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Williams et al.

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(54) **SYSTEMS AND METHODS FOR CREATING ROUTES FOR POWERED INDUSTRIAL VEHICLES**

(75) Inventors: **David E. Williams**, Stafford, VA (US); **Stephen J. McElroy**, Manassas, VA (US)

(73) Assignee: **United States Postal Service**, Washington, DC (US)

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(51) **Int. Cl.**

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G06F 17/00	(2006.01)
G01C 21/00	(2006.01)
B60R 25/04	(2006.01)
G06Q 10/00	(2006.01)

(52) **U.S. Cl.** **701/1**; 701/35; 701/202; 705/1; 705/8; 705/9; 307/9.1; 307/10.4

(58) **Field of Classification Search** 701/1, 701/23, 24–26, 35, 36, 201, 202, 207–210, 701/216, 220–221, 300–302; 340/506, 988–994, 340/995.16, 995.18, 995.19, 995.23–995.24, 340/995.27; 705/1, 7–9, 18; 307/9.1, 10.1–10.6
See application file for complete search history.

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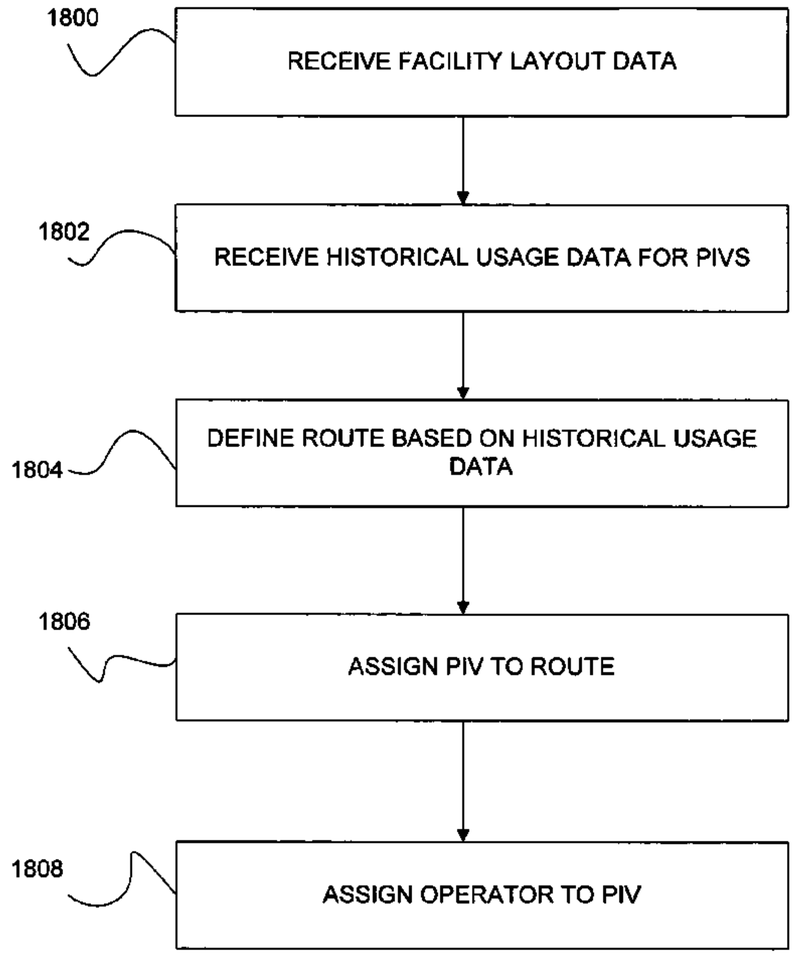
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Primary Examiner—Edward Pipala
(74) *Attorney, Agent, or Firm*—Knobbe Martens Olson & Bear LLP

(57) **ABSTRACT**

Systems and methods for creating route for powered industrial vehicles are provided. In one embodiment, the system includes a route generation module configured to determine route data based on facility layout data and historical usage data. The system also includes a PIV equipped with various sensors and a user interface module configured to allow selective access to the operative components of the PIV.

30 Claims, 12 Drawing Sheets



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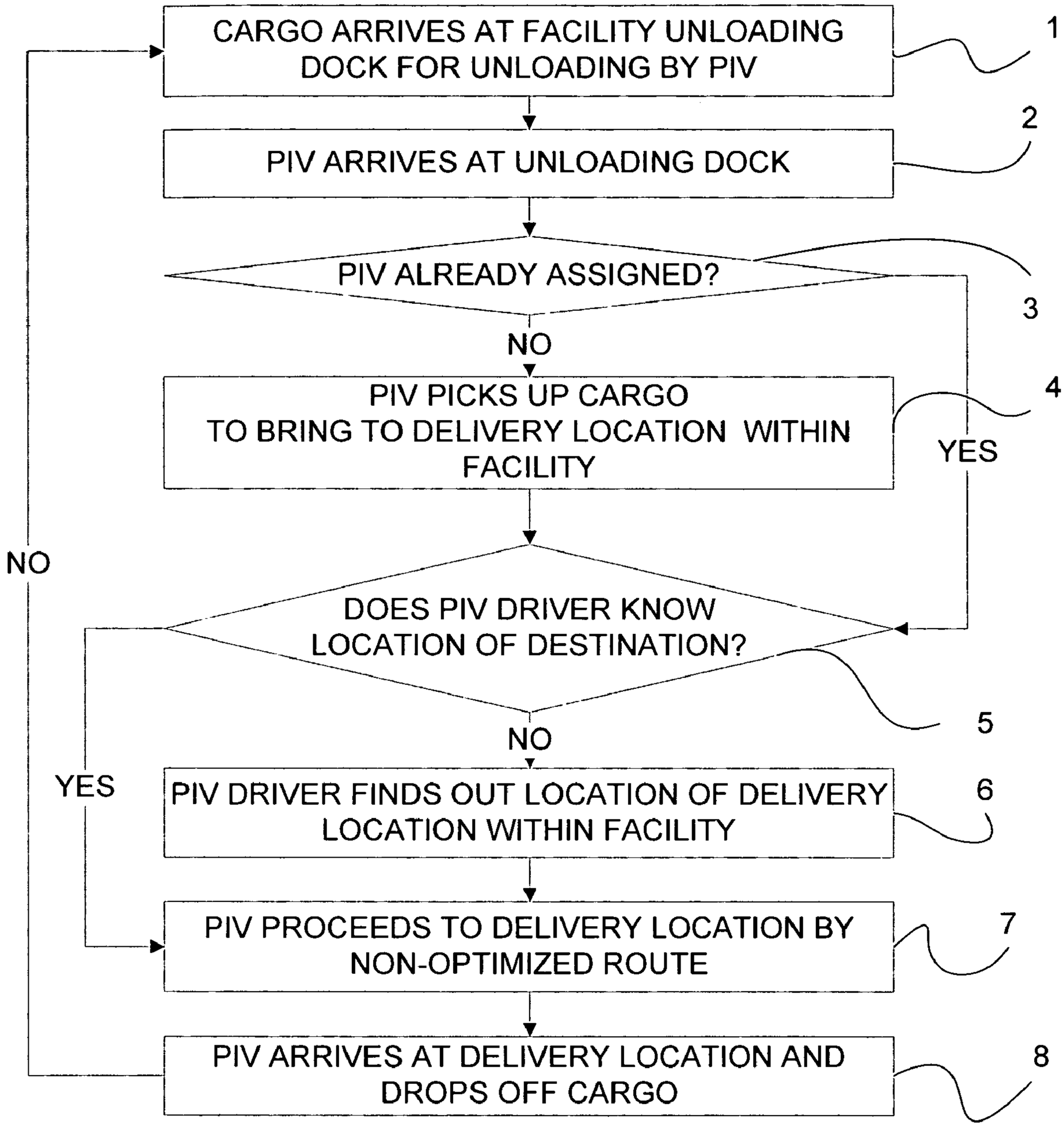


FIG. 1 (PRIOR ART)

