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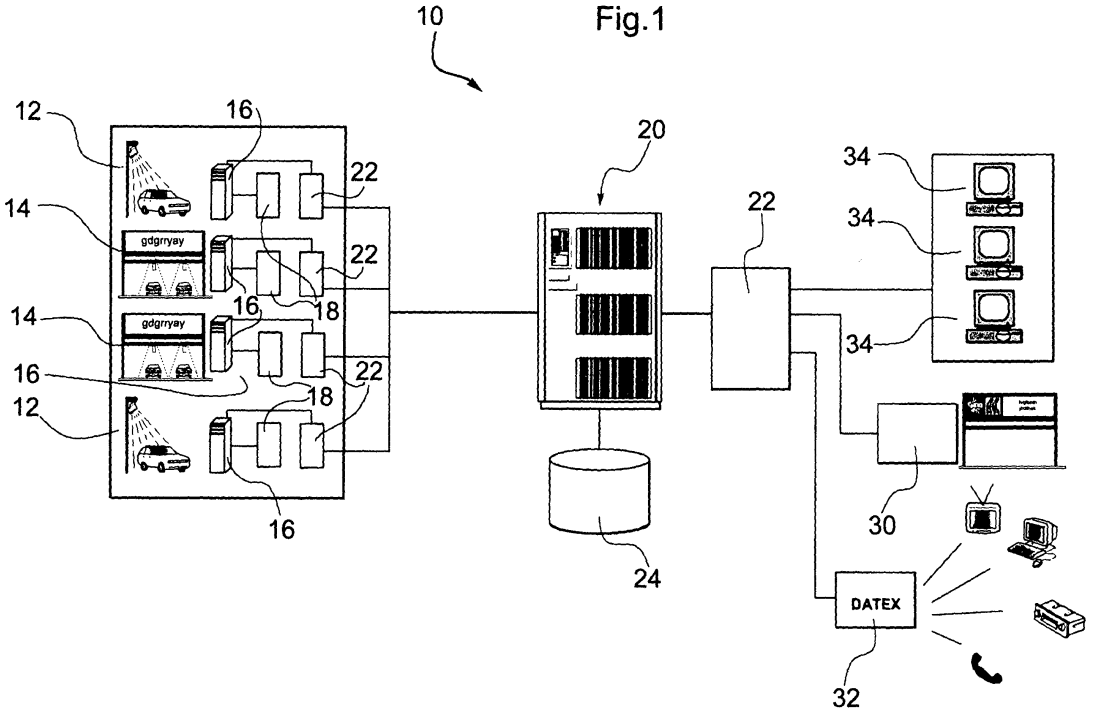
(54) A system and method of determining the average time for covering a road section by motor vehicles

(57) A system and a method for determining the average time taken by vehicles to travel along road sections are described, in which a plurality of peripheral units (12, 14) distributed along a road network is used to detect the transit of vehicles by interrogating an on-board apparatus (B) of said vehicles, in particular an on-board apparatus designed for interfacing with land-based apparatus of an automatic toll collection system.

The peripheral units (12, 14) are connected to a central processing unit (20) which collects the data relating to the identification codes of the on-board apparatus (B) of the vehicles and the associated moments of transit past at least one pair of peripheral units (12, 14) and determines the average travel time of the section on the basis of the travel times of a plurality of vehicles detected passing by said peripheral units (12, 14).

Fig.1



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Description

[0001] The present invention relates to a system and a method for determining the average time taken by motor vehicles to travel along a road section, in order to determine the travel conditions of said section and provide this information to users. In particular, the invention relates to a system and a method for determining the average time taken to travel along a section of motorway, by making use of on-board apparatus of an automatic toll collection system, provided on the motor vehicles.

[0002] Providing information for road users is a matter of particular interest both nationally and internationally speaking owing to the constant increase in the amount of traffic on the road network and is very important for increasing the safety levels and avoiding critical situations in particular weather conditions or peak travel periods.

[0003] The limitations of the present-day information systems are essentially linked to the sources, which are always of an "instantaneous" nature, whether they consist of recordings made by roadside personnel (traffic police or traffic assistants) or sensors (TV monitoring cameras or induction coils), and to the human element which is involved in providing a qualitative definition of the overall travel conditions of a road section. Ultimately, in fact, it is always an operator in a control centre who, on the basis of the various information received, provides a qualitative assessment as to the event affecting a given road section.

[0004] Improvement in the quality of the information is therefore an objective which is generally of common interest and has the aim of increasing the trust of the person travelling, this trust being the base for the efficiency of an information system intended to increase safety and accident prevention.

[0005] The travel time of a road section, which is defined as being the time needed to travel from one point to another within the road network, is a fundamental parameter for an increase in the quality of the information. The travel time has, in fact, an immediate and important meaning for a very wide audience which embraces the transport engineer, the road network management company, the designer and users of the road network, whether they be frequent or occasional travellers.

