(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 243 635
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 87103562.2

(22) Date of filing: 12.03.87

(51) Int. Cl.³: G 08 G 1/09
G 08 G 1/12

(30) Priority: 14.03.86 JP 57369/86

(43) Date of publication of application:
04.11.87 Bulletin 87/45

(84) Designated Contracting States:
DE FR GB

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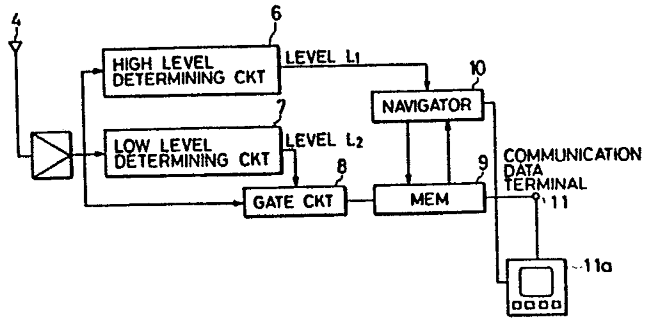
(54) **Roadside beacon system.**

(57) A navigation system in which road side antennas transmit both position calibrating data and local information to navigator devices installed in traveling vehicles. The navigator devices process the local information when the signal received from any of the antennas is above a relatively low level but processes the position calibrating data only when the signal is above a relatively high level, whereby recalibration is performed only in the immediate vicinity of one of the antennas but local information is received over a wider area.

FIG. 1



EP 0 243 635 A2

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ROADSIDE BEACON SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates generally to a roadside beacon system. More particularly, this invention relates to a roadside beacon system which is used to calibrate the position of a vehicle and to perform data transmission in a navigation system in which, after data on a departure point are inputted, vehicle speed data and direction data are inputted to enable the display of the present position of the vehicle.

Background of the Invention

A so-called "navigation system" for vehicles has been known in the art. In the system, a small computer and a small display unit are installed on a vehicle. A road map is read out of memory means such as a compact disk and displayed on the display unit. On the other hand, the vehicle speed data outputted by a vehicle speed sensor and the direction data provided by a direction sensor are inputted, so that calculation of the position of the vehicle and determination of the traveling direction of the vehicle are performed at all times. According to the results of the calculation and the determination, the vehicle is marked on the road map displayed on the display unit.

With the navigation system, the operator in the vehicle can visually detect the present position and the traveling direction of his vehicle. Therefore, he can reach his destination without losing his way.

However, the navigation system described above is disadvantageous in the following point. In the system, the errors inherent in the vehicle speed sensor and the direction sensor are accumulated as the vehicle runs. When the distance traveled by the vehicle exceeds a predetermined value (which is not always constant, being determined by the errors of the vehicle speed sensor and the direction sensor of each vehicle and by the environmental conditions of the positions where the sensors are installed), then the position of the vehicle displayed on the display unit is greatly shifted from the true position. That is, the system becomes unreliable and the vehicle operator may lose his way.

In order to overcome this difficulty, a so-called "roadside beacon system" has been proposed. In the system, roadside antennas are installed at intervals shorter than the distance with which the error accumulated exceeds the above-described predetermined value. The roadside antennas are used to transmit signals including position data and road direction data to predetermined relatively small areas, respectively. On the other hand, the signals thus transmitted are received through the antenna installed on a vehicle so that the position and the traveling direction of the vehicle are calibrated with a computer.

With the roadside beacon system, the error accumulated is smaller than the predetermined value so that the position of the vehicle can be displayed according to the correct position data and the accurate direction data at all times. This means the navigation system is reliable. If the roadside antenna is installed for instance near a railroad or a railroad crossing where the magnetic direction sensor is liable to erroneously operate, then errors attributed to external factors such as the railroad can be effectively eliminated.

