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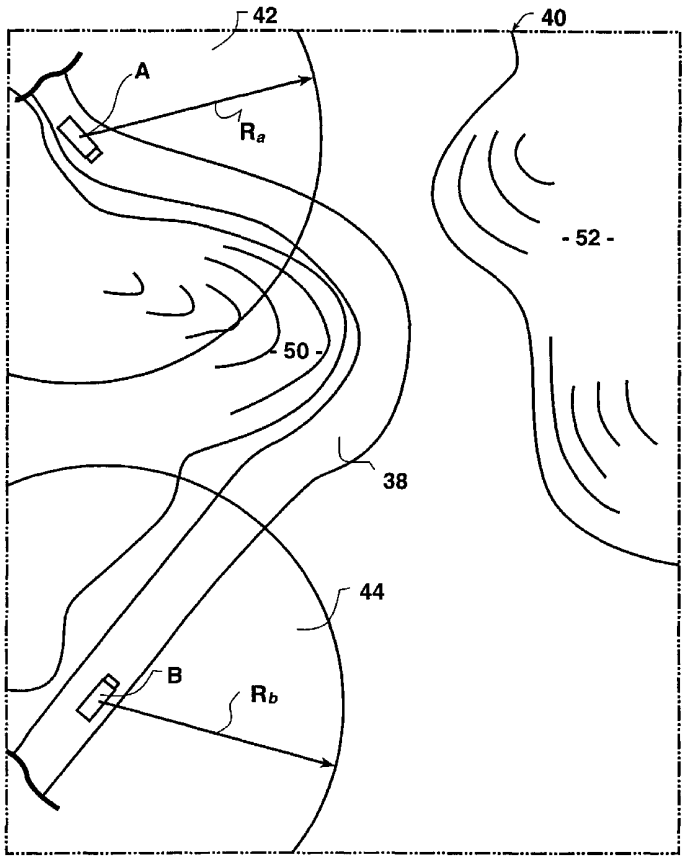
(54) Title: PORTABLE VEHICLE-TRACKING MODULE FOR TRAFFIC MONITORING



(57) Abstract: A portable module (10, 30) is installed in each vehicle (A, B, C, D) and other moving equipment at a worksite. Each module includes at least a GPS unit (12), a transceiver (14), a programmed processor with memory (16), an alarm (18), and a power source (20). Through the module, each vehicle is able to communicate with other vehicles around it at the worksite in order to track their positions and determine when another vehicle is found within a predetermined distance (Ra, Rb) and then activate an alarm to alert the operator of the presence of the other vehicle.

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IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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PORTABLE VEHICLE-TRACKING MODULE FOR TRAFFIC MONITORING

BACKGROUND OF THE INVENTION

Field of the Invention

This invention is related in general to traffic in a surface facility such as a surface mine. In particular, the invention is related to a tracking system that is based on assigning an interference zone to each vehicle and equipping it with a device for monitoring the presence of other vehicles within the vehicle's interference zone.

Description of the Related Art

Automation of vehicles at worksites such as surface mines has been of primary concern during the last decade and various levels of implementation are well under way. Such automated systems incorporate traffic-control protocols and related apparatus designed to ensure safety and efficiency when a plurality of autonomous and manual vehicles operate at the same time. See, for example, copending U.S. Serial Nos. 09/521,436 and 09/571,495, hereby incorporated by reference. See also U.S. Patents No. 4,630,685, No. 4,677,555, No. 4,776,750, No. 5,862,501, No. 5,897,595, No. 5,913,914, and No. 6,037,901. These disclosures are concerned with systems that pertain exclusively to unmanned vehicles and are directed to the optimization or implementation of particular autonomous functions. The control of manned vehicles at the worksite is left to the operator of each unit, without a systematic approach for interaction with automated units.

Current guidance and control systems do not provide means for readily alerting each vehicle, especially manned vehicles, of the impending presence of another vehicle within a potentially dangerous proximity. Typically, manual vehicles rely on the vigilance of the operator and,

sometimes, on line-of-sight instruments capable of detecting obstacles and other vehicles operating in the vicinity, such as radar and other equivalent detection devices used for identifying unexpected obstacles on the vehicle's planned travel trajectory. Thus, for example, two approaching vehicles coming together around an obstructed corner are not likely to be aware of each other because neither the operators nor the obstacle-detection systems with which they may be equipped will "see" the other vehicle.

Another problem at worksites arises from the presence of visiting vehicles that are only temporarily on the premises, such as those operated by providers of services, inspectors, visitors, and the general public. Because of the typically absolute absence of traffic-monitoring apparatus on these vehicles, the relative lack of familiarity of their drivers with the premises and the general randomness of their travels, these vehicles normally represent a serious traffic-monitoring problem and a potential safety hazard at worksites such as surface mines and similar facilities. Moreover, these vehicles tend to operate independently of any traffic-control system that may exist at the worksite. Since they are normally not equipped with positioning and communication systems, their travels within the site, the impact they may have on overall traffic and safety, and the control over their continued presence or departure is left entirely at the discretion of the operator, without supervision from the management of the facility.

A particularly serious problem at mine sites is the inability of haulage-truck and excavator operators to see pick-up trucks and other small vehicles that approach them and/or park near them. In spite of mirrors installed at all possible angles to provide the operator with a view of all vehicle sides, unavoidable blind spots remain because

of equipment configuration and the position the operator necessarily has to assume within it. As a result, several serious accidents, including deaths, are reported each year at each mine from small vehicles run over by large pieces of equipment.

Accordingly, there is a need for a system of traffic control and guidance that includes all vehicles potentially operating at a surface worksite. Such a system should be compatible with autonomous-guidance protocols and hardware, and should have the flexibility of including on a temporary basis all vehicles entering the worksite. This invention is directed at providing a simple general solution that meets that need.

BRIEF SUMMARY OF THE INVENTION

The primary objective of this invention is a system and related apparatus that provide each vehicle at a worksite with an indication of the presence of another vehicle traveling within a predetermined distance, regardless of whether or not either vehicle is visible to the other, is manually or autonomously operated, or is also controlled by a separate traffic-guidance system.