[0006] The object of the present invention is to provide a solution for determining the average travel time of a road section, and in particular a motorway section, which allows one to have objective data for assessing difficulties in the travel conditions, with a particular view to providing information for the users of the road network.

[0007] In particular, the object of the present invention is to provide a system for determining the average travel time of a road section, which is highly reliable, simple to produce and able to be installed at a competitive cost by a management company which already employs a system for automatic toll collection, in particular from vehicles in movement.

[0008] Such an example of an automatic toll collection system is, for example, the system according to the Italian patent IT 1,236,633, which is currently used in the Italian motorway system and referred to by the trade name Telepass®. The European standards governing systems for automatic collection of tolls from vehicles in movement instead consist of the ETSI standards 300 674, 200 674-1 and 200 674-2.

[0009] A system for automatic collection of tolls from vehicles in movement (referred to below in the remainder of the present description more briefly as a "dynamic toll collection system") comprises on-board apparatus which can be installed in each motor vehicle and are able to store at least one respective subscriber identification code, and a plurality of land-based apparatus associated with the road network and installed in the road network access gates, these land apparatus being able to interrogate the on-board apparatus which pass by in the vicinity in order to acquire therefrom the identification code and manage a toll payment operation.

[0010] Such a system ensures a greater fluidity of the traffic at the toll collection stations which are distributed along a road section, since the vehicle thus equipped does not have to stop on the roadway, but is able to pass by close to a land-based apparatus at a speed in keeping with a predetermined maximum threshold limit.

[0011] A further object of the present invention is to provide a system and a method for determining the average travel time of a road section, and in particular a section of motorway, which allow the automatic control of variable-message panels which are situated along the road network with information messages showing the times recorded, and wherein this information may be easily made available to different information channels in standard format as a traffic condition attribute. In this connection, information channels are regarded as being public utility services such as radio, television, call centres, Internet sites, automatic answering systems, information points, etc.

[0012] Yet another object of the present invention is to provide a system for determining the average travel time of a road section which allows alarm messages to be sent to an operator in an operations centre managing the road network, so as to increase the number of information sources available to the operations centre and extend the monitoring coverage to sections of the road network where roadside personnel are not present or where conventional sensors emitting an instantaneous alarm have not been installed.

[0013] The abovementioned objects together with others are achieved by a system for determining the average time taken by motor vehicles to travel along road sections, having the characteristic features defined in Claim 1.

[0014] The present invention relates furthermore to a method for determining the average travel time according to Claim 12.

[0015] Particular embodiments are defined in the de-

pendent claims.

[0016] Further characteristic features and advantages of the present invention will emerge more clearly from the following detailed description provided by way of a non-limiting example, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of the architecture of the system according to the invention;
Figure 2 is a block diagram of a portion of the architecture of the system shown in Figure 1;
Figure 3 is a schematic view of the layout, within a road network, of the units forming the system; and
Figure 4 is a flow diagram illustrating processing of the information detected by means of the system according to the invention.

[0017] With reference to the abovementioned figures, the system according to the invention, which is denoted in its entirety by the reference number 10, comprises a plurality of peripheral units 12, 14 for detecting the passing-by of vehicles V, each comprising a respective data processing unit 16 linked to a time synchronisation module 18.

[0018] Each processing unit 16 of a peripheral unit 12, 14 is linked to a central processing unit 20 by means of a local communication unit 22 over a communication network N of the known type.

[0019] Each peripheral unit 12, 14 for detecting passing-by of the vehicles V is constructed in the form of a land-based apparatus of a dynamic toll collection system and includes, for example, a radiofrequency antenna A arranged for communication with an on-board apparatus B installed on a vehicle V and able to keep stored, for example in a nonvolatile memory, at least one associated unique identification code.

[0020] The technological infrastructure coinciding with the pre-existing infrastructure used for the purposes of toll collection advantageously does not require the installation of TV cameras or magnetic coil sensors embedded in the roadway.

[0021] The peripheral units 12 may be distinguished as units 12 comprising a land-based apparatus installed in through-gates situated at the automatic toll collection stations and units 14 comprising a land-based apparatus installed in gates situated in transit in predefined locations along the road section where the recording operations are to be performed.

[0022] The peripheral units 12 at the toll collection stations use the same land-based apparatus which are provided on the gates for automatic toll collection, conveniently programmed for simultaneous management of the respective data processing unit 16.

[0023] The peripheral units 14 installed in transit comprise, instead, land-based apparatus including a subassembly of the apparatus used in the equipment at the toll collection gates and are installed on the bridges which are normally arranged over the roadway and contain, for example, panels for displaying variable messages with useful information for travellers.