In the above-described roadside beacon system, roadside antennas considerably high in directivity are used to transmit the aforementioned signals including position data and road direction data at all times. The vehicles receive the signals only when passing through the areas converted by the signals and the calibration is carried out according to the signals thus received. Therefore, if the area covered by the signal thus transmitted through each roadside antenna is increased, then the signal receiving position of the vehicle with respect to the roadside antenna is greatly shifted. As a result, the position and the traveling direction of the vehicle cannot be effectively calibrated.

The roadside beacon system is provided primarily for transmitting signals including position data and road direction data to vehicles having navigation systems. However, it is desirable to give the following functions to the system for more effective utilization:

(1) Traffic information such as traffic congestion, construction work and road condition near a roadside antenna are additionally transmitted to the navigation system to allow the smooth movement of the vehicle;

(2) Data concerning a detailed map including buildings with names around a roadside antenna are added to facilitate the navigation of the vehicle to a desired destination near the antenna; and

(3) Information on a relatively wide road map including the area where a roadside antenna is installed is additionally transmitted to the navigation system to renew the road map displayed on the display unit so that the operator can smoothly drive his vehicle to a distant place.

For these purposes, it is necessary to increase the frequency band of the signals transmitted through the roadside antennas and to increase the areas covered by the signals thus transmitted.

However, if the frequency band of the signals transmitted and the areas covered by the signals are increased, then the signal receiving position will be greatly separated from the position of the roadside antenna. Therefore, the calibration of the vehicle position, which is the original object of the navigation system, cannot be accurately achieved.

SUMMARY OF THE INVENTION

In view of the foregoing, an object of this invention is to provide a roadside beacon system in which a variety of function can be readily performed and calibration of a vehicle position can be achieved with high accuracy.

The foregoing object of the invention has been achieved by the provision of a roadside beacon system in which according to the invention, a navigator device is installed on a vehicle and is adapted to receive signals transmitted through each of several roadside antennas to calibrate and display vehicle position data. The navigator device includes data receiving means for receiving a transmitted signal when the level of the transmitted signal is higher than a relatively low level. Position determining means receive a transmitted signal when the level of the transmitted signal is higher than a relatively high level in order to output a position determination signal. Calibrating means calibrates position data based on data representing positions of antennas, for instance, which has been stored in navigator devices and direction data according to the position determination signal and data received.

In the system, the relatively low level should be set to a value with which the signals transmitted through the roadside antennas can be received without being affected by noise or the like. On the other hand, the relatively high level should be set to a value which is close to the peak value in level of a signal received by the navigator device when the vehicle confronts the roadside antenna.

Furthermore in the system, data transmitted for a relatively long period of time which is determined by the relatively low level are applied to a communication data terminal.

Therefore, a variety of data including a variety of data are transmitted to the vehicles through the roadside antennas installed along roads at predetermined positions. In the roadside beacon system thus organized, of the signals transmitted through the roadside antennas, the signal whose level is higher than the relatively low level can be received by the data receiving means and the signal whose level is higher than the relatively high level can be received by the position determining means thus providing the position determination signal. The calibrating means, receiving the data received by the data receiving means and the position determination signal outputted by the position determining means, calibrates the position data and the direction data. Then, navigation of the vehicle is continued by using the output signals of a vehicle speed sensor and a direction sensor.

Thereafter, the above-described calibration and navigation are repeatedly carried out so that the vehicle can smoothly travel.

In the above roadside beacon system, the relatively low level is set to the value with which the signals transmitted through the roadside antennas can be received without being affected by noise or the like. Then, the navigation system on the vehicle can receive signals including data necessary for additional functions as well as the position data and the road direction data which are absolutely required for the original position finding function.

Furthermore, in the above roadside beacon system, the relatively high level is set to the value which is close to the peak level value of the signal received by the navigator device when the vehicle confronts anyone of the roadside antennas. Thereby, the position data and the road direction data can be calibrated when the vehicle has approached the roadside antenna.

Moreover, in the above roadside beacon system, the data transmitted for a relatively long period of time which is determined by the relatively low level are applied to the communication data terminal, necessary communication data can be read with means connected to the communication data terminal.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing one example of a roadside beacon system according to this invention.