A goal of the invention is also a vehicle-tracking system of general application that can be used to monitor traffic at surface worksites, particularly surface mines.

Another objective of the invention is an approach suitable for implementation with autonomous as well as manned vehicles.

Another goal is a system that can be readily implemented with worksite vehicles as well as with visiting vehicles entering the premises on a temporary basis, thereby

enabling complete coverage of traffic monitoring over the worksite at all times.

Yet another objective is a system of traffic monitoring that is independent of other guidance and control systems in effect at the worksite, so that it can be operated independently or integrated with existing systems.

Another goal of the invention is a system that can be used solely for locating vehicles and monitoring traffic, or can be incorporated with guidance and control protocols to enhance efficiency and/or improve safety.

Still another objective is a system that includes apparatus suitable for implementation as a removable module for each vehicle at a worksite, whether its presence is permanent or temporary.

Another goal is a system that is suitable for implementation with current surface-mine haulage and mining equipment.

A final objective is a system that can be implemented economically according to the above-stated criteria.

Therefore, according to these and other objectives, the preferred embodiment of the invention consists of a module, either plug-in or fixed, adapted for ready installation in each vehicle and other moving equipment at or coming to a worksite. Each module includes at least a GPS unit, a transceiver, a programmed processor with memory, an alarm, and a power source. Through the module, each vehicle is able to communicate with other vehicles around it at the worksite in order to track their positions and determine when another vehicle is found within a predetermined distance, a so called "interference zone," and then activate an alarm to alert the operator of

the presence of the other vehicle.

The interference zone consists of a space bubble or hub surrounding each vehicle as it travels through the worksite. It may be defined simply by a radius around the vehicle, or by a more complex geometry suited for particular applications. The interference zone assigned to each vehicle may be fixed, for simplicity, or dynamically variable to account for changed circumstances within the worksite. Similarly, different vehicles may have different interference zones to account for distinct individual tasks, physical characteristics, and functional requirements.

According to one aspect of the invention, portable modular units are installed in each vehicle upon entering a worksite and can be removed upon its departure. Alternatively, the unit can be permanently mounted in the vehicle. In operation, the unit provides the vehicle with direct and continuous monitoring of the current location of all other vehicles within its interference zone to improve traffic and facilitate avoidance of hazardous situations. Such indication of potential interference may be obtained directly from the vehicles in question, without a need for linkage of all vehicles to a central communication base. Alternatively, the modular unit of the invention also provides a means for communication with a central control facility, so that the position and proximity information generated by each vehicle can be advantageously used within the overall traffic-guidance network of the worksite.

In a particular implementation of the invention, the power source for the modular unit consists of a plug suitable for connection with conventional vehicle cigarette-lighter outlets. The alarm may be visible, audible, or both. A monitor may be included to illustrate the relative

position of vehicles present within the interference zone of the vehicle carrying the unit. Indications of direction and speed may also be included.

Various other purposes and advantages of the invention will become clear from its description in the specification that follows and from the novel features particularly pointed out in the appended claims. Therefore, to the accomplishment of the objectives described above, this invention consists of the features hereinafter illustrated in the drawings, fully described in the detailed description of the preferred embodiment and particularly pointed out in the claims. However, such drawings and description disclose only some of the various ways in which the invention may be practiced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram illustrating the combination of hardware components required to implement the portable vehicle-tracking device of the invention.

Fig. 2 is a perspective view of a portable device incorporating the components of Fig. 1.

Fig. 3 is an illustration of a mine-map area showing a roadway with two vehicles approaching a blind curve from opposite directions.

Fig. 4 is another view of the map area of Fig. 3 showing the vehicles after each has entered the interference zone of the other.

Fig. 5 is a block diagram showing the steps performed by the microprocessor of the invention in order to implement the required tracking and alerting functions thereof.

Fig. 6 is an illustration of variable shapes and sizes of interference zones.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

This invention is based on the idea of providing a portable, modular unit, compatible for use with any vehicle at or entering a worksite, to allow for its continuous tracking and detection of other vehicles. Particularly significant is the concept of a self-contained or plug-in unit which can be used to promptly include or exclude any vehicle in or from the traffic-control system of a worksite. While the hardware components utilized to describe the invention are well known in the art, no system exists currently that utilizes the same combination of components to implement the disclosed vehicle-tracking idea for all vehicles coming into a worksite like a surface mine.

For the purposes of this disclosure, every reference to a vehicle is intended to apply also to any other movable piece of equipment or object that may be found at a site, including a person carrying the device of the invention. Surface mines utilize a variety of work machines for excavating and transporting ore, grading and stabilizing roadways and slopes in the mine pit, and for providing all support functions necessary to the operation of a mine. Most work and haulage machines are human-operated, mobile pieces of equipment constantly being moved around the premises. In addition, a continuous stream of outside vehicles temporarily on the premises is normally found to further crowd traffic at the mine site. Skilled operators ensure that each machine or vehicle is maneuvered optimally to perform its intended function while avoiding accidents and injury to people and property. The same sort of traffic conditions exist at other types of

worksites, such as construction sites, waste sites, underground mines, quarries, factories, warehouses, airports, roads and the like. Therefore, this invention is described in the context of a surface mine operation, but its concept is applicable to any operation involving moving equipment and vehicles and should not be understood to be limited to surface mines.

Referring to the drawings, wherein like parts are designated throughout with like numerals and symbols, Fig. 1 illustrates schematically the combination of components required to practice the present invention. A portable, modular unit 10 is provided that includes a positioning device 12, preferably a GPS unit, a two-way communication device 14, such as a transceiver unit, a microprocessor with memory 16 programmed to perform the steps required to implement the invention, an alarm unit 18, and a means 20 for energizing all components. The unit 10 is constructed as a self-contained portable module that is intended for use independently of any other component that may already be present in a vehicle. For example, all autonomous vehicles in a mine are equipped with positioning and communication hardware and with control software designed to effect vehicle guidance. The unit 10 of the invention is used concurrently as an additional system that may be added to or removed from a vehicle at will without the need to disengage any hardwired connection. Whether powered by a battery included in the module or by a plug inserted into the cigarette-lighter outlet of the vehicle carrying it, the modular unit 10 of the invention is readily removable and transferable to another vehicle.