[0024] A data base 24 is associated with the central processing unit 20.

[0025] The central processing unit 20 is interfaced in turn, by means of a further communication unit 22', with a system 30 for driving variable-message panels which is arranged for controlling the display of messages indicating the average travel time calculated, with an interface system for transmitting information to information channels 32, in which the average travel time is associated with road traffic conditions as an attribute, and with a plurality of client systems 34 where the average travel times are shown in the form of a summary synoptic panel of the motorway network and the alarm conditions are notified. As regards the format for interchange of information on the road conditions, in the remainder of the description reference is made preferably to the European standard language protocol DATEX.

[0026] The peripheral units 12, 14 are able to communicate with the on-board apparatus B of each vehicle V equipped therewith by means of the radiofrequency antenna A, and in particular acquire from it the associated stored code.

[0027] They are also able to recognise the code of the on-board apparatus and associate a temporal moment of transit therewith. The time synchronisation module 18 associated conveniently with each peripheral unit allows synchronisation of all the units associated with the road network so as to allow accurate definition of the moment of transit within a common time reference system.

[0028] The peripheral units 12, 14 transmit to the central processing unit 20 via the local communication unit 22 the data relating to the transit of individual vehicles acquired by means of interrogation of the respective on-board apparatus.

[0029] Essentially, the radiofrequency antennas A detect the codes of the on-board apparatus B, for example the on-board apparatus of the Telepass® system in the case of Italian motorway sections, for all the vehicles in transit along the toll collection lanes or at the bridges situated over the roadway.

[0030] The data detected in connection with transit of the vehicles V identified by the abovementioned code are then sent to the central processing unit 20 and stored by it in the data base 24.

[0031] Periodically the processing unit 20 checks whether the vehicles V detected in transit by a first peripheral unit 12, 14 have also been detected by a second unit.

[0032] Following two successive transit detection operations by two separate peripheral units and involving a same vehicle identified by its on-board apparatus code, the central processing unit determines the time which the abovementioned vehicle has taken to travel along the road section which separates the points where the abovementioned peripheral units are installed. The transit is defined by the on-board apparatus code and the

moment in which the latter was detected, so that the travel time between two peripheral units, namely between two points along the road section, is obtained by means of the simple difference between the moments of transit recorded.

[0033] Once a predetermined time interval for monitoring a road section has been determined, if the number of vehicles recorded by both the peripheral units 12, 14 which define this section is greater than a predetermined minimum threshold number, the travel time which is obtained by taking the average of all the times taken by the individual vehicles to travel along the abovementioned road section is regarded as the average travel time along that section.

[0034] The transits when entering and leaving the motorway network, recorded at the gates of the toll collection stations (for example, the Telepass® stations for entering and exiting from the road network), are not always sufficient in number to be able to be regarded as a sample useful for calculation of the average time. This is due essentially to the fact that the length of the motorway sections considered must not be excessive. In fact this would result in long travel times even under normal traffic conditions and therefore delays in detecting problems in the traffic flow.

[0035] If traffic flow problems are regarded as being all those events which disturb the normal travel of the vehicles along a road section, the system and the method according to the invention enable these events to be detected automatically when the vehicles in transit affected by these problems leave the road section being analysed and the average travel time determined is different from a reference average time as a result of these problems.

[0036] This and other considerations have resulted in a limitation in the length of the sections under observation and therefore the need to install peripheral detection units 14 situated in transit directly above the roadway, i.e. so that they are able to record all the passing vehicles, including those vehicles travelling long distances, and thus compensate for the absence of those passing vehicles (entering or exiting) between adjacent toll collection stations.

[0037] The system is conventionally programmed to associate the data recording the transit of a same vehicle at two separate peripheral units 12, 14 on the basis of the single code of the on-board apparatus B of the vehicle. In order to ensure the confidentiality of the data relating to users of the road sections under observation, the recorded transits, which are used to make up the sample forming the set of average times, are preferably deleted immediately after processing, while the recorded transits which are not used, for example because they are not considered to be sufficient within the time interval monitored for providing a valid estimate as to the average travel time, are in any case deleted after a predetermined and predefinable storage time.

[0038] The central processing unit 20 is controlled by a program or group of software application programs. The functions which must be performed by the abovementioned programs are:

- determining the average travel times for the road sections monitored by means of processing of the data received from the peripheral units 12, 14;
- transmission of the average travel times determined to the system 30 for controlling the variable-message panels;
- association of the average travel times determined with the road traffic events which have occurred in the form of times required to cover the road sections affected by the event and transmission thereof to the DATEX translation system 32;
- sending of alarm messages to the client systems 34 and display on the summary synoptic panel of the average travel times determined; and
- administration of the system.

