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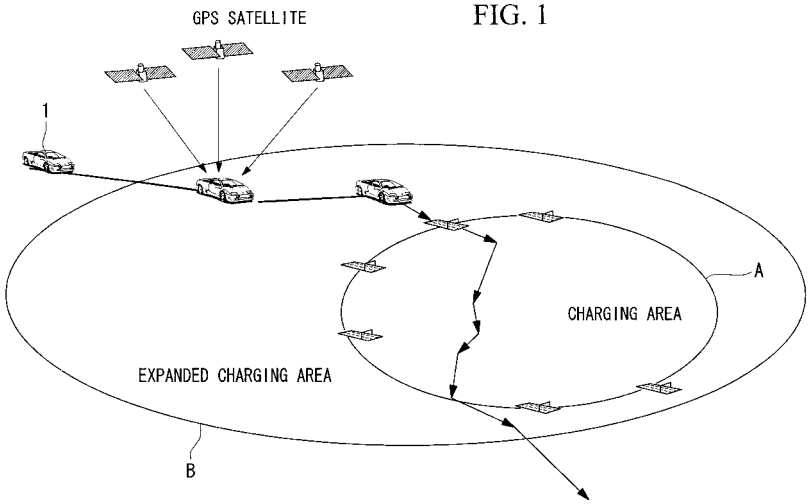
(54) TOLL COLLECTION SYSTEM

(57) An objective is to provide a fee collection system that can expand a charging area at low cost, while effectively using current facilities. A fee collection system is provided with a fee collection device installed in a charging area (A), and a vehicle-mounted device, fitted in a vehicle (1), and exchanging information relating to charging with the fee collection device, the vehicle-mounted device detecting whether or not an expanded charging area has been entered based on location information acquired by a GPS receiver, and, when the charging area (A) is entered, notifying whether or not the expanded area (B) has been entered to a fee collection device by transmitting the state of an entry flag that represents whether or not the expanded charging area (B) has been entered to the fee collection device that is installed at a toll gate of the charging area (A). In this way, in the fee collection device, it is possible to also levy a road usage fee for an expanded charging area (B).

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a fee collection system, and particularly relates to a fee collection system for collecting a predetermined fee from the owner of a vehicle that has entered a toll road or an area subject to a charge.

Background Art

[0002] In recent years, so-called road pricing has been implemented, where areas that are subject to charging are provided in urban areas, as measures for tackling problems such as traffic jams and air pollution caused by too many vehicles driving into the center of large metropolitan areas.
With this road pricing, gantries are provided at each of the entrances and exits of charging area, on which wireless communications equipment for charging is mounted. Also, vehicles driving into the charging area are required to be fitted with a vehicle-mounted device. If a vehicle passes the gantries and drives in to the charging area, transfer of information required for charging is carried out between the wireless communication equipment and the vehicle-mounted device, and charging processing for the vehicle is carried out by electronic sections (refer to Japanese Unexamined Patent Application, Publication No. 2003-323648, for example).
Also, as the above described charging method, for example, a method of deducting a fixed sum from a balance of a prepaid card inserted into the vehicle-mounted device, and updating and storing the balance as a balance in the prepaid card, or a method of automatically deducting a fixed sum from a users bank account that has be pre-registered, have been adopted.

[0003] An ETC (Electronic Toll Collection) system is also known as a system for automatically collecting a road usage fee. This ETC system can automatically collect a fee by performing wireless communication between roadside wireless units installed at a tollgate, and a vehicle-mounted device mounted in a vehicle.
Patent Document 1:
Japanese Unexamined Patent Application, Publication No. 2003-323648 (Fig. 11)

Disclosure of Invention

[0004] However, in the above described fee collection system related to road pricing, and the ETC system, there may be demands to expand a current charging area, and it is necessary to newly install gantries and toll gates etc. at the entrances and exits to the expanded charging area. Building these installations will require enormous expense. Further, with respect to existing facilities provided at a boundary between an expanded charging area and a current charging area, since there is no longer any utility value it is also necessary to consider effective utilization of these current facilities.

[0005] An object of the present invention is to provide a fee collection system that can expand a charging area at low cost, while effectively using current facilities.

[0006] A first aspect of the present invention is directed to a vehicle-mounted device that is mounted in a vehicle, and transfers information relating to a charge between a fee collection device installed at a toll gate of a charging area, comprising a storage device for storing map information of an expanded charging area newly established outside the charging area, a position information acquisition section, and an entry detection section for detecting entry into the expanded charging area based on position information acquired by the position information acquisition section and map information of the expanded charging area, wherein with respect to communication between the fee collection devices, entry determination information representing whether or not there has been entry into the expanded charging area is transmitted.

[0007] According to the above-described first aspect, the fact that an expanded charging area has been entered is detected based on position information from the position information acquisition section and map information stored in a storage unit. In this way, in the case where a charging area has been expanded, in other words, even when an expanded charging area is newly established, it is possible to reliably detect that the expanded charging area has been entered without installing new facilities at the entrances to the expanded area.
Also, with respect to fee collection devices installed in the charging area, since entry determination information indicating whether or not the expanded area has been entered is transmitted, a collection charge is determined also taking into account road usage fee for the expanded charging area.
As the above described position information acquisition section, a GPS receiver has been attracting attention as one example. Also, various component parts constituting the above-described vehicle-mounted device do not need to be provided inside a case of the vehicle-mounted device, and the invention also includes, for example, an aspect where components are used connected to external parts by means of external component terminals etc.

[0008] The vehicle-mounted device of the above described first aspect can also be constructed having an entry flag indicating whether or not it has entered into the expanded charging area, where the entry flag is set in the event that there is entry into the expanded charging area, and in communication with a charge communication devices, the state of the entry flag is transmitted as the entry determination information, and after the transmission the entry flag is reset.

[0009] With this type of structure, by transmitting the entry flag state as entry determination information, it is possible for the fee collection devices to easily determine whether or not there is entry into the expanded charging area.

[0010] It is also possible for the vehicle-mounted device of the above described first aspect to have a structure whereby, in the event that a plurality of the expanded charging areas are provided, there are respective entry flags corresponding to each of the expanded charging areas, and the state of each entry flag and identification information for each expanded charging area are transmitted to a corresponding charge communication device.

[0011] With this type of structure, by transmitting the entry flag state as entry determination information in correspondence with each expanded charging area, it is possible for the fee collection devices to easily specify the expanded charging area a vehicle has entered. In this way, it is possible to easily determine a road usage fee for an expanded charging area a vehicle has entered.

[0012] It is also possible for the vehicle-mounted device of the above-described first aspect to have a structure where a clock section for clocking time spent in the expanded charging area is provided, and the time spent is transmitted to the fee collection devices.

[0013] With this type of structure, since time spent in the expanded charging area is transmitted to the fee collection devices, it is possible for the fee collection devices to determine a road usage fee taking account of time spent in the expanded charging area. In this way, it is possible to give a road usage fee that more correctly reflects the road usage conditions.

[0014] It is also possible for the vehicle-mounted device of the above-described first aspect to have a structure where the spent time is transmitted in encrypted form.

[0015] With this type of structure, since the spent time is transmitted to the fee collection devices in an encrypted form, it is possible to prevent fraudulent acts such as falsification and interception of information. In this way, it is possible for the fee collection devices to determine a road usage fee based on accurate spent time.

[0016] It is also possible for the vehicle-mounted device of the above-described first aspect to have a structure where for a period of time for which a vehicle is parked in a car park provided inside the expanded charging area, operation of the clock section is stopped.

[0017] With this type of structure, it is possible to prevent the period of time for which a vehicle is parked in a car park provided inside the expanded charging area being included in the time spent in the expanded charging area. In this way, it becomes possible to accurately clock the actual time spent in the expanded charging area.

[0018] It is also possible for the vehicle-mounted device of the above-described first aspect to have a structure where a travel distance calculating section for measuring travel distance inside the expanded charging area is provided, and the travel distance is transmitted to the fee collection devices.

[0019] With this type of structure, since travel distance in the expanded charging area is transmitted to the fee collection devices, it is possible for the fee collection devices to determine a road usage fee taking account of travel distance in the expanded charging area. In this way, it is possible to give a road usage fee that more correctly reflects the road usage conditions.

[0020] A second aspect of the present invention is directed to a vehicle-mounted device provided with a GPS receiver and an FM multiplex receiver, wherein position information acquired by the GPS receiver is corrected using correction data of a GPS satellite acquired by the FM multiplex receiver.

[0021] According to the second aspect, correction data for a GPS satellite transmitted by FM multiplex broadcast, for example D-GPS correction data, is received, and the position information acquired by the GPS receiver is corrected using this correction data, which means that it is possible to improve position detection accuracy. Also, by transmitting the correction data using FM multiplex broadcast, it is possible to receive correction data with a simpler structure.

[0022] A third aspect of the present invention is directed to a fee collection device, arranged in a charging area, for performing transfer of information relating to a charge to and from a vehicle-mounted device fitted to a vehicle passing through the charging area, comprising a storage device for storing first charging information relating to an expanded charging area newly established outside the charging area, and second charging information relating to the charging area, a entry determination section for, when entry determination information has been received from the vehicle-mounted device, determining whether or not a vehicle fitted with the vehicle-mounted device has entered the expanded charging area based on the entry determination information, and a charge determination section for determining a collection charge based on the determination result, and the first charging information and the second charging information.

[0023] According to the above described third aspect, whether or not a vehicle enters an expanded charging area is determined, and when the vehicle enters the expanded charging area a road usage fee for the expanded charging area and a road usage fee for the charging area are collected together. In this way, it is possible to carry out fee collection for both an expanded charging area and a charging area with a single device. As a result, since there is no need to newly install a fee collection device for the expanded charging area it is possible to reduce installation cost, and accordingly it becomes possible to carry out new construction for an expanded charging area easily.

[0024] The fee collection device of the above described third embodiment can also have a structure where the first charging information includes a charge table having time spent in the expanded charging area as a parameter, and when the time spent in the expanded charging area is received from the vehicle-mounted device, the charge determination section determines a road usage fee for the expanded charging area using the time spent and the charge table.

[0025] With this type of structure, in the road usage

fee calculation process, time spent in the expanded charging area is taken into consideration, which means that it is possible to give a road usage fee that more accurately reflects road usage conditions.

[0026] The fee collection device of the above described third embodiment can also have a structure where the first charging information includes a charge table having travel distance in the expanded charging area as a parameter, and when the travel distance in the expanded charging area is received from the vehicle-mounted device, the charge determination section determines a road usage fee for the expanded charging area using the travel distance and the charge table.

[0027] With this type of structure, in the road usage fee calculation process, travel distance in the expanded charging area is taken into consideration, which means that it is possible to give a road usage fee that more accurately reflects road usage conditions.

[0028] It is also possible for the fee collection device of the above described third aspect to have a structure with the first charging information corresponding to respective expanded charging areas, in the case where a plurality of the expanded charging areas are provided, wherein the entry determination section receives the entry determination information that has been associated with identification information of each expanded charging area from the vehicle-mounted device, and specifies the expanded charging area the vehicle has entered based on the entry determination information, and the charge determination section determines a road usage fee for the expanded charging area using the first charging information corresponding to the expanded charging area the vehicle has entered.

[0029] With this type of structure, in the event that a plurality of expanded charging areas are provided, first charging information is registered in correspondence with each expanded charging area, and so it is possible to carry out detailed fee setting for every expanded charging area. Further, even if a vehicle enters a plurality of expanded charging areas, it is possible to carry out fee collection in one go.

[0030] It is also possible, when the charging area is an area for which a constant fee is levied at the time of entry regardless of road usage conditions, for the fee collection device of the above described third aspect to have a refund points table with time spent in the charging area as a parameter, wherein, when time spent in the charging area has been received from the vehicle-mounted device, the charge determination section determines refund points using the time spent and the reduction points table, and these reduction points are allocated to the owner of the vehicle.

[0031] Like road pricing etc., when the charging area is an area for which a fixed fee is levied at the time of entry regardless of the road usage conditions, by having points according to the time spent in the charging area cause a refund for the owner of the vehicle, it is possible to give financial relief to users who may have inadvertently entered the charging area by mistake.

[0032] A fourth aspect of the present invention is directed to fee collection system, provided with a fee collection device installed in a charging area, and a vehicle-mounted device, mounted in a vehicle and performing transfer of information relating to a charge to and from the fee collection device, the vehicle-mounted device comprising a storage section for storing map information of an expanded charging area newly set outside the charging area, a position information acquisition section, and an entry determination section for detecting entry into the expanded charging area based on position information acquired by the position information acquisition section and the map information of the expanded charging area, wherein, when the fee collection device is approached, entry determination information indicating whether or not the expanded charging area was entered is transmitted, and the fee collection device comprises a storage device for storing first charging information relating to the expanded charging area and second charging information relating to the charging area, an entry determining section for, when the entry determination information has been received from the vehicle-mounted device, determining whether or not a vehicle fitted with the vehicle-mounted device has entered the expanded charging area based on the entry determination information, and a charge determination section for determining a charge to be levied based on the determination result, and the first charging information and the second charging information.

[0033] According to the above-described fourth aspect, the fact that an expanded charging area has been entered is detected based on position information from the position information acquisition section and map information stored in a storage unit. In this way, in the case where a charging area has been expanded, in other words, even when an expanded charging area is newly established, it is possible to reliably detect that the expanded charging area has been entered without installing new facilities at the entrances to the expanded area. Further, it is possible to carry out fee collection for both an expanded charging area and a charging area using a single fee collection device installed in the charging area. In this way, since there is no need to newly install a fee collection device for the expanded charging area, it is possible to reduce installation costs. As a result, new construction for expanded charging areas, in other words expansion of charging areas, can be carried out easily.

[0034] It is possible for the fee collection system of the above describe fourth aspect to have a fitted determination section for determining whether or not the vehicle-mounted device has a position information acquisition section, and for the charge determination section to cause different charges to be levied depending on whether the vehicle-mounted device has, or does not have, a GPS function.

[0035] In the vehicle-mounted device, it is detected whether or not an expanded charging area has been en-

tered based on position information acquired by the position information acquisition section. Accordingly, a vehicle-mounted device that is not fitted with a position information acquisition section can no longer detect whether or not an expanded charging area has been entered. Therefore, with a vehicle-mounted device that can detect entry into an expanded charging area, road usage fees for both the expanded charging area and the charging area are billed together, while on the other hand, with a vehicle-mounted device that can not detect entry into an expanded charging area, road usage fee is only billed for a charging area. In this type of situation, by making a road usage fee for a vehicle-mounted device that is provided with a position information acquisition section, and a road usage fee for a vehicle-mounted device that is not provided with a position information acquisition section, different, it is possible to balance the charges levied. Also, by setting a road usage fee for a vehicle-mounted device that is not provided with a position information acquisition section higher, it is possible to promote the use of vehicle-mounted devices that are fitted with a position information acquisition section.

[0036] It is also possible for the fee collection system of the above described fourth aspect to have a structure wherein, for a case where the position information acquisition section is a GPS receiver, in an expanded charging area that is an area in which it is difficult for the vehicle-mounted GPS receiver to receive position information from a GPS satellite, a wireless antenna for transmitting position data to the vehicle-mounted device is installed.

[0037] With this type of structure, in an area where it is difficult for a vehicle-mounted GPS receiver to receive data from a GPS satellite a wireless antenna for transmitting position data is installed, which means that it is possible to reliably detect that an expanded charging area has been entered. Incidentally, the respective structures described above can be combined where possible.

[0038] According to the present invention, the effect is achieved of being able to expand a charging area at low cost, while effectively using current facilities.

Brief Description of Drawings

[0039]

FIG. 1 is a drawing showing the overall structure of a charging system of a first embodiment of the present invention.

FIG. 2 is a block diagram showing the schematic structure of a fee collection device of a first embodiment of the present invention.

Fig. 3 is a drawing of an entry lane to a charging area, looking from the road shoulder.

Fig. 4 is a drawing showing one example of markings laid out underneath the vehicle detection unit shown in Fig. 3.

Fig. 5 is a drawing showing the appearance of the markings shown in Fig. 4 when a vehicle passes over.

FIG. 6 is a block diagram showing the schematic structure of a vehicle-mounted device of the first embodiment of the present invention.

FIG. 7 is a drawing for simply describing the operation content of the vehicle-mounted device of the first embodiment of the present invention.

Fig. 8 is a drawing showing a processing sequence for communication carried out between a vehicle-mounted device and a first antenna control unit, in the first embodiment of the present invention.

FIG. 9 is a block diagram showing the schematic structure of a first antenna control unit of the first embodiment of the present invention.

Fig. 10 is a drawing showing a processing sequence for communication carried out between a vehicle-mounted device and a first antenna control unit, in the first embodiment of the present invention.

Fig. 11 is a drawing for describing an entry flag.

Fig. 12 is a drawing for describing handling of a vehicle-mounted device that is not fitted with a GPS receiver and a vehicle-mounted device that is fitted with a GPS receiver.

FIG. 13 is a drawing for simply describing the operation content of a vehicle-mounted device of a second embodiment of the present invention.

FIG. 14 is a block diagram showing the schematic structure of the vehicle-mounted device of the second embodiment of the present invention.

FIG. 15 is a block diagram showing the schematic structure of a first antenna control unit of the second embodiment of the present invention.

FIG. 16 is a block diagram showing the schematic structure of a vehicle-mounted device of a third embodiment of the present invention.

FIG. 17 is a drawing for simply describing the operation content of the vehicle-mounted device of the third embodiment of the present invention.

Fig. 18 is a drawing for describing handling of a case where a vehicle is parked in a car park that is inside an expanded charging area, in the fee collection system of the third embodiment of the present invention.

FIG. 19 is a block diagram showing the schematic structure of a vehicle-mounted device of a fourth embodiment of the present invention.

FIG. 20 is a drawing for simply describing the operation content of the vehicle-mounted device of the fourth embodiment of the present invention.

FIG. 21 is a block diagram showing the schematic structure of a vehicle-mounted device of a fifth embodiment of the present invention.

FIG. 22 is a drawing for simply describing the operation content of the vehicle-mounted device of the fifth embodiment of the present invention.

Fig. 23 is a timing chart showing one example of a refund points table.

Fig. 24 is a timing chart showing another example of a refund points table.

Fig. 25 is a drawing for describing the fee collection system of the present invention when applied to an ETC system.
Fig. 26 is a drawing for describing the fee collection system of the present invention when applied to an ETC system.
Fig. 27 is a drawing for describing a method of acquiring position information when it is not possible for a GPS receiver to receive data from a GPS satellite.
Fig. 28 is a drawing showing the schematic structure of a D-GPS system in the case of transmitting D-GPS correction data using FM multiplex broadcast.
Fig. 29 is a block diagram showing the schematic structure of a vehicle-mounted device in the case of receiving D-GPS correction data using FM multiplex broadcast.

Explanation of Reference Signs:
[0040]

1: vehicle
2: fee collection device
5: first antenna
8: second antenna
9, 9a: first antenna control unit
12: second antenna control unit
17: center unit
20, 20a, 20b, 20c, 20d: vehicle-mounted device
24: receiver
25, 25a: storage device
26, 26a, 26b, 26c, 26d: control section
27: communication section
30: IC card insertion section
31: IC card interface
A: charging area
B, B1, B2: expanded charging area
C: car park
37: storage device
32: timer
33: travel distance calculation unit
34: wide area communication unit
35, 35a, 35b: first charge table
36: second charge table
38, 38a: entry determination section
39, 39a: charge determination section
40: entrance antenna
41: exit antenna
45: antenna
50: base station
51: center station
52: FM broadcast station
53: FM multiplex receiver

Best Mode for Carrying Out the Invention

[0041] One embodiment of a fee collection system of the present invention will be described in the following with reference to the drawings.

[First Embodiment]

[0042] Fig. 1 is an overall structural drawing of the fee collection system of this embodiment.
As shown in Fig. 1, fee collection devices (not shown) for collecting a road usage fee from a vehicle 1 that has entered a charging area A are provided on all roads passing across boundaries between charging areas A, which are areas subjected to road pricing. These fee collection devices are provided in correspondence with respective entry lanes that a vehicle 1 enters in a charging area A, and transfer information for collecting a road usage fee to and from vehicle-mounted devices fitted to vehicles passing the corresponding entry lane.