Fig. 2 is a perspective illustration of an actual embodiment 30 of the schematic modular unit 10 of the invention shown in Fig. 1. A power cord 32 with a terminal plug 34 adapted for connection with a conventional vehicle cigarette-lighter outlet is provided

to energize the portable unit 30. Obviously, a different plug designed to fit a specific power outlet found in a particular vehicle of interest may be provided in lieu of or in addition to the standard cigarette-lighter plug 34. A GPS antenna 36 enables the unit to receive periodic position information that permits placement of the unit and the vehicle carrying it within a predetermined coordinate system, as is routinely done in all GPS applications. The microprocessor 16 is programmed to function within a system that utilizes the position information generated by the GPS unit 12 to track each vehicle within a predetermined distance from the vehicle carrying the module. As illustrated in Fig. 3, each vehicle traveling within the mine site, such as along a roadway 38 of a particular area 40 of the mine, is assigned a predetermined hub or bubble, called interference zone for the purposes of the invention, represented in the figure by the exemplary area shown within a particular radius from the vehicle. For example, vehicle A is assigned an interference zone 42 defined by the area within radius Ra, and vehicle B is assigned an interference zone 44 defined by radius Rb, which may be the same or different, depending on the degree of sophistication with which the system of the invention is implemented. For instance, different interference zones may be used for different kinds of vehicles to reflect differences in average traveled speeds, stopping abilities, and other factors that may justify a different treatment among vehicles. Similarly, the interference zone of each vehicle may be changed dynamically to account for changed circumstances, such as current speed and road conditions.

In all cases, a critical feature of the vehicle-tracking unit 30 of the system of the invention is its ability to monitor the presence of other vehicles around the vehicle carrying the unit and to alert its operator when any such

other vehicle is found to be within its interference zone. Thus, for example, the unit installed in vehicle B would alert its operator when vehicle A enters its interference zone 44, as illustrated in Fig. 4. Similarly, the unit installed in vehicle A would alert its operator when vehicle B enters the interference zone 42 of vehicle A. In order to implement this feature, the transceiver unit 14 periodically broadcasts the position of the vehicle carrying it (for example, vehicle B) through its antenna 46 to other vehicles in the vicinity (for example, vehicle A) and receives the position concurrently being broadcast by such other vehicles. The current position of all vehicles within the range of broadcast is inputed into the microprocessor 16, which is programmed to calculate the distance between its vehicle and all other vehicles, and to compare each such distance to the radius of the interference zone of the vehicle carrying the unit (for example, the distance between vehicles A and B is compared to Rb to determine whether vehicle A is within the interference zone 44 of vehicle B). In general terms, the microprocessor 16 is programmed to identify any vehicle with a position found to be within the interference zone of the vehicle carrying the portable tracking unit of the invention. The microprocessor is also programmed to then signal the presence of such other vehicle to the operator through an audible and/or visual alarm 18, or through a monitor screen 48 (Fig. 2) that displays a map of the area 40 being traveled and symbolic images Ia,Ib superimposed on the map to indicate the relative position of the two vehicles A and B. Thus, the operator of the vehicle is alerted about the fact that another vehicle is traveling within the interference zone of its vehicle.

The main advantage provided by the invention with respect to prior-art alert systems is illustrated with reference to Figs. 2-4. The area 40 of the mine being traveled by vehicle A is characterized by two high banks 50 and 52

between which the roadway 38 meanders. As the roadway curves around the high wall created by bank 50, two vehicles approaching from opposite directions cannot see each other, as illustrated by vehicles A and B in Fig. 3. So long as the distance between the vehicles is deemed safe, as determined arbitrarily or empirically when assigning interference zones 42 and 44 as part of the design of the system of the invention, the vehicle-tracking unit 30 of each vehicle A,B will not signal the presence of the other to its operator. As soon as vehicle A enters the interference zone 44 of vehicle B, this vehicle's unit 30 will signal the event to its operator by energizing (possibly intermittently) a visible light 54, and/or sounding an audible alarm 56, and/or displaying the position of the two vehicles through corresponding images Ia and Ib on the screen 48, or any combination of the above. With this information at hand, the operator of vehicle B will be aware of the around-the-corner proximity of vehicle A even though it is not visible, nor easily detectable by line-of-sight instruments, and can thus take the necessary precautions to proceed safely.

It is noted that this advantage is provided without a need for linking both vehicles A and B (as well as all other vehicles on the premises) to a central control location through a general network, as is instead necessary to achieve the same result with prior-art tracking and communication systems. Moreover, because of the self-contained and portable aspects of the invention, any vehicle within the mine site can be immediately plugged into the system without delay for installation or calibration. Each module 30 is already tuned for GPS reception and for two-way communication with all other modules present within a predetermined range of operation at the site. All units contain the same software for carrying out an analysis of the information produced by the positioning and communication devices and for

activating the alarm component of the invention according to a predetermined logic of operation. The necessary steps implemented by such a computer program for each cycle of operation are outlined in Fig. 5.

As mentioned, the interference zone assigned to each vehicle is a moving space relative to the vehicle; that is, the zone travels with the vehicle. The zone may be fixed and simply defined by a radius, as illustrated in the figures, or it may assume any form suitable for a particular application, or also be variable in time to dynamically optimize traffic and other mine conditions. For example, because each vehicle travels in a given direction, it would make sense to skew the shape of the interference zone to cover more territory ahead of rather than behind the vehicle, as illustrated by zones 58 and 60 for vehicles C and D, respectively, in Fig. 6. Similarly, the shape of the zone could vary depending on whether the vehicle is traveling along a substantially straight or a winding road and could increase with increased speed, as shown by the different shapes and sizes of zones 58 and 60 in Fig. 6, or as a function of the location of the vehicle or of proximity to other vehicles. As one skilled in the art would readily appreciate, these alternative options depend only on the degree of sophistication deemed necessary for optimal performance and are all implemented through various levels of programming. For instance, since the position data of all vehicles of interest are periodically updated, they can be stored to calculate the current speed and direction of each vehicle, and this information in turn can be used to adjust the current size and shape of a variable interference zone. Furthermore, the speed and direction can also be displayed, such as by arrows Aa,Ab associated with each vehicle and having a length proportionate to the vehicle speed and a relative direction consistent with the vehicle's current trajectory, as illustrated in Fig. 2. Appropriate control

buttons 62 may be provided in the modular unit 30 to give a user the capability of switching between options.

