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(54) Automatic toll pay system

(57) There is described an automatic toll pay system (1) having an on-vehicle unit (2) installable on a vehicle (3) to receive and memorize toll information; and at least one ground unit (4) installable at a toll point and in turn having a detecting device (13) for detecting passage of one or more vehicles (3) through the toll point, and a transmitting device (7) activated by the detecting device (13), upon detection of one or more vehicles (3), to transmit toll information to the on-vehicle unit (2); the on-vehicle unit (2) having a receiving device (7a) for receiving the toll information transmitted by the ground unit (4), and a transmitting device (7, 10) for transmitting the toll information to a remote unit (5) which processes it to collect the toll of the vehicle (3).

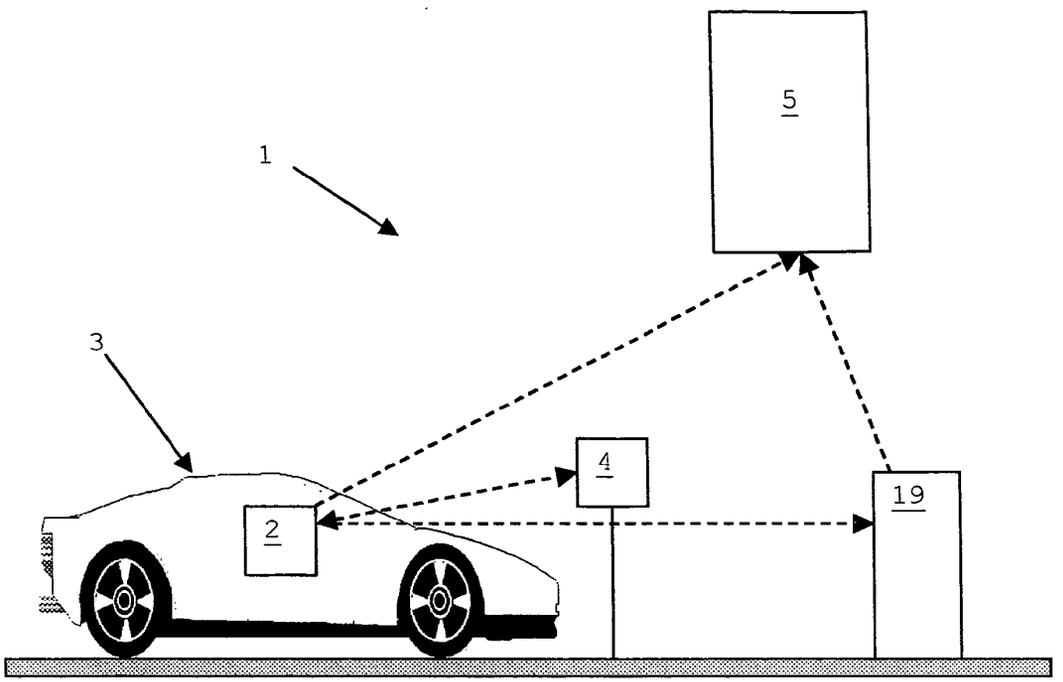

Fig.1

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Description

[0001] The present invention relates to an automatic toll pay system.

[0002] More specifically, the present invention relates to a vehicle automatic toll pay system for city roads and/or highways, motorways, car-parks, city areas and restricted traffic areas, or any vehicular traffic toll area in general; to which application the following description refers purely by way of example.

[0003] As is known, conventional highway or motorway vehicle toll pay systems comprise a number of entrance stations or booths where the vehicle entering the highway toll section is identified, and a number of exit stations or booths where the toll of the highway section travelled by the vehicle is collected manually or automatically.

[0004] To prevent traffic jams forming at motorway toll stations or booths, legislation has been passed whereby these will be completely eliminated over the next few years, so that toll pay systems are required permitting automatic so-called "free-flow" toll collection, i.e. in which vehicles are not required to travel between an entrance and exit booth.

[0005] It is an object of the present invention to provide an automatic toll pay system employing no toll area entrance/exit booths.

[0006] According to the present invention, there is provide an automatic toll pay system as claimed in Claim 1.

[0007] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows, schematically, an automatic toll pay system in accordance with the teachings of the present invention;
Figure 2 shows a block diagram of an on-vehicle unit forming part of the Figure 1 system;
Figure 3 shows a block diagram of a ground unit forming part of the Figure 1 system;
Figure 4 shows a block diagram of a local data collection device forming part of the Figure 1 system;
Figures 5 and 6 show flow charts of the operations performed respectively by the ground and on-vehicle units forming part of the automatic toll pay system in Figure 1.

[0008] Number 1 in Figure 1 indicates as a whole an automatic toll pay system comprising at least one on-vehicle unit 2 installed on a vehicle 3 to receive and memorize information by which to determine the toll of vehicle 3 relative to a corresponding highway toll section or toll area.

[0009] System 1 also comprises at least one ground unit 4 installed at a given toll point of a toll area and/or highway section, and which communicates toll information to on-vehicle unit 2 of vehicle 3 as vehicle 3 travels past ground unit 4, i.e. through the toll point.

[0010] System 1 also comprises a remote data collection unit 5 which, as vehicle 3 comes to the end of the toll sections, receives from each on-vehicle unit 2 the toll information memorized in on-vehicle unit 2, and processes the information to calculate the total toll payable by the user of vehicle 3.

