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Sorden et al.

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[54] **EVENT-ACTIVATED REPORTING OF VEHICLE LOCATION**

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[51] **Int. Cl.**[5] **G01S 3/02**

[52] **U.S. Cl.** **342/457**; 342/357

[58] **Field of Search** 342/457, 50, 357

[56] **References Cited**

U.S. PATENT DOCUMENTS

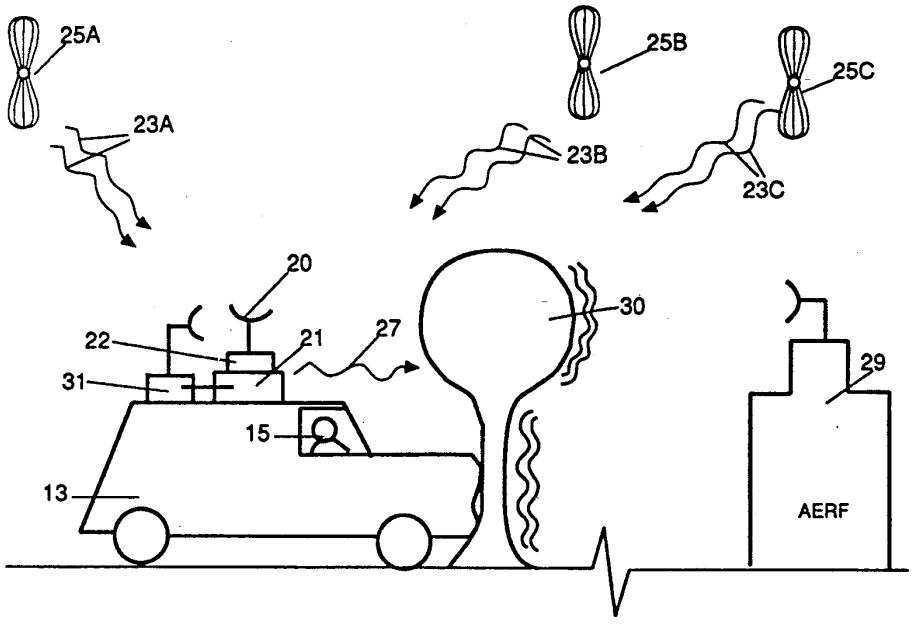
4,740,792	4/1988	Sagey et al.	342/475
5,119,102	6/1992	Barnard	342/457 X

Primary Examiner—Mark Hellner
Attorney, Agent, or Firm—John Schipper

[57] **ABSTRACT**

Apparatus that is carried on a land vehicle, a marine vehicle or vessel, or an airborne vehicle or vessel for notifying others that a vehicle accident or other abnormal situation has occurred and for notifying others of the location of the vehicle at the time of the accident. The vehicle carries an distance measuring system (DMS) signal antenna and receiver/processor that receives DMS-type signals from one or more DMS signal broadcasters and determines the present position of the vehicle, plus an activatable transmitter. The vehicle also carries an abnormality sensing means that senses the occurrence of an accident or other abnormal situation involving the vehicle or a vehicle occupant. When an abnormal situation is sensed, the abnormality sensing means automatically activates the transmitter, which then communicates the fact that an abnormal situation has occurred and the location of the vehicle at the time the event occurred. Alternatively, the abnormality sensing means can activate the transmitter only after a vehicle operator has taken affirmative action indicating that the transmitter should be activated. Optionally, the transmitter can also communicate the time the event occurred. If the abnormal situation is (1) a vehicle accident, (2) inoperability of the vehicle, (3) inability of the vehicle operator or other vehicle occupant to continue (e.g., because of a rapid change in a present health condition of the occupant), the transmitter can also communicate information on (1) the severity of the accident, (2) the type or cause of vehicle inoperability, (3) the reason the operator or other occupant is unable to continue. Optionally, the system can also transmit, or hold for future analysis, the values of one or more vehicle operating parameters sensed at a sequence of times preceding occurrence of the abnormal situation. The DMS may be a Satellite Positioning System, such as the Global Positioning System (GPS) or the Global Orbiting Navigation System (GLONASS), or a ground-based radionavigation system, such as LORAN, Shoran, Decca or TACAN.