[0043] Fig. 2 is a block diagram showing the schematic structure of the fee collection device. As shown in Fig. 2, a fee collection device 2 comprises a first antenna 5, a camera 6, a vehicle detection unit 7 and a second antenna 8. The fee collection device 2 further comprises a first antenna control unit 9 connected to the first antenna 5, a camera control unit 10 connected to the camera 6, a vehicle detection control unit 11 connected to the vehicle detection unit 7, and a second antenna control unit 12 connected to the second antenna 8. The fee collection device 2 also comprises a unified control unit 13 an environment control unit 14 connected to the unified control unit 13, and a communication control unit 15 connected to the unified control unit 13. The above described first antenna control unit 9, camera control unit 10, vehicle detection control unit 11, second antenna control unit 12 and unified control unit 13 are connected together by means of a bus 16, to give a state where exchange of information is made possible. The communication control unit 15 performs communication between the fee collection device 2 and a center unit 17 which is an upper device.

[0044] In the fee collection device 2 having the above described structure, the first antenna 5, camera 6, vehicle detection unit 7 and second antenna 8 are attached to a double column type support pillar arranged across a travel road on a boundary of a charging section A. Fig. 3 is a drawing of a traffic lane looking from the side. The first antenna 5 and the second antenna 8 are arranged so that it is easy to receive signals from a vehicle-mounted device of the vehicle 1 traveling in the corresponding traffic lane. For example, the first antenna 5 and the second antenna 8 are arranged with an antenna beam facing the corresponding traffic lane. Also, the first antenna 5 and the second antenna 8 are installed a distance of from about 10 m to 15 m apart. The purpose of this is so that a vehicle-mounted device receives a road usage fee via the first antenna 5, this road usage fee is reflected to an IC card, and a processing time until the result is notified to the second antenna 8 is ensured. Incidentally, information that is transferred between the first antenna 5, the second antenna 8 and the vehicle-mounted device

will be described in detail later.

[0045] The camera 6 is for taking pictures of number plates of vehicles acting improperly, in the event that a vehicle acting improperly is detected. A vehicle acting improperly may be, for example, a vehicle without a vehicle-mounted device fitted, a vehicle with no IC card inserted into the vehicle-mounted device, a vehicle having a balance stored in the IC card that is less than the charge being levied that can not correctly perform charging, or a vehicle fitted with a counterfeit vehicle-mounted device or IC card. These vehicles acting improperly are determined based on information received from the vehicle-mounted device by the first antenna etc.

The vehicle detection unit 7 detects a vehicle 1 passing through. For example, markings of a striped pattern as shown in Fig. 4 are placed on the road underneath the vehicle detection unit 7. The vehicle detection unit 7 monitors the striped pattern from above, and when this striped pattern cannot be correctly detected, as shown in Fig. 5, the passage of the vehicle 1 is detected.

[0046] Also, as shown in Fig. 1, a newly established expanded charging area B is established outside the charging area A. For example, when there is a demand to expand the originally existing charging area A, this expanded charging area B is a subsequently established area. This expanded area B can be provided surrounding the charging area A, provided so that part of the expanded charging area B is in contact with the charging area A, or can be an area provided separately and not connected to charging area A.

[0047] Fee collection devices 2 are not installed at the entry lanes at area boundaries in the above described expanded charging area B as they are for the charging area A. Instead, detection of entry into the expanded charging area B is carried out using the vehicle-mounted device fitted to the vehicle 1.

Fig. 6 is a block diagram showing the schematic structure of the vehicle-mounted device of this embodiment. As shown in Fig. 6, the vehicle-mounted device 20 comprises, as its main structural components, a power supply circuit 23 connected to a vehicle power supply 21 and an internal battery 22, a GPS receiver (position information acquisition section) 24 for detecting current position by acquiring information relating to position information from a GPS satellite, a storage device (storage section) 25 for storing various information, a control section (entry detection section) 26, a communication section 27 for carrying out communication with the first antenna 5 and the second antenna 8 of the fee collection device 2 etc., a display section 28, a notification section 29 such as buzzer or LED, an IC card insertion section 30 into which an IC card is inserted, and an IC card interface 31 provided in the IC card insertion section 30.

[0048] In Fig. 6, it is possible for various structural components, such as the GPS receiver 24 etc. to not be incorporated inside the vehicle-mounted device. For example, each structural component can be constructed capable of information transfer. As one example, it is possible to have a structural aspect where a mobile terminal unit having a GPS function is connected by means of an external terminal, and the GPS function provided by the mobile terminal unit is used as the GPS receiver 24.

[0049] The power supply circuit 23 mainly controls a voltage supplied from the vehicle power supply 21 to a voltage adopted in the vehicle-mounted device 20, and supplies this voltage to each of the sections constituting the vehicle-mounted device 20. The internal battery 22 is provided so as to be able to ensure electrical power to an extent sufficient to permit communication, even if the supply of power from the vehicle power supply 21 is cut off. Map information for the expanded charging area B is stored in the storage device 25. Also, various information that is necessary for the charging process, that will be described later, is held in the storage device 25, such as car owner information, vehicle information including type of vehicle information, an entry flag indicating whether or not an expanded charging area B has been entered, balance information read out from an IC card, and card information etc.

[0050] An IC card to be inserted into the IC card insertion section 30 is, for example, a contact type IC card, and is internally fitted with an IC chip such as a flash memory or an MPU. As well as card information such as a card ID number, a balance and usage history are stored in this IC card. Information stored in the IC card can be written or read by the control section 26 via the IC card interface 31.

[0051] With this type of vehicle-mounted device 20, if the IC card is inserted into the IC card insertion section 30, the control section 26 reads out IC card information and a balance that are stored in the IC card via the IC card interface 31, and writes this information to the storage device 25, and temporarily, for example, for about 10 seconds) displays the balance on the display section 28. Also, the control section 26 causes operation of the notification section 29 in order to notify normal operation to the user when it has been possible to read information normally from the IC card. In this way, if the notification section 29 is a buzzer, for example, the buzzer is sounded, or if the notification section 29 is an LED or the like the LED is lit, to give notification of the fact that the situation is normal. On the other hand, in the event that information was not read from the IC card, the control section 26 causes display of indication that there is an error on the display section 28, and by causing operation of the notification section 29 notifies the fact that there is an error to the user, and then prompts for the IC card to be inserted again. Incidentally, the manner of the notification by the notification section 29 takes can be different for normal operation and for abnormal operation.

[0052] Next, operation content of the above described vehicle-mounted device 20 when the vehicle 1 enters the charging area A after entering the expanded charging area B will be described.

As shown in Fig. 6 and Fig. 7, the GPS receiver 24 of the vehicle-mounted device 20 acquires information relating

to current position from a plurality of GPS satellites while traveling, detects current position from this information, and outputs the current position to the control section 26. The control section 26 then determines whether or not the vehicle 1 has entered an expanded charging area B based on the current position and map information for stored charging areas stored in the storage device 25. As a result, if entry into an expanded charging area B is detected the entry flag is set. Next, when the expanded charging area B is passed through and the charging area A is entered, the control section 26 of the vehicle-mounted device 20 transits vehicle information and state of the entry flag etc. to the fee collection device 2 via the communication section 27. At the fee collection device 2, a road usage fee to be levied is determined based on the received information, and this road usage fee is transmitted to the vehicle-mounted device 20. If the control section 26 of the vehicle-mounted device 20 receives this road usage fee via the communication section 27, a fixed rate fee is deducted from the balance stored in the IC card, and this balance is updated and stored in the IC card as a new balance.

[0053] Next, communication processing carried out between the vehicle-mounted device 20 and the fee collection device 2 when the charging area A is entered will be described in detail with reference to Fig. 8 to Fig. 10. First of all, if the boundary of the charging area A is approached, the control section 26 of the vehicle-mounted device 20 receives an enquiry signal emitted from the first antenna 5 of the fee collection device 2 via the communication section 27 (step SA1 in Fig 8). If the control section 26 receives the enquiry signal, vehicle information, IC card information, IC card balance, and entry flag state are read out from the storage device 25, and transmitted via the communication section 27 (step SA2 in Fig. 8).

[0054] The first antenna control unit 9 of the fee collection device 2 determines a charge to be levied based on the received information. Specifically, as shown in Fig. 9, the first antenna control unit 9 comprises a storage device 37 for storing a first charge table (first charge information) 35 holding charge information relating to expanded charging area B, and a second charge table (second charge information) 36 holding charge information relating to charging area A, an entry determining section 38 for determining whether or not a vehicle 1 fitted with a vehicle-mounted device 20 has entered the expanded charging area B based on entry flag state received from the vehicle-mounted device 20, and a charge determination section 39 for determining a road usage fee using the result of determination from the entry determining section 38, as well as the first charge table 35 and the second charge table 36. Charges to be levied are stored in the first charge table 35 according to vehicle type (large type, medium type, small type, etc.), for example. For example, rates of 0.8 dollars for small type, 1 dollar for medium type, and 2 dollars for large type, are stored.

[0055] Also, charges corresponding to vehicle type, as described above, are held in the second charge table 36, and further, road usage fees divided into charges to be levied when the expanded charging area B has been entered, and charges to be levied when the expanded charging area B is not entered, are held. For example, for a medium type vehicle, rates of 0.5 dollars for the case where the expanded charging area B is entered and 1 dollar where the expanded charging area B is not entered, are held. By having different charges depending on whether the expanded charging area B is entered or not entered in this way, it is possible to give an advantage to a driver of a vehicle 1 that has passed through the expanded charging area B.

[0056] The entry determination section 38 determines that there has been entry into the expanded charging area B when the entry flag received from the vehicle-mounted device 20 is set, and determines that the expanded charging area has not been entered when the entry flag has been cleared, and the result of determination is output to the charge determination section 39(step SA3 in Fig. 8). The charge determination section 39 determines the type of the vehicle 1 based on vehicle information received from the vehicle-mounted device 20. Then, a road usage fee is determined according to the vehicle type and whether or not the expanded charging area B was entered (step SA4 in Fig. 8). For example, in the case where the vehicle type is medium type and the expanded charging area has been entered, charges of 1 dollar from the first charge table and 0.5 dollars from the second charge table are extracted, and a road usage fee of 1.5 dollars is finally calculated by adding these two charges together. The calculated road usage fee is then transmitted to the vehicle-mounted device 20 via the first antenna 5 (step SA5 in Fig. 8).

[0057] Upon receiving the road usage fee via the communication section 27, the control section 26 of the vehicle-mounted device 20 transmits an affirmation signal indicating completion of communication to the first antenna 5 (step SA6 in Fig 8), and also updates the balance of the IC card by subtracting the road usage fee from the balance of the IC card (step SA7 in Fig. 8). Next, when balance update processing has been carried out normally, the control section 26 reads the balance after update and authorization data from the IC card (Step SA8 in Fig 8).

[0058] Next, if an enquiry signal emitted from the second antenna 6 is received (step SB1 in Fig. 10), the control section 26 transmits vehicle information, IC card information, IC card balance, and authorization data via the communication section 27(step SB2 in Fig. 10). Here, the authorization data is information for notifying the fact that fee collection has been executed normally.

[0059] If the second antenna control unit 12 receives authorization data via the second antenna 8, a confirmation command is transmitted via the second antenna 8 (step SB3 in Fig. 10). Upon receipt of this confirmation command, the control section 26 of the vehicle-mounted device 20 transmits an affirmation signal via the commu-

nication section 27 (step SB4 in Fig. 10), and writes a usage history to the IC card (step SB5 in Fig 10). The control section 26 then clears the entry flag in the storage device 25 (step SB6 in Fig. 10), and completes the communication processing.

[0060] Incidentally, transfer of information carried out between the vehicle-mounted device 20 and the second antenna 8 described above can be carried out utilizing known encryption methods. By carrying out communication using an encryption method it is possible to prevent malpractice such as falsification or interception of information. As encryption methods, examples that have been drawing attention are AES for carrying out encryption using a common key, RSA for carrying out encryption using a public key and a private key, etc. In particular, since there is important information for notifying of the normal completion of fee collection, by carrying out transfer of this authorization data transfer in an encrypted manner it is possible to increase confidence in the fee collection.

[0061] As has been described above, according to the fee collection system of this embodiment, the fact that the expanded charging area B has been entered is detected in the vehicle-mounted device 20 based on position information from the GPS receiver 24 and map information stored in the storage device 25. In this way, in the case where a charging area A has been expanded, in other words, even when an expanded charging area B is newly established, it is possible to reliably detect that the expanded charging area B has been entered without installing new facilities at the boundary of the expanded charging area B.

Further, it is possible to carry out fee collection for both the expanded charging area B and the charging area A using a single fee collection device 2 installed in the charging area A. In this way, since there is no need to newly install a fee collection device 2 for the expanded charging area B, it is possible to reduce installation costs. As a result, new construction for the expanded charging area B can be carried out easily.

[0062] Incidentally, an entry flag that has been temporarily set is established so that it is not cleared until the vehicle 1 enters the charging area A, and further, the series of communication processes relating to fee collection that are carried out to and from the fee collection device 2, that will be described later, completes normally. Accordingly, as shown in Fig. 11, after the expanded charging area B has been entered, even if the expanded charging area B is left without entering the charging area A, the set entry flag is not cleared. That is, the entry flag that has been set is not cleared simply by the expanded charging area B being left. In this way, the next time the charging area A is entered a record of the fact that the expanded charging area B was entered remains, and so it is also possible to reliably levy road usage fee for the expanded charging area B.

[0063] It is also possible to provide a counter for counting the number of times the expanded charging area B has been entered, instead of the entry flag. In this way, when a vehicle 1 enters and leaves the expanded charging area B a number of times without entering the charging area A, as shown in Fig. 11, and then enters the charging area A, it is possible to levy a road usage fee according to the number of times the expand charging area B has been entered up to now.

Also, instead of this type of counter, with the above described entry flag it is possible to enter the expanded charging area B a number of times on a single road usage fee, and so in this case it is possible to give an advantage to a driver.

[0064] Also, in step SA2 of Fig. 8, in addition to the vehicle information, IC card information, IC card balance and entry flag state, it is possible to transmit information notifying whether or not there is a GPS receiver 24, for example, to transmit the vehicle-mounted device version from the vehicle-mounted device 20 to the first antenna 5. By transmitting the vehicle-mounted device version in this way, for the reasons described below, it is possible to determine in the fee collection device 2 whether or not there is a GPS receiver 24.

[0065] With the fee collection device of the present invention, whether or not the vehicle 1 has entered the expanded charging area B is determined based on location information acquired using the GPS receiver 24. For this reason, with a vehicle-mounted device that is not fitted with a GPS receiver 24 it can not be determined whether or not the expanded charging area B has been entered because the vehicle-mounted device cannot specify current location itself, and therefore it is impossible to levy a road usage fee relating to the expanded charging area B.

[0066] Accordingly, by changing the charge levied by the fee collection system 2 according to whether or not a GPS receiver 24 is equipped, a balance is maintained for collection fees between a vehicle 1 fitted with a vehicle-mounted device that is not equipped with a GPS receiver 24, and a vehicle 1 fitted with a vehicle-mounted device 20 that is equipped with a GPS receiver 24. In particular, as shown in Fig. 12, by having a setup where road usage fee is further increased for a vehicle 1' fitted with a vehicle-mounted device that is not equipped with a GPS receiver 24 (for example, double compared to when a GPS receiver 24 is equipped), it is possible to promote the increased use of vehicle-mounted devices 20 equipped with a GPS receiver 24.

[0067] In the fee collection system of this embodiment, it is also possible, when fee collection has been executed correctly at the entrance to the charging area A, to transmit authentication information indicating this fact from the fee collecting device 2 to the vehicle-mounted device 20, and further, to display a random number on a display section 28 of the vehicle-mounted device 20. By doing this, in a vehicle where fee collection has been executed normally, since authentication information indicating this fact is displayed on the display section 28 of the vehicle-mounted device 20, for example, by having an observer

monitoring the road confirming this display, it is possible to easily determine improper vehicles. The authentication information is not particularly limited, and can be, for example, a predetermined random number. Also, instead of display, it is possible, for example, to light an optical element such as an LED.

[Second Embodiment]

[0068] Next, a fee collection system of a second embodiment of the present invention will be described.
The fee collection system of this embodiment differs from the above described first embodiment in that a plurality of expanded charging areas are established. The fee collection system of this embodiment will be described below, omitting description of points that are common to the first embodiment and focusing only on points of difference.

[0069] In the case where a plurality of expanded charging areas B1, B2 are established, as shown in Fig. 13, then as shown in Fig. 14 map information for each of the expanded charging areas B1 and B2, and identification information b1 and b2 assigned to each of the expanded charging areas B1 and B2, are stored in the storage device 25a of the vehicle-mounted device 20a in association with each other, and entry flags F1 and F1 corresponding to each of the expanded charging areas B1 and B2 are also registered.
Also, as shown in Fig. 15, first charge tables 35a and 35b relating to each of the expanded charging areas B1 and B2, and identification information b1 and b2 assigned to each of the expanded charging areas B1 and B2, are stored in the storage device 37a of a first antenna control section 9a of the fee collection device, in association with each other.

[0070] In Fig. 13 to Fig. 15, if a vehicle 1 enters the expanded charging area B1, the control section 26a of the vehicle-mounted device 20a detects entry of the vehicle 1 into the expanded charging area B1 based on information received from the GPS receiver 24 and map information stored in the storage device 25a, and sets the flag F1 corresponding to this expanded charging area B1. If the vehicle 1 then enters the expanded charging area B2, the control section 26a detects this fact, and sets the flag F2 corresponding to the expanded charging area B2. Next, when the charging area A is entered, the control section 26a of the vehicle-mounted device 20 transits vehicle information and state of the entry flags F1 and F2 etc. to the fee collection device via the communication section 27.

[0071] In the first antenna control unit 9a, if vehicle information and the states of the entry flags F1 and F2 etc. are received, the entry determination section 38a extracts the flags F1 and F2 that are set, and outputs identification information b1, b2 for the expanded charging areas B1, B2 corresponding to the extracted flags F1, F2 to the charge determination section 39a.
The charge determination section 39a references respective first charge tables 35a, 35b associated with identification information b1, b2 acquired from the entry determination section 38a, to acquire a road usage fee for the expanded charging areas B1, B2, and acquires a road usage fee for the charging area A by referring to the second charge table 36. A road usage fee for the vehicle 1 is then calculated by adding these charges together. This road usage fee is then transmitted via the first antenna 5 to the vehicle-mounted device 20a.
If the control section 26a of the vehicle-mounted device 20a receives this road usage fee via the communication section 27, the above described road usage fee is deducted from the balance stored in the IC card, and this balance is updated and stored in the IC card as a new balance. Incidentally, details of the communication between the first antenna control unit 8a and the vehicle-mounted device 20a are carried out in accordance with the processing sequence shown in Fig. 8.

[0072] As described above, according to the fee collection system of this embodiment, when a plurality of expanded charging areas are established, an entry flag is established corresponding to each expanded charging area, and by associating states of these entry flags with the identification information of each expanded charging area and transmitting from the vehicle-mounted device 20a to the first antenna control unit 9a, it is possible to easily specify an expanded charging area the vehicle has entered at the fee collection device side. In this way, it is possible to rapidly determine a road usage fee for an expanded charging area a vehicle has entered.
Further, by registering first charge tables 35a, 35b corresponding to each of the expanded charging areas B1, B2 in the storage device 37a of the first antenna control unit 9a, it becomes possible to carry out detailed fee setting for every expanded charging area. Further, even if a vehicle enters a plurality of expanded charging areas it is possible to carry out fee collection in one go.
Incidentally, description has been given for this embodiment of a case where two expanded charging areas are established, but the number of expanded charging areas B is not limited. It is also possible for a plurality of expanded charging areas to be established adjacent to each other.

[Third Embodiment]

[0073] Next, a fee collection system of a third embodiment of the present invention will be described.
The fee collection system of this embodiment differs from the above described first embodiment in that a road usage fee for an expanded charging area B is set according to amount of time spent in the area.
The fee collection system of this embodiment will be described below, omitting description of points that are common to the first embodiment and focusing only on points of difference.

[0074] As shown in Fig. 16, the vehicle-mounted device 20b of this embodiment is further provided with a

timer (clock section) 32 for clocking the time spent in the expanded charging area B. Also, the first antenna control unit 9b of this embodiment is basically the first antenna control unit 9 shown in Fig. 9, but the first charge table 35 provided in the storage device 37 is a charge table having time spent as a parameter (not shown).

[0075] As shown in Fig. 16 and Fig. 17, if a vehicle 1 enters the expanded charging area B, the control section 26b of the vehicle-mounted device 20 b detects the entry into the expanded charging area B and sets the entry flag, as well as causing the timer 32 to operate. In this way, the time spent in the expanded charging area B is clocked by the timer 32. Next, when the charging area A is entered, the control section 26b of the vehicle-mounted device 20b transits the spent time clocked by the timer 32, in addition to vehicle information etc., to the fee collection device via the communication section 27. For example, when an enquiry signal is received from the first antenna 5 of the fee collection device, the control section 26b stops operation of the timer 32, and also reads out the spent time at that time and transmits the spent time to the fee collection device.