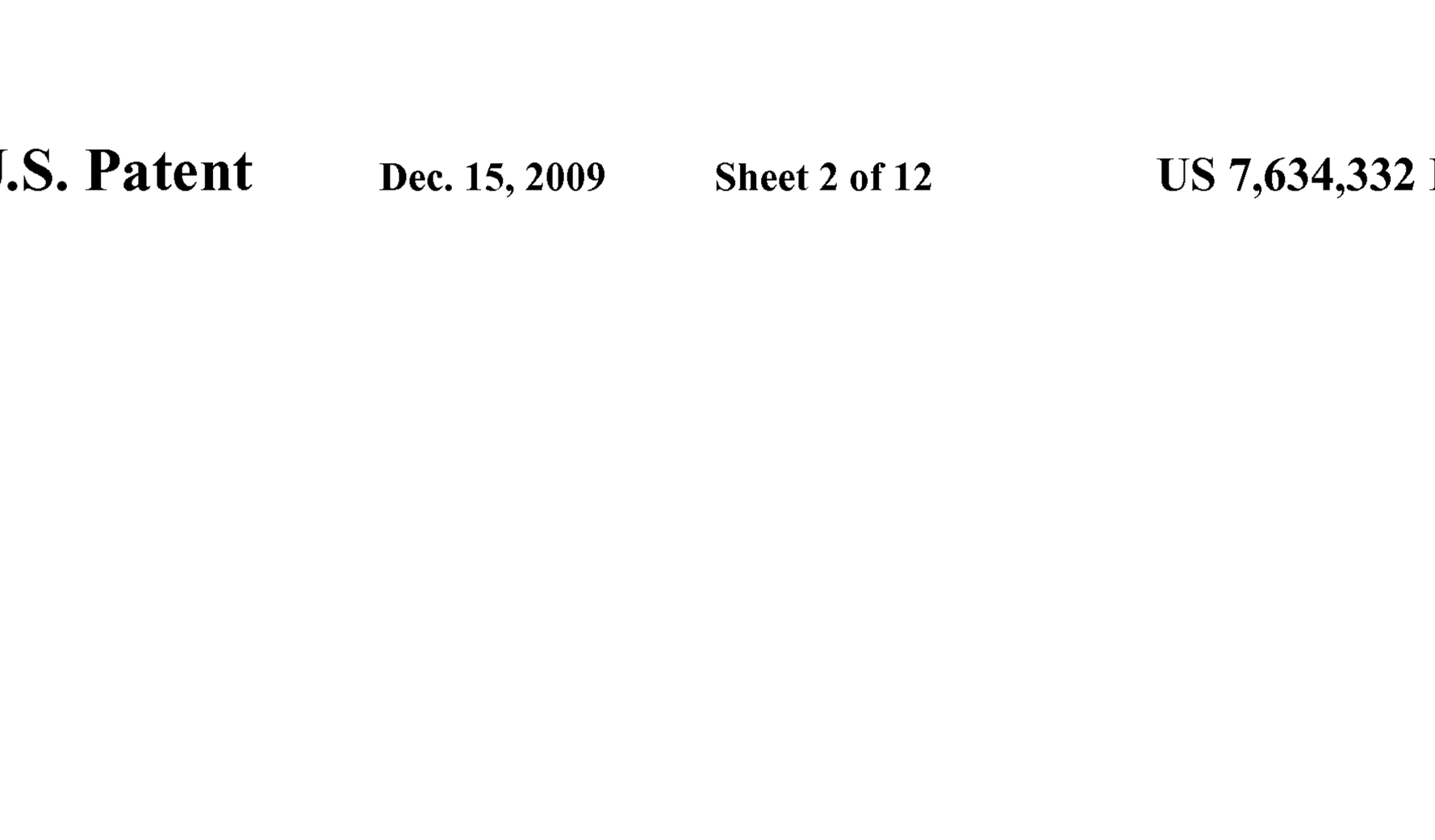


FIG. 2

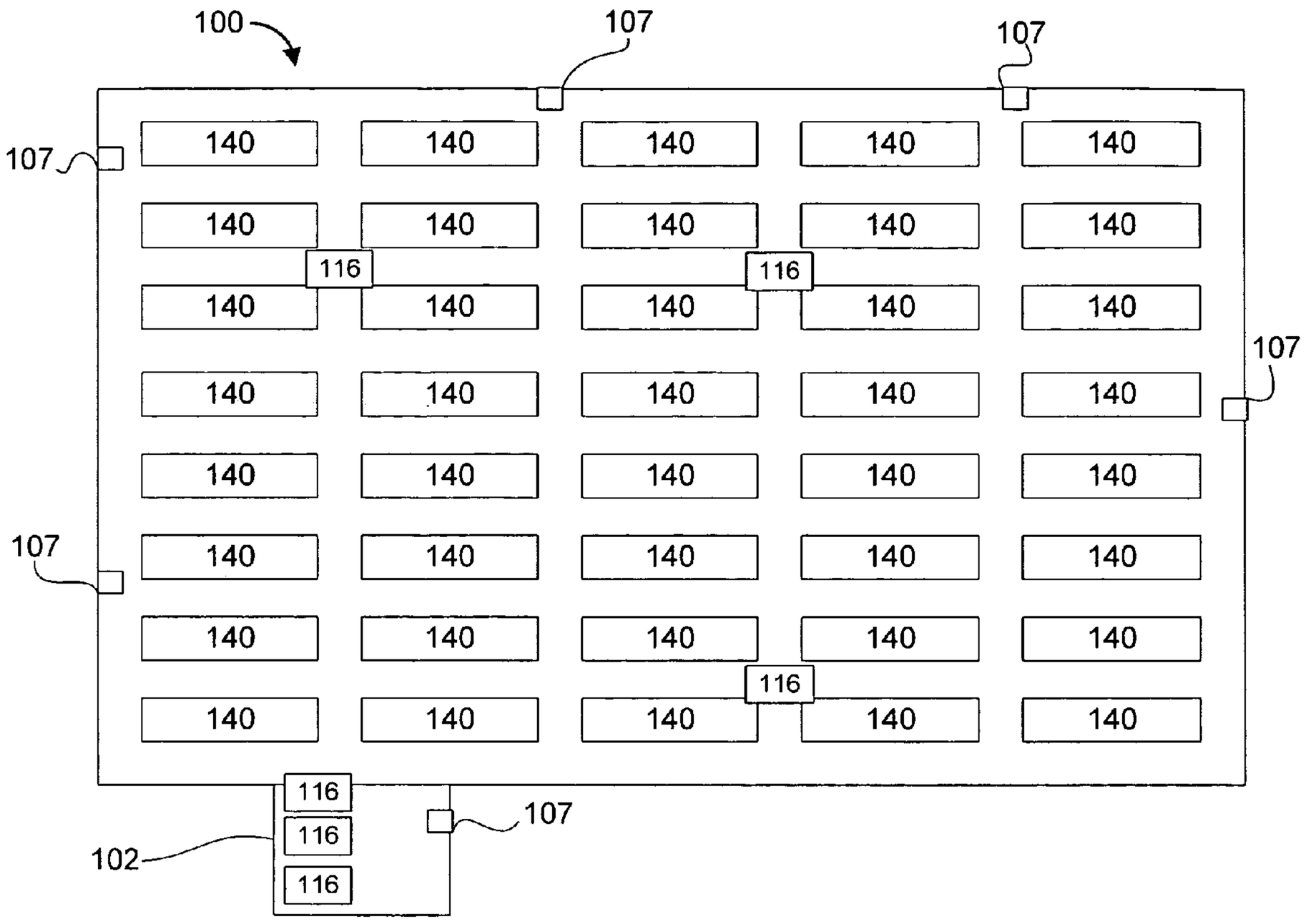


FIG. 3

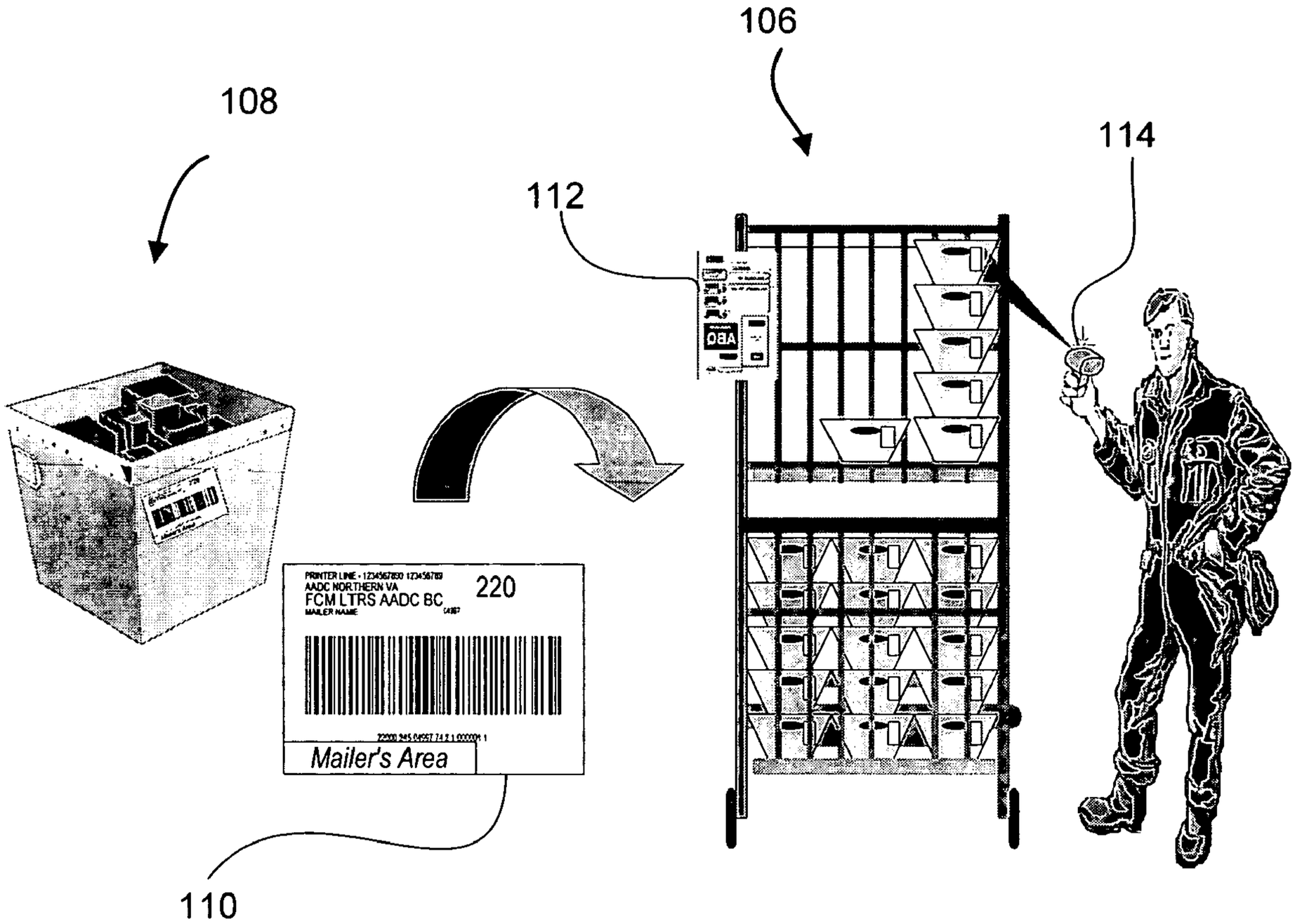

108
106
112
114
PRINTER LINE • 1234567890 1234567890
AADC NORTHERN VA
FCM LTRS AADC BC
MAILER NAME
220
Mailer's Area
110

FIG. 4

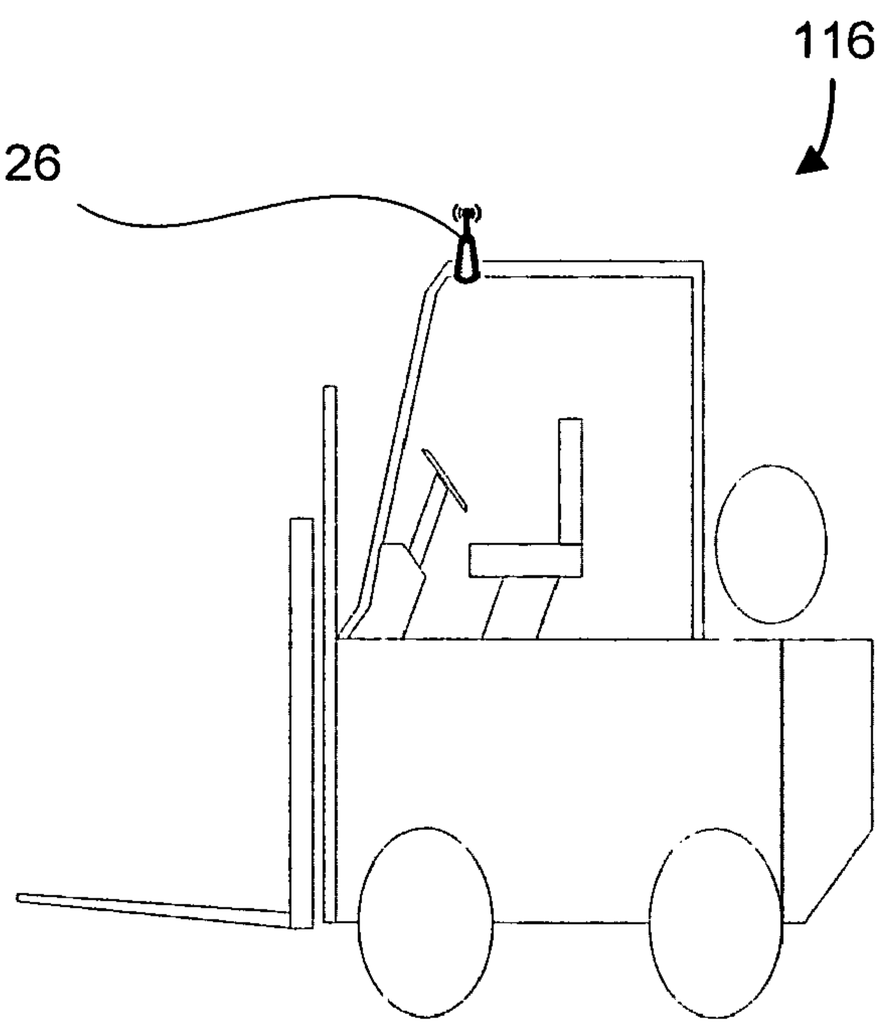

116
126
PIV

FIG. 5

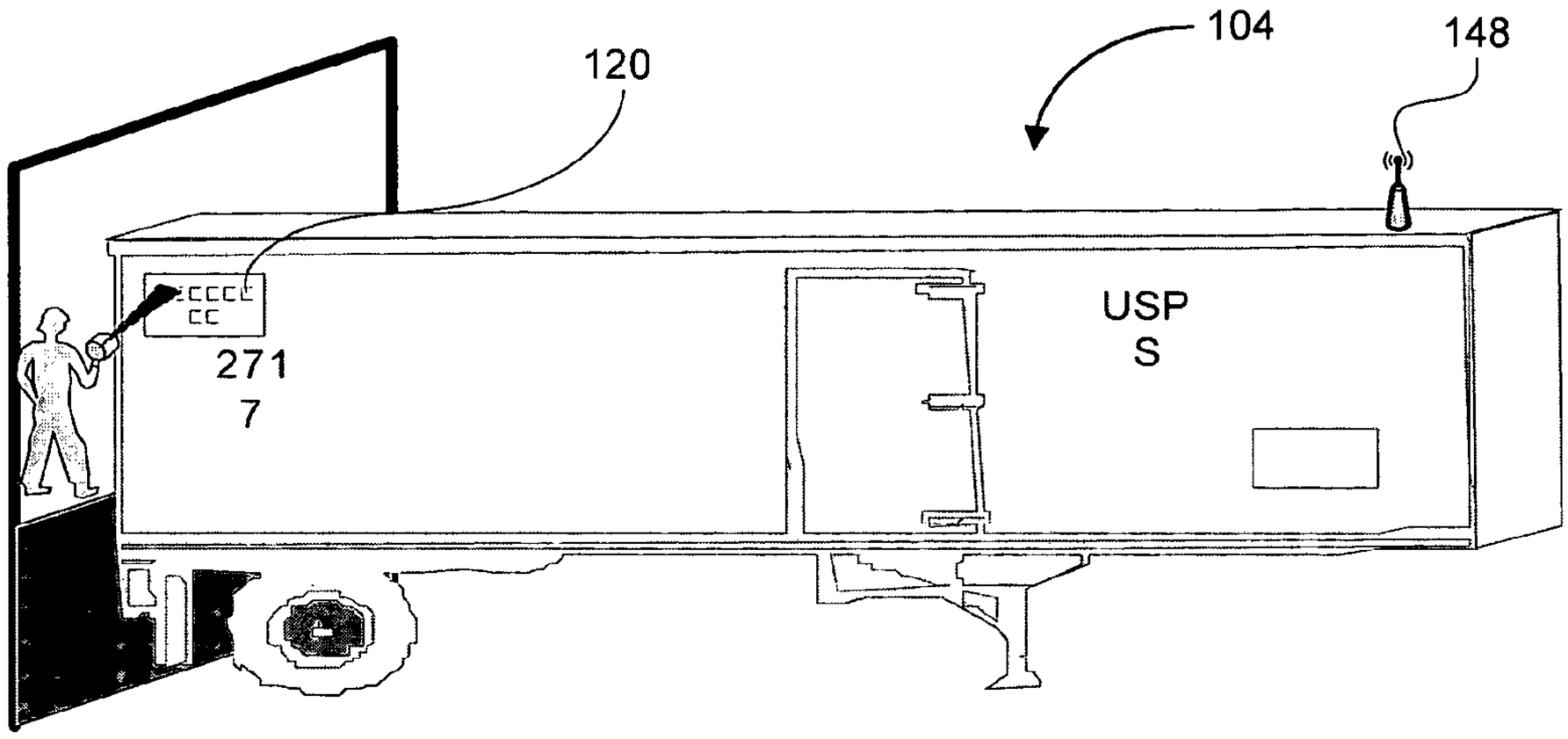


FIG. 6

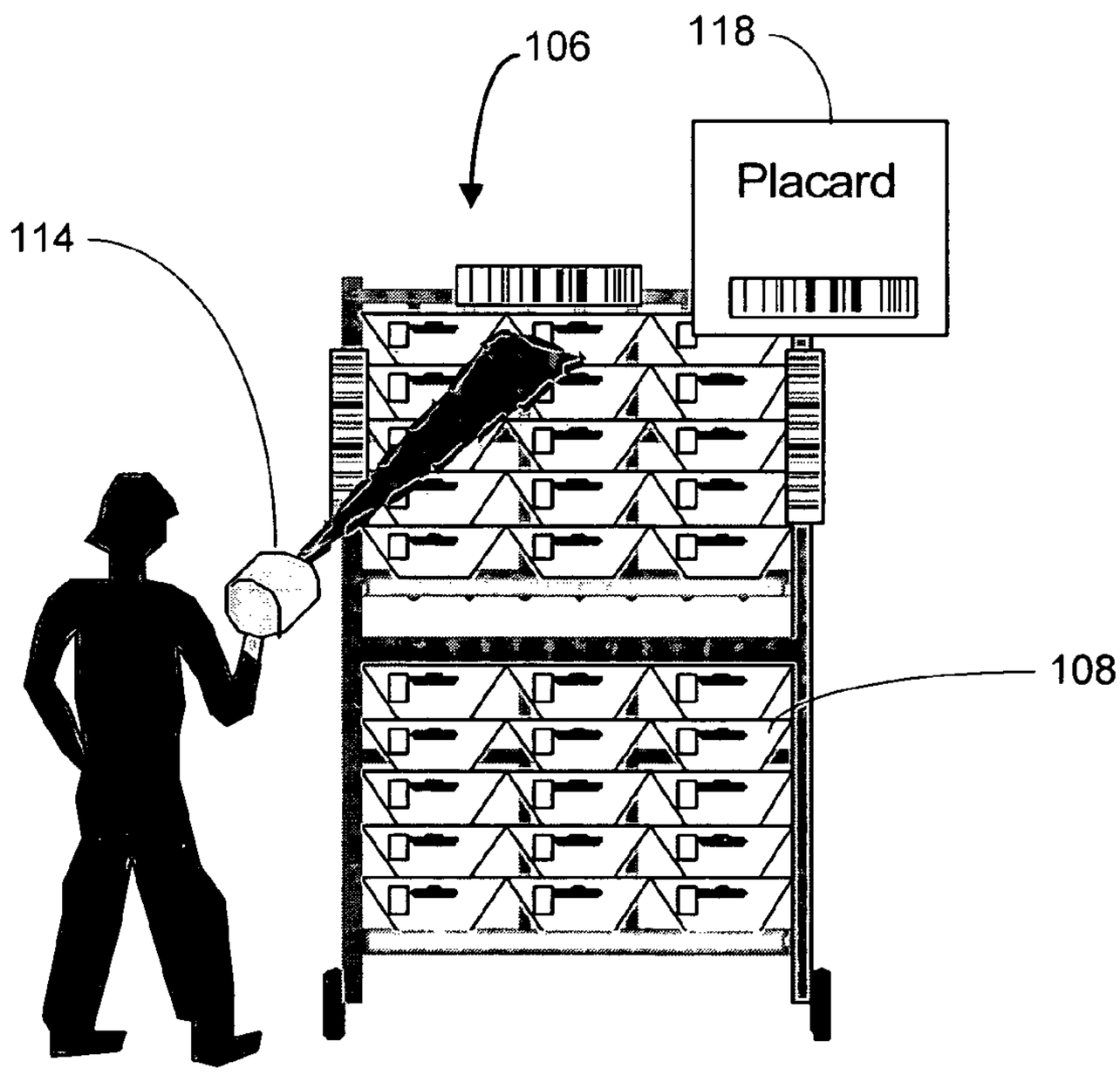


FIG. 7

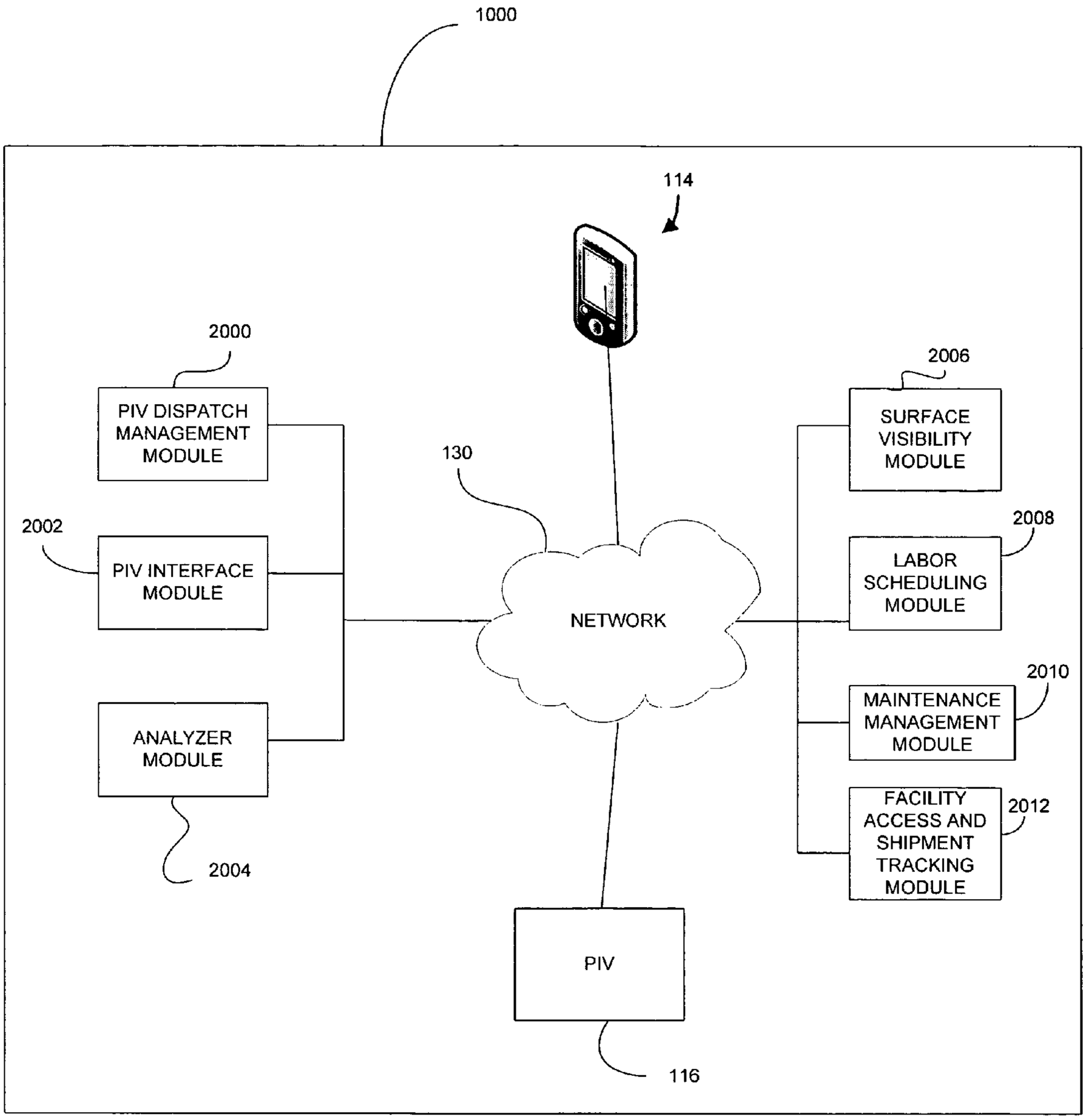

1000
114
2000
PIV DISPATCH MANAGEMENT MODULE
2002
PIV INTERFACE MODULE
ANALYZER MODULE
2004
130
NETWORK
2006
SURFACE VISIBILITY MODULE
2008
LABOR SCHEDULING MODULE
2010
MAINTENANCE MANAGEMENT MODULE
2012
FACILITY ACCESS AND SHIPMENT TRACKING MODULE
PIV
116