Fig. 2 is a graphical representation indicating the relation between the variation in level of a signal received by a mobile antenna and reference levels.

Figs. 3 and 4 are a plan view and a perspective view, respectively, outlining the roadside beacon system.

Fig. 5 is a schematic diagram showing one example of a road map displayed on a display unit in the system of the invention.

DETAILED DESCRIPTION OF THE PREFEERRED EMBODIMENTS

One embodiment of this invention will be described with reference to the accompanying drawings.

Fig. 5 is a diagram showing one example of a road map displayed on a display unit. The present position and traveling direction of the vehicle is indicated by the arrow A. The positions of roadside antennas P_1, P_2,... and P_n are also indicated (the indication of these roadside antennas not always being required). In addition, buildings or the like (not shown in Fig. 5) which can be used a guides are indicated.

Figs. 3 and 4 are schematic diagrams for a description of the road-side beacon system according to the invention. A roadside antenna 2 is installed at a predetermined position near a road 1. The roadside antenna 2 is connected to a navigation data transmitter 2a to transmit a signal including position data and road direction data. On the other hand, a mobile antenna 4 for receiving the aforementioned signal is installed at a predetermined position on a vehicle 3 which runs along the road 1. The signal received by the mobile antenna 4 is supplied to a navigation device (not shown in Figs. 3 and 4). The roadside antenna 2 is so high in directivity that it covers only a relatively small area R in Fig. 4. In addition, the roadside antenna 2 is such that it is non-directional for instance in a horizontal direction.

Fig. 1 is a block diagram showing one example of the roadside beacon system according to the invention.

The signal received by the mobile antenna 4, after being amplified by an amplifier 5, is supplied to a high level determining circuit 6, a low level determining circuit 7 and a gate circuit 8 which is opened by the output signal of the second level determining circuit 7. The signal passed through the gate circuit 8 is temporarily stored in a memory 9. Thereafter, necessary communication data are read out by a CRT display device 11a connected to a communication data terminal 11. On the other hand, data such as road direction data and map data are transferred into a navigation device. The present position data is applied to a navigator 10 in response to a position determining signal (or timing pulse signal) outputted by the high level determining circuit 6, so that the present position is calibrated.

The determining reference levels of the level determining circuits 6 and 7 are set, to L_1 and L_2 ($L_1 > L_2$) respectively.

The operation of the roadside beacon system thus organized will be described with reference to Fig. 2.

Let us consider the case where the vehicle 3 comes nearer to the roadside antenna 2 and then goes away it, i.e., the vehicle 3 passes by the roadside antenna 2.

First, the level of as signal received by the mobile antenna 4 is substantially zero (0). Therefore, signals whose levels are lower than the determining reference levels L_1 and L_2 are applied to both the level determining circuits 6 and 7. Therefore, the gate circuit 8 is maintained closed and no data is transferred to the memory 9, e.g., during the period T_1 in Fig. 2.

As the vehicle 3 approaches the roadside antenna 2, the level of the signal received by the antenna 4 gradually increases. However, the above-described operation is continued until the level of the signal applied to the low level determining circuit 7 becomes higher than the determining reference level L_2, (e.g., during the period T_2 in Fig. 2).

That is, during the above-described operation, no data is transferred to the navigator 10 from the memory 9, and the navigator 10 calculates and determines the present direction and the traveling direction of the vehicle according to the vehicle speed data outputted by a vehicle speed sensor (not shown) and the traveling direction data provided by a direction sensor (not shown), so that the present position and traveling direction of the vehicle together with the road map are displayed on the display unit (not shown).

As the vehicle 3 further approaches the roadside antenna 2, the level of the signal received by the antenna becomes higher. When the level of the signal supplied to the low level determining circuit 7 exceeds the lower reference level L_2, the gate circuit 8 is opened by the data-transmitting-area determination signal outputted by the low level determining circuit 7. As a result, the signal received by the mobile antenna 4 and amplified by the amplifier 5 is stored in the memory 9, (e.g., during the period T3 in Fig. 2) and predetermined data are applied to the communication data terminal 11 and the necessary data are inputted into the navigator 10.

