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(54) Vehicle traffic monitoring system, central control unit, and method

(57) A vehicle traffic monitoring central control unit (2) installable along a road section (3) and having a first and a second infrared sensor (7) supplying respective presence signals (S_p) indicating the passage of a vehicle (4) along the road section (3); a clock circuit (8) for supplying a clock signal (S_{TIM}) indicating the instant at which passage of the vehicle (4) past each infrared sensor (7) occurs; a processing circuit (9) for processing the presence signals (S_p) and the clock signal (S_{TIM}) to obtain a number of information items relating to passage of the vehicle (4) along the road section (3), and for supplying an information signal (S_A) containing such information items; and a transmitting device (10) for transmitting the information signal (S_A) over a communication network (5) to a remote processing unit (6) for forecasting road traffic along the road section (3).

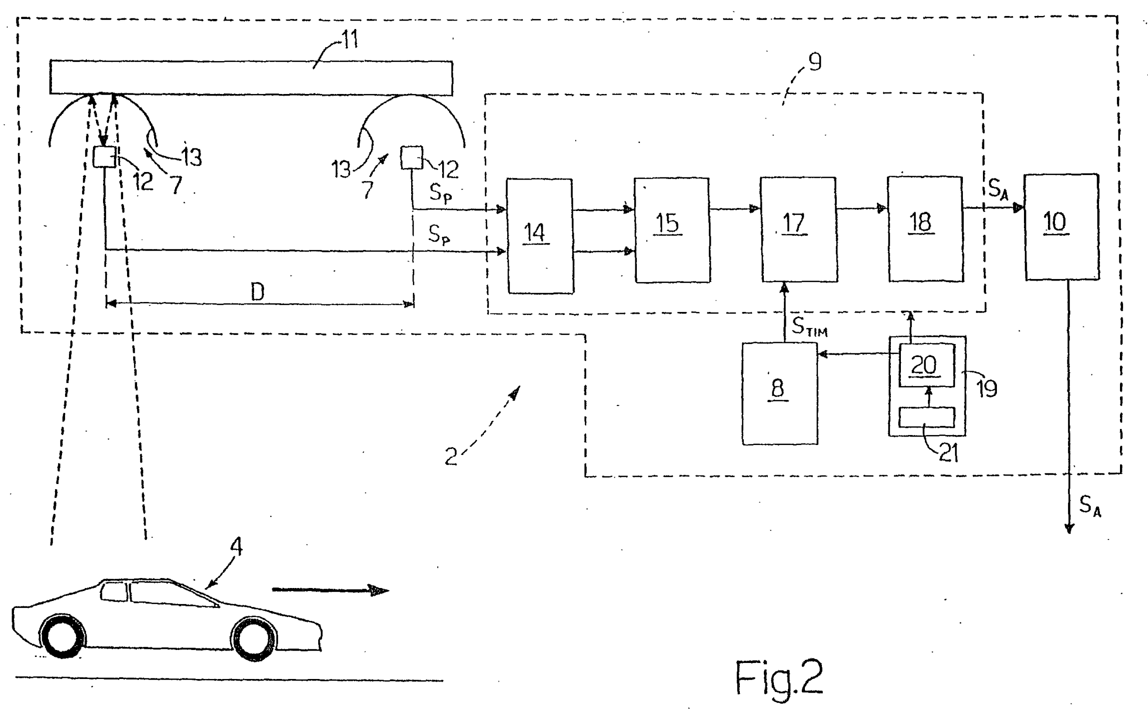

Fig.2

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Description

[0001] The present invention relates to a vehicle traffic monitoring system, central control unit, and method.

[0002] In particular, the present invention relates to a system for monitoring and forecasting rail, sea, or road traffic, to which the following description refers purely by way of example.

[0003] As is known, currently used road traffic monitoring systems feature a number of detecting devices arranged in a predetermined manner along the roads for monitoring, so as to detect the passage of vehicles at a number of predetermined road points.

[0004] More specifically, the detecting devices transmit information relative to passage of the vehicles at the predetermined road points to a remote processing unit, which processes the information to indicate general road traffic conditions.

[0005] The detecting devices most commonly used in known road traffic monitoring systems are defined by television cameras for detecting the passage of vehicles and transmitting images of