[0011] As explained in detail later on, in actual use, as vehicle 3 travels along a highway toll section or enters a toll area, on-vehicle unit 2 receives from each ground unit 4, located along the highway section or at the entrance to the toll area, all the information required to calculate the toll, memorizes it temporarily, and then downloads, i.e. transmits, it remotely to remote data collection unit 5, which in turn processes it to calculate the total toll payable by the user of vehicle 3.

[0012] With reference to Figure 2, each on-vehicle unit 2 substantially comprises a user interface unit 6, a short-range communication device 7, a memory device 8, a central processing unit 9, and an interface device 10.

[0013] User interface unit 6 generates an audio and/or visual warning signal to inform the user of vehicle 3 that vehicle 3 is approaching a toll point of a toll area and/or highway toll section. User interface unit 6 preferably also generates the warning signal to indicate other specific conditions, such as a malfunction of on-vehicle unit 2 caused, for example, by space run-out of memory device 8, or any other malfunction of on-vehicle unit 2 preventing correct reception, storage, or transmission of toll data or information. In the example shown, user interface unit 6 may be defined by a display and/or a number of LED's and/or one or more speakers for informing the user of vehicle 3 of any of the above critical conditions.

[0014] Short-range communication device 7 provides for two-way communication between on-vehicle unit 2 and each ground unit 4 as vehicle 3 approaches the toll point, i.e. drives past at a limited distance from ground unit 4.

[0015] More specifically, short-range communication device 7 may comprise a preferably radio-frequency receiving module 7a for receiving an identification request signal transmitted by ground unit 4 and containing the toll information of vehicle 3.

[0016] Short-range communication device 7 also comprises a preferably radio-frequency transmitting module 7b which, upon reception of the identification request signal, transmits to ground unit 4 a reply signal containing information unequivocally identifying on-vehicle unit 2 of relative vehicle 3. In the example shown, the identification request signal comprises a code identifying ground unit 4 generating the signal; and toll information.

[0017] The identification request signal may preferably, though not necessarily, also contain additional information indicating the arrival time of vehicle 3 at the toll point of the highway toll section or toll area, such as the

date and time vehicle 3 drives through, and/or other types of general information concerning road conditions, traffic flow, accidents or detours, or information such as advertising and/or motorway service announcements.

[0018] The reply signal contains a code identifying on-vehicle unit 2; and a code identifying vehicle 3 and preferably, though not necessary, corresponding to the licence plate number.

[0019] With reference to Figure 2, memory device 8 memorizes the toll information and identification codes transmitted by ground unit/s 4; and interface device 10 interfaces on-vehicle unit 2 with any telephone apparatus 11, such as a cellular telephone or any device incorporating a telephone communication module on vehicle 3, to establish telephone communication over apparatus 11 with remote data collection unit 5, and transmit the toll information memorized in on-vehicle unit 2 to remote data collection unit 5.

[0020] In other words, the toll data and information memorized in on-vehicle unit 2 can be downloaded by interfacing on-vehicle unit 2 with a telephone apparatus 11, such as a cellular telephone, which transmits the toll data directly to remote data collection unit 5. The transmission may obviously be made by conveniently coding the toll information over the cellular telephone in one or more SMS (Short Message System) messages, which are then sent to a telephone module (not shown) of remote data collection unit 5, or by automatically connecting the cellular telephone to a predetermined (e.g. freephone) number associated with remote data collection unit 5.

[0021] Interface device 10 may be defined by a communication circuit for establishing communication, over a wired or wireless transmission system, with the cellular telephone or any other type of telephone apparatus 11 on vehicle 3, to download and transmit the memorized toll information to remote data collection unit 5 over apparatus 11. In the example shown, information is transmitted to the cellular telephone by the above circuit in known manner by wireless communication technology, in which data is received and transmitted by the dialoguing equipment by radio-frequency (RF) or infrared (IR) communication, e.g. BLUETOOTH technology or similar; or by wired technology using, for example, USB communication ports or communication systems employing similar protocols.

[0022] With reference to Figure 2, the functions performed by the above devices forming part of on-vehicle unit 2 are coordinated and controlled by central processing unit 9 defined, for example, by a microprocessor, which is therefore able to control the operations performed by user interface unit 6, short-range communication device 7, memory device 8, and interface device 10.

[0023] On-vehicle unit 2 may preferably, though not necessarily, also comprise a locating module 23 of vehicle 3, which may be defined by a navigation device for determining at any instant the geographic position of vehicle 3 equipped with on-vehicle unit 2 (a GPS or similar navigation system). It should be pointed out that, by determining the position and travelling direction of the vehicle, locating module 23 provides for more accurately tracing and determining passage of the vehicle at each toll point.

[0024] On-vehicle unit 2 may also comprise a protective casing (not shown) housing the above devices and appropriately installed inside the passenger compartment of vehicle 3.

[0025] As stated, each ground unit 4 is installed at a given toll point, which may be located at an entrance and/or exit or in any other position, depending on the type of highway toll section or toll area concerned.

[0026] For example, in the case of a "self-contained" section of highway, such as a section of motorway, in which the toll varies depending on the distance travelled by vehicle 3, ground units 4 may be installed in place of toll stations or booths at the entrances and exits to and from the motorway. In which case, on-vehicle unit 2 of vehicle 3 interacts with the ground units 4 encountered on entering and exiting the highway section respectively, from which it receives all the information required to determine the distance actually travelled and on which the toll is calculated. In the case of a toll area or "open" highway toll section, on the other hand, in which the toll is fixed regardless of the distance travelled, one toll point equipped with one ground unit 4 is obviously sufficient.

[0027] With reference to Figure 3, each ground unit 4 substantially comprises a vehicle detecting device 13, a memory device 14, a short-range communication device 15, a long-range communication device 16, a licence plate recognition device 17, and a data processing device 18.