When the vehicle 3 substantially confronts the roadside antenna 2, the level of the signal received by the mobile antenna 4 is further increased and the level of the signal supplied to the high level determining circuit 6 exceeds the high reference level L_1 so that the high level determining circuit 6 outputs a position determination signal which is applied to the navigator 10. At the same time, of the data stored in the memory 9, the position data is transferred to the navigator 10, so the present position stored in the navigator 10 is calibrated. Thus, the position data and the traveling direction data have been calibrated. That is, the correct present position and traveling direction can be displayed on the display unit.

Thereafter, with the present position and traveling direction thus calibrated as references, the position and the traveling direction of the vehicle 3 can be displayed as a function of time with the arrow A on the display unit 11a together with the road map using the vehicle speed data outputted by the vehicle speed sensor and the traveling direction data provided by the direction sensor.

Fig. 2 shows the variation in level of the signal received by the vehicle 3 which runs at a constant speed. In the case when the vehicle moves at different speeds, the periods T_1, T_2 and T_3 are merely varied, shortened or lengthened, according to the speeds, which will not change the effect of the invention.

As was described above, in the roadside beacon system according to the invention, when the level of the signal received by the mobile antenna exceeds the relatively low level, i.e., the data transmission can be effectively carried out, the necessary data are stored in the memory 9 temporarily, and the predetermined data are store in the navigator 10. Only when the vehicle has sufficiently approached the roadside antenna 2 is the position data transferred to the navigator 10 so that the present position and the traveling direction of the vehicle are calibrated. Therefore, even if the number of pieces of data transmitted through the roadside antenna 2 increases, the data can be positively written in the navigator 10. Therefore, the system can perform a variety of functions (such as displaying road conditions and traffic congestion). Furthermore, other necessary communication data can be transmitted to the communication data terminal 11. Since the position detection of the vehicle 3 is carried out when the vehicle comes sufficiently close to the roadside antenna 2 and the received signal level reaches the peak value, the position of the vehicle 3 can be detected with high accuracy.

In the system of the invention, the threshold level for storing data transmitted through the roadside antenna is set at a low level and the treshould level for detecting the position of the vehicle is set to a high level with the result that the position detection is carried out with high accuracy and the number of pieces of data transmitted can be increased.

CLAIMS

What is claimed is:

1. A roadside vehicle system, comprising:

a plurality of antennas installed along sides of roads at predetermined positions and connected to at least one data transmitter for transmitting a data signal to vehicles; and

a navigator device installed in at least one of said vehicles, each said navigator device comprising

a data signal receiving means for receiving said transmitted data signal from one of said antennas when a level of said transmitted data signal is higher than a first level and outputting a data signal,

position determining means for receiving said transmitted data signal when said transmitted signal is substantially higher than a second level higher than said first level, and outputting a position determining signal,

calibrating means for calibrating according to said data and position determining signals position data of said vehicle in which said each navigator device is installed, and

means for displaying said calibrated position data on said vehicle.

2. A roadside beacon system as recited in Claim 1, wherein said first level is set relative to a noise level of transmission from said antennas.

3. A roadside beacon system as recited in Claim 1, wherein said second level is set to a substantial fraction of a level of said transmitted signal received by said vehicle immediately confronting one of said antennas while positioned on said roads.

4. A road side beacon system as recited in Claim 1, wherein said navigator device includes a gate circuit receiving said data signal, a memory receiving an output of said gate circuit, a first determining circuit triggered at said first level for causing said gate circuit to pass said data signal to said memory, and a second determining circuit triggered at said second level for causing said navigator device to process said position calibrating data received from said memory.