[0076] At the first antenna control unit 9b of the fee collection device, entry into the expanded charging area is detected by the entry detection section 38, and notified to the charge determination section 39. The charge determination section 39 calculates a road usage fee according to time spent relating to the expanded charging area B, using the first charge table 35 showing functions related to time spent, and also extracts a road usage fee for the charging area A corresponding to the vehicle 1 from the second charge table 36, and by adding the fees together calculates a road usage fee for the vehicle 1. The determined road usage fee is then transmitted via the first antenna 5 to the vehicle-mounted device 20b.

If the control section 26b of the vehicle-mounted device 20b receives a road usage fee corresponding to spent time via the communication section 27, the above described road usage fee is deducted from the balance stored in the IC card, and this balance is updated and stored in the IC card as a new balance, and the value of the timer 32 is cleared. Incidentally, details of the communication between the first antenna control unit 8b and the vehicle-mounted device 20b are carried out in accordance with the processing sequence shown in Fig. 8.

[0077] As has been described above, according to the fee collection system of this embodiment, by transmitting time spent in the expanded charging area B to the fee collection device it becomes possible to perform calculation of a road usage fee taking into consideration the time spent in the expanded area B. In this way, it is possible to give a road usage fee that more correctly reflects the road usage conditions.

[0078] Incidentally, in this embodiment, the timer 32 and entry flag have been used together, but since it is possible to confirm entry into the expanded charging area B by operating the timer 32 it is possible to not use the entry flag.

Also, the timer 32 has been adopted as a section for detecting spent time, but instead of this it is possible to clock spent time using time data contained in GPS data acquired using the GPS receiver 24.

[0079] Also in this embodiment, road usage fee is determined according to time spent in the expanded charging area B, and so if a vehicle is parked in a car park inside the expanded charging area B this spent time will be clocked by the timer 32, and that time will be wrongly reflected in the road usage fee. Therefore, as shown in Fig. 18, operation of the time is suspended for the period of time the vehicle is parked in the car park C inside the expanded charging area B.

In this case, for example, if an enquiry signal is received from an entrance antenna 40 installed at the entrance to the car park C, the control section 26b of the vehicle-mounted device 20b suspends operation of the timer 32, and when a confirmation signal, for the fact that a car parking fee has been received, is received from an exit antenna 41 installed at the exit of the car park C, the control section 26b starts the timer 32. By suspending the timer 32 for the period of time the vehicle is parked in the car park C in this way, it is possible to stop the time spent in the car park being included.

Incidentally, in this embodiment it is also possible to encrypt communication data containing the spent time that is exchanged between the vehicle-mounted device 20d and the center device 17, in order to prevent improper acts such as falsification and interception of information.

[Fourth Embodiment]

[0080] Next, a fee collection system of a fourth embodiment of the present invention will be described.

The fee collection system of this embodiment differs from the fee collection of the above described third embodiment for determining road usage fee according to time spent, in that road usage fee is determined according to distance traveled in the expanded travel area B.

The fee collection system of this embodiment will be described below, omitting description of points that are common to the third embodiment and focusing only on points of difference.

[0081] As shown in Fig. 19, the vehicle mounted device 20c of this embodiment is provided with a travel distance calculating unit (travel distance calculating section) 33 for calculating travel distance, instead of the timer 32 of the vehicle-mounted device 20b of the third embodiment.

The travel distance calculating unit 33 calculates travel distance using information from, for example, the GPS receiver 24 fitted in the vehicle-mounted device, a gyro 19, and speed pulses output from the vehicle 1.

Also, the first antenna control unit of this embodiment is basically the first antenna control unit 9 shown in Fig. 9, but with the first charge table 35 provided in the storage device 37 having travel distance as a parameter.

[0082] In Fig. 19 and Fig. 20, if the vehicle 1 enters the expanded charging area B the control section 26c of the

vehicle-mounted device 20c detects the entry into the expanded charging area B, and as well as setting the entry flag causes operation of the travel distance calculating unit 33. In this way, travel distance in the expanded charging area B is calculated by the travel distance calculating unit 33. Next, when the charging area A is entered, the control section 26c of the vehicle-mounted device 20c transits travel distance calculated by the travel distance calculating unit 33 to the fee collection device, in addition to vehicle information etc., via the communication section 27. For example, in the event that a query signal is received from the first antenna 5 of the fee collection device 2 by the control section 26c, the operation of the travel distance calculating unit 33 is stopped, and the travel distance at that time is read out and transmitted to the fee collection device.

[0083] In the first antenna control unit 9 of the fee collection device, the fact that the expanded charging area has been entered is detected by the entry detection section 38, and notified to the charge determination section 39. The charge determination unit 39 calculates road usage fee according to travel distance relating to the expanded charging area B, using the first charge table 35 showing function relating to travel distance, and also extracts road usage fee for the charge area A according to the type of vehicle 1 from the second charge table 36, adding the two fees together to calculate a road usage fee for the vehicle 1. The determined road usage fee is then transmitted via the first antenna 5 to the vehicle-mounted device 20c.

If the control section 26c of the vehicle-mounted device 20c receives the road usage fee according to travel distance via the communication section 27, the control section 26c deducts the road usage fee from the balance stored in the IC card, updates this balance and stores it in the IC card as a new balance, and clears the value of the travel distance calculating unit 33. Incidentally, details of the communication between the first antenna control unit and the vehicle-mounted device 20c are carried out in accordance with the processing sequence shown in Fig. 8.

[0084] As described above, according to the fee collection system of this embodiment, travel distance in the expanded charging area B is transmitted to the fee collection device, and so it is made possible for the fee collection device to perform calculation of a road usage fee taking into consideration travel distance in the expanded charging area B. In this way, it is possible to give a road usage fee that more correctly reflects the road usage conditions.

[0085] Incidentally, with this embodiment, the travel distance calculating unit 33 and the entry flag are used together, but it is also possible to not use the entry flag, because by operating the travel distance calculating unit 33 it is possible to recognize that the expanded charging area B has been entered.

Incidentally, in this embodiment it is also possible to encrypt communication data containing the travel distance that is exchanged between the vehicle-mounted device 20c and the center device 17, in order to prevent improper acts such as falsification and interception of information.

[Fifth Embodiment]

[0086] Next, a fee collection system of a fifth embodiment of the present invention will be described.

The fee collection system of this embodiment is for a charging area A such as where a fixed charge is wrongly levied only when a fixed area is entered, like road pricing. With this embodiment, taking into consideration when a charging area A is entered by mistake, or when leaving the charging area A almost immediately after entering, when time spent in the charging area A is a predetermined period of time or less, points corresponding to that time spent are refunded to the user. The fee collection system of this embodiment will be described below, omitting description of points that are common to the third embodiment and focusing only on points of difference.

[0087] As shown in Fig. 21, the vehicle mounted device 20d of this embodiment is provided with a wide area communication unit 34 in addition to the structure of the vehicle-mounted device 20b of the third embodiment. As shown in Fig. 22, this wide area communication unit 34 carries out communication with external units, and is for connecting to a center unit 17 (refer to Fig. 2), which is an upper device of the fee collection system, for example. This wide area communication unit 34 can be fitted inside the vehicle-mounted device 20d, and can be used by connecting a mobile communication terminal 2 such as a portable telephone by means of connection terminals provided in the vehicle-mounted device 20d.

[0088] In Fig. 21 and Fig. 22, if a vehicle 1 enters a charging area A, and further a series of processes relating to charging between the control section 26d of the vehicle-mounted device 20d and the first antenna 5 and the second antenna 9 is completed, the control section 26d causes operation of the timer 32 after a value of the timer 32 has been reset. In this way, time spent in the charging area A is clocked.

[0089] Next, if the vehicle 1 leaves the charging area A, the control section 26d of the vehicle-mounted device 20d detects this, and stops operation of the timer 32. By then reading out the clocked time of the timer 32 the time spent in the charging area A is acquired, and this spent time is associated with vehicle information etc. and transmitted to the center unit 17 via the wide area communication section 34. Once the center unit 17 receives this spent time associated with the vehicle information, points corresponding to this spent time are determined based on a refund point table. Here, one example of a refund point table is shown in Fig. 23. In Fig. 23, the horizontal axis represents spent time and the vertical axis represents refund points. In this way, the refund points table is set so that as long as spent time is less than or equal to Tmax, the refund points are reduced as the spent time becomes longer. In Fig. 23, a case where spent time and

refund points have an inverse proportional relationship is shown, but this in only one example and this example is not predetermined. For example, it is possible to divide the spent time into a number of stepped levels, and vary the refund points in a stepwise manner according to each level, as shown in Fig. 24.

[0090] Returning to Fig. 21 and Fig 22, if the refund points P1 corresponding to the spent time T1 are obtained in the center unit 17 based on the above described refund points, the center unit 17 transmits the refund points to the vehicle-mounted device 20d. If the control section 26d of the vehicle-mounted device 20d receives the refund points via the wide area communication section 34, the refund points are stored in the storage device 25. At this time, if there are already refund points stored in the storage device 25, refund points are updated and stored by adding the refund points P1 received this time to the stored refund points.

Then, in transfer of information with the first antenna control unit 9 carried out the next time the vehicle 1 enters the charging area A, the control section 20d transmits the refund points stored in the storage device 25 together with information such as the vehicle information and the entry flag. In this way, in the first antenna control unit 9 a road usage fee with an amount corresponding to the refund points deducted is calculated.

[0091] As has been described above, according to the fee collection system of this embodiment, for a charging area A for which a fixed fee is levied at the time of entry regardless of the road usage conditions, as with road pricing etc., since points according to the time spent in the charging area A are refunded to the owner of the vehicle, it is possible to give financial relief to users who may have inadvertently entered the charging area A by mistake.

[0092] Incidentally, in this embodiment it is also possible to encrypt communication carried out between the vehicle-mounted device 20d and the center unit 17, in order to prevent improper acts such as falsification and interception of information. Also, in order to prevent the improper act of tampering with the vehicle-mounted device 20d to intentionally increase the refund points, it is possible to employ a method where the center unit 17 lists the refund points and vehicle information, and transmits this information to all fee collection devices 2. By doing this, the fee collection device can recognize whether or not the refund points transmitted from the vehicle-mounted device are valid. Incidentally, transmission of information in this case is carried out by means of a public line or the Internet network, for example.

[0093] Also, in a case where the vehicle 1 is parked in a car park that is inside the charging area A, it is possible to prevent the parking time being mistakenly included in the spent time by stopping operation of the timer 32. Further, with this embodiment, refund points corresponding to time spent in the charging area A are determined, but it is also possible, instead, to determine refund points according to travel distance in the charging area A. In this case, if the travel distance calculating unit 33 (refer to Fig. 19) is provided instead of the timer 32 in Fig. 21, the control section 26c calculates travel distance in the charging area A by causing operation of the travel distance calculating unit 33 at the same timing as the timing for causing operation of the timer 32 described above.

[Other Applied Examples]

[0094] In the above, cases of applying the fee collection system of the present invention to road pricing have been described, but it is also possible to apply the present invention to an ETC system. For example, as shown in Fig. 25, in the case of expanding a charging area (already existing toll road) A, entry into the expanded charging area B (expanded toll road) is detected using the GPS receiver 24 of the vehicle-mounted device 20, and an entry flag is set. In this case, at the exit tollgate, the entry flag is transmitted together with vehicle information. In this way, at the ETC system side it is possible to recognize that the charging area A has been entered from the expanded charging area B, and so a road usage fee is calculated also taking into consideration a fee for the expanded charging area B.

[0095] Also, as shown in Fig. 26, in a case where there is entry from charging area A, and the expanded charging area B is passed through and left, the fact that the expanded charging area B has been left is detected using the GPS receiver 24.

In this case the charging area A is left without passing through the exit tollgate, and so the fee remains unpaid. In this type of situation, it is possible to store the road usage history for this time in the IC card, and then transmit the unpaid road usage history to the fee collection device installed at the exit tollgate the next time. In this way, payment is also made for a road usage fee according to the road usage condition this time. Also, instead of this type of payment method, it is possible to construct a system such that road usage fee is automatically debited from a pre-registered bank account of a user etc. In this case, in the event that the charging area A is left without passing through the exit tollgate, then after leaving the expanded charging area B, road usage history for this time is transmitted by means of the above described wide area communication unit 34 (refer to Fig. 21) to the center unit 17, which is an upper device. In this way, the center unit 17 calculates a road usage fee for this time and carries out an automatic debit of this charge from a bank account etc.

[0096] Incidentally, with the above described first to fifth embodiments, current position is detected using only the GPS receiver, but in addition to the information received from the GPS receiver24, it is also possible to detect current position using information such as speed pulses detected by a speed sensor fitted to the vehicle 1, or a vehicle-mounted gyro etc. In this way, it is possible to further improve accuracy of current position.

[0097] Also, as shown in Fig. 27, when the vehicle 1

is traveling in a tunnel or the like, it is not possible to receive information from the GPS satellite, and even if the expanded charging area B is temporarily entered this can not be detected. In this type of case, it is preferable to install an antenna 45, for notifying the fact that the expanded charging area B has been entered to the vehicle-mounted device 20, for the boundary of the expanded charging area B established at a position where communication with the GPS satellite is difficult. At this time, in the event that a plurality of expanded charging areas B are established, identification information for the expanded charging area B is also transmitted.

[0098] Also, because entry is detected using the GPS receiver 24 even for a car park that is inside the expanded charging area B or the charging area A, it is preferable to also install the same antenna 45 at the entrance to a car park that is in a position where communication with the GPS satellite is difficult. In this case, it is preferable to transmit information for identifying which car park has been entered to the vehicle-mounted device 20.

[0099] Further, it is possible to use a D-GPS system in order to further improve accuracy of position detection by the GPS receiver 24. In this case, it is possible to receive correction data via an FM multiplex station, as shown in Fig. 28. Also in this case, as shown in Fig. 29, an FM multiple receiver 53 is further provided in the vehicle-mounted device 20.

In the D-GPS system shown in Fig. 28, D-GPS position correction data analyzed by the base station 50 is transmitted to an FM broadcast station 52 via the center station 51 of the FM broadcast station. At the FM broadcast station 52, received D-GPS correction data is provided using FM multiplex broadcasting. D-GPS correction data transmitted by FM multiplex broadcast is received by the FM multiplex receiver 53 provided in the vehicle-mounted device 20, and correction of position information using this D-GPS correction data is carried out in the GPS receiver 24. In this way it is possible to further improve the position detection accuracy.

[0100] Also, the embodiments above have been described with a contact type IC card as one example, but it is also possible to the use a non-contact IC card instead.

Claims

1. A vehicle-mounted device that is mounted in a vehicle, and transfers information relating to a charge with a fee collection device installed at a toll gate of a charging area, comprising:

   a storage device for storing map information of an expanded charging area newly established outside the charging area,
   a position information acquisition section, and
   an entry detection section for detecting entry into the expanded charging area based on position information acquired by the position information acquisition section and map information of the expanded charging area, wherein
   with respect to communication with the fee collection device, entry determination information representing whether or not there has been entry into the expanded charging area is transmitted.

2. The vehicle-mounted device of claim 1, having an entry flag indicating whether or not there has been entry into the expanded charging area, wherein the entry flag is set in the event that there is entry into the expanded charging area, and in communication with a charge communication device the state of the entry flag is transmitted as the entry determination information, and after the transmission the entry flag is reset.

3. The vehicle-mounted device of claim 2, wherein, in the event that a plurality of the expanded charging areas are provided, there are respective entry flags corresponding to each of the expanded charging areas, and the state of each entry flag and identification information for each expanded charging area are transmitted to a corresponding charge communication device.

4. The vehicle-mounted device of any one of claim 1 to claim 3, wherein a clock section for clocking time spent in the expanded charging area is provided, and the time spent is transmitted to the fee collection device.

5. The vehicle-mounted device of claim 4, wherein the time spent is encrypted and transmitted.

6. The vehicle-mounted device of claim 4 or claim 5, wherein, for a period of time a vehicle is parked in a car park provided inside the expanded charging area, operation of the clock section is stopped.

7. The vehicle-mounted device of any one of claim 1 to claim 3, wherein a travel distance calculating section for measuring travel distance inside the expanded charging area is provided, and the travel distance is transmitted to the fee collection device.

8. A vehicle-mounted device provided with a GPS receiver and an FM multiplex receiver, wherein position information acquired by the GPS receiver is corrected using correction data of a GPS satellite acquired by the FM multiplex receiver.

9. A fee collection device, arranged in a charging area, for performing transfer of information relating to a charge to and from a vehicle-mounted device fitted to a vehicle passing through the charging area, comprising:

a storage device for storing first charging information relating to an expanded charging area newly established outside the charging area, and second charging information relating to the charging area,
an entry determination section for, when entry determination information has been received from the vehicle-mounted device, determining whether or not a vehicle fitted with the vehicle-mounted device has entered the expanded charging area based on the entry determination information, and
a charge determination section for determining a charge to be levied based on the determination result, and the first charging information and the second charging information.

10. The fee collection device of claim 9, wherein the first charging information includes a charge table having time spent in the expanded charging area as a parameter, and when the time spent in the expanded charging area is received from the vehicle-mounted device, the charge determination section determines a road usage fee for the expanded charging area using the time spent and the charge table.

11. The fee collection device of claim 9, wherein the first charging information includes a charge table having travel distance in the expanded charging area as a parameter, and when the travel distance in the expanded charging area is received from the vehicle-mounted device, the charge determination section determines a road usage fee for the expanded charging area using the travel distance and the charge table.

12. The fee collection device of any one of claim 9 to claim 11, having first charging information corresponding to respective expanded charging areas, when a plurality of the expanded charging areas are provided, and wherein the entry determination section receives the entry determination information that has been associated with identification information of each expanded charging area from the vehicle-mounted device, and specifies the expanded charging area the vehicle has entered based on the entry determination information, and the charge determination section determines a road usage fee for the expanded charging area using the first charging information corresponding to the expanded charging area the vehicle has entered.

13. The fee collection device of any one of claim 9 to claim 12, having a refund points table with time spent in the charging area as a parameter, when the charging area is an area for which a constant fee is levied at the time of entry regardless of road usage conditions, wherein, when time spent in the charging area has been received from the vehicle-mounted device, the charge determination section determines refund points using the time spent and the reduction points table, and these refund points are allocated to the owner of the vehicle.

14. A fee collection system, provided with a fee collection device installed in a charging area, and a vehicle-mounted device that is mounted in a vehicle and exchanges information relating to a charge with the fee collection device, wherein
the vehicle-mounted device comprises,
a map information storage device for storing map information of the expanded charging area newly established outside the charging area,
a position information acquisition section, and
an entry detection section for detecting entry into the expanded charging area based on position information acquired by the position information acquisition section and map information of the expanded charging area,
with entry determination information representing whether or not the expanded charging area has been entered being transmitted when the fee collection device is approached,
and wherein the fee collection device comprises
a storage device for storing first charging information relating to the expanded charging area, and second charging information relating to the charging area,
an entry determination section for, when the entry determination information has been received from the vehicle-mounted device, determining whether or not a vehicle fitted with the vehicle-mounted device has entered the expanded charging area based on the entry determination information, and
a charge determination section for determining a charge to be levied based on the determination result, and the first charging information and the second charging information.

15. The fee collection system of claim 14, provided with a fitted determination section for determining whether or not the vehicle-mounted device is fitted with a position information acquisition section, wherein the charge determination section causes different charges to be levied depending on whether the vehicle-mounted device has, or does not have, a GPS function.

16. The fee collection system of claim 14 or claim 15, wherein, in a case where the position information acquisition section is a GPS receiver, in the expanded charging area that is an area in which it is difficult for the vehicle-mounted GPS receiver to receive position information from a GPS satellite, a wireless antenna for transmitting position data to the vehicle-mounted device is installed.

