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(54) Roadside communication system

(57) Antennas 1a and 1b are located above each lanes of the road so that the antennas can communicate with mobile stations which are loaded on vehicles that approache the toll gate along each of the lanes. When a vehicle approaches the toll gate, a beacon detects the vehicle and requests an ID signal toward the mobile station that is loaded on the vehicle. In response, the mobile station transmits an ID signal on a radio frequency toward each of the antennas. Then, the beacon receives the ID signal with each antenna, and analyses the signal voltage levels. Then, the beacon selects an antenna which provided the highest voltage signal, and proceeds communication between the mobile station with the antenna of the highest level.

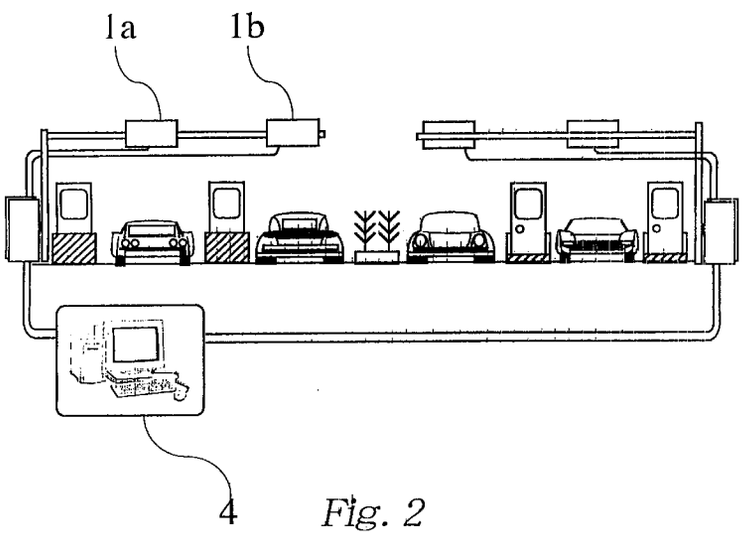

Fig. 2

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Description

BACKGROUND OF THE INVENTION

This invention relates to an communication systems on toll roads, including automatic toll gate systems.

This application is a counterpart application of Japanese application Serial Number 302765/1996,filed November 14, 1996, the subject matter of which is incorporated herein by reference.

In the automatic toll gate system, this invention relates to a vehicle identifier system that detects and identifies vehicles which pass through the toll gate.

And this invention especially relates to the system which is settled beside a road which comprises a plurality of lanes on each way.

Fig. 1 shows elements of a typical automatic toll gate system.

As shown in the figure, the automatic toll gate system comprises a roadside system and a mobile station including a transponder.

As shown in the figure, the roadside system comprises an antenna assembly 1, a beacon 2, and a roadside controller 4.

The antenna assembly 1 transmits and receives information signals between the antenna assembly 1 and mobile station (shown below) while a vehicle runs through under the antenna assembly 1 along the road.

The beacon 2 has three functions. One function is to detect vehicle. Another function is to communicate with the mobile station while the vehicle runs through below the antennas 1 or 2. And still another function is to detect received signal level from the mobile station .

The roadside controller 4, in addition to general control of popular beacon 2 functions, compares plural received signal level.

The antenna assembly 1 comprises plane antennas 1a and 1b. The antennas are located above each lanes of the road. Each of the antennas 1a and 1b radiates a radio frequency over service areas on each lanes. The service areas are elongated along each lanes so that the beacon 2 can take a time period long enough to communicate with the mobile station.

The roadside controller 4 detects vehicle when a vehicle comes into the service area. The detection is established by the beacon 2, through the radio communication between the antenna 1 and the mobile station. Then, the roadside controller 4 sends a request signal toward the mobile station to request a response including a vehicle identification signal.

On the other hand, the mobile station is set on each vehicles.

On receiving the request signal from the roadside controller 4, the mobile station transmits an identification signal. The identification signal is unique with each transponder.

This identification signal is utilized to identify a vehicle from another. If the roadside controller 4 receive two different identification signals, the roadside controller 4is regarded to detect two different vehicles.

After that identification, the controlller researches whether the vehicle is permitted to pas through the toll gate without toll payment. If roadside controller 4 finds the vehicle is permitted, the roadside controller 4 tells a electronic banking system (not shown) that the vehicle goes through the toll gate. Then the banking system carries out the toll payment operation automatically.

Fig. 2 shows a sectional view of a roadside tollgate utilizing the automatic toll gate system.

As shown in the figure, antennas 1a and 1b are located straight above the lanes so that the vehicles go through near one of those antennas. Each antenna communicates with vehicles that go through the lanes stright under the antenna.

Because the antenna has to identify each vehicle to communicate individually, each antenna communicates with vehicles on the lanes in pararell.

This pararell communication by each of the antennas is indispensable in the case that two or more vehicles run along each lane substantially side by side.

Because, in such a case, one antenna can communicate with only one vehicle. This limitation is effective in order to avoid communication failure caused by confusion.

In the toll gate communitcation, it is important to assume communication accurcy at the toll gate. In order to assume the communication accurcy, each datas received by the antenna must be identified to be transmitted from the same vehicle. To assume that, one effecive resolution is to join each antenna to each lane (or vehicle on the lane) one by one. In this case, each antenna never communicates with two or more vehicles in pararell. As a result of the above design, the communications between each antenna and each vehicles are not interrupted by inaccurate communication dates.

