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— as to applicant's entitlement to apply for and be granted
a patent (Rule 4.17(ii))— as to the applicant's entitlement to claim the priority of
the earlier application (Rule 4.17(iii))

[Continued on next page]

(54) Title: AUTONOMOUS SKIMMING SYSTEM AND METHOD

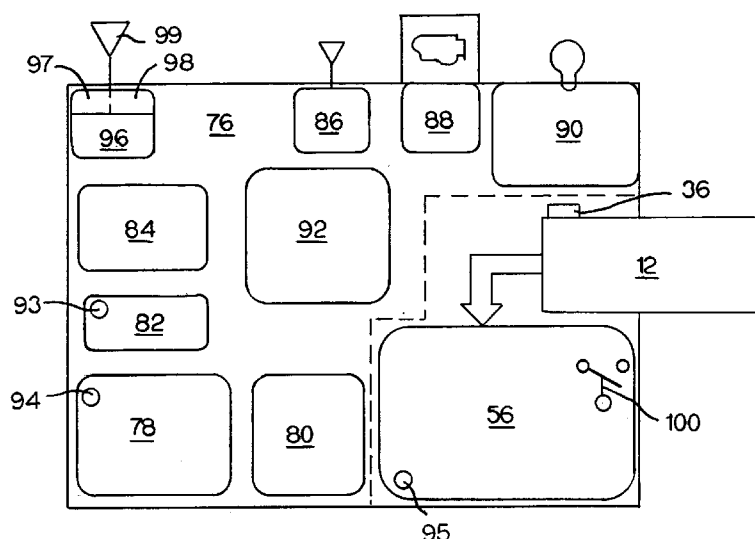


FIG. 2

(57) Abstract: A skimming system and method for remotely tracking and operating a fleet of autonomous skimmers from a single remote command center. The skimmers are deployed over a wide area, each gathering oil or other floating contaminants or debris into a holding tank. Control and command signals are transmitted to the skimmers and status and operating conditions are received from the skimmers over a wireless communication link between each skimmer and the command center. GPS receivers in the skimmers report the geodetic locations of the skimmers so that they can be located for contaminant recovery or re-deployment in a different location.

Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

Autonomous Skimming System and Method

BACKGROUND

The invention relates generally to skimming systems and more particularly to autonomous oil skimmers that can be operated remotely from a single command center.

Oil skimmers are used to clean up oil spills by skimming oil floating at the surface of a body of water and collecting the skimmed oil in a reservoir for disposal or processing. Belt conveyors extending into the water are often used to catch the oil and convey it to a reservoir. Typically, the skimmers are affixed to or deployed from a powered vessel, such as a boat. Consequently, the skimmers' range is limited to the immediate vicinity of the boat.

SUMMARY

This shortcoming is overcome by a skimming system embodying features of the invention. Such a system for skimming oil or other contaminants from a body of water comprises a plurality of skimmers, each including a floating platform, on which are mounted a holding tank and a collector arranged to gather contaminants from a body of water and deposit the gathered contaminants in the holding tank. A positioning system receiver on the platform determines its geodetic location. A wireless communication system on the platform includes a transmitter transmitting data, including the geodetic location. A remote command center communicates with the skimmers over the wireless communication system and processes the data. A fleet of these skimmers can be deployed at different locations and maintained in regular communication with the remote command center.

In another aspect of the invention, a method for skimming oil or other contaminants from a body of water comprises: (a) towing a plurality of autonomous skimmers through water to different locations for deployment over a wide area, wherein each skimmer includes a wireless communication system; (b) gathering contaminants in the water with the skimmers; (c) locally determining the geodetic location of each skimmer; (d) transmitting the geodetic location of each skimmer to a remote command center over the wireless communication system; and (e) tracking the location of each skimmer at the remote command center.

BRIEF DESCRIPTION OF THE DRAWINGS

These features and aspects of the invention, as well as its advantages, are better understood by referring to the following description, appended claims, and accompanying drawings, in which:

FIG. 1 is an isometric view of an autonomous floating oil skimmer embodying features of the invention;

FIG. 2 is a block diagram of the oil skimmer of FIG. 1; and

FIG. 3 is a block diagram of a deployment of oil skimmers as in FIG. 1 under the control of a remote command center.