FIG. 1

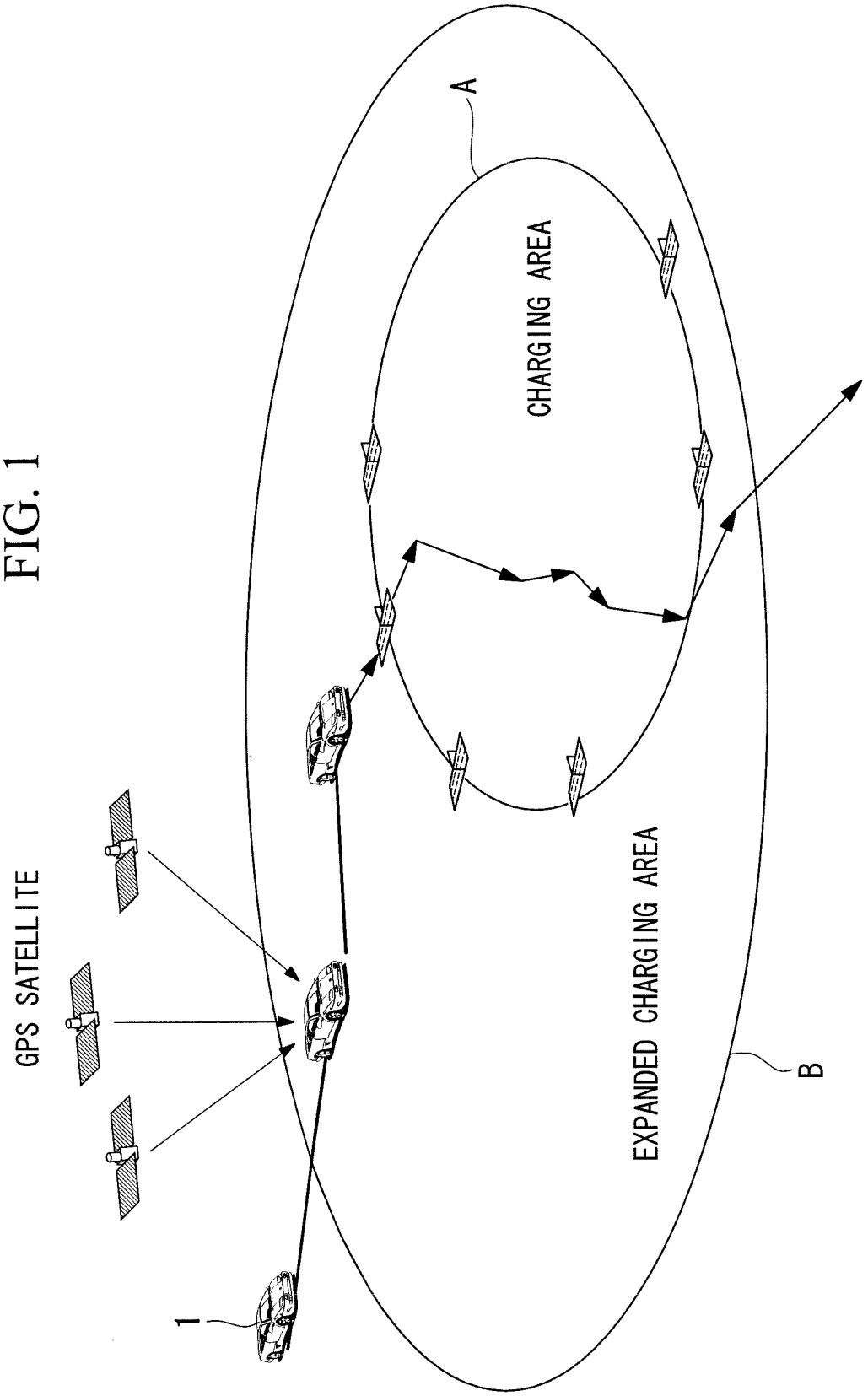


FIG. 2

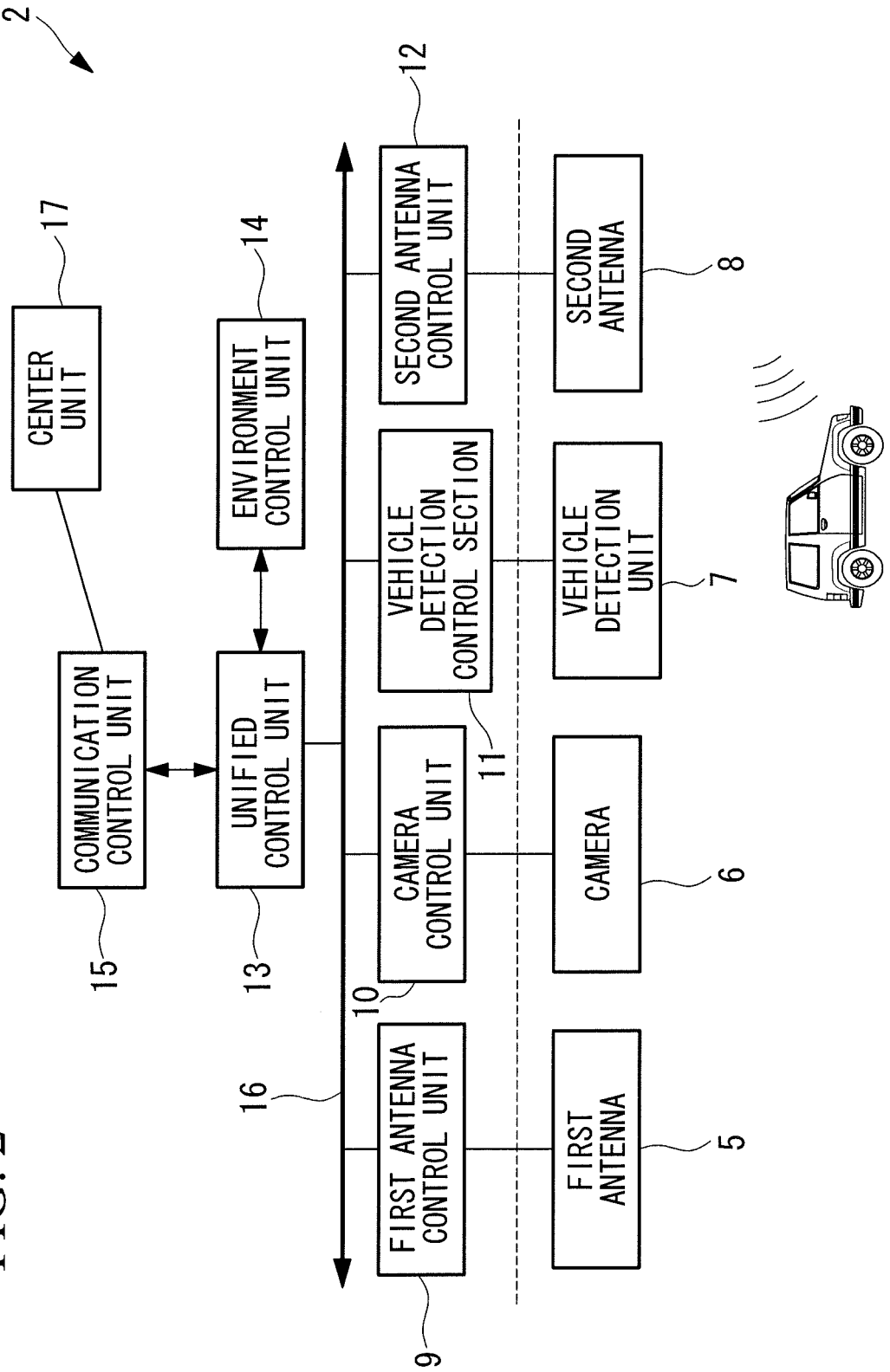

2
CENTER UNIT
17
ENVIRONMENT CONTROL UNIT
14
SECOND ANTENNA CONTROL UNIT
12
SECOND ANTENNA
8
COMMUNICATION CONTROL UNIT
15
UNIFIED CONTROL UNIT
13
VEHICLE DETECTION CONTROL SECTION
11
VEHICLE DETECTION UNIT
7
CAMERA CONTROL UNIT
10
CAMERA
6
16
FIRST ANTENNA CONTROL UNIT
9
FIRST ANTENNA
5

FIG. 3

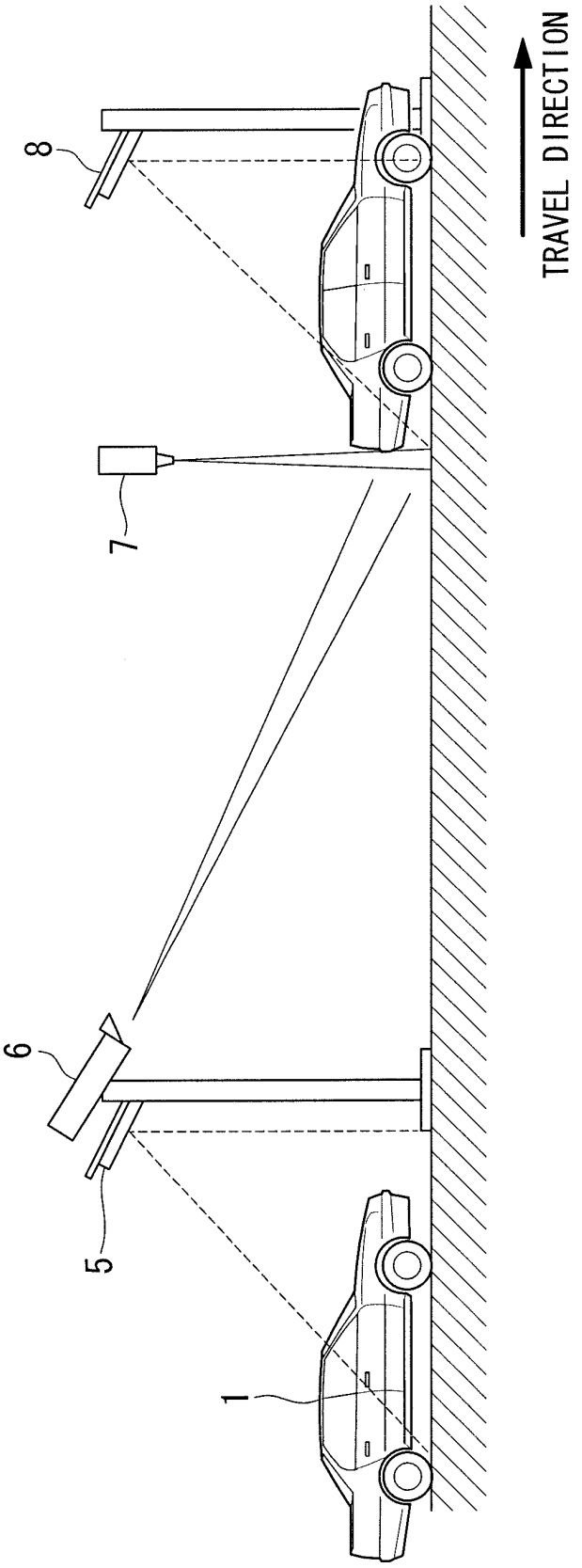


FIG. 4

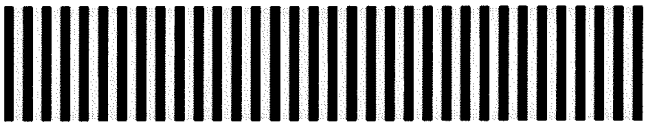


FIG. 5

FIG. 6

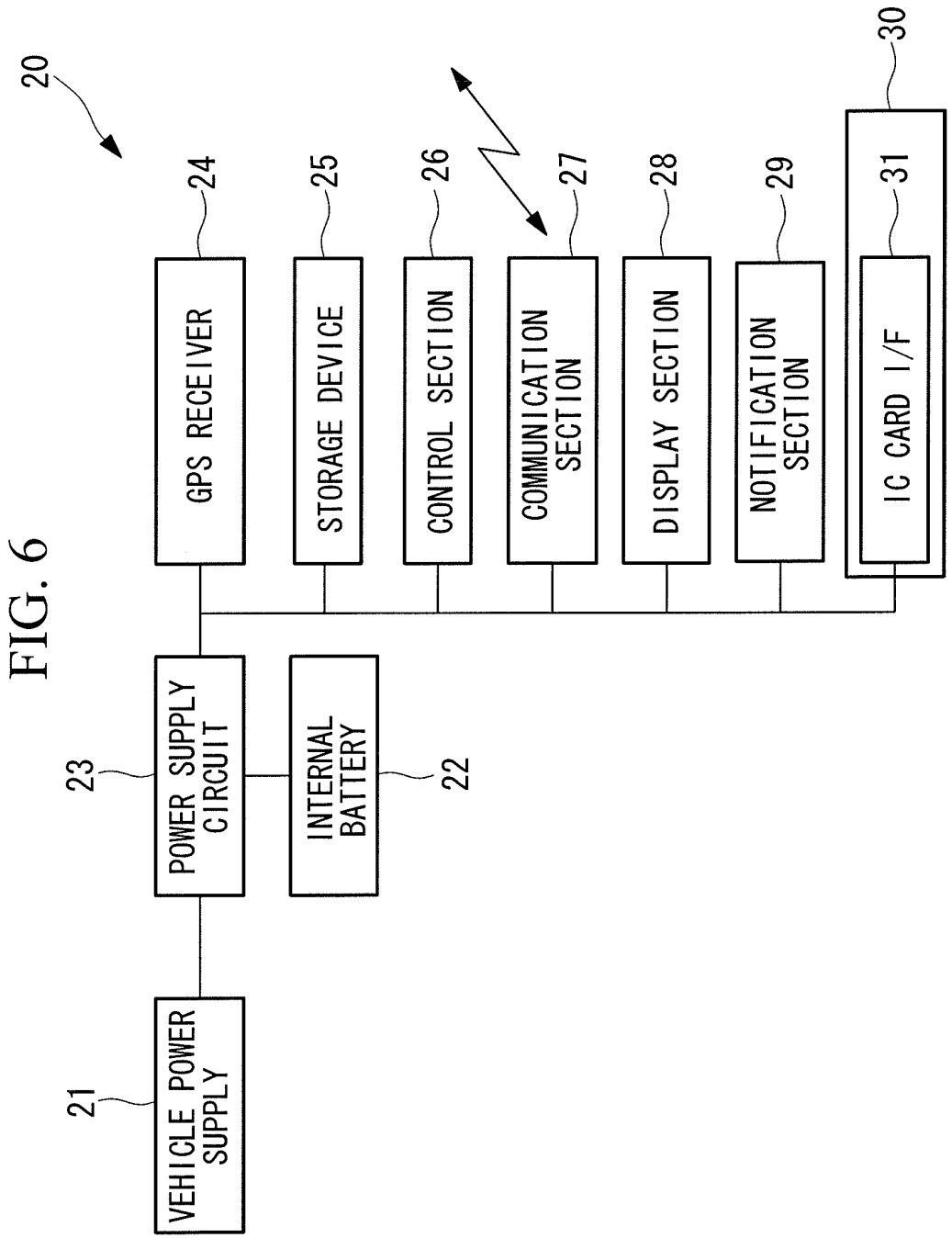

20
24
GPS RECEIVER
25
STORAGE DEVICE
26
CONTROL SECTION
27
COMMUNICATION SECTION
28
DISPLAY SECTION
29
NOTIFICATION SECTION
30
31
IC CARD I/F
23
POWER SUPPLY CIRCUIT
22
INTERNAL BATTERY
21
VEHICLE POWER SUPPLY

FIG. 7

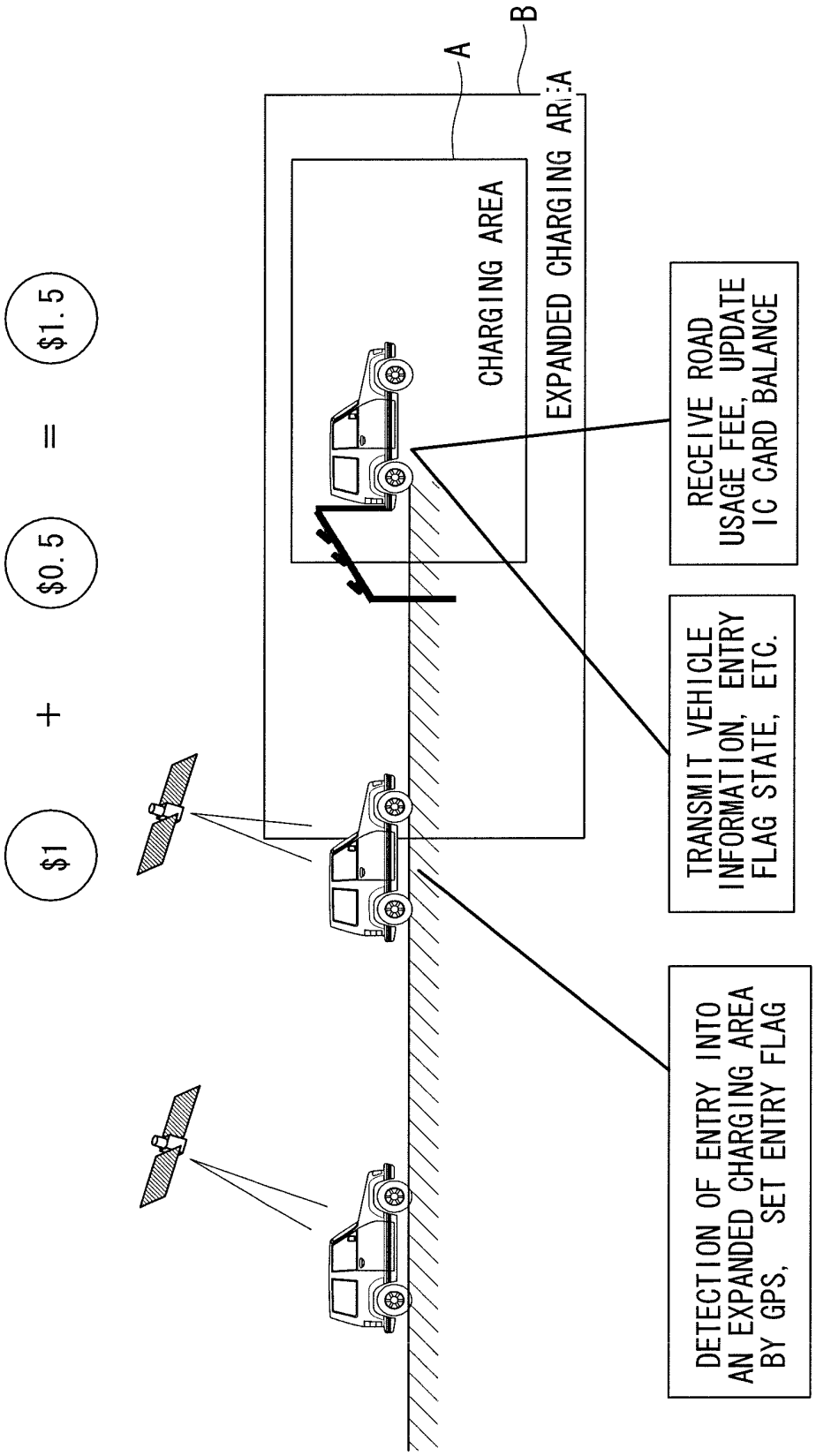

$1
+
$0.5
=
$1.5
A
B
CHARGING AREA
EXPANDED CHARGING AREA
RECEIVE ROAD USAGE FEE, UPDATE IC CARD BALANCE
TRANSMIT VEHICLE INFORMATION, ENTRY FLAG STATE, ETC.
DETECTION OF ENTRY INTO AN EXPANDED CHARGING AREA BY GPS, SET ENTRY FLAG