[0039] The program or group of application programs for determining the average travel times of the road sections allow processing of the data recorded by the peripheral units 12 and 14, i.e. both that of peripheral units intended to operate in automatic toll collection stations at an entry/exit gate of a road network, and that of peripheral units for recording passing traffic situated in transit, such as those installed on bridge structures with panels displaying variable messages.

[0040] The central processing unit of the system, at predetermined and predefinable time intervals, extracts from the data base 24 the data relating to the transit of vehicles past two predefined peripheral units and performs the calculation as to the average travel time for the section situated between these units using the methods described.

[0041] Subsequently, the calculated average times are compared with the reference average times stored for normal traffic conditions. If a comparison of the times shows that the times detected are greater than the reference times and - preferably - greater than at least one predefined cautionary threshold value, the system sends out a corresponding alarm to an operator station.

[0042] The mechanism which emits the alarms is a threshold mechanism, so that a given road section is considered to be in an alarm state if the average travel time determined exceeds the predefined threshold for that section.

[0043] For this purpose, the operator at the control centre conveniently has access to a synoptic panel which shows in map form the portion of road network which is under observation. In this summary synoptic panel the individual sections may, for example, be shown in different colours depending on the alarm level assigned to them. The list of active alarms is also preferably shown in text form. The operator at the road network control centre is thus able to check the alarm and associate a reason with the event causing slowing down of the traffic, for example "delays due to heavy traffic".

[0044] Essentially, the operating sequence followed by the system in order to process a potential alarm condition triggered when an average travel time is determined for a section to be greater than the reference value, comprises the steps of:

- displaying the alarm conditions present in the geographical area being monitored;
- processing of a new alarm condition with display of the detailed data (road section for which it was generated, average reference travel time, average travel time calculated, average speed calculated, trend (graph) of the average travel time for the section during a previous specified time period (for example, during the last hour) and variation tendency);
- if appropriate, acceptance of the alarm condition with recording of an event creating a disturbance in the traffic conditions and associated reason.

[0045] After verification and, if applicable, acceptance of the alarm condition by the operator at the control centre, the calculated average time is made available to the various channels transmitting traffic information to the road users.

[0046] The system for controlling the variable-message panels 30 receives the verified and accepted average travel times for road sections in the alarm condition and prepares the messages to be sent to the panels on the basis of the type of event and the associated cause. The messages are then sent from the system to the individual bridges and displayed by them.

[0047] The system 32 for translating the events into DATEX language, which is the European standard for the interchange of road traffic information, receives the calculated average travel times and adds them as attributes to the events. The road traffic information thus coded is transmitted to the different bodies for distribution to different information channels for public utility services.

[0048] The method described above is illustrated in greater detail in the flow diagram of Figure 4.

[0049] The first step involving calculation of the average travel time of a road section, denoted by 100, is followed by a decision-making instant where the system determines whether the average time calculated exceeds a reference value, for example the average reference value plus a predefined cautionary threshold (step 110). If this is the case, it generates a new possible alarm (step 120) which is subsequently compared with those already rejected (step 130), for example owing to an established malfunction of one or more peripheral units, and if the outcome is affirmative it is considered void (step 140).

[0050] In the case where it has not already been rejected, the alarm is to be considered valid (step 150) and is compared with those alarms already accepted (step 160). If the alarm has already been accepted by an operator, in step 170 the system automatically updates the average travel time attribute of the associated event, otherwise it sends the alarm message to an operator (step 180). Following verification by the operator in step 190, if the alarm is rejected it is recorded in step 200 among the rejected alarm messages and the system prepares for a new calculation of the average travel time of the section. If the alarm is instead accepted, in step 210 the system records the event with the associated calculated average travel time and sends the information to the various information channels (step 220).

[0051] Obviously, without modifying the principle of the invention, the embodiments and the constructional details may be widely varied with respect to that described and illustrated purely by way of a non-limiting example, without thereby departing from the scope of protection of the present invention defined by the accompanying claims.

Claims

1. System for determining the average time taken by vehicles to travel along a road section, **characterized in that** it comprises:

   - a plurality of peripheral units (12, 14) distributed along a road network, for detecting the passing-by of vehicles (V) equipped with an on-board apparatus (B) adapted to keep stored at least one unique identification code, said peripheral units (12, 14) being arranged for acquiring the identification code of the on-board apparatus (B) of a vehicle (V) in transit, correlated to the moment of transit;
   - and a central processing unit (20) to which said peripheral units (12, 14) are connected,

   in which said central unit (20) is adapted to determine the average travel time of a road section situated between two peripheral units (12, 14) on the basis of detection of the moments of transit of a plurality of vehicles past said two peripheral units (12, 14).

2. System according to Claim 1, **characterized in that** said on-board apparatus (B) is an apparatus designed for interfacing with land-based apparatus for automatic toll collection.