In the above case, there are two important technical subjects. However, those technical subjects make a contradiction, and will bring a system design of the system into a technical dilemma.

The first subject is to lengthen a service area of the antenna along the lanes. That is, to lengthen the distance L shown in Fig. 3. The main purpose to lengthen the service area is, to elongate a time period which allows data communication between the antenna 1a or 1b and the vehicle transmitter 3.

The first subject is an important subject in order to assure communication accuracy between the antenna 1a or 1b and the vehicle transmitter, because the distance shown in Fig.3 must be longer when the vehicle runs at higher speed, in order to elongate the time period to complete the data communication between the antenna 1a or 1b and the vehicle transmitter 3. It is because, vehicle at higher speed only needs less time to run through the distance L of the service area .

It is also important because the communication must be repeated between the antenna 1a or 1b and the

vehicle transmitter in case the communication failed by some reasons. The repeated communications take a considerably long time. In order to complete the communication by repetition, the time period which allows data communication must be elongated enough.

The communication accuracy is a critical problem in the toll gate system case, because the toll gate system handles money transaction.

And, the second subject is to sharpen the service area of the antenna across the lanes. That is, to contract the width W shown in Fig. 4. The main purpose to sharpen the service area is, to keep the antenna from communication with improper vehicles on the other lanes.

In case the improper communication occurs, a plurality of antennas 1s will try to communicate with only one vehicle transmitter. As a result, the beacon 2 misdetects the one vehicle as a plurality of vehicles. If two antennas communicate with one vehicle, the beacon misdetects the vehicle as two vehicles.

In this case, the system will request for fee payment twice.

On the contrary, another case of misdetection could occur. It is to overlook a vehicle when two or more vehicle come along substantially side by side. In this case, one or more antennas communicate with a n improper vehicles, and ignore another proper vehicle which should have been detected, because the antenna fully spends its limited communication capacity to the wrong communication with the improper vehicle, and never keeps its capacity for communication with the proper vehicle.

In addition to the two main subjects cited above, still another extra subject to sharpen the service area is, to keep the communication from radiowave or electromagnetic noize.

Moreover, there is still another technical problem that the antenna tends to be larger and heavier. It will be inevitable because directional antennas are utilized in order to sharpen the service area. The directional antennas are relatively large and heavy.

SUMMARY OF THE INVENTION

Reviewing the above cited technical problems, this invention will try to provide a suitable solution against the dilemma. Objectively, this invention will keep the toll gate system free from the misdetection of vehicles when the service area is elongated.

In order to prevent the misdetection, the system observes the received radiowave signals from the mobile station, and detects signal levels from the radiowave signals. If the plurality of antennas receive radiowave signals from one mobile station, the beacon compares the signal levels from each antennas, and employs only one signal that shows higher (or highest) signal level. Then, the following signals from the antenna which received the higher (or highest) level signal will be employed by the beacon.

The higher (or highest) signal level shows a relatively closer (or closest) communication between an antenna and a mobile station. It means that the antenna than brings a higher (or highest) signal level is one the antennas which is positioned straight above the lane along which the vehicle is running.

At the same time, other signals which show relatively lower signal levels are cancelled to be improper, and the following signals are as well.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a driver's view when a vehicle comes up to an automatic toll gate.

Fig. 2 shows a summarized sectional view of an automatic toll gate system.

Fig. 3 shows a conceptional view of a service area length.

Fig. 4 shows a conceptional view of a service area width, and also of a misdetection of vehicles.

Fig. 5 shows a conceptional view that the plurality of antennas request an ID signal for a mobile station.

Fig. 6 shows a conceptional view that the mobile station transmits ID signal in response to the request.

Fig. 7 shows a conceptional view that the beacon detects signals and compares the signal levels.

DESCRIPTION OF THE PREFFERED EMBODIMENTS

The following description will explain an desirable embodiment of this invention.

Fig. 5 shows a conceptional view of the toll gate system from the driver's position. As shown in the fig. 5, antennae 1a and 1b are held aloft above the road. Each of the antennas are positioned substantially straight above each lane, so that each of the antennas correspond with each lanes one by one.

These antennas 1a and 1b communicate with the vehicle transmitter (cited as 3 below) being kept under control of beacon 2. Under the control of the beacon 2, the antennas 1a and 1b synchronize with each other in communication process between the antennas and the vehicle transmitter.

On the other hand, a vehicle comprises a mobile station 3. The transponder has a radiowave transceiver that can exchange digital dates between the antennas 1a and 1b. The datas include vehicle ID data, which is unique to each transponder 3.

When a vehicle approaches the toll gate, the beacon 2 detects the vehicle. Then the beacon 2 generates a request signal (not shown), and transmits the request signal from the antennas 1a and 1b toward the vehicle. In this condition, the beacon 2 does not recognize whether the vehicle is on the right lane (above which the antenna 1a is held aloft) or on the left lane (above which the antenna 1b is held aloft).

This request signal should be synchronized, because the mobile station 3 should correctly regard that the request signal was transmitted only once, not twice.

When the request signal is transmitted from the antenna 1a or 1b, the mobile station 3 receives the request signal. In this condition, the mobile station 3 does not distinguish from which antenna 1a or 1b the request signal was received.

