and represents a system for presenting interactive UIs depicting or otherwise presenting real-time location information of the parts in the manufacturing facility. The client computing device 300 represents any device executing instructions (e.g., as application programs, operating system functionality, or both) to implement the operations and functionality associated with the client computing device 300 disclosed herein. The client

computing device **300** may include a personal computer, laptop, mobile phone, mobile tablet, smart television, projector, portable media player, or other type of computing device. Additionally, the client computing device **300** may represent a group of interconnected or communicatively connected computing devices, e.g., a computer connected to a projector, a smart phone wirelessly communicating with a television, or the like.

[0091] The client computing device **300** has at least one processor **304**, memory **306**, and input/output ports **308**. The processor **304** may include any quantity of processing units programmed to execute computer-executable instructions for presenting the interactive UIs disclosed herein. In some embodiments, the processor **304** is programmed to execute instructions such as those illustrated in the flowchart figure of this disclosure.

[0092] Memory **306** may include any of the aforementioned computer-storage media and, in one embodiment, stores executable instructions for an operating system **310**, a communications interface component **312**, a user interface component **314**, a part tracking component **316**, a virtual board component **318**, and a spatial map component **320**. The depicted computer-executable instruction components **310-318** are executable by the processor **304** to perform various functions and may include different hardware or firmware for execution—e.g., graphics cards, network cards, etc.

[0093] The operating system **310** controls the executable environment of the client computing device **300**. Specific to the embodiments discussed herein, the operating system **310** may include one or more rendering programs for displaying UIs on an attached presentation device **306**, which may take the form, in some embodiments, of a computer display, television, projector, or other presentation component. Additionally or alternatively, the operating system **310** may control the look and display of various UIs tracking the locations of parts in the manufacturing facility.

[0094] The communications interface component **314** includes a network interface card and/or computer-executable instructions (e.g., a driver) for operating a network interface card that provides access over a public or private network. Communication between the client computing device **300** and other devices (e.g., receiver device, monitoring server, database cluster) over a public or private network may occur using any protocol or mechanism over any wired or wireless connection. In some examples, the communications interface is operable with short-range communication technologies, such as by using near-field communication (NFC) tags, BLUETOOTH brand communications tags, or the like. Examples of network transfer protocols include, for example but without limitation, the hypertext transfer protocol (HTTP), file transfer protocol (FTP), simple object access protocol (SOAP), or the like. Requests and responses may be passed as different markup language messages—e.g., extensible markup language (XML), hypertext markup language (HTML), or the like—or as parameters for scripting languages. One skilled in the art will appreciate that numerous scripting languages may be used by different distributed applications, a list of which, while not exhaustive, includes JAVASCRIPT brand scripts, personal home page (PHP), or the like. Examples are not limited to any particular communication protocol, message language, or scripting language, as one skilled in the art will

appreciate that different languages and protocols may be used to interact with distributed applications.

[0095] The user interface component **314** includes a graphics card and a corresponding graphics-card driver for displaying data to the user and receiving data from the user. The user interface component **314** may also or alternatively include a display (e.g., a touch screen display or natural user interface) and a corresponding driver operating the display. The user interface component **314** may also include one or more of the following to provide data to the user or receive data from the user: speakers, a sound card, a camera, a microphone, a vibration motor, one or more accelerometers, a Bluetooth-compatible communication module, GPS circuit, and a photoreceptive light sensor.

[0096] Parts in a manufacturing facility may be tracked by the client computing device **300** (in some embodiments) or the monitoring server **400** shown in FIG. 4 (in alternative embodiments). When tracked by the client computing device **300**, memory **306** includes the part tracking component **314**, which, in operation, analyzes location signals received from the wireless beacons **100** to determine the work areas and sub-work areas of the manufacturing facility where corresponding parts are located. In one embodiment, the part tracking component **314** determines the locations of wireless beacons **100**, and their thus coupled parts, by analyzing the strength of the location signals received at different receiver devices, as described in the Concurrently Filed Application. Additionally or alternatively, in some embodiments, the part tracking component **316** determines wireless beacon **100** locations using the triangulation techniques described in the Concurrently Filed Application. Other embodiments may locate the wireless beacons **100** and their coupled parts in the manufacturing facility using values captured by the sensors **112**, e.g., GPS; acceleration; movement; x, y, or z coordinates; rotational vectors; temperatures; pressures; etc.

[0097] One embodiment displays the locations of parts tracked in the manufacturing facility in a “virtual board” UI showing the parts located in the current work areas or sub-work areas of the facility. For example, one particular embodiment may display five different work areas (e.g., receiving, welding, machining, assembly, shipping) along with the currently detected locations of parts being detected in those five different areas. As the parts move through the manufacturing facility to new work or sub-work areas, the coupled wireless beacons **100** of the parts broadcast new locations signals that are analyzed by the part tracking component **316** tracking part locations, and the virtual board UI is updated to show the moving or moved parts being in the new work or sub-work areas. For example, if a valve body **202** is moved from the holding area of a machining work area to the holding area of a welding work area, the virtual board component **318** accordingly depicts the new location of the valve body in the holding sub-work areas of the welding work area. An example of such a virtual work board UI is depicted in FIG. 9 of this disclosure and discussed in more detail below.

[0098] Another embodiment displays the locations of parts tracked in the manufacturing facility in a two- or three-dimensional “spatial” UI presentation. In one embodiment, detected wireless beacons **100** are displayed in real time in the spatial UI presentation, as are the various work or sub-work areas. For example, one particular embodiment may display a three-dimensional rendition of the manufac-

turing facility showing five different work areas (e.g., receiving, welding, machining, assembly, shipping) along with the currently detected locations of parts being detected in those five different areas. As the parts move through the manufacturing facility to new work or sub-work areas, the wireless beacons **100** of the parts broadcast new locations signals that are analyzed by the part tracking component **316** tracking the part locations, and the spatial UI is updated to show the moved parts being in the new work or sub-work areas. For example, if a valve body **202** is moved from the holding sub-work area of a welding work area to the holding area of an assembly work area, the spatial map component **320** accordingly depicts the new location of the valve body in the presented representation of the manufacturing facility. Examples of such spatial UIs are illustrated in FIGS. 7 and 8 of this disclosure.

