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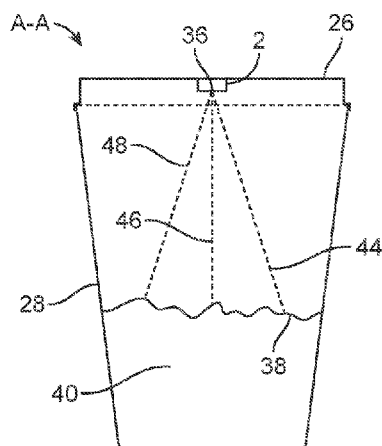


FIG. 4B

(54) Title: STORAGE AND COLLECTION SYSTEMS AND METHODS FOR USE

(57) Abstract: Systems and methods for managing the collection of contents from geographically distributed containers are disclosed herein. The systems can have a sensor in the container in data communication with a server system. The sensor can send data regarding the volume of contents in the container to the server system. The server system can then create routing information for a fleet of vehicles to empty the containers based on which containers are full enough for immediate collection, other predictive data for less full containers, and traffic and other routing factors for the vehicles. The server system can then transmit the routing information to the vehicles, track the vehicles, and prepare reports.

1 TITLE

2 **STORAGE AND COLLECTION SYSTEMS AND METHODS FOR USE**

7 CROSS-REFERENCE TO RELATED APPLICATION

8 **[0001]** This application claims priority to U.S. Provisional Application No. 62/550,475,
9 filed August 25, 2017, which is incorporated by reference herein in its entirety.

11 BACKGROUND

12 **[0002]** Typical garbage collection entails a government or private organization sending
13 out a fleet of vehicles, which are usually specially designed trucks, on a regular basis to
14 collect the contents of distributed garbage bins in a particular geographic area.

15 **[0003]** Because the operators of the trucks do not know the quantity of contents of any
16 bin before they arrive at and inspect the bin, they must stop their truck at every bin along
17 their path and inspect every bin. Since the operators are scheduled to perform routes at a
18 fixed frequency (e.g., route 1 would be performed once a week on Mondays), they will
19 typically collect whatever contents are in the bin at that time they arrive, even if the
20 contents are minimal, since they would not visit the bin again for a week.

21 **[0004]** In contrast, if the bin is not serviced frequently enough, the bin can overflow
22 with waste, resulting in loose waste and pollution in streets and sidewalks, creating health
23 and safety risks and diminishing the appearance of the area and value of the local real
24 estate.

25 **[0005]** Similar processes exist for collection of other refuse container contents, such as
26 for septic tanks, portable toilets (commonly referred to as port-a-potties), and other toxic
27 waste collection.

28 **[0006]** This process of stopping at and inspecting every container on a fixed time
29 frequency carries with it a number of inherent inefficiencies and other service issues.
30 Operators' time is wasted by stopping, inspecting, and collecting contents from containers
31 not in need of emptying. Operators are not able to empty the containers that fill up before
32 their scheduled visit in a timely fashion resulting in overflowing containers – or the
33 inability of users to dispose of refuse. The wear and tear on vehicles and equipment is

1 accelerated due to the extra stops, collections, and distance traveled. This also causes
2 increased carbon dioxide emissions, noise pollution, and traffic congestion.

3 **[0007]** Also, some containers on low frequency collection intervals are un-serviced for
4 long periods of time despite being unexpectedly full. This can especially be a concern for
5 portable toilets or other containers that fill at irregular rates, are located in remote or hard-
6 to-access locations, or are otherwise expensive or difficult to manually service.

7 **[0008]** Accordingly, a system and method is desired that can better manage distributed
8 container collections. A system and method for reducing the route distance, time, and
9 stops for collection of contents of refuse containers is desired.

10 SUMMARY

11 **[0009]** Systems and methods for monitoring and collecting contents of containers are
12 disclosed herein.

13 **[0010]** A method for the collection of contents of one or more geographically
14 distributed containers is disclosed. The method can include determining a fill level of the
15 contents in one of the containers. The determining can include detecting the position of
16 more than one point on the surface of the contents. The method can include transmitting to
17 a server system the fill level of the contents and an identity of the one of the containers.
18 The method can include calculating by the server system whether to include the container
19 in a route data set defining a route. The route can have stops at one or more of the
20 containers. The method can include creating the route data set and wirelessly sending the
21 route data set from the server system to a mobile device.

22 **[0011]** The container can have one or more sensors for determining the fill level. The
23 determining of the fill level can include forming a topography of the surface of the
24 contents.

25 **[0012]** The method can include attaching a time of determination (e.g., a time stamp) in
26 a data set with the fill level and the identity of the one of the containers. The transmitting
27 can include transmitting the data set to the server system.

28 **[0013]** The method can include transporting along the route. The transporting along
29 the route can include transporting a self-driving vehicle along the route. The mobile device
30 can be in communication with a navigation system of the self-driving vehicle.

31 **[0014]** A system for the collection of contents of one or more geographically
32 distributed containers is disclosed. The system can have one or more sensors for detecting
33 the amount of contents in a container. The one or more sensors can have one or more
34

1 detectors for detecting more than one point on the surface of the contents. The system can
2 have a server system in wireless communication with the one or more sensors. The one or
3 more sensors can transmit data to the server. The data can include data representing a fill
4 level of the contents in the container. The system can have a mobile device in wireless
5 communication with the server system. The mobile device can display instructions for
6 routing a collection vehicle to the container.

7 **[0015]** The container can have a lid. A first sensor of the one or more sensors can be
8 attached to the lid. The first sensor can be a time of flight sensor.

9 **[0016]** The first sensor can emit a first sensing energy. The first sensing energy can
10 include a laser.

11 **[0017]** The one or more sensors can have a first sensor and a second sensor. The
12 container can have a lid. The first sensor can be attached to the lid. The second sensor can
13 be attached to the lid. The second sensor can emit a second energy that can include a laser
14 or no laser energy.

15 **[0018]** The first sensor can be spaced at a distance from the second sensor. The second
16 sensor can be attached to an inside wall of the body.

17 **[0019]** The first sensor can have a first emitter for emitting a first sensing energy and a
18 second emitter for emitting a second sensing energy. The first emitter can be directed to a
19 first point on the surface of the contents. The second emitter can be directed to a second
20 point on the surface of the contents.

21 **[0020]** A device for fill volume detection is disclosed. The device can have a container
22 having a body and a lid hingedly attached to the body. The container can contain contents
23 constituting the fill volume within the container. The device can have a first sensor in the
24 container. The first sensor can have a first emitter for emitting a first sensing energy, a first
25 detector for detecting a reflection of the first sensing energy, and a first wireless radio. The
26 first emitter can be directed so the first sensing energy is emitted in the direction of the
27 surface of the contents.

28 **[0021]** The device can have a second sensor having a second emitter for emitting a
29 second sensing energy, a second detector for detecting a reflection of the second sensing
30 energy, and a second wireless radio.

31 **[0022]** The first sensor can have a second emitter for emitting a second sensing energy,
32 and a second detector for detecting a reflection of the second sensing energy. The first
33 emitter can be directed to a first point on the surface of the contents. The second emitter
34 can be directed to a second point or the first point on the surface of the contents.

1 **[0023]** A method for fill volume detection is disclosed. The method can include
2 emitting a sensing energy from a sensor in a container. The container can contain contents
3 defining the fill volume within the container. The emitting can include directing the sensing
4 energy to multiple points on the surface of the contents. The method can include detecting
5 reflections of the sensing energy off of the multiple points of the surface of the contents.
6 The method can include tracking the amount of time elapsed between the emitting of the
7 sensing energy and the detecting of the reflections of the sensing energy. The method can
8 include calculating a length associated with the amount of time for reflections of the
9 sensing energy for each of the multiple points. The method can include forming a
10 topography of the surface of the contents. The forming can include utilizing the calculated
11 lengths to form the topography.

12 **[0024]** The method can include calculating the fill volume by at least processing the
13 topography. The forming can include displaying a three-dimensional image.

14 **[0025]** The container can have a body and a lid hinged attached to the body.

15 **[0026]** The emitting can include emitting from a first sensor in the container. The first
16 sensor can have a first emitter for emitting the first sensing energy, a first detector for the
17 detecting a reflection of the first sensing energy, and a first wireless radio.

18 **[0027]** Multiple sensors can be used per container. For example, multiple time of flight
19 (TOF) cameras can be used to measure the content of a container. By using multiple
20 cameras one would be able to obtain multiple points either originating from single points
21 per camera or multiple points per camera. For example, five TOF cameras can be placed
22 around a rectangular container - one to image each corner of the container and one to image
23 the center of the container - to monitor the fill level in respective regions of the container.
24 These points can be combined to build a topology of the content of the container, thereby
25 determining the container's fill level. The system can estimate the fill level, for example,
26 when contents of the container, such as solid waste, do not evenly fill the container from
27 side-to-side. The resolution of the calculation of the fill level and topography of the
28 surface of the contents can increase with the more emitters and detectors or sensors for the
29 given container. The algorithms for combining the sensors can use simple image stitching,
30 or voting algorithms to establish conditions where some or all of the sensors are reporting
31 fill levels.

32 **[0028]** The system can use multi-point sensors. Each TOF camera can have, for
33 example, about 16 sub-points of sub-pixels. Some TOF cameras can measure multiple
34 points on the image. A virtual TOF camera can be built by combining multiple TOF

1 cameras and obtain multiple points in the measurement. By using multiple points the
2 system can build a topology map of the image observed by the camera (e.g., the surface of
3 the contents of the container). The topology map can represent the fill pattern of the
4 container. The system can estimate the fill level of containers where the contents have an
5 irregular shape (e.g., solids, garbage bags, cardboard boxes). The system, for example via a
6 multi-point TOF camera, can estimate the volume of the contents if the contents are evenly
7 distributed across the container or all accumulate towards one side.

8 **[0029]** The system can have multiple types of sensors. One modality of sensor can be
9 used with other types or modalities of sensors, for example, to establish fill levels and fill
10 topology. For example, TOF cameras and weight sensors can be used together to calculate
11 a volume and weight of the contents. The system can prompt collection a container that is
12 at or near its limit for maximum volume or weight. Another example is that TOF cameras
13 can be used with temperature sensors. As materials in the contents expand with rising
14 temperature a corrected volume measurement can be produced by taking into account the
15 temperature of the content of the container. The temperature of the container can be
16 transmitted to the server system, and can be used to generate alerts independent of or
17 associated with the fill level of the container. For example, the sensors can generate an
18 alert if the temperature and/or temperature-time (i.e., measured in degree-hours) in the
19 container exceeds a threshold temperature, regardless of the fill level of the container. The
20 threshold level for the alert can be altered based on other sanitation issues (e.g., the
21 presence of rodents and/or insects – such as detected by visual images and/or manually
22 entered information from the operator or container owner; or decomposition rate or smells
23 or detected fumes or gasses – such as detected by humidity, gas, pH detectors, or
24 combinations thereof, in the sensor).

25 **[0030]** The sensor can have an accelerometer and a GPS sensor. If the sensor detects
26 movement of the device via the accelerometer, the sensor can use the GPS sensor to
27 determine the device's location. The location can be stored in a memory on the sensor
28 and/or reported to the server. For example, the sensor can report its location to the server if
29 the motion detected by the accelerometer exceeds a predefined threshold, indicating that
30 the device has been moved from its mounting position on the container.

31 **[0031]** The sensor can turn on the TOF camera to measure the fill level of the container
32 at specified intervals. For example, the sensor can measure the fill level at a timer interval
33 set by the server system and stored in a memory in the sensor. When not measuring the fill
34 level, the sensor can operate in a low power mode to conserve energy.

1 **[0032]** The fill level detected by the sensor can be dependent on placement of the
2 device in the container, including the distance between the device and the bottom of the
3 container and the orientation of the device with respect to the container. The server system
4 and/or sensor can calibrate the sensor to compensate for the placement of the sensor within
5 the container and the orientation of the container. For example, a baseline fill level reading
6 can be transmitted to the server system when the sensor is first installed on an empty
7 container. Future measurements received from the sensor can be compared to the baseline.
8 Dimensions of the container can be manually entered at the server system (e.g., wirelessly
9 via a device and an app) and compared to measurements taken by the sensor. The server
10 system can perform the calibration or compensation, or can transmit parameters (e.g., a
11 baseline fill level) to the sensor for calibration, or the sensor can store the parameters and
12 perform the calibration without interacting with the server system.

13 **[0033]** The sensor can report data measured by the TOF camera or other sensor(s) to
14 the server system. The sensor can report fill level measurements to the server when each
15 measurement is taken or at a preset interval (e.g., once per day). The Sensor can store fill
16 level measurements in sensor memory and send an alert to the server when a threshold fill
17 level has been reached.

18 **[0034]** The server system can use the fill level measurements to schedule emptying of
19 the container. The server system can send a notification to an individual responsible for
20 emptying the container (i.e., an operator) when the container reaches a threshold fill level.

21 **[0035]** The server system can generate a schedule for an individual listing containers to
22 be emptied, based on the fill level of the containers. The server system can add the
23 container to an existing schedule when the container reaches a threshold fill level. The
24 schedule to which the container is added can be based on location of the container (e.g.,
25 add the container to an operator's route or schedule with nearby containers), on other
26 business logic rules such as timing for when an operator can be dispatched to the full
27 container, or combinations thereof. If an operator is currently dispatched to empty
28 containers in the region of a full container, the server system can dynamically modify the
29 operator's pick-up schedule and route to add the newly reported full container.

30 **[0036]** The server system can predict when a container will be full by applying a
31 regression model or machine learning/artificial intelligence to fill level data received from
32 the sensor. For example, the server system can determine that a garbage truck scheduled to
33 pass by a garbage container should empty the garbage container, even though the garbage

1 container may be less than a threshold fill level, because the container will likely be
2 overflowing before the next time the garbage truck is scheduled to pass the container.

3 **[0037]** The server system can transmit software updates as well as preset parameters to
4 the sensor. For example, the server system can transmit a threshold fill level to the sensor,
5 and can define an interval of time for measuring the fill level of the container. Firmware
6 updates received by the sensor can be authenticated to the server system, for example, to
7 reduce the likelihood of unauthorized third parties uploading their own code or
8 configurations to the sensor.

9 **[0038]** The sensor, server system, and mobile devices can communicate using
10 encrypted data. Data sent between the sensor, the server system, and the mobile device can
11 be encrypted by an encryption algorithm such as public key encryption. The server can
12 create a unique access point for each sensor and/or mobile device and configure each
13 sensor and mobile device to communicate on its respective access point, for example, to
14 reduce the likelihood that an unauthorized third party can find and abuse a server access
15 point.

16 **[0039]** Fill levels for a container can be tracked over time (e.g., by a clock or time
17 sensor on the sensor or server system). By comparing the measured fill levels to threshold
18 fill levels, the server system can predict when a container needs to be serviced.

20 BRIEF DESCRIPTION OF THE DRAWINGS

21 **[0040]** Figure 1 illustrates a method for the collection of distributed containers'
22 contents.

23 **[0041]** Figure 2 illustrates a system for the collection of distributed containers'
24 contents.

25 **[0042]** Figure 3 illustrates a variation of a container.

26 **[0043]** Figures 4a, 4b, and 5 illustrate variations of cross-section A-A of figure 3.

27 **[0044]** Figure 6 is a bottom perspective view of a variation of lid.

28 **[0045]** Figures 7 through 9 illustrate variations of cross-section A-A of figure 3.

29 **[0046]** Figures 10a and 10b are perspective views of variations of the sensor.

30 **[0047]** Figures 11a through 11c are top perspective, top, and bottom perspective views,
31 respectively, of a variation of the sensor.

32 **[0048]** Figures 12a and 12b are perspective views of variations of the sensor.

33 **[0049]** Figures 13a and 13b are top perspective and top, and bottom perspective views,
34 respectively, of a variation of the sensor.

1 **[0050]** Figures 13c and 13d are top perspective and top, and bottom perspective views,
2 respectively, of the sensor of figures 13a and 13b with a cover.

3 **[0051]** Figure 14a is a top view of a variation of a circuit board in the sensor.

4 **[0052]** Figure 14b is a simplified schematic view of a variation of a circuit board in the
5 sensor.

6 **[0053]** Figure 15 is a block diagram illustrating functional modules that can be
7 executed by the sensor.

8 **[0054]** Figure 16 is a flowchart illustrating a variation of a method for monitoring the
9 fill level of a container using the sensor.

10 **[0055]** Figures 17a through 17e are variations of screenshots of an installation software
11 for the sensor.

12 **[0056]** Figure 18 illustrates a variation of a local network of adjacent sensors.

13 **[0057]** Figure 19 is a screenshot of a display of data from sensors and an analysis
14 thereof.

15 **[0058]** Figure 20 through 22 are screenshots of variations of displayed reports of sensor
16 data via the server system.

17 **[0059]** Figure 23 is a screenshot of a variation of a display of real-time tracking of a
18 collection operator on a collection route.

19 **[0060]** Figure 24 is a screenshot of a variation of a display of a route summary and
20 replay of a collection operator on a collection route.

21 **[0061]** Figure 25 is a screenshot of a variation of a display of the selection of a group
22 of sensors to combine their data during data analysis by the server system.

23 **[0062]** Figure 26a is a screenshot of a variation of the navigator app showing available
24 vehicles.

25 **[0063]** Figure 26b illustrates a variation of the operator's mobile device displaying
26 screenshots of the navigator app showing upcoming routes.

27 **[0064]** Figure 26c is a screenshot of a variation of the navigator app showing a map
28 with containers on the current route.

29 **[0065]** Figure 26d and 26e are screenshots of variations of the navigator app showing
30 turn-by-turn instructions for a selected route.

31 **[0066]** Figure 26f is a screenshot of a variation of the navigator app displaying turn-by-
32 turn instructions for a selected route.

33 **[0067]** Figure 26g is a screenshot of a variation of the navigator app displaying route
34 and container information.

1 **[0068]** Figure 26h is a screenshot of a variation of the navigator app displaying route
2 information.

3 **[0069]** Figure 27 is a variation of a screenshot of the navigator app displaying a trip
4 summary report.
5

6 DETAILED DESCRIPTION

7 **[0070]** Figure 1 illustrates that a method for collection of the contents of distributed
8 containers, such as trash bins or cans, septic tanks, portable toilets, toxic waste containers
9 (e.g., oil disposal drums), or combinations thereof, can include detecting the quantity of
10 contents in the container (e.g., a fill level) by a sensor in, on, or near a container. The
11 sensor can detect sensor data such as a fill-level of the contents in the container, the
12 orientation, geographical location, movement, and temperature of the container, remaining
13 battery energy, or combinations thereof. One sensor can be used to detect sensor data for
14 multiple containers, such as a group of bins at a single site or within a larger container.

15 **[0071]** The sensor can wirelessly or otherwise (e.g., over a wired connection)
16 communicate or transmit all or part of the sensor data to a server system, as shown by
17 arrow. The server can analyze the sensor data. The server system can calculate and predict
18 trending of sensor data. The server system can use the real-time (i.e., present) and historic
19 sensor data trends to plan and assign collection routes for the collection vehicles (e.g.,
20 garbage trucks, dump trucks, liquid containment trucks, flat bed trucks, pickup trucks, cars,
21 bicycles, motorcycles, or combinations thereof), or operators otherwise (e.g., if on foot),
22 and assign resources (e.g., number, types, and sizes of vehicles and/or operators)
23 accordingly.