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FIG. 1

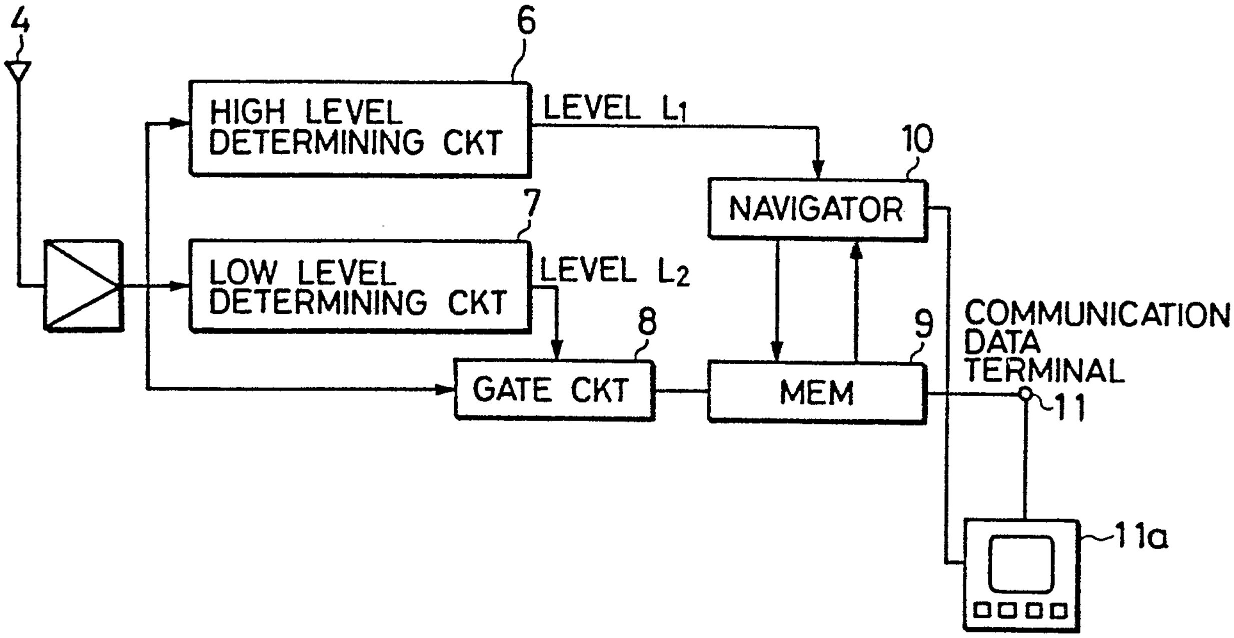

FIG. 2

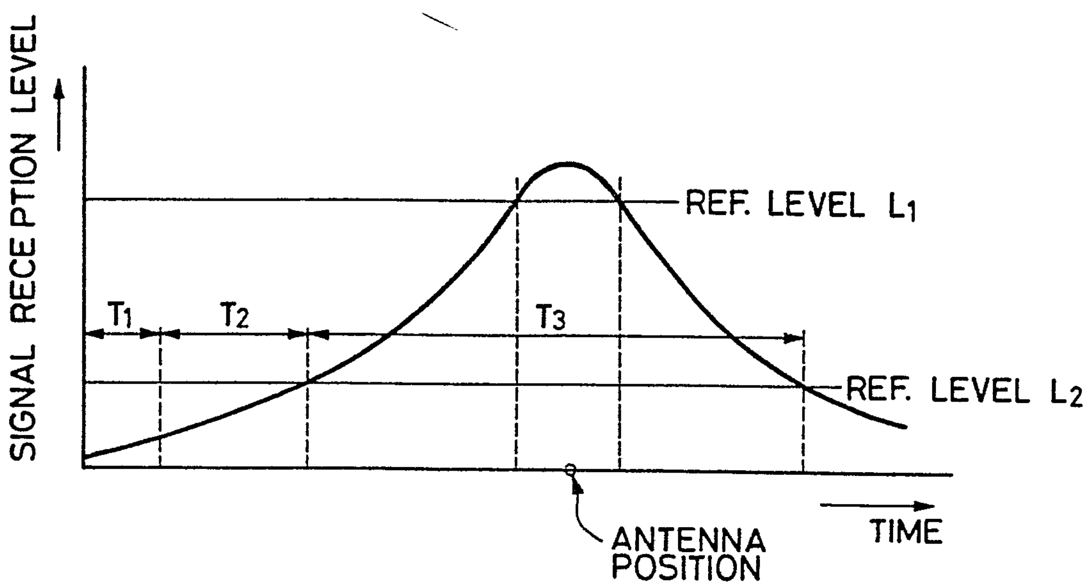