FIG. 8

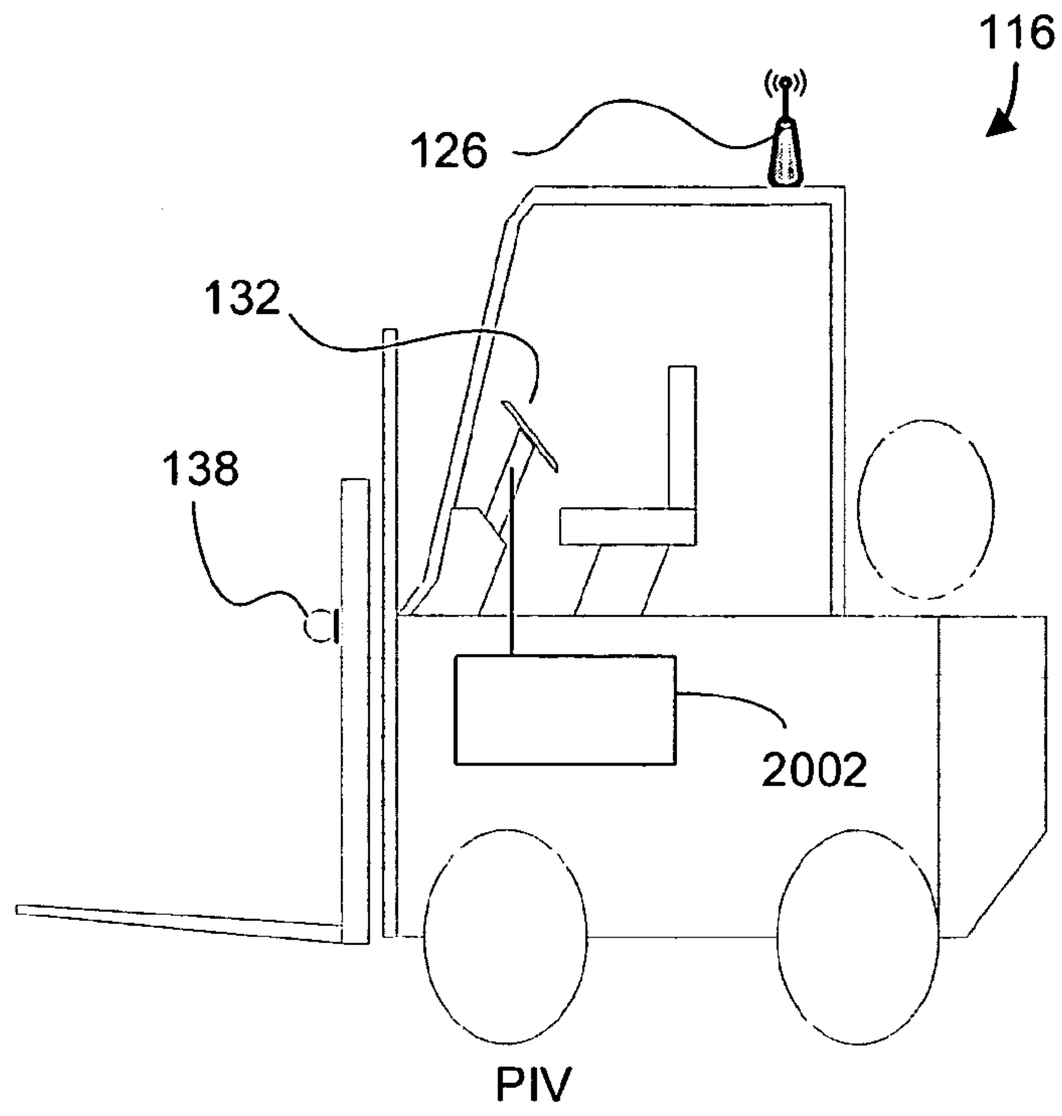


FIG. 9A

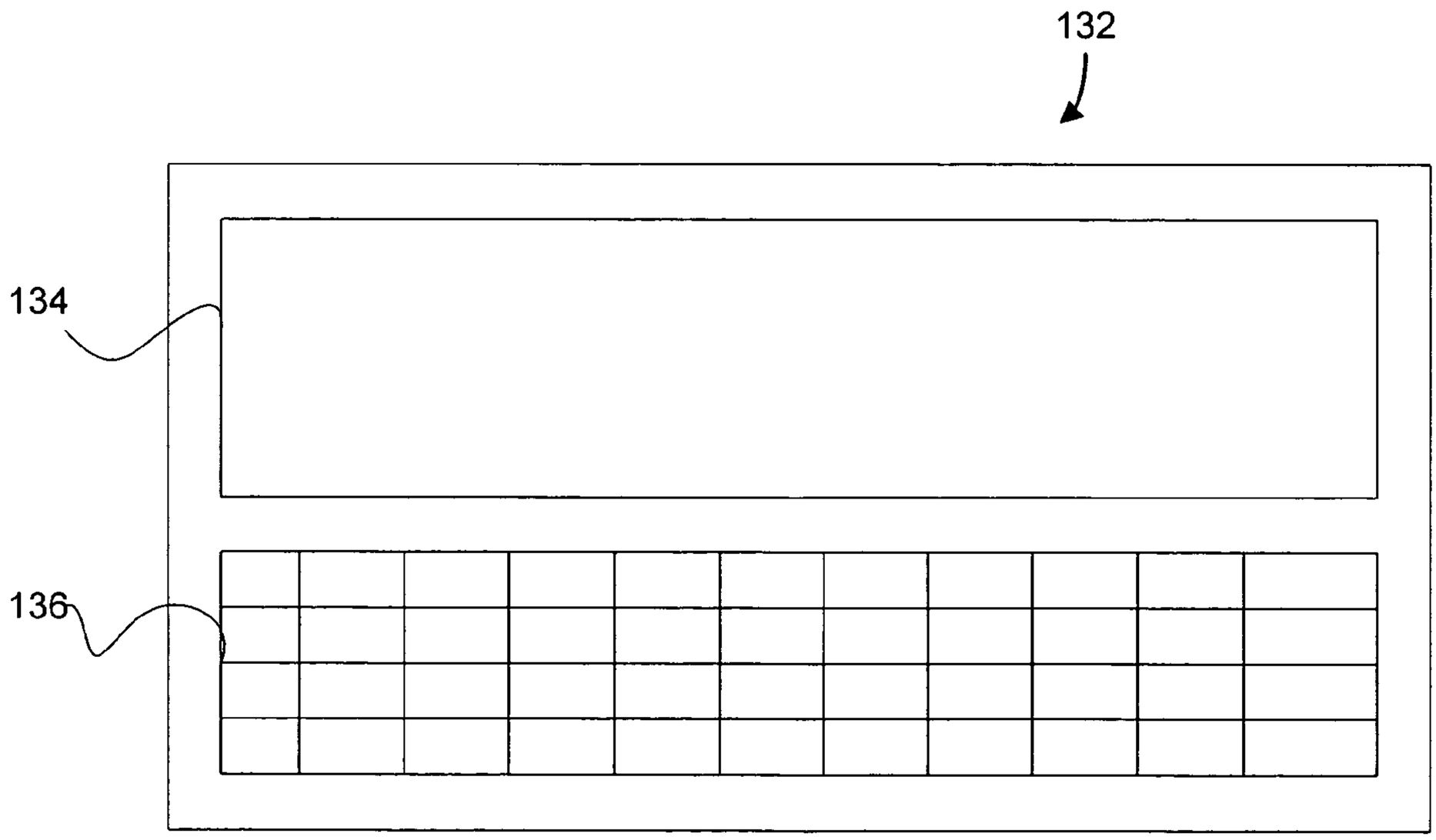


FIG. 9B

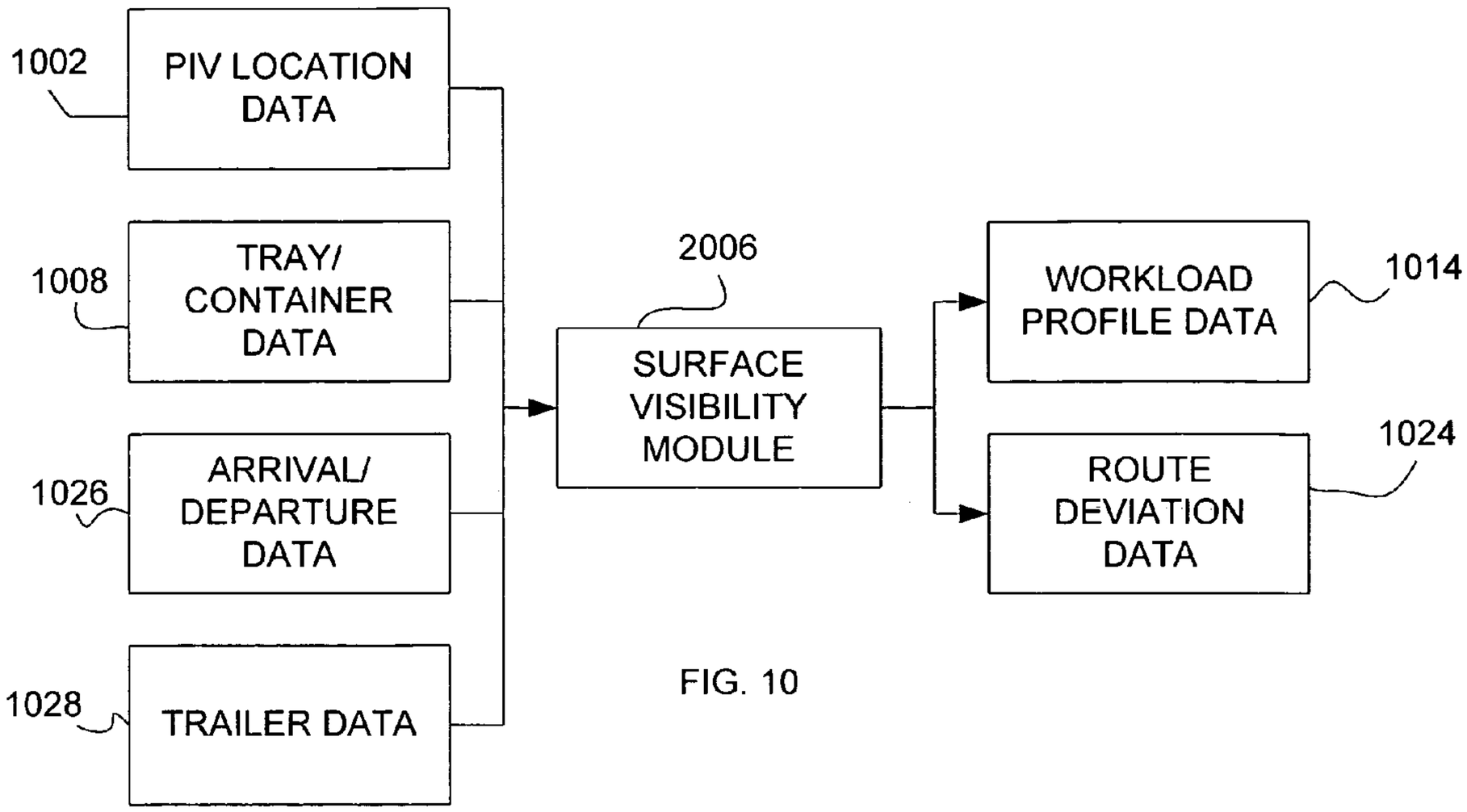

1002
PIV LOCATION DATA
1008
TRAY/ CONTAINER DATA
1026
ARRIVAL/ DEPARTURE DATA
1028
TRAILER DATA
2006
SURFACE VISIBILITY MODULE
WORKLOAD PROFILE DATA
1014
ROUTE DEVIATION DATA
1024

FIG. 10

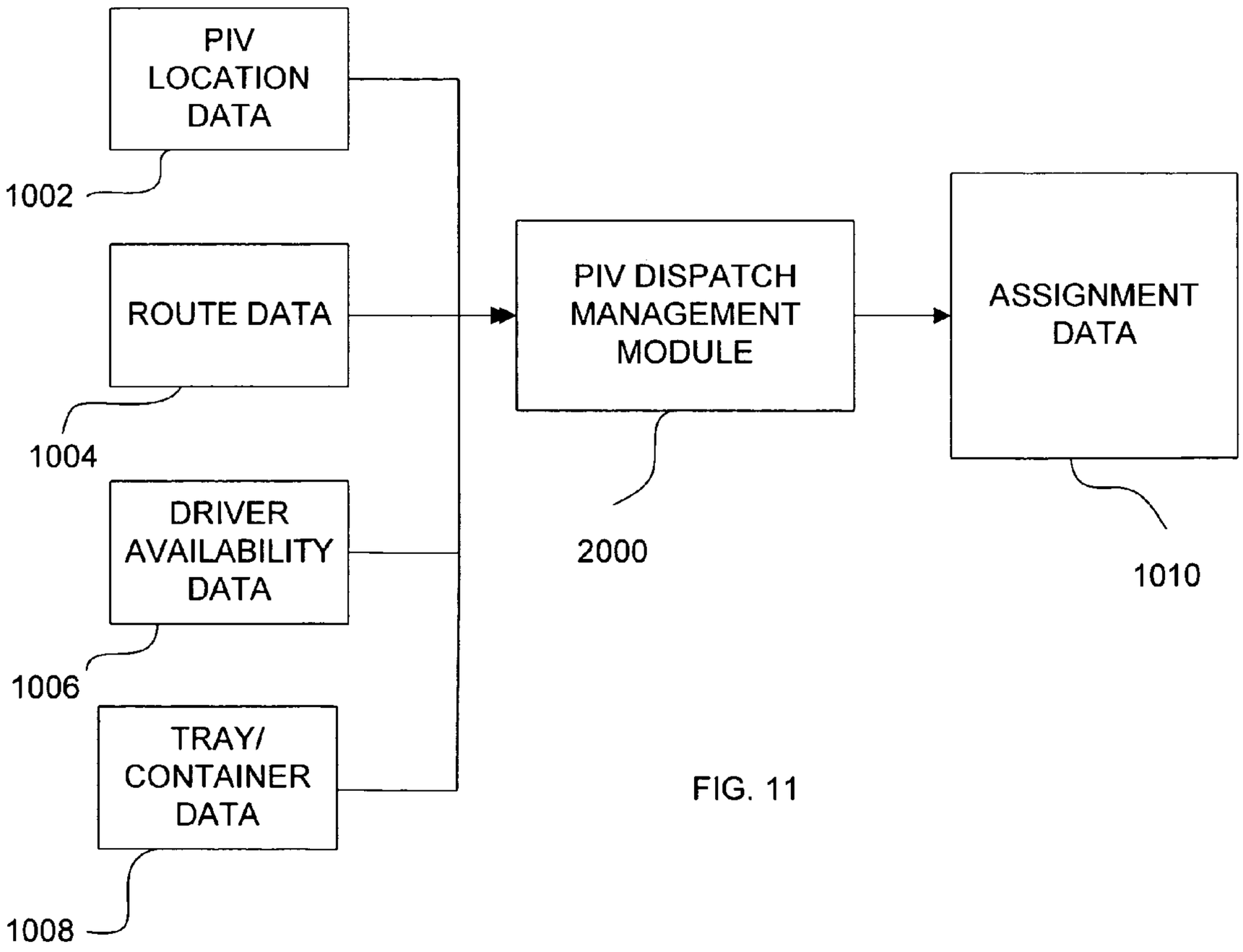

PIV LOCATION DATA
1002
ROUTE DATA
1004
DRIVER AVAILABILITY DATA
1006
TRAY/ CONTAINER DATA
1008
PIV DISPATCH MANAGEMENT MODULE
2000
ASSIGNMENT DATA
1010