It is understood that the general concept of the invention can be implemented in various ways based on different design choices. For example, as a matter of system design, it is necessary to select an arbitrary time cycle for broadcasting the position of each vehicle within the system. Similarly, an arbitrary criterion must be chosen to select the shape and size of the interference zones for each vehicle. Currently, the preferred approach has been to define each zone for all vehicles by a fixed radius, which is simple to implement and computationally efficient without any significant disadvantage. Interference-zone parameters can be defined by the end user, and could be any range, including within the entire mine, or within a closer proximity, such as within 100 meters, or within some close distance appropriate for the equipment in question (such as a loader working within a limited space).

The device can generate any combination of proximity warnings, messages, or displays. These warnings, messages, or displays can inform the equipment operator, and/or any terminal that is accessible by the network, to display the location of any vehicle that is in the mining operation, and also to use that information to report deviations and proximities.

The preferred location device is a GPS unit, but it could equivalently be a GPS unit with a beacon system, or a triangulation device using lasers, radar, radio signals, a similar location-determination unit, or any combination of these. The radio communication device may also be used to transmit and receive instructions to and from other computing devices for dispatching, safety, production, or any other storage, display, or processing purposes. The

radio communication device can be UHF, VHF, spread spectrum, or any other radio device adapted for this purpose.

The invention is based on the idea of providing each moving vehicle at a worksite, especially including outside vehicles visiting the site, with a means for tracking all other vehicles that may become relevant to its travel. An important aspect of the invention is its direct and immediate availability to all vehicles regardless of whether or not the worksite has a central communication and traffic-guidance network, and whether or not part of the vehicles at the site are automated. If so, the tracking apparatus of the invention is also installed in autonomous vehicles and the alarm signals produced by the microprocessor 16 may be incorporated into the control protocol of the autonomous system. For example, an alarm signal alerting of the presence of another vehicle within the interference zone of an autonomous vehicle can be used as an additional level of supervision to appropriately conduct a safe operation of that vehicle.

Implementation of this invention is expected to virtually eliminate accidents caused by mine-vehicle operators' inability to see other vehicles operating in the vicinity of their equipment. Accordingly, it is believed that it will have a significant safety and economic impact on a mining operation.

Various changes in the details, steps and components that have been described may be made by those skilled in the art within the principles and scope of the invention herein illustrated and defined in the appended claims. Therefore, while the present invention has been shown and described herein in what is believed to be the most practical and preferred embodiments, it is recognized that departures can be made therefrom within the scope of the

invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent apparatus and procedures.

I claim:

1. A device for indicating to a first vehicle at a worksite the presence of a second vehicle within an interference zone associated with the first vehicle, comprising:

a positioning unit for determining a current position of the first vehicle;

a two-way communication unit for broadcasting the current position of the first vehicle and for receiving a current position of the second vehicle;

a processing unit for processing the current positions of the first vehicle and the second vehicle to determine a current distance therebetween;

an alarm unit responsive to a signal from the processing unit to provide an alert signal when said current distance is within the interference zone; and

means for energizing the device;

wherein the processing unit is programmed to assign an interference zone to said first vehicle and to maintain a predetermined spatial relationship between the interference zone and the current position of the first vehicle.

2. The device of Claim 1, wherein said positioning unit includes a GPS unit.

3. The device of Claim 1, wherein said two-way communication unit includes a transceiver.

4. The device of Claim 1, wherein said alarm unit includes a visible light.

5. The device of Claim 1, wherein said alarm unit includes an audible alarm.

6. The device of Claim 1, wherein said alarm unit

includes a display screen and said processing unit is programmed to display an indication of a relative position of said first and second vehicles on said screen.

7. The device of Claim 6, wherein said processing unit is further programmed to calculate and display on said screen an indication of speed and relative direction of said first and second vehicles.

8. The device of Claim 1, wherein said interference zone is defined by a fixed radius around said first vehicle.

9. The device of Claim 1, wherein said interference zone is dynamically varied as a function of current speed of said first vehicle.

10. The device of Claim 1, wherein said interference zone is dynamically varied as a function of current location of said first vehicle.

11. The device of Claim 1, wherein said interference zone is dynamically varied as a function of current proximity of said first vehicle to said second vehicle.

12. The device of Claim 1, wherein said means for energizing the device includes a plug adapted for connection to a power outlet in said first vehicle.

13. A method of indicating to a first vehicle at a worksite the presence of a second vehicle within an interference zone associated with the first vehicle, comprising the steps of:

(a) providing a device for installation in each of said first and said vehicles, said device comprising a positioning unit, a two-way communication unit, a processing unit, an alarm unit responsive to a signal from the processing unit, and means for energizing the device;

(b) assigning an interference zone to said first vehicle;

(c) determining a current position of the first vehicle;

(d) broadcasting the current position of the first vehicle and receiving a current position of the second vehicle;

(e) processing the current positions of the first vehicle and the second vehicle to determine a current distance therebetween;

(f) repeating steps (c)-(e) at predetermined time intervals while maintaining a spatial relationship between the interference zone and the current position of the first vehicle; and

(g) providing an alert signal when said current distance is within the interference zone.

14. The method of Claim 13, wherein said positioning unit includes a GPS unit.

15. The method of Claim 13, wherein said two-way communication unit includes a transceiver.

16. The method of Claim 13, wherein said alarm unit includes a visible light.

17. The method of Claim 13, wherein said alarm unit includes an audible alarm.

18. The method of Claim 13, further including the steps of providing a display screen and displaying an indication of a relative position of said first and second vehicles on said screen.