[0099] I/O ports **308** allow client computing device **300** to be logically coupled to a presentation device **306**. Presentation device **306** may include, without limitation, a computer monitor, glasses, a projector, a mobile tablet, virtual surface, a television, or the like. In one particular embodiment, the client computing device **300** projects the virtual board and spatial map UIs onto screens or walls using one or more projectors in an administrative office. Administrative and managerial workers can then see the real-time locations of parts in the manufacturing facility in the virtual board or spatial UIs. The UIs described herein may also be made accessible over a public network (e.g., the Internet), allowing workers to view the virtual board or spatial UIs on a web page or otherwise see them remotely.

[0100] FIG. 3 depicts embodiments where the virtual board component **318** and spatial map component **320** are maintained and executed on a client computing device **300**. Alternative embodiments may process the virtual board UI or spatial UI on a server that is accessible to the client computing device **300** over a network. Such an embodiment is illustrated in FIG. 4, which shows a block diagram of a

[0102] The processors **402** include one or more microprocessors, microcontrollers, graphic processing units (GPUs), ASICs, ICs, ALUs, or the like. I/O ports **406** allow monitoring server **400** to be logically coupled to various I/O peripherals **408**. I/O peripherals **408** may include a host of different input and output presentation devices, including, for example without limitation, a display device (e.g., computer monitor, projector, touch screen display, television, glasses, virtual surface, etc.), speaker, printer, vibrating component, microphone, speaker, a microphone, a joystick, a satellite dish, a scanner, a remote control, a graphical user interface (GUI), wearable (e.g., watches, glasses, headsets, or earphones), or the like. In one particular embodiment, the I/O peripherals **408** include connectivity to a video projector or display monitor configured to present real-time information about the location of parts in the manufacturing facility, as determined by a part location component **414** analyzing location signals **412** received from the receiver devices.

[0103] In one embodiment, memory **404** stores computer-executable instructions comprising an operating system **410**, stored location signals **412** originating from the wireless beacons **100** coupled to parts in the manufacturing facility, the part location component **414**, a receiver device map component **416**, a virtual board component **418**, and a spatial map component **420**. The operating system **410** controls the software computational environment of the monitoring server **400**. Various server-focused operating systems **410** may be used.

[0104] In one embodiment, as disclosed in the Concurrently Filed Application, location signals **412** are wirelessly communicated from the wireless beacons **100** to receiver devices in the manufacturing facility, and the receiver devices transmit the location signals—either with or without identifiers specific to the receiver devices themselves—over a network to the monitoring server **400**. Table 1 below provides exemplary data attributes that may be communicated by the receiver device to the monitoring server **400**:

TABLE 1

Date	Time	Signal Strength	Beacon ID	Part ID	Receiver Device ID
July 13, 2015	2:15:36 pm	2.2 dBmW	MM:MM:MM:SS:SS:SS	1234567890	10003
July 13, 2015	2:15:37 pm	0.5 dBmW	MM:MM:MM:SS:SS:SS	1234567890	10001
July 13, 2015	2:15:38 pm	3.0 dBmW	MM:MM:MM:SS:SS:SS	1234567890	10002
July 13, 2015	2:25:39 pm	7.3 dBmW	ZZ:YY:AA:BB:CC:DD	4567890123	10001
July 13, 2015	2:45:45 pm	1.1 dBmW	AA:BB:CC:DD:EE:FF	5678901234	10001

monitoring server **400** configured to track parts in a manufacturing facility and provide the interactive UIs disclosed herein to client computing devices **300**. Still other embodiments may process the virtual board and spatial UIs in a hybrid client-server model, with an applet on the client computing device **300** processing the UI display elements and a servlet on a server processing locations of the parts in the manufacturing facility.

[0101] Looking closer at FIG. 4, the monitoring server **400** includes one or more processors **402**, computer-storage memory **404**, input/output (I/O) ports **406**, and I/O peripherals **408**. While the illustrated monitoring server **400** appears to be a single physical device, the shown embodiment may actually operate across a plurality of physical devices—e.g., multiple servers in a relational server configuration.

Knowing the signal strength of the location signals at the receiver devices allows some embodiments to determine the closest receiver device in the manufacturing facility to the wireless beacons **100** and their coupled parts. For example, receiver devices capturing location signals at lower strengths can be considered to be further away from broadcasting wireless beacons **100**—and their coupled parts—than receiver devices capturing stronger location signals. In some embodiments, the low-powered transmissions from the wireless beacons **100** dissipate over distance, allowing the monitoring server **400** to correlate the distance that the wireless beacons **100** are from the receiver devices to the strengths of location signals.

[0105] The location signals **412** received and stored on the monitoring server **400** may include data transmitted from either the wireless beacons **100** and/or the receiver devices,

e.g., part ID, beacon ID, time, date, MAC address, code-word, signal strength, receiver device ID, etc. In one embodiment, the part location component **414** determines the location of parts in the manufacturing facility based on the received location signals **412** and a map of the different work areas and/or sub-work areas in the manufacturing facility generated by the receiver device map component **416**. The receiver device map component **416** generates a map of the various work areas and sub-work areas, in one embodiment, based on the strategic placement of the receiver devices in the manufacturing facility. Receiver devices may be placed within a certain proximity to the different work and sub-work areas, and each receiver device can be assigned a particular work or sub-work area. For example, one receiver device may be assigned to the holding sub-work area of a welding work area, another receiver device may be assigned to a machining area's completed sub-work area, and another receiver device may be assigned to a shipping work area. Thus, users may define the various work and sub-work areas of the manufacturing facility through strategic placement of the receiver devices.