FIG. 11

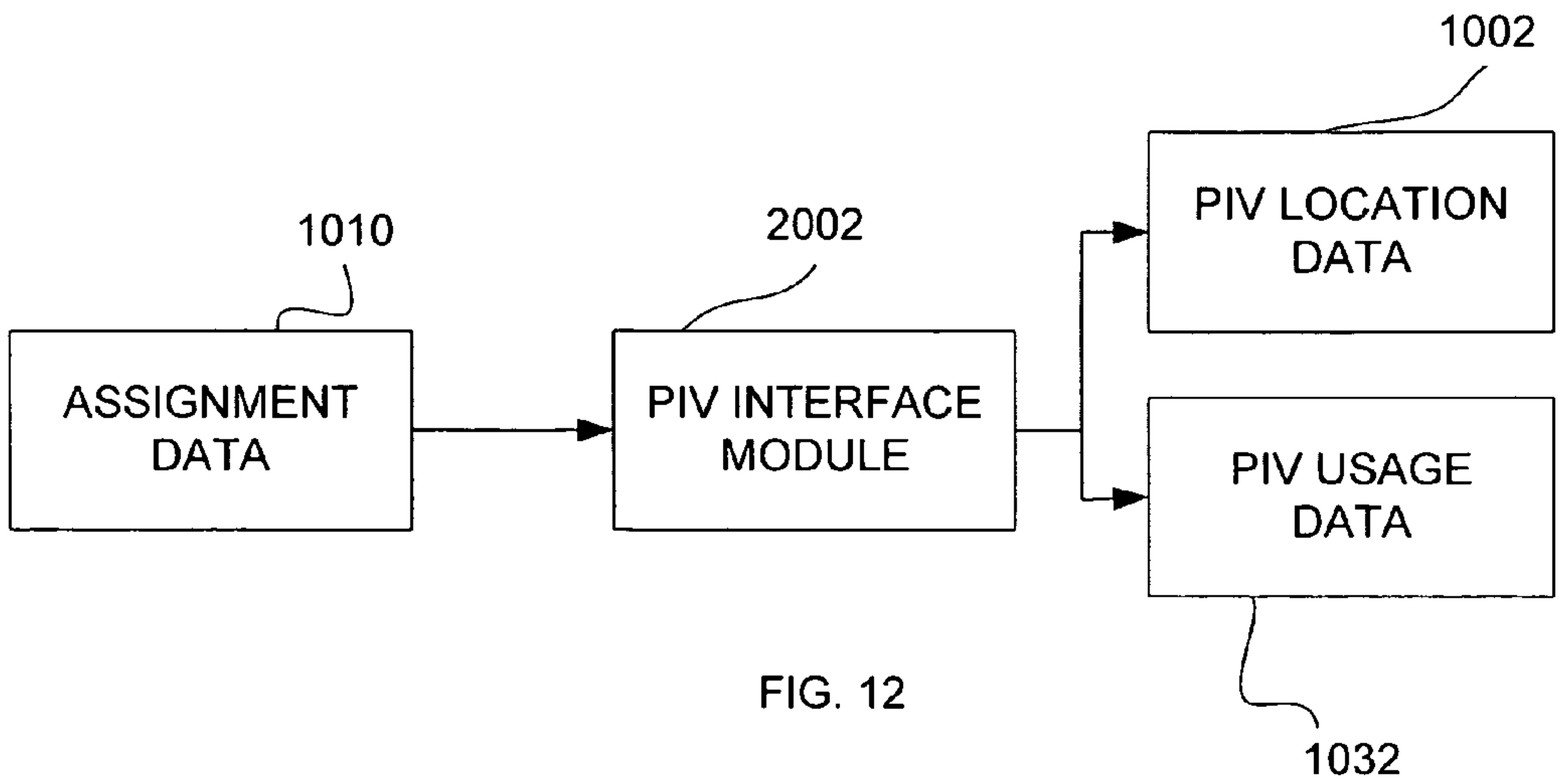

1002
1010
2002
ASSIGNMENT DATA
PIV INTERFACE MODULE
PIV LOCATION DATA
PIV USAGE DATA
1032

FIG. 12

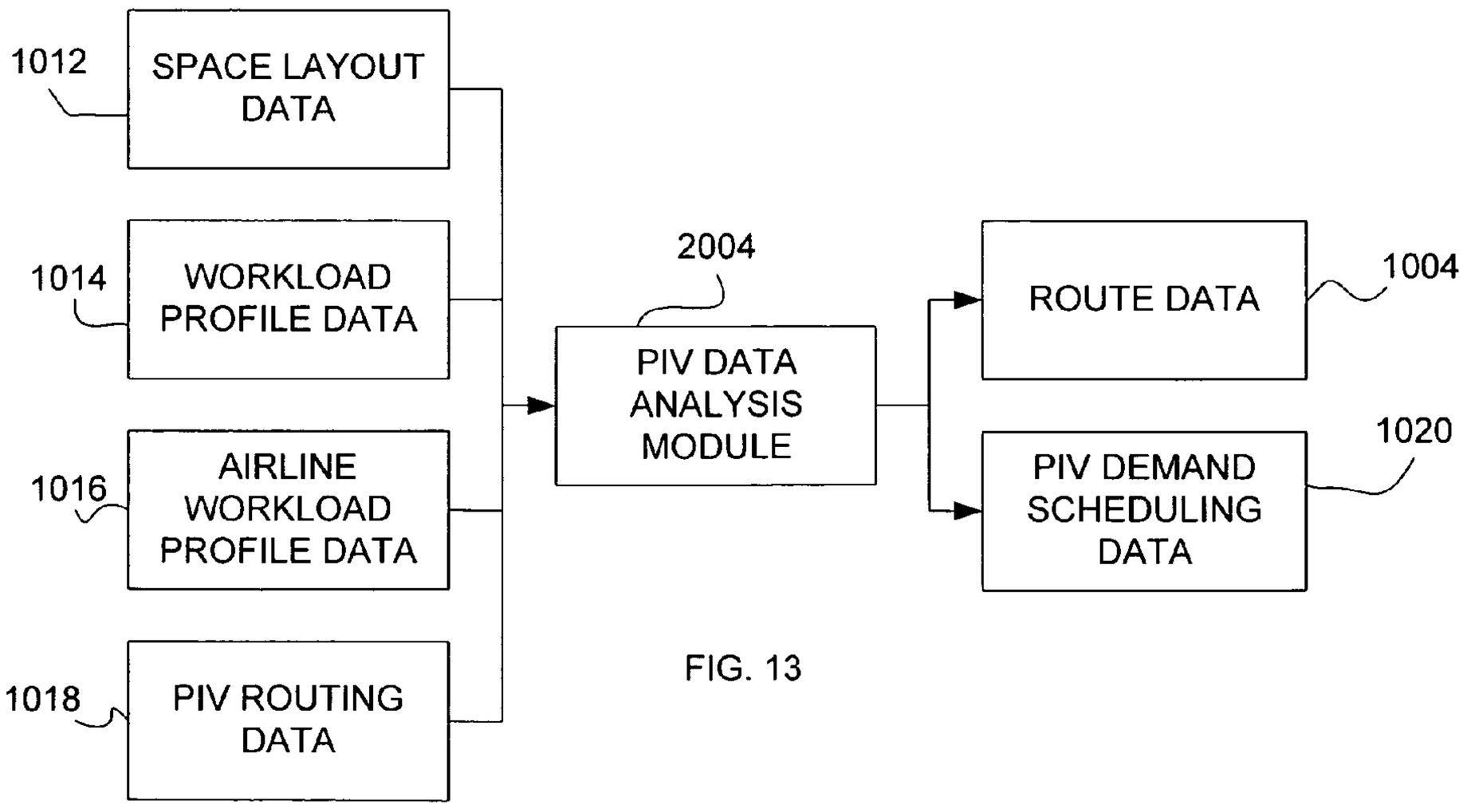

1012
SPACE LAYOUT DATA
1014
WORKLOAD PROFILE DATA
1016
AIRLINE WORKLOAD PROFILE DATA
1018
PIV ROUTING DATA
2004
PIV DATA ANALYSIS MODULE
ROUTE DATA
1004
PIV DEMAND SCHEDULING DATA
1020