24 **[0072]** The server system can transmit (send) the routing and resource assignment data
25 to one or more mobile devices, as shown by arrow. The mobile devices can be
26 smartphones, computer tablets or laptops, on-board computers in vehicles, or combinations
27 thereof. The mobile devices can be executing navigation software (e.g., a mobile app) that
28 can receive and display the routing and resource data. The navigation software can provide
29 optimized, dynamic routes with turn-by-turn navigation and spoken instructions that can
30 incorporate real-time traffic data with the routing data from the server. The mobile devices
31 can display the routing information for the respective operator's mobile device. The
32 mobile device can be an on-board computer in a self-driving vehicle and can route the
33 vehicle based on the routing data received from the server system.

1 **[0073]** Self-driving vehicles can follow the automatically route. Self-driving vehicles
2 can stop at collection points for containers on the route. Self-driving vehicles can await
3 manual instructions to proceed after collection of a container, and/or await the weight of
4 the vehicle to change for the container contents and the operator (if the operator left the
5 vehicle) before proceeding along the route.

6 **[0074]** The mobile device can collect and transmit location and collection (e.g., which
7 containers have been collected, the weight and/or type of collected contents from each
8 container, the sensor data from the container's sensor) to the server system, as shown by
9 arrow. The server system can transmit data (e.g., software updates, ambient temperatures
10 and forecast temperatures, sensing frequencies, or combinations thereof), to the sensor.
11 The sensor and the mobile device can also directly transmit to each other, as shown by
12 arrow, any of the aforementioned data or data listed below, for example during the
13 container collection when the mobile device and sensor are in proximity (e.g., within 10
14 meters) to each other over wired communication or a low power or close-proximity
15 wireless communication (e.g., Bluetooth).

16 **[0075]** Figure 2 illustrates that the architecture of the system can include a server
17 system that can have one or more socket servers in communication with one or more back-
18 end servers. The back-end servers can execute artificial intelligence and machine learning
19 algorithms on the data collected by the server system.

20 **[0076]** The server system can communicate with and store and retrieve data from one
21 or more databases, such as a Postgres SQL database and/or a Cassandra database.

22 **[0077]** Various APIs can communicate with the server system. When the APIs
23 communicate with the server system, the communications can be authenticated through an
24 authentication filter. The authentication filter can verify the identities of the devices
25 executing the APIs can be verified to the server system.

26 **[0078]** Third party devices can execute third party system APIs. The third party
27 system APIs can, for example, access data available from the server system for further
28 analysis (e.g., a third party analysis of route information from the server system combined
29 with third party data on public traffic flow).

30 **[0079]** The operations center, such as for the collection entity (e.g., the trash
31 collection company), can have an operations center device (e.g., a server) on which
32 operations center API software can be executed. The operations center API software can
33 communicate with the server system to get all of the data and reports otherwise available
34 (optionally with the exception of some reports for the container owner) to the owner,

1 mobile device, and server system. The operations center software can track the routing of
2 collections vehicles in real time (e.g., via data from the navigation app).

3 **[0080]** The mobile device and/or on-board vehicle computer can execute a navigation
4 app. The navigation app can send routing, orientation, and vehicle status data for the
5 vehicle from the server system. The routing app can record, track, display on the mobile
6 device, and send vehicle location, orientation, and vehicle status data to the server system.

7 **[0081]** An installation app can be executed on the container owner's device (e.g., a
8 smartphone, tablet, desktop computer, laptop computer, or combinations thereof) (as
9 shown), the mobile device, a container manufacturer's device, or combinations thereof.
10 The installation app can link a sensor to the server system and set-up and calibrate the
11 sensor for use.

12 **[0082]** A back office center device can execute a back office center API that can
13 interact with the server system. The back office center device can be used, for example, to
14 remotely monitor and maintain the server system.

15 **[0083]** A device API can be executed on the sensor. For example, the device API can
16 be executed by a processor on a circuit board in the sensor, as described herein.

17 **[0084]** Figure 3 illustrates a container, such as a trash bin, that can have a body and an
18 openable lid. The lid can have a hinge and be rotatably attached to the body, as shown.
19 The lid can be a cap that can be screwed onto and off of the body. The container can have
20 no lid or cap (e.g., the sensor can be attached to a wall of the body of the container, and
21 exhaust tube, a nearby surface (e.g., pole) outside of the container, or combinations thereof.
22 The lid can be tethered to the body. The lid can be non-porous, non-permeable by gas or
23 liquid, gas permeable, liquid permeable, or combinations thereof. The lid can latch to the
24 body to remain closed once closed unless manually opened. The lid can lock closed to the
25 body, for example, to only be openable by an individual having a key, combination, or
26 other access device to unlock the lid.

27 **[0085]** The container can have a lid controller can actively open the lid when activated.
28 The lid controller can be a foot pedal, hand button, or combinations thereof. The lid
29 controller can be a rotational gauge on the lid that measures rotation of the lid but does not
30 actively open the lid. The activation of the lid controller can send a signal to or through the
31 sensor. The time, date, length, and amount of opening from the lid controller can be
32 recorded by the sensor as part of the sensor data or communicated directly from the lid
33 controller to the server system (e.g., over a wired or wireless connection).

1 **[0086]** The container can have one or more wheels. The wheels can be connected to
2 the body through a suspension, which can have an axle and/or one or more springs. The
3 suspension can have a weight gauge (e.g., measuring strain of the axle, compression of the
4 spring(s), or combinations thereof). The weight gauge can send a signal to or through the
5 sensor. The weight – and/or merely the amount of change in weight - and associated time
6 and date, and indications of change in weight and the amount of change in weight and their
7 associated times and dates can be recorded by the sensor as part of the sensor data or
8 communicated directly from the weight gauge to the server system (e.g., over a wired or
9 wireless connection).

10 **[0087]** Figure 4a illustrates that the container can have contents (e.g., solid and/or
11 liquid refuse) that define a fill surface along the top surface of the contents. In a two-
12 dimensional view, as shown in Figure 4, the fill surface is projected as a fill line.

13 **[0088]** Fill levels and fill patterns can be measured in containers using distance sensors
14 mounted in, on, or near the containers. The sensor can be mounted on the top of the
15 container, the lid of the container, or a mounting bracket placed on the container. For
16 example, the lid can have a sensor fixedly or removably mounted or attached to the side of
17 the lid facing the inner cavity, chamber or reservoir of the body of the container (in Figure
18 4, this is the underside or bottom side of the lid).

19 **[0089]** The sensor can be used to measure the fill level of containers by measuring the
20 distance to the contents of the container from the mounting position of the sensor.
21 Depending on the configuration of the container, the sensor may be mounted at an angle or
22 aimed toward a particular area of interest in the container. The mounting of the sensor can
23 be fixed, or can be mechanically actuated to allow the camera to scan the container.

24 **[0090]** The sensor can have one or more emitters facing into the cavity, chamber or
25 reservoir body of the container. The emitter can emit a sensing energy into the body of the
26 container. The sensing energy can reflect off of the fill line and be detected by a sensing
27 component (i.e., detector) of the sensor. The detector can be essentially located at the
28 position of the emitter (e.g., combined within as a single physical component on a circuit
29 board).

30 **[0091]** The sensing energy can reflect off of the surface of the contents and/or transmit
31 through the surface of, and possibly the remaining volume of the contents (e.g., to be
32 received by a detector on the opposite side of the container) and/or be absorbed by the
33 surface of the contents. The sensing energy can be an RF signal, such as a laser beam,
34 radar (e.g., ultra wide-band radar), microwave, visible light, and/or ionizing radiation, such

1 as X-rays, gamma rays, alpha particles, beta particles, or combinations thereof. Different
2 sensors in the same container can emit the same or different types of sensing energy. For
3 example, a first sensor in a container can emit a laser and a second sensor in the same
4 container can emit radar.

5 **[0092]** The sensor can be a time-of-flight camera (TOF camera), a distance-sensing
6 camera. A TOF camera can be a range imaging camera system that can resolve distance
7 based on the known speed of light, measuring the time-of-flight of a light signal between
8 the camera and the subject for each point of the image. A TOF Camera can detect the
9 distance from the sensor to a single point on the fill area or many points on the fill area. A
10 TOF Camera can be composed of a light source (i.e., emitter) and a detection system (i.e.,
11 detector). The TOF camera emitter can have or be a laser or other light source, such as a
12 Vertical Cavity Surface Emitting Laser (VCSEL).

13 **[0093]** The TOF camera can produce a measurement that can be correlated to the
14 distance between a point on the object being observed and the camera itself.

15 **[0094]** As mentioned elsewhere herein, the sensor can communicate with the server
16 system. The server system can provide software updates and preset parameters to the fill
17 monitoring device, and the fill monitoring device can send data describing fill levels of a
18 container to the server system as well as other data measured or otherwise obtained by the
19 sensor. The sensor can report absolute and/or relative distances between the emitter or
20 distance sensor and contents of the container to the server.

21 **[0095]** Figure 4b illustrates that the sensor can perform multi-point sensing. The
22 sensor can emit first, second, and third sensing energies. Some or all of the sensing
23 energies can be emitted by a single emitter (as shown) at different angles, and/or each of
24 the sensing energies can be emitted by its own emitter in the sensor, with each of the
25 emitters directed in different directions. The sensing energies can each have the same type
26 of energy (e.g., laser), or different types of energy (e.g., the first sensing energy can be
27 laser, the second sensing energy can be radar, and the third sensing energy can be laser).
28 The sensing energies can be the same or different wavelengths or frequencies of each other.
29 The sensing energies can each be directed at different points on the surface of the contents
30 and/or the inside wall of the container. Some of the sensing energies can be directed at the
31 same points of the surface of the contents (e.g., for a first sensing energy to verify or
32 supplement a second sensing energy, for example to supplement distance information from
33 a first sensing energy with a visual image from a second sensing energy, and spectroscopy
34 information from a third sensing energy). The reflection of the multiple sensing energies

1 can be received by a single detector or multiple detectors in the sensor. The multiple
2 detectors can be for detecting the same or different types or frequencies or wavelengths of
3 energy.

4 **[0096]** In an example, a single emitter can emit a first laser energy at a first wavelength
5 of 700 nm in a first direction, a second laser energy at a second wavelength of 750 nm in a
6 second direction, and a third laser energy at a third wavelength of 800 nm in a third
7 direction. When the detector receives the reflected laser energies, the detector can
8 distinguish between which of the laser energies is detected based on the wavelength of the
9 reflection, and the sensor can make a time of flight calculation (i.e., resulting in the
10 distance from the sensor to the surface of the contents) at multiple points along the surface
11 based on the direction of the emitted energy.

12 **[0097]** The sensor can detect sub-points or sub-pixels with the multi-point sensing.
13 The sensor, optionally or additional via processing by the server system, can form
14 topographical data or a topographical image with the multiple distance data points along
15 the surface of the contents, for example, calculating the weight distribution, curvature or
16 contours at points, lengths, and areas along the surface, and density of the contents (e.g.,
17 based on the irregularity of the top surface topography). The topography of the surface can
18 be rendered as a three-dimensional graphical image and displayed (e.g., as shown in figure
19 20).

20 **[0098]** The multi-point sensor can dynamically select which emitters and detectors to
21 use, for example, based on the consistency and lack of noise in the received signals from
22 each emitter and detector.

23 **[0099]** The multi-point sensor (and/or multiple sensors in a single container), can be
24 used to detect the boundaries of the container by analyzing the sensed data, and detecting
25 the static elements in the data set over time periods where the fill line changes. The sensor
26 can disable those points in the readings, for example, to avoid including static elements
27 (e.g., representing the container wall) into the data set that do not represent the desired fill
28 level data. The sensor data analysis (e.g., by the sensor and/or the server system) can
29 determine the static components and remove the static elements, filtering for the data
30 representing the fill levels.

31 **[0100]** The sensors can be mounted in a non-static (i.e., movable) way with respect to
32 the container (e.g., on a sliding lid, a sliding or rotating bracket, an extension arm, or
33 combinations thereof).

1 **[0101]** Figure 5 illustrates that the lid can have multiple sensors, such as first through
2 third sensors, having multiple emitters and detectors, such as the first through third
3 emitters, as shown. The multiple sensors can detect at least one extra dimension of the fill
4 level surface. Also, if the container has multiple chambers, at least one sensor can be
5 positioned above each chamber to get at least one direct height data point for each
6 chamber. The container can have a single multi-point sensor positioned above the multiple
7 chambers, for example, to detect the fill levels in each chamber with a single sensor.

8 **[0102]** Figures 6 illustrates that the emitters can be spatially distributed over the area of
9 the lid from left to right and front to back. For example, the sensors can be positioned in an
10 orthogonal grid evenly distributed on the lid with evenly spaced rows and columns. Figure
11 6 illustrates a six-by-six grid of 36 sensors. The lid can have from one to 1,000 sensors,
12 more narrowly from one to 10 sensors, yet more narrowly from 1 to 8 sensors, for example,
13 1, 2, 3, 4, or 5 sensors.

14 **[0103]** The sensors on a single lid can be in data communication with each other, via
15 wired or wireless data connections, for example forming a local area network, such as a
16 mesh network. The sensors can transmit any or all of their sensor data to the other sensors
17 on the same container or same local network. All of the sensors on a single lid can
18 communicate with the server system, and/or a primary sensor can receive and optionally
19 process data from the remaining sensors on a single lid, and the primary sensor can
20 communicate all of the sensor data to the server system and receive all data communication
21 from the server system and distribute the incoming data, as needed, to the remaining
22 sensors on the lid.

23 **[0104]** Multiple sensors, and/or multiple emitters on a single sensor, can sense a
24 topography of the fill line. Sensors arranged along a single line (e.g., as shown in Figure 5
25 if the sensors shown are the only sensors in the container, or as shown by a single row or a
26 single column in Figure 6) can produce a two-dimensional topography of the fill line.
27 Sensors arranged in two-dimensions (e.g., as shown in Figure 6) can produce a three-
28 dimensional topography of the fill line.

29 **[0105]** Figure 7 illustrates that a trash bag or other liner can be inserted into the
30 container body. The bag can, for example, be pulled over or otherwise attached to the top
31 rim of the container body. The bag can be originally packaged in a closed configuration.
32 When inserted into the container, the length of the bag in a relaxed state may remain
33 closed, for example due to static electrical forces holding the two sides of the bag together.
34 The bag can have an opened bag length near the top of the container and a closed bag

length lower in the body of the container. The fill line can be defined by the opened bag length when no other contents are in the container. The sensors and/or server can detect that an otherwise empty or almost otherwise empty but partially closed bag is in the container, for example, based on how recently the container was emptied (e.g., as determined by the sensor data history, and/or the collection data history provided by the operators collecting the contents of the container), the sensor data since the last emptying (e.g., if the fill line has not moved or has moved downward since the suspected partially-closed bag was inserted into the container), the topography of the fill line, the activation of the lid, the change in weight of the container, or combinations thereof. If the sensor and/or server system concludes that a bag is in the container, future routing of collection of the contents of the container can be delayed until more contents other than the bag are inserted into the container.

[0106] Figure 8 illustrates that the sensors can be attached to the lid, as described above, and along the wall of the container. For example, the container can have lid sensors, and upper body wall sensors, lower body wall sensors, or combinations thereof. The body wall sensors can be arranged in a grid along the wall, and/or can be positioned at equal heights and/or unequal heights with the other body wall sensors. The wall sensors can project sensing energy in a lateral direction across the container body (e.g., being completely horizontal, or having a horizontal component with respect to the horizon or with respect to the undisturbed resting position of the container).

[0107] The sensors can estimate the shapes of individual items within the contents. For example, the sensors can detect the topography and the scattering of the sensing energy. The sensors can detect the spectroscopy of reflected, and/or absorbed, and/or transmitted energy, for example to determine the materials of the contents. The sensors and/or server system can calculate the volume of the contents (e.g., the volume estimated by the fill surface or the volume calculated from a 3-dimensional map of the contents, inclusive of the contents below the fill surface, created by the sensors and/or server system).

[0108] The content of the containers can be a number of different things, for example waste/trash including wrapped and unwrapped waste, liquids such as oil and water, sewer and slurry, clothing items, donations to charities either wrapped and unwrapped, recycling materials, human and animal food products, or industrial production materials, or combinations thereof.

[0109] Figure 9 illustrates that the container can have a container vertical axis (the vertical axis is the longitudinal axis for the container shown in figure 9, but can be a lateral

1 or other axis, such as for a container that is a horizontally elongated tank). The vertical
2 axis can be intended to be aligned and collinear with the direction of gravity. When the
3 container is tipped or rotated so the container vertical axis is not collinear with gravity, the
4 contents and fill line can shift in the container due to the rotational acceleration and/or
5 gravity. The sensor(s) can have one or more accelerometers and/or gyroscopic sensors for
6 determining the vertical alignment of the container, and whether the container is being
7 agitated or otherwise shaken. The sensor(s) can detect a change of the fill line topography
8 and/or the average fill line being at an angle with respect to the container vertical axis, for
9 example, to determine the vertical alignment of the container. These data and
10 determinations can be sensor data, and can be transmitted to the server system. The server
11 system can send data (e.g., via apps to an operator and/or the container owner) that the
12 container has tilted and needs to be uprighted or otherwise re-aligned, and can indicate that
13 the container should be emptied sooner (e.g., to correct the alignment and/or to prevent
14 premature overflow since additional the contents will reach the lid before the container is
15 as full as the container would have been if the container were upright or otherwise properly
16 positioned).

17 **[0110]** The sensors can calculate a weight distribution within the container, for
18 example using the height of the detected fill line across the container, the sensed sizes of
19 the objects of the contents, the sensed materials of the contents, data inputted by the owner
20 of the container through an API to the server with information about the materials being
21 deposited into the container, or combinations thereof.

22 **[0111]** The server system can effectively split data from a single sensor into multiple
23 virtual sensors.

24 **[0112]** The containers can have (as described above) or not have a lid, such as an open-
25 bed container. The sensor can be mounted on a bracket attached to the container, or to a
26 post placed in the vicinity of the container such that the sensor can measure the distance
27 between its mounting point and contents of the container. The distances measured by the
28 sensor can be adjusted to compensate for different placements of the sensor.

29 **[0113]** Each sensor can be placed along the top of the container. The sensors can
30 measure the distance from the sensor to either the opposite side of the container, or to the
31 closest object to the sensor. The fill level of the container can be decided by, for example, a
32 voting-like algorithm between different sensors in the container. A combination of these
33 measurement techniques could be used.

1 **[0114]** The container can be a compactor container (a compressor container). For
2 example, the container can hold the contents in a reservoir with one wall of the reservoir
3 being defined by a front face of a compressor piston. The compressor piston can compress
4 the contents in the reservoir (e.g., a trash compactor). The sensor(s) can be used as
5 described above and/or be mounted to the back face of a compressor piston, out of the
6 reservoir holding the contents. The sensor can measure the distance between its mounting
7 position and the back side of the compression piston inside the container, thereby
8 measuring the position of the piston and, by extension, the fill depth or height (if vertical)
9 of the contents. The distances measured by the sensor can be adjusted to compensate for
10 different placements of the sensor and the thickness of the piston plate.