[0106] The map maintained by the receiver device map component **416** may include an x/y coordinate mapping of the manufacturing facility with various portions assigned to different work and sub-work areas. Receiver devices may be assigned to the different portions of the x/y coordinate mapping and work/sub-work areas. In one embodiment, receiver devices are mapped to the x/y coordinates in a one-to-one manner, meaning that each coordinate may be assigned to just one receiver device. Alternative embodiments map x/y coordinates of the map on a one-to-many basis such that coordinates are assigned to more than one receiver device. Each receiver device can then be assigned to a specific work area or sub-work area. For instance, considering the example illustrated in Table 1 above, the receiver device **300** with receiver device ID 10001 may be assigned to a welding work holding sub-work area, the receiver device **300** with receiver device ID 10002 may be assigned to a completed assembly sub-work area, and the receiver device **300** with receiver device ID 10003 may be assigned to a shipping work area.

[0107] In operation, the part location component **414** uses the location signals **412** to identify in real-time the work area and/or sub-work area in the manufacturing facility where the parts are located. To do so, the part location component **414** may determine the closest receiver devices to the wireless beacons **100** and assign the parts associated with the wireless beacons **100** to work areas and/or sub-work areas associated with the nearest receiver devices—as identified by the x/y coordinate mapping maintained by the receiver device map component **416**. The nearest receiver devices may be identified by analyzing the strength of the location signals **412** for a particular wireless beacon captured by multiple receiver devices **300** at or within a given time window (e.g., 30 ms, 1 s, 1 minute, etc.).

[0108] Multiple receiver devices may capture location signals being broadcast by a wireless beacon **100**. For example, considering Table 1 again, three of the receiver devices identified by receiver device IDs 10003, 10001, 10002 captured location signals from the same wireless beacon **100** having beacon ID MM:MM:MM:SS:SS:SS at varied signal strengths 2.2 dBmW, 0.5 dBmW, and 3.0 dBmW, respectively. In one embodiment, the part location component **414** determines that the 10002 receiver device is

closest to the MM:MM:MM:SS:SS:SS wireless beacon **100** due to the relatively high signal strength of the location signal captured by the 10002 receiver device **300**. Going a step further, the part location component **414** may then associate the MM:MM:MM:SS:SS:SS wireless beacon **100** as being located in a particular work area and/or sub-work area assigned to the 10002 receiver device in the map of the different work areas and/or sub-work areas maintained by the receiver device map component **416**.

[0109] In another embodiment, the part location component **414** uses the two, three, or more signal strengths to triangulate the location of the MM:MM:MM:SS:SS:SS wireless beacon **100** using, for example, the techniques discussed below in reference to FIG. 7. Once the location is triangulated, the part location component **414** may identify the closest assigned receiver device **300** to the triangulated location of the MM:MM:MM:SS:SS:SS wireless beacon **100** and identify corresponding work areas and/or sub-work areas in the receiver device **300** map maintained by the receiver device map component **416**. Another embodiment generates the UIs on a client computing device **300** and receives updates of part locations from the monitoring server **400**.

[0110] Also, in some embodiments, the location signals of the wireless beacons **100** include sensor data from the sensor(s) **112** of the wireless beacon **100**. The part location component **414** may use the sensor data (or the absence of sensor data) in the location signals to determine the location in the facility of the wireless beacon **100**—and its coupled part. For example, a particular temperature reading captured by the thermometer **128** may be used by the part location component **414** of the monitoring server **400** to determine that the wireless beacon **100** is in a welding work area. Acceleration or direction information from the accelerometer **120** in conjunction with the previous determined location of a part (or wireless beacon **100**) may be used by the part location component **414** to determine that the part has moved to an adjacent work area (e.g., the part was previously in a welding work area and then moved in the direction of an assembly work area). Detected magnetic fields captured by the magnetometer **122** may indicate to the part location component **414** that the wireless beacon **100** is near a particularly large piece of machinery (e.g., a blast furnace) that has been identified to be in a particular work area (e.g., smelting work area). Thus, the data from the sensor(s) **112** in the location signals may be used to determine the real-time locations of the parts.

[0111] The virtual board component **418** and the spatial map component **420** generate the previously discussed virtual board and spatial UIs showing the real-time locations of parts in the manufacturing facility and continually update these UIs to show the parts as they move to different work and sub-work areas. One embodiment generates these UIs on the monitoring server **400** and includes the server-generated virtual board or spatial UIs in web pages, mobile applications (e.g., smart phone or mobile table applications), or as part of a server-client application.

[0112] In one embodiment, indications of the individual parts themselves are shown, and various manufacturing or service documentation may be tagged to the parts' representative indications. For example, a part being shown in a machining work area may be clicked on by a worker to drill down to the part's manufacturing specific work area. The order may be kept up to date such that when specific

manufacturing tasks are completed, the order itself, which is tagged to the representation of the part in the UIs disclosed herein, is also updated. Such an integrated system allows workers to quickly identify the locations of parts in the manufacturing facility and also quickly access the parts' relevant up-to-date work documentation.

[0113] FIG. 5 is a block diagram of a networking environment 500 for implementing some of the disclosed embodiments. Networking environment 500 includes numerous wireless beacons 100 that wirelessly communicate (e.g., using Bluetooth LE) location signals inside a manufacturing facility 550 to a multitude of receiver devices 506. Network environment 500 also includes a monitoring server 400, a database cluster 502, and one or more client computing devices 504 that, along with the receiver devices 506, communicate over a network 540.

[0114] The network 540 is a public or private computer network. Examples of such networks include, for example but without limitation, a local area network (LAN), a wide area network (WAN), or the like. When network 540 comprises a LAN networking environment, components may be connected to the LAN through a network interface or adaptor. When network 540 comprises a WAN networking environment, components may use a modem to establish communications over the WAN. The network 540 is not limited, however, to connections coupling separate computer units. Instead, the network 540 may also include subsystems that transfer data between computing devices. For example, the network 540 may include a point-to-point connection.