[0028] Detecting device 13 detects the presence of one or more vehicles 3 at the toll point where ground unit 4 is installed, and may be defined by an optoelectronic sensor or any other similar sensor capable of generating a presence signal indicating passage of one or more vehicles 3 past the toll point.

[0029] Memory device 14 memorizes the identification code of relative ground unit 4, and the toll information relative to the highway section or area covered by ground unit 4.

[0030] Memory device 14 preferably, though not necessarily, also memorizes additional information, such as traffic announcements, advertising, or similar messages, which may be transmitted to ground unit 4 by remote data collection unit 5.

[0031] When the reply signal is received, memory device 14 also memorizes the code of on-vehicle unit 2 and the licence plate number of the vehicle 3 detected by detecting device 13.

[0032] With reference to Figure 3, short-range communication device 15 provides for two-way communication with short-range communication device 7 of on-vehicle unit 2 as vehicle 3 approaches the toll point. More

specifically, short-range communication device 15 may be defined by a preferably radio-frequency transmitting module 15a for transmitting the identification request signal to on-vehicle unit 2; and by a preferably radio-frequency receiving module 15b for receiving from transmitting module 7b of on-vehicle unit 2 the reply signal containing information unequivocally identifying on-vehicle unit 2 and relative vehicle 3.

[0033] Licence plate recognition device 17 provides for detecting in image format the licence plate of vehicle 3 driving past the toll point, in the event ground unit 4 fails to identify vehicle 3.

[0034] Such is the case when on-vehicle unit 2 fails to transmit the reply signal to ground unit 4, which in turn may depend on various factors: vehicle 3 has no on-vehicle unit 2; space run-out of memory device 8 (full-memory condition); or any other malfunction of on-vehicle unit 2 of vehicle 3.

[0035] In the example shown, licence plate recognition device 17 may be defined by one or more image acquisition devices, such as still cameras, video cameras or similar equipment set up appropriately at the toll area or highway toll section to pick up, on command, an image of the licence plate of vehicle 3 travelling through the toll area or highway toll section.

[0036] With reference to Figure 3, long-range communication device 16 provides for two-way communication with remote data collection unit 5 to permit remote updating of the information stored in each ground unit 4, such as toll rates, or to communicate fresh information, such as traffic announcements, advertising, etc.

[0037] Data processing device 18 may be defined by a microprocessor for controlling and coordinating the operations performed by the above devices forming part of ground unit 4.

[0038] With reference to Figures 1 and 4, system 1 preferably, though not necessarily, also comprises one or more local data collection devices 19, each of which is appropriately installed along the highway toll section or in the toll area to communicate short-range with respective on-vehicle units 2 as vehicles 3 drive through, and receive from on-vehicle units 2 the toll information memorized in respective memory devices 8. On receiving the data downloaded by on-vehicle unit 2, each local data collection device 19 transmits the information "long-range" to remote data collection unit 5. In other words, in use, each on-vehicle unit 2 downloads the memorized toll data to a local data collection device 19, which in turn sends it on to remote data collection unit 5.

[0039] More specifically, with reference to the Figure 4 example, each local data collection device 19 substantially comprises a short-range communication block 20 enabling "short-range" communication between on-vehicle unit 2 and local data collection device 19 to "download" the toll data memorized in on-vehicle unit 2; a long-range communication block 21 enabling "long-range" communication between local data collection device 19 and remote data collection unit 5 to transmit the data downloaded by on-vehicle unit 2 to remote data collection unit 5; and a processing device 22 for controlling data reception from on-vehicle unit 2 and data transmission to remote data collection unit 5.

[0040] In connection with the above, it should be pointed out that, in an embodiment not shown, local data collection device 19 may be integrated directly in ground unit 4 to download the data memorized in on-vehicle unit 2 at the toll point.

[0041] Remote data collection unit 5 provides for collecting the toll, i.e. collects the data transmitted remotely by each on-vehicle unit 2, processes it to calculate the toll sum, and identifies the on-vehicle unit 2 to determine the user the calculated sum is to be debited to. Remote data collection unit 5 may obviously be enabled to communicate the total toll sum of each user to a bank circuit (not shown) which, in turn, carries out the transaction automatically in known manner.

[0042] Operation of system 1, and in particular of ground unit 4 and on-vehicle unit 2, as a vehicle 3 drives through a toll point equipped with ground unit 4, will now be described with reference to Figures 5 and 6 respectively. For the sake of simplicity, reference is made to a toll point of a highway toll section.

[0043] With reference to Figure 5, the ground unit 4 installed at the toll point at the entrance or exit to or from a highway toll section remains on standby until detecting device 13 detects the passage of one or more vehicles 3 through the toll point (block 100).

[0044] The standby condition ends (YES output of block 100) when detecting device 13 detects the presence of a vehicle 3 and supplies data processing device 18 with a signal containing coded information relative to the passage of vehicle 3 through the toll point.

[0045] On receiving the signal indicating detection of vehicle 3, data processing device 18 of ground unit 4 commands transmission by transmitting module 15a of short-range communication device 15 of the identification request signal which, as stated, contains the code identifying the ground unit 4 at the toll point, and the toll information memorized in memory device 14 (block 110).

[0046] Following transmission of the identification request signal, ground unit 4 prepares to receive the reply signals from on-vehicle units 2 of the detected vehicles 3 (block 120). At this point, ground unit 4 processes each incoming reply signal to determine and memorize the respective code identifying the on-vehicle unit 2, and the code identifying vehicle 3 and preferably corresponding to the licence plate number of vehicle 3.