3. System according to Claim 2, **characterized in that** said peripheral units (12, 14) for detecting the transit of vehicles comprise radiofrequency antennas (A) which are arranged in the vicinity of the roadway and are adapted to communicate with said on-board apparatus (B).

4. System according to Claim 2 or 3, **characterized in that** said peripheral units (12, 14) comprise units (12) installed on gates at the automatic toll collection stations and units (14) installed in transit at predeter-

mined locations along the road section.

5. System according to Claim 1, in which said central unit (20) is arranged for determining the average travel time of a road section on the basis of recording of the moments of transit of a plurality of vehicles which have travelled along said section within a predetermined time interval.

6. System according to Claim 5, **characterized in that** said central unit (20) is coupled to at least one data base (24) adapted to store the identification codes acquired from the on-board apparatus (B) of the vehicles and the associated moments of transit in the vicinity of at least one peripheral unit (12, 14).

7. System according to any one of the preceding claims, **characterized in that** each peripheral unit (12, 14) comprises a time synchronization module (18).

8. System according to any one of the preceding claims, **characterized in that** each peripheral unit (12, 14) comprises a local communication unit (22) adapted to link said peripheral unit (12, 14) to the central processing unit (20).

9. System according to any one of the preceding claims, comprising means (22') for communication with at least one client system (34) adapted to display a summary synoptic panel of the state of the network in terms of average travel times, together with a list of sections in the alarm condition.

10. System according to any one of the preceding claims, comprising communication means (22') for the transfer of data to a module (30) for the control of information messages intended for variable-message panels.

11. System according to any one of the preceding claims, comprising means (22') for communication with a system (32) for translation of road traffic events into DATEX language.

12. Method for determining the average time taken by vehicles to travel along a section of a road network, **characterized in that** it comprises the operations of:

- detecting an identification code of an on-board apparatus (B) of a vehicle (V) and the moment of transit past a peripheral detection unit (12, 14) located along the road network;
- associating with said identification code the moment of transit past a further peripheral detection unit (12, 14) located along the road network;
- determining, for each identification code having associated therewith two moments of transit detected at two different peripheral units (12, 14), the travel time of the associated vehicle (V) between said units (12, 14) as the difference between the moments of transit detected; and
- determining the average travel time of the section situated between said peripheral units (12, 14) by calculating the average travel time of a plurality of vehicles which have travelled along said section within a predetermined time interval.

13. Method according to Claim 12, comprising the automatic generation of an alarm when the value of the average travel time for a predetermined section is greater than a predefined threshold value.