[0115] The client computing devices 300 may be any type of computing device previously discussed, including, without limitation, a laptop, smart phone, mobile tablet, television, projector, or other computing device capable of presenting UIs indicating the real-time work and sub-work area locations of parts being tracked in the manufacturing facility 550. In operation, the client computing devices 300 are used by workers who want to view the real-time locations of parts in the manufacturing facility. Such workers may be on the manufacturing floor, in separate offices, or at home.

[0116] The database cluster 502 represents one or more servers configured to store and manage databases of historical locations and/or location signals associated with the parts in the manufacturing facility 550. The historical location signals or history of locations in the manufacturing facility are useful data points that can be analyzed to determine facility production efficiency, employee efficiency, manufacturing or service capacity, and shipping times. The servers in the database cluster 502 may include their own processors, computer-storage media, database software, and other necessary components for maintaining records of part traffic in the manufacturing facility.

[0117] In operation, the wireless beacons 100 wirelessly transmit (e.g., via Bluetooth LE or other 2.4 GHz range transmission) location signals to the receiver devices 506, either periodically or upon interrupts triggered by one or more sensors 112. The receiver devices 506 transmit the location signals—with or without a receiver device ID—to either the monitoring server 400 or the client computing devices 300. Real-time locations of parts in the manufacturing facility are determined by either the client computing devices 300 (in one embodiment) or the monitoring server 400 (in another embodiment) by identifying real-time work or sub-work area locations of the wireless beacons 100

transmitting the location signals on the floor of the manufacturing facility 550. In one embodiment, the strength of the location signals captured by the various receiver devices 506 and the position of the receiver devices 506 are used to determine part locations. Alternatively, part locations may be triangulated using the triangulation techniques disclosed in the Concurrently Filed Application.

[0118] In embodiments where part locations are determined by the monitoring server 400, the monitoring server 400 may transmit the real-time locations of the parts to the client computing devices 300 for display to workers—for example, as part of a web page or through a client-server application. The client computing device 300 may then present the part locations in the virtual board UIs or spatial UIs disclosed herein. Embodiments that locally compute part locations directly on the client computing devices 300 may just present such location information in the virtual board UIs or spatial UIs disclosed herein without server interaction. Additionally, the monitoring server 400 or client computing device 300—whichever is tasked with locating parts in the manufacturing facility 550—may also transmit the locations of the parts or any data elements of the location signals to the database cluster 502 for storage.

[0119] FIG. 6 is a map diagram of a manufacturing facility 550 with strategically positioned receiver devices 506 for tracking the real-time locations of parts 202, in accordance with different embodiments. The manufacturing facility 550 includes work areas 602, 604, 606, 608, 610, 612, and 614 that are operationally partitioned into various sub-work areas 620, 622, 624, 626, 628, 630, 632, 634, 636, 638, 640, 642, 644, and 646. Also, walkways 660, 662, and 664 represent traffic areas in the manufacturing facility 550. The delineated lines of the work and sub-work areas may be physically partitioned from one another or just operationally separated. For example, work area 604 may be the area in the manufacturing facility 550 dedicated to machining or welding of part 202, and sub-work area 620 may be a holding area, sub-work area 622 may be where the machining of part 202 is performed, and sub-work area 624 may be a finished holding area where parts 202 are stored after machining. The work and sub-work areas may take any shape in the manufacturing facility, as indicated by the various patterns shown.

[0120] FIG. 6 shows one embodiment in which receiver devices 506 are strategically placed in a grid-like manner in the manufacturing facility 550. The receiver devices 506 are specifically oriented at or about 90° angles to each other, in one embodiment. Alternative embodiments may strategically position the receiver devices 506 in different patterns.

[0121] The wireless beacon 100 coupled to the part 202 transmits wireless signals as the part moves through the manufacturing facility through work from area 602 to 614. Receiver devices 506 capture the wireless signals and transmit such signals over a network to a monitoring server 400 (in one embodiment) or client computing device 300 (in another embodiment), which, as discussed above, identifies the work area or sub-work area in which the part is currently located. The client computing device 300 presents the real-time locations of the parts in a virtual board UI or a spatial UI.

[0122] FIG. 7 is a UI diagram illustrating an example of a three-dimensional spatial UI 700 showing real-time locations of parts 202 in a manufacturing facility 550, according to one embodiment. The three-dimensional spatial UI 700

includes a three-dimensional UI area **702** and a search UI area **704**. The three-dimensional UI area **702** provides a three-dimensional graphical representation of the various work areas **602-614** of the manufacturing facility **550**. Sub-work areas may also be shown, but for the sake of clarity are not illustrated to aid the reader. The locations of parts **202** are shown in respective work areas **602-614** and moved within the three-dimensional UI area **702** as the parts **202** move in the manufacturing facility. In some embodiments, the monitoring server **400** or client computing devices **300** create the three-dimensional UI area **702** and continually updates positions of the parts **202** based on x, y, and/or z coordinates—as determined through strengths of signals or triangulation techniques.

[0123] The three-dimensional spatial UI **700** is interactive in a number of ways. The search UI area **704** provides users with the ability to search for particular parts or highlight specific work or sub-work areas. Users can search various search criteria, including, for example but without limitation, part names (e.g., “valve bodies,” “flow line safety restraints fasteners,” “blowout preventers,” etc.); part IDs (e.g., 1234567890); work areas (e.g., “shipping,” “welding,” etc.); sub-work areas (e.g., “welding holding area,” “machining completed area,” etc.); beacon IDs (e.g., MM:MM:MM:SS:SS:SS); parts worked on by specific employees (e.g., “John Doe”); parts originating from a specific supplier or received in the manufacturing facility at specific dates or times (e.g., “valve bodies from ABC Corporation” or “valve bodies received on Aug. 7, 2015”); parts destined for a particular customer or prospective shipping order (e.g., “blowout preventers for XYZ Corporation,” “blowout preventers for Manufacturing Order 87654321,” “blowout preventers for Service Order 9876532,” etc.); parts needing certain tasks to be completed (e.g., “valve bodies to be machined,” “valve bodies to be assembled,” etc.); or other search criteria related to the parts, wireless beacons **100**, receiver devices, manufacturing or service orders, work areas, sub-work areas, or employees.