DETAILED DESCRIPTION

A floating skimmer embodying features of the invention is shown in FIG. 1. The skimmer 10 includes an inclined belt conveyor 12 having a conveyor belt 14 advancing along an inclined upper run 16 from a lower end 18 of the conveyor to an upper end 19. The conveyor belt returns along a return run on the bottom side of the skimmer. The conveyor 12 is mounted in a frame that includes on the outer sides 20, 21 of the conveyor two lower posts 22 near the lower end of the conveyor and two upper posts 23 near the upper end. Cross-braces 24 connect between top ends 26, 27 of the lower posts and the upper posts for stability. Floats, such as pontoons 28, are also mounted to the posts near their bottom ends 30. The pontoons shown are in the form of hexagonal tubes. The floats and other frame elements can be made of lightweight aluminum for easier handling and constitute a floating platform for the conveyor, the tank, and other equipment. The skimmer is used to collect oil or other contaminants suspended or floating in a body of water.

The endless conveyor belt 14 is trained around a rotating drive element 36 at the upper end 19 of the conveyor 12 and a reversing element 38 at the lower end 18. The drive element is realized in this example as a set of sprockets or pulleys mounted on a shaft whose ends are supported in bearing blocks 43 mounted to the side frames 20, 21 of the conveyor. A motor, such as a hydraulic motor or an electric motor, is coupled to the shaft by a gearbox. Teeth on the sprockets engage structure in the inner side of the conveyor belt to positively drive it in a direction of belt travel 48 up the incline on the top run 16. A modular plastic conveyor belt, which has inner-side drive structure that allows it to be positively driven, is

preferable to a flat belt, which is friction driven and may tend to slip in an oily environment. One example of a lightweight modular plastic conveyor belt that could be used is the INTRALOX® Series 1600 Open Hinge Flat Top belt manufactured and sold by Intralox, L.L.C. of Harahan, Louisiana 70123. The reversing element 38 at the lower end is realized in this example as a set of idle rollers rotatably mounted on a fixed shaft spanning the width of the conveyor 12.

A holding tank 56 is attached to the conveyor frame by a pair of short posts 58. The trough is positioned below the upper end 19 of the top run 16 of the conveyor so that oil 60 or other contaminants or debris gathered at the submerged lower end 18 of the conveyor and riding on or adhering to the outer surface of the belt drops into the tank 56 from the belt as it rounds the rotating drive element, as indicated by arrow 61. The bottom 68 of the tank provides a bow that allows high-speed towing of the skimmer by boat to another location.

The top ends of the posts 22, 23 are topped with flat plates 70, 71 for seating the bottoms of the corresponding posts of another skimmer. In this way, skimmers can be stacked one atop the other for convenience during storage or out-of-water transit. Pins 72 upstanding from the longer posts 22, 23 restrict the lateral motion of the stacked skimmers to prevent their posts from accidentally disengaging. A plate 74 supported by the short posts 58 and the upper long posts 23 serves as a mount for the devices and equipment generally indicated by reference number 76 and depicted further in FIG. 2. The skimmer depicted in FIG. 1 and described in detail is just one example of a suitable skimmer that can be operated autonomously. Other skimmers that have a collector, such as the belt conveyor 12 of FIG. 1, and a holding tank can be used as well.

FIG. 2 shows other skimmer equipment and devices 76, in addition to the belt conveyor 12 and the holding tank 56, used to make the skimmer capable of autonomous operation. A main power source 78, including, for example, a generator or a battery, supplies power to the skimmer. If the main power source includes a generator, it may also include a backup battery. A solar cell 80 charges the battery, whether used as the main power source or as the backup to a generator, during daylight hours. If a generator is used, a fuel tank 82 on the platform is provided. A hydraulic power pack 84, powered by the main power source 78, drives a hydraulic motor coupled to the drive element 36 of the belt conveyor 12. A positioning receiver 86, such as a GPS receiver unit and antenna, determines