Regardless of which antenna has transmitted the request signal that is received by the mobile station 3, the mobile station 3 transmits a response signal (not shown) toward both of the antennas 1a and 1b. The mobile station 3 does not specify a transmission object as the antenna 1a or 1b but radiates the radiofrequency response signal broadly forward.

On receiving the response signal from the mobile station 3, the beacon 2 interrupts the signal transmission temporally. During the interruption, the beacon 2 analyses the response signals received by the antennas 1a and 1b.

The analysis contains two sequential processes; a first process to find vehicle IDs contained in the response signals both from the antennas 1a and 1b, and a second process to compare whether the vehicle IDs from the antenna 1a and the one from the antenna 1b are the same or not.

If each vehicle IDs from the antenna 1a and the one from the antenna 1b are different, the beacon 2 resumes each communication utilizing the antennas 1a and 1b. In this condition, the antennas 1a and 1b are communicating with respective mobile station 3s. That is, two (or more) vehicles are approaching the toll gate substantially side by side. So, the beacon 2 must continue communication with each mobile station 3s, in order to settle account on each vehicle respectively.

If the vehicle IDs from the antenna 1a and one from the antenna 1b are the same, the two response signals from the antennas 1a and 1b are transmitted from the same vehicle, and the response signals are all the same. In this condition, the beacon 2 utilizes only one response signal for fee account.

In order to determine which response signal to utilize for account, the beacon 2 measures signal levels of each response signals. Then the beacon 2 translates the signal levels into additional level signals.

These additional level signals indicate distances between antennas 1a or 1b and mobile station 3, because the signal levels of the response signals fluctuate on the distances. The response signal recedes when it is radiated from the mobile station 3.

Then, the beacon 2 transmits the additional level signals to the beacon controller.

On receiving the additional level signals, the beacon controller 4 compares the singnal levels of the response signals each received by the antenna 1a and received by the antenna 1b.

As cited above, each of the signal levels indicate the distances between the mobile station 3 and each antennas 1a and 1b.

The distances inform that along which lane the vehicle is going. By comparing the distance, it is identified which antenna was of the shortest distanse from the mobile station 3.

Then, the antenna of the shortest distance should continue communication with the mobile station 3. The other antenna should cease their communication, because it has been communicating with improper vehicle on the lane that =`X not positioned straight below the antennas.

After that identification, the antenna 1a, of the shortest distance, resumes the communication process.

Accorcding to the identifidation, the beacon controller 4 registers the ID of the mobile station 3. Then the vehicle corresponding to the ID is regarded to run along the lane which is straight below the antenna 1a.

Following to the charge processing, the beacon 2 transmits following signals. The following signals show that the beacon controller 4 has registered the vehicle ID to the system.

On the other hand, the antenna 1b, of the longer distsance, keeps the following communication process in suspend.

Instead of the following communication process, the antenna 1b transmits the request signal repeatedly, because the antenna 1b must communicate with another vehicle that approaches the toll gate along the lane below the antenna 1b.

By this cease of the communication and repetition of the request signal, the antenna 1b is free from wasting communication ability.

According to the process as cited above, the communication between the antenna 1a or 1b and the mobile station 3 is completed only once for one mobile station 3. This process is effective for fee transaction accuracy, because the toll gate system can avoid double charge of the fee. And this process is also effective for accuracy, because the beacon will not overlook any vehicles which have mobile stations.

Claims

1. A roadside communication system for vehicle comprising;

   a beacon which can promote a plurality of communication processes in pararell,
   plurality of antennas which are connected to said beacon so that the antennas can promote each communication process,
   a mobile station which is loaded on a vehicle and
   communicates between said antennas,
   wherein said beacon selects the nearest antenna to said mobile station from said plurarily of antennas to communicate with said

mobile station, utilizing said selected antenna.

2. A roadside communication system cited in claim 1, wherein said beacon selects the antenna which received a signal from sid mobile station by the highest level.

3. A roadside communication system cited in claim 1, wherein said antennas which are not slected by the beacon do not continue communication with said mobile station when said beacon selects said antenna.

4. A roadside communication system cited in claim 2, wherein said antennas which are not slected by the beacon do not continue communication with said mobile station when said beacon selects said antenna.

5. A roadside communication system cited in claim 2, wherein said mobile station transmits communication signals which include an ID signal that is unique to each of said mobile stations.

6. A roadside communication system cited in claim 4, wherein said mobile station transmits communication signal which include an ID signal that is unique to each of said mobile stations.