[0124] In response to submitted search queries, the monitoring server **400** or the client computing devices **300** may identify the parts or work and sub-work areas being queried using various tags or data elements associated with the parts and work areas. For example, a part may be tagged by the monitoring server **400** or client computing device **300** with a data element indicating the work or sub-work area where the part is located. Parts may be identified in particularly searched work or sub-work areas by the tagged data elements. Other data elements that may be tagged or associated with the parts include, for example but without limitation, beacon IDs, part IDs, part manufacturers, manufacturing or service order numbers, employee identifiers, tasks, dates, times, shipping orders, client identifiers, or the like. Any such data element may be used to search for, highlight, or otherwise identify the parts in the three-dimensional spatial UI **700**.

[0125] Additionally or alternatively, the three-dimensional spatial UI **700** provides the ability for users to drill down on individual or groups of parts shown in the three-dimensional UI area **702**. Users may click any of the illustrated representations of the parts to obtain part-specific information. As illustrated, when the user clicks or hovers a mouse cursor **706** on a specific part, a UI menu **750** is presented showing various data elements specific to the clicked or hovered-over part, including, for example, but without limitation, the part

ID **752**, the beacon ID **754**, the part name **756**, and a link or pathway to a manufacturing order **758**. An example of such a manufacturing order **758** is illustrated in FIG. **10** and described in detail below. Moreover, other documentation may be linked or provided in the UI menu **750**, including, for example, but without limitation, service orders, shipping orders, retail orders, wholesale orders, employee certifications, employee work records, or the like. For the sake of clarity, embodiments are discussed as displaying a linked manufacturing order **758**; however, any of the aforementioned documents may alternatively or additionally be linked or provided in the UI menu **750**.

[0126] FIG. **8** is a UI diagram illustrating an example of a two-dimensional spatial UI **800** showing real-time locations of parts **202** in a manufacturing facility **550**, according to one embodiment. The two-dimensional spatial UI **800** includes a two-dimensional UI area **802** and a search UI area **804**. The two-dimensional UI area **802** provides a two-dimensional graphical representation of the various work areas **602-614** of the manufacturing facility **550**. Sub-work areas **620-646** are also shown to the user in the two-dimensional UI area **802**.

[0127] The locations of parts are shown in respective work areas **602-614** and moved within the two-dimensional UI area **802** as the parts move through the manufacturing facility. In some embodiments, the monitoring server **400** or client computing devices **300** create the two-dimensional UI area **802** and continually update positions of the parts **202** based on x, y, and/or z coordinates of the location signals conveyed by receiver devices **506** or determined by the part location components disclosed herein. Alternatively, the monitoring server **400** or client computing devices **300** may update the positions of the parts in the two-dimensional UI area **802** using triangulation techniques disclosed in the Concurrently Filed Application.

[0128] Similar to the three-dimensional spatial UI **700**, the two-dimensional spatial UI **800** may be searched for the previously mentioned search criteria. In response to submitted search queries, the monitoring server **400** or the client computing devices **300** may identify the parts **202** or work and sub-work areas being queried using the previously discussed data elements tagged or otherwise associated with the parts **202**.

[0129] Additionally or alternatively, the two-dimensional spatial UI **800** provides the ability for users to drill down on individual or groups of parts **202** shown in the three-dimensional UI area **802**. Users may click any of the illustrated representations of the parts **202** to obtain part-specific information. As illustrated, when the user clicks or hovers a mouse cursor **806** on a specific part **202**, a UI menu **850** is presented showing various data elements specific to the clicked or hovered-over part **202**, including, for example, but without limitation, the part ID **852**, the beacon ID **854**, the part name **856**, and a link or pathway to a manufacturing order **858**. Again, other documentation may be linked or provided in the UI menu **850**, including, for example, but without limitation, service orders, shipping orders, retail orders, wholesale orders, employee certifications, employee work records, or the like.

[0130] FIG. **9** is a UI diagram illustrating an example of a virtual board UI **900** showing real-time locations of parts in a manufacturing facility, according to one embodiment. The virtual board UI **900** includes a virtual board UI area **950** and a search UI area **952**. The virtual board UI area **950** shows

different work areas (Work Area_A 902, Work Area_B 904, Work Area_C 906, and Work Area_D 908) and sub-work areas (Sub-Work Area_1 910, Sub-Work Area_2 912, Sub-Work Area_3 914, Sub-Work Area_4 916, Sub-Work Area_5 918, Sub-Work Area_6 920, and Sub-Work Area_7 922) of the manufacturing facility 550. Parts being tracked are shown as part representations 961-998 in the virtual board UI area 950, organized according to the currently located work areas and sub-work areas.

[0131] Part representations 961-965 indicate parts that are currently located in Sub-Work Area_1 910 of Work Area_A 902. Part representations 966-969 indicate parts that are currently located in Sub-Work Area_2 912 of Work Area_A 902, part representations 970-976 indicate parts that are currently located in Sub-Work Area_3 914 of Work Area_B 904. Part representations 977-980 indicate parts that are currently located in Sub-Work Area_4 916 of Work Area_B 904. Part representation 981 indicates a part currently located in Sub-Work Area_5 918 of Work Area_B 904. Part representations 982-985 indicate parts that are currently located in Sub-Work Area_6 920 of Work Area_C 906. Part representations 986-991 indicate parts that are currently located in Sub-Work Area_7 922 of Work Area_C 906. Part representations 992-998 indicate parts that are currently located in Work Area_D 908.