FIG. 8

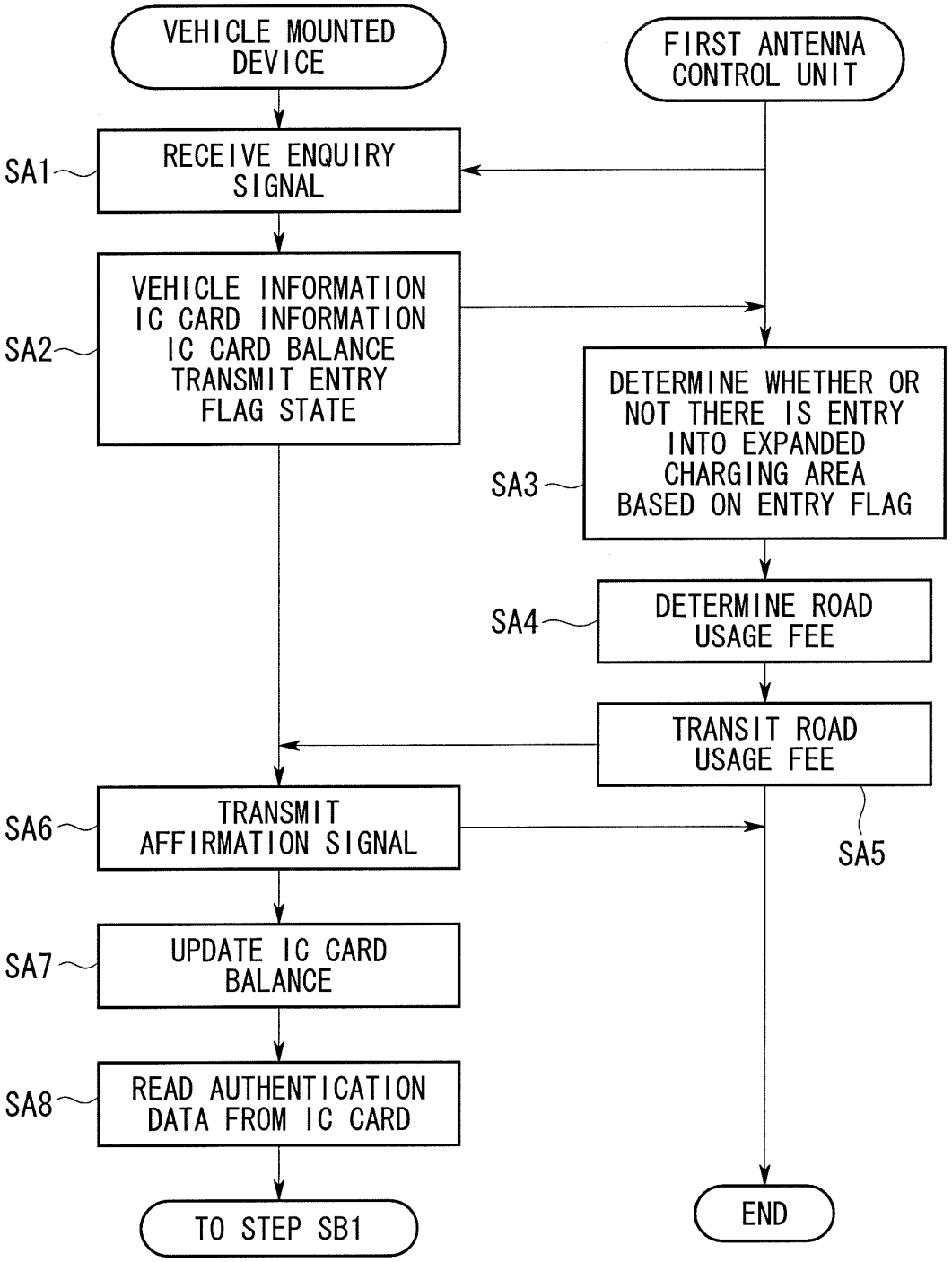

VEHICLE MOUNTED DEVICE
FIRST ANTENNA CONTROL UNIT
SA1
RECEIVE ENQUIRY SIGNAL
SA2
VEHICLE INFORMATION
IC CARD INFORMATION
IC CARD BALANCE
TRANSMIT ENTRY
FLAG STATE
SA3
DETERMINE WHETHER OR NOT THERE IS ENTRY INTO EXPANDED CHARGING AREA BASED ON ENTRY FLAG
SA4
DETERMINE ROAD USAGE FEE
TRANSIT ROAD USAGE FEE
SA5
SA6
TRANSMIT AFFIRMATION SIGNAL
SA7
UPDATE IC CARD BALANCE
SA8
READ AUTHENTICATION DATA FROM IC CARD
TO STEP SB1
END

FIG. 9

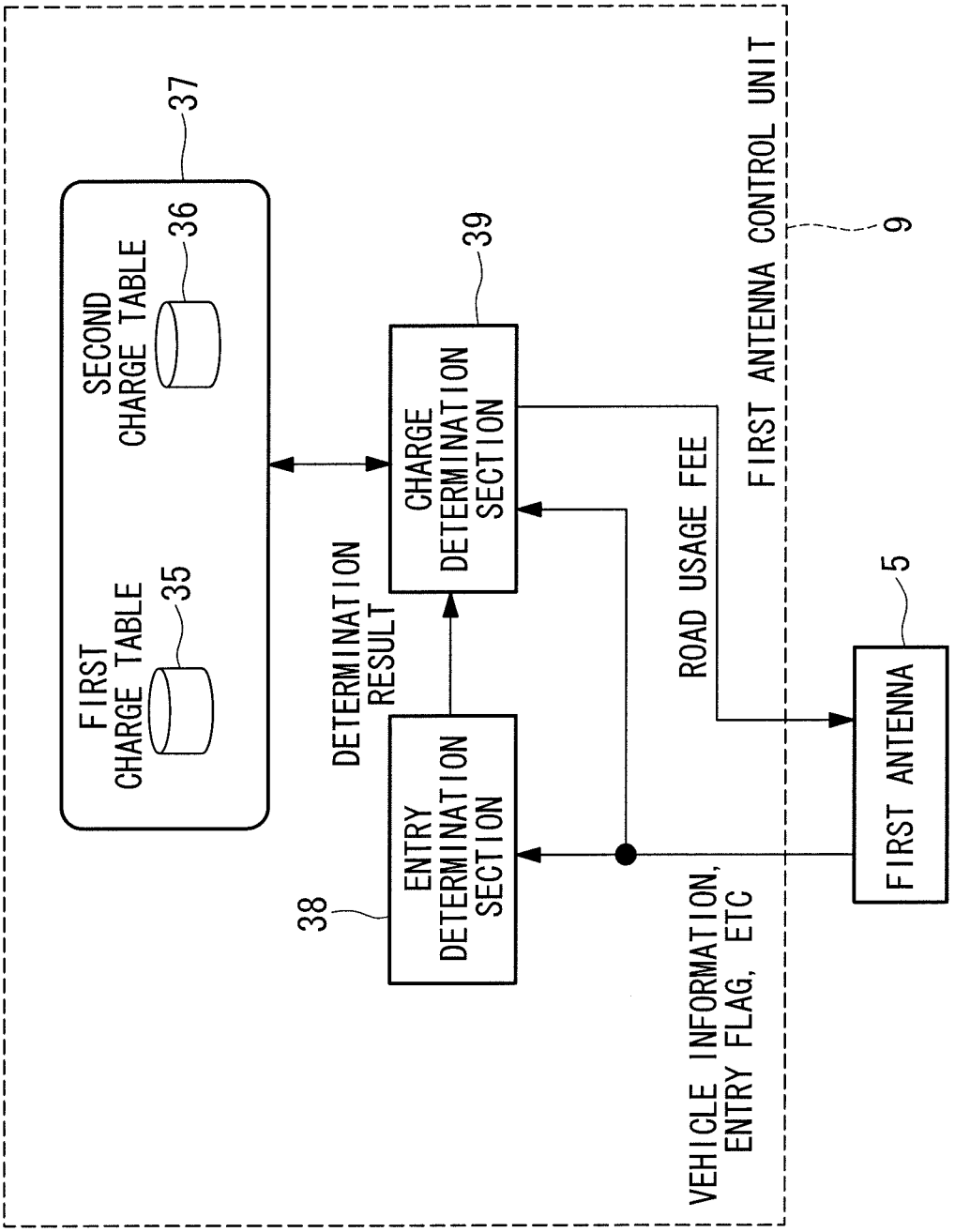

FIRST ANTENNA CONTROL UNIT
9
37
SECOND CHARGE TABLE
36
FIRST CHARGE TABLE
35
39
CHARGE DETERMINATION SECTION
DETERMINATION RESULT
38
ENTRY DETERMINATION SECTION
ROAD USAGE FEE
5
FIRST ANTENNA
VEHICLE INFORMATION, ENTRY FLAG, ETC

FIG. 10

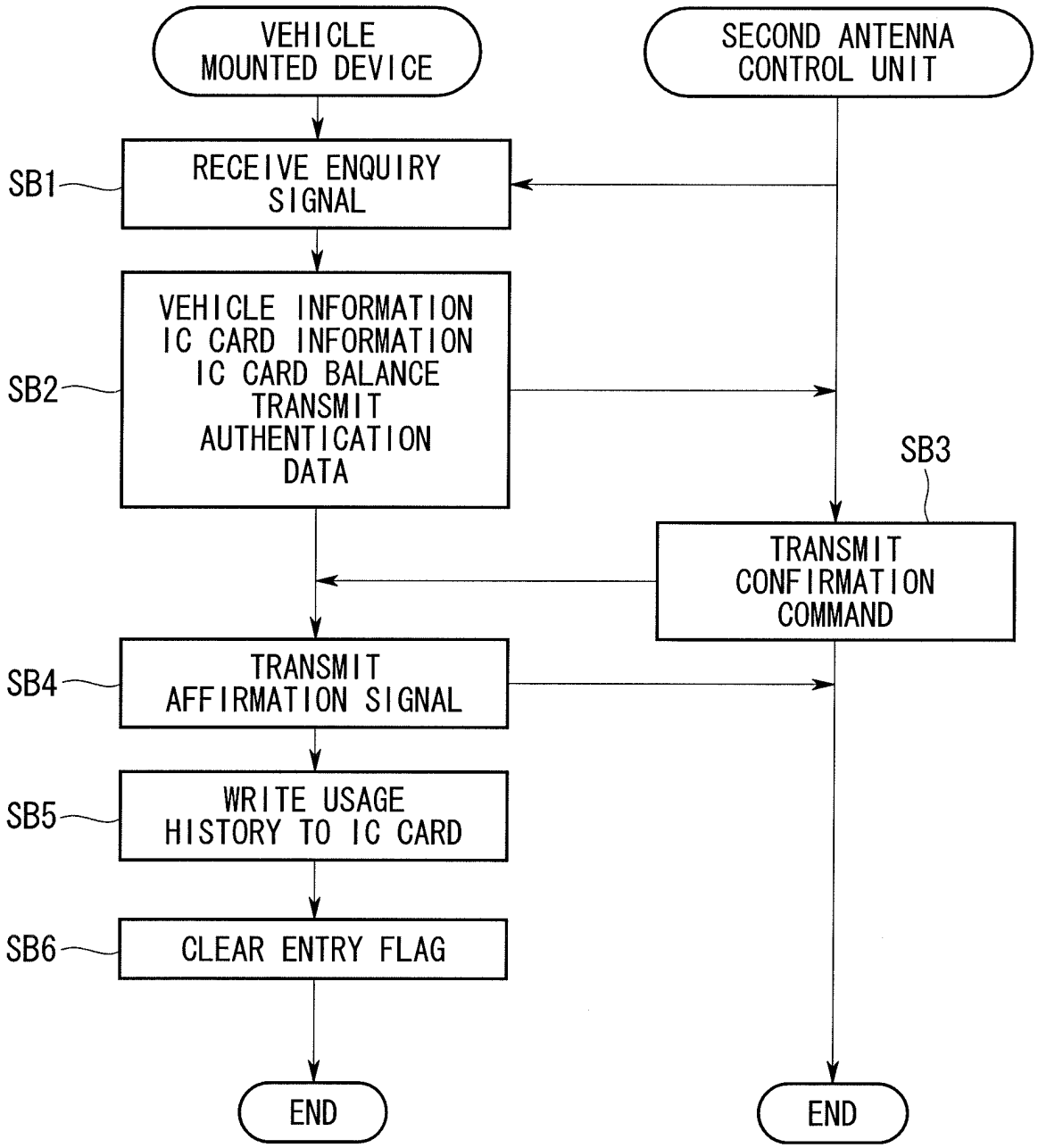

VEHICLE MOUNTED DEVICE
SECOND ANTENNA CONTROL UNIT
SB1
RECEIVE ENQUIRY SIGNAL
SB2
VEHICLE INFORMATION
IC CARD INFORMATION
IC CARD BALANCE
TRANSMIT AUTHENTICATION DATA
SB3
TRANSMIT CONFIRMATION COMMAND
SB4
TRANSMIT AFFIRMATION SIGNAL
SB5
WRITE USAGE HISTORY TO IC CARD
SB6
CLEAR ENTRY FLAG
END
END