11 **[0115]** The container can be positioned fully or partially underground, for example,
12 with an over ground entry point. The sensor can either in the over ground entry point such
13 that the sensor can measure the distance between its mounting point and bottom the
14 container. The sensor can be mounted in the supporting structure above the container itself,
15 and measure the distance between its mounting point and the bottom of the container. The
16 sensors and/or server can send an alert if the underground container is producing sensor
17 data indicating that the container has been partially or completely removed from the
18 ground.

19 **[0116]** The container can be a slurry tank, portable and/or stationary toilet, other fluid
20 tank, (e.g., water, recyclable oil), or combinations thereof. The sensor can be in a
21 ventilation pipe for the container.

22 **[0117]** The sensor can have an extension, such as a pipe or rod, to interface (e.g., be
23 submerged into or floating on) the contents of the tank, keeping the sensor raised above the
24 container top, preventing any contact between the contents and the sensor.

25 **[0118]** Figure 10 illustrates that the sensor can have a generally rectangular or square
26 cross-section in each dimension. The sensor can have a sensor height from about 10mm to
27 about 100 mm, more narrowly from about 15 mm to about 70 mm, for example about 22
28 mm, about 30 mm, about 50 mm, about 52 mm, about 59 mm, or about 60 mm. The sensor
29 can have a sensor length from about 50 mm to about 150 mm, more narrowly from about
30 70 mm to about 125 mm, for example about 73 mm, about 97 mm, about 103 mm, or about
31 112 mm. The sensor can have a sensor width from about 20 mm to about 100 mm, more
32 narrowly from about 30 mm to about 70 mm, for example about 30 mm, 41 mm, about 52
33 mm, about 55 mm, about 59 mm, or about 60 mm. The sensor can weigh from about 50 g
34 to about 1000 g, more narrowly from about 80 g to about 500 g, for example about 100g or

1 about 310 g. The sensor case can be made from metal and/or plastic, such as a
2 thermoplastic polymer, for example ABS, and/or a polycarbonate. The sensor case can be
3 sealed liquid (e.g., water resistant) and/or dust-tight, for example rated IP65, IP66, IP 67, or
4 IP68.

5 **[0119]** The sensor can have one or more sensor ports. The sensor ports can be circular.
6 The sensor ports can be on the top and/or on one or multiple sides of the sensor. (In
7 reference to the sensor itself, the top side of the sensor can be pointed downward when
8 attached to the lid. The bottom side of the sensor can be attached to and thereby can be
9 facing the surrounding surface, such as the lid or container wall.) The emitter and detector
10 can be in, extend from, or be positioned behind the sensor port. The emitted sensing
11 energy and reflected sensing energy can pass through the sensor port.

12 **[0120]** The sensor can have one or more attachment points or mounting holes, such as
13 screw holes. Connectors, such as screws, bolts, brads, barbs, pins, spikes, snaps, rivets, or
14 combinations thereof can extend from the sensor – for example, after being pushed through
15 the screw holes – and fixedly or removably attach to an adjacent surface, such as the lid,
16 the container wall, the pole, a bracket (e.g., the bracket mounted to the lid or pole), or
17 combinations thereof.

18 **[0121]** All or part of the surface of the sensor can have texturing, for example the top
19 surface can have increasing-radius circular or semi-circular grooves or ridges
20 concentrically centered at the sensor port.

21 **[0122]** Figure 10b illustrates that the sensor port can have a segmenting wall dividing
22 the sensor port into a first emitter/detector opening and a second emitter/detector opening.
23 The first emitter and detector can be in, flush with, or extend out of the first
24 emitter/detector opening. The second emitter and detector can be in, flush with, or extend
25 out of the second emitter/detector opening.

26 **[0123]** Opposite corners and/or each corner of the sensor can have one or more
27 mounting hole (e.g., a screw hole).

28 **[0124]** Figures 11a through 11c illustrate that the screw holes can extend through the
29 entire height of the sensor. The sensor port can be rectangular, square, oval, circular, or
30 combinations thereof. The bottom or base of the sensor case can have a base recession.
31 The base recession can be surrounded on one, some, or all sides by a base shoulder.
32 Adhesive and/or double-sided tape can be attached to the base recession and/or the base
33 shoulder. For example, the base recession can be partially or completely filled with resin,
34 epoxy, silicon, double sided tape, or combinations thereof, and then pressed against the

1 attaching surface (e.g., container lid, bracket, container wall, pole) to attach the sensor to
2 the lid. Connectors (e.g., screws, rivets) can be inserted through the screw holes and
3 attached to or through the attaching surface.

4 **[0125]** Figure 12a illustrates that the top surface of the sensor can be curved. The top
5 of the sensor can have a non-infinite radius of curvature, for example, the radius of
6 curvature can be from about 10 mm to about 100 mm, for example about 50 mm.

7 **[0126]** The sensor port can be in a sensor cover recession, recessed below the
8 surrounding surface of the sensor case.

9 **[0127]** Figure 12b illustrates that the sensor port can have a segmenting wall dividing
10 the sensor port into a first emitter/detector opening and a second emitter/detector opening.
11 The first emitter and detector can be in, flush with, or extend out of the first
12 emitter/detector opening. The second emitter and detector can be in, flush with, or extend
13 out of the second emitter/detector opening.

14 **[0128]** Figures 13a and 13b illustrate that the sensor can be operated without a sensor
15 cover.

16 **[0129]** Figures 13c and 13 d illustrate that the sensor can have a sensor cover over the
17 sensor port. The sensor cover can be recessed within (as shown), flush with, or extend
18 outward from the sensor cover recession. The sensor cover can be over a lens of the emitter
19 and/or detector. The sensor cover can prevent liquid, particles, or object impacts from
20 contacting the emitter and/or detector. The sensor cover can be transparent to the sensing
21 energy. The sensor cover can be polarized or non-polarized. The sensor cover can be
22 fixedly or removably attached to the remainder of the sensor case. For example, the sensor
23 cover can be replaced (e.g., when scratched or dirty).

24 **[0130]** Figure 14a illustrates an example printed circuit board (PCB) of a sensor. The
25 circuit board can be in the sensor, within a cavity in the sensor case. The cavity holding the
26 circuit board can be water-tight and dust-tight or can have access to the surrounding
27 environment, for example to measure characteristics of the environment (e.g.,
28 environmental temperature, environmental humidity, environmental pH), and/or contents
29 (e.g., content pH, content temperature).

30 **[0131]** The circuit board can have a processor or controller. The processor can have
31 non-transitory and/or transitory memory. The processor can execute software, for example,
32 installed during manufacture and/or downloaded from the server system.

33 **[0132]** The circuit board can have one or more location sensing modules, such as a wi-
34 fi network-based location system, and/or a satellite-based radionavigation system, for

1 example a GPS module. The location sensing module can have a GNSS antenna and/or a
2 wi-fi antenna. The location sensing can be used for purposes described elsewhere herein
3 and anti-theft tracking of the sensor and/or the entire container.

4 **[0133]** The circuit board can have one or more wireless communication antennas, for
5 example Bluetooth, wi-fi, cellular (e.g., PCS, GSM, 2G, 3G, 4G, CAT-M1, NB-IoT), or
6 LoRa antennas, or combinations thereof. The circuit board can have a fixed or replaceable
7 SIM card.

8 **[0134]** The circuit board can have one or more emitters and detectors. The emitter can
9 be configured to emit the sensing energy. The detector can be an optical sensor or a sensor
10 for any energy modality mentioned herein. The detector can be configured to detect
11 reflected and/or absorbed and/or transmitted and/or refracted sensing energy from the
12 emitter or emitters on other sensors (e.g., sensors in the same container). The emitter and
13 detector can measure a length to the content surface with an accuracy of about 1 cm or
14 about 1 mm. The emitter and detector can have a resolution of up to about 1 mm. The
15 emitter and detector can have a range from about 0 to 5 m, more narrowly from about 0 to
16 2 m.

17 **[0135]** The circuit board can have a battery (not shown, but can be positioned on the
18 reverse side of the circuit board shown in figure 14). The battery can be rechargeable. The
19 battery can be replaceable. The battery life under typical use and environmental conditions
20 can be from about 5 years to about 20 years, for example about 7 years or about 10 years.

21 **[0136]** The circuit board can have one or more input and output connectors. The input
22 and output connectors can be connected to wired networks, additional emitters and
23 detectors, other sensors' circuit boards, additional batteries, diagnostic electronics,
24 additional environmental or content sensing elements, or combinations thereof.

25 **[0137]** The circuit board can have a speaker and/or a display (e.g., full video, lights, an
26 LED, or combinations thereof), for example to flash, broadcast visual messages, chimes or
27 alert tones based on actions and confirmations (e.g., identifying the sensor from an
28 instruction in an app, warning of a low battery, confirming pickup of contents, alerting
29 when the lid is ajar and/or if the temperature or noxious gas sensors indicate the contents
30 are on fire), or messages (e.g., a voice message left by the container's owner for the
31 collecting operator). Any message delivered on the speaker and/or display can also be
32 included in the sensor data and transmitted to the server system and/or the owner and/or
33 operator's devices on their respective apps.

1 **[0138]** The circuit board can have environmental and content sensors (other than those
2 mentioned above). For example, the circuit board can have one or more temperature
3 sensors (e.g., and can report immediately if the container is outside a specified temperature
4 range or if the contents are on fire), accelerometers (e.g., for reporting container
5 movement), gyroscopic or other orientation sensors, humidity sensors, pH sensors, toxic or
6 noxious material sensors (e.g., for detecting toxic or corrosive gasses or liquids, or smoke
7 in the event of a fire), physical separation sensor (e.g., attached to a spring-loaded pad on
8 the sensor base to determine if the sensor has been removed from its attachment surface),
9 or combinations thereof. The circuit board can alert the server system and/or through the
10 speaker and/or owner's app if the temperature sensor detects a temperature below -25° C or
11 -40° C or above 80° C. The circuit board can operate in temperatures, for example, from
12 about -25° C to about 80° C.

13 **[0139]** The circuit board can have an onboard fan and/or liquid cooling system, for
14 example with a finned heat radiator. The circuit board can be wrapped or coated in thermal
15 insulation and/or anti-corrosion material.

16 **[0140]** The circuit board can be configured to report sensor data at fixed or variable
17 intervals. For example, the sensor, server system, and/or the owner can alter the reporting
18 schedule based on the historical and current frequency of collections, rate of content
19 accumulation within the container, battery use and remaining life, and combinations
20 thereof.

21 **[0141]** The sensor can record video data for example still frames or moving videos
22 (e.g., JPEG and/or MPEG files), audio data, or combinations thereof of the inside of the
23 container as part of the sensor data. These video and audio files with the rest of the sensor
24 data can be used to train the artificial intelligence, for example to identify and send an alert
25 to any or all of the APIs regarding contaminated waste streams (e.g., a plastic bag in a
26 paper recycling container). The audio can be used to determine the topology of the fill
27 surface by echolocation.

28 **[0142]** Figure 14b illustrates that the circuit board and/or other components in
29 connection with each other can have a processor (MCU) with internal memory in direct
30 communication and connection with external memory and a clock (time reference). The
31 processor can be connected to multiple radios, a battery, and sensing components. The
32 radios can send and receive wireless communications. The battery can directly power the
33 radios through power conditioning components. The radios can connected to each other.

1 The sensing components can be TOF detectors and emitters, radar, accelerometers,
2 temperature sensors, cameras, and positioning sensors, for example that send or receive
3 positioning data wirelessly (e.g., from GPS satellites).

4 **[0143]** Figure 15 is a block diagram illustrating functional modules that can be
5 executed by the sensor. The functional modules executable by the sensor can include a
6 processing module, a fill measurement module, a data storage module, and a
7 communications module. The processing module can collect data measurements from the
8 sensor's sensing components, and can perform local processing and communications tasks
9 on the sensor's components. The processing module can perform energy management for
10 elements of the sensor, operating the device in an energy-efficient manner (e.g., increasing
11 or decreasing the sampling frequency of the emitting and sensing components and
12 communications by the wireless communications components). The fill measurement
13 module can perform tasks to calculate a fill measurement of the container based on the data
14 measurements received from the sensor components. The data storage module can store
15 the sensed data measurements, calculated fill levels, and parameters for operating the
16 sensor. The communications module can communicate with an external device, such as a
17 remote server system. The modules executable by the fill monitoring device can be
18 implemented in hardware and/or software.

19 **[0144]** Figure 16 is a flowchart illustrating a method for monitoring the fill level of a
20 container using the sensor.

21 **[0145]** The sensors can be installed on containers already in use (e.g., retrofit) or during
22 the manufacture of new containers. To prepare the sensor for use in a system, installation
23 software (e.g., an installation app) on a remote device, such as the server system or the
24 container owner's device, can be executed to install the sensor into the system.

25 **[0146]** Figure 17a illustrates that the installation software can install the sensor for a
26 new container, signal replacement of the sensor, unpair the sensor, enhance the location of
27 the container, check the container status, or combinations thereof.

28 **[0147]** During installation for a new container, the installation software can link the
29 sensor with a server system, location (e.g., address, as shown in figure 17b), type of
30 container, and container name (e.g., identifying number, as shown in figure 17c), sensor
31 position in the container, the container height, volume, width, and the sensor angle and
32 offset from center (as shown in figure 17d – which also graphically shows the sensor
33 position, angle of orientation, and relative container dimensions), or combinations thereof.
34 This installation information can be automatically attained by the sensor components on

board the sensor and information from the server system, and/or can be manually entered or corrected by the user of the installation app.

[0148] The installation software can enhance the location of the container, for example, by showing the location of the container on a map as designated by the selected street address or entered by the container owner, and also overlaying the location of the container as asserted by GPS information provided by the sensor, and the location of nearby sensors (e.g., if the sensor is on a container that is in a close group of containers each with its own sensor). The user of the installation app can then manually calibrate the location of the container on the map in light of the available location data.

[0149] The installation software can unpair a sensor from a system, and can restore factory settings, deleting previously recorded sensed and server system data from the sensor. For example, the restoring of factory settings can be performed after the sensor is removed from a container (in preparation for use on a new container elsewhere, such as when resold or if the owner moves). The server system and/or installation software can copy all of the old sensor data, including data described herein including location and identifying information, from an old sensor to a new sensor replacing the old sensor.

[0150] As shown in Figure 17e, the installation software can link the sensor to a door sensor, for example a doorbell or keypad on a door or gate. For example, a collection operator may need to key in a passcode to open a gate in order to access the container. The sensor can communicate with the gate to alert the server system and/or the owner's device when the operator's access code has been used on the gate. The sensor can also make the gate's access code active when alerted by the server system that the operator is nearby. The operator's gate code can remain inactive and unusable during other times.

[0151] Figure 18 illustrates that a group of containers can each have a sensor. The containers can be in close proximity to each other. The sensors can have a network connection with the next closest sensor. All of the sensors in the group can be in wired or wireless communication with each other. For example, the sensors can for a local area network (e.g., over Bluetooth 5.0), such as a mesh network. All (e.g., for redundancy) or one of the sensors can act as a (e.g., cellular) network connection to the server system for the local network of sensors. A router near the sensors can have a wired or wireless network connection with one or more of the sensors. The router can act as a (e.g., cellular) network connection to the server system for the local network of sensors. For example, the sensors can use their respective reduce the frequency of using their wireless radios for

1 communication with the server system when relating communications over the local
2 network to the server.

3 **[0152]** Multiple sensors can be used in a single container. Door sensors or access
4 controllers can be put on cabinets or cages holding containers.

5 **[0153]** The server system can receive the sensor data from the sensor. The server
6 system can maintain a real-time overview of sensor data from all sensors. The sensor data
7 can be validated and checked for data errors by the server system. The server system can
8 flag and report erroneous or extreme sensor data for further review by operations control,
9 the container owner, the operator, or combinations thereof. The server system can flag
10 sensors that are low on battery energy, appear to have dirty or failing sensors corrupting the
11 sensor data, do not report data during an expected reporting period, or combinations
12 thereof. The server system can indicate to dispatch an operator to the sensor to clean,
13 maintain, replace the batteries on the sensor, or combinations thereof.

14 **[0154]** The server system can interpret and analyze the sensor data. All or some data
15 from all or some of the sensors and the analyzed and interpreted data can be made available
16 from the server system to display for any or all of the aforementioned APIs and apps via a
17 data dashboard (e.g., a website, app, other software, or combinations thereof) as shown in
18 Figure 19. Similarly any alerts and data flags mentioned herein can be pushed to or
19 otherwise available for display to any or all of the APIs and apps mentioned herein.

20 **[0155]** The data dashboard can display real-time and historical maps of the sensor
21 locations, the current and historical container fill levels, the ability to manually trigger
22 urgent collection scheduling for specific containers (e.g., “empty now”), notifications and
23 flags from the server system for urgent data and alerts and data errors.

24 **[0156]** Figure 20 illustrates that the server system can display sensor data and analysis
25 from a selected container. For example, the display can have a three-dimensional color-
26 coded topographical image reporting the fill surface and levels for the container. Historical
27 fill levels are also graphed and displayed. Discrete sensing of the time and date of the
28 reading, the fill level for the reading, the temperature for the reading, the (e.g., average)
29 distance from the sensor to the content surface, and the minimum and maximum distances
30 for the sensors for the reading are also displayed. The container type, content category,
31 minimum and maximum thresholds for the fill level, sampling interval for the sensor,
32 reporting interval for the sensor are shown. The method by which the operator collects the
33 container and whether there is a mandatory pickup at a particular time frequency are

1 shown. The user can also edit the editable data (e.g., container type, waste type, threshold
2 levels, sampling and reporting intervals, route profile, and mandatory pickup frequency).

3 **[0157]** Additional information from other sensor data can be shown (e.g.,
4 accelerometer events). The display can be customized by the user's API.

5 **[0158]** Figure 21 illustrates a variation of the display for a container presented to the
6 APIs from the server system. The display can show the container's historical fill height
7 graphed for over 7 days.

8 **[0159]** Figure 22 illustrates a variation of the display for a container presented to the
9 APIs from the server system. The display can show the address and mapped location of the
10 container, the container's fill level, and the last updating to the server system of the
11 container's data.

12 **[0160]** The server system can have a hysteresis control on the fill level data so a preset
13 number of data samples are registered above or below a threshold level before the server
14 system indicates (e.g., in collection route calculations and reporting to APIs) that the
15 threshold has been crossed. The hysteresis control can, for example, minimize false
16 positive readings from compressible contents that need time to compress, or an item on top
17 of the remainder of the contents that will fall deeper into the container in short time, but is
18 causing an high fill level reading for a short period of time that is not reflective of the total
19 volume of contents.

20 **[0161]** The server system can allow users to manually tailor report data and
21 presentation style (e.g., presenting data as a graph, table, or comma separated list) for
22 displays.