[0132] As the parts 202 move between different work and sub-work areas, corresponding part representations 961-999 disappear from prior areas and reappear in current areas. To illustrate this, part representation 969 moved from Sub-Work Area_1 910 to Sub-Work Area_2 912, indicating physical movement of the corresponding part from one sub-work area to another. Likewise, part representation 976 moved in the virtual board UI area 950 from Sub-Work Area_2 912 to Sub-Work Area_3 914 when the corresponding part moved between the two sub-work areas. Thus, the virtual board UI 900 updates the virtual board UI area 950 in real time as parts move between different work and sub-work areas of the manufacturing facility.

[0133] In one embodiment, each part representation 961-998 in the virtual board UI area 950 indicates a corresponding part in the manufacturing facility that has a coupled wireless beacon 100. Part representations 961-998 may depict parts with any combination of text, identifiers, logos, images, video, audio, or other indicators.

[0134] Moreover, in one embodiment, the part representations 961-998 are interactive and may provide access to corresponding part documentation disclosed herein. The search UI area 952 provides users with the ability to search for particular parts or highlight specific work or sub-work areas. Users can search various search criteria, including, for example, but without limitation, part names, part IDs, work areas, sub-work areas, beacon IDs, employees, parts originating from a specific supplier or received in the manufacturing facility at specific dates or times, parts destined for a particular customer or prospective shipping order, parts needing certain tasks to be completed, or other search criteria related to the parts, wireless beacons 100, receiver devices, manufacturing or service orders, work areas, sub-work areas, or employees.

[0135] In response to submitted search queries, the monitoring server 400 or the client computing devices 300 may identify corresponding part representations 961-998 or work and sub-work areas being queried using various tags or data elements associated with the parts and work areas. Identified

part representations 961-998 meeting the search criteria may be highlighted in the virtual board UI 900, or alternatively, part representations 961-998 not meeting the search criteria may be grayed out or otherwise displayed less prominently than the part representations 961-998 of parts that meet the search criteria.

[0136] Additionally or alternatively, the virtual board UI 900 provides the ability for users to drill down on individual or groups of parts shown in the virtual board UI 900. Users may click any of the part representations 961-998 to obtain part-specific information. For example, user interaction with the part representations 961-998 may trigger presentation of part IDs, beacon IDs, part names, and link or pathways to relevant orders (e.g., manufacturing order, service orders, shipping orders, retail orders, wholesale orders, employee certifications, employee work records, or the like).

[0137] FIG. 10 illustrates a diagram of a digitally presented manufacturing order 1000, according to one embodiment. The manufacturing order 1000 represents one type of order that may be associated with parts in a manufacturing facility and presented in the UIs disclosed herein—e.g., by clicking various part representations in the spatial or virtual board UIs illustrated in FIGS. 7-9. The manufacturing order 1000 of FIG. 10 includes various data specific to the part and is presentable in digital form by client computing devices 300. Embodiments may include additional or alternative data relating to the part, coupled wireless beacon 100, manufacturing facility, workers, order, work tasks, or other relevant information to manufacturing or servicing.

[0138] As shown, the manufacturing order 1000 includes a bar code ID 1002 that uniquely identifies the part and may be read by a bar-code reader. In one embodiment, the part ID is encoded as the bar code 1002. Alternative embodiments may encode the part name, part manufacturer, order number, customer number, date and time stamps, part serial number, or a combination thereof.

[0139] A manufacturing order (MO) number 1004 indicates a particular manufacturing order, and a customer order (CO) number 1006 indicates part order's prospective customer. The part's beacon ID is identified by beacon ID 1008. A product number 1010 and product description 1012 are listed to indicate either the part individually or the assembled part to which the part is a constituent—e.g., a valve hand wheel to an assembled valve. Production and quality control information 1016 may be listed, including, for example, but without limitation, time stamps of quality control checks, responsible personnel, test values for the part, or the like. Similarly, testing and certification data 1018 may be displayed, e.g., certificate of compliance (C of C), certified mill test reports (CMTRs), heat values, and the like.

[0140] Various required manufacturing or service inspection and performance metrics 1020 may be listed. Examples of such metrics include, without limitation, magnetic particle inspection results, liquid penetrant inspection results, welding specifics, hardfacing results, minimum wall thicknesses or measurements, weld end drawing documents, or any other particular manufacturing or servicing inspection and performance metrics.

[0141] Additionally or alternatively, manufacturing or servicing procedures 1022, work tasks 1024, and additional notes 1026 may also be provided. The procedures 1022 represent the various areas, operational stages, and applicable data or drawing sheets for manufacturing or servicing the part. The data or drawing sheets may be linked to the

manufacturing order **1000** in some embodiments, or provided separately in other embodiments. Work tasks **1024** refer to a sequence of jobs that need to be performed by the workers. Details about the work tasks **1024** may also be captured and stored on the manufacturing order **1000**. Such details may include, for example, but without limitation, run times and dates of specific tests or tasks, task-performing or task-supervising worker initials, name of a particular inspector (shown as an American Society of Mechanical Engineers Nuclear Inspector or “A.N.I.”), or other relevant information to ensure work tasks **1024** are completed efficiently and safely. Notes **1026** may be entered on interactive computing devices (e.g., mobile phone, mobile tablet, testing device, laptop, etc.) and stored with the manufacturing order **1000**, thereby making the notes **1026** accessible to viewers of the various spatial and virtual board UIs disclosed herein.

[0142] FIG. 11 is a three-dimensional diagram of a facility room **1100** in which a two-dimensional spatial UI **800** and a virtual board UI **900** showing real-time locations of parts in a manufacturing facility are being displayed in accordance with some of the embodiments disclosed herein. The two-dimensional spatial UI **800** and the virtual board UI **900** are projected on walls of the facility room **1100** by projectors **1104** and **1106**, respectively. Projectors **1104** and **1106** may act as presentation devices **306** of one or more client computing devices **300**, or may operate as the client computing devices **300** themselves. For instance, in the latter case, the projectors **1104** and **1106** may include a processor **304** executing the part tracking component **316**, the virtual board component **318**, and the spatial map component **320** described above in reference to FIG. 3. While the two-dimensional spatial UI **800** is shown, embodiments may alternatively display the three-dimensional UI **700**.