19. The method of Claim 18, further including the steps of calculating and displaying on said screen an indication of speed and relative direction of said first and second

vehicles.

20. The method of Claim 13, wherein said interference zone is defined by a fixed radius around said first vehicle.

21. The method of Claim 13, wherein said interference zone is dynamically varied as a function of current speed of said first vehicle.

22. The method of Claim 13, wherein said interference zone is dynamically varied as a function of current location of said first vehicle.

23. The method of Claim 13, wherein said interference zone is dynamically varied as a function of current proximity of said first vehicle to said second vehicle.

24. The method of Claim 13, wherein said means for energizing the device includes a plug inserted into a power outlet in said first vehicle.

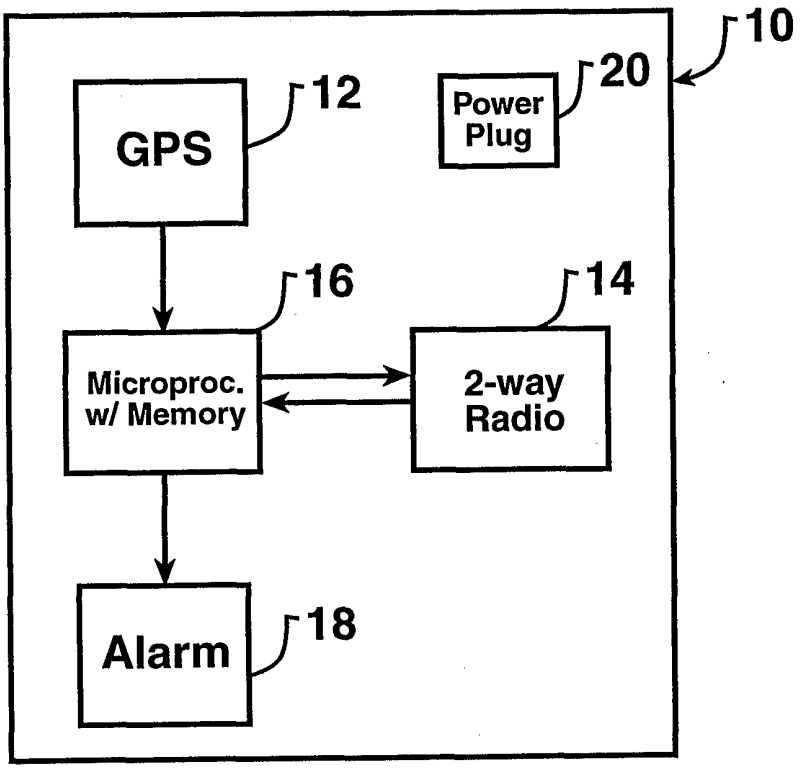
10
GPS
12
Power Plug
20
16
14
Microproc. w/ Memory
2-way Radio
Alarm
18