23 **[0162]** Using the sensor data and external data, the server system can create collection
24 routes for each operator. The collection routes can be dynamic and event driven.
25 Containers can be added to collection routes when the contents of the specific containers
26 can be when the containers are above a specified fullness threshold. The server system can
27 include current and predicted traffic conditions, current and predicted weather conditions,
28 the day of the week, nearby events, existing traffic detours, road work areas, active school
29 zones, other irregular traffic congestion (e.g., due to concerts, demonstrations, sports
30 events), and combinations thereof in route planning. The server system can also match the
31 appropriate vehicle with the container, and/or weight, and/or volume, and/or waste type to
32 be serviced. For example, the server system can manage containers that include mixed
33 household waste, portable toilets, septic tanks, and biohazard containers, and can have
34 vehicles that can process one or more types of the containers and their respective waste, but

1 not the others. During route planning, the server system can incorporate navigation on
2 accessible non-public streets and driveways (e.g., to which access is permitted), indoor
3 locations, on-foot movement by the operator, routes across political (e.g., state borders),
4 and physical boundaries (e.g., fences) and provide instructions for the operator through the
5 navigator app when doing so.

6 **[0163]** The server system can optimize routes in real-time, for example, changing
7 routes for particular operators while the operator is mid-route. The updated route can be
8 transmitted from the server system to the mobile device.

9 **[0164]** The server system can employ artificial intelligence (AI) and machine learning
10 to optimize route creation and predict future routes. The server system can schedule pre-
11 emptive collection of container contents when determined to be appropriate (e.g., for
12 efficiency and/or effectiveness) by the routing (e.g., AI) models.

13 **[0165]** Operators' vehicles can be routed to arrive on the correct side of the road for
14 accessing and transferring the contents of the container. For example, a garbage truck may
15 have a grappling arm for gripping the container, picking the container up, positioning the
16 container upside down over the collection area in the truck, and shaking the container to
17 empty the contents into the truck's collection area. If the arm only extends from the right
18 side of the truck, the routing can be limited to orient each garbage truck so it arrives on the
19 right side of the road when picking up a container so the arm can be used without requiring
20 a U-turn of the truck at the destination.

21 **[0166]** Operators' vehicles can have weighing components to track the weight of
22 collected contents. The server system can use the real-time collection vehicle diagnostic
23 information from mobile devices and other vehicle on-board diagnostics (e.g., to determine
24 the weight of currently gathered contents) for reports, and to avoid exceeding road and
25 vehicle weight restrictions during route – for example when in conjunction with the
26 predicted weight of the remaining containers to be collected during the route. The server
27 system can track other on-board vehicle diagnostics along with the weight of collected
28 contents to predict vehicle maintenance and alert operators and other personnel when
29 vehicle maintenance is due and schedules or predicted future maintenance. When creating
30 future routes, the server system can take into account the available vehicle fleet based on
31 predicted future maintenance and other servicing of vehicles.

32 **[0167]** The server system can alert container owners (e.g., via an app) when their
33 container needs to be pushed to the curb for pickup by the collection operator, for example,

1 at a time length before their estimated collection set by the owner of the container in their
2 app, which can then be stored by the server system for that owner's sensor.

3 **[0168]** The server system can assess and regulate power consumption by each sensor,
4 and alter the frequency of measurement and data transmission by each sensor to increase
5 battery life based on battery status, current and predicted weather conditions (e.g.,
6 temperature and humidity), signal strength, frequency of collections for the respective
7 sensor, and combinations thereof.

8 **[0169]** The server system can monitor operators' positions in real-time through
9 communications from the navigation app. Figure 23a illustrates a screenshot of a map
10 tracking a location of a collection vehicle in real-time. The area map, starting point (a
11 flag), route already driven (a line), current location (truck icon), containers already picked
12 up (numbered circles on the route already driven), and containers to be picked up
13 (numbered circles) are displayed. The containers displayed on the map are numbered by
14 their order in the pickup sequence.

15 **[0170]** Figure 24 illustrates a screenshot showing that the server system can display a
16 route summary and replay of the operators' position from a previous route (or a partially-
17 completed route).

18 **[0171]** As shown in Figure 25, the server system can allow a user to manually (or set
19 the server system to automatically) group sensor data from different sensors, for example
20 for the sensors defined within the borders drawn on the map in figure 25. The grouped
21 sensor data can be combined and analyzed as a single data set.

22 **[0172]** The server system can be set (e.g., by an API) to restrict access to some sensors
23 and/or some data for different APIs based on the API type, the individual user account, the
24 location of the user, the user's team (e.g., restrict access to collections operators, but not to
25 collections managers), or combinations thereof.

26 **[0173]** The server system data can be accessed by urban planners, for example, to place
27 public waste containers in locations where waste is collecting in public waste containers
28 more rapidly compared to the average public waste container in the larger area, as
29 measured by the system, and to remove or move public waste containers from areas where
30 waste is collecting in public waste containers less rapidly compared to the average public
31 waste container in the larger area.

32 **[0174]** Cameras on the operators vehicles, and the waste collection centers, in the
33 sensors, or combinations thereof, can record images and send them to the server system to
34 identify (manually and/or via machine vision algorithms) the detailed identity of the

1 contents of the waste. These identified contents and their quantity can be used for
2 consumer and/or producer behavior monitoring and tracking changes in consumer habits
3 for the collection address.

4 **[0175]** The server system can attain localized pollution levels and their respective
5 locations, and report the pollutions levels with aggregated route and collection data to
6 display mapped changes in pollution emissions with respect to the increased efficiency of
7 container collections.

8 **[0176]** The navigator app can direct the route for operators, for example, when driving
9 in or riding on collections vehicles or on foot. The navigator app can display and audibly
10 announce turn-by-turn navigation along the route with spoken directions. The navigator
11 app can deliver traffic-aware routing and hands free directions to the operator. The
12 navigator app language can be selected by the operator.

13 **[0177]** Figure 26a illustrates that the navigator app can display available vehicles and
14 allow the operator to identify and communicate with the server system which vehicle the
15 operator will be operating of the available vehicles. The navigator app can be on a mobile
16 device fixed to a vehicle and, for example, can prohibit the operator from selecting the
17 vehicle.

18 **[0178]** Figure 26b illustrates that the navigator app can allow the operator to start one
19 or a number of routes. The server system can show routes in the navigator app that are
20 allowed for the vehicle the operator selected and/or the vehicle for which the navigator app
21 is assigned (e.g., for a navigator app running on a mobile device fixed to a vehicle). The
22 navigator app can list or rank the routes in chronological order for which the operator is to
23 proceed. The navigator app can lock out the operator from opening later routes until the
24 earlier routes are complete and/or until a start time is reached for the route.

25 **[0179]** Figure 26c illustrates that once a route is selected, the navigator app can display
26 a map showing the containers for collection and the start and end points for the route. The
27 navigator app also can display the name of the route, the distance of the route, the number
28 of containers to be collected, the estimated time to complete the route (“47min”, as shown
29 in figure 36b), and the estimated time at which the route will be completed (“13:41” as
30 shown in figure 36b). The navigator app can provide the options to abort the route and/or
31 to resume the route.

32 **[0180]** Figure 26d and 26e illustrate that the navigator app can display turn-by-turn
33 instructions to proceed along the route. Figure 26d illustrates that the route can be
34 projected on a map. Figure 26e illustrates that the route can be shown as a list of turns and

1 straights. The navigator app can display the number of served containers and the number
2 of containers in the queue to be serviced along the rest of the route.

3 **[0181]** The navigator app can communicate special instructions for the operator during
4 container collection (e.g., “Container 3 is immediately behind the gate on the right side of
5 the house.”, “The dog is loose in the yard but is friendly.”, “Container 7 needs its sensor
6 cleaned.”).

7 **[0182]** Figure 26f illustrates that the navigator app can graphically display the number
8 of containers to collect during the route (shown by white circles in figure 26d) and the
9 number of containers already collected (shown by black circles in figure 26d).

10 **[0183]** Figure 26g illustrates that the navigator app can display container information,
11 for example for the next container along the route or a container selected by the operator on
12 the display. The navigator app can show the fill level, the type of container, the container
13 identifying number or name, the container address, the distance to the container, and a
14 photographic image of the container. The image can include the visual appearance of the
15 container and the container’s surroundings. The navigator app can allow the operator to
16 press on a button image on the display to indicate (e.g., to the navigator app and the server
17 system) when the container is serviced, or if the operator is going to skip servicing the
18 container.

19 **[0184]** Figure 26h illustrates that the navigator app, and/or the other APIs or apps can
20 display historical and/or real-time (i.e., current) route information for multiple operators
21 and vehicles.

22 **[0185]** The navigator app can communicate gate or door passcode information to the
23 operator, and/or send a wireless access code to the gate or door to unlock or otherwise
24 permit access through the gate or door, for example, to permit the operator to retrieve a
25 container from behind the gate or door.

26 **[0186]** The navigator app can communicate to the server system the time the operator
27 is at a location, the velocity, acceleration, the directional orientation of the operator and/or
28 the operator’s vehicle, the identity and classification (e.g., professional title and/or
29 responsibility level) of the operator, when and where the operator stops, when and where
30 the operator loads the contents of a container into the vehicle, the weight of the contents
31 (e.g., communicated wirelessly from a scale on the vehicle or container to the mobile
32 device), the identity of the operator’s vehicle. The server system can track the operator in
33 real-time, for example through the data from the navigator app, and can record the
34 navigator app data for analysis and replay.

1 **[0187]** The navigator app can supplement or alter the route from the server system due
2 to data updates from sources other than the server system (e.g., an immediate traffic update
3 from a third party source). When the navigator app changes the route from the route
4 provided by the server system, the navigator app can alert the server system of the route
5 change. The server system can confirm or abort the route change from the navigator app.

6 **[0188]** If the operator deviates from the route, the navigator app can alert the server
7 system of the deviation.

8 **[0189]** The server system can create and display reports through the APIs or apps for
9 any of the sensor data, mobile device data, and/or server system data.

10 **[0190]** Figure 27 illustrates that, in addition to the reports disclosed elsewhere herein,
11 when an operator's route is complete, the server system can produce a report that can
12 display a trip summary for the route. The trip summary report can include a map of the
13 route inclusive of mapped locations of the containers collected during the route, the number
14 of total containers serviced, the start and stop times and locations, the distance and time
15 traveled, the vehicle used and its identifying information (e.g., license plate, vehicle
16 identification number), the gas (or electrical) mileage for the vehicle, alerts, the current cost
17 of gas (or electrical charge), and the total cost of gas (or electricity) for the route, the
18 depreciation and estimated wear and tear costs for route for the vehicle based on
19 depreciation and wear and tear cost rates for the vehicle, or combinations thereof. Any
20 reports can be shared over e-mail to the operator or others, as shown in figure 27.

21 **[0191]** Use of the systems and methods disclosed herein have mitigated container over-
22 flows, reduced owner complaints, reduced the number of daily collections by 91%, reduced
23 service route times from 4.5 hours to about 25 minutes (i.e., reduction of route time by
24 91%), optimized placement of trash bins, resulted in a 93% reduction in street cleaning
25 requests.

26 **[0192]** Any method or apparatus elements described herein as singular can be
27 pluralized (i.e., anything described as "one" can be more than one). Any of the APIs listed
28 herein can be apps and vice versa. Any species element of a genus element can have the
29 characteristics or elements of any other species element of that genus. The above-
30 described configurations, elements or complete assemblies and methods and their elements
31 for carrying out the disclosure, and variations of aspects of the disclosure can be combined
32 and modified with each other in any combination.

33

CLAIMS

We claim:

1. A method for the collection of contents of one or more geographically distributed containers comprising:
 - determining a fill level of the contents in one of the containers, wherein the determining comprises detecting the position of one point or more than one point on the surface of the contents;
 - transmitting to a server system the fill level of the contents and an identity of the one of the containers;
 - calculating by the server system whether to include the container in a route data set
 - defining a route, wherein the route comprises stops at one or more of the containers;
 - creating the route data set;
 - wirelessly sending the route data set from the server system to a mobile device.
2. The method of claim 1, wherein the container comprises a sensor for determining the fill level.
3. The method of any of the aforementioned claims, wherein the container comprises multiple sensors for determining the fill level.
4. The method of claim 3, wherein the determining of the fill level comprises forming a topography of the surface.
5. The method of any of the aforementioned claims, further comprising attaching a time of determination in a data set with the fill level and the identity of the one of the containers, and wherein the transmitting comprises transmitting the data set to the server system.
6. The method of any of the aforementioned claims, further comprising transporting along the route, wherein the transporting along the route comprises transporting a self-driving vehicle along the route, wherein the mobile device is in communication with a navigation system of the self-driving vehicle.

- 1 7. A system for the collection of contents of one or more geographically distributed
2 containers comprising:
3 one or more sensors for detecting the amount of contents in a container, wherein the
4 one or more sensors comprises one or more detectors for detecting more than one point on
5 the surface of the contents;
6 a server system in wireless communication with the one or more sensors, wherein
7 the one or more sensors transmit data to the server, wherein the data comprises a fill level
8 of the contents in the container;
9 a mobile device in wireless communication with the server system, wherein the
10 mobile device displays instructions for routing a collection vehicle to the container.
11
- 12 8. The system of claim 7, wherein the container comprises a lid, and wherein a first sensor
13 of the one or more sensors is attached to the lid.
14
- 15 9. The system of claims 7 or 8, wherein a first sensor of the one or more sensors is a time
16 of flight sensor.
17
- 18 10. The system of any of claims 7-9, wherein a first sensor of the one or more sensors
19 emits a first sensing energy, and wherein the first sensing energy comprises a laser.
20
- 21 11. The system of any of claims 7-10, wherein the one or more sensors comprise a first
22 sensor and a second sensor, and wherein the container comprises a lid, and wherein the first
23 sensor is attached to the lid.
24
- 25 12. The system of claim 11, wherein the second sensor is attached to the lid.
26
- 27 13. The system of claim 11, wherein the first sensor emits a sensing energy comprising a
28 laser.
29
- 30 14. The system of claim 13, wherein the second sensor emits a second energy comprising a
31 laser.
32
- 33 15. The system of claim 13, wherein the second sensor emits a second sensing energy
34 comprising no laser energy.

1
2 16. The system of claim 11, wherein the first sensor is spaced at a distance from the
3 second sensor.

4
5 17. The system of claim 11, wherein the second sensor is attached to an inside wall of the
6 body.

7
8 18. The system of any of claims 7-11, wherein a first sensor of the one or more sensors
9 comprises a first emitter for emitting a first sensing energy and a second emitter for
10 emitting a second sensing energy, wherein the first emitter is directed to a first point on the
11 surface of the contents, and wherein the second emitter is directed to a second point on the
12 surface of the contents.

13
14 19. A device for fill volume detection comprising:

15 a container having a body and a lid hingedly attached to the body, wherein the
16 container contains contents defining the fill volume within the container; and

17 a first sensor in the container, wherein the first sensor comprises a first emitter for
18 emitting a first sensing energy, a first detector for detecting a reflection of the first sensing
19 energy, and a first wireless radio; and

20 wherein the first emitter is directed so the first sensing energy is emitted in the
21 direction of the surface of the contents.

22
23 20. The device of claim 19, wherein the first sensor is attached to the lid.

24
25 21. The device of claims 19 or 20, wherein the first sensor is a time of flight sensor.

26
27 22. The device of any of claims 19-21, wherein the first sensing energy comprises a laser.

28
29 23. The device of any of claims 19-22, further comprising a second sensor comprising a
30 second emitter for emitting a second sensing energy, a second detector for detecting a
31 reflection of the second sensing energy, and a second wireless radio.

32
33 24. The device of claim 23, wherein the second sensor is attached to the lid.

1 25. The device of claim 23, wherein the first sensing energy comprises a laser.

2
3 26. The device of claim 25, wherein the second sensing energy comprises a laser.

4
5 27. The device of claim 25, wherein the second sensing energy comprises no laser energy.

6
7 28. The device of claim 23, wherein the first sensor is spaced at a distance from the second
8 sensor.

9
10 29. The device of claim 23, wherein the second sensor is attached to an inside wall of the
11 body.

12
13 30. The device of any of claims 19-23, wherein the first sensor further comprises a second
14 emitter for emitting a second sensing energy, and a second detector for detecting a
15 reflection of the second sensing energy.

16
17 31. A method for fill volume detection comprising:

18 emitting a sensing energy from a sensor in a container, wherein the container
19 contains contents defining the fill volume within the container, wherein the emitting
20 comprises directing the sensing energy to one or multiple points on the surface of the
21 contents; and

22 detecting reflections of the sensing energy off of the one or multiple points of the
23 surface of the contents;

24 tracking the amount of time elapsed between the emitting of the sensing energy and
25 the detecting of the reflections of the sensing energy;

26 calculating a length associated with the amount of time for reflections of the
27 sensing energy for each of the multiple points;

28 forming a topography of the surface of the contents, wherein the forming comprises
29 utilizing the calculated lengths.

30
31 32. The method of claim 31, further comprising calculating the fill volume comprising
32 processing the topography.

1 33. The method of claims 31 or 32, wherein the forming comprises displaying a three-
2 dimensional image.

3
4 34. The method of any of claims 31-33, wherein the container comprises a body and a lid
5 hingedly attached to the body.

6
7 35. The method of any of claims 31-34, wherein the emitting comprises emitting from a
8 first sensor in the container, wherein the first sensor comprises a first emitter for emitting
9 the first sensing energy, a first detector for the detecting a reflection of the first sensing
10 energy, and a first wireless radio.