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FIG. 3

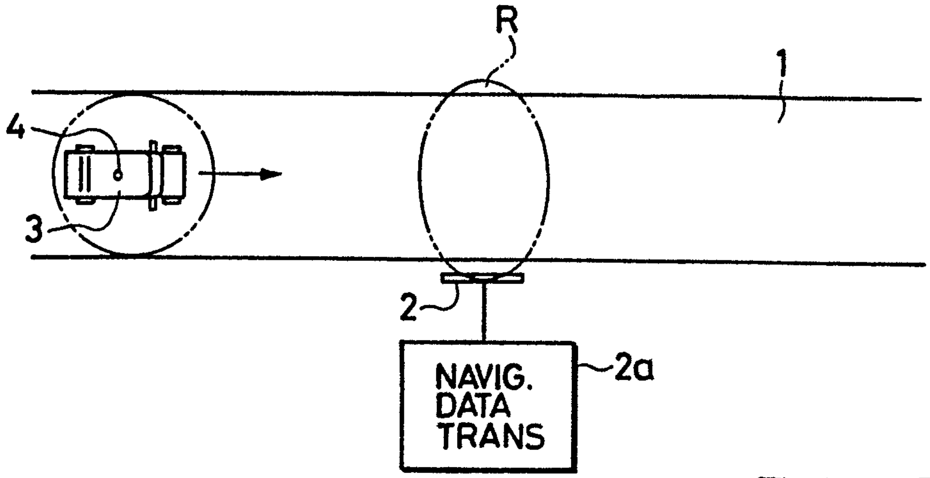

FIG. 4

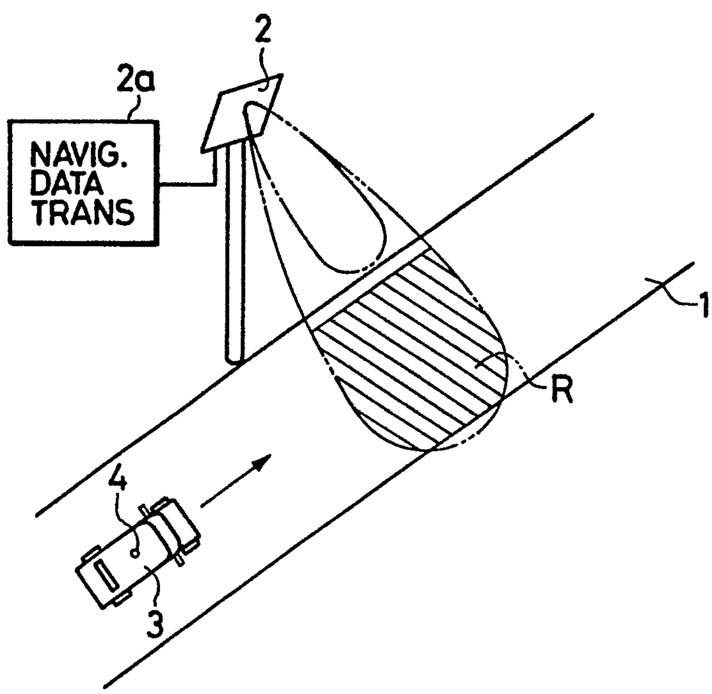

FIG. 5