FIG. 1

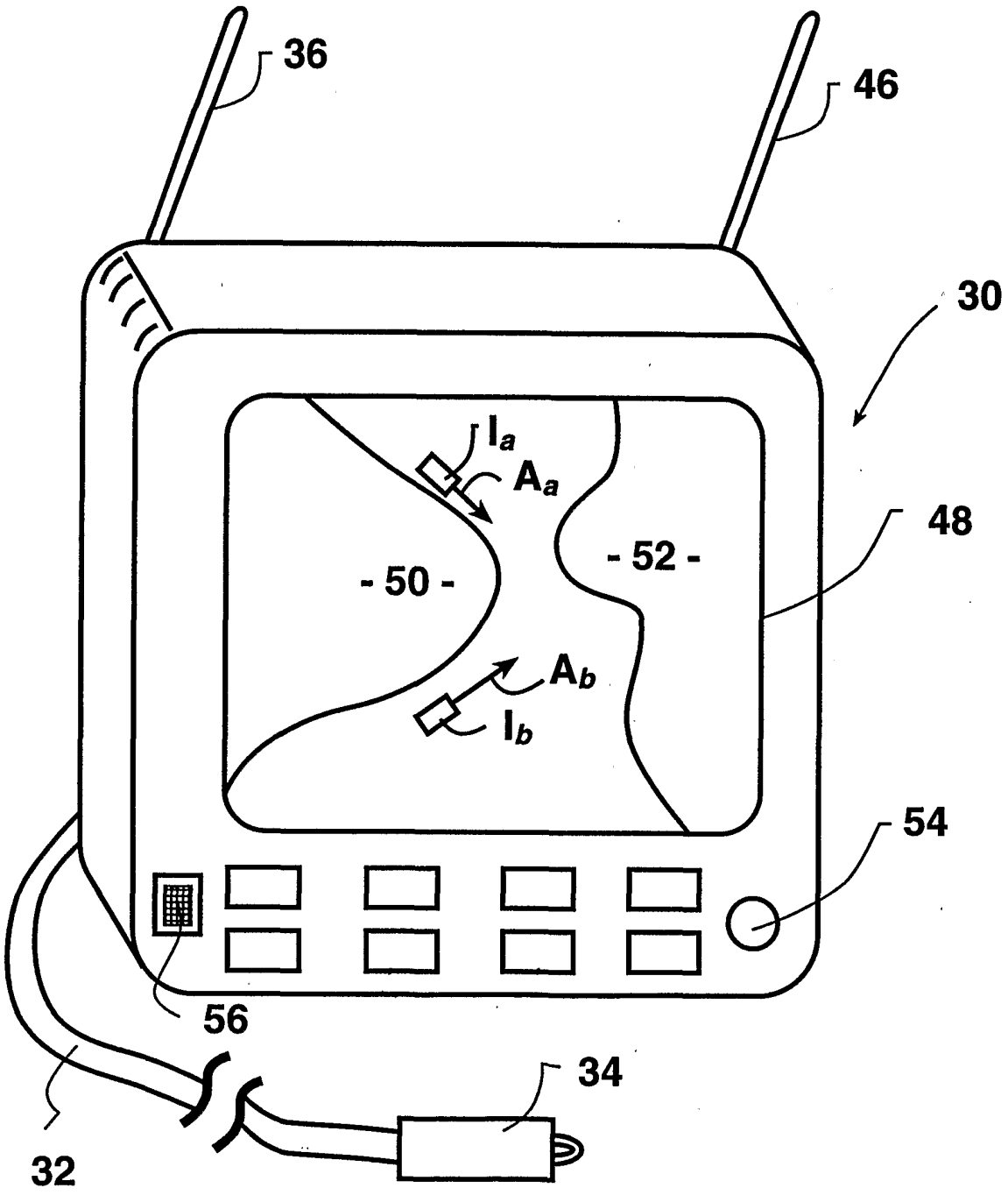

FIG. 2

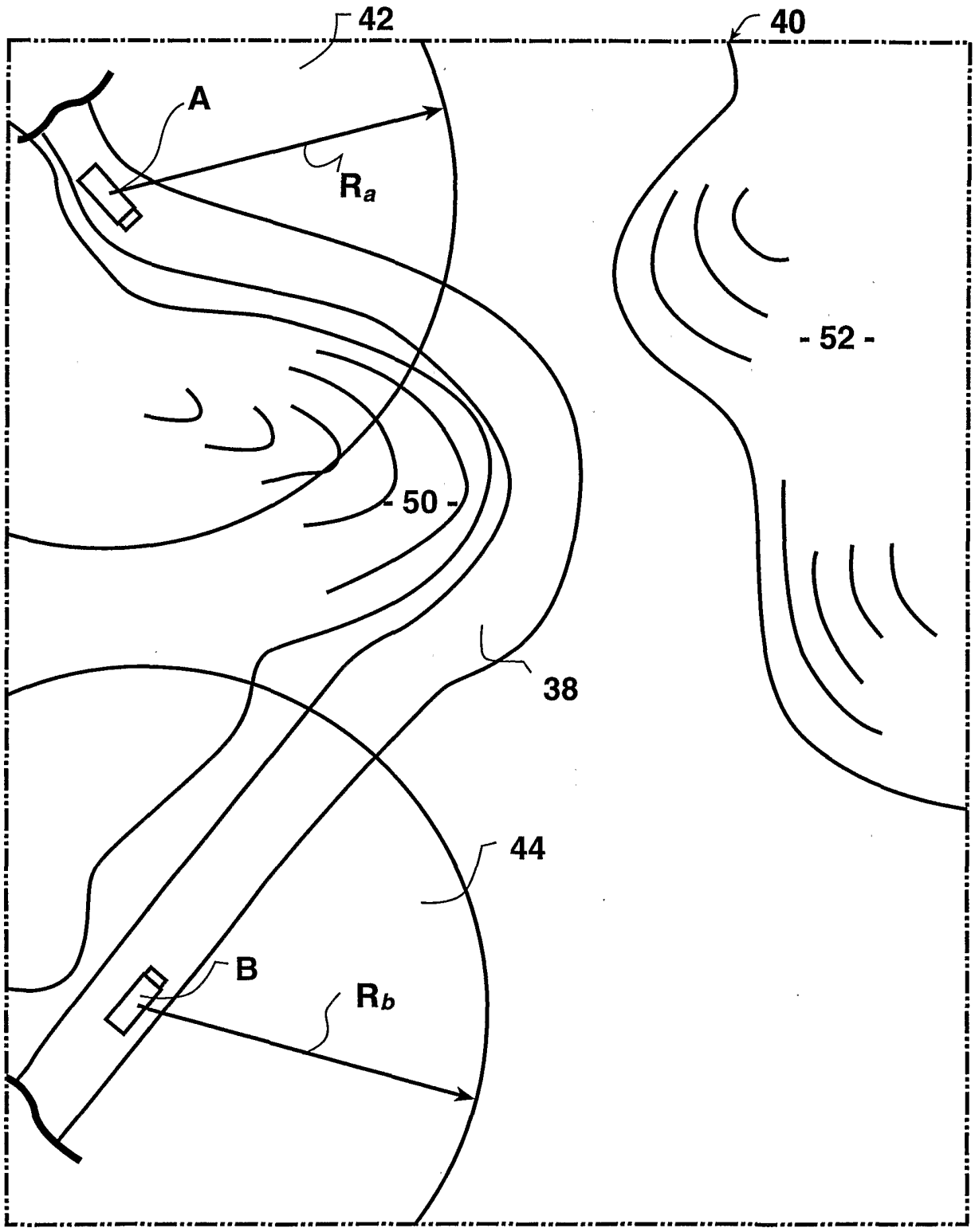

FIG. 3

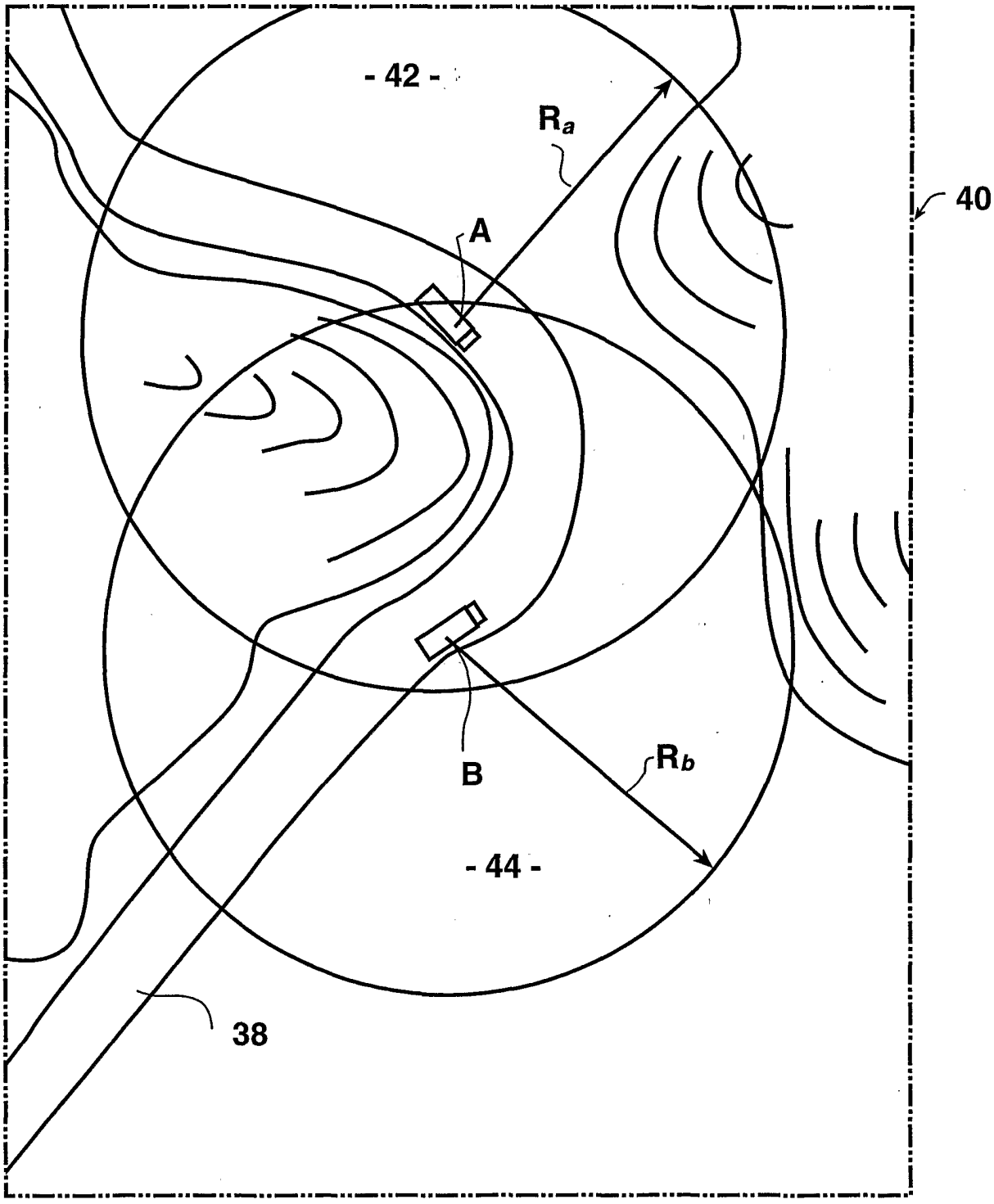

FIG. 4

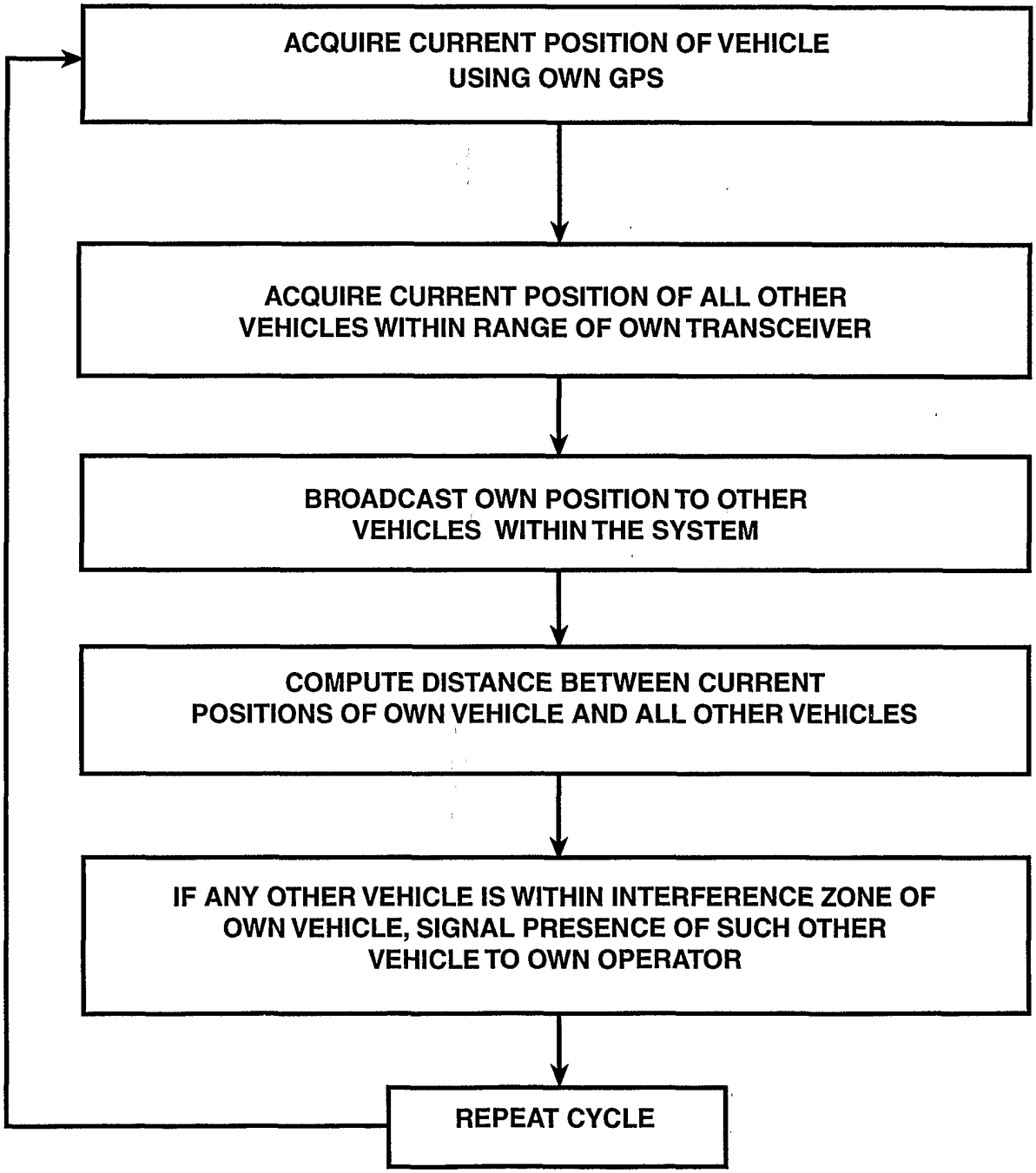
ACQUIRE CURRENT POSITION OF VEHICLE USING OWN GPS
ACQUIRE CURRENT POSITION OF ALL OTHER VEHICLES WITHIN RANGE OF OWN TRANSCEIVER
BROADCAST OWN POSITION TO OTHER VEHICLES WITHIN THE SYSTEM
COMPUTE DISTANCE BETWEEN CURRENT POSITIONS OF OWN VEHICLE AND ALL OTHER VEHICLES
IF ANY OTHER VEHICLE IS WITHIN INTERFERENCE ZONE OF OWN VEHICLE, SIGNAL PRESENCE OF SUCH OTHER VEHICLE TO OWN OPERATOR
REPEAT CYCLE