FIG. 11

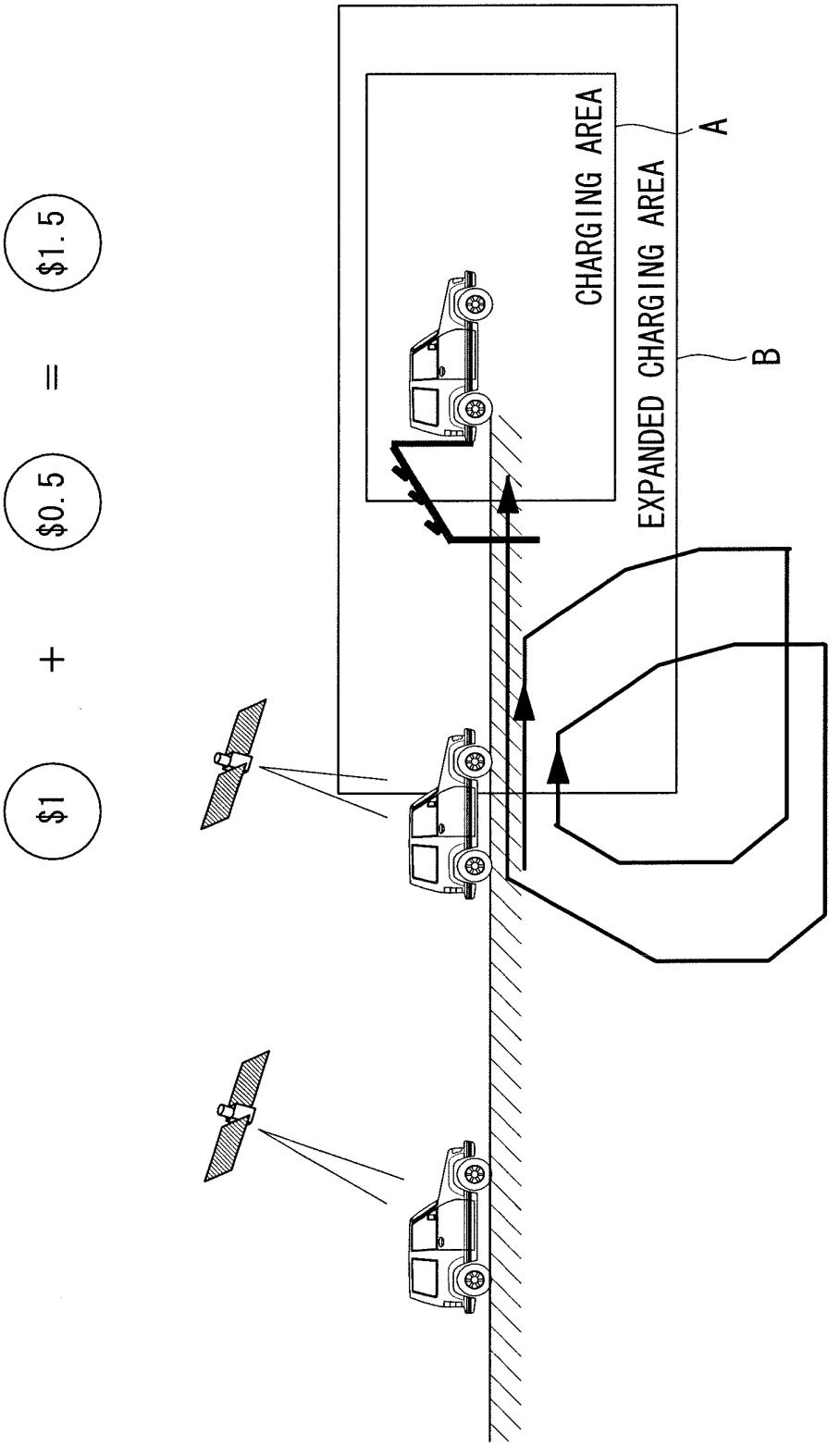


FIG. 12

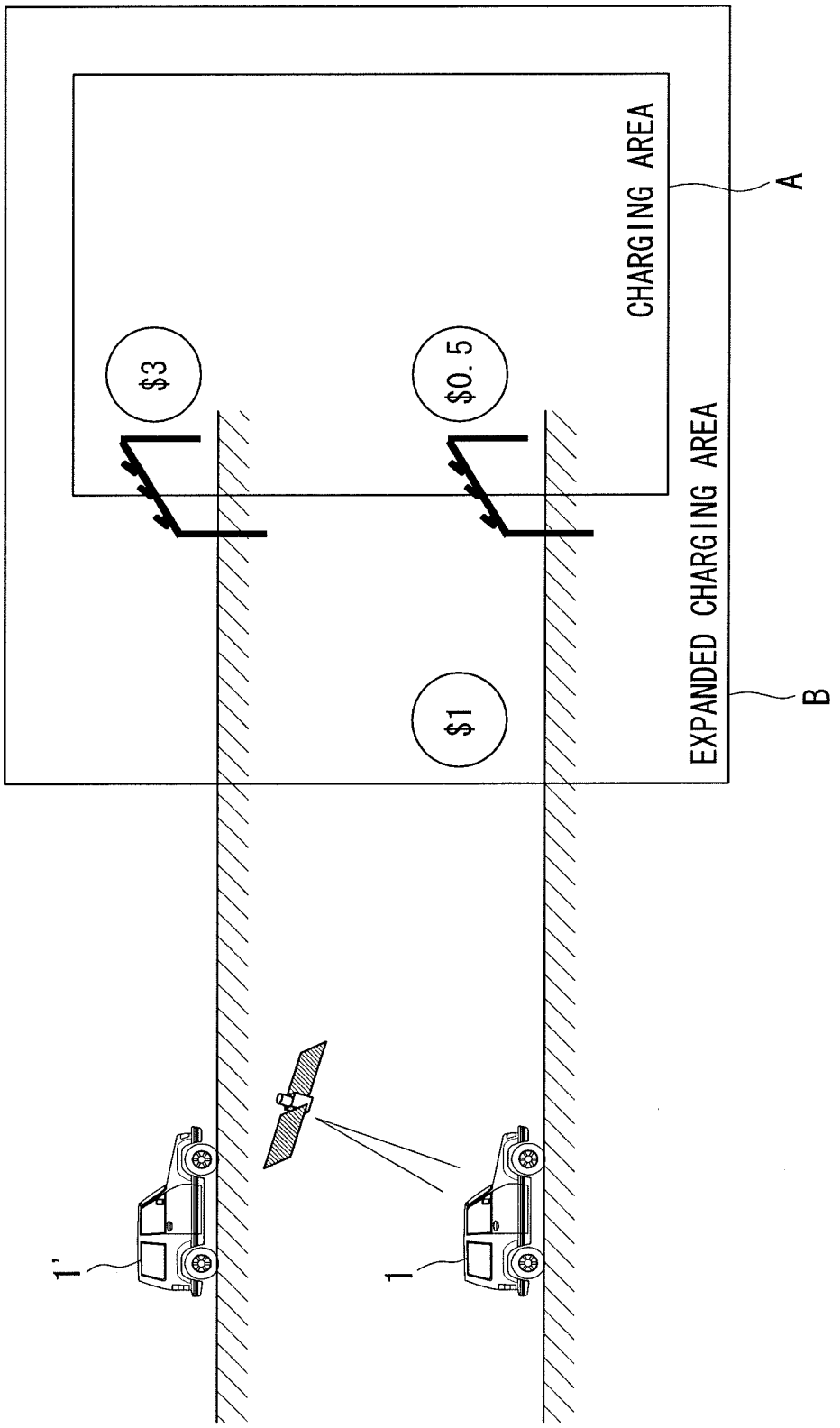


FIG. 13

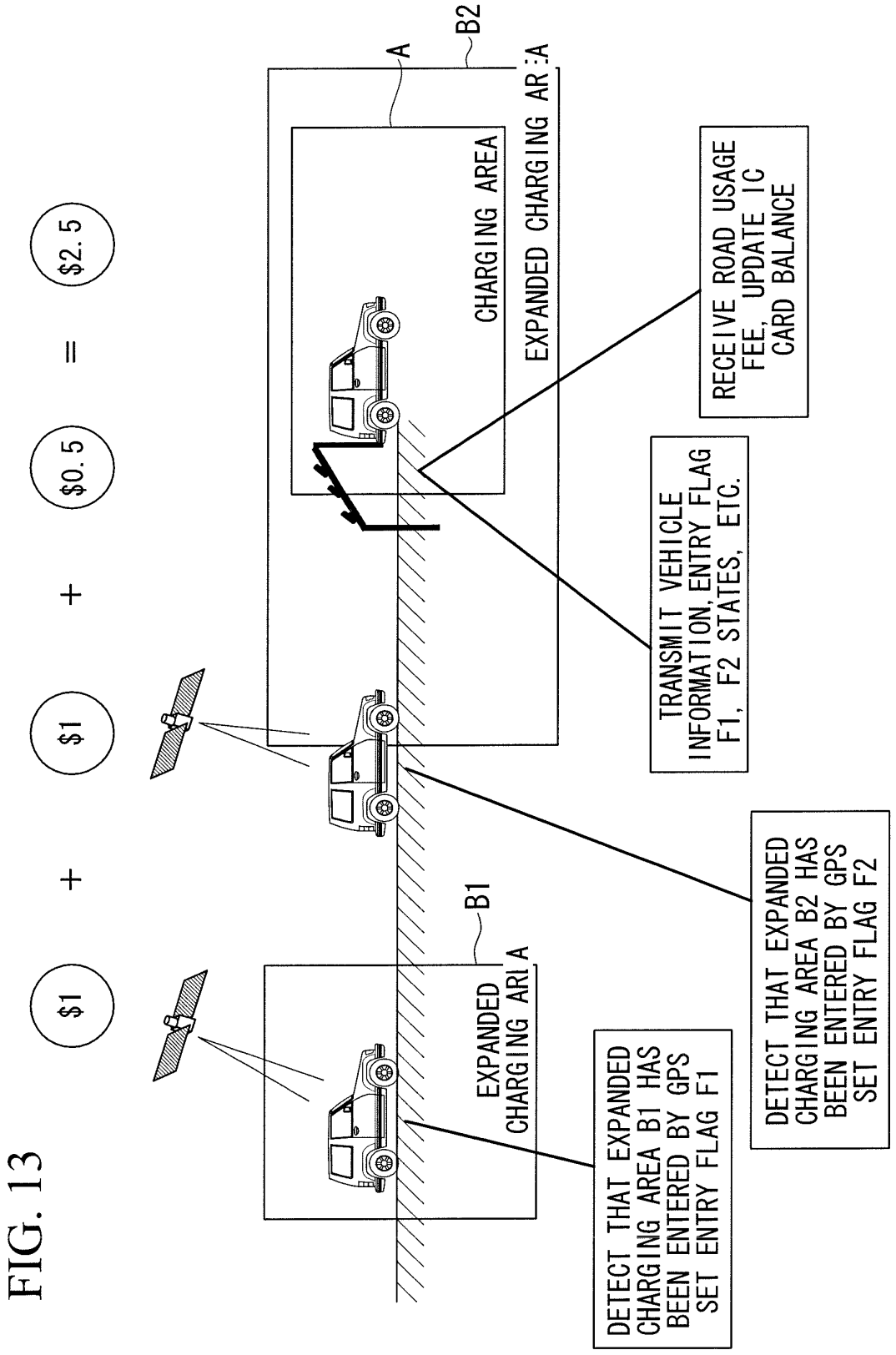

$1
+
$1
+
$0.5
=
$2.5
A
B2
CHARGING AREA
EXPANDED CHARGING AREA
B1
EXPANDED CHARGING AREA
RECEIVE ROAD USAGE FEE, UPDATE IC CARD BALANCE
TRANSMIT VEHICLE INFORMATION, ENTRY FLAG F1, F2 STATES, ETC.
DETECT THAT EXPANDED CHARGING AREA B2 HAS BEEN ENTERED BY GPS SET ENTRY FLAG F2
DETECT THAT EXPANDED CHARGING AREA B1 HAS BEEN ENTERED BY GPS SET ENTRY FLAG F1

FIG. 14

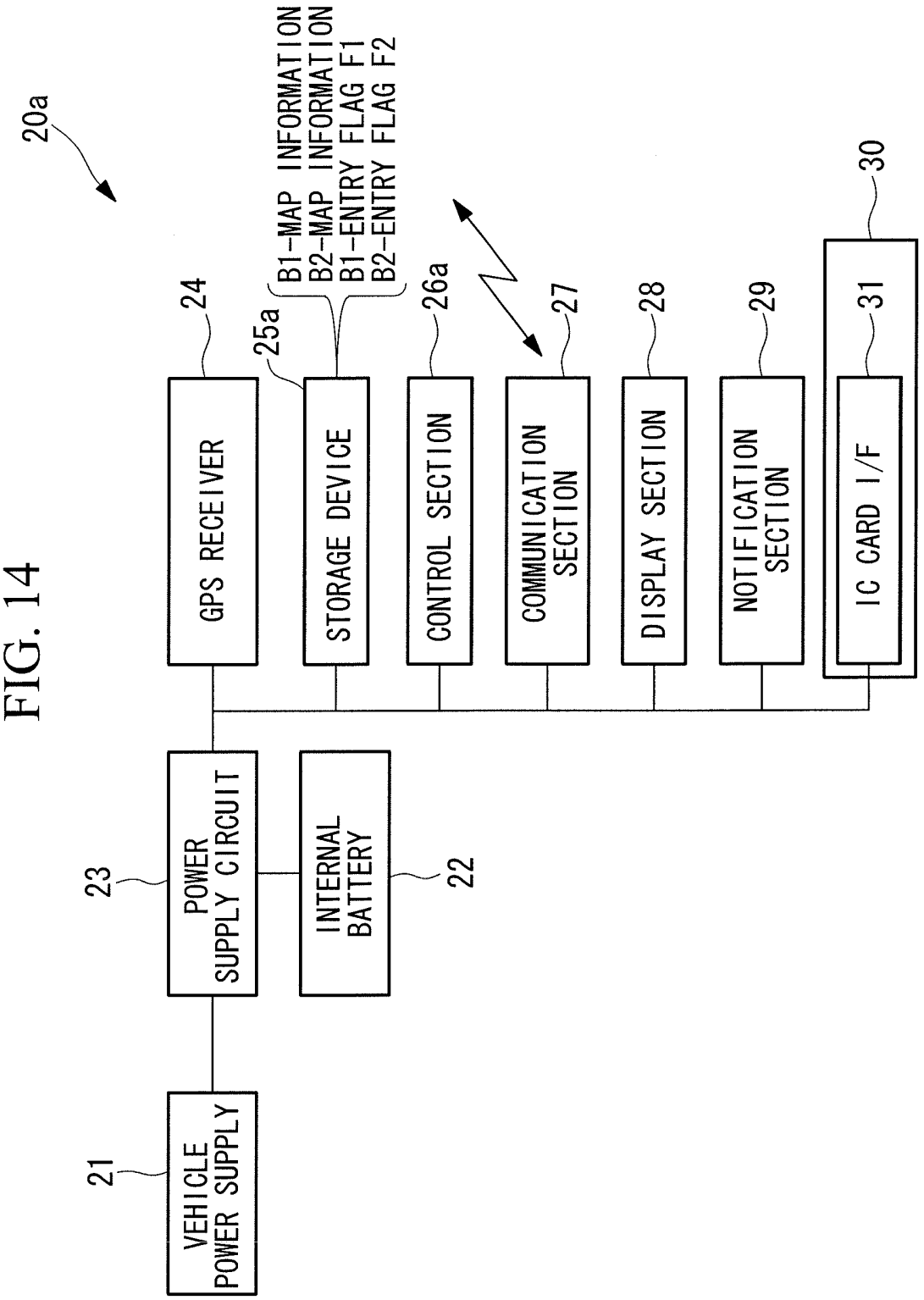
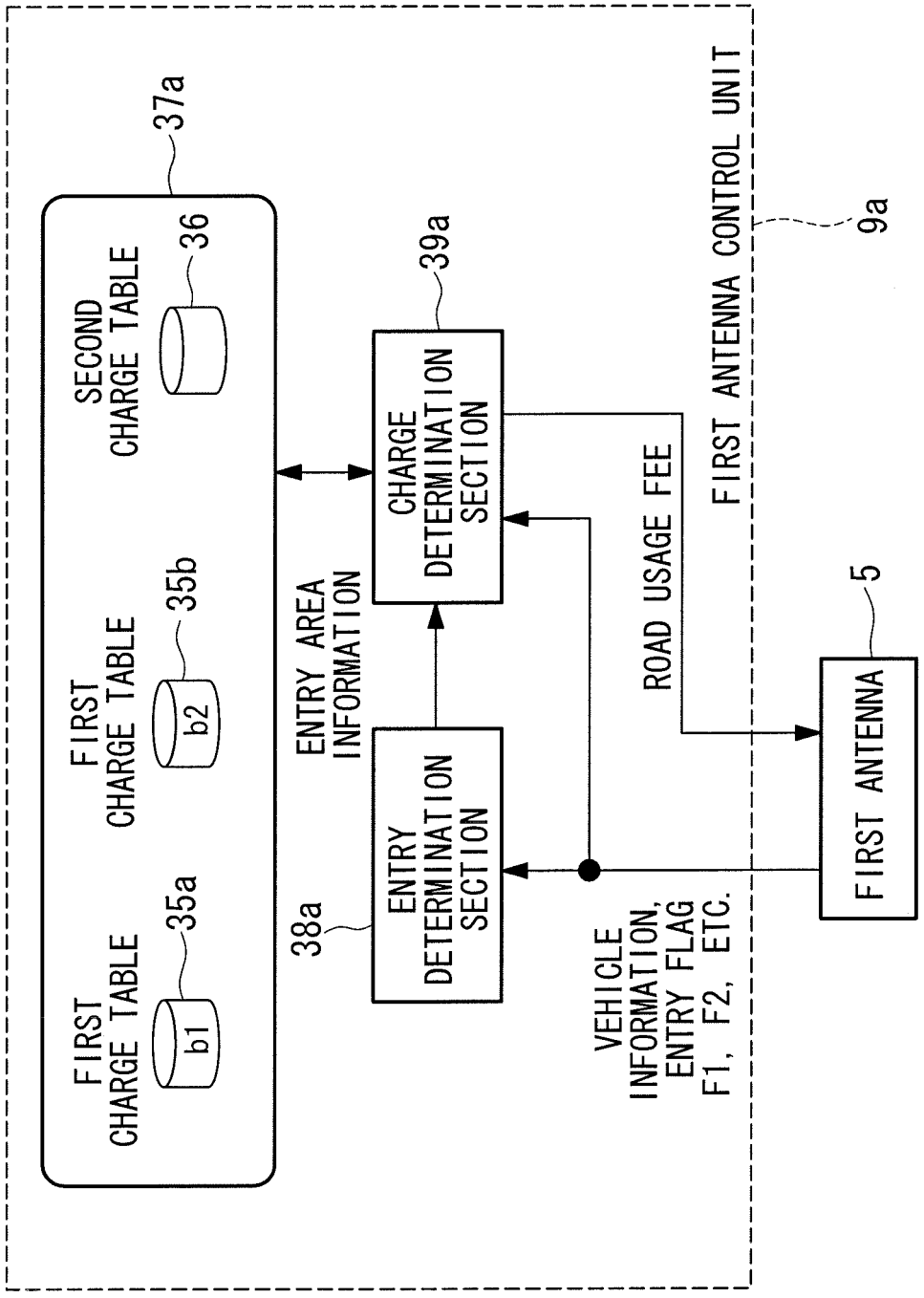

20a
B1-MAP INFORMATION
B2-MAP INFORMATION
B1-ENTRY FLAG F1
B2-ENTRY FLAG F2
24
25a
26a
27
28
29
30
31
GPS RECEIVER
STORAGE DEVICE
CONTROL SECTION
COMMUNICATION SECTION
DISPLAY SECTION
NOTIFICATION SECTION
IC CARD I/F
23
POWER SUPPLY CIRCUIT
INTERNAL BATTERY
22
21
VEHICLE POWER SUPPLY

FIG. 15


FIRST ANTENNA CONTROL UNIT
9a
37a
FIRST CHARGE TABLE
35a
b1
FIRST CHARGE TABLE
35b
b2
SECOND CHARGE TABLE
36
38a
ENTRY DETERMINATION SECTION
ENTRY AREA INFORMATION
CHARGE DETERMINATION SECTION
39a
ROAD USAGE FEE
VEHICLE INFORMATION, ENTRY FLAG F1, F2, ETC.
FIRST ANTENNA
5

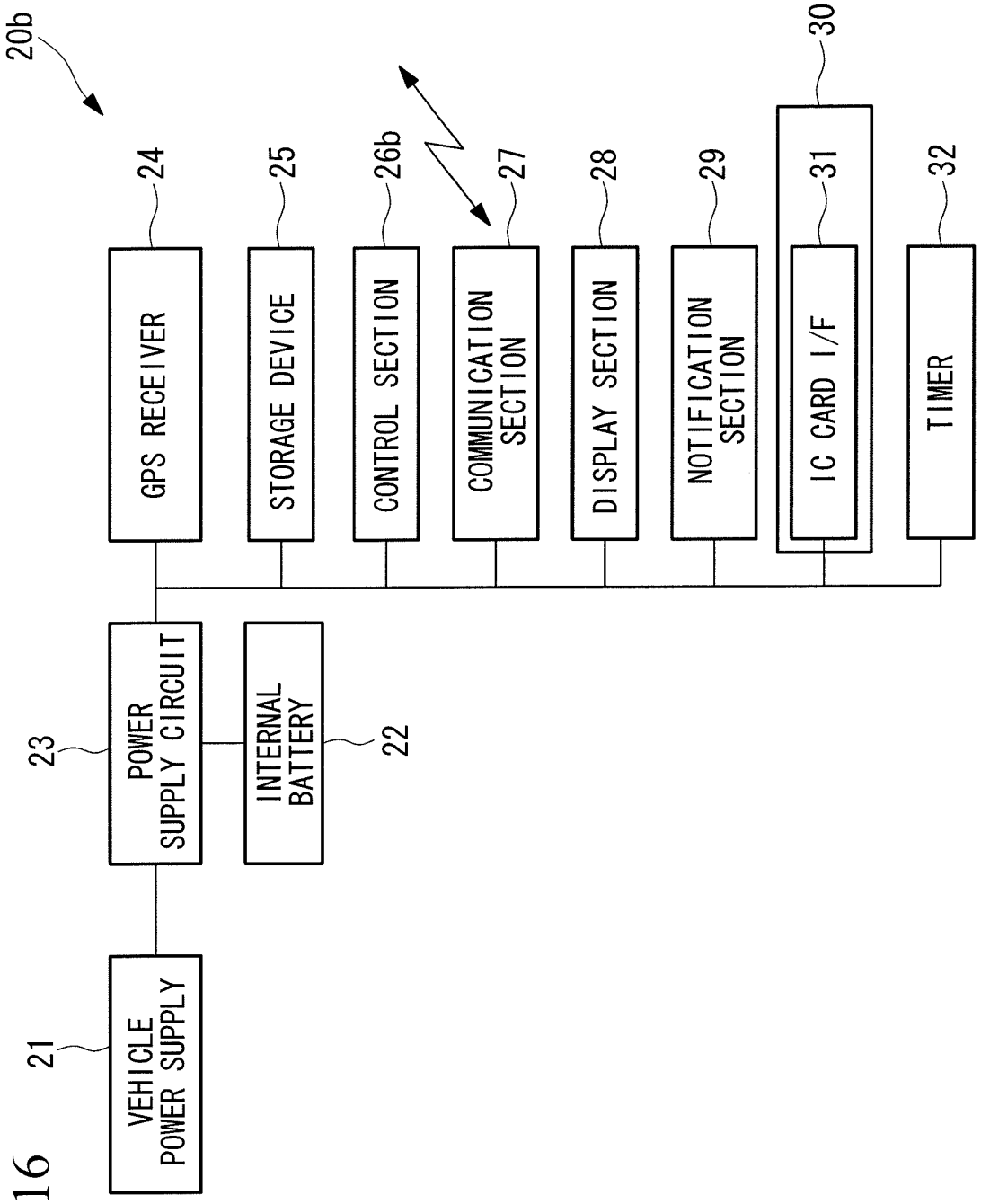

20b
24
GPS RECEIVER
25
STORAGE DEVICE
26b
CONTROL SECTION
27
COMMUNICATION SECTION
28
DISPLAY SECTION
29
NOTIFICATION SECTION
30
31
IC CARD I/F
32
TIMER
23
POWER SUPPLY CIRCUIT
INTERNAL BATTERY
22
21
VEHICLE POWER SUPPLY

FIG. 16

FIG. 17

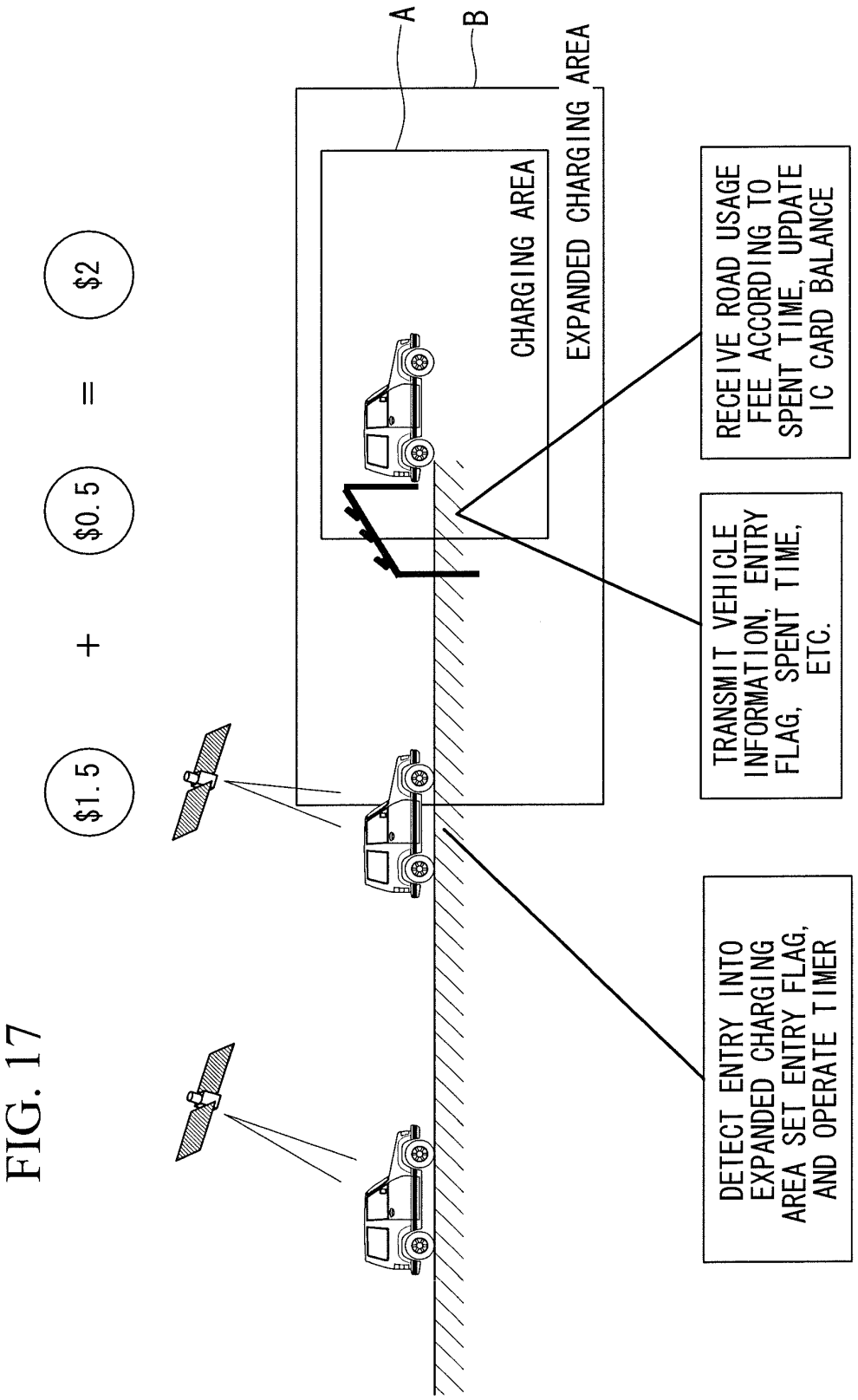

$1.5
+
$0.5
=
$2
A
B
EXPANDED CHARGING AREA
CHARGING AREA
RECEIVE ROAD USAGE FEE ACCORDING TO SPENT TIME, UPDATE IC CARD BALANCE
TRANSMIT VEHICLE INFORMATION, ENTRY FLAG, SPENT TIME, ETC.
DETECT ENTRY INTO EXPANDED CHARGING AREA SET ENTRY FLAG, AND OPERATE TIMER