32 Claims, 2 Drawing Sheets



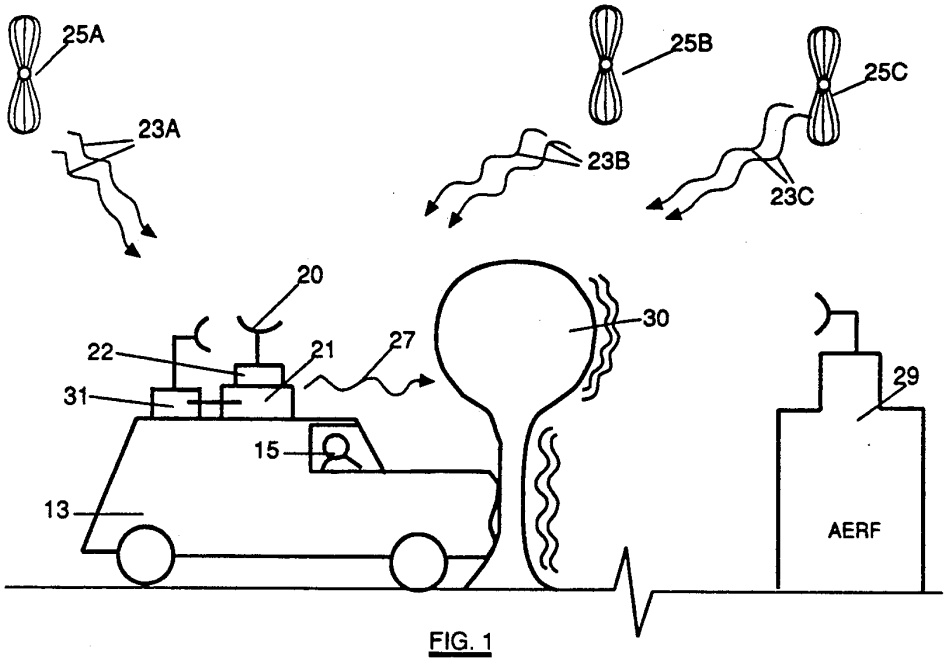


FIG. 1

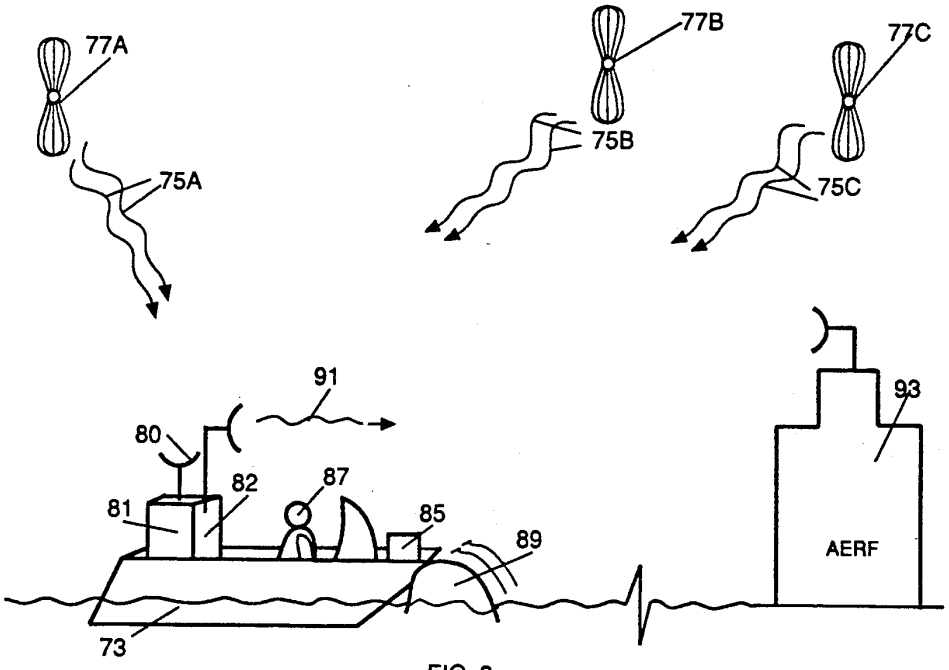


FIG. 3

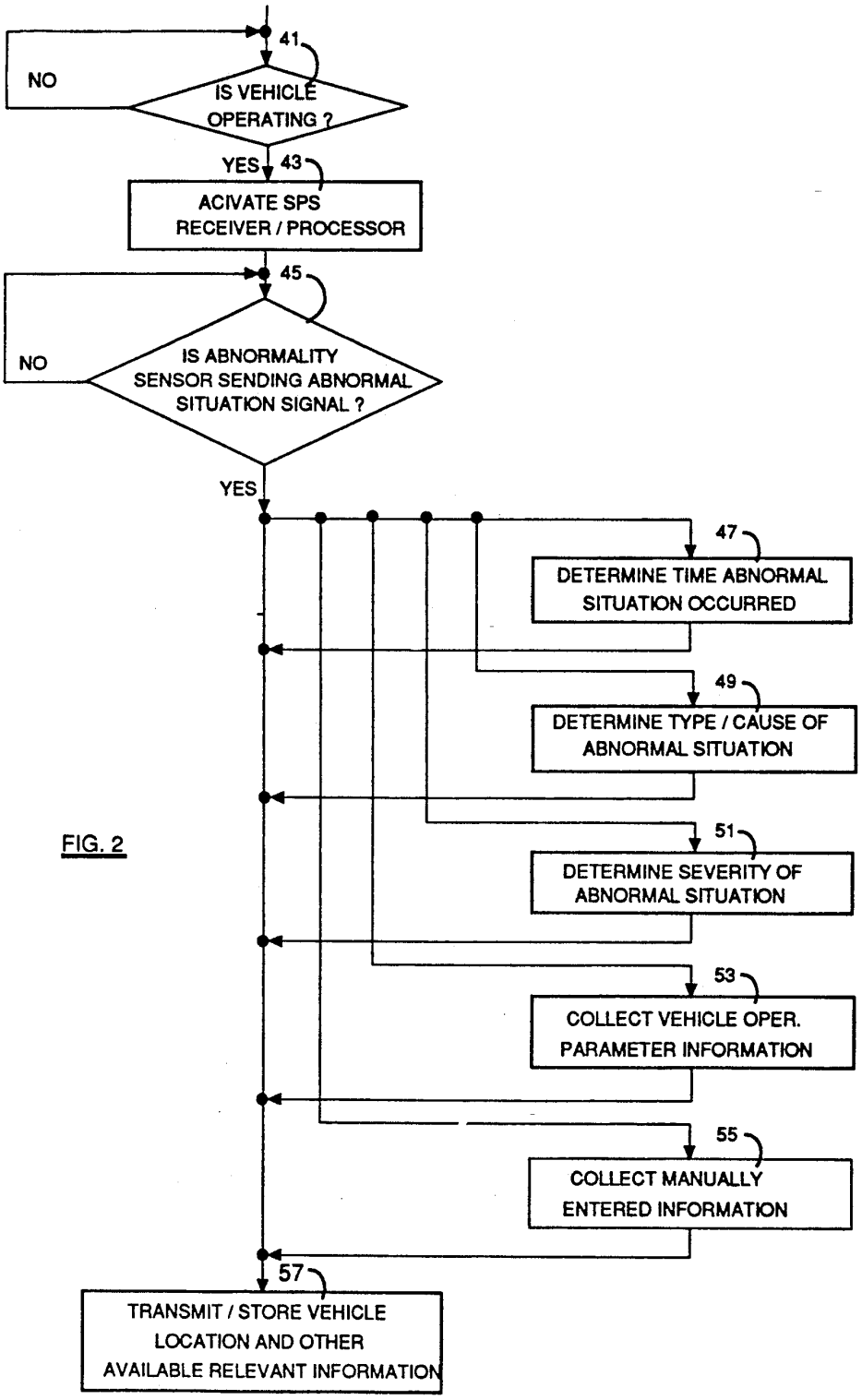


FIG. 2

EVENT-ACTIVATED REPORTING OF VEHICLE LOCATION

FIELD OF THE INVENTION

This invention relates to determination of location of a vehicle upon occurrence of an event, and more particularly to determination of vehicle location by a satellite-based or ground-based radiowave navigation system.

BACKGROUND OF THE INVENTION

When a land vehicle, such as an automobile, bus or truck, or a marine or airborne vessel encounters an abnormal situation, such as a collision, loss of vehicle control or abrupt inoperability of the vehicle, a safety device attached to the vehicle is activated to minimize injury or damage to the vehicle occupants or to the vehicle itself. The safety device may be an air bag or other vehicle or passenger safety mechanism, activated in response to an imminent or extant vehicle collision, or may be a redundant or parallel power supply or mechanical control device for the vehicle. Normally, such device is activated automatically by a signal issued by a vehicle sensor that senses and responds quickly to occurrence of any one of a predetermined group of abnormal vehicle conditions. If this abnormal condition threatens the health or safety of a vehicle occupant, it might be preferable to issue a distress signal automatically and at once, without waiting for a volitional act by a vehicle occupant.