FIG. 5

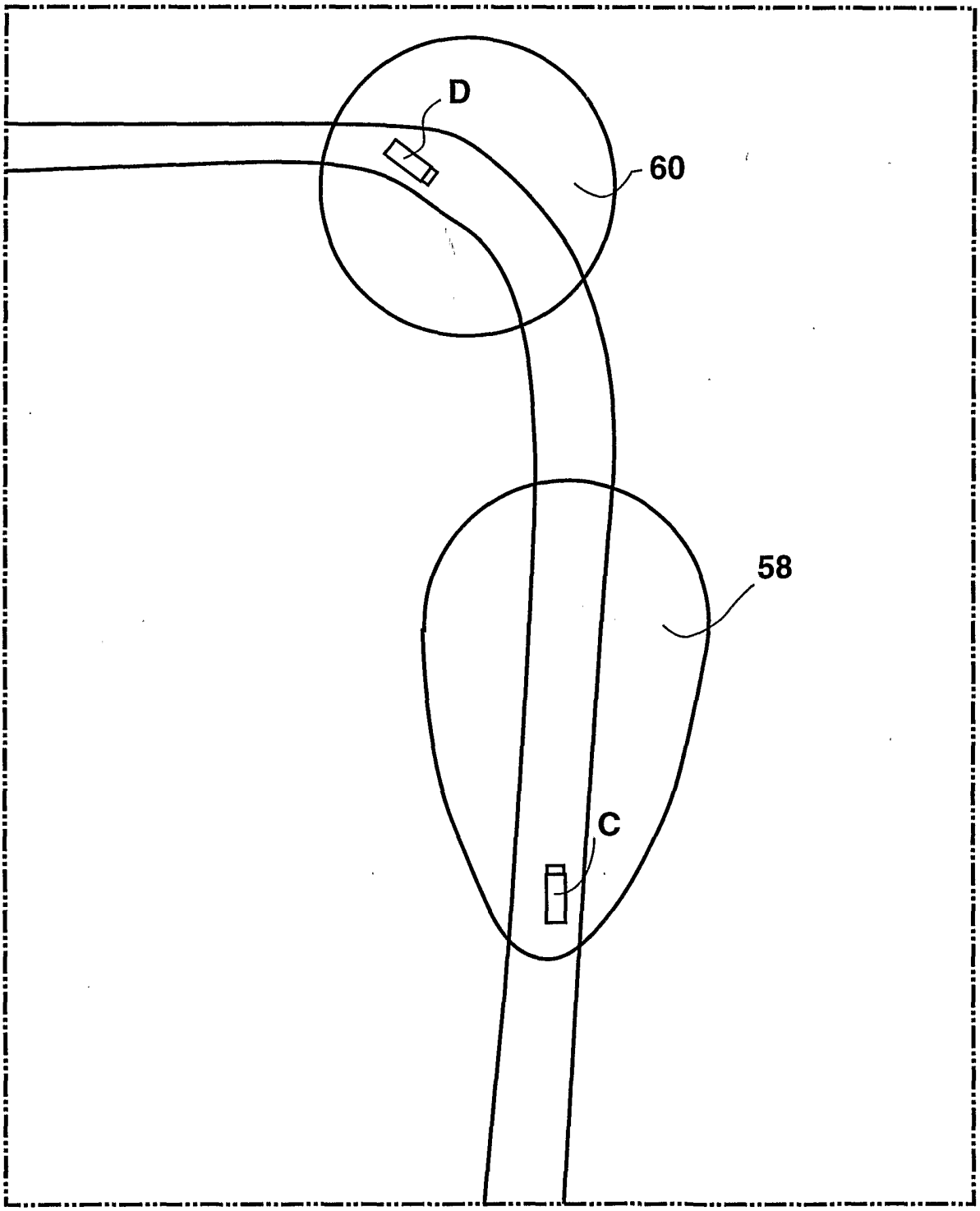

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/19603

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06F 17/10; G06G 7/78; H04B 7/185

US CL : 701/301; 340/903; 342/357.08

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)

U.S. : 701/301; 340/903; 342/357.08

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,872,526 A (Tognazzini) 16 February 1999 (16.02.1999), column 2-3.	1-8,12-20,24
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Y		9-11,21-23
Y	US 5,936,574 A (Klaschka) 10 August 1999 (10.08.1999), column 3.	9-11,21-23
A	US 5,952,959 A (Norris) 14 September 1999 (14.09.1999).	1-24
A	US 5,907,293 A (Tognazzini) 25 May 1999 (25.05.1999).	1-24
A	US 6,038,502 A (Sudo) 14 March 2000 (14.03.2000).	1-24
A	US 5,983,161 A (Lemelson et al.) 09 November 1999 (09.11.1999).	1-24

☐ 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

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Date of the actual completion of the international search	Date of mailing of the international search report
07 August 2001 (07.08.2001)	28 AUG 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer William A. Cuchlinski Diane Smith for Telephone No. 703-308-1113

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