[0047] At this point, ground unit 4 checks that each vehicle 3 detected by detecting device 13, and which has therefore actually passed through the toll point, has completed its identification, i.e. has transmitted the relative reply signal. This may be done, for example, by checking the number of vehicles 3 detected by detecting device 13 matches the number of identification codes transmitted by on-vehicle units 2 of vehicles 3 (block

130). In the event of a negative response (NO output of block 130), i.e. if the check shows one or more vehicles 3 have not sent a reply signal identifying vehicle 3, ground unit 4 enables licence plate recognition device 17 (block 140) which acquires an image of the licence plate of each vehicle 3 travelling through.

[0048] At this point, ground unit 4 proceeds to identify the vehicles 3 not recognized due to non-reception of the reply signal (block 150), by checking for a match between the licence plate numbers recognized by image acquisition, and the licence plate numbers memorized by decoding the reply signals. Ground unit 4 thus picks out the licence plate numbers of the vehicles 3 not identified by receiving the reply signals, and, by means of long-range communication device 16, transmits the licence plate numbers of the unidentified vehicles 3 to remote data collection unit 5, which identifies and debits the tolls to the users of vehicles 3 in known manner.

[0049] Conversely, if each detected vehicle has been identified (YES output of block 130), operation is terminated, and ground unit 4 switches back to standby pending passage of another vehicle 3.

[0050] Figure 6 shows operation of on-vehicle unit 2 of vehicle 3 as the vehicle travels through the toll point equipped with ground unit 4.

[0051] As vehicle 3 approaches ground unit 4, relative on-vehicle unit 2 receives the identification request signal, and, by means of interface device 6 (block 400), activates the visual and/or sound signal informing the user that vehicle 3 is approaching the toll point (at the entrance or exit to or from the highway toll section).

[0052] At this point, on-vehicle unit 2 checks relative memory device 8 is in condition to receive the toll information transmitted by ground unit 4 (block 410) - in the example shown, checks whether the space in memory device 8 has run out.

[0053] If it has, i.e. if memory device 8 cannot store any more data (memory run out) (YES output of block 410), central processing unit 9 disables short-range communication device 7 and interface device 10 to cut off transmission of the reply signal (block 420), and ground unit 4 proceeds to acquire an image of the licence plate number of the vehicle.

[0054] Conversely, if it has not, i.e. memory device 8 is in condition to receive data (memory not run out) (NO output of block 410), transmission of the reply signal by transmitting module 7b is activated to identify both vehicle 3 (preferably the licence plate number) and the relative on-vehicle unit 2 (identification code).

[0055] On-vehicle unit 2 then processes the identification request signal to determine and memorize the toll information in memory device 8 (block 430).

[0056] Once the toll information is memorized, on-vehicle unit 2 of each vehicle 3 transmits - at predetermined instants and/or when the space occupied in memory device 8 reaches a predetermined maximum threshold corresponding, for example, to half the total available space in the memory - all the memorized information to remote data collection unit 5, which proceeds to enable collection of the memorized toll/s.

[0057] More specifically, information can be transmitted by on-vehicle unit 2 in two modes : a first by downloading the toll information via short-range communication device 7 to local data collection devices 19; and a second by transmitting information over an on-vehicle telephone apparatus 11, e.g. a cellular telephone.

[0058] In the example shown, the first transmission mode (block 440) may be implemented as vehicle 3 approaches a local data collection device 19; in which case, transmitting module 7b of on-vehicle unit 2 transmits the toll information and the information identifying on-vehicle unit 2 to short-range communication block 20 of local data collection device 19, upon which, processing device 22 enables long-range communication device 21 to transmit the information to remote data collection unit 5, which then processes the information to calculate the toll owed by the user of vehicle 3.

[0059] In the second transmission mode (block 450), the toll information and the information identifying on-vehicle unit 2 and stored in memory device 8 is transmitted over telephone apparatus 11 which, when connected to interface device 10, receives the information from on-vehicle unit 2 and transmits it telephonically to remote data collection unit 5.

[0060] System 1 is particularly advantageous by permitting fully automatic toll payment and, therefore, elimination of the toll stations or booths at motorway entrances and exits. The entire vehicle recognition and toll calculation process, in fact, is performed directly by system 1, with no direct intervention whatsoever required of the user of the vehicle travelling along the toll section. Payment by the user in coin or paper currency or by credit card, typically required by current pay systems at the end of the motorway, is completely eliminated, thus resulting in smoother traffic flow at motorway entrances and exits, with obvious advantages in terms of entrance/exit hold-ups, road-user convenience, and reduced pollution of toll points.

[0061] The system is also extremely straightforward, by the ground unit being installable directly on the shoulder, with no fixed gantry structure required over the road, and at the same time is extremely flexible, by enabling transmission of the toll data stored in the on-vehicle unit over a cellular telephone or by means of local data collection devices.

[0062] Clearly, changes may be made to the system as described and illustrated herein without, however, departing from the scope of the present invention.

Claims

1. An automatic toll pay system (1), **characterized by** comprising:

an on-vehicle unit (2) installable on a vehicle

(3) to receive and memorize toll information; and
at least one ground unit (4) installable at a toll point and in turn comprising:

- vehicle detecting means (13) for detecting passage of one or more vehicles (3) through said toll point;
- transmitting means (15a) activated by said detecting means (13), upon detection of one or more vehicles (3), to transmit toll information to said on-vehicle unit (2);

said on-vehicle unit (2) comprising receiving means (7a) for receiving said toll information transmitted by said ground unit (4); and transmitting means (7b, 10) for transmitting said toll information to a remote unit (5) which processes it to collect the toll of said vehicle (3).