11

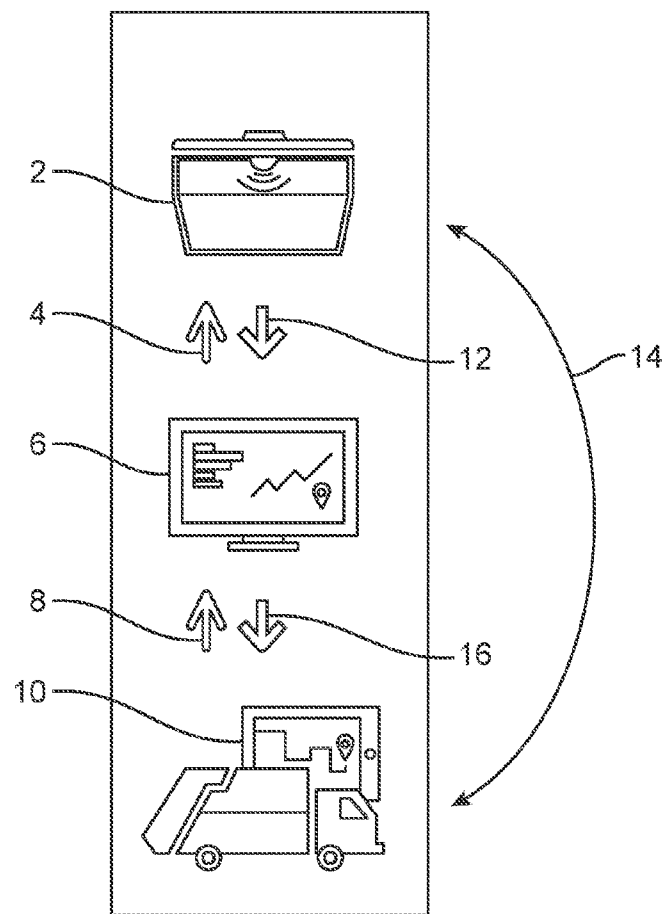


FIG. 1

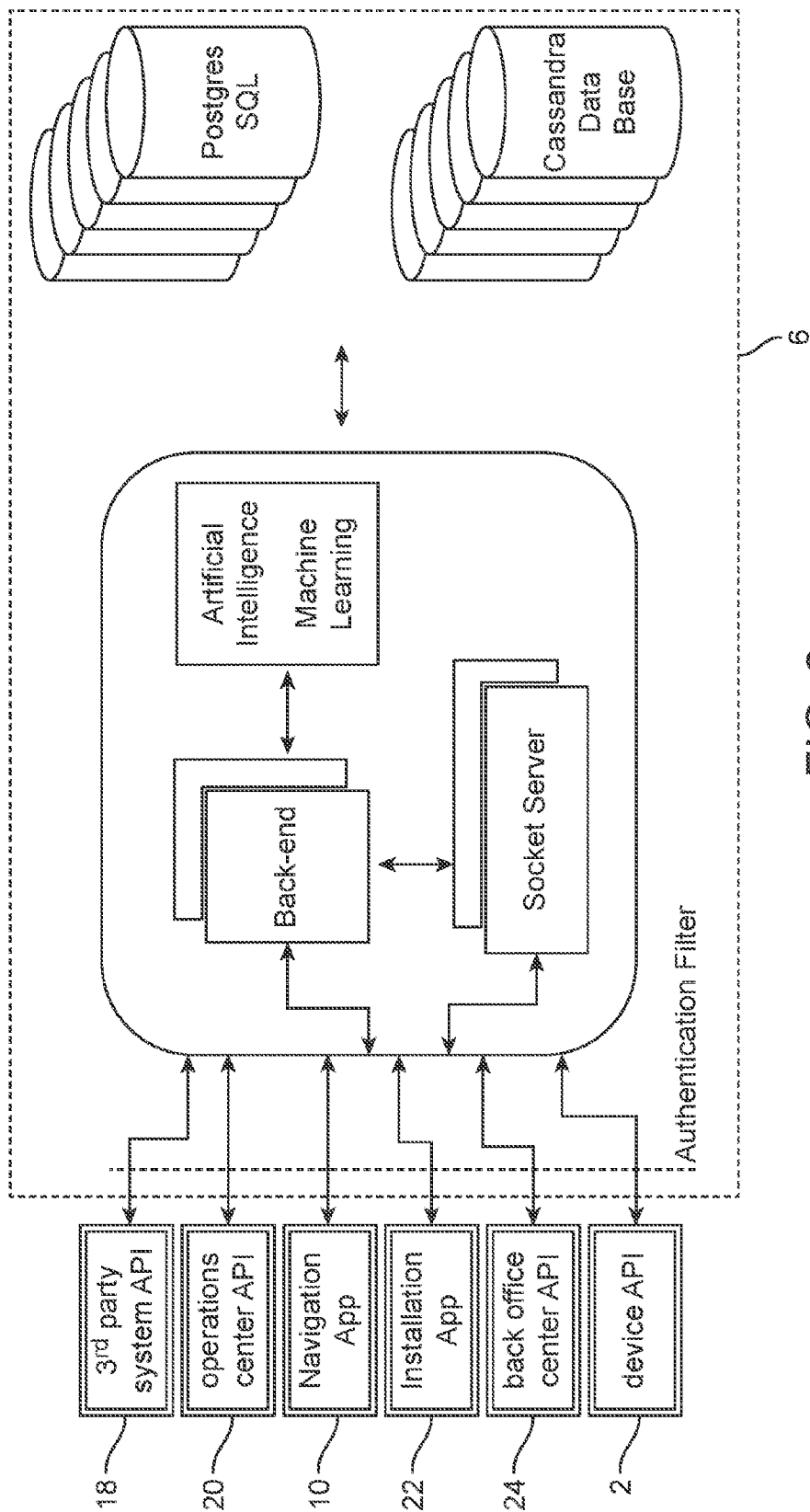


FIG. 2

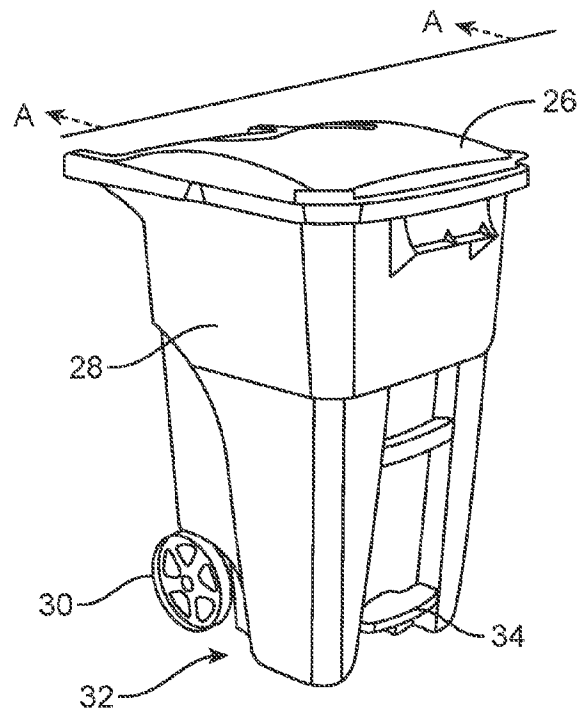


FIG. 3

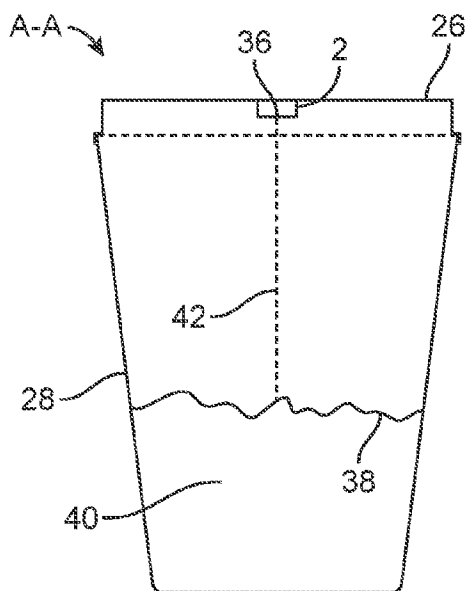


FIG. 4A

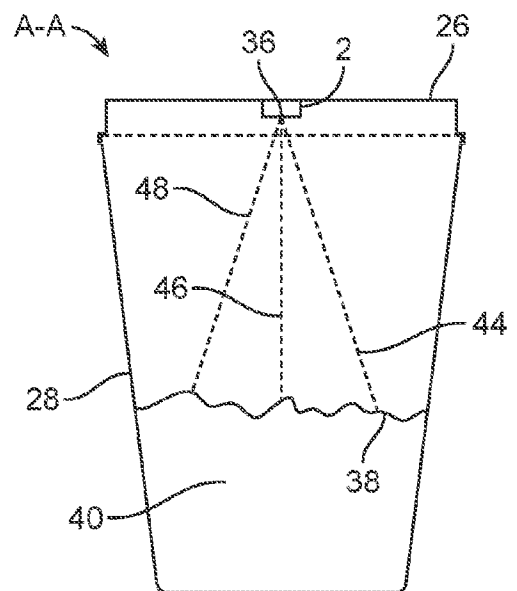


FIG. 4B

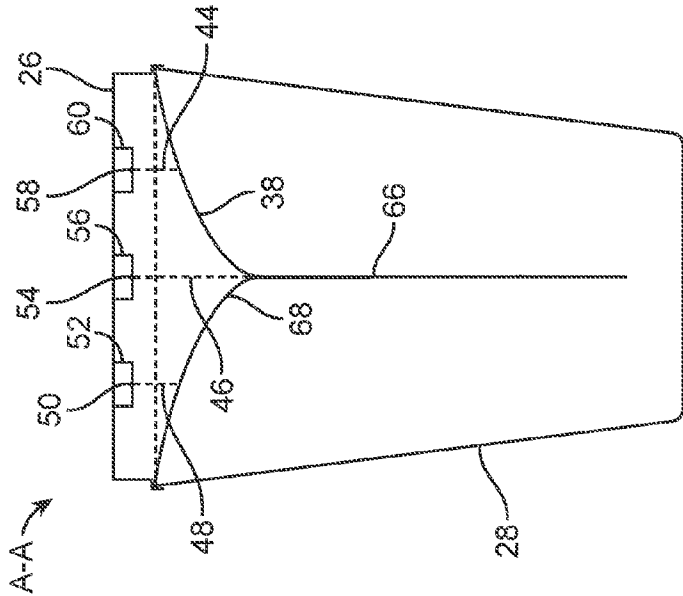


FIG. 5

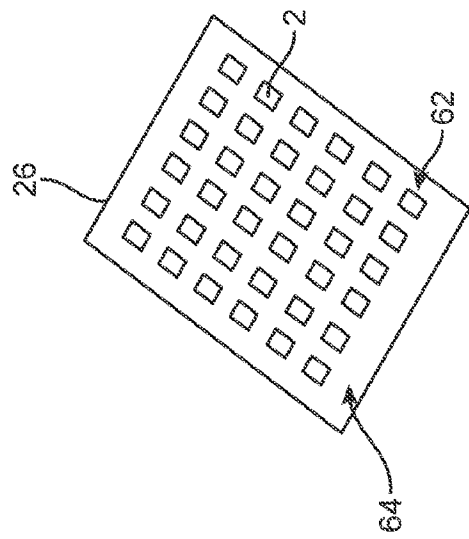


FIG. 6

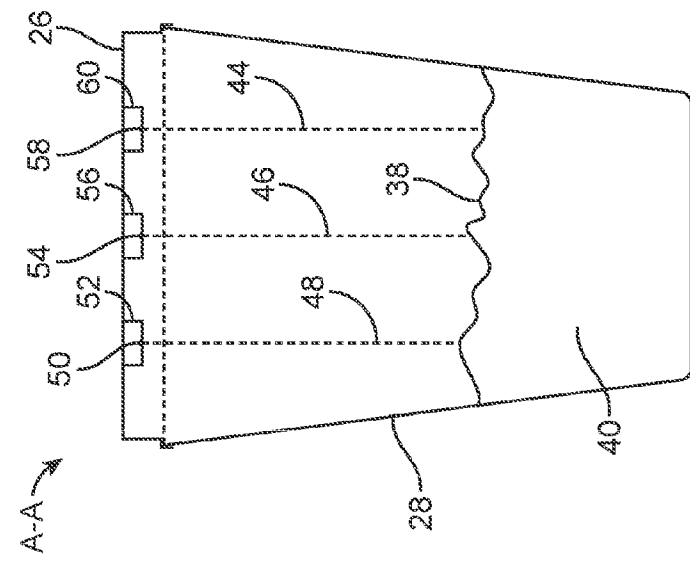
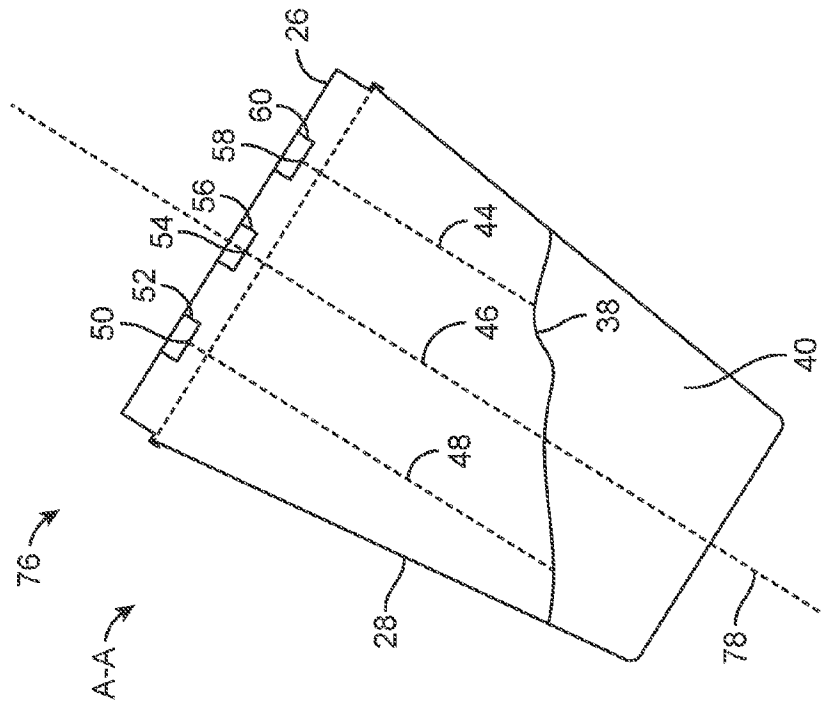
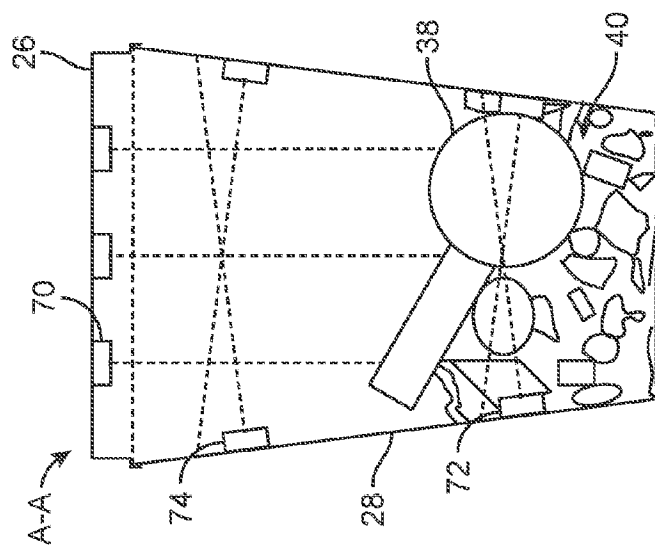