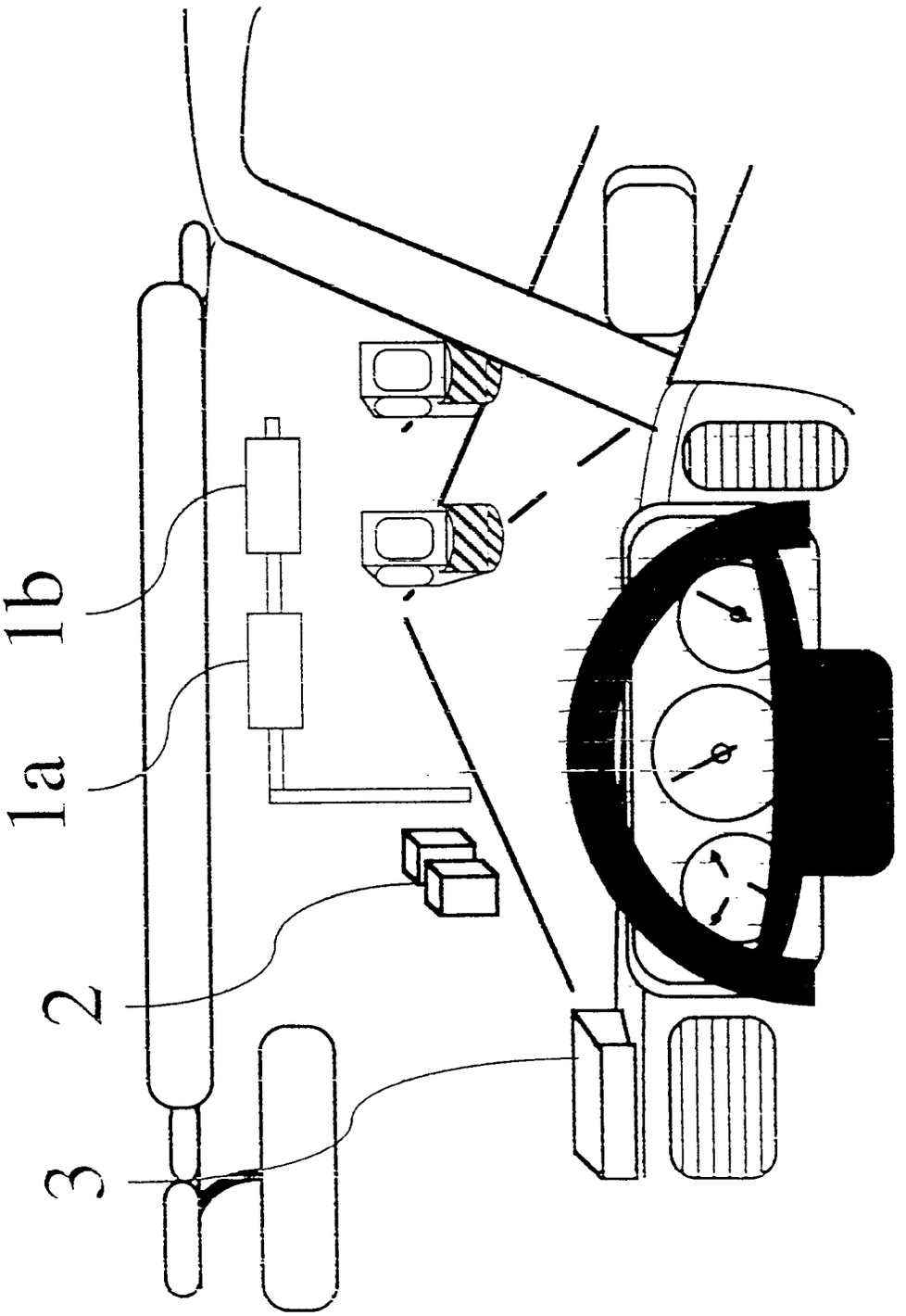

Fig. 1

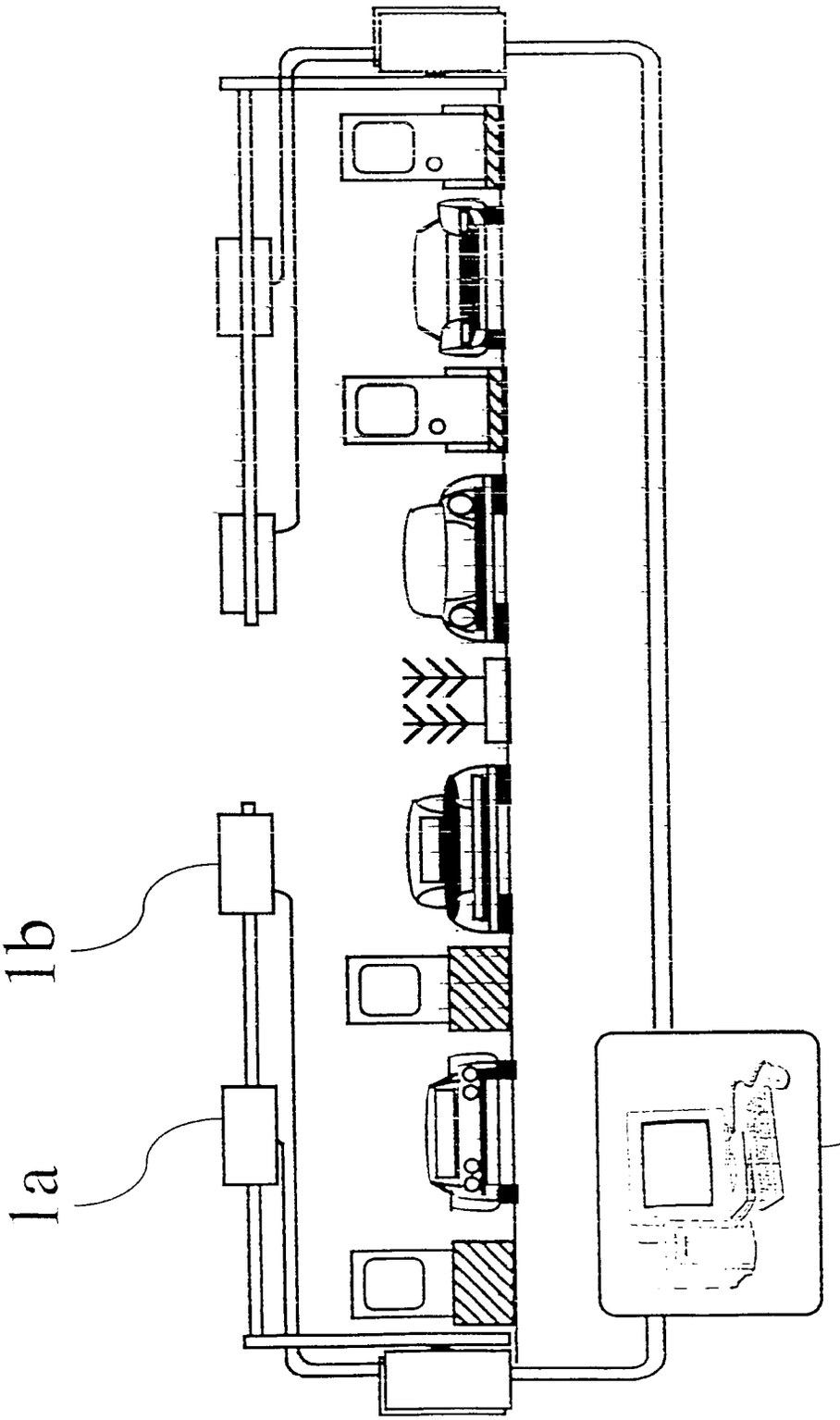

Fig. 2

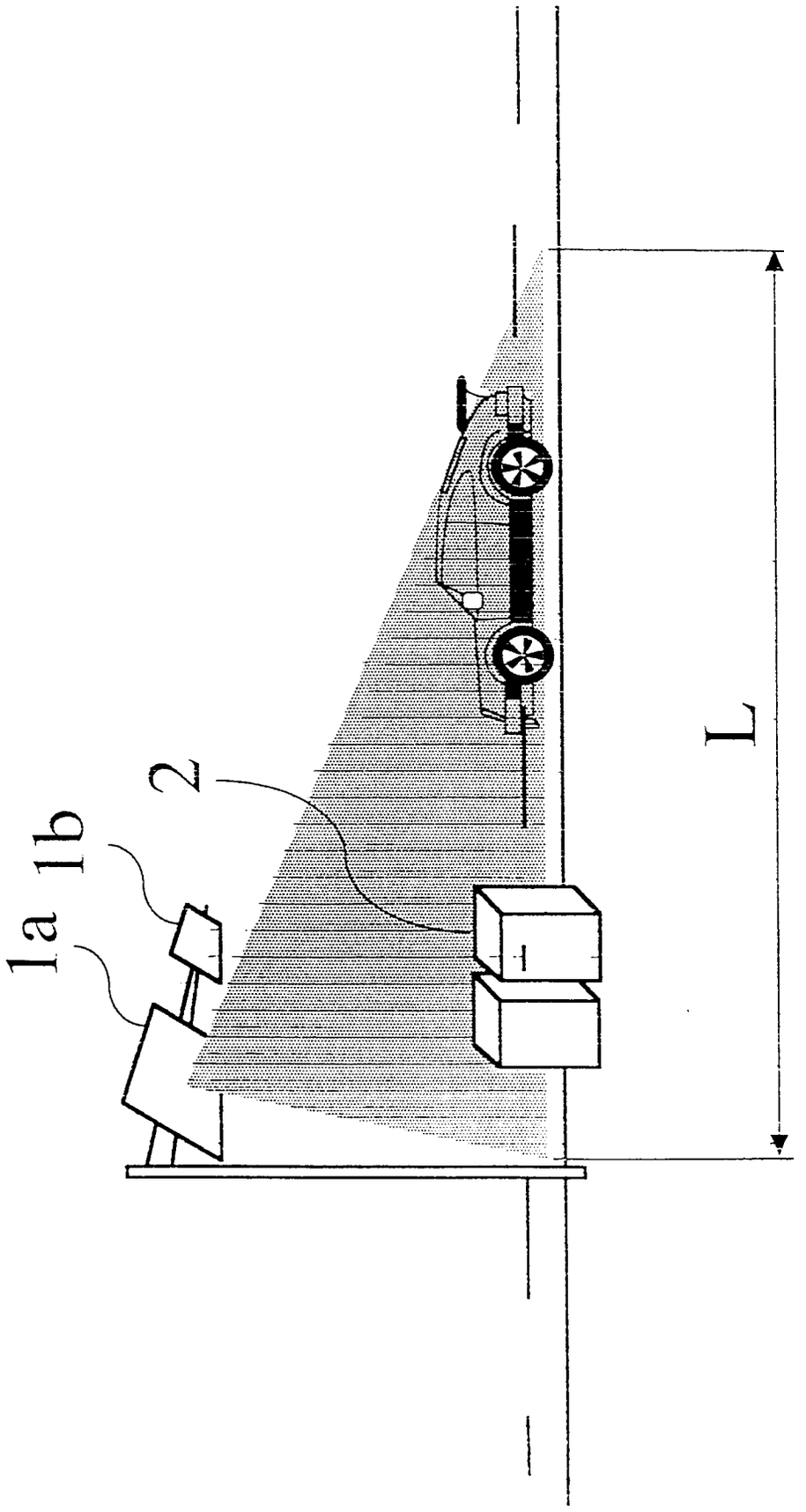

Fig. 3

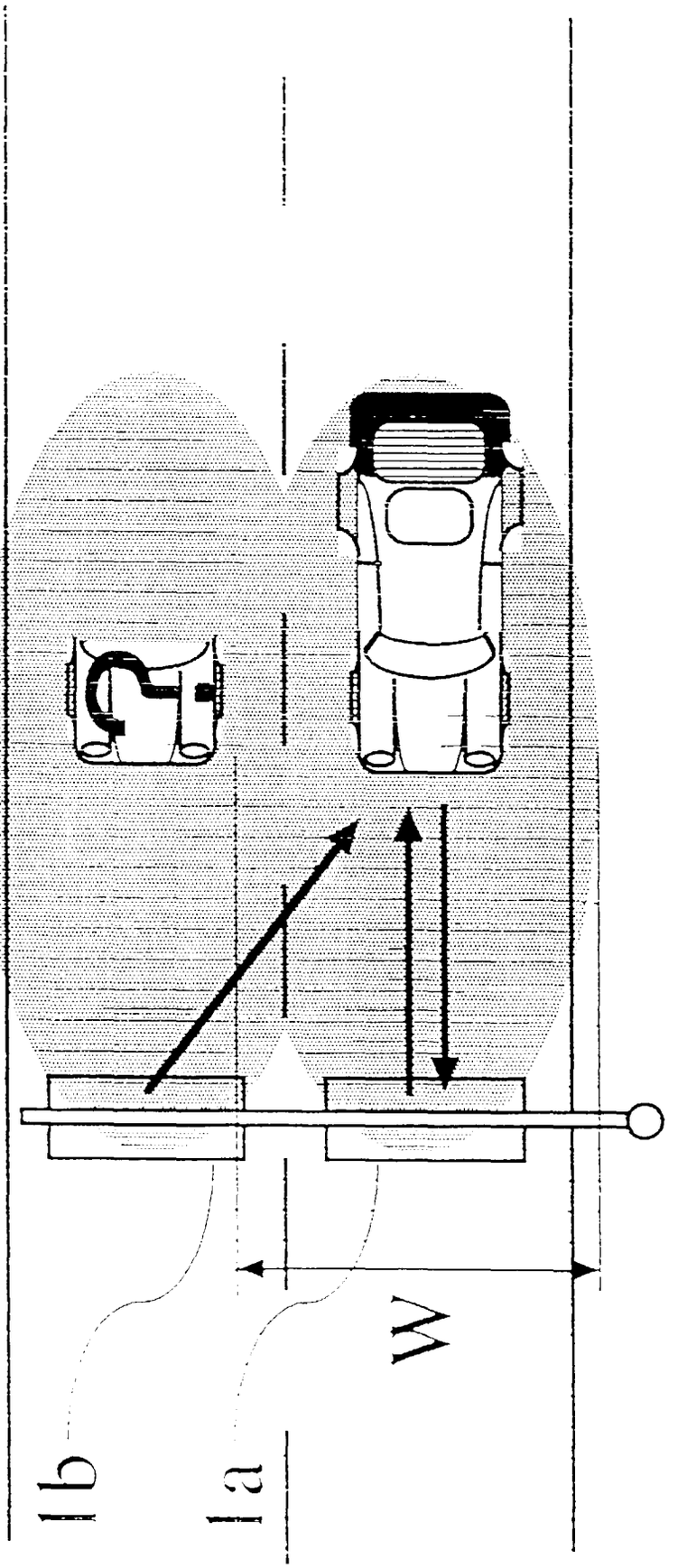