the geodetic location of the skimmer. A video camera 88 mounted on the skimmer provides video data of the skimmer and its surroundings. A navigation light 90 warns other vessels of the presence of the skimmer at night. A processor 92 on board the skimmer collects geodetic location data from the GPS receiver 86, video data from the camera 88, and sensor data from sensors associated with various equipment and devices on board the skimmer. Examples of sensors include a fuel level sensor 93 in the fuel tank 82, a voltage or current sensor or sensors 94 at the generator or battery, and a contaminant-level sensor 95 in the holding tank 56. The processor 92 reports the sensor, video, and geodetic information to a remote command center over a wireless radio link with an on-board communication system 96 that includes a transmitter 97, a receiver 98, and an antenna 99. The processor can also analyze the sensor data to flag alarm conditions and report them to the remote command center. The processor can also use the sensor data to compute various operating conditions, such as by using the contaminant-level sensor data to compute the contaminant-collection rate and report it remotely. The processor can also shut off skimmer equipment in the event of problems. For example, the processor can stop the belt conveyor when the contaminant-level sensor indicates that the holding tank is close to full or operate the skimmer equipment in an energy-conserving manner during generator outages or when the fuel level drops below a minimum level by shedding load in a hierarchical manner from least critical to most critical. As a fail-safe, the contaminant holding tank 56 includes a float switch 100 that is wired to shut off the contaminant-collecting belt conveyor 12 when the contaminant level in the tank exceeds a predetermined level.

As shown in FIG. 3, a fleet of autonomous skimmers 10A, 10B, 10C, ..., 10N can be towed to various locations and then moored, anchored, towed through, or otherwise deployed over a large area—even out of each other's sight—to skim contaminants 60 in the water. A remote command center 102 includes a communications base station 104 that communicates with all the skimmers over the wireless link. A video map 106 of the deployment area pinpoints the location of each skimmer from the GPS positioning data. Besides monitoring and displaying all the status information transmitted from the skimmers, the command center can transmit command and control signals over the wireless link to each skimmer's radio receiver 98 to request information from the processor 92, to set alarm levels and other operating parameters, and to control skimmer processes, such as

camera direction and conveyor speed and start-stop. Thus, the skimming system 108 depicted in FIG. 3 allows an entire fleet of skimmers to be deployed and tracked over a wide area and tended by one operator stationed at a single remote command center. The operator may also use the data received from the skimmers to schedule and efficiently deploy

5 maintenance crews to empty the contaminant holding tanks, supply additional fuel, conduct repairs, and otherwise tend to the skimmers.

What is claimed is:

CLAIMS

1. A skimming system for skimming oil or other contaminants from a body of water, comprising:

a fleet of skimmers, each including:

- 5 a floating platform;
- a holding tank disposed on the platform;
- a collector arranged on the platform to gather contaminants from a body of water and deposit the gathered contaminants in the holding tank;
- a positioning system receiver on the platform determining its geodetic location;
- 10 a wireless communication system on the platform having a transmitter transmitting data, including the geodetic location; and
- a remote command center communicating with the skimmers over the wireless communication system and processing the data.

2. A skimming system as in claim 1 wherein each skimmer further includes a video camera
15 mounted on the platform.

3. A skimming system as in claim 1 wherein the wireless communication system further includes a receiver receiving command and control signals from the remote command center.

4. A skimming system as in claim 1 wherein each skimmer further includes a contaminant-
20 level sensor sensing the contaminant level in the oil holding tank.

5. A skimming system as in claim 4 wherein the contaminant-level sensor comprises a float switch in the holding tank operative to stop the collector from gathering contaminants when the contaminant level in the holding tank exceeds a predetermined level.

6. A skimming system as in claim 1 wherein each skimmer further includes a processor and
25 a plurality of sensors on the platform sensing local conditions and sending signals representing the local conditions to the processor, wherein the processor converts the signals into the data transmitted by the transmitter.

7. A skimming system as in claim 6 wherein the sensors include at least one of the following:

- 30 a contaminant-level sensor in the holding tank;
- a video camera on the platform;

a voltage sensor on a power source on the platform;
a current sensor on a power source on the platform; and
a fuel-level sensor in a fuel tank on the platform.

8. A skimming system as in claim 1 wherein each skimmer further includes a battery for
5 power and a solar cell connected to the battery to charge the battery.
9. A skimming system as in claim 1 wherein the positioning system receiver in each
skimmer is a GPS receiver.
10. A skimming system as in claim 1 wherein the remote command center includes a display
showing the locations of the skimmers on a map.
- 10 11. A method for skimming oil or other contaminants from a body of water, comprising:
towing a plurality of autonomous skimmers through water to different locations for
deployment over a wide area, wherein each skimmer includes a wireless
communication system;
gathering contaminants in the water with the skimmers;
15 locally determining the geodetic location of each skimmer;
transmitting the geodetic location of each skimmer to a remote command center over the
wireless communication system;
tracking the location of each skimmer at the remote command center.
12. The method of claim 11 further comprising displaying the locations of each of the
20 skimmers on a map.
13. The method of claim 11 further comprising locally sensing operating conditions in each
of the skimmers and transmitting the operating conditions to the remote command
center over the wireless communication system.
14. The method of claim 12 further comprising transmitting command and control signals
25 from the remote command center to each skimmer over the wireless communication
system to remotely control the operation of the skimmers.
15. The method of claim 11 further comprising towing the autonomous skimmers through
the water while gathering contaminants.