2. A system as claimed in Claim 1, **characterized in that** said on-vehicle unit (2) comprises memory means (8) for temporarily memorizing said toll information.

3. A system as claimed in Claim 1 or 2, **characterized in that** said transmitting means (7b, 10) of said on-vehicle unit (2) comprise a communication module (10) connectable to a telephone apparatus (11) to transmit said toll information over the telephone apparatus (11) to said remote unit (5).

4. A system as claimed in Claim 3, **characterized in that** said telephone apparatus (11) is a cellular telephone.

5. A system as claimed in any one of the foregoing Claims, **characterized in that** said transmitting means (7b,10) of said on-vehicle unit (2) comprise a transmitting device (7b) for transmitting to said ground unit (4) a reply signal identifying the licence plate of said vehicle (3) and said on-vehicle unit (2).

6. A system as claimed in Claim 5, **characterized in that** said transmitting device (7b), on command, transmits said toll information memorized in said on-vehicle unit (2); and by comprising at least one local data collection device (19) installed at a transit point of said vehicle (3) to receive, as said vehicle (3) drives through, said toll information transmitted by said transmitting device (7b); said local data collection device (19), on receiving said toll information, enabling long-range transmission of said toll information to said remote unit (5).

7. A system as claimed in any one of the foregoing Claims, **characterized in that** said on-vehicle unit (2) comprises a licence plate recognition device (17) for acquiring, on command, an image of the licence plate of each said vehicle (3).

8. A system as claimed in Claim 7, **characterized in that** said ground unit (4) comprises control means (13) for enabling said licence plate recognition device (17) on determining non-transmission of said reply signal by an on-vehicle unit (2) of a vehicle detected by said detecting means (13).

9. A system as claimed in Claim 8, **characterized in that** said ground unit (4) comprises communication means (16) for transmitting to said remote unit (5) the licence plates of the vehicles not identified by said ground unit (4) by processing said reply signal.

10. A system as claimed in any one of the foregoing Claims, **characterized in that** said on-vehicle unit (2) comprises an interface device (6) for acoustically and/or visually informing the user of the vehicle (3) that the vehicle (3) is approaching a toll point.