Several workers have attempted to provide for broadcasting of distress signals when a vehicle experiences a collision or some other disabling condition. Graham, in U.S. Pat. No. 3,441,858, discloses an electronic calling and reply system that may be activated, either automatically or manually, to broadcast one of a selected group of distress signals after a vehicle accident occurs. The vehicle carries one transceiver unit. A central aid station has a second transceiver unit that responds to receipt of the distress signal by broadcasting a unique coded signal indicating that assistance is being sent to the vehicle. The distress signal may indicate that (1) a vehicle tow truck is needed, (2) an ambulance is needed, or (3) both a tow truck and an ambulance are needed. The distress signal is automatically sent by the vehicle-mounted transceiver when vehicle impact of sufficient magnitude occurs, as in a collision.

A vehicle distress tone generator that produces a selected one of three different tones is disclosed in U.S. Pat. No. 3,461,423, issued to Trumble. The distress signal can be automatically broadcast in response to occurrence of a vehicle accident or can be manually initiated by a vehicle occupant. The three tones broadcast correspond to three predetermined levels of severity of the accident.

In U.S. Pat. No. 3,646,583, Scuderi discloses automatic vehicle accident signalling apparatus, including a sensor that senses that a vehicle collision of a predetermined severity level (or more) has occurred. The accident signal is, presumably, received and answered by a central assistance station or by another vehicle. This patent is concerned primarily with the mechanics and electronics of collision sensing and signal broadcasting. None of the patents discussed thus far discusses means for determining where the vehicle in distress is located.

Angeloni discloses a highway distress signal broadcast system, in U.S. Pat. No. 3,828,306, in which the vehicle is located by triangulation by three or more

nearby radio direction finding devices (RDFs), such as the old Mariner MR-18 marketed by Heathkit. Each RDF receives the vehicle distress signal and determines the direction of the signal source. A central station receives this information from the RDFs, determines the location of the vehicle in distress, and dispatches assistance for the vehicle. The RDFs must be located within 15 miles of the accident scene., the vehicle transmitter has low power ($P \leqq 10$ Watts), and the contemplated broadcast frequency is about 450 MHz.