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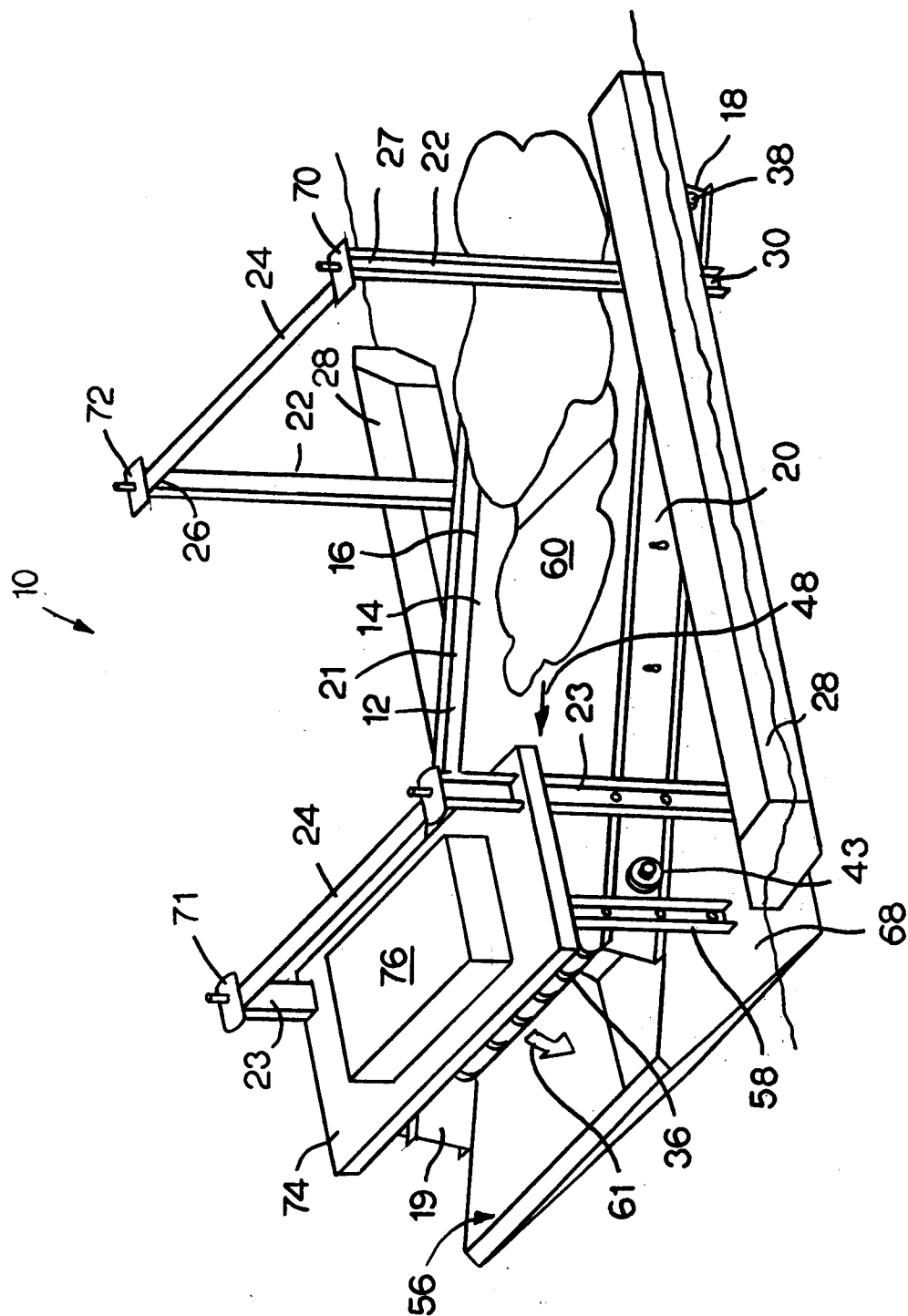