11. An on-vehicle unit (2) for an automatic toll pay system (1) as claimed in any one of the foregoing Claims.

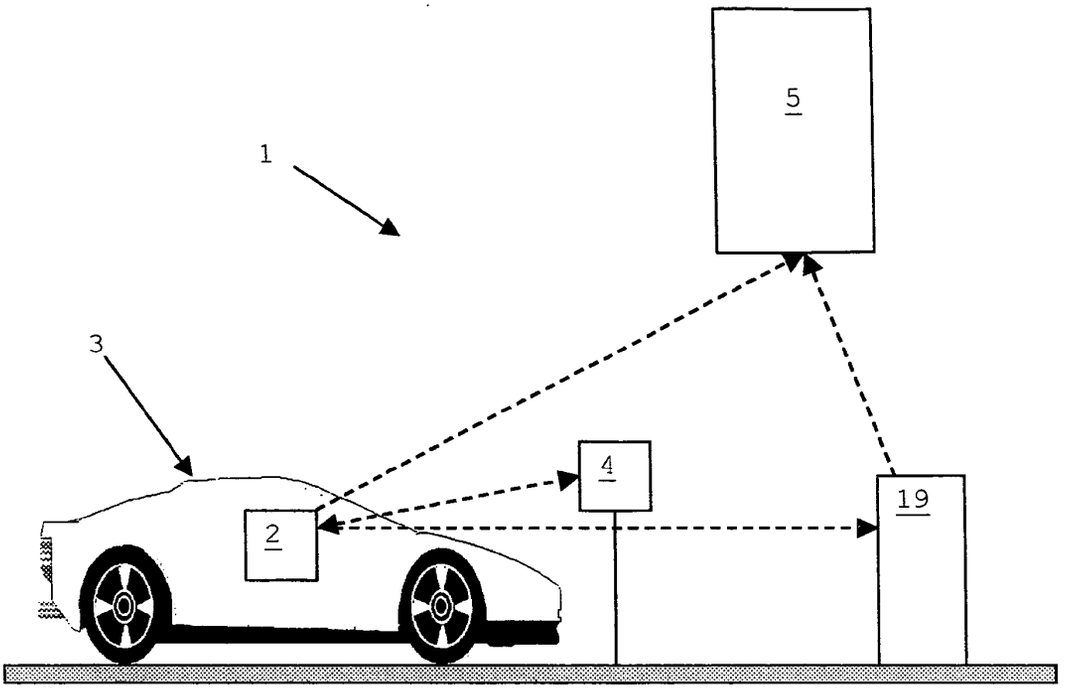

Fig.1

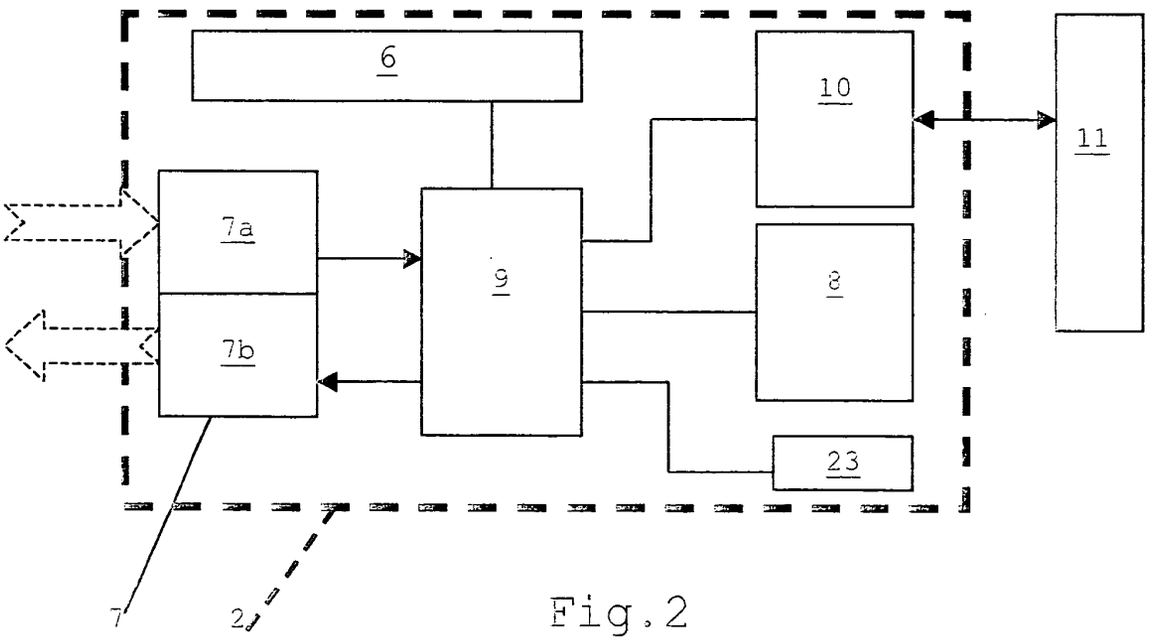

Fig.2

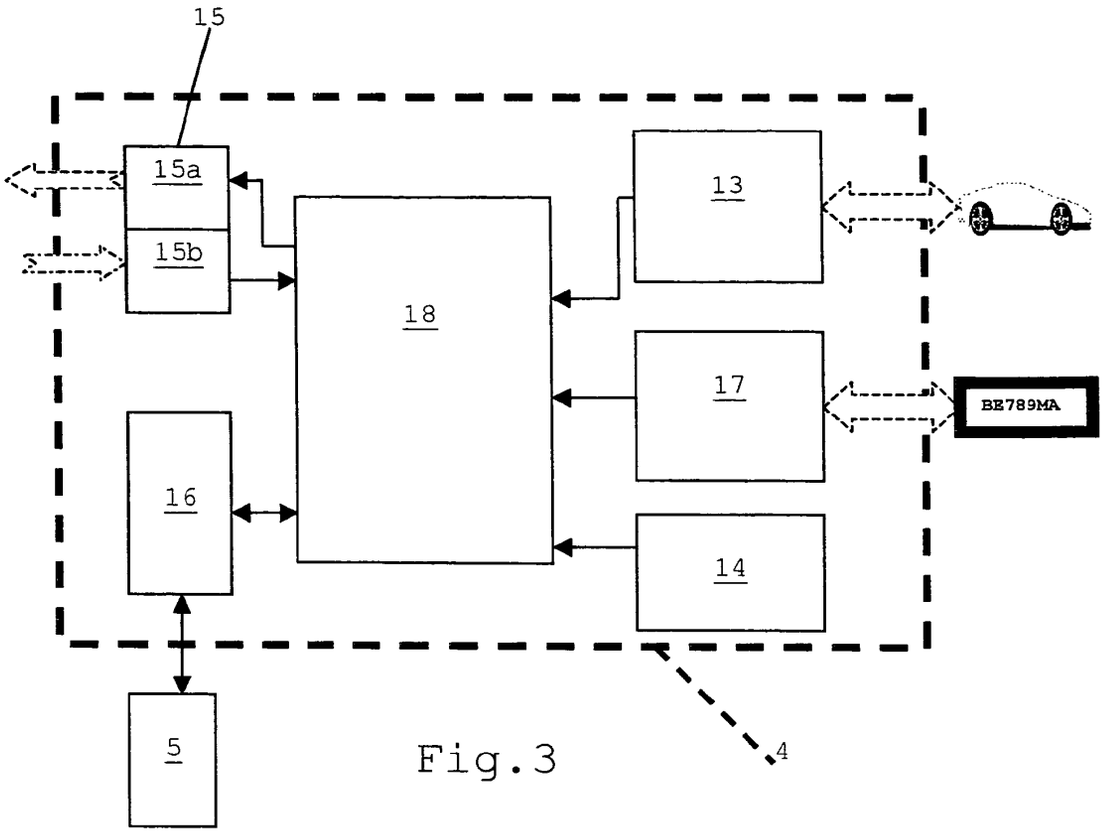

Fig.3

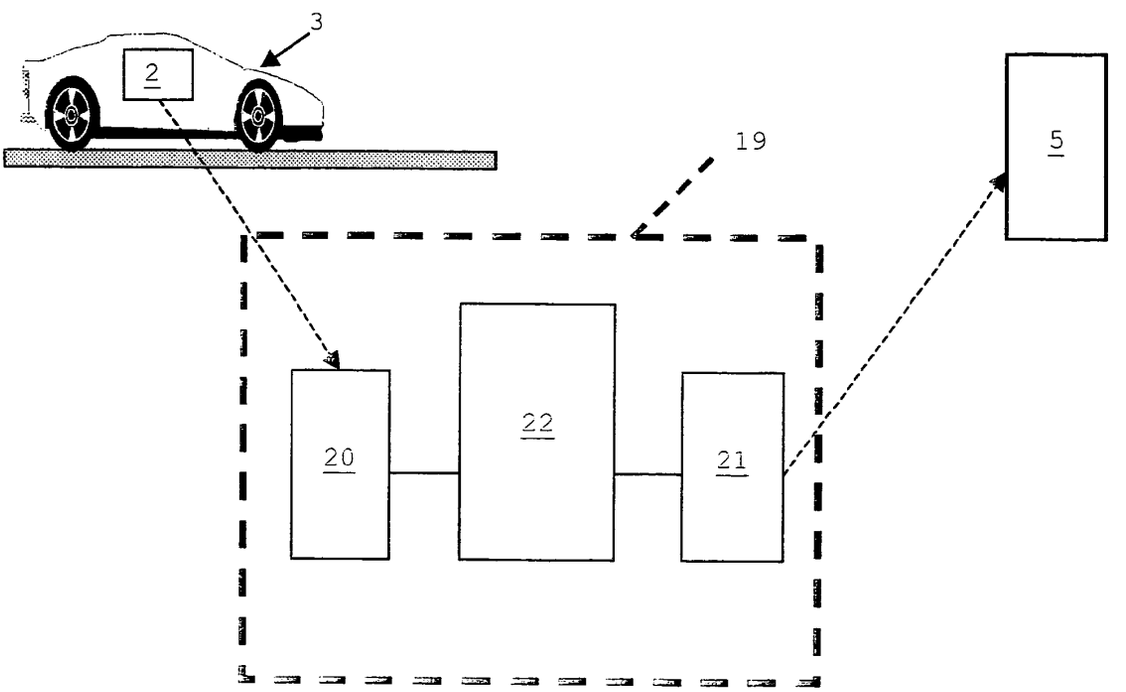

Fig.4