Gleitz et al disclose apparatus having a vehicle impact sensor and a vehicle deformation sensor attached to a vehicle in U.S. Pat. No. 3,990,040. The apparatus broadcasts a first distress signal if vehicle impact is sensed and broadcasts a second distress signal if vehicle deformation is sensed, and the transmitter continues to broadcast after activation. Broadcast of vehicle location by the transmitter is not discussed.

Edelbock discloses a low technology solution in U.S. Pat. No. 4,091,369, a collision-responsive alarm that is attached at the top of a vehicle. If the vehicle collides with another object, a light source, rotating reflector and warning light is activated. Light from the source is reflected in a circular pattern by the rotating reflector, thus advising other persons nearby that a vehicle collision has occurred. No electromagnetic distress signal is broadcast by this apparatus.

A vehicle emergency signal system using Citizens Band (CB) radio channels is disclosed by Flickshu et al in U.S. Pat. No. 4,216,545. When a vehicle accident occurs, an emergency switch (manual or automatic) activates a CB radio transceiver carried in the vehicle, and the transceiver broadcasts a distress signal in each of a sequence of CB radio bands and then is set to Channel 9, the only CB emergency channel, to receive inquiries or other information from nearby CB radio users. By sequentially broadcasting the vehicle distress signal in each CB channel, the inventor contemplates that some CB users will hear and respond to the distress signal. However, this requires that at least one occupant of the vehicle in distress be in condition to receive the CB inquiries and be able to provide the location of that vehicle.

In U.S. Pat. No. 4,229,725, issued to Marcus, vehicle location indicator apparatus provides a visual readout of the last mile marker the vehicle has passed and of the distance (fraction of a mile) traveled by the vehicle since that last marker was passed. The apparatus is operable only for travel on a road or highway on which mile marker sensors are located at regular spatial intervals. A counter in the vehicle is initially set equal to zero and then is incremented as successive mile markers are passed. Particular events that may occur at particular mile markers c .n be stored in the apparatus and then displayed to the vehicle occupants as the vehicle approaches the stored event mile marker. An optional keyboard allows a vehicle occupant to enter relevant information as the vehicle proceeds.

Juhasz et al disclose a vehicle monitoring and recording system in which a plurality of sensors provide continuous or intermittent measurements of vehicle and engine operating parameters, in U.S. Pat. No. 4,258,421. These measurements are stored in a computer, which may be carried on the vehicle or may be spaced apart from the vehicle and connected to the sensors by a portable data link. The operating parameters provided by the sensors may be compared with fixed parameter

limits to assess the present operating performance of the vehicle.

A vehicle emergency or distress signal broadcasting system is disclosed in U.S. Pat. No. 4,369,426, issued to Merkel, in which the distress signal also indicates the vehicle location. Distress signal transmission is activated by sensors that sense occurrence of a vehicle collision, or some other recognizable, non-normal event. These sensors may have different activation thresholds that correspond to the severity of the collision and may thereby cause transmission of different distress signals. Vehicle location is determined (probably by triangulation) by a plurality of geographically distributed stations that are electronically connected with a central data processing station. Information received by the central station may indicate the severity of the collision and whether certain safety equipment, such as seat belts or air bags, was operable when the collision occurred.

Zottnik, in U.S. Pat. No. 4,638,289, discloses use of a short time data recordation and storage system that continuously records and temporarily saves measurements of vehicle operating parameters as the vehicle moves. The recorded data are stored in a modest size buffer that is overwritten by new data after a fixed time interval ($\Delta t \approx 1$–30 sec). If a vehicle accident occurs, operating data in the buffer at that time are "frozen" and not subsequently overwritten. Data preserved in the buffer are then available to provide a perspective on what happened in a time interval immediately preceding the vehicle accident.

Murakami positions a plurality of transmitting antennae at various locations and orientations on a vehicle in U.S. Pat. No. 4,717,904. An emergency or distress signal is transmitted by a transmitter connected to these antennae whenever a serious abnormality is sensed in vehicle operation. This abnormality may be vehicle acceleration/deceleration (as in a vehicle collision), sharp change in vehicle inclination (as when a vehicle abruptly moves over the edge of an incline) or the unexpected presence of water within the vehicle (as when a vehicle abruptly encounters a river or other large body of water). The distress signal is broadcast sequentially from each of the antennae so that inoperability of one or a few antennae will not permanently preclude broadcast of the vehicle distress signal.