FIG. 1

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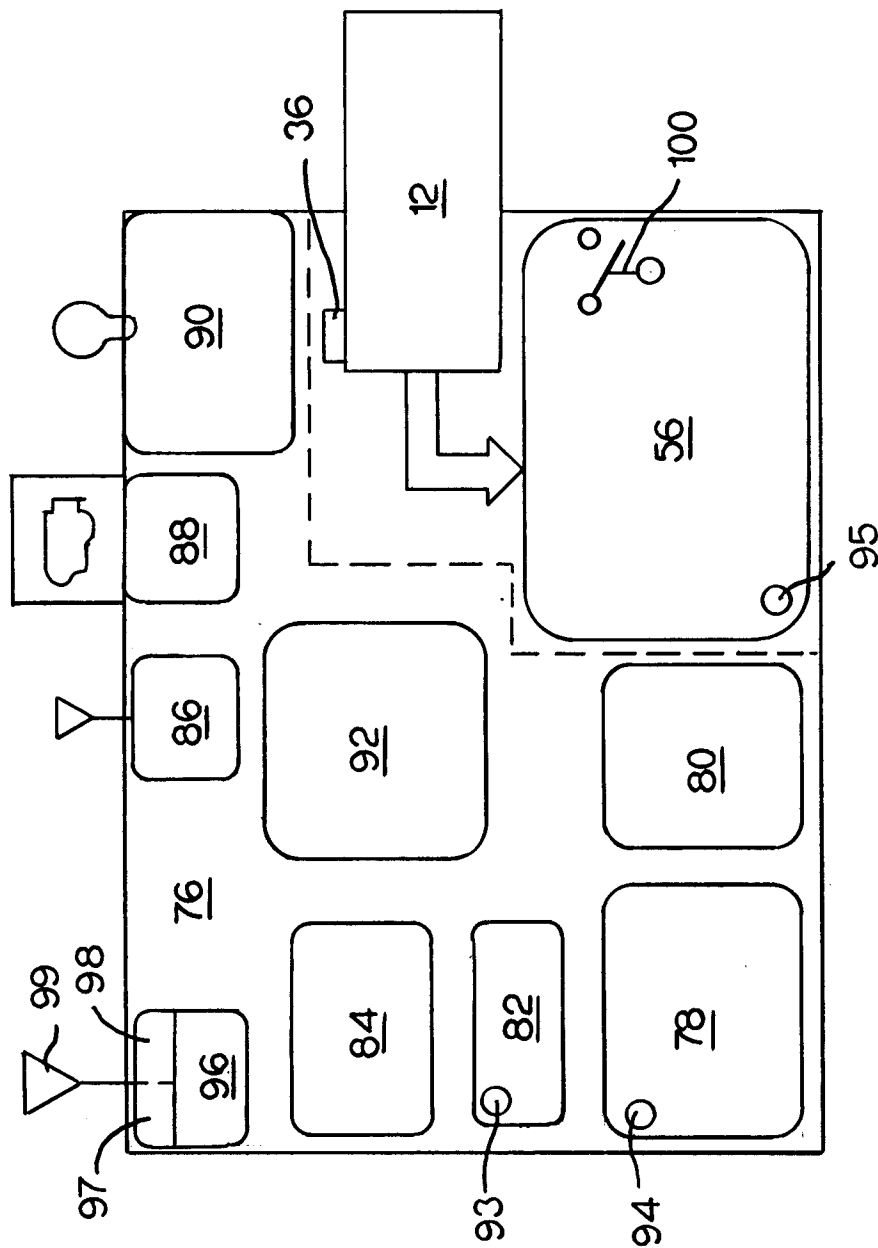