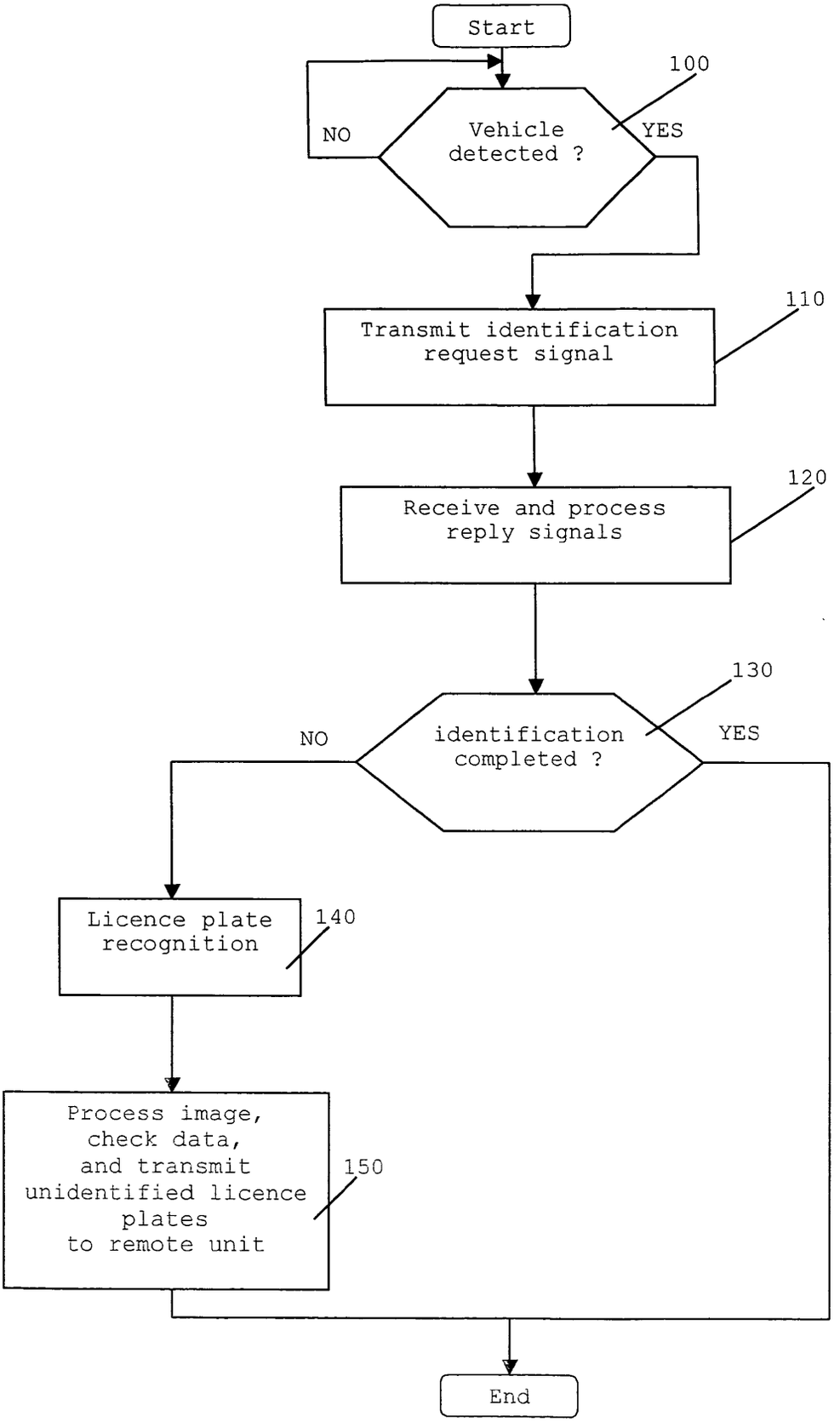
Start
100
Vehicle detected ?
NO
YES
110
Transmit identification request signal
120
Receive and process reply signals
130
identification completed ?
NO
YES
140
Licence plate recognition
150
Process image, check data, and transmit unidentified licence plates to remote unit
End