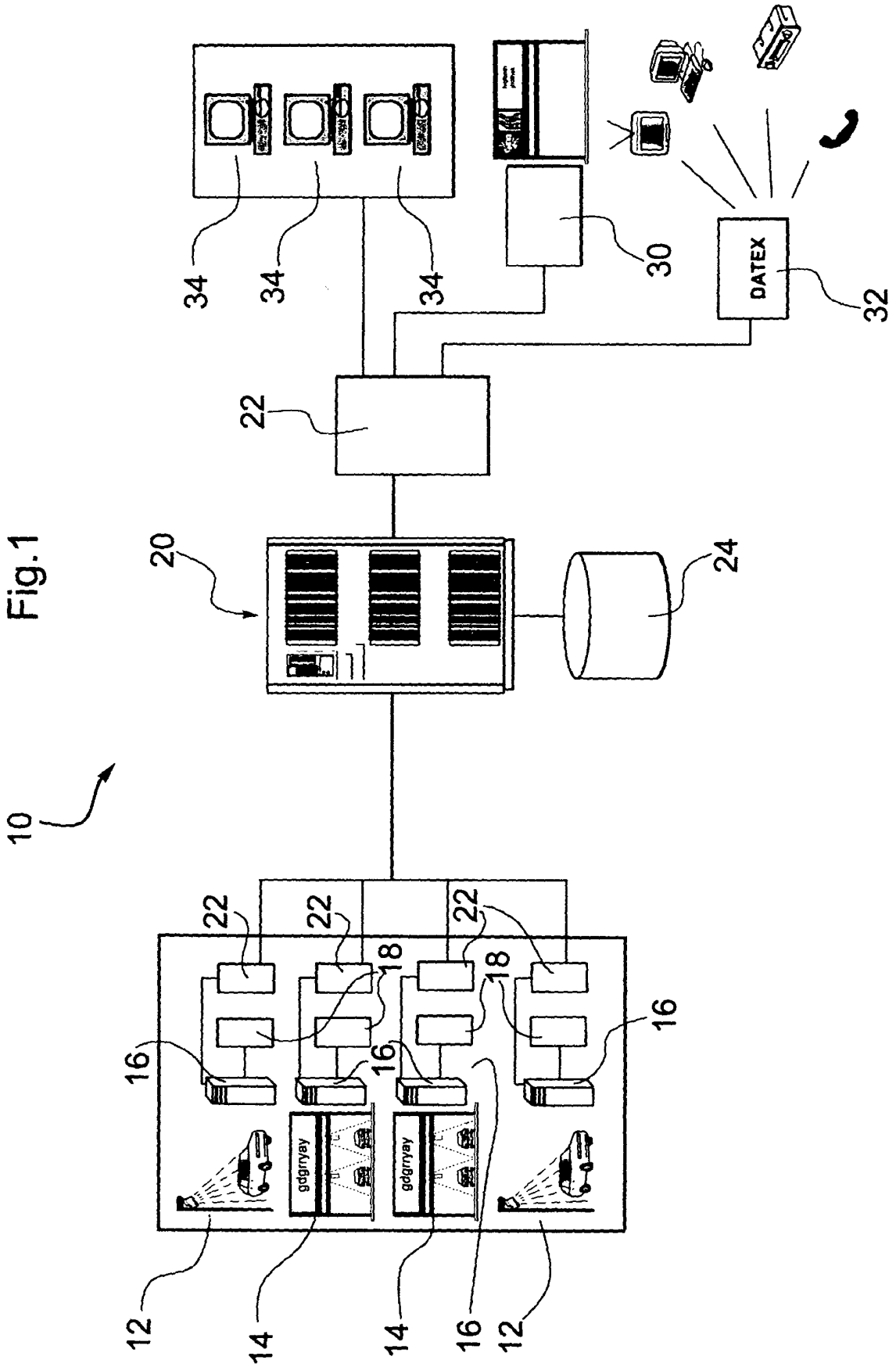
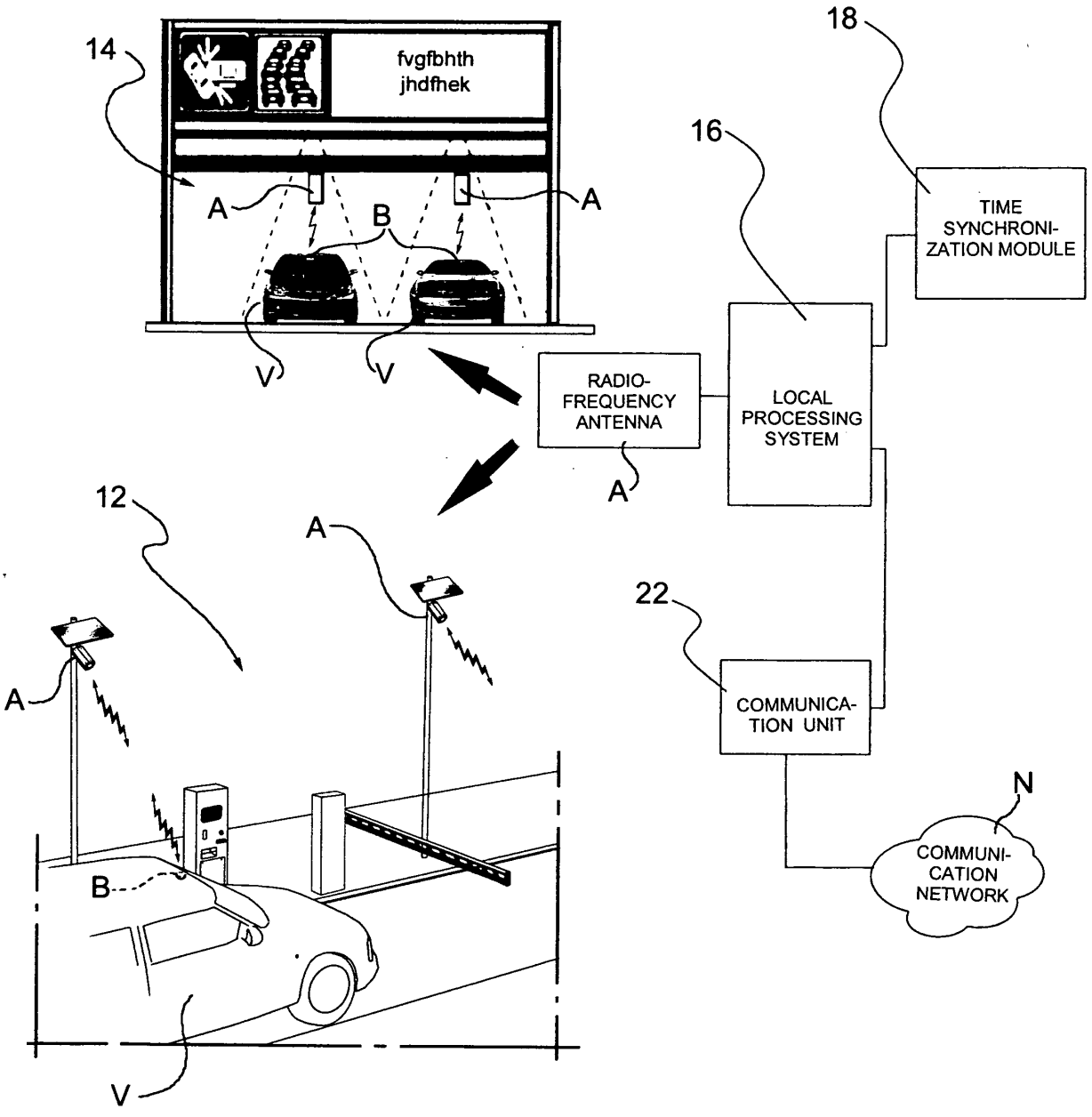