FIG. 13

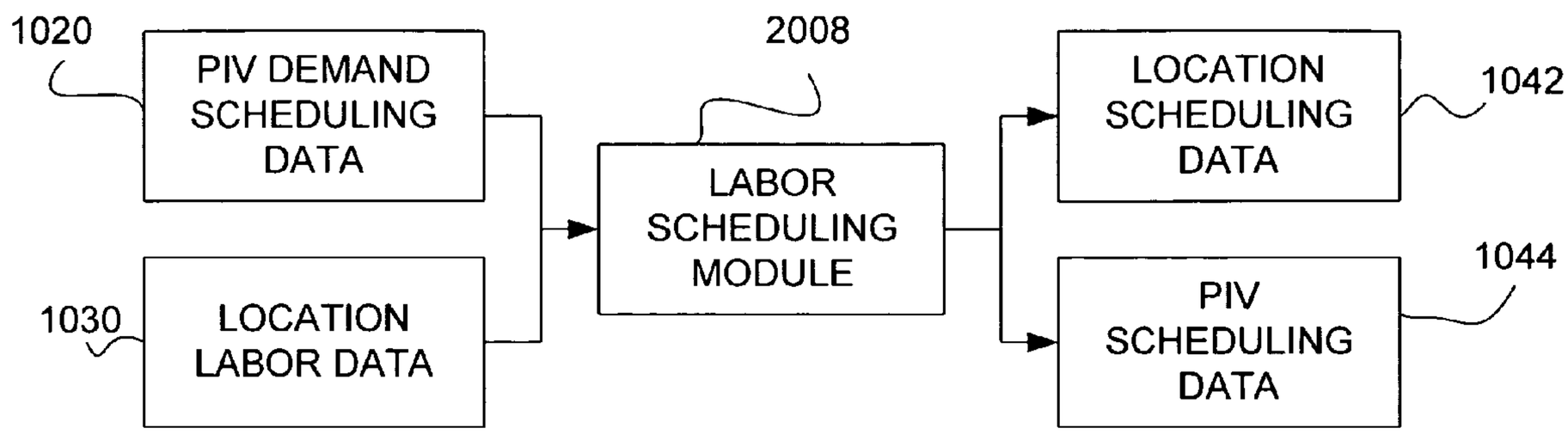


FIG. 14

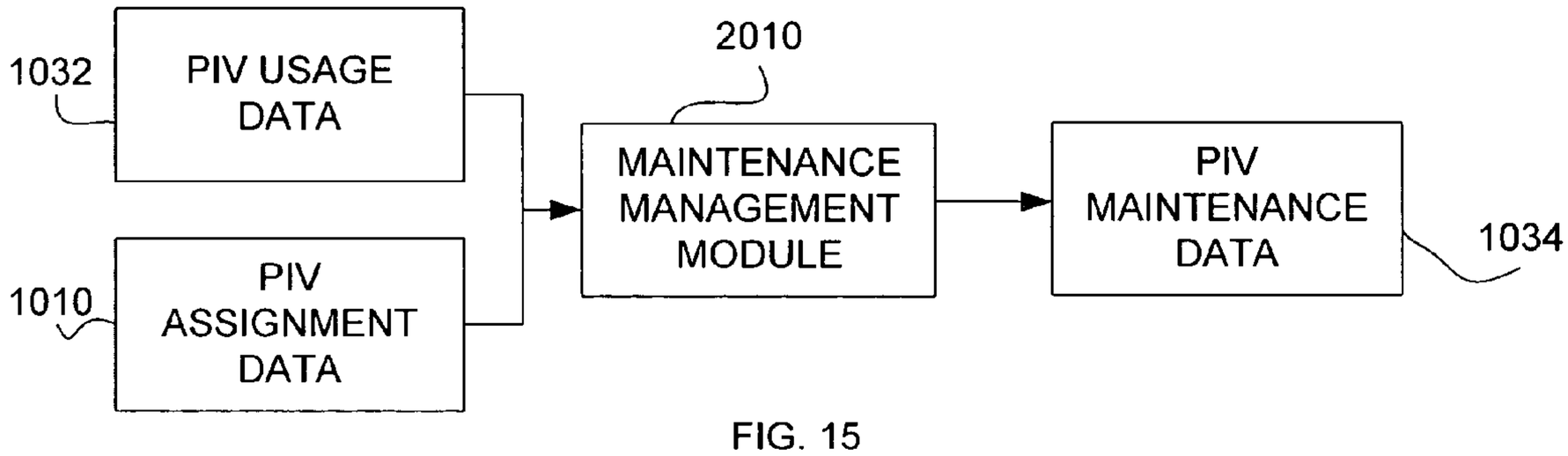


FIG. 15

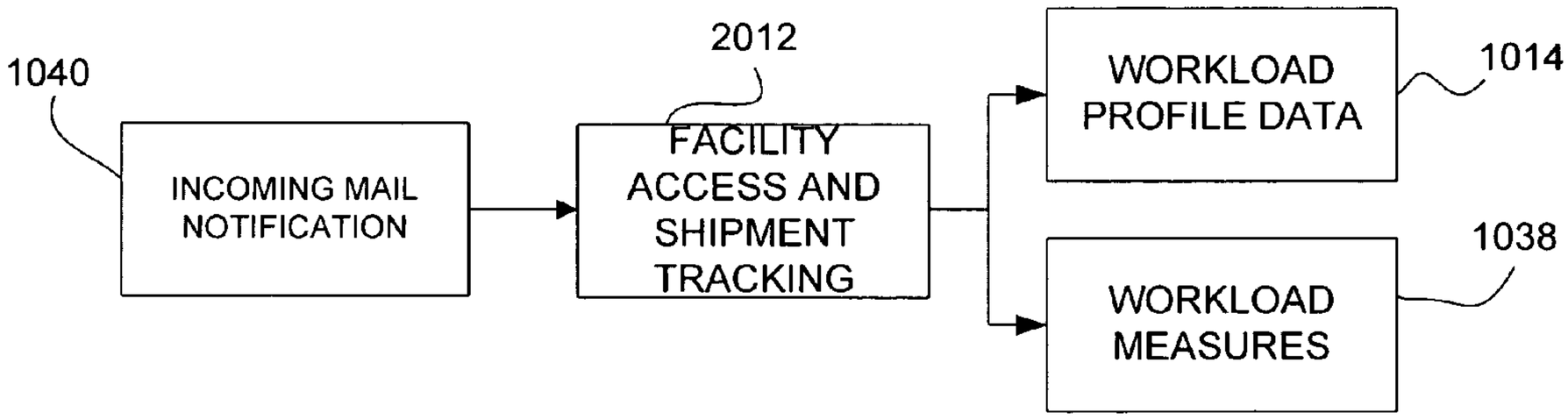


FIG. 16

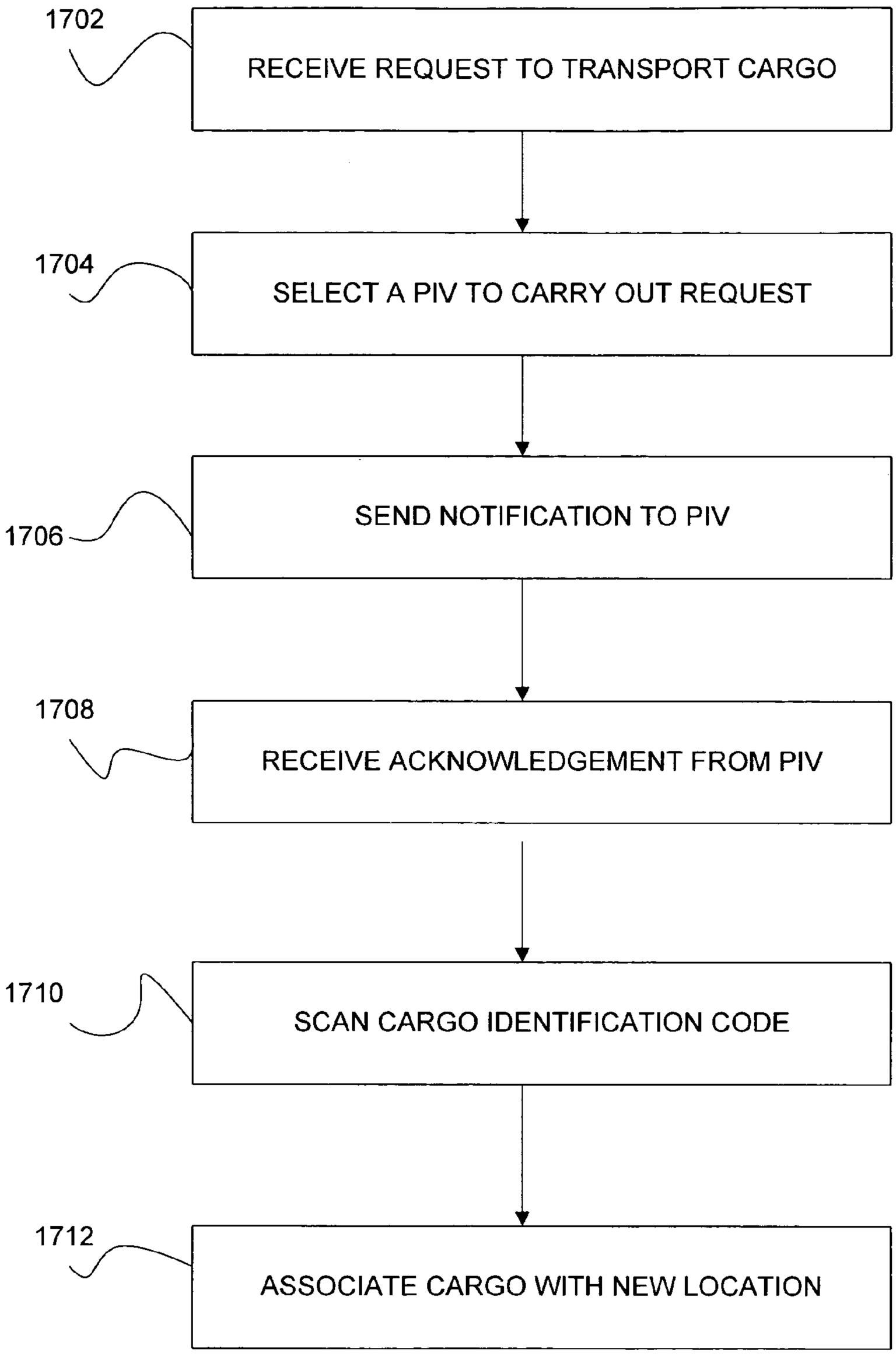

1702
RECEIVE REQUEST TO TRANSPORT CARGO
1704
SELECT A PIV TO CARRY OUT REQUEST
1706
SEND NOTIFICATION TO PIV
1708
RECEIVE ACKNOWLEDGEMENT FROM PIV
1710
SCAN CARGO IDENTIFICATION CODE
1712
ASSOCIATE CARGO WITH NEW LOCATION

Fig. 17

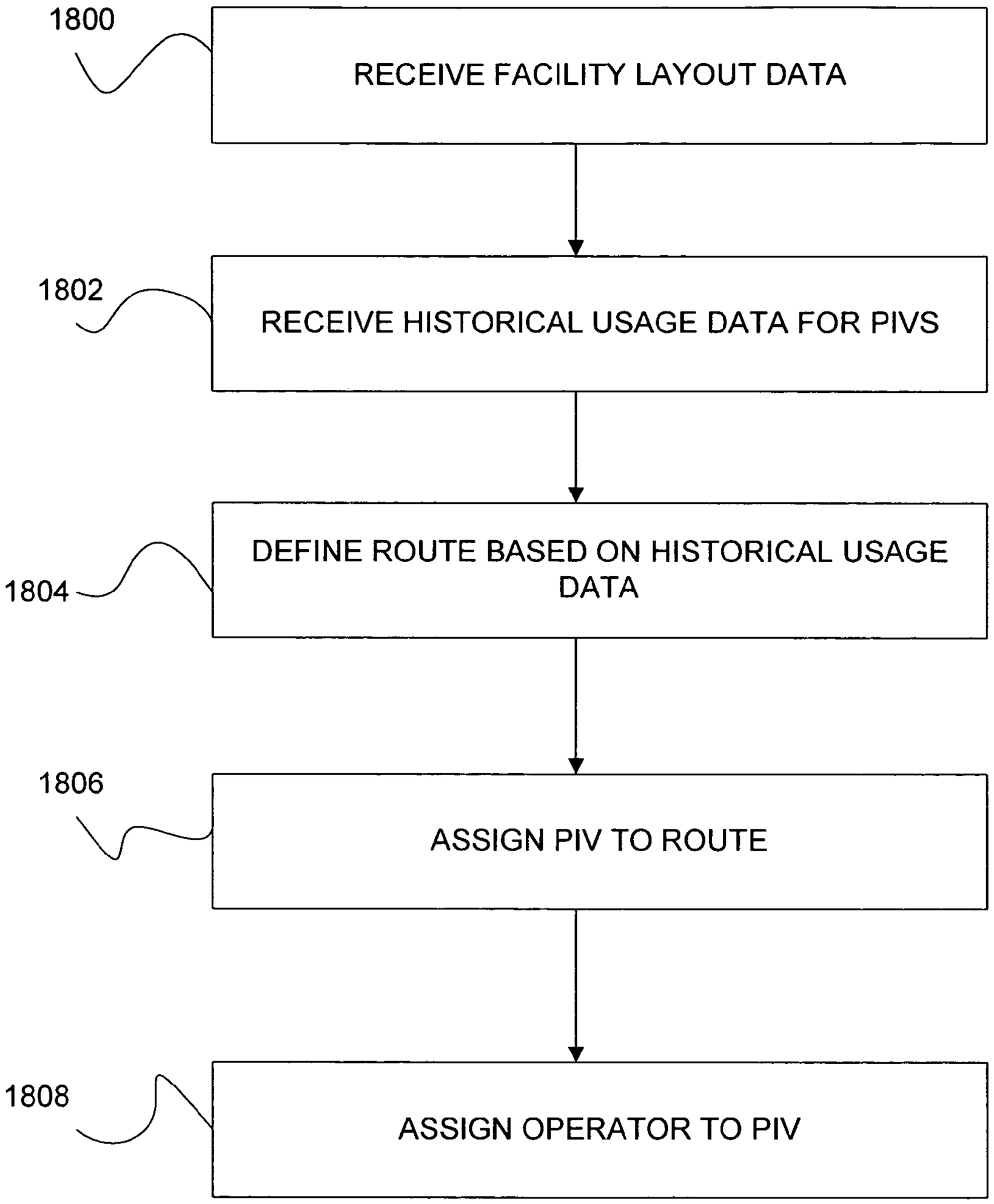

1800
RECEIVE FACILITY LAYOUT DATA
1802
RECEIVE HISTORICAL USAGE DATA FOR PIVS
1804
DEFINE ROUTE BASED ON HISTORICAL USAGE DATA
1806
ASSIGN PIV TO ROUTE
1808
ASSIGN OPERATOR TO PIV

FIG. 18

SYSTEMS AND METHODS FOR CREATING ROUTES FOR POWERED INDUSTRIAL VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/775,440, filed Feb. 21, 2006, the entire disclosure of which is incorporated by reference herein. This application is also related to the following applications filed concurrently herewith: (1) U.S. patent application Ser. No. 11/417,007, entitled "SYSTEMS AND METHODS FOR MANAGING POWERED INDUSTRIAL VEHICLES," and (2) U.S. patent application Ser. No. 11/416,614, entitled "SYSTEMS AND METHODS FOR CREATING ON-DEMAND ROUTES FOR POWERED INDUSTRIAL VEHICLES,". Each of the above-referenced patent applications is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to management of industrial vehicles. More particularly, the invention relates to management of such vehicles in environments such as facilities, including for example, plants, construction sites, warehouses, docks, airports, campus, and other specified mapped areas.

2. Description of the Related Art

In many cargo-handling environments, cargo is transported by powered industrial vehicles (PIVs). In larger warehouses, it is not uncommon for a dozen or more PIVs to be operating within the warehouse at the same time. In these large warehouses, it is difficult to track the location of each PIV and to distribute the work load evenly among all PIVs, because it is difficult to ascertain the availability of a PIV at any given moment. Sometimes, a PIV may be constantly on the run throughout the day, carrying cargo from one location to the next. At the same time, other PIVs may be sitting idle with very little work to do.

Many factors can affect the utilization of a particular PIV. For example, if PIVs are assigned regular delivery routes, it may be that some routes are significantly busier than others. Moreover, some PIV operators may be more experienced and skilled than others, which results in dispatchers seeking to use these drivers as much as possible. Other factors affecting the utilization of PIVs may include the familiarity of the operator with the layout of the workspace in which he is operating. For example, in a large warehouse environment, drivers with superior knowledge of the warehouse environment may be able to reach delivery destinations more efficiently than those without that knowledge. The motivation of the operator of the PIV may also play a role in a PIV's rate of utilization. Some operators may be more motivated and may actively seek out additional work. Other operators may be less motivated, and fail to quickly return to a dispatch area to receive an additional assignment. Uneven usage of PIVs can lead to problems in scheduling maintenance (which often depends on utilization rate). Therefore, it would be a valuable improvement to provide a system in which utilization of PIVs can be evenly distributed among an entire fleet of PIVs.

Existing schemes for managing PIV fleets also suffer from an inability to easily provide an operator of the PIV with information that may help the operator more effectively do his job. FIG. **1** provides a flowchart of a process that illustrates some of these difficulties. At block **1**, cargo arrives at a facility for unloading by a PIV. At block **2**, the PIV arrives at a loading dock in the facility. However, in order to accept a load from the inbound truck the PIV must be unassigned and not carrying cargo. Thus at decision block **3**, the process determines whether the PIV is already assigned. If the PIV is not already assigned, the process proceeds to block **4**, where the PIV picks up the cargo and destination assignment. The process then proceeds to block **5**. If it was determined in block **3** that the PIV is already carrying cargo when it arrives at the loading dock, the process skips down to block **5**.

At block **5**, the PIV operator must determine whether he knows the location of the delivery destination for the cargo. Some warehouse environments may span 75 acres or more, so if the PIV operator does not know the location for delivery, he must first obtain this information in block **6** before the process then proceeds to block **7**. If, in block **5**, the PIV operator is familiar with the destination of the cargo, the process skips to block **7**. At block **7**, the PIV operator proceeds to the delivery destination. Unfortunately, in larger warehouses, the operator may not know the most direct route to his destination, so often times the chosen route is not an optimal route for traversing the facility. Next, at block **8**, the PIV arrives at its destination and delivers its cargo. From that point, the PIV operator must return to the loading dock to receive another assignment.

The process shown in FIG. **1** is inefficient because the operator of the PIV does not have easy access to relevant data that may help him more efficiently operate the PIV. For example, upon delivering the cargo in block **8** of FIG. **1**, there may be additional cargo at a nearby location that needs to be returned to the loading dock. However, in the system of in FIG. **1**, the PIV must return to the loading dock to receive a dispatch assignment, and only then will it proceed to that new location to pickup the cargo.

Another problem associated with the operation of PIVs in existing warehousing environments stems from the difficulty associated with predicting PIV workloads in advance. Sometimes, unexpected shipments may arrive at the warehouse facility, leading to an unusually heavy volume of cargo that must be transported throughout the facility. These unanticipated spikes in arriving cargo tend to result in uneven utilization and inefficient scheduling of PIVs and their operators, as operators may need to be called in and work overtime to handle the unexpected spike in cargo volume.

Significant costs may also be incurred as a result of unauthorized or unlicensed operators taking control of PIVs and operating them unsafely. Moreover because PIVs may be dispatched for long periods of time, if a PIV is involved in an accident, it is very difficult to track when and where the accident occurred, or even who was responsible. Therefore it would be a valuable improvement to provide a system in which operators could be associated with PIVs and data could be collected regarding the operator's control of the PIV.

SUMMARY OF THE INVENTION

The system, method, and devices of the invention each have several aspects, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of this invention, several of its features will now be discussed briefly.

In one embodiment, a networked PIV management system is provided. The system comprises a PIV analyzer module configured to determine PIV route data based on facility layout data, the facility layout data being electronically generated by a software mapping tool and the route data substantially comprising an optimal route between two points in the warehouse; a PIV dispatch management module configured to receive a request to transport a cargo from a first location to

a second location in the warehouse, the PIV dispatch management module being further configured to receive route data from the PIV analyzer tool and select, based at least in part on the route data and a location of the first location, a PIV for transporting the cargo; and a surface visibility module configured to track the cargo after it is transferred from the first location to the second location by receiving scanned barcode data from the cargo via a scanner connected to the network.

In another embodiment, a computer-implemented method of managing the use of PIVs comprises receiving a request to transport cargo from a first location to a second location; selecting a PIV to carry out the request, the request being based on at least one of a current location of the PIV within the facility, the status of an operator of the PIV, and a maintenance schedule of the PIV. The method further includes sending a notification to the PIV about the request, the notification including a cargo identification code, a cargo location, a cargo destination, and an optimal route; and receiving an acknowledgement from the PIV of receipt of the notification.

In yet another embodiment, a system is provided for creating routes for PIVs. One or more PIVs are equipped with various sensors. The sensors may include odometric sensors, weight sensors, and collision sensors. The PIV also has a storage device for storing data measured by the sensors, and an interface module configured to selectively permit access to the operating capabilities of each PIV. The system also includes a route creation module configured to receive space layout data about the facility and historical usage data, stored in the storage device, about the PIVs in the facility. Based on the received data, the system may define a route in the facility, and then assign PIVs and operators to the route based on labor scheduling data.

In yet another embodiment, a method is provided for creating routes for PIVs. In various embodiments, the method may include receiving space layout data about a facility or other operating environment and historical usage data regarding PIVs operating in the facility. The historical usage may include data measured by sensors on the PIVs. Based on the received data, a route in the facility is defined. After defining the route, at least one PIV may be assigned to run the route, and an operator may be assigned to operate the PIV while it runs the defined route.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flowchart illustrating an existing method for operating a PIV in a warehouse environment.

FIG. **2** is a front elevation view of a facility with a multi station loading dock.

FIG. **3** is a block diagram providing an aerial view of the layout of a facility.

FIG. **4** is a perspective view of various items that may be carried by PIVs throughout a facility.

FIG. **5** is a side elevation view of a PIV.

FIG. **6** is a detailed side view of a trailer which may deliver cargo to a loading dock according to aspects of the invention.

FIG. **7** is a front view of a barcoded container loaded with barcoded trays according to one or more aspects of the invention.

FIG. **8** is a block diagram of a PIV facility management system in accordance with aspects of the invention.

FIG. **9** is detailed view of a PIV, including a block diagram of an operator interface for use in accordance with aspects of the invention.

FIG. **10** is a block diagram showing various inputs and outputs to a surface visibility module according to one more embodiment of the invention.

FIG. **11** is a block diagram showing the PIV dispatch management module according to aspects of the invention.

FIG. **12** is a block diagram illustrating a PIV interface module along with various inputs and outputs which may be used in accordance with aspects of the invention.

FIG. **13** it is a block diagram illustrating a PIV data analysis module which may be used in accordance with aspects of the invention.

FIG. **14** is a block diagram of a labor scheduling module which may be used in accordance with aspects of the invention.

FIG. **15** is a block diagram of a PIV maintenance management tool in accordance with aspects of the invention.

FIG. **16** provides a block diagram of a facility access to shipment tracking module that may be used in accordance with aspects of the invention.