FIG. 18

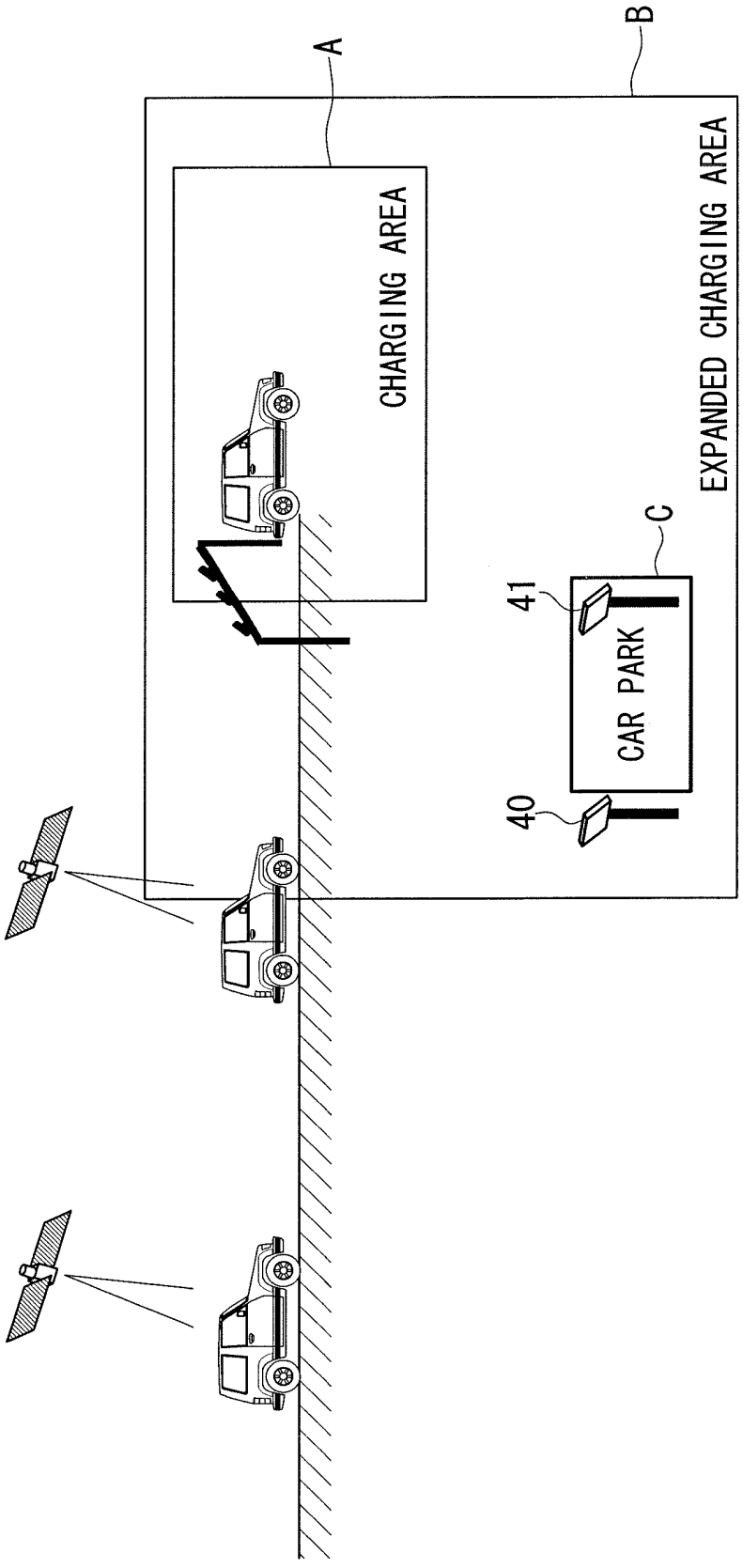


FIG. 19

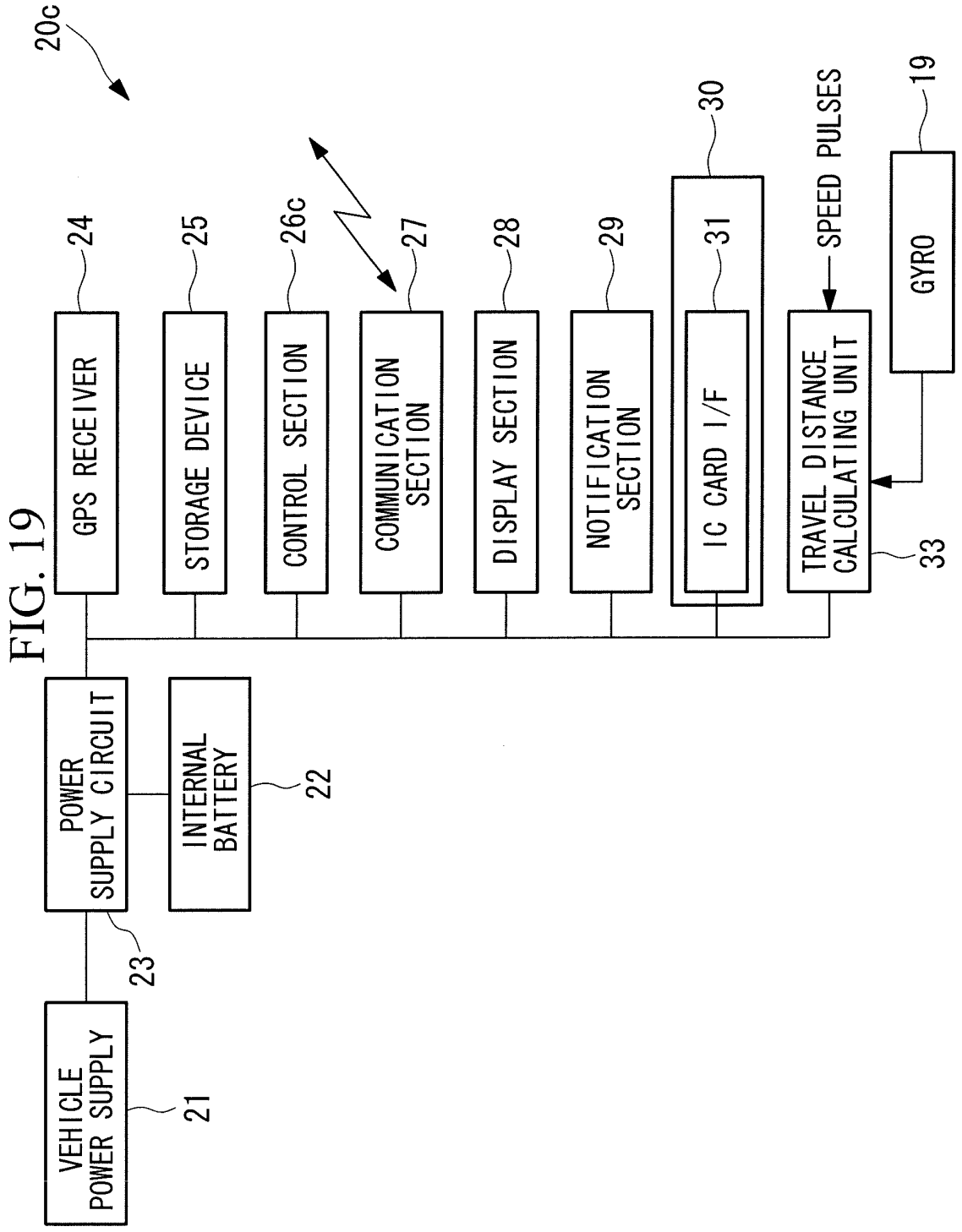

20c
GPS RECEIVER
24
STORAGE DEVICE
25
CONTROL SECTION
26c
COMMUNICATION SECTION
27
DISPLAY SECTION
28
NOTIFICATION SECTION
29
IC CARD I/F
31
30
TRAVEL DISTANCE CALCULATING UNIT
33
SPEED PULSES
GYRO
19
POWER SUPPLY CIRCUIT
23
INTERNAL BATTERY
22
VEHICLE POWER SUPPLY
21

FIG. 20

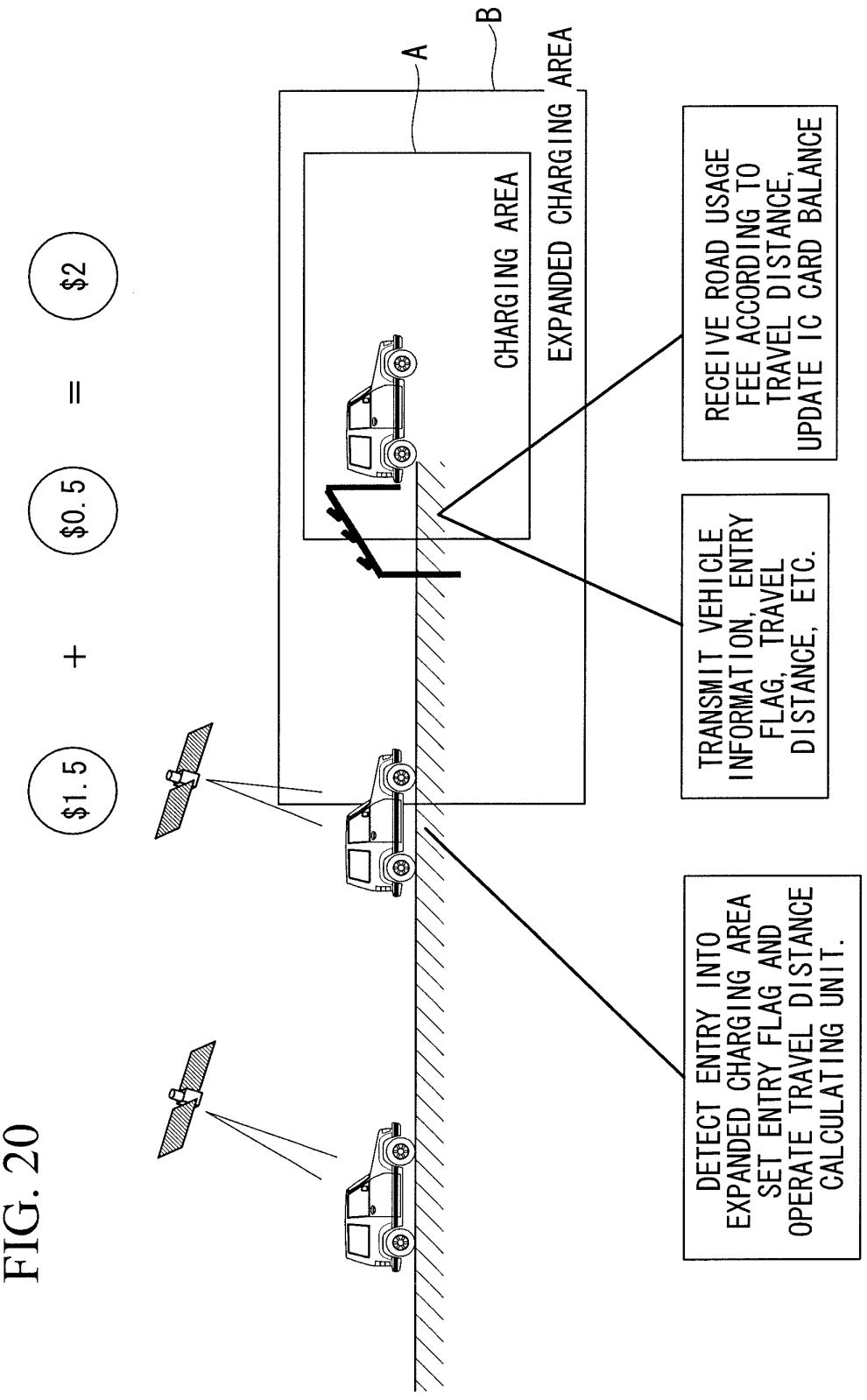

$1.5
+
$0.5
=
$2
A
B
CHARGING AREA
EXPANDED CHARGING AREA
RECEIVE ROAD USAGE FEE ACCORDING TO TRAVEL DISTANCE, UPDATE IC CARD BALANCE
TRANSMIT VEHICLE INFORMATION, ENTRY FLAG, TRAVEL DISTANCE, ETC.
DETECT ENTRY INTO EXPANDED CHARGING AREA SET ENTRY FLAG AND OPERATE TRAVEL DISTANCE CALCULATING UNIT.

FIG. 21

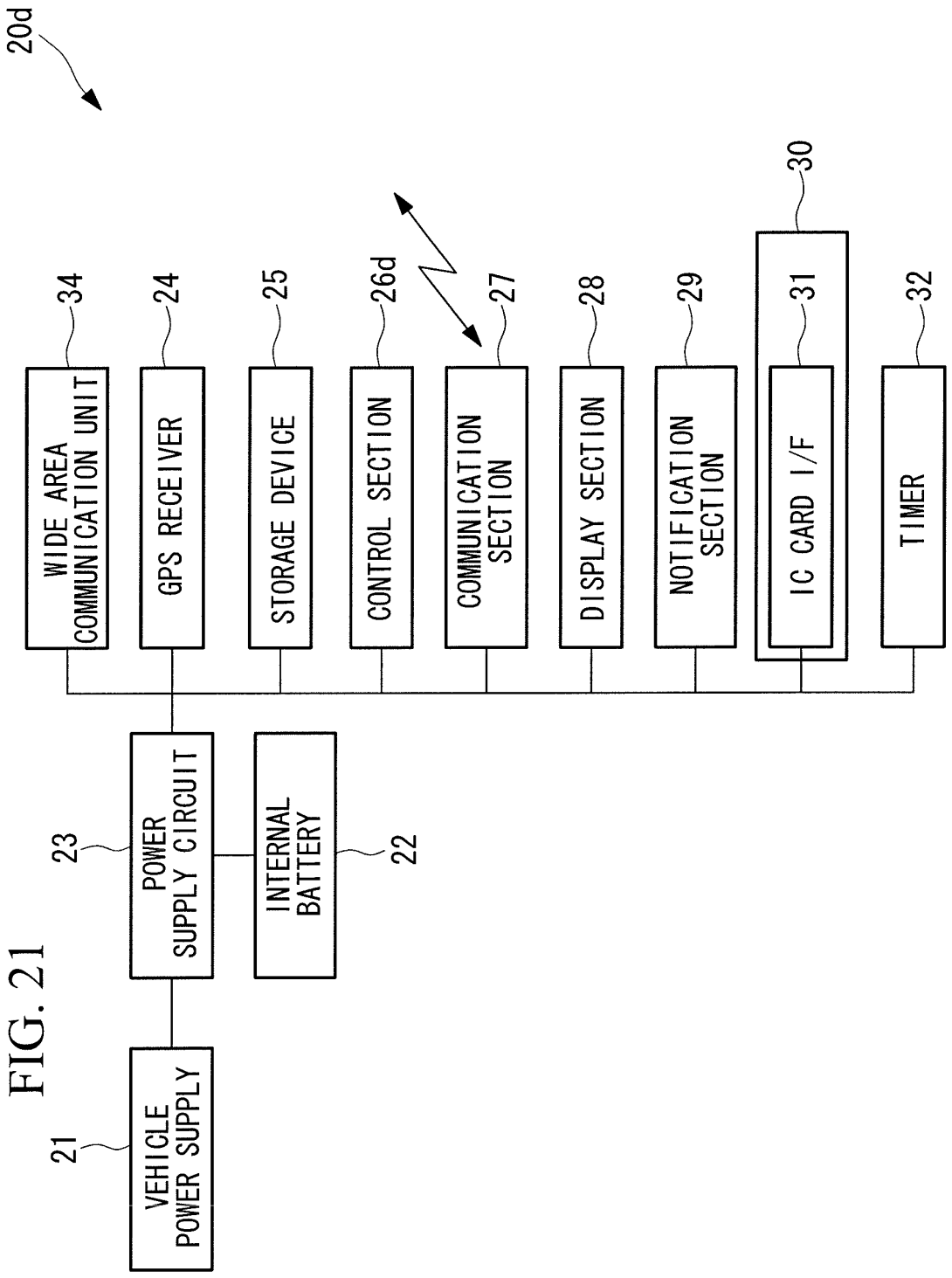

20d
WIDE AREA COMMUNICATION UNIT
34
GPS RECEIVER
24
STORAGE DEVICE
25
CONTROL SECTION
26d
COMMUNICATION SECTION
27
DISPLAY SECTION
28
NOTIFICATION SECTION
29
IC CARD I/F
31
30
TIMER
32
POWER SUPPLY CIRCUIT
23
INTERNAL BATTERY
22
VEHICLE POWER SUPPLY
21