Fig.5

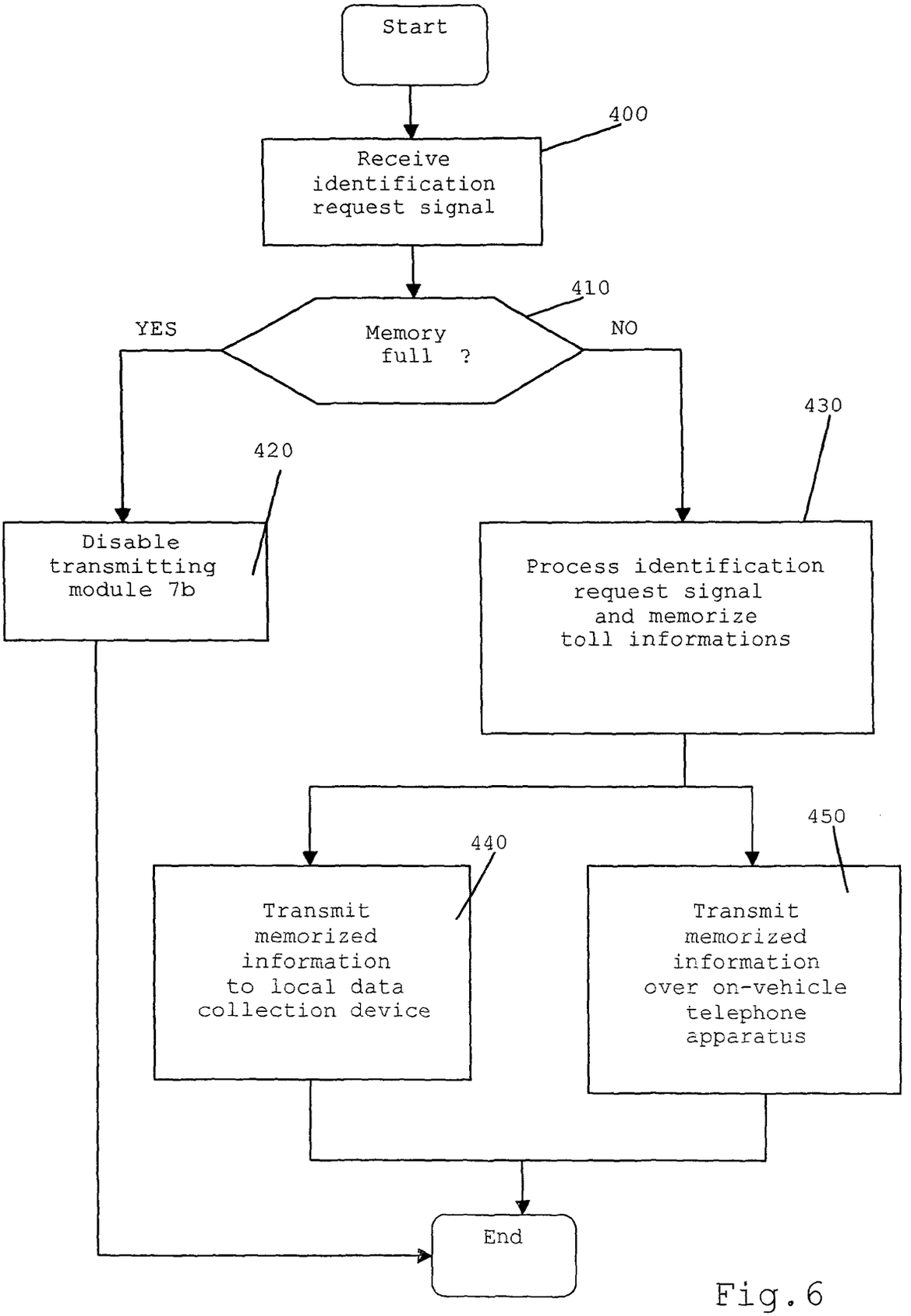
Start
400
Receive identification request signal
410
YES
Memory full ?
NO
420
430
Disable transmitting module 7b
Process identification request signal and memorize toll informations
440
450
Transmit memorized information to local data collection device
Transmit memorized information over on-vehicle telephone apparatus
End

Fig.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 42 5216

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	WO 00/45343 A (FEDERICI MARCELLO) 3 August 2000 (2000-08-03) * page 5, line 28 - page 10, line 12 * * page 12, line 11 - line 19 * * figures 1-3 * -----	1-4,10, 11 5-9	G07B15/00
Y	EP 0 425 961 A (AUTOSTRADE CONCESS CONST) 8 May 1991 (1991-05-08) * column 2, line 31 - column 9, line 45 * -----	5-9	
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A	EP 0 798 668 A (DENSO CORP) 1 October 1997 (1997-10-01) * column 4, line 26 - column 8, line 29 * -----	1-11	
A	US 5 204 675 A (SEKINE HIROYOSHI) 20 April 1993 (1993-04-20) * abstract * -----	5,7	TECHNICAL FIELDS SEARCHED (Int.Cl.7) G07B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 August 2004	Van Der Haegen, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 42 5216

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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31-08-2004

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