FIG. 7









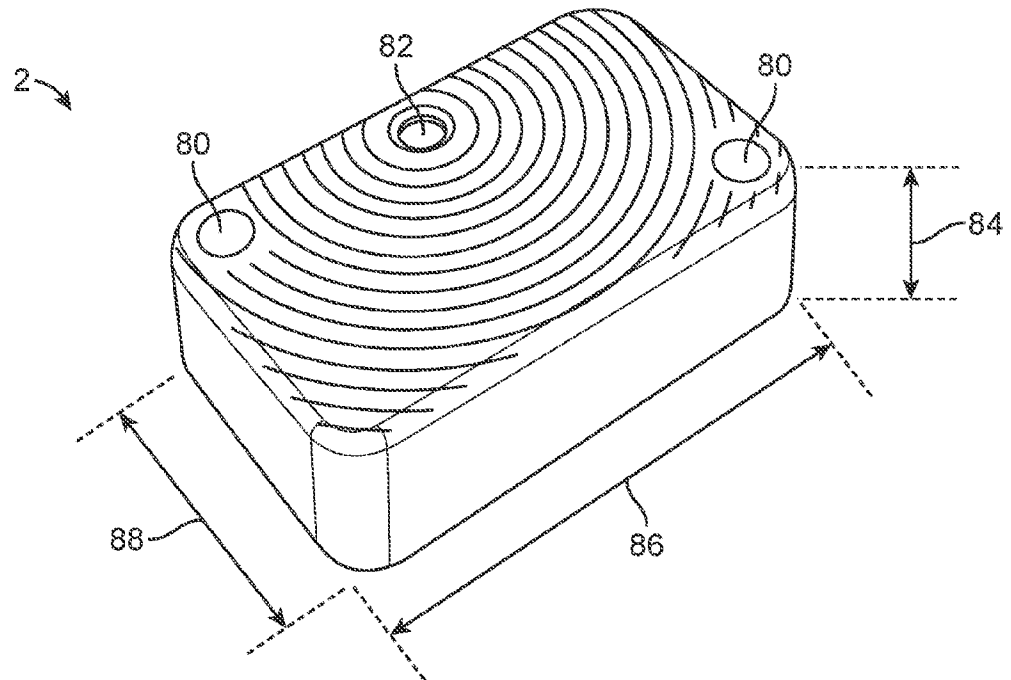


FIG. 10A

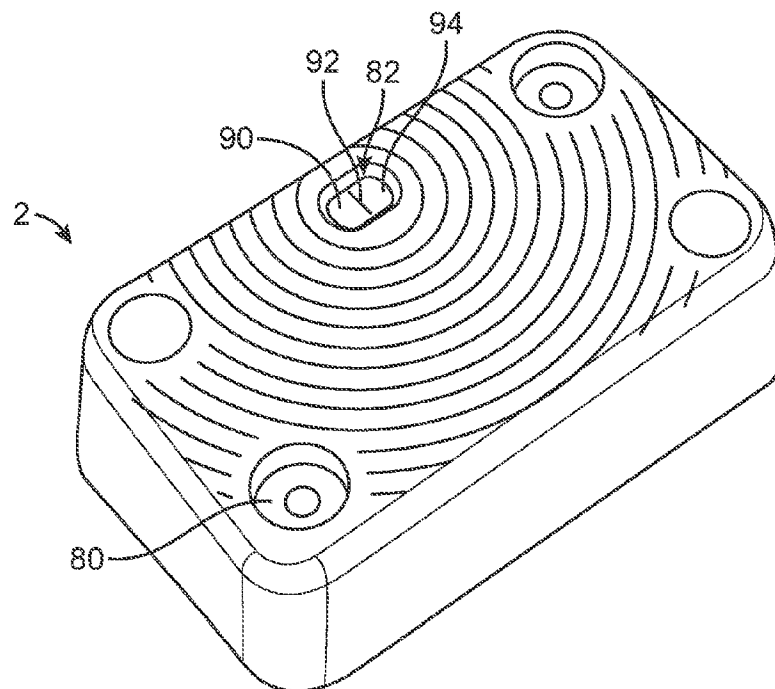


FIG. 10B

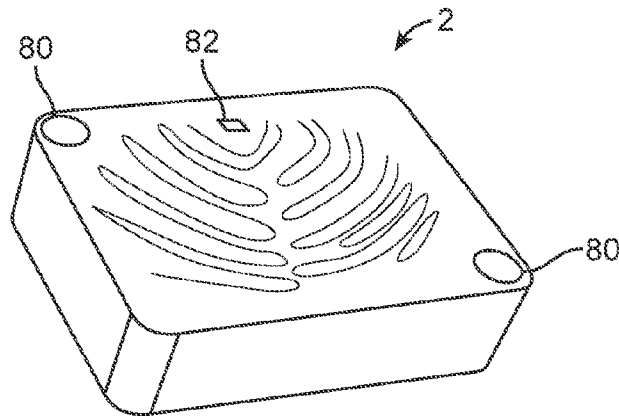


FIG. 11A

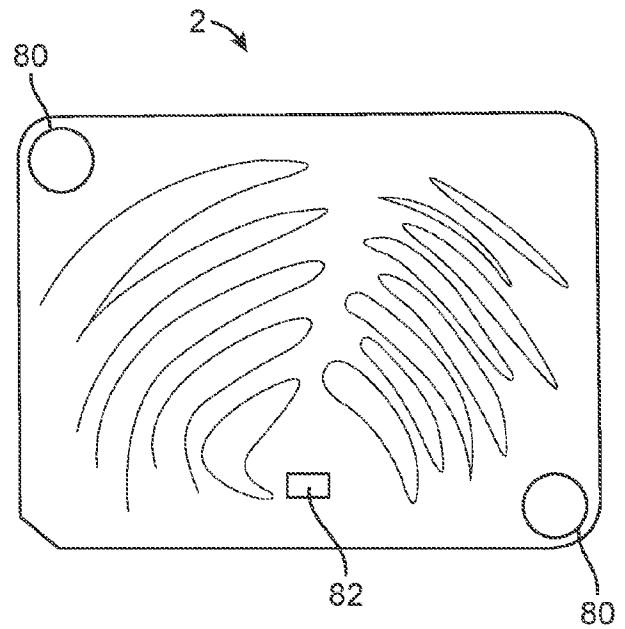


FIG. 11B

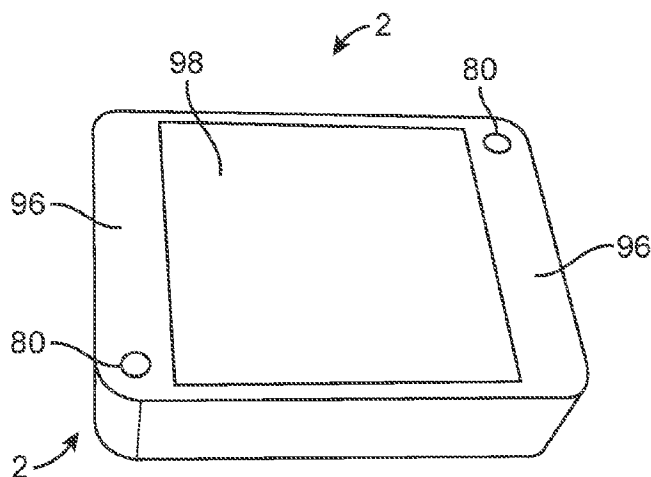


FIG. 11C

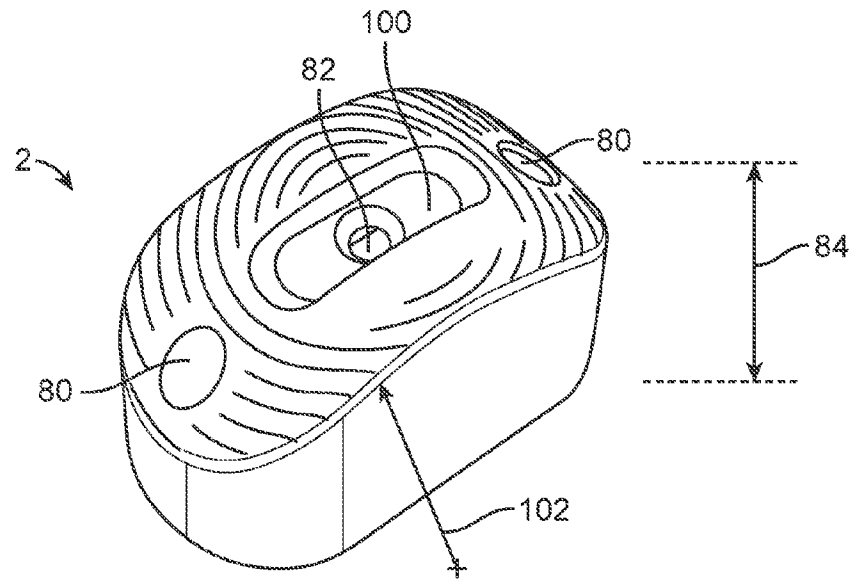


FIG. 12A

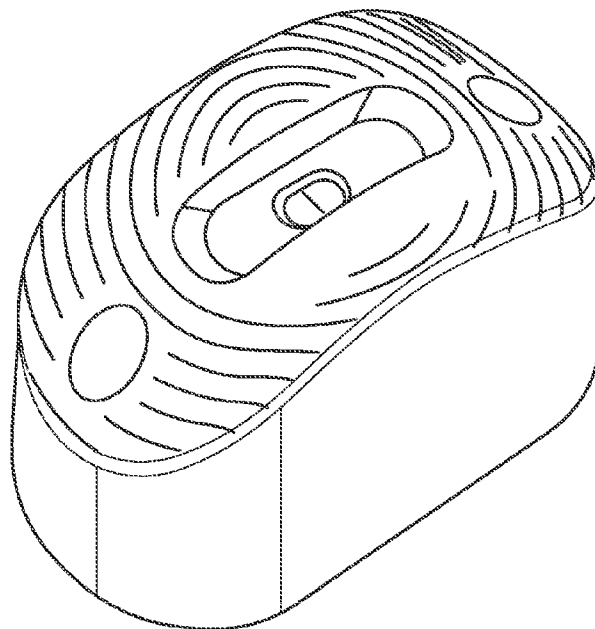


FIG. 12B

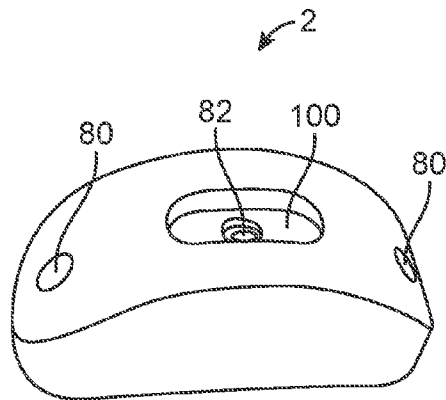


FIG. 13A

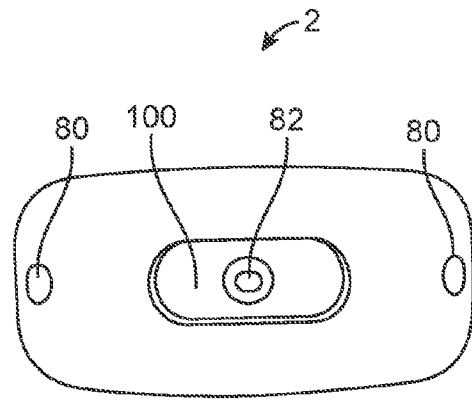


FIG. 13B

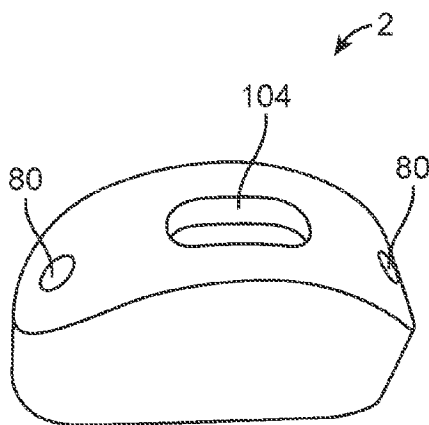


FIG. 13C

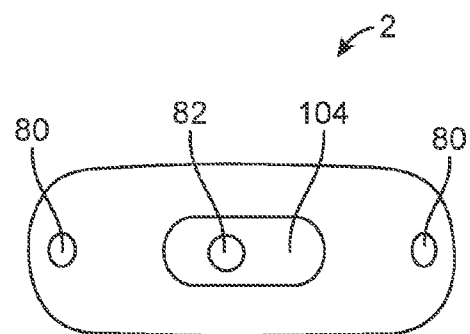


FIG. 13D

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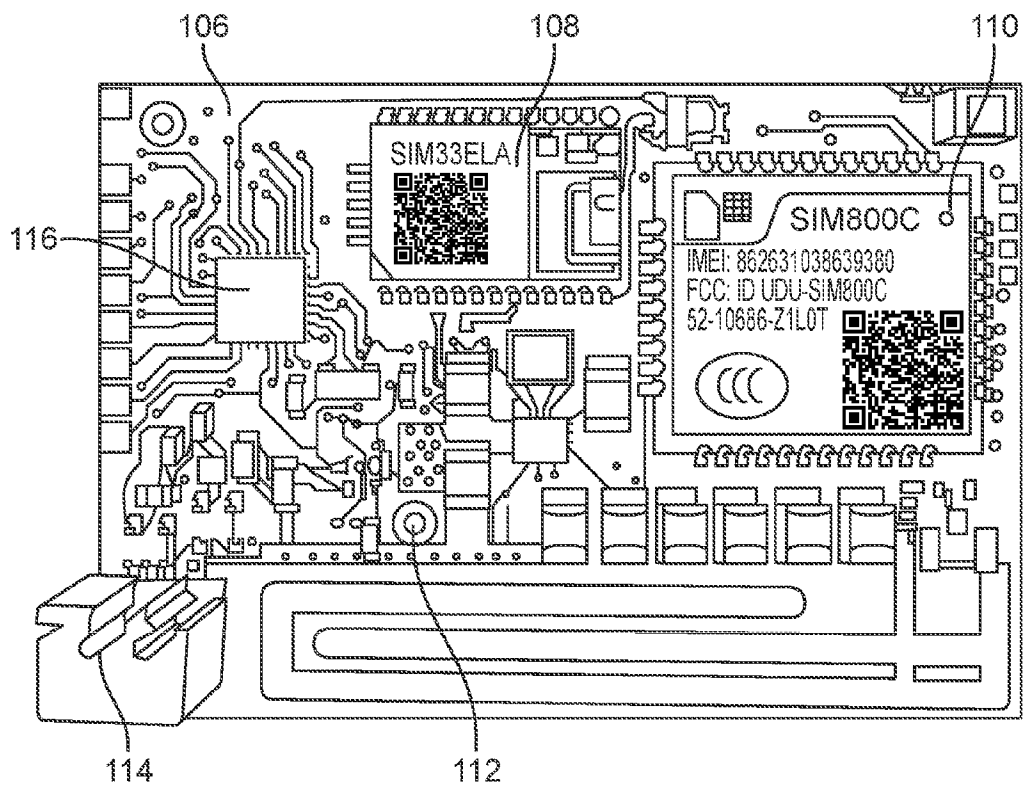


FIG. 14A

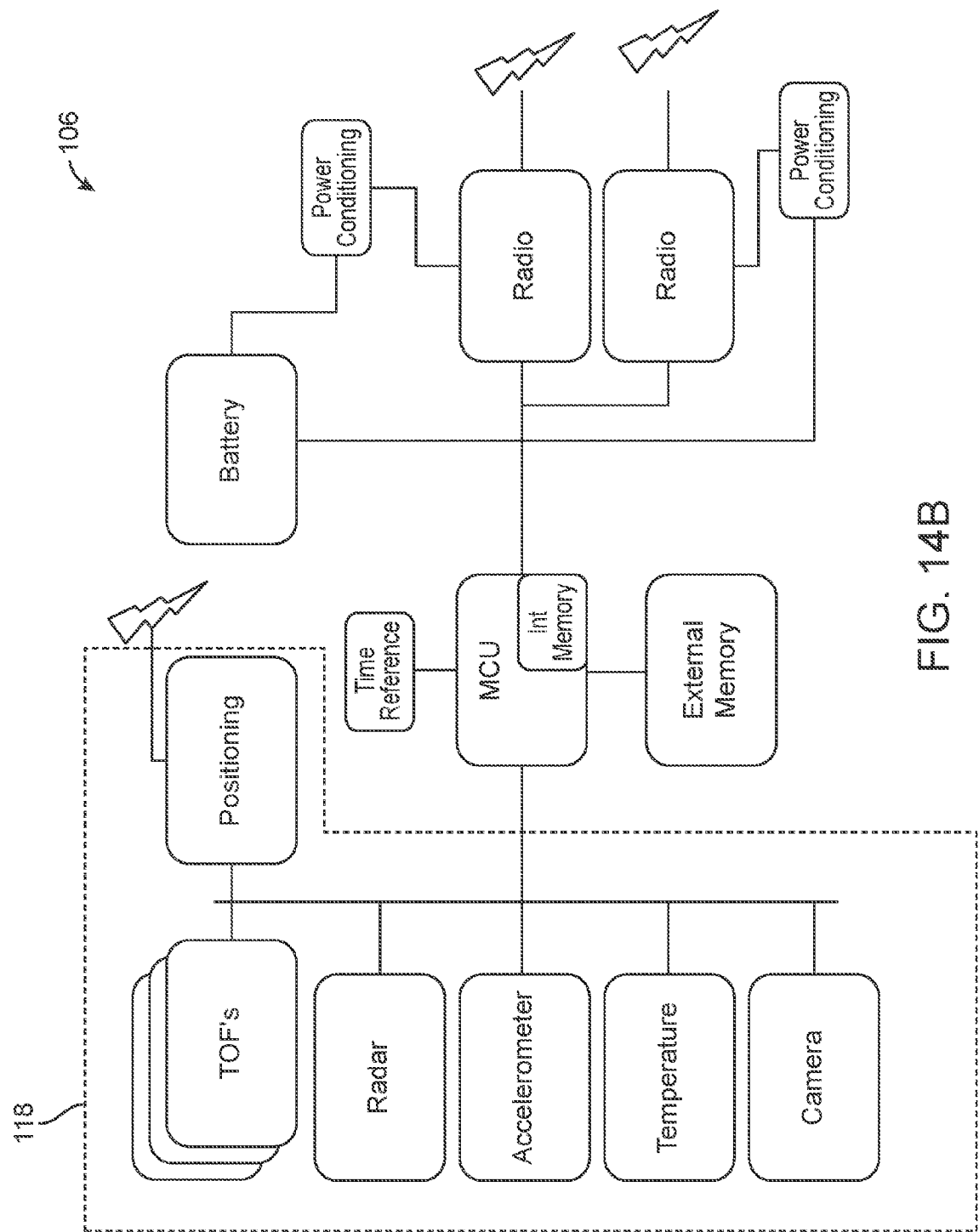


FIG. 14B

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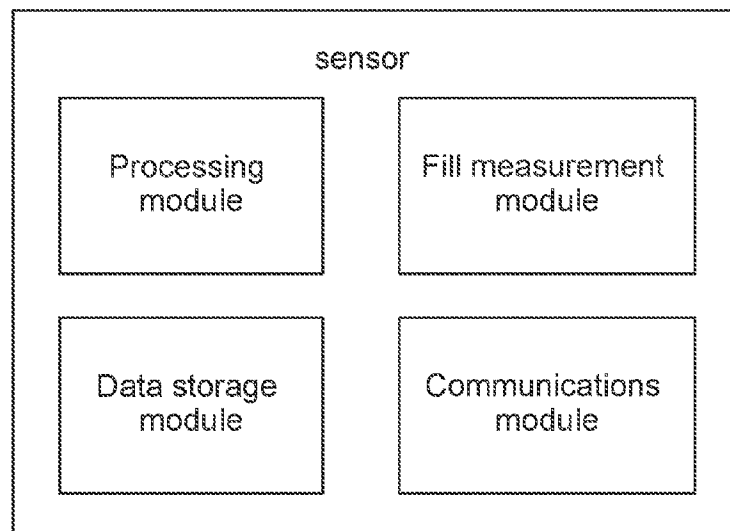


FIG. 15

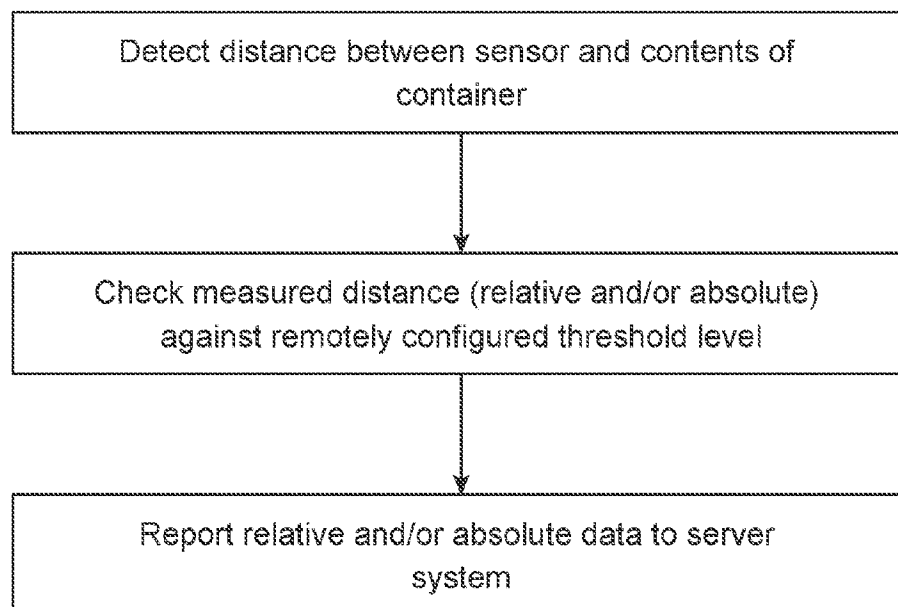


FIG. 16

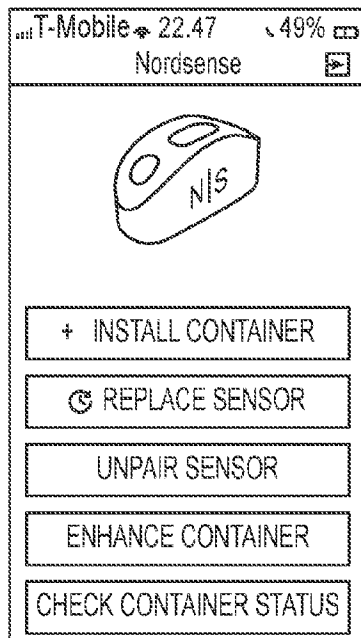


FIG. 17A

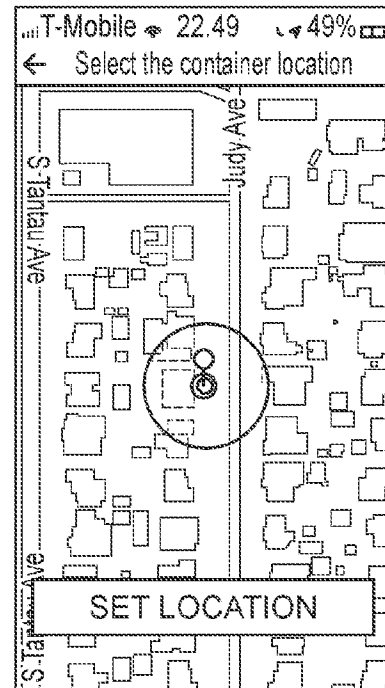


FIG. 17B

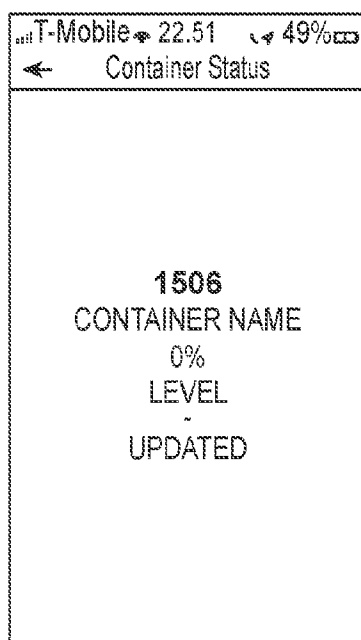


FIG. 17C

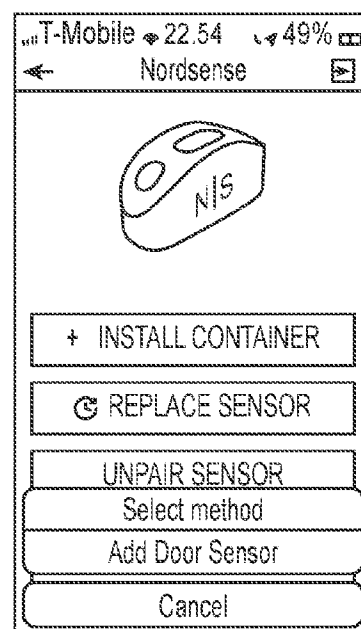
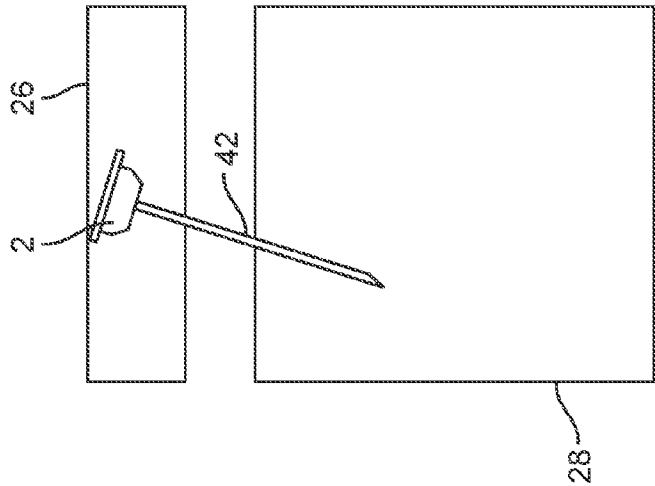


FIG. 17E



Sensor location		Sensor Angle	
TOP	SIDE	17	3°

Capacity Height		Device Offset	
90	3 cm	0	3 cm
?		?	