FIG. 22

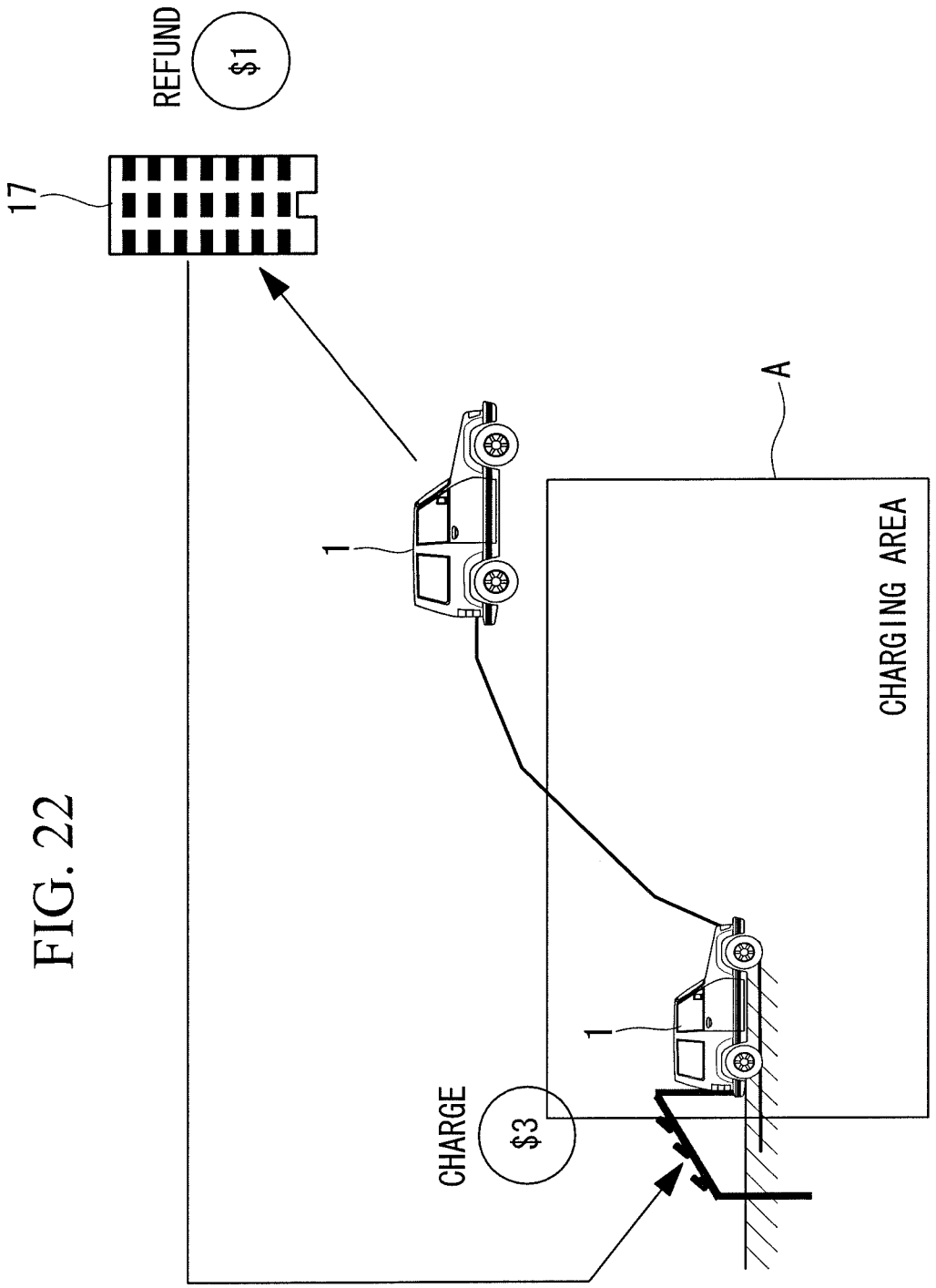


FIG. 23

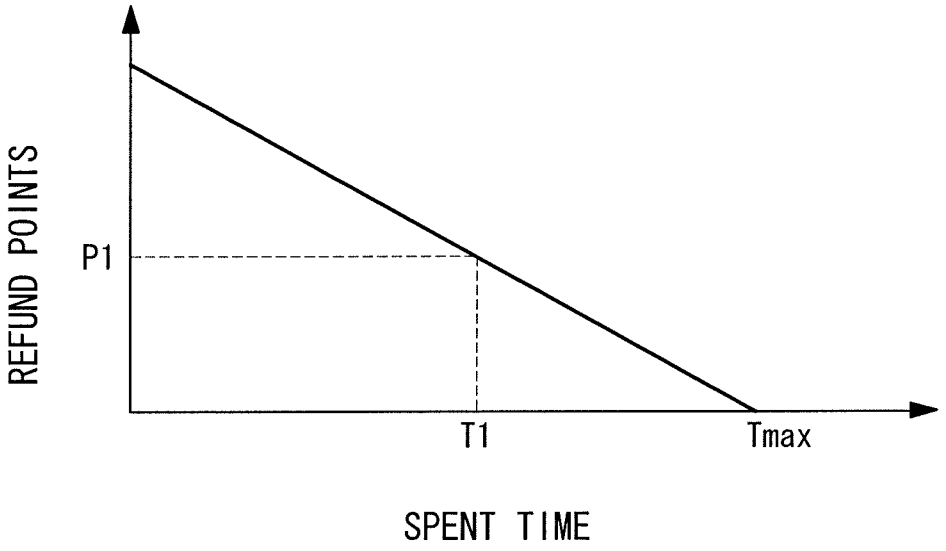

REFUND POINTS
P1
T1
Tmax
SPENT TIME

FIG. 24

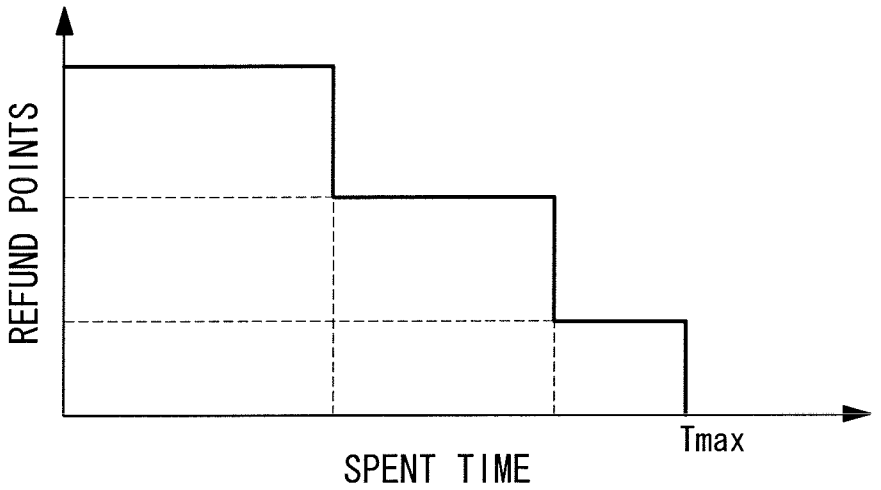

REFUND POINTS
Tmax
SPENT TIME

FIG. 25

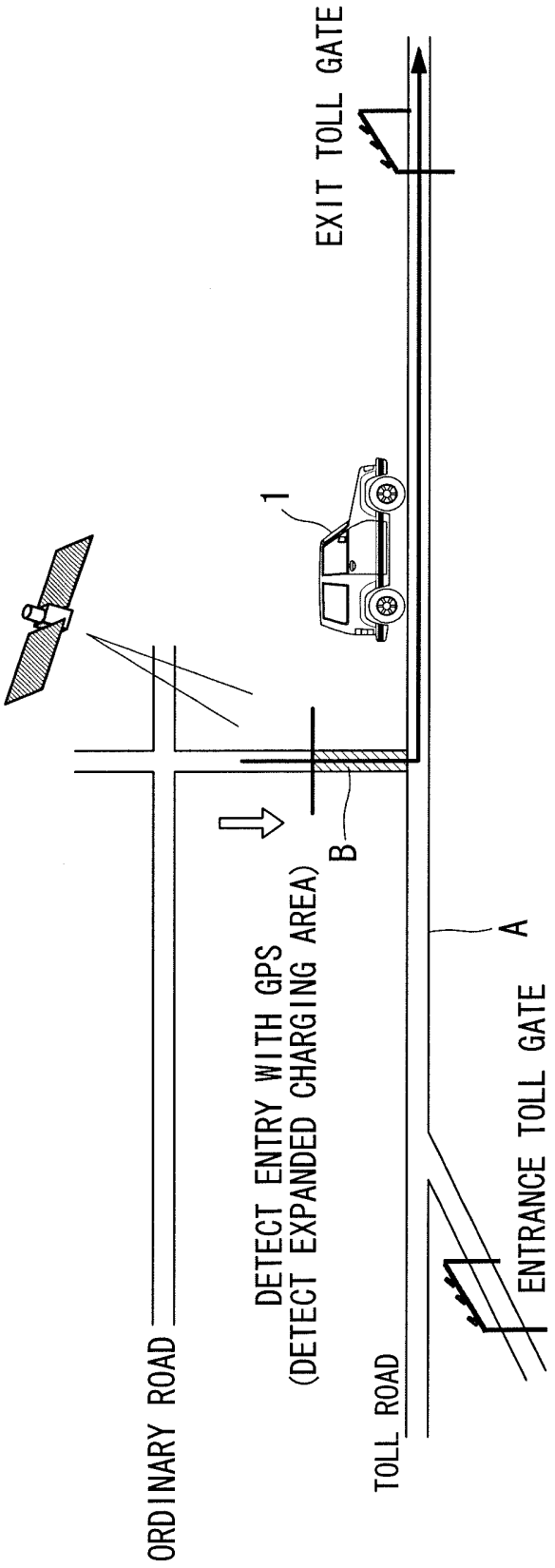
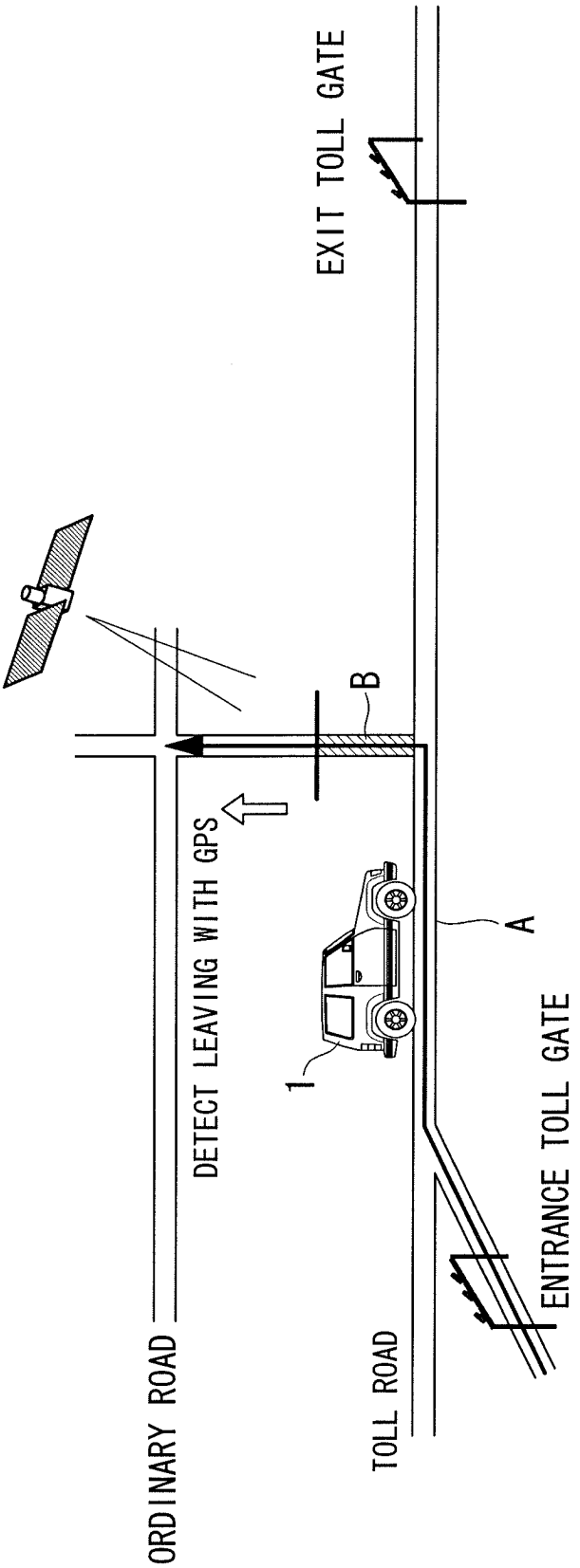

EXIT TOLL GATE
1
B
DETECT ENTRY WITH GPS
(DETECT EXPANDED CHARGING AREA)
A
ENTRANCE TOLL GATE
ORDINARY ROAD
TOLL ROAD

FIG. 26


EXIT TOLL GATE
B
DETECT LEAVING WITH GPS
A
1
ENTRANCE TOLL GATE
ORDINARY ROAD
TOLL ROAD

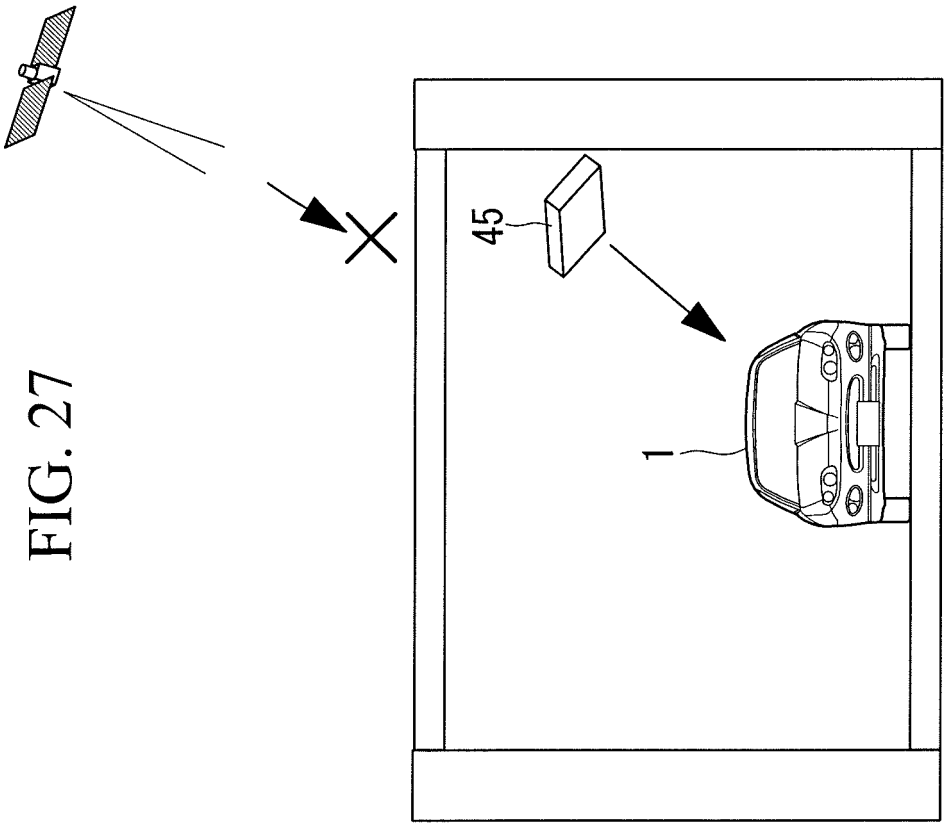
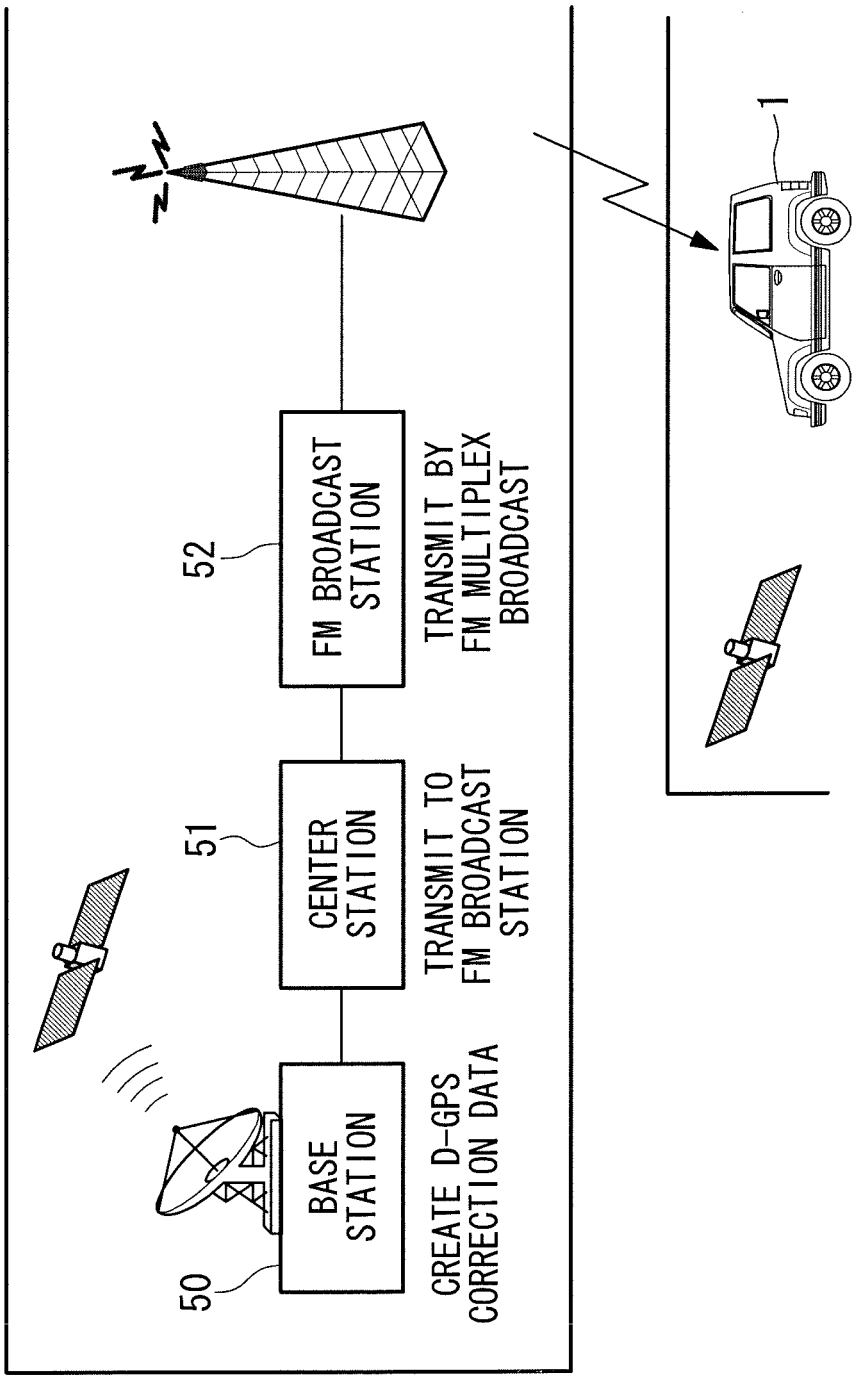


FIG. 27

FIG. 28


1
52
FM BROADCAST STATION
TRANSMIT BY FM MULTIPLEX BROADCAST
51
CENTER STATION
TRANSMIT TO FM BROADCAST STATION
50
BASE STATION
CREATE D-GPS CORRECTION DATA

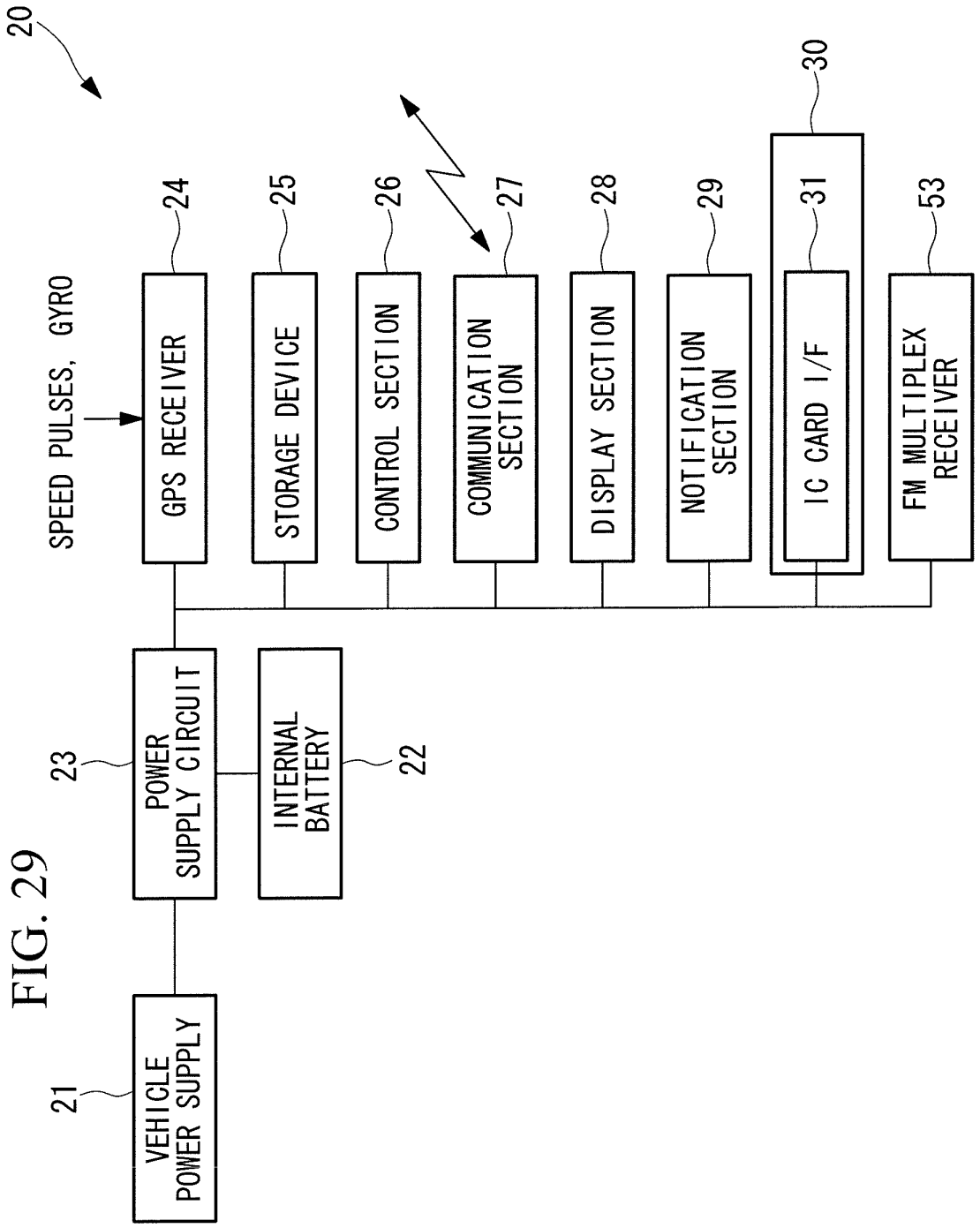

20
SPEED PULSES, GYRO
GPS RECEIVER
24
STORAGE DEVICE
25
CONTROL SECTION
26
COMMUNICATION SECTION
27
DISPLAY SECTION
28
NOTIFICATION SECTION
29
IC CARD I/F
31
30
FM MULTIPLEX RECEIVER
53
POWER SUPPLY CIRCUIT
23
INTERNAL BATTERY
22
VEHICLE POWER SUPPLY
21

FIG. 29

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/062343

A. CLASSIFICATION OF SUBJECT MATTER
G07B15/00(2006.01)i

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)
G07B15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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 Y	JP 2004-326263 A (NTT InfraNet Kabushiki Kaisha), 18 November, 2004 (18.11.04), Full text (Family: none)	1-5,9,10, 14-16 6-7,11-13
X	JP 2005-233719 A (Matsushita Electric Industrial Co., Ltd.), 02 September, 2005 (02.09.05), Full text (Family: none)	8
Y	JP 2002-175550 A (Hitachi, Ltd.), 21 June, 2002 (21.06.02), Column 24 (Family: none)	6

☒ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 July, 2007 (09.07.07)	24 July, 2007 (24.07.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/062343

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-38692 A (Mitsubishi Heavy Industries, Ltd.), 05 February, 2004 (05.02.04), Column 45 (Family: none)	7,11-13

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/062343

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This international application includes two inventions that are the invention of claims 1-7, and 9-16 and the invention of claim 8.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee..

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003323648 A **[0002] [0003]**