[0143] FIG. 12 illustrates a flow chart diagram illustrating a work flow **1200** for locating parts in a manufacturing facility and presenting user interfaces showing the real-time locations of the parts, in accordance with one embodiment. A monitoring server or client computing device generates a map of the work areas and/or sub-work areas in a manufacturing facility, as indicated at block **1202**. The work areas or sub-work areas may be specified by a user. Once the work areas and sub-work areas are specified, receiver devices in the facility are associated with the work areas and sub-work areas based on the receiver devices locations in the facility, as indicated at block **1204**. One embodiment associates receiver device IDs of the receiver devices with the work and sub-work areas. For example, receiver devices in the welding work area may be associated accordingly.

[0144] The monitoring server or client computing device receives location signals of wireless beacons coupled to parts in the manufacturing facility over a network, as indicated at block **1206**. The location signals may be received from the receiver devices. Additionally, the monitoring server or client computing device also receives, either along with the location signals or separately, receiver device identifiers that are unique to the receiver devices sending the location signals, as indicated at block **1208**. One embodiment uses the location signals, the generated map of work and/or sub-work areas, and the receiver device identifiers to locate wireless beacons in the manufacturing facility being in various work or sub-work areas, as indicated at block **1010**. The locations of the wireless beacons are used as the locations of the beacons’ coupled parts. For example, the location signals of valve body’s coupled wireless beacon

and the receiver device identifiers transmitting the location signals may indicate a valve body is in a shipping work area. Locations of the parts are stored either on the monitoring server or the client computing device, as indicated at **1212**. If stored on the monitoring server, the locations of the parts may be transmitted to the client computing device for display. Whether computed locally or received from the monitoring server, the locations of the parts are presented in the interactive UIs disclosed herein—e.g., the spatial UI, the virtual board UI, or a combination thereof.

[0145] Tracking the real-time locations of parts provides numerous benefits over conventional manufacturing part-tracking systems. Using the wireless beacons described herein as trackers of parts eliminates the need to constantly hunt down paperwork to determine where parts are located. This saves worker time and increases worker production. Tracking parts electronically eliminates many costly and unsafe human errors associated with inaccurately filling out paperwork or otherwise noting when and where parts have been moved.

[0146] The virtual board and spatial UIs allow workers to quickly see and understand where parts are located without having to waste critical time hunting down paper or walking through the facility itself. Both UIs also allow workers to easily drill down on individual parts and obtain part-specific data about where a part has been, who is handling it, and where it needs to go through a simple click of a mouse. The per-part searchability of the UIs greatly enhance the user experience, allowing workers to identify any part being tracked from a single computing device.

[0147] The various embodiments also greatly enhance safety in manufacturing facilities with large machinery, because the electronic part-tracking system components disclosed herein largely reduce the amount of time workers need to spend hunting for parts in work areas in which they are not working and running paperwork to and from offices for proper storage. Thus, the various embodiments help keep workers put in their respective work areas, thereby reducing worker traffic in the manufacturing facility and diminishing work accidents caused by heavy machinery that has to move throughout the facility. For example, a worker who spends more time in a welding area is at less risk at getting struck by a forklift carrying parts between other work areas of a facility. Moreover, along the lines of safety, some parts in manufacturing facilities may be hazardous (e.g., in a nuclear-part facility) and only allowed to be handled or exposed to certain accredited workers. Reducing the amount of workers straying out of their respective work areas reduces the number of people accidentally coming into contact with parts they are not trained to handle.

[0148] Additionally, the embodiments disclosed herein allow manufacturing facilities to tighten up their safety programs. Tracking parts through a given facility allows safety managers to get a better understanding of where work bottlenecks occur. Once these are understood, work areas can be easily reorganized for more efficiency and to enhance safety.

[0149] The use of wireless beacons that only transmit location signals upon sensed events allows some embodiments to greatly reduce the amount of battery power needed by the wireless beacons disclosed herein to track parts in a facility. Also, the transmission of sensor data as part of the location signals, along with various part or beacon identi-

fiers, provides a highly accurate way to locate parts in a manner that does not require human interaction.

[0150] Having described aspects of the disclosure in detail, it will be apparent that modifications and variations are possible without departing from the scope of aspects of the disclosure as defined in the appended claims. As various changes could be made in the above constructions, products, and methods without departing from the scope of aspects of the disclosure, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

[0151] When introducing elements of aspects of the disclosure or the examples thereof, the articles “a,” “an,” “the,” and “said” are intended to mean that there are one or more of the elements. The terms “comprising,” “including,” and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements. The term “exemplary” is intended to mean “an example of.” The phrase “one or more of the following: A, B, and C” means “at least one of A and/or at least one of B and/or at least one of C.”

[0152] The subject matter disclosed herein is described with specificity to meet statutory requirements. The description itself is not intended to limit the scope of this patent. Rather, the inventors have contemplated that the claimed subject matter might also be embodied in other ways, to include different steps or combinations of steps similar to the ones described in this document, in conjunction with other present or future technologies. Although the terms “step” and/or “block” may be used herein to connote different elements of methods employed, the terms should not be interpreted as implying any particular order among or between various steps herein disclosed unless and except when the order of individual steps is explicitly described. The order of execution or performance of the operations in examples of the disclosure illustrated and described herein is not essential, unless otherwise specified. The operations may be performed in any order, unless otherwise specified, and examples of the disclosure may include additional or fewer operations than those disclosed herein. It is therefore contemplated that executing or performing a particular operation before, contemporaneously with, or after another operation is within the scope of aspects of the disclosure.