Volume		Width	
600	3 L		3 cm
Optional		Optional	

FIG. 17D

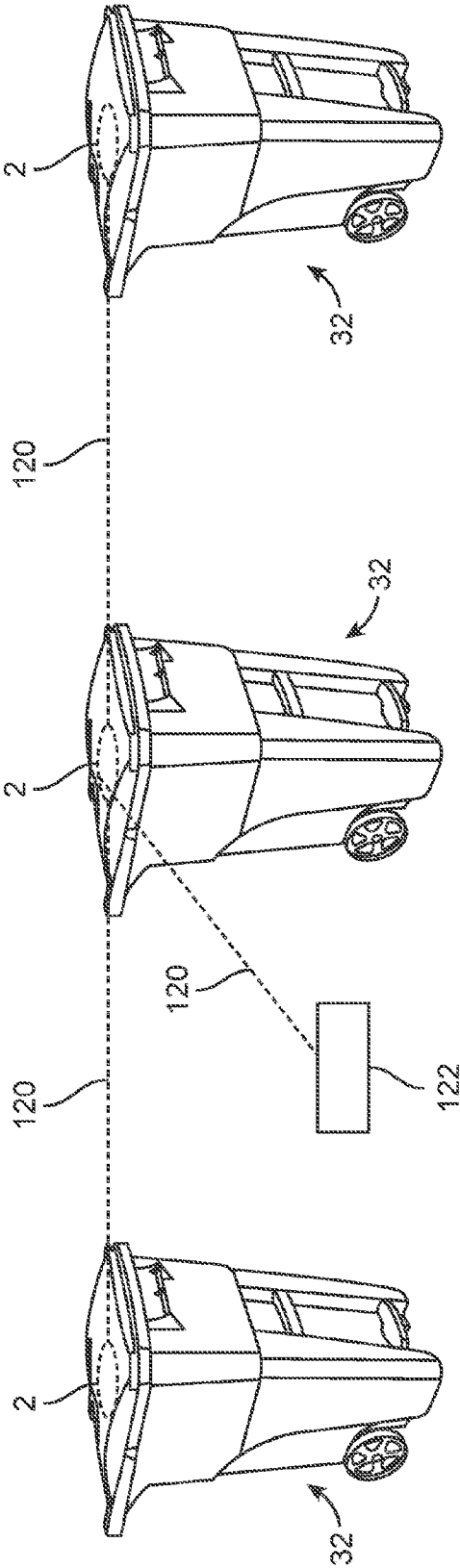


FIG. 18



FIG. 19

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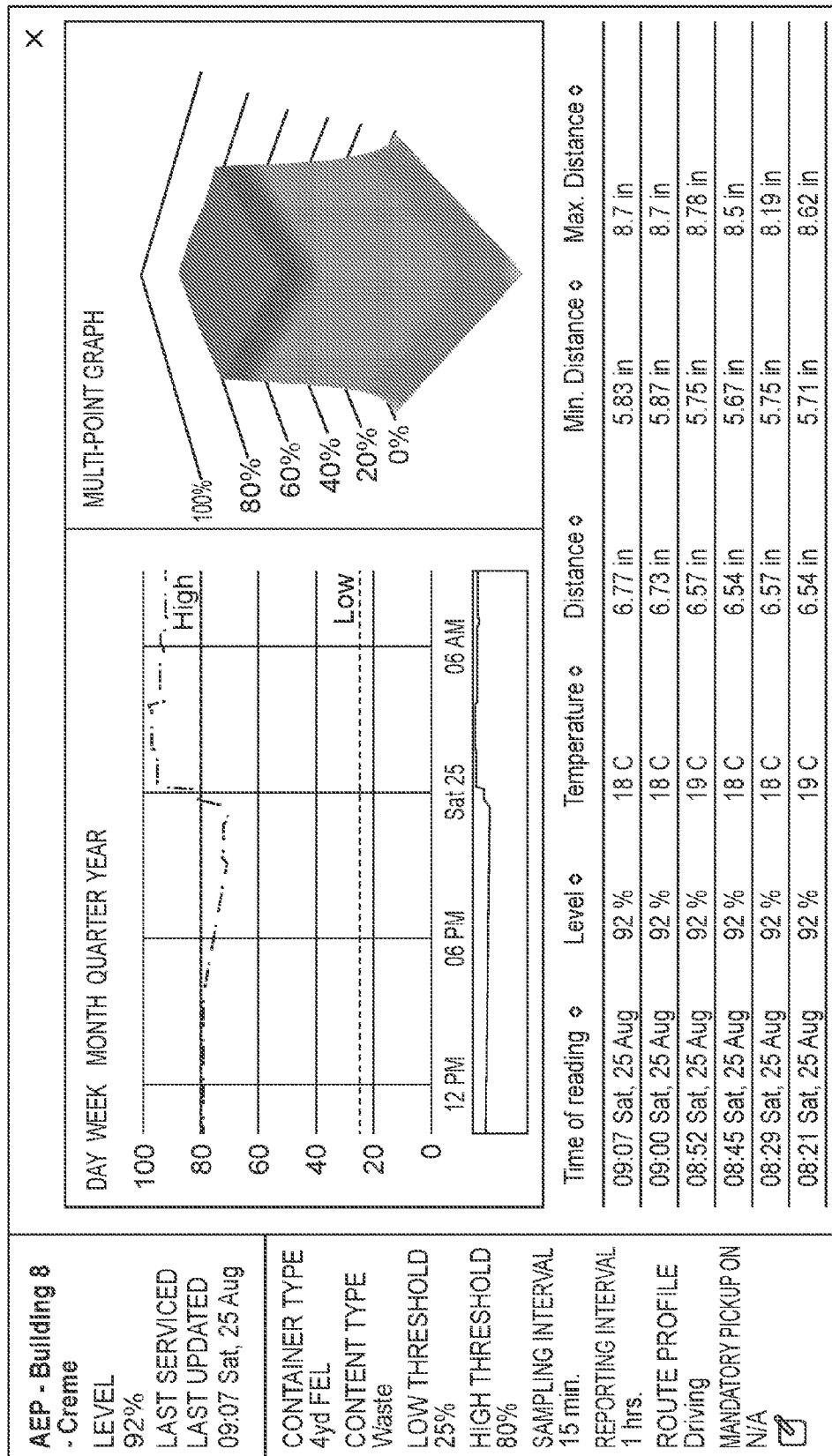


FIG. 20

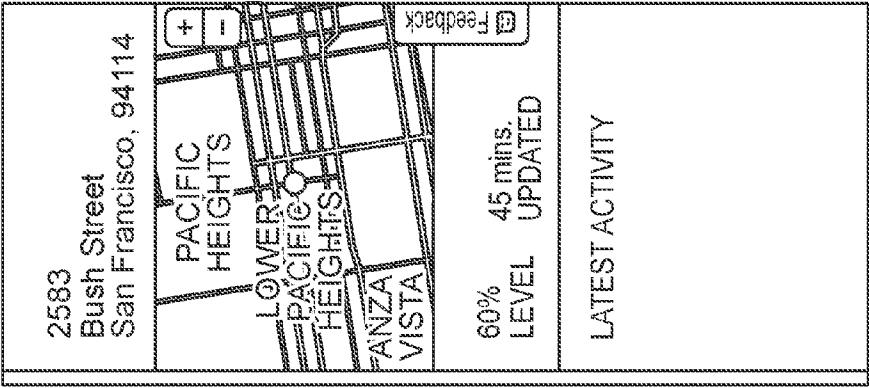


FIG. 22

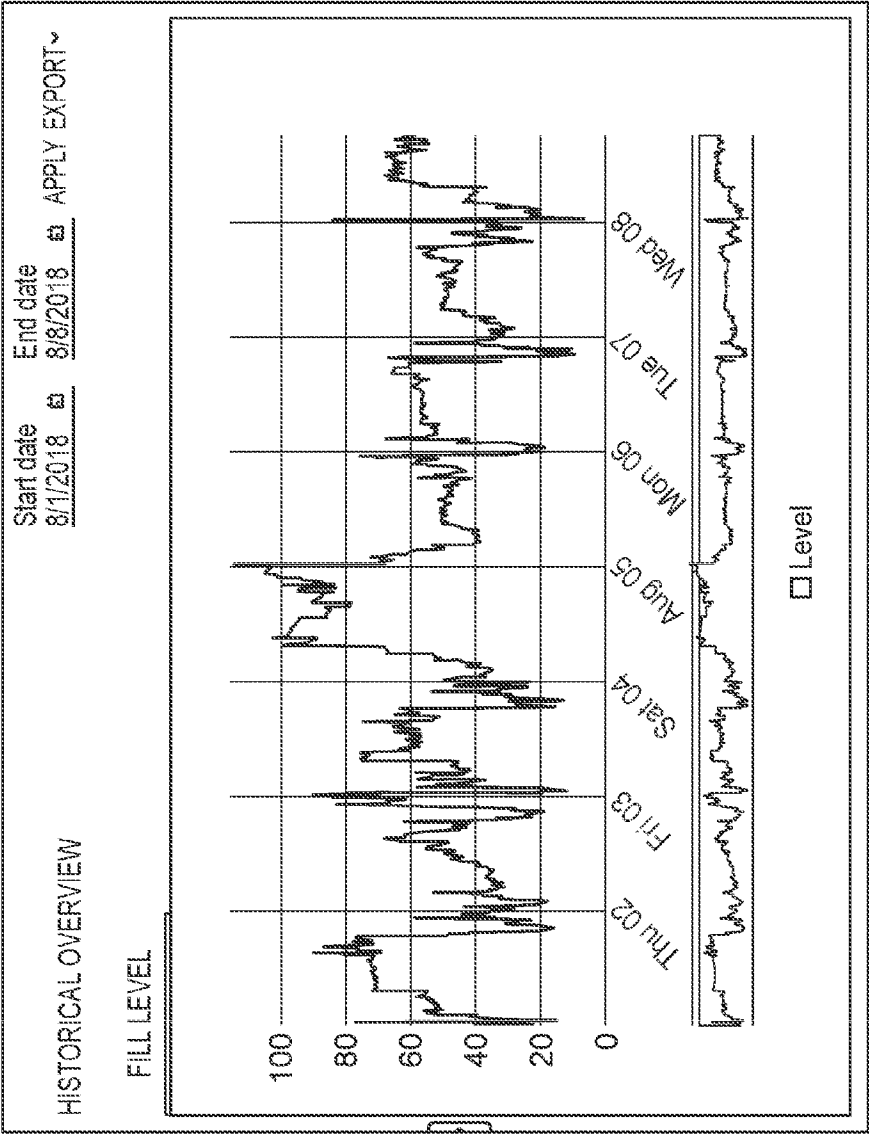


FIG. 21

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FIG. 23

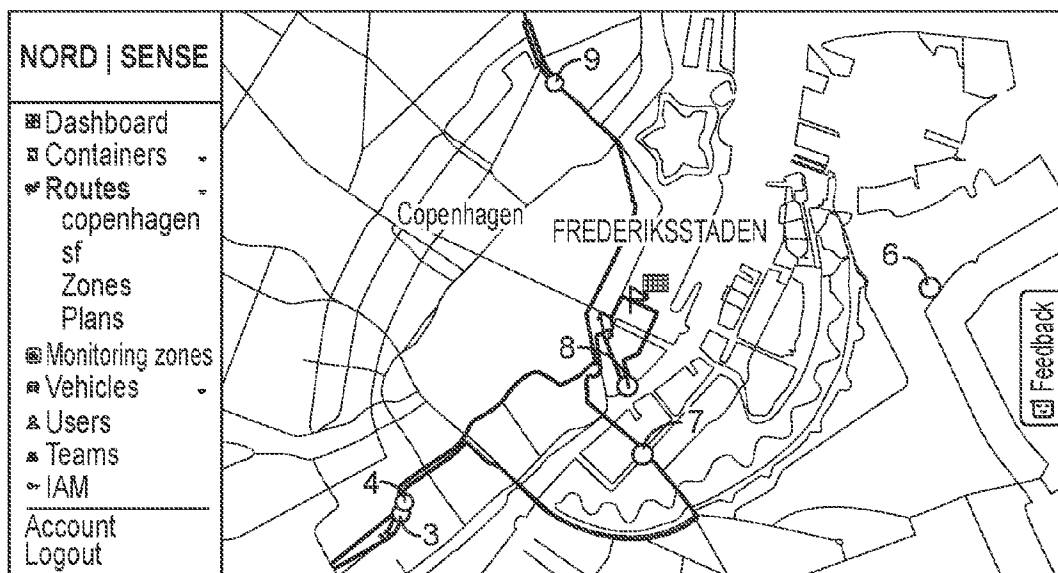
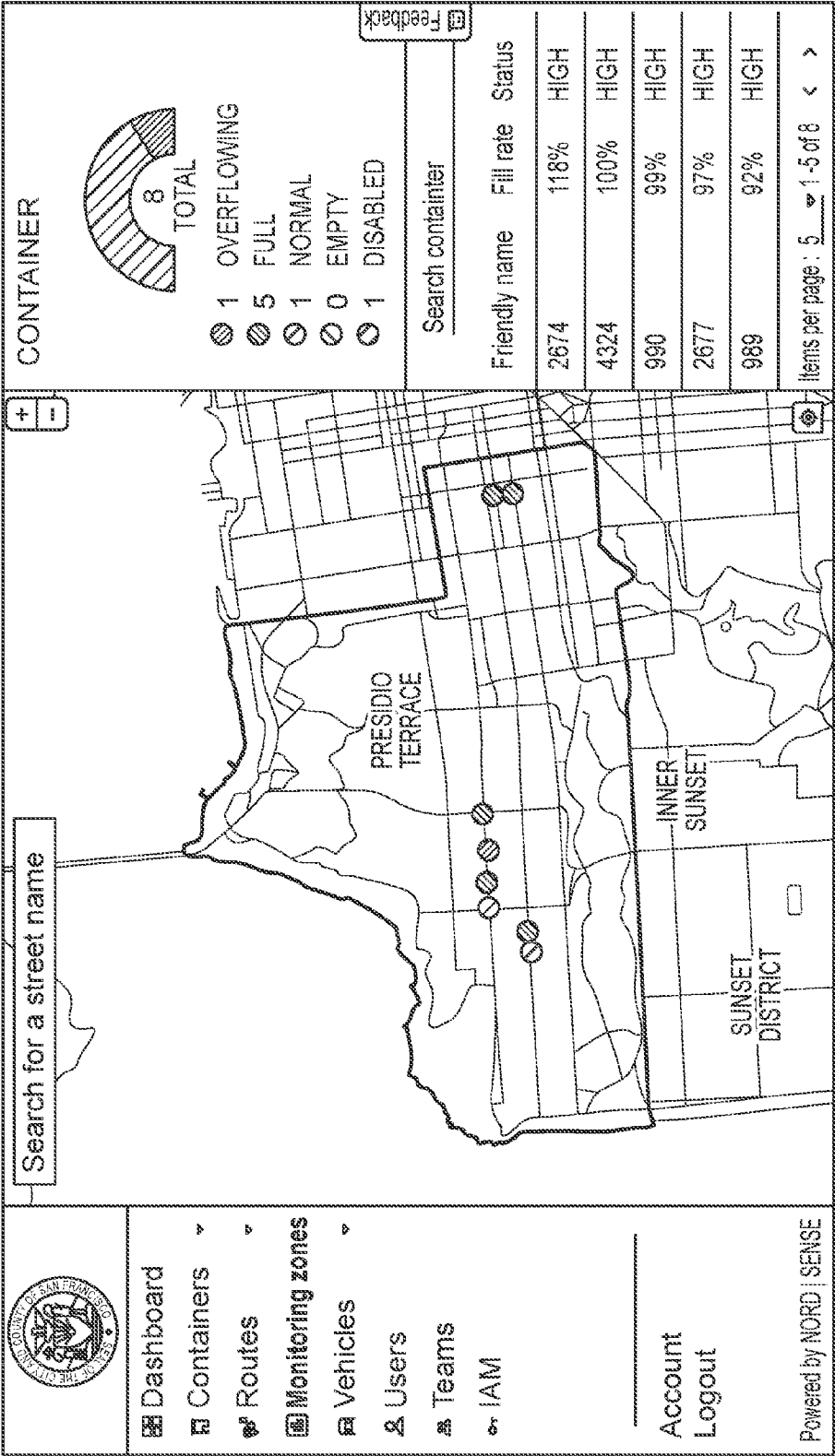