FIG. **17** is a flow chart illustrating a method for managing a fleet of PIVs in accordance with one or more embodiments of the invention.

FIG. **18** is a flow chart illustrating a method for defining a route.

In this description, reference is made to the drawings wherein like parts are designated with like numerals throughout.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Various embodiments of the invention provide for a system and method for collecting interrelated data to achieve automation of the operation and management of PIVs.

Aspects of the invention may be practiced in various environments in which PIVs are utilized including, but not limited to, docks, hotels, campuses, airports, and warehouses. In an embodiment described herein, aspects of the invention may be implemented in a facility **100** as shown in FIG. **2**. As noted above, the facility **100** may be any of a number of different types of operating environments in which PIVs are used for transporting materials between locations. By way of example and not of limitation, the facility **100** may be a fulfillment warehouse, a factory, a shipment facility, a mail processing facility, or some other facility in which PIVs are used to transport materials or cargo.

The facility **100** may include a loading dock **102**. The loading dock **102** is a platform where vehicles such as trucks or trains can be loaded or unloaded. The loading dock **102** may be a raised platform that allows large trailers to be positioned in front of it so that the bed of a trailer is positioned at a similar height as the platform of the loading dock **102**.

FIG. **3** provides an overhead view of the exemplary facility **100**. The facility **100** may include one or more areas where cargo may be picked up or delivered. In one embodiment, such areas may be referred to as locations **140**. A location **140**, as used herein, refers to a machine location or area such as a processing area in the facility **100**. In one embodiment, the facility **100** is a mail processing facility, in which locations **140** may include mail sorting devices which receive stacks of mail and sort them into various trays by scanning the parcels and categorizing them based on criteria such as class of mail, the final destination, routing information, or based on some other information. A location **140** may also be an incoming loading dock **102** or an outgoing loading dock **102**. Cargo such as postal mail that enters the facility **100** may be routed to one or more locations within the facility **100** prior to being

routed to the outgoing loading dock **102** for transportation to another facility on a trailer **104** (or some other transportation device), or to its ultimate destination.

The facility **100** may also include several radio frequency identification (RFID) scanners **107** positioned to provide scanning coverage to various areas of the facility. In one embodiment, the RFID scanners may be placed about fifty feet from one another to provide complete coverage of the facility. One of skill in the art will appreciate, however, that depending on the particular RFID scanning technology employed, this distance may be greater or less than fifty feet, and still provide complete coverage of the facility. The RFID reader **107** may receive radio frequencies from either active or passive RFID tags that may be placed on PIVs **116**, trailers **104**, or items of cargo. The RFID readers **107** query RFID tags in order to obtain identification, location, and other information about the PIVs, trailers, or cargo devices carrying the tags. FIG. **3** illustrates how a plurality of locations may be distributed throughout the facility **100**. As is apparent from the diagram, PIVs **116** may travel throughout the facility from location to location and may return to a loading dock **102** to pick up additional cargo for transport to another location in the facility **100**.

Referring now to FIG. **4**, an exemplary embodiment of cargo that may be transported within facility **100** is shown. Although in the example shown and described the cargo is related to postal operations, one of skill in the art will readily appreciate that cargo may include any material that is transported within a facility by a PIV. For example the materials may include cargo to be delivered such as parts, commercial goods, food items, or any materials that may be transported from a first location to a second location. In the illustrated embodiment, a tray **108** includes parcels of mail to be delivered to an intended destination. The tray **108** may include a barcode **110**, which may provide information about the destination for the mail that is in the tray **108**. For example, tray barcode **110** may include information regarding a final zip code destination for the items in the tray **108**. FIG. **4** also illustrates a container **106**, which may be used for storage or stacking one or more trays **108**. The container **106** may be a shipping container such as that shown in FIG. **4** which allows the trays **108** to be stacked in an orderly manner. The container **106** may have a set of wheels which allows it to be rolled from a vehicle on to the loading dock **102** and into the facility **100**. Alternatively, the container **106** may include skids or slots for receiving prongs from a forklift or some other PIV for transportation through the facility **100**.

The containers **106** may also include a container identification barcode **112** affixed to the body of the container. The container identification barcode **112** may be used to uniquely identify the container, although not necessarily the contents or materials transported in the container. Alternatively, the container identification barcode may also include information related to the contents of the container **106**. The container identification barcode **112** and the tray barcode **110** may each be scanned by a barcode scanner **114** which may read the barcodes and store these values in a memory or transmit the values for storage in a database.

Referring now to FIG. **5**, an example of a powered industrial vehicle (PIV) **116** is provided. PIV **116** may be any number of different types of vehicles, including forklifts, motorized carts, or any other vehicle that can be used to transport cargo or other materials within the facility **100**. A PIV **116** may include a wireless transceiver **126** configured to send and receive data wirelessly. Wireless transceiver **126** may take the form of an RFID receiver, or it may work in conjunction with an RFID tag placed on the PIV **116** to transmit identifying information. The RFID tag/receiver allows the wireless transceiver **126** to transmit the location of the PIV **116** over a network. In other embodiments, wireless transceiver **126** may be a GPS transmitter/receiver, or a GSM cellular transmitter or receiver which may be used to pinpoint a location of the PIV **116** and report the location by sending a text message over a mobile phone network.

Referring now to FIG. **6**, a more detailed example of a trailer **104** is provided. Trailer **104** may include a trailer identification barcode **120** located, for example, on its outer surface at eye-level so that it may be scanned by a detector such as scanner **114**. The trailer identification barcode **120** may be used to uniquely identify the trailer **104** when scanned by the scanner **114**. The trailer identification barcode **120** may be scanned by the scanner **114** upon arrival or dispatch at loading dock **102** so that the system can insure accurate and timely loading and unloading of the trailer **104**. The trailer **104** may also include a GPS receiver **148**, which is configured to be used in conjunction with a global positional system to track the location of the trailer **104**.

FIG. **7** is a more detailed view of a container **106**. In the example provided, the container **106** is loaded with thirty trays **108** and each of the trays includes a tray barcode **110** located, for example, on its exterior shell where it can be easily scanned by the scanner **114**. The barcode **110** includes information associated with the destination of the tray **108**. This information may include an identifier which can be associated with data stored in a database which is related to the identifier. For example, the scanner **114** may scan the barcode and from that scan receive the identifier. The identifier may be sent by the scanner to a database which stores additional information about the tray **108**, such as the destination zip code for the cargo in the tray, or the tray's next delivery location **140** within the facility **100**. The database may be stored on the scanner **114** in a storage area, or it may be stored remotely, accessible to the scanner **114** via the network **130**.

The container **106** may also include a container identification barcode **112** located on an exterior portion of the container **106** and not shown in FIG. **7**. Locating the container identification barcode on the exterior portion of the container **106** allows the barcode to be scanned without difficulty. The container identification barcode **112** may be used to uniquely identify the container much in the same way that a license plate may identify an automobile. In addition to the container identification barcode **112**, the container may also include a second barcode, the container destination barcode **119**, which may be placed on the container **106** by attaching a removable placard **118** to the outer surface of the container **106**.

The container destination barcode **119** may include information which can be used to identify the destination and the routing information for the container **106**. In one embodiment, the routing information may be predetermined based on the destination information. For example, if the destination of the container is a location **140** in the facility **100**, the routing information may be based on a predefined route from the loading dock to the location that is stored either in the scanner **114** or in a database accessible via the network **130**. Alternatively, if the destination is another facility, the routing information may be derived from a mapping table which stores shipping routes between various facilities. When a container **106** reaches a new location, a user of a handheld scanner **114** may scan the container identification barcode **112** and then scan the container destination barcode **119** to associate the container **106** with its new location.

Because the placard **118** is removable, when the container reaches the destination indicated by the container destination

barcode **119**, the placard **118** may be removed and replaced with another placard **118**. The new placard **118** may have a new container destination barcode **119** which may then be scanned and associated with the container identification barcode **112**.

FIG. **8** is a block diagram of a PIV facility management system **1000** that may be implemented in a network according to one or more aspects of the invention. The details of various exemplary components of the network **130** shown in FIG. **8** will be described below with reference to FIGS. **10-16**. Various system components of the management system **1000** may be in communication with each other via a computer network **130**. The computer network **130** may be any of a number of different types of computer networks such as a local area network (LAN), a wide area network (WAN), an ATM network, an ISDN network, a token ring network, an intranet/extranet, or some other network environment. The network may also include a fiber optic network for high speed transmission of data. The computer network **130** may include a series of routers, hubs, access points, or other components for sending and receiving data across the network from one component to the next. Various computer systems may be connected to the computer network **130**. These connections may be wired connections, wireless connections, or a combination of both.

In one embodiment, a PIV **116** may include a wireless transceiver **126** that connects wirelessly to the computer network **130**. Similarly, the barcode scanners **114** may also connect wirelessly with network **130** to share data with other devices connected to the network. Through this wireless network connection, the barcode scanners **114** may be configured to scan barcodes at the loading dock **102** and other areas of the warehouse facility **100** and quickly send scanned data to other system components.

Also connected to the network **130** are various other computer systems examples of which will be described in greater detail below. These components include a PIV dispatch management module **2000** which manages dispatch of PIVs to warehouse locations **140** and a PIV interface module, which provides PIV-specific data to the network. Also connected to network **130** is a PIV data analysis module **2004**, which performs predictive analysis of data supplied by various other system components. The network **130** may also send/receive data from a surface visibility module **2006** which may be used to track materials such as containers **106**, trailers **104**, and trays **108**, as they arrive at the facility **100** and are transported through various locations within the facility. The network **130** may also be connected to a labor scheduling tool **2008** which may be used to schedule shifts for PIV operators based on manpower needs. The network **130** may also include a PIV maintenance management module **2010** which may be used to schedule both preventative and unanticipated maintenance for the PIVs **116**. The PIV facility management system **1000** may also include a facility access and shipment tracking module **2012** which may be used to track irregular or large shipments into the facility **100**. In an embodiment where the facility is a mail processing facility, the facility access and shipment tracking module **2012** may be used to track incoming bulk mail shipments that are typically comprised of cargo from a single sender, such as magazines or catalogs.

Additional system components may also be connected to the network **130**, and one of skill in the art will appreciate that the various components described herein may be embodied in various hardware and software configurations without departing from the scope and sprit of the invention disclosed herein. For example, in one embodiment, each module described above may be a separate server configured to perform specialized functions. In other embodiments, various modules may be combined into a single server system. Moreover, one of skill in the art will also appreciate that data may be shared among these various systems by way of any number of common data formats such as XML, EDI, or some other data format so long as it is machine readable by both the sending and receiving device.

As shown in FIG. **9**A, the PIV **116** may be connected to the network **130** by way of a wireless transceiver **126**. In one embodiment, a PIV **116** may include an interface module **2002**. The interface module **2002** may be a computing device such as a mobile computer placed in the PIV **116** which is configured to communicate with a network **130** and via the wireless transceiver **126**. In one embodiment, the interface module **2002** may include a user interface **132**. Alternatively, the user interface **132** may be a separate component that is in electrical communication with the interface module **2002**. The user interface **132** may be used by the operator of the PIV to send and receive data from the network **130** (via the network transceiver **126** or some other means). The data may include information such as cargo pickup locations, cargo destination locations, route maps, or other data. The user interface **132** may be positioned in close proximity to the operating controls of the PIV so that the operator of the PIV is able to safely interact with the user interface **132** while operating the PIV **116**.

In another embodiment, the user interface **132** may be fully integrated into the operating controls of the PIV, allowing the PIV operator to control the operation of the PIV and to send and receive data communications through a single unified interface. The PIV **116** may also include sensors **138** which may be configured to detect collisions involving the PIV and send data about each collision to the interface module **2002**, which may then send the data back to the maintenance management module **2010** via the wireless transceiver **126**. Alternatively, the sensors **138** may be configured to send collision data directly to the network **130**, bypassing PIV interface module **2002**.

Referring now to FIG. **9**B, the user interface **132** may include a display **134**. The display may be any one of the number of different types of displays including an LCD display with a touch screen functionality a CRT display, or some other type of display. The display may be used to display information received in the user interface from a data source such as the network **130** via the wireless transceiver **126**. The user interface **132** may also include an input device **136** such as a keypad which may be used by the PIV operator to enter data into the interface module **2002** for communication to other network components via the wireless transceiver **126**. Although the input device **136** shown in FIG. **9**B is a keypad, one of skill in the art will appreciate that the input device may take many different forms. For example, the input device **136** may be a touchpad, a touch screen accessible via a stylus, a microphone configured to receive voice data and work in conjunction with a voice recognition system, or some other input device such as a computer mouse or standard keyboard.

In some embodiments, the interface module **2002** may be configured to permit selective access to the operating controls of the PIV **116**. By way of example and not of limitation, in one embodiment, the interface module may include a database of authorized operators for the PIV. In order for an operator to access the PIV, the operator may be required to login to the PIV via the user interface **132** and the input device **136**. The operator may have user identification and a password that is entered into the system. Alternatively, the input could be a voice command, a keycard associated with the operator, or some other input.

The database of authorized operators of the PIV may be specific to the PIV on which it is stored, or it may be a more general type of database based on the model of the PIV. For example, the database may include a list of each type or model of PIV, and may include a list of authorized operators for each model. The authorization of operators of the PIV may be based on various qualifying metrics. For example, the system may require that an operator be certified by some governmental entity, such as OSHA (Occupation and Safety and Health Administration) and that the certification be current. Thus, the database may be updated regularly to account for changes in certification status.

In some embodiments, the database may be downloaded in real-time from the network **130** into the interface module **2002** when access to the PIV **116** is requested by an operator. This real-time download helps to ensure that the most up to date certification data is relied upon by the login routine. In addition, the real-time download of the data also allows the system to prevent multiple simultaneous logins by a single user. Prevention of multiple logins helps to ensure that an unauthorized operator does not use another operator's login data to access the PIV **116**. Alternatively, the interface module **2002** may receive pushed updates over the network **130** from a centralized server that maintains the certification data. In one embodiment, the central server may be the PIV dispatch management module **2000**. In other embodiments, the central server may include a dedicated server that connects to an external database such as a governmental certification database accessible via the Internet.

Additionally, the certification database may be configured to track accident events or collision events for each operator of the PIV. This is possible due to the sensors **138** on the PIV and the requirement that all operators login to the PIV in order to operate the PIV. Thus, in addition to requiring a government certification for logging into a particular PIV, the system may restrict access when a particular operator has been in one or more collision events. Such a configuration may provide an additional layer of safety in the operating environment. The sensors may also track speeds at which the PIV is operating. If a particular operator exceeds a speed limit within the facility, this event may be recorded, and may be used to deny authorization to operate PIVs after repeated offenses. Referring now to FIG. **10**, a block diagram illustrating the data flow into and out of a surface visibility module **2006** is provided. The surface visibility module **2006** collects data by receiving scanned data about the cargo and vehicles. The surface visibility module **2006** links the data to support planning, management, and optimization of the transportation of the cargo from its original location to its final destination. In this sense, the surface visibility module **2006** is an end-to-end cargo tracking solution. The surface visibility module **2006** may be implemented as a network-enabled database management system that is configured to receive data inputs via various inputs sources. The surface visibility module **2006** may be implemented as a relational database, an object-relational database, or an objected-oriented database. Although it may store additional data, the surface visibility module **2006** may record location data for barcoded items in the facility **100**, and update its database with new information each time a barcode is scanned.

The surface visibility module **2006** receives its data inputs through various means. For example, the PIV location data **2002** may be collected from the RFID tags on the PIV **116** that are read by RFID scanners located within the warehouse facility **100**. The RFID scanners **107** may relay this location information to the surface visibility module **2006** where it may be stored for additional processing. The RFID scanners **107** may take the form of gateway beacons which provide a gateway to the surface visibility module **2006**, the PIV dispatch management module **2000** and the PIV data analysis module **2002** via an Ethernet or fiber optic network. In some embodiments, this network may be a private dedicated network that is separate from a larger WAN environment.