FIG. 2

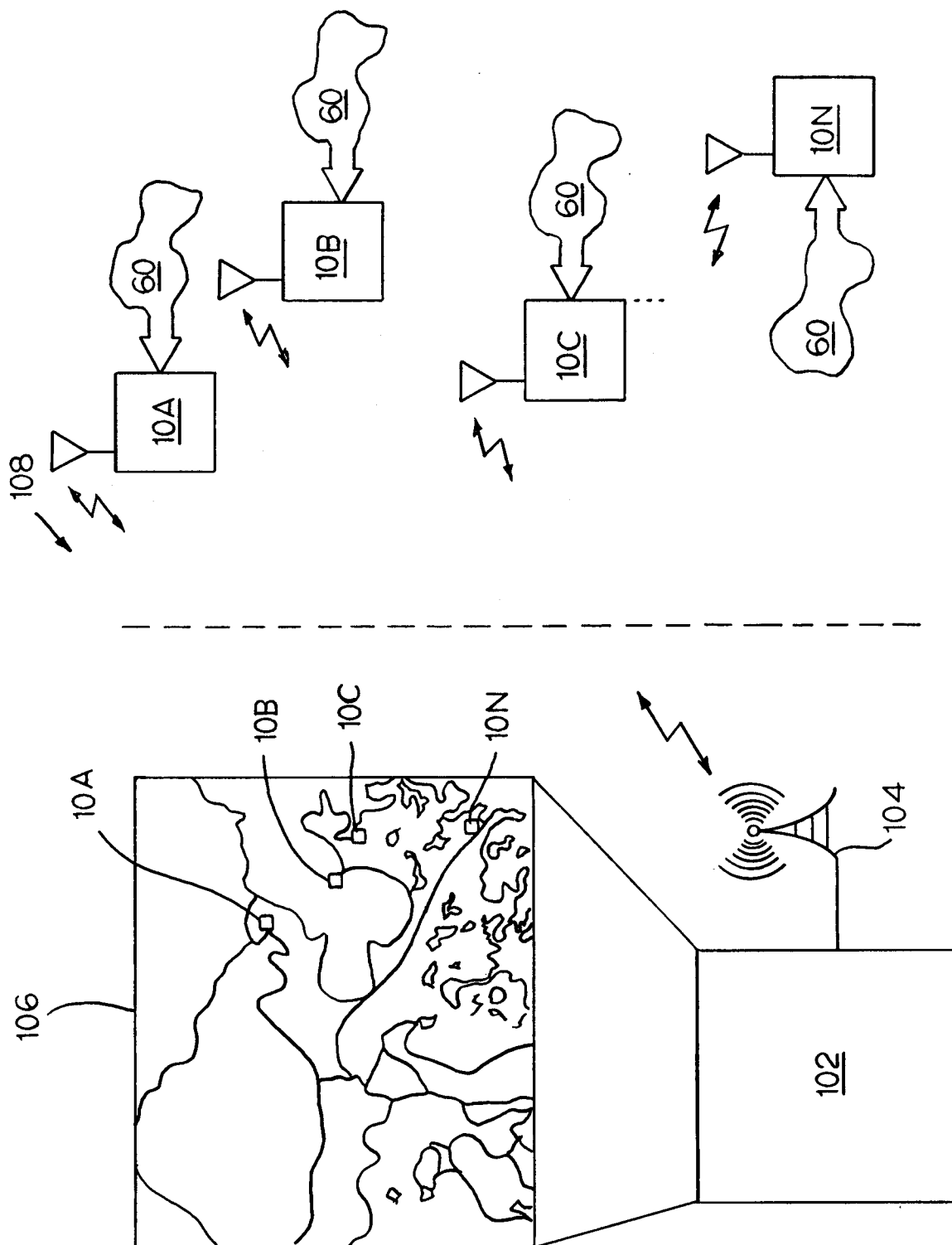


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/59561

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B63B 35/00; E02B 15/04 (2012.01)

USPC - 210/242.3; 210/242.4; 114/382; 114/144A

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)

IPC(8): B63B 35/00; E02B 15/04 (2012.01); USPC:

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 210/242.3; 210/242.4; 114/382; 114/144A

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

Google Scholar, Google Patents, PubWEST (PGPB,USPT,EPAB,JPAB)

Search terms used - Skimmer, oil, water, collect, contaminant, float, tank, camera, wireless, transmitter, communicate, receiver, GPS, video, camera, fuel, sensor, display, monitor, battery, solar, pollutants, waste, current, voltage, level, gauge s

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,269,763 B1 (WOODLAND) 07 August 2001 (07.08.2001), Fig 10D, 36; col 8, ln 7-9, ln 60-67; col 9, ln 9-15, ln 30-36; col 11, ln 25-29, ln 43-52; col 13, ln 53-59; col 14, ln 15-17; col 17, ln 48-56; col 19, ln 59-66	1-15
Y	US 2009/0194472 A1 (JACK, et al.) 06 Aug 2009 (06.08.2009), para [0031]-[0036]	1-15

☐ Further documents are listed in the continuation of Box C.

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"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

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