Fig.1

Fig.2


14
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A
B
A
V
V
18
16
TIME SYNCHRONI-ZATION MODULE
RADIO-FREQUENCY ANTENNA
LOCAL PROCESSING SYSTEM
A
12
A
A
B
V
22
COMMUNICA-TION UNIT
N
COMMUNI-CATION NETWORK

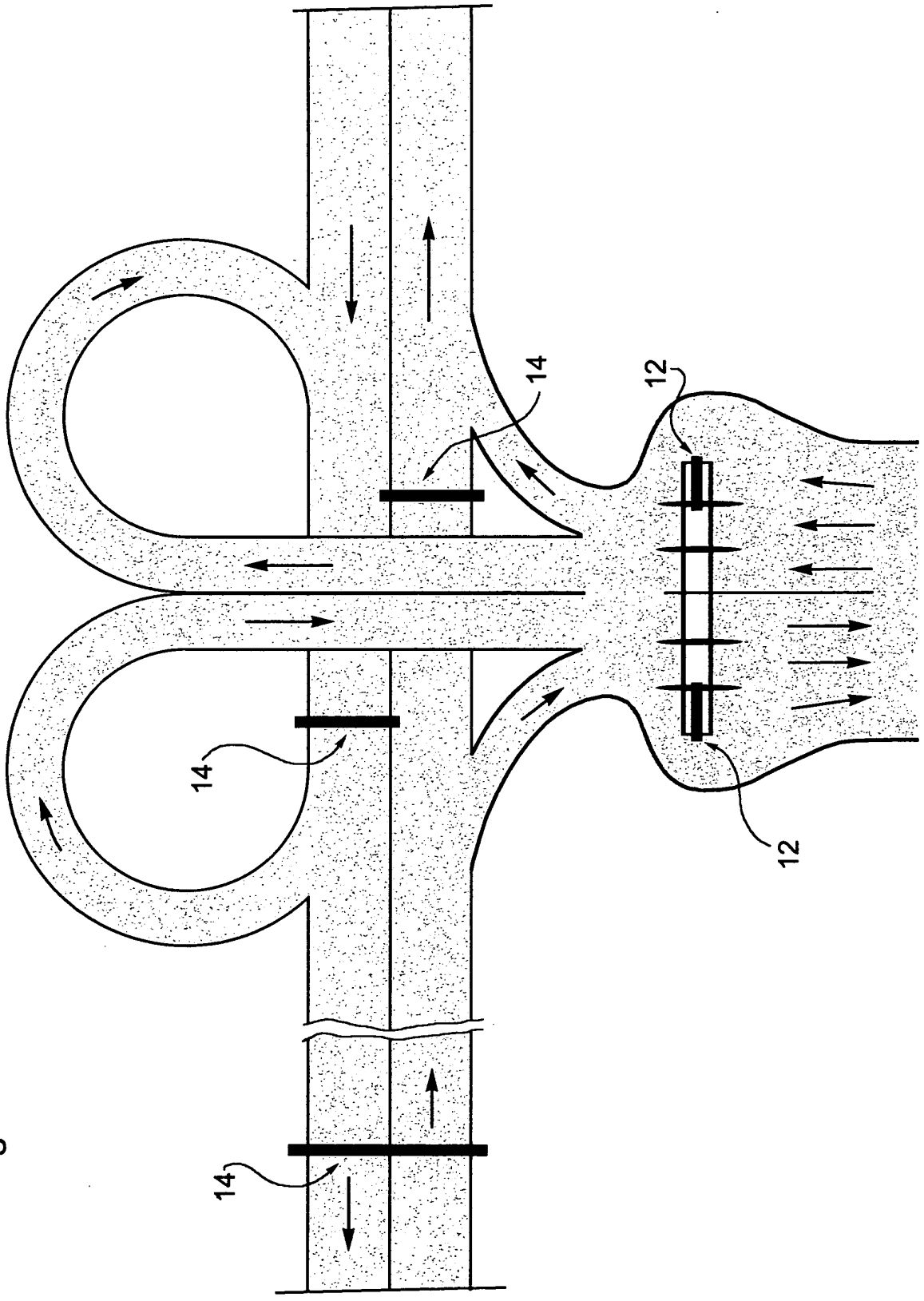
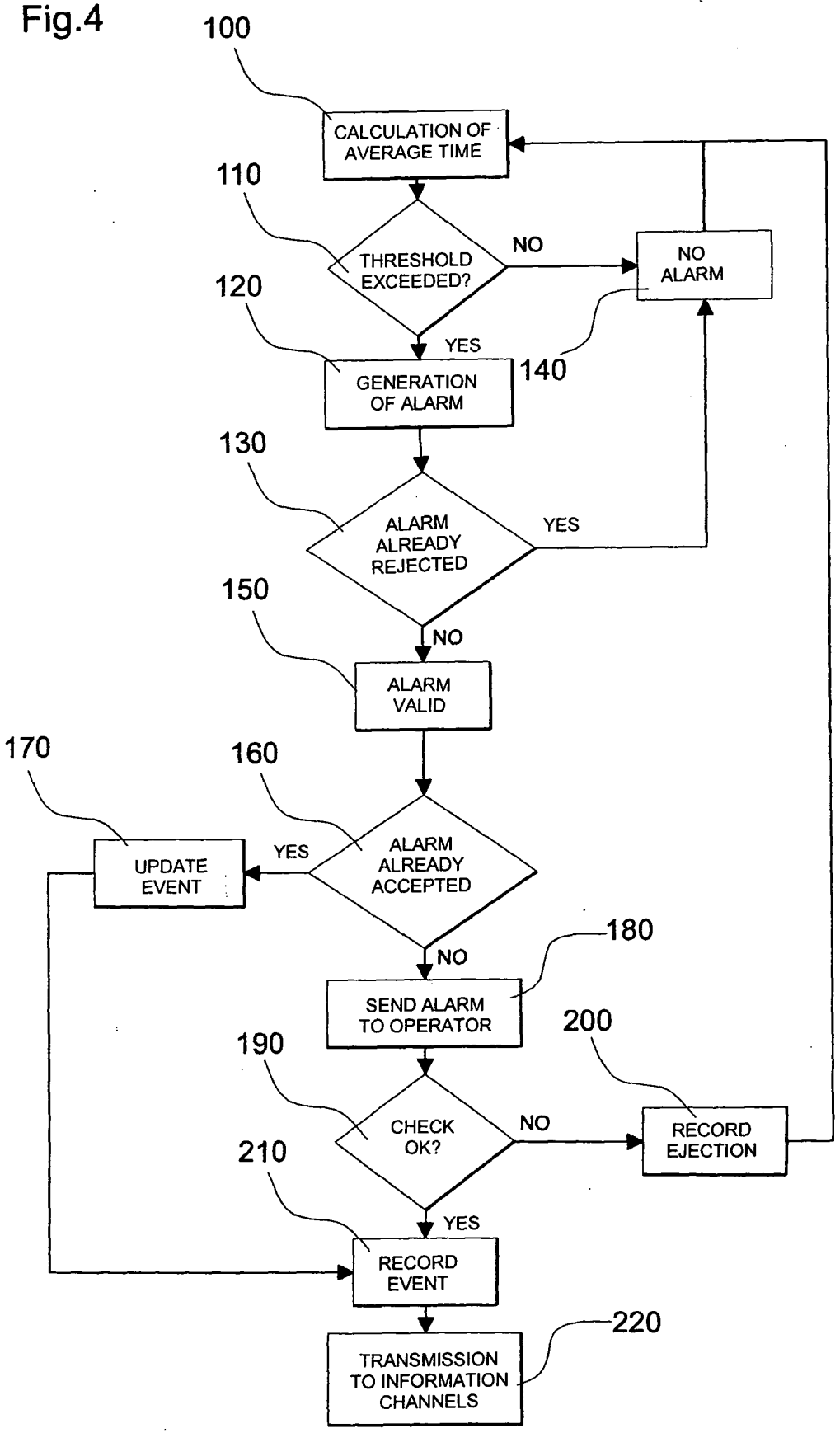


Fig.3

Fig.4


100
CALCULATION OF AVERAGE TIME
110
THRESHOLD EXCEEDED?
NO
NO ALARM
120
YES
GENERATION OF ALARM
140
130
ALARM ALREADY REJECTED
YES
150
NO
ALARM VALID
170
160
UPDATE EVENT
YES
ALARM ALREADY ACCEPTED
180
NO
SEND ALARM TO OPERATOR
200
190
CHECK OK?
NO
RECORD EJECTION
210
YES
RECORD EVENT
220
TRANSMISSION TO INFORMATION CHANNELS