A vehicle location system activated by vehicle motion, vehicle collision, vehicle theft or other abnormal event is disclosed by Sagey et al in U.S. Pat. No. 4,740,792. Each vehicle has a transmitter attached thereto that has a unique transmission signal signature, and a signal broadcast by such a vehicle is received and relayed by each of three or more satellites or signal relay towers that communicate directly with one or more central data processing stations distributed throughout the U.S. A central station receives a relayed signal and identifies the transmitter, and thus the associated vehicle, by the signature. The transmitter can broadcast a signal with first frequency if the vehicle is stationary, a signal with a second frequency if the vehicle is in motion, a signal with a third frequency if the vehicle is being tampered with or stolen, and a signal with a fourth frequency if a vehicle collision is imminent or has already occurred. Optionally, a stationary transmitter with known position broadcasts a signal that is also received by the central station. The known and computed positions of this stationary transmitter are compared at the central station to calibrate the system and provide corrective adjustments of locations of the other vehicle transmitters. The satellites or signal relay towers receive location-determining signals from the vehicle, which is the inverse of the situation in the subject invention.

Takai discloses, in U.S. Pat. No. 4,743,913, a hybrid navigation system in which vehicle location and velocity vector are determined by an on-board geomagnetic sensor that senses the local geomagnetic field direction. The system also uses location information derived from GPS. However, it appears that the system is intended to operate only on a predetermined system of straight roads.

In U.S. Pat. No. 4,815,840, Benayad-Cherif et al disclose a position locating system for a robot vehicle that uses a plurality of elevated towers that each emit a guidance beacon. The beacons are received by sensors in, and provide individually coded guidance signals for, the vehicle, using triangulation or phase shift techniques. The location of the robot vehicle may be determined on board, but this location is not communicated to another entity.

Manion discloses a burst collision avoidance system for aircraft ground-based, aircraft-servicing vehicles and structures that provides warnings and avoidance maneuvers, in U.S. Pat. No. 4,835,537. The system provides telemetry equipment and a computer aboard each such vehicle and structure to determine and broadcast the present location and intended direction of movement for each such vehicle and structure. Information thus broadcast is received by each vehicle and structure in the local region and used to determine if a collision is imminent. A Global Positioning System or other means for location determination provides each vehicle with its current location information. This system requires constant transmission and receipt of location signals and substantial computer power to receive and process all incoming location signals.

A locator system for a movable vehicle is disclosed in U.S. Pat. No. 4,884,208, issued to Marinelli et al. Each of a plurality of fixed location transceivers communicates with a satellite through a first antenna and receives signals emitted by nearby vehicles individually through a second antenna. The strength of the signal received by the second antenna from a nearby vehicle determines its distance from the transmitter and second antenna. The transceivers receive and relay the vehicle signals to the satellite, which serves as a master data processing station and determines these vehicle-second antenna distances. Each transceiver serves as a local object locator station but has a relatively small effective diameter ($\approx$20 miles).

Scribner et al disclose a vehicle tracking system that transmits the location of a vehicle whenever one or more predetermined events occurs, in U.S. Pat. No. 5,014,206. The vehicle carries sensors that respond to occurrence of a predetermined event and carries a Global Positioning System or LORAN navigational system that receives vehicle location information, such as longitude and latitude. This vehicle location information is stored in a memory on board the vehicle only when one or more of the predetermined events occurs. The vehicle location information is assumed to be read out when the vehicle returns to a home base.

Barnard, in U.S. Pat. No. 5,119,102, discloses a vehicle location system that uses provides a Global Positioning System signal receiver, temporary signal storage and signal retransmitter aboard each vehicle whose

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