The surface visibility module **2006** also collects tray/container data **1008** via scans of container information barcodes **112**, container destination barcodes **118**, and tray barcodes **110** at all handoff points in their distribution channels. Although the embodiments described herein utilize barcode technology for tracking the location or cargo, one of skill in the art will appreciate that containers, trays and other items of cargo may similarly be tracked and located utilizing RFID tags and readers **107**. Handoff points that are scanned into the surface visibility module **2006** may include arrival scans, departure scans, and various interim points within facility **100**, such as locations **140**. The surface visibility module **2006** may also receive arrival/departure data **1026** which may include information regarding the arrival and departure of trailers **104** at the loading dock **102** of the warehouse facility **100**. The arrival/departure data **1026** may be captured by scanning the trailer identification barcode **120** upon arrival and departure from the loading dock **102**. Alternatively, each trailer **104** may be equipped with RFID tags that are scanned by RFID scanners **107** as they come in proximity to the facility **100**. The surface visibility module **2006** may also receive trailer loading data **1028**. This data may include a trailer space utilization measurement based on arrival and departure scans, to determine whether it is full.

The surface visibility module **2006** may also generate data output based on the received data inputs. By way of example and not of limitation, the surface visibility module **2006** may generate workload profile data **1014** which may be sent to the PIV data analysis module **2004** where it may be analyzed to predict future volumes of incoming cargo. The workload profile data **1014** may include average incoming mail volume for certain time periods. The surface visibility module **2006** can derive this data based on the number of incoming barcode scans over time. For example, in one embodiment, the surface visibility module will generate workload profile data by querying its database to determine the average incoming cargo volume for each hour of the day over the course of two months. This derived data may be further refined to analyze the workload based on days of the week and hours of the day. Where the surface visibility data is stored in a relational database, the workload profile data may be extracted through the use of SQL select queries as are known in the art. Alternatively, the surface visibility module **2006** may also simply send raw data to the PIV data analysis module **2004** for analysis, as will be discussed further below.

In addition to generating workload profile data **1014**, the surface visibility module may also generate route deviation data **1024** to account for changed circumstances within the warehouse facility. Route deviation data **1024** is data that alters routing information for a particular container **106** or tray **108** based on changed conditions in the facility **100** such as an early departure by trailer **104** on which the container **106** or tray **108** was to have been loaded prior to its departure. When this occurs, the surface visibility module **2006** will identify the next best destination for that particular parcel or container, and modify the data associated with its barcode accordingly.

Referring now to FIG. **11**, a data input/output diagram showing the data flow for PIV dispatch management module **2000** is provided. PIV dispatch management module **2000** manages the dispatch of PIVs by generating assignments, in

the form of assignment data **1010**, for the PIVs to pick up and deliver cargo throughout the facility **100**. As used herein, an assignment includes any task given to a PIV and its operator/driver directing it to proceed to one or more locations **140** in the facility **100** to pick up and/or deliver cargo. In one embodiment, the assignment data **1010** may be stored in a relational database table of comprising a set of assignment records. The assignment records may include, for example, a beginning location, a destination location, a barcode number indicative of the materials to be included in the assignment, and possibly a PIV/operator associated with the assignment. The assignment data **1010** may be sent in the form of a notification message to a PIV **116**, or more precisely, to the PIV interface module **2002** where it can be retrieved by the PIV operator through the user interface **132**, and responded to accordingly.

The PIV dispatch management module **2000** may be configured to receive various data inputs shown in FIG. **10** in order to efficiently create the assignment data **1010**. In one embodiment the PIV dispatch management module **2000** generates assignment data **1010** based on input data which is received into the PIV dispatch management module **2000**. The input data includes PIV location data **1002**. PIV location data **1002** may provide the current location of each PIV within the facility **100**. The PIV location data **1002** may be sent via the wireless transceiver **126** of each PIV **116**. The PIV location data **1002** may be generated by various means including GPS technology, RFID technology, or some other locating device, and the data may be in the form of a set of coordinates for each PIV operating within the facility **100**.

PIV dispatch management module **2000** also may receive route data **1004** which allows it to determine an appropriate route to include in each assignment record. In some embodiments, the route data **1004** may be generated from a map of the operational space layout data **1012** (discussed below) of the facility **100**. The map may be generated by mapping software such as AutoCAD®, Visio®, or some other mapping software. A digital version of the space layout of the facility **100** may be included in each assignment record so that the PIV operator can use the map to traverse the facility. In other embodiments, the route data **1004** may include a series of routing instructions that indicate one or more specific routes for traveling from one location to another within the facility. In yet another embodiment, the route data **1004** may be calculated on the fly in order to account for possible PIV traffic congestion that may be present in an otherwise optimal route. Instances of PIV traffic congestion may be identified by receiving PIV location data **1002** and flagging defined areas in the facility **100** in which the number of PIVs exceeds a defined threshold. When a calculated optimal route passes through a congested area, an alternate route may be calculated and provided to avoid the congestion.

PIV dispatch management module **2000** also processes driver availability data **1006**, which describes the status of PIVs and their operators, in order to generate assignment data **1010**. Driver availability data **1006** may include a list of PIV operators currently on duty and available to pick up cargo. The driver availability data **1006** may be derived by first determining those operators currently on duty and operating a PIV. This information may be stored in a labor scheduling module **2008** (discussed in further detail below), or it may alternatively be stored in some electronic time-tracking or ERP software application that is known in the art. Next, the list of on-duty operators can be cross-referenced or compared to a list of operators currently dispatched to a location **140** within the warehouse facility **100**. Those operators on the first list, but not on the second, may be flagged as being available for dispatch.

Driver availability data **1006** may also include next stop information for those drivers/operators that are currently dispatched on an assignment. This information may be used to identify currently dispatched operators that might be best situated for a particular assignment based on the destination location of the current assignment.

PIV dispatch management module **2000** also receives tray/container data **1008** which includes barcode and location data for trays **108** and containers **106** as they are scanned each time they arrive at a new location in the facility **100**. As discussed above, the tray barcode **110** and the container destination barcode **118** may be used to determine the next location within with the facility **100** for each particular piece of cargo. The PIV dispatch management module **2000** analyzes the tray/container data, and generates assignment data **1010** based on the tray/container data **1008**.

Referring now to FIG. **12**, the data flow for the PIV interface module **2002** is provided. As previously discussed in connection with FIG. **11**, the PIV interface module **2002** receives assignment data **1010** from the PIV dispatch management module **2000**. Upon receiving the assignment data **1010**, the PIV interface module **2002** displays assignment details to the operator of the PIV **116** on the display **134** of the user interface **132**.

The PIV interface module **2002**, in addition to receiving assignment data, may also be configured to generate and send data back to the network for processing by various other network components. This generated data includes PIV location data **1002**, which may be generated at regular intervals and reported back to the PIV dispatch management module **2000** and/or to the surface visibility module **2006**.

In one embodiment, the PIV location data may generated based on data provided by a GPS receiver on the PIV **116** which is in communication with the PIV interface module **2002**. Alternatively, the PIV location data **1002** may be determined based on assignment data **1010**. In this embodiment, the PIV interface module **2002** determines whether the PIV is currently dispatched on an assignment by examining the status of the most recent assignment data **1010** received into the PIV interface module **2002**. For example, if the assignment data indicates that the PIV has picked up an assigned cargo, but has not yet delivered the cargo, the location data **1002** may be structured to indicate that the PIV **116** is located at a midpoint between the pickup location and destination location reflected in the assignment data **1010**.

PIV interface module **2002** may also generate PIV usage data **1032**. PIV usage data may include operational metrics such as total distance traveled by the PIV **116**, the number of operating hours, the total weight carried over time, or some other data reflecting how the PIV **116** has been used over a period of time. The PIV usage data **1032** may be captured by various instruments that may be installed in the PIV **116** and configured to communicate with the PIV interface module. For example, the distanced traveled may be measured by an odometer, and this measured distance may be communicated to the PIV interface module **2002**. In addition to displaying the odometric information on the display **134**, the user interface **132** of the PIV interface module **2002** may also store this information to be included with the PIV usage data **1032** that is sent. Similarly, the PIV **116** may be configured with an operating clock that records the amount of time that the PIV is operating, and this information may be communicated to the PIV interface module **2002** for storage and further processing. In some embodiments, the PIV usage data **1032** is

sent over the network **130** to the maintenance management module **2010**. Based on that data, the maintenance management module **2010** may be configured to schedule routine maintenance for the PIV **116**, as will be discussed in greater detail below.

The PIV facility management system **1000** may also include the PIV data analysis module **2004** which functions as illustrated in FIG. **13**. The PIV data analysis module **2004** interfaces with various other modules in the system to provide an operational framework based on data collected from the various other subsystems and modules. This framework may be utilized by the PIV dispatch management module **2000** to manage PIVs **116** within the facility **100**.

The PIV data analysis module **2004** includes various inputs from which data to be analyzed is received. In order to create the operational framework for the PIV dispatch management module **2000**, the PIV data analysis module **2004** may receive operational space layout data **1012** that has been generated by a mapping tool. As noted previously in connection with FIG. **11**, various software tools may be used to create the operational layout data. These tools may include some computer assisted design (CAD) software such as Visio® or AutoCAD®, or some other integrated mapping tool known in the art. Based on the available space in the facility **100**, space layout data **1012** is used by the PIV data analysis module to generate specific route data **1004** to be provided to the PIV dispatch management module **2000** for use in creating assignment records which comprise the assignment data **1010** given to PIVs and their operators.

In some embodiments, the PIV data analysis module **2004** may also receive workload profile data **1014**, airline workload profile data **1016**, and PIV routing data **1018**, which may be used to compile PIV demand scheduling data **1020**. By combining and analyzing aspects of each of these data inputs, the PIV data analysis module **2004** is able to create a framework within which PIVs can be efficiently deployed.

Workload profile data **1014** received by the PIV data analysis module **2004** may include volume metrics of incoming cargo over time. These measurements may be provided by the surface visibility module **2006** as discussed above in connection with FIG. **10**. In a mail processing environment, workload profile data **1014** may also include information regarding the shape, the class, and the type of mail received during certain time intervals. Additionally, workload profile data **1014** may also be generated by the facility access and shipment tracking module **2012** based on irregular shipments received that are not tracked through the surface visibility module due to their irregular nature.

In one embodiment, the facility access and shipment tracking module **2012** and the surface visibility module **2006** may be configured to report incoming volumes of mail to the PIV data analysis module **2004** at set time intervals. For example, each of the reporting modules may be configured to query its database to determine the amount of cargo arriving each hour. Upon completing their respective queries, the surface visibility module **2006** and the facility access and shipment tracking module **2012** may then send the query results over the network **130** to the PIV data analysis module **2004**.

In addition to receiving workload profile data **1014**, the PIV data analysis module **2004** may also receive airline workload profile data **1016** which may include measurements of high priority cargo brought to the facility **100** that has been designated for air shipment. In an embodiment in which the facility is a mail processing facility, the high priority cargo may include overnight mail or air-mail being sent overseas. Airline workload profile data **1016** may be tracked separately from first class or bulk mail because air mail and Express Mail may include different barcode data that requires different treatment within the warehouse facility **100**.

As briefly discussed above, the PIV data analysis module **2004** may be configured to analyze the workload profile data to generate PIV demand data **1020** which includes information regarding the anticipated demand for PIV services at various times. The PIV data analysis module **2004** may use historical workload profile data to predict incoming cargo volumes. Based on these predicted incoming cargo volumes, the PIV data analysis module may create a schedule of anticipated PIV demand data **1020** to send to the labor scheduling module (as will be discussed further below). In one embodiment, the PIV demand data **1020** is a weekly schedule that indicates a minimum number of PIVs **116** necessary to accommodate the predicted incoming volume of cargo for each hour in the week. The PIV demand data **1020** may also provide an optimal number of PIVs **116** for each hour in the week. In certain industries, where seasonal demand is variable, the PIV demand data **1020** may be configured to account for this variability. By examining data reflecting incoming workload volume over several years, seasonal variations and trends can be accurately tracked and predicted.

In addition to the workload profile data, the PIV data analysis module **2004** may also receive or generate PIV routing data **1018** which may include average time measurements for dispatches from a first location **140**(**1**) to a second location **140**(**2**). The PIV routing data **1018** may be generated by examining pickup and delivery times entered into either the PIV dispatch management module **2000** or the surface visibility module **2006**, for certain PIV delivery routes. The PIV routing data **1018** may be used by the PIV data analysis module **2004** to periodically or continuously reevaluate the route data **1004** that it provides to the PIV dispatch management module **2000**, so that it may determine whether there are superior routes that can be added to the route data **1004**. For example, where the route data **1004** is stored as a mapping table of routes between each location within the facility **100**, the PIV routing data **1018** may be used to evaluate whether certain PIV routes are inefficient.

Various external factors may lead to route inefficiency. For example, if too many location to location routes pass through the same area of the facility **100**, the traffic congestion may affect efficiency and require adjustment of some of the routes. Thus if a particular route between two locations regularly encounters delays, the PIV data analysis module **2004** may be configured to provide an improved or alternate route between the two locations by analyzing secondary route options. Moreover, changes in the space layout data **1012** may also affect the efficiency, accuracy, or even the correctness of route data **1004**. When these types of changes are detected by the PIV data analysis module **2004** in the space layout data **1012**, the PIV data analysis module **2004** may be configured to automatically recalculate route data **1004** and send it to the PIV dispatch management module **2000**.

The facility management system **1000** may also include a labor scheduling module **2008** as shown in FIG. **14**. The labor scheduling module **2008** is used to schedule and staff various locations in the facility **100**. The labor scheduling module **2008** also schedules operators for PIVs **116**. The labor scheduling module may receive and store location labor data **1030** which includes the necessary man hours to staff each location **140** in the facility **100** to achieve maximum efficiency.

Different locations in the facility will have different staffing requirements. Moreover, certain locations may have staffing requirements that differ based on the volume of cargo passing through the facility **100** at a given time. For example, in a mail processing environment, some locations **140** may

consist of mail sorting machines. These machines may be staffed by two persons during normal operation. A first operator may feed mail pieces into the machine, while a second operator may manage the placement of output trays at the downstream discharge end of the mail sorting device. However, during especially busy times, an additional operator may be necessary to assist in loading the machine. The location labor data **1030** may be entered manually into the labor scheduling module **2008**, or it may be received via network **130** from some other subsystem.

Based on the location labor data **1030**, the labor scheduling module **2008** may generate a location labor schedule and output it as location scheduling data **1042**. In generating the location scheduling data **1042**, the labor scheduling module **2008** may be configured to assign operators to each location based on the number of operators needed at each location. If the placement of additional operators at a particular location will increase efficiency, then the labor scheduling module may be configured to assign extra operators based on availability. Thus, if each of the locations is at least minimally staffed, but there are operators available for scheduling, the labor scheduling module may place additional operators throughout various locations **140** in the facility **100**.

The labor scheduling module **2008** may also be used to schedule and assign PIV operators to PIVs by creating PIV scheduling data **1044**. The labor scheduling module receives PIV demand data **1020** from the PIV analysis module **2004**. As discussed above in connection with FIG. **13**, the PIV demand data **1020** may include both a minimal and an optimal staffing level. The labor scheduling module **2008** may create a PIV operator schedule for each day by first ensuring that minimal staffing requirements are met. Next, for those periods during which the minimal and optimal staffing levels are different, the labor scheduling module **2008** may, based on operator availability, schedule additional operators for PIV duty. In considering operator availability, the labor scheduling module **2008** may be provided with certain work rules to apply, such as union labor agreement rules, which may affect the availability of certain operators by limiting their available hours and requiring certain break periods during shifts. In addition, the labor scheduling module may also access the database of operator certifications to determine which operators may be assigned to which PIVs **116** in the facility **100**. The labor scheduling module **2008** may also provide data that allows the PIV data analysis module **2004** to create efficient routes and operate the routes with authorized drivers. The labor scheduling module **2008** may be configured to send operator data to the data analysis module **2004**. The operator data may include work schedules and break schedules for possible operators of the PIVs. The the data analysis module **2004** may be configured to consider these parameters when constructing routes and operations within the facility.

A regular route through the facility may be defined as including a start time indicating when the PIVs assigned to the route start running the route, and a finish time indicating when the assigned PIVs quit running the route. Thus, in order to adequately staff PIVs with operators during the duration of the route, work schedules provided by the labor scheduling module **2008** may be used to optimize the labor scheduling. Referring now to FIG. **15**, a block diagram shows an example of a data input/output scheme for the maintenance management module **2010**. PIVs **116** require regular maintenance to ensure that they operate reliably and safely. The maintenance management module **2010** tracks and schedules the removal of PIVs **116** from service for maintenance. Because PIVs **116** can each have differing usage patterns and routines over time, the maintenance management module **2010** may consider total usage of a PIV when scheduling maintenance. For example, if one PIV in the fleet tends to be used heavily, while another PIV in the fleet is used less frequently, the first PIV should be scheduled for routine maintenance more often then the second PIV. In order to provide such scheduling, the maintenance management module **2010** may receive PIV usage data **1032** and PIV assignment data **1010** in order to determine the appropriate schedule and then output the schedule as PIV maintenance data **1036**.