What is claimed is:

1. A method for presenting a user interface indicating the real-time locations of parts in a manufacturing facility, wherein the parts are coupled to wireless beacons configured to wirelessly transmit a location signal, the method comprising:

receiving signal strengths of location signals captured by multiple receiver devices, the signal strengths corresponding to distances the wireless beacon is from the multiple receiver devices;

determining locations of the parts in the manufacturing facility based on the signal strengths; and

presenting a user interface having:

a first user interface area showing a first set of the parts being located in a first work area, and

a second user interface area showing a second set of the parts being located in a second work area.

2. The method of claim 1, further comprising moving at least one part from the first work area to the second work area as a second set of signal strengths associated with a

second location signal associated with the at least one part indicates movement from the first work area to the second work area.

3. The method of claim 1, wherein the user interface comprises a virtual board user interface showing the real-time locations of the parts in a plurality of work areas.

4. The method of claim 2, wherein the user interface comprises a virtual board user interface showing the real-time locations of the parts in a plurality of sub-work areas.

5. The method of claim 1, wherein the user interface comprises a spatial map user interface showing the real-time locations of the parts in a plurality of work areas.

6. The method of claim 1, further comprising:

receiving a user selection of at least one part;

retrieving a manufacturing or service order associated with the at least one part; and

presenting the manufacturing or service order.

7. The method of claim 1, wherein the first set of parts and the second set of parts comprise at least one of a fluid end, a swivel, a joint, a manifold trailer, safety iron, a safety hammer, a valve, a hose, a conduit, a dart valve, a plug valve, a clapper check valve, a pressure relief valve, an emergency unloading valve, a gate valve, a subsea dosage valve, a hydraulic valve, a valve seat, a butterfly valve, a steadseal valve, a hyperseal valve, a Polytetrafluoroethylene-lined valve, a swingthrough valve, a rubber-sealing valve, a rubber-line valve, a fire safe valve, a swing and lift check valve, a T-pattern globe valve, a Y-pattern globe valve, a three-way globe valve, a compressor check valve, a cold reheat check valve, a cold heat check valve, a testable check valve, a reverse current valve, a parallel slide valve, a gate valve, a safety valve, a safety relief valve, an isolation valve, a relief valve, a mounted-ball valve, a ball valve, a diaphragm valve, a butterfly valve, a gate and globe valve, a check valve, a lift check valve, a swing check valve, a steam isolation valve, a feedwater isolation valve, an integrated safety valve, a single-stage turbine, a multi-stage turbine, a hydraulic turbine, a pump turbine, a quad-runner turbine, a gear operator, a pneumatic actuator, a pressure control panel, a lifting clamp, a flow line safety restraint, a choke, a drop ball injector, a pump, a blowout preventer, a gas separator, an overshot connector, a wellhead, a frac pump, a manifold system, a fluid end system, a slurry pump, a water pump, a subsea pump, a premix tank, a frac tree, a swellable packer, a manifold skid, a tubing head, a wellhead, a rod rotator, a stuffing box, a casing head, a tubing head, a positive displacement pump, a hydrocyclone, a dewatering pump, a vortex pump, a trailer, a conveyor, a screening machine, a material handling machine, a communiton machine, a feeder, a crusher, a modular plant, a barge, or a control valve.

8. One or more computer storage memories embodied with computer-executable components, for causing a computing device to present a user interface indicative of the real-time locations of parts in a facility, the media comprising:

a communications interface component configured to receive location signals associated with wireless beacons coupled to the parts in the facility;

a part location component configured to determine the real-time locations of the parts in the facility based on the location signals; and

a virtual board component configured to present a virtual board user interface showing the real-time locations of the parts in relation to one or more work areas of the facility.

9. The one or more memories of claim 8, wherein the virtual board user interface is further configured to show the real-time locations of the parts in relation to one or more work areas and one or more sub-work areas of the facility.

10. The one or more memories of claim 8, wherein the one or more work areas comprise at least one member comprising a welding work area, a machining work area, an assembly work area, a shipping work area, or a receiving work area.

11. The one or more memories of claim 8, further comprising a spatial map component configured to present a spatial map user interface showing the real-time locations of the parts in relation to the one or more work areas of the facility.

12. The one or more memories of claim 11, wherein the spatial map user interface shows a three-dimensional representation of the parts in relation to the one or more work areas of the facility.

13. An apparatus for presenting a user interface that illustrates real-time locations of parts in a facility, the apparatus comprising:

- a presentation device with a touch-screen display;
- memory configured to store location signals of wireless beacons coupled to parts in the facility and a virtual board component; and
- one or more processors programmed to:
 - identify work areas in the facility;
 - determine the real-time locations, related to the work areas, of the parts based on the location signals of the wireless beacons, and

execute the virtual board component to generate a virtual board user interface for presenting the real-time locations of the parts on the presentation.

14. The apparatus of claim 13, further comprising a receiver for receiving the location signals from one or more receiver devices over a public or private network.

15. The apparatus of claim 13, further comprising a receiver for receiving the location signals from a monitoring server over a public or private network.

16. The apparatus of claim 13, wherein the virtual board user interface comprises a virtual board user interface area displaying a plurality of sub-work areas in the facility and showing at least some of the parts being located in the plurality of sub-work areas.

17. The apparatus of claim 16, wherein:

the work areas are displayed indicating at least one member of a group comprising a welding work area, a machining work area, an assembly work area, a shipping work area, and a receiving work area; and

the sub-work areas are displayed indicating at least one member of a group comprising a holding sub-work area, an inspection sub-work area, and a completion sub-work area.

18. The apparatus of claim 13, wherein the presentation device comprises a projector, computer monitor, or a television.

19. The apparatus of claim 13, wherein the presentation device with the touch screen display is part of a mobile tablet, a smart phone, or a digital kiosk.

20. The apparatus of claim 13, wherein the one or more processors are programmed to update the real-time locations of the parts in the virtual board user interface based on the location signals.

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