Fig. 4

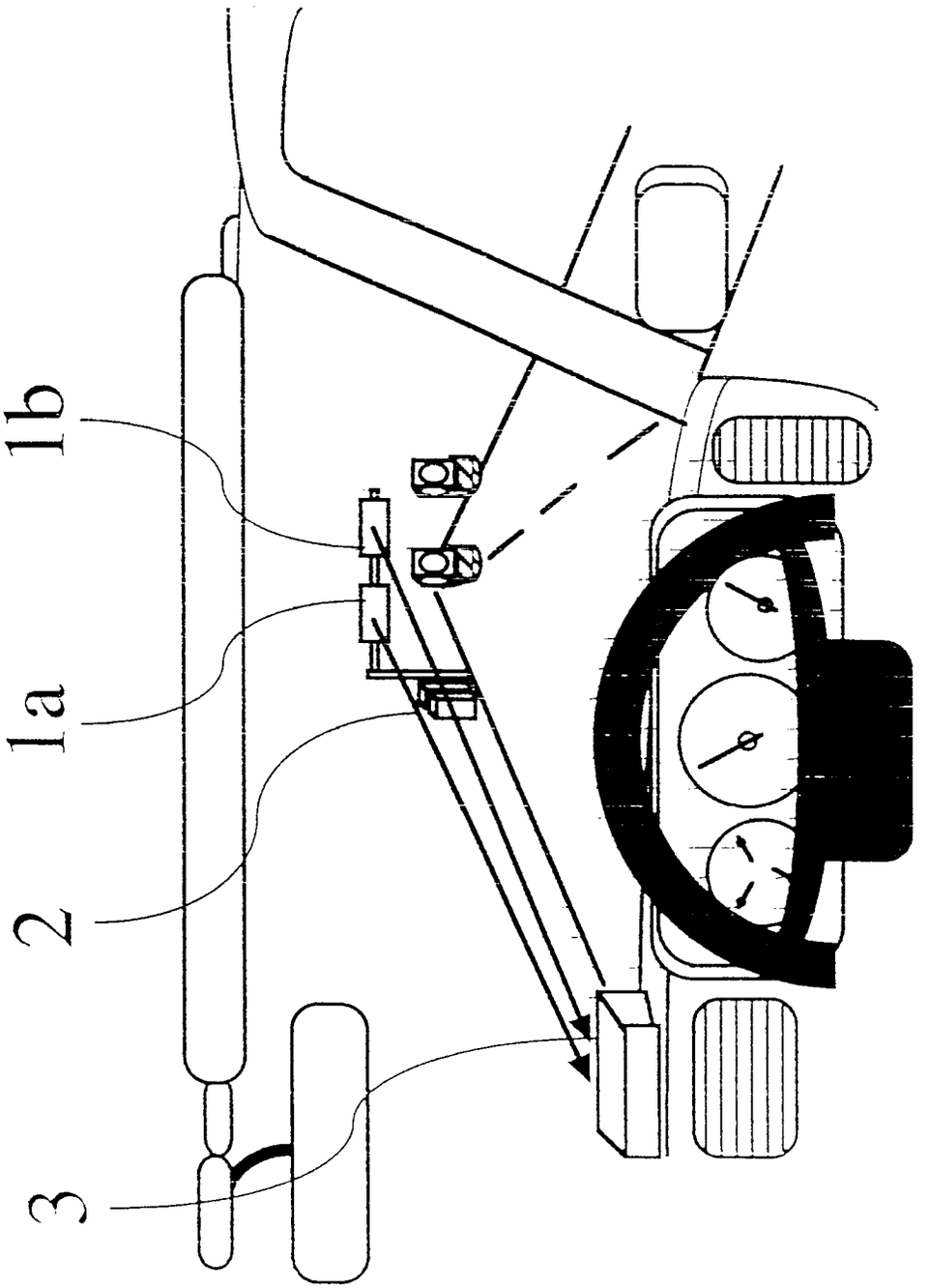

Fig. 5

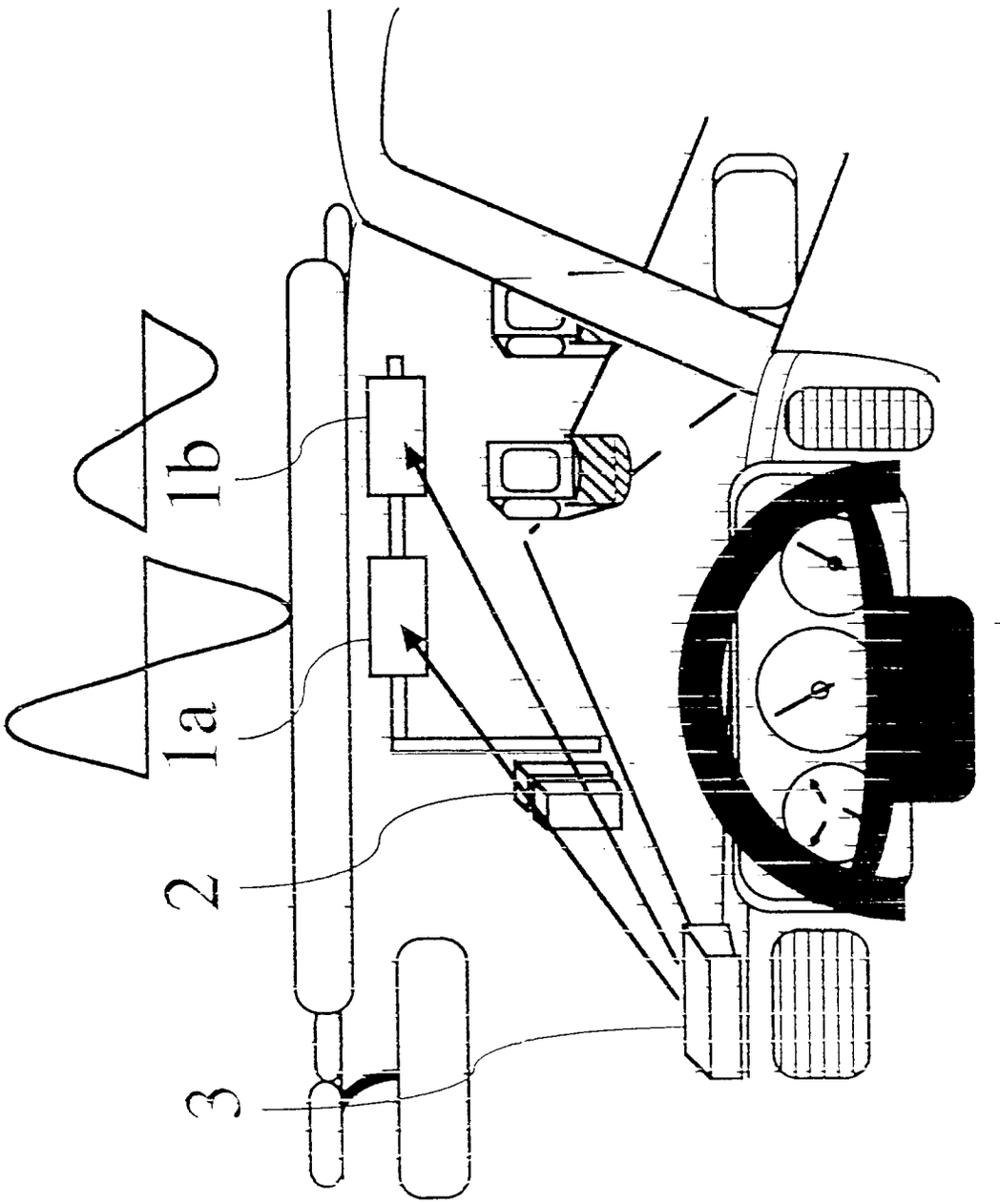

Fig. 6

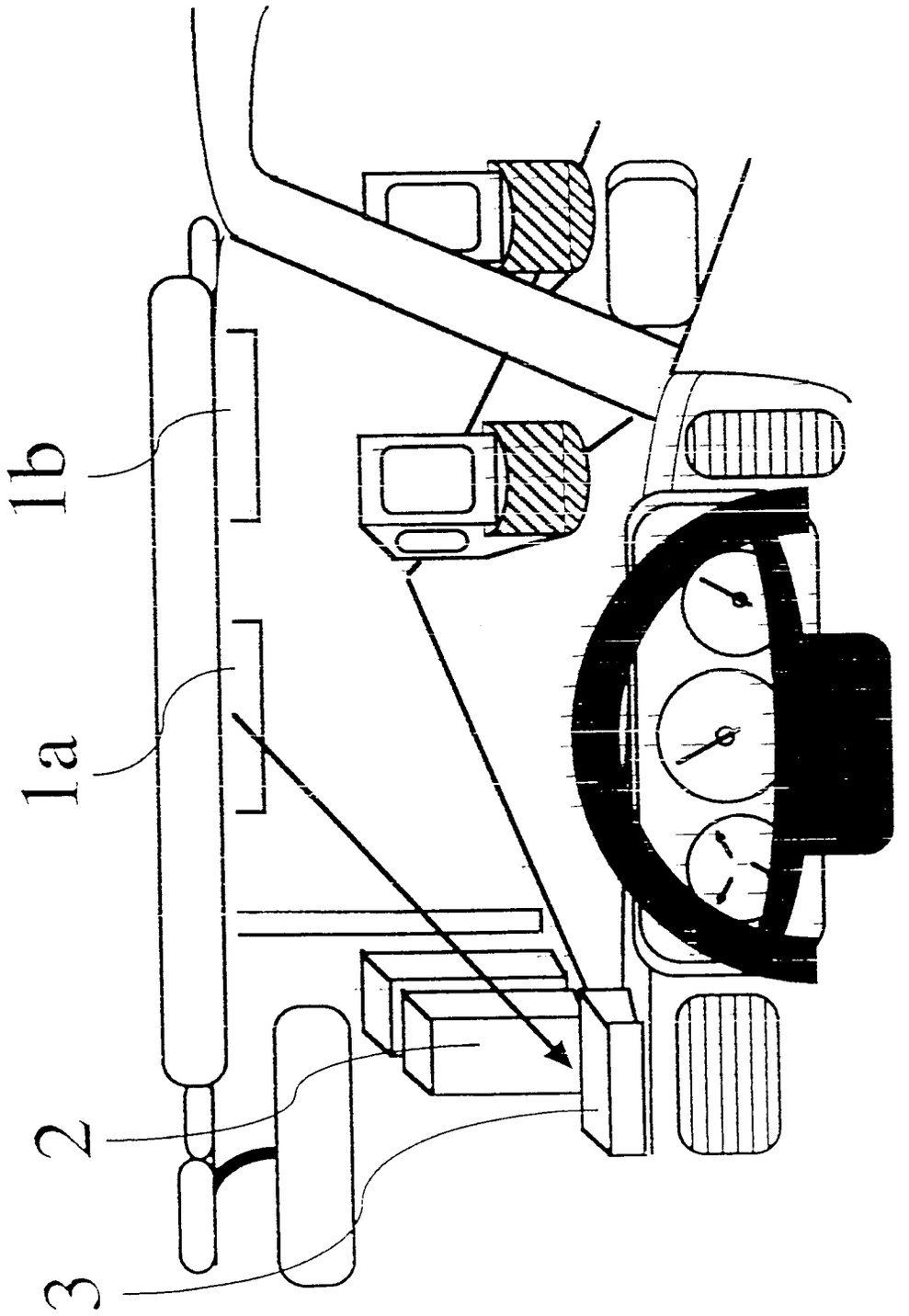

Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 12 0015

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 567 905 A (BOSCH GMBH ROBERT) * the whole document *	1,2	G08G1/017
A	---	3-6	
X	EP 0 613 108 A (TEXAS INSTRUMENTS INC) * the whole document *	1	
A	--- EP 0 249 951 A (SUMITOMO ELECTRIC INDUSTRIES) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G08G
G07B
H04B
G01S

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 February 1998	Crechet, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
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