As discussed above, the PIV assignment data **1010** may include a beginning location, a destination location, a PIV operator, a barcode number or some other identifying information for the materials included in the assignment, the time and date of the assignment dispatch, and possibly an operator associated with the assignment. This data may be sent to the maintenance management module **2010** as it is generated by the PIV dispatch management module **2000** and the PIV interface module **2002**. The PIV usage data **1032** for each PIV **116** in the fleet may be sent at regular intervals by the PIV interface module **2002** over the network to the maintenance module. As noted above, this data will include operational data about the PIV **116** which may be captured by various sensor and other measuring devices. The operational data may include total distance traveled by the PIV **116**, the number of operating hours, or some other data reflecting how the PIV **116** has been used over a period of time.

The maintenance management module **2010** receives both the PIV usage data **1032** and the PIV assignment data **1010** to determine when maintenance is required and to further determine what maintenance may be required. For example, by analyzing the PIV assignment data **1010**, which may include the barcode ID of cargo picked up and delivered by the PIV **116** in each assignment, the maintenance management module can derive the total weight carried by a particular PIV **116** over time. As more weight is carried over time, required maintenance for various parts of the PIV may increase. For example, by carrying additional weight over time, the wear and tear on tires may increase, because the additional pressure placed on the tires by the heavier cargo may cause the tires to deteriorate more quickly and to develop slow leaks. Thus, by analyzing the type or weight of cargo carried by the PIV **116** over time, the maintenance management module can determine which type of inspections and preventative maintenance are required.

The maintenance management module may also schedule maintenance based on the PIV usage data **1032**. The PIV **116** may require certain maintenance based on the distance that it has traveled since the last scheduled maintenance. By receiving the PIV usage data **1032** from the PIV operator interface **2002** of each PIV, the maintenance management module **2010** may create a schedule for required preventative maintenance for the entire PIV fleet in view of the differing requirements for each PIV **116**. The PIV maintenance data **1034** also may include scheduled and non scheduled maintenance histories for each PIV **116**. Maintaining a non-scheduled maintenance history for each PIV **116** allows the PIVs susceptible to breakdown to be identified and removed from the fleet.

The PIV maintenance data may further include a record of the battery charge status in an environment where the PIVs are powered primarily via battery or fuel cell. This information can be transmitted to the maintenance management module **2010** by configuring the interface module **2002** of each PIV **116** to transmit the information via the network **130** at a set time interval, e.g., every 20 minutes. By collecting this information in a single location, the maintenance management module **1010** can be configured to ensure that at least a minimum number of PIVs always have the required fuel or

charge to be operational at all times. In another embodiment, the PIV maintenance data **1034** generated by the maintenance management module **2010** may further include scheduling data regarding the next scheduled maintenance event for the PIV **116**. The generated PIV maintenance data **1036** may sent to the labor scheduling module **2008** which can use it to ensure that PIV operators scheduled to work by the labor scheduling module **2008** will have a functioning PIV **116** throughout the duration of their shift.

In embodiments where the facility **100** is a mail processing facility, postal parcels and other cargo may in some instances be of an irregular or special handling type that is treated differently than standard cargo. For example, bulk mailers such as catalog companies may bring their catalogs directly to the facility **100** for shipment as bulk mail rather than taking the bulk mail shipment to a post office. Because of the volume of mail which may be included in a delivery of this type, the party bringing the irregular delivery to the facility **100** may be required to give advance notice of the delivery to allow appropriate staffing measures to be taken.

With reference to FIG. **16**, a facility access and shipment tracking module **2012** is provided which may be used to manage the process of receiving irregular cargo such as bulk mail shipments, for example. Although the facility access and shipment tracking module is described in terms view of bulk mail shipments, one of skill in the art will appreciate that various other types of irregular mail such as oversized packages, delicate or fragile packages, or other types of non-mail cargo having some irregularity may be managed similarly.

When a bulk mailer wishes to deliver a truckload of bulk mail to a facility, it sends a request to the facility access and shipment tracking module via the computer network **130**. In one embodiment, this request is sent over the Internet via a secure web site in a manner known in the art. The bulk mailer may then schedule a drop-off time by submitting incoming irregular cargo notification data **1040**. The irregular cargo notification data **1040** may include the drop off time, the type of cargo being dropped off, any special handling procedures necessary, and additional data relating to the nature of the shipment. Based on the data entered into the facility access and shipment tracking module **2012**, workload profile data **1014** and workload measurement data **1038** are generated and sent to the PIV analysis module **2004** where it is used to create PIV demand scheduling data **1020** as described above in connection with FIG. **13**.

With reference to FIG. **17**, an additional embodiment of the invention provides a method of managing the use of powered industrial vehicles (PIVs) in a facility. Although the method described herein is carried out primarily in PIV dispatch management module **2000**, one of skill in the art will appreciate that various system components may perform the steps described herein without departing from the scope of the invention.

At block **1702**, PIV dispatch management module **2000** receives a request to transport cargo from a first location to a second location within the warehouse facility **100**. As discussed above, this request may be created by the surface visibility module or it may be manually entered into the PIV dispatch management module **2000**. Based on driver availability data **1006**, tray/container data **1008**, optimal route data **1004**, and current PIV location data **1002**, the PIV dispatch management module **2000** selects a PIV to carry out the request at block **1704**. Next, at block **1706**, the PIV dispatch management module **2000** sends a notification to the selected PIV **116** about the request. The notification may include assignment data **1010** such as cargo or container identification code, a cargo or container location, a cargo or container destination, and an optimal route. Next at block **1708**, the PIV dispatch management module receives an acknowledgement from the PIV of receipt of the notification. The method then proceeds to block **1710**, where the scanner **14** scans the container identification code, and associates the container with its new location at step **1712**.

In yet another embodiment, the invention provides for a method of creating and managing routes within the facility **100**. In this embodiment, some or all of the PIVs may be equipped with various sensors **138** which record collision data as described above in reference to FIG. **9**. Additionally, sensors may also be provided that measure odometric data such as distanced traveled by the PIVs. The PIVs may also include weight sensors that measure the amount of weight carried by the PIV. In some embodiments, the PIV may have more than one weight sensor. For example, certain PIVs may be capable of both carrying cargo (on a forklift, for example), and towing cargo such as a mini-trailer or some other cargo. Accordingly, the PIV may be equipped with sensors to measure both of these types of weight-bearing activities performed by the PIVs. The PIV interface module **2002** may be configured to receive all of the measurements provided by the sensors **138**, and may be further configured to send these measurements to a central server such as the PIV data analysis tool **2004** via the network **130**, or it may send these measurements to some other central server computer.

FIG. **18** illustrates how the system may create an efficient series of routes through the facility **100** based on the recorded data described above. At block **1800**, the system receives space layout data about the facility. As noted previously, the space layout data may be provided by specialized software such as a computer-aided design (CAD) package, or it may be some other process engineering software package. Next, at block **1802**, the system receives the historical usage data about the PIVs. As described above, this data may include various measurements regarding the usage of the PIVs. The measurements may include data compiled by the sensors **138** and stored in the interface module **2002** of each PIV. This data may be sent over the network **130** to the system and be compiled into a single historical usage database.

Proceeding to block **1804**, the system may define a route through the facility based on the historical usage data. The route may be defined by applying an optimization algorithm to the historical usage data. In defining the route, the system may first determine the prior utilization rate of the PIVs in order to identify inefficiencies in previous routing schedules and maps. The utilization rate may be defined in several ways. In one embodiment, the utilization rate may be based on the distance traveled by the PIV while carrying cargo. In this embodiment, the interface module **2002** may be configured to receive data from the weight sensors and odometric sensors and compile a data set indicating the distance traveled while carrying cargo, and the distance traveled while without a load. If the ratio of distance traveled while carrying cargo is low relative to the total distance traveled for a PIV, this indicates the PIV was not utilized efficiently.

In order to improve the utilization, the system may be configured to define the new route to minimize the distance traveled without loads. This optimization may be performed by deriving routes in which the cargo pickup points are close to cargo drop off points. In order to perform this optimization, the system may receive data from the PIV dispatch management module **2000**, which identifies locations within the facility that have historically been active pickup points and delivery points.

Various techniques may be used to define the routes. Using the historical user data as customer demand inputs, route

definition software may define the routes within the facility. In one embodiment, the route definition software applies a two phase heuristic algorithm (such as a sweep algorithm) to define the route. Alternatively, a Clarke and Wright savings algorithm or a Fisher and Jaikumar algorithm may be utilized. Moreover, because the historical usage data may show that incoming cargo volume may vary during particular times, the route may be defined to include specific times during which it is active. For example, in a postal processing facility, a route that typically carries priority overnight mail may have a start time defined early in the morning and a finish time defined at 9:00 AM because all priority overnight mail will have left the facility for delivery by 9:00 AM.

After the routes have been defined to improve the utilization rates of the PIVs, PIVs are assigned to the routes at block **1806**. Each route may have at least one PIV assigned to it, but some busier routes may have many PIVs assigned due to the high volume of activity for the route. Finally, at block **1808**, each PIV assigned to run the route may have an operator assigned to the PIV while it runs the route defined at block **1804**. In one embodiment, the system may select the operator based on the shift schedule of the operator and the operator's certification status as it relates to the type of PIV that is assigned to the route. In some cases, the system may create a pool of available operators that meet a certain scheduling and certification criterion, and allow a user, such as a facility manager for example, to select which operator to assign to the PIV.

It will be understood by those of skill in the art that numerous and various modifications can be made without departing from the spirit of the present invention. Therefore, it should be clearly understood that the forms of the invention are illustrative only and are not intended to limit the scope of the invention.

What is claimed is:

1. A computer-implemented method of creating and managing routes for transporting cargo by powered industrial vehicles (PIVs) in a facility, the PIVs being equipped with one or more of an odometric sensor, a weight sensor, and a storage device for storing data measured by the sensors; the PIVs being further equipped with an interface module configured to selectively permit access to the operating capabilities of each PIV, the method comprising:

receiving space layout data associated with the facility;

receiving historical usage data for the PIVs, the historical usage data including data measured by the sensors;

defining a customized route comprising direction of travel for the PIV in the facility, the customized route being based at least in part on the received space layout data, and the received historical usage data;

communicating the route data to the PIV;

assigning at least one PIV to run the route;

assigning an operator to operate the PIV; and

subsequent to defining the customized route, modifying the route to reflect changes in at least one of current conditions of the PIV and current conditions in the facility.

2. The computer-implemented method of claim **1**, wherein the data measured by the sensors and stored in the storage device includes a distance traveled by each PIV while carrying cargo and a distance traveled by each PIV while not carrying cargo.

3. The computer-implemented method of claim **1**, wherein the stored measured sensor data is transmitted from the storage device to a central server through a wireless transponding device of the PIV.

4. The computer-implemented method of claim **1**, wherein the interface module includes a security module that provides selective access to the PIV by requiring an operator of the PIV to login to the security module.

5. The computer-implemented method of claim **1**, wherein assigning the operator for the PIV is based on certification data including a certification status for operators of the PIV.

6. The computer-implemented method of claim **1**, wherein the route includes a start time and a finish time, the start time indicating when each assigned PIV begins running the route, and the finish time indicating when each assigned PIV finishes running the route.

7. The computer-implemented method of claim **6**, further comprising receiving operator data, the operator data including shift schedules for operators of the PIVs.

8. The computer-implemented method of claim **7**, wherein the operator data further includes certification data.

9. The computer-implemented method of claim **8**, wherein assigning an operator for the PIV running the route further comprises:

selecting, based on the shift schedules and the certification data, operators available for assignment; and

selecting, from the operators available for assignment, an operator for the at least one PIV.

10. The computer-implemented method of claim **5**, wherein the certification data includes an indication of whether the operator has received OSHA-mandated training for operating the PIV.

11. The computer-implemented method of claim **4**, wherein the storage device stores data about login events by operators of the PIV.

12. The computer-implemented method of claim **3**, wherein the transponding device is substantially regularly polled by one or more gateway beacons in the facility.

13. The computer-implemented method of claim **12**, wherein the one or more gateway beacons are in communication with a central server through a dedicated fiber optic network.

14. The computer-implemented method of claim **2**, wherein defining the route based on the historical usage data further comprises:

determining, based on the measured sensor data, a previous utilization rate of the PIVs, the utilization rate comprising a ratio of distanced traveled while carrying a load to a distanced traveled while carrying no load; and

defining the routes so as to improve the utilization rate of the PIVs as they run the route.

15. A system for creating and managing routes for powered industrial vehicles (PIVs) in a facility comprising:

one or more PIVs, the PIVs being equipped with one or more of an odometric sensor, a weight sensor, a storage device for storing data measured by the sensors, and an interface module configured to selectively permit access to the operating capabilities of each PIV; and

a route creation module configured to:

receive space layout data associated with the facility;

receive historical usage data for the PIVs, the historical usage data comprising data measured by the sensors;

define a customized route comprising direction of travel for the PIV in the facility, the customized route being based at least in part on the received space layout data and the received historical usage data;

communicate the route data to the PIV;

assign at least one PIV to run the route;

assign an operator to operate the PIV as it runs the route; and

subsequent to defining the customized route, modify the route to reflect changes in at least one of current conditions in the PIV and current conditions in the facility.

16. The system of claim **15**, wherein the data measured by the sensors and stored in the storage device includes a distance traveled while carrying cargo and a distance traveled while not carrying cargo.

17. The system of claim **15**, wherein the stored measured sensor data is transmitted from the storage device to the route creation module through a wireless transponding device of the PIV.

18. The system of claim **15**, wherein the interface module includes a security module that provides selective access to the PIV by requiring an operator of the PIV to login to the security module.

19. The system of claim **15**, wherein assigning the operator for each of the PIVs is based on the certification data including a certification status for operators of the PIV.

20. The system of claim **15**, wherein the route includes a start time and a finish time, the start time indicating when the assigned PIV begins running the route, and the finish time indicating when each assigned PIV finishes running the route.

21. The system of claim **20**, further comprising receiving operator data, the operator data including shift schedules for operators of the PIVs.

22. The system of claim **21**, wherein the operator data further includes certification data.

23. The system of claim **22**, wherein assigning an operator for the PIV running the route further comprises:

selecting, based on the shift schedules and the certification data, operators available for assignment; and

selecting, from the operators available for assignment, an operator for the at least one PIV.

24. The system of claim **19**, wherein the certification data includes an indication of whether the operator has received OSHA-mandated training for operating the PIV.

25. The system of claim **18**, wherein the storage device stores data about login events by operators of the PIV.

26. The system of claim **17**, wherein the route creation module is a central server.

27. The system of claim **17**, wherein the transponding device is substantially regularly polled by one or more gateway beacons in the facility.

28. The system of claim **26**, wherein the one or more gateway beacons are in communication with the central server through a dedicated fiber optic network.

29. The system of claim **16**, wherein defining the route based on the historical usage data further comprises:

determining, based on the measured sensor data, a previous utilization rate of the PIVs, the utilization rate comprising a ratio of distanced traveled while carrying a load to a distanced traveled while carrying no load; and

defining the routes so as to improve the utilization rate of the PIVs.

30. A system for creating and managing routes for powered industrial vehicles (PIVs) in a facility comprising:

one or more PIVs, the PIVs being equipped with one or more of means for sensing odometric data, means for sensing weight data, means for storing the weight data and odometric data, and means for selectively permitting access to the operating capabilities of each PIV;

means for creating a customized route comprising direction of travel of the PIV in the facility, the customized route being based at least in part on space layout data associated with the facility and historical usage data for the PIVs, the historical usage data comprising data measured by the means for sensing weight data and the means for sensing odometric data;

means for communicating the data to the PIV;

means for assigning at least one PIV to run the route;

means for assigning an operator to operate the PIV; and

subsequent to defining the customized route, modify the route to reflect changes in at least one of current conditions in the PIV and current conditions in the facility.

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