FIG. 24



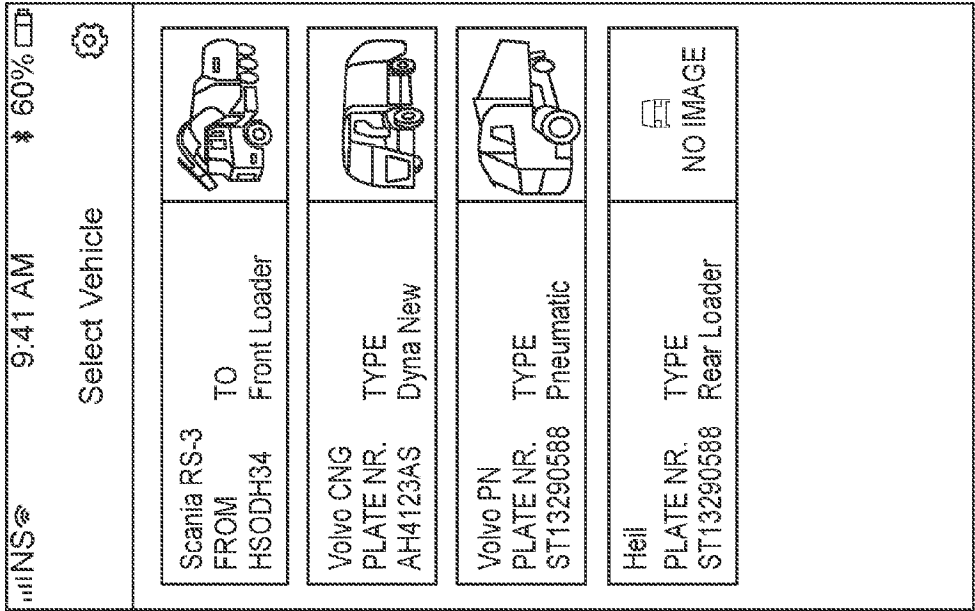


FIG. 26A

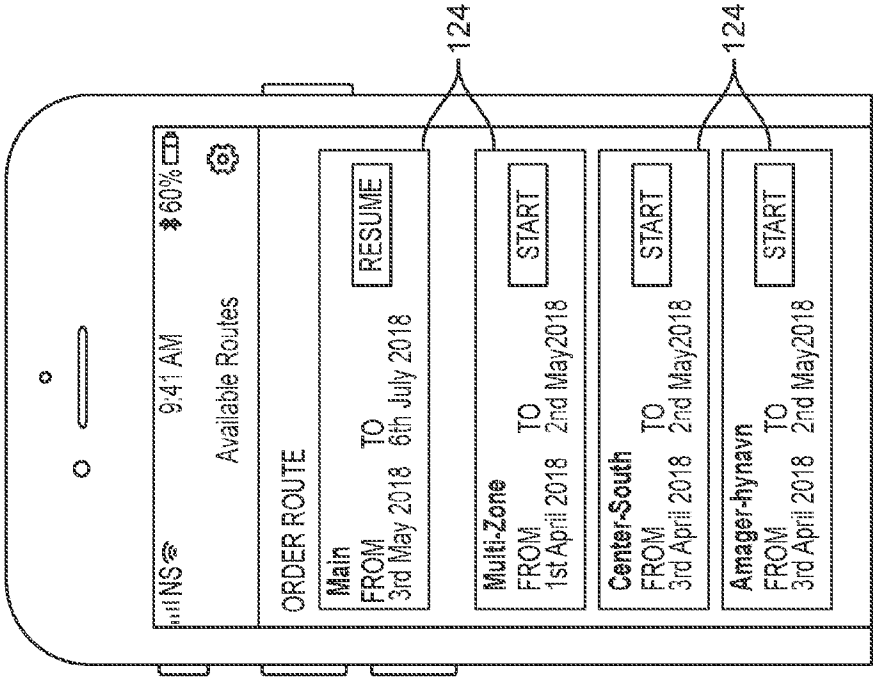


FIG. 26B

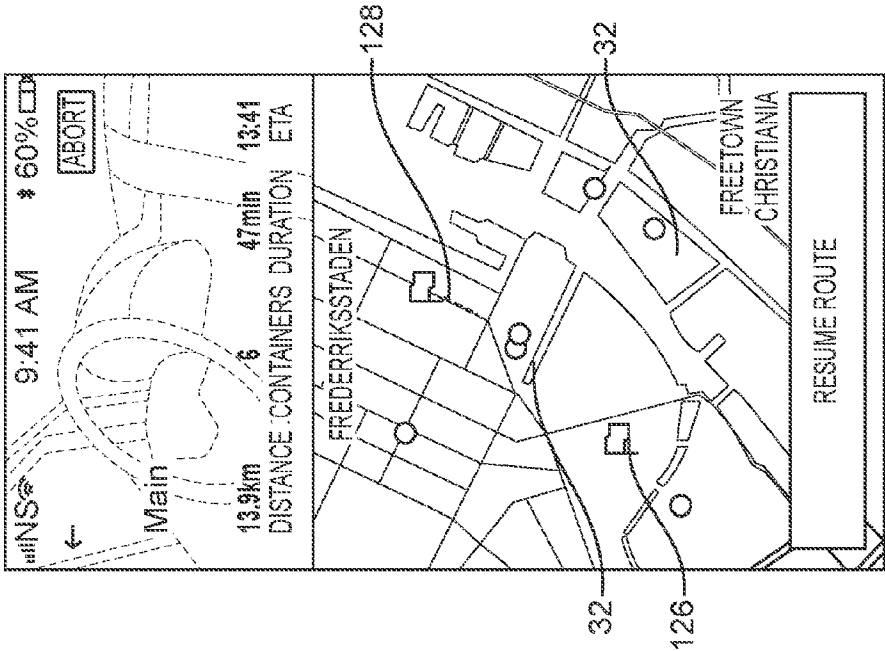


FIG. 26C

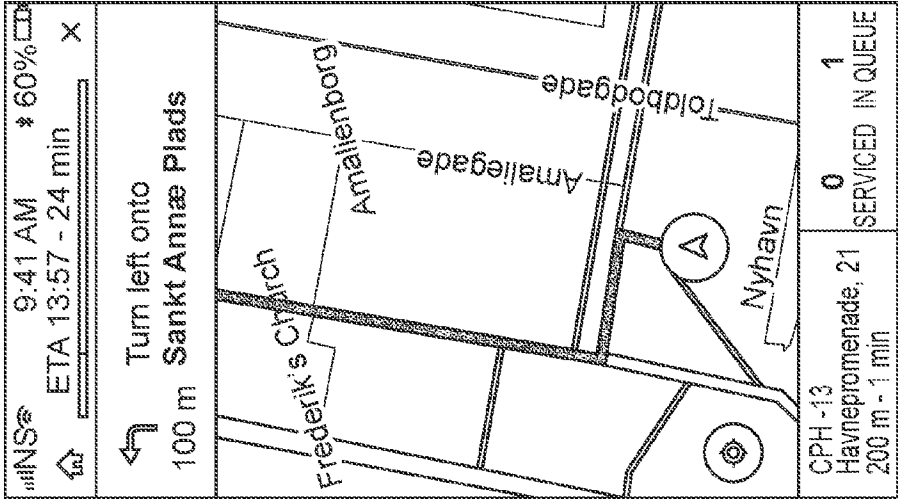


FIG. 26D

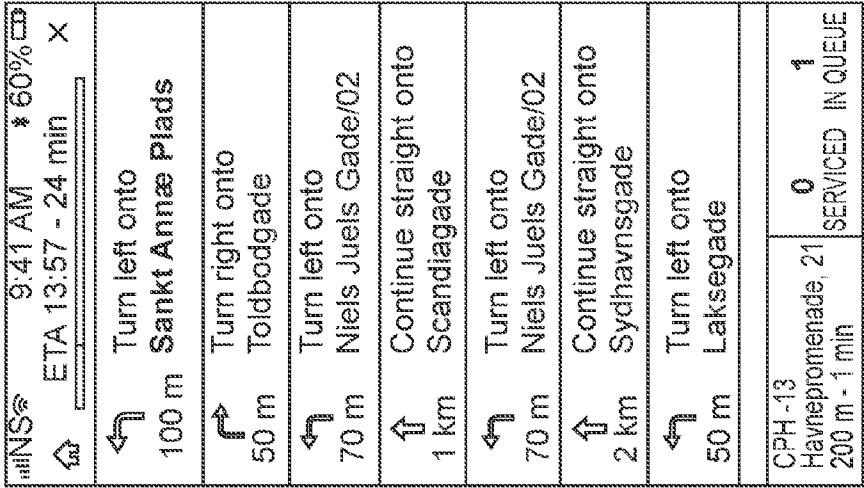


FIG. 26E

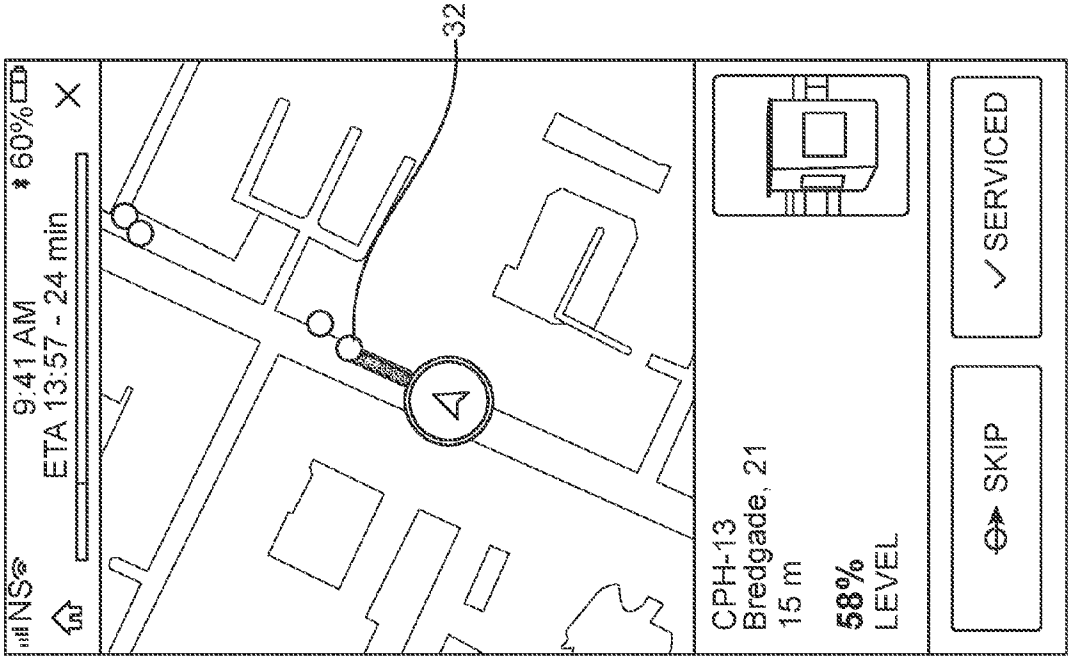


FIG. 26G

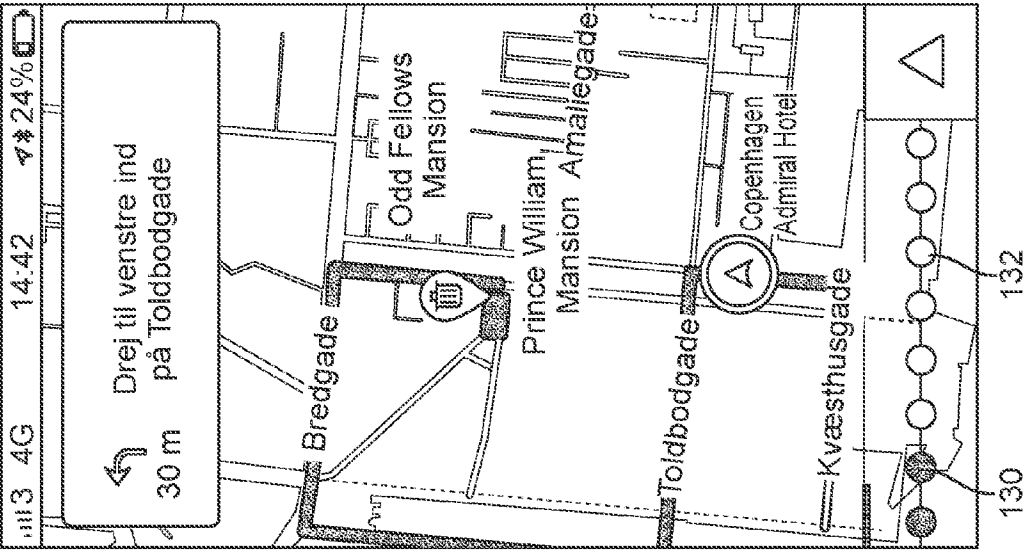


FIG. 26F

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 kopenhavns kommune Dashboard Containers Routes Zones Plans Restrictions Locations Users Teams Vehicles or IAM	Routes			UPCOMING ROUTES		COMPLETED ROUTES	
	ACTIVE ROUTES						
	 3 ROUTES	 25/87 DONE	 154 / 332km KM. DRIVER	 52 USD TOTAL FUEL COST	 2 ALERTS		
	Search route...						
	Route Name Driver Vehicle Started at Est. end						
	Daily Plastic Route Franek Volvo 54-9888-22 May 19th 2018 06:32 13:54 May 19th 2018						
	Glass Weekend Marcin Scania 13-2905-88 May 19th 2018 08:29 10:15 May 19th 2018						
	Center-South Piotr VolvoSx 91-9888-22 May 19th 2018 14:11 19:44 May 19th 2018						
	Glass weekend CURRENT LOCATION Nerre Farinasgade 70, 1364 SERVICED SKIPPED IN QUEUE DISTANCE PASSED TO GO 4 2 8 5 km 17 km						
	MAP CONTAINERS ALERTS						
Container Location Fill Level Service time Netanya-13 David Levi 21 94% 10:36 Netanya-54 Alif Baraam 12 48% 10:45 Netanya-74 Yizhak Rabin 234 11% 10:57 Netanya-75 Yizhak Rabin 234 9% 10:57 Netanya-101 Dana International 46 95% 11:12 Netanya-103 Dana International 46 91% 11:14 TO BE SERVICED Netanya-102 Dana International 46 76% 11:17 Netanya-21 Tzivika Pique 87 100% 11:36 Netanya-26 Tzivika Pique 96 97% 11:41							

FIG. 26H

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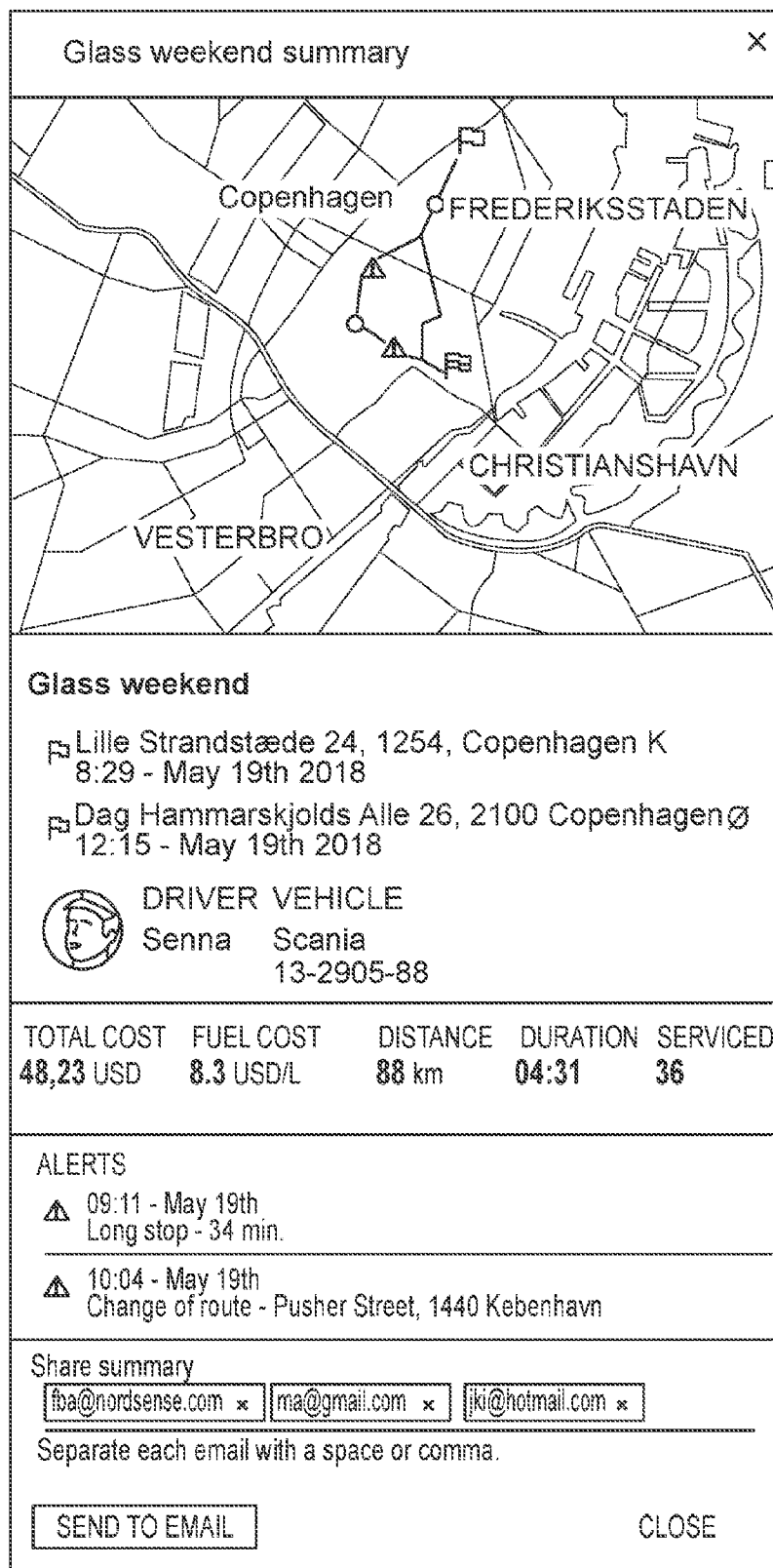


FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/048194

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G01C 21/34; G01C 21/20; G01C 21/36; G07B 15/02 (2018.01)

CPC - G01C 21/343; G01C 21/34; G01C 21/3407; G01C 21/3415; G01G 23/3728; G06Q 10/087 (2018.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

USPC - 701/23; 701/24; 701/25; 701/26; 705/13 (keyword delimited)

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	US 2015/0294431 A1 (FIORUCCI et al) 15 October 2015 (15.10.2015) entire document	1-3, 7 ---
Y		4, 8, 9
Y	US 2011/0061762 A1 (MADSEN et al) 17 March 2011 (17.03.2011) entire document	4, 31-33
Y	US 2016/0176630 A1 (ZAN COMPUTE INC.) 23 June 2016 (23.06.2016) entire document	8, 9, 19-21, 31-33
Y	US 2016/0300297 A1 (ENEVO OY) 13 October 2016 (13.10.2016) entire document	19-21
A	US 2013/0286783 A1 (SUSSMAN et al) 31 October 2013 (31.10.2013) entire document	1-4, 7-9, 19-21, 31-33

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 October 2018

Date of mailing of the international search report

05 NOV 2018

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Blaine R. Copenheaver

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/048194

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 5, 6, 10-18, 22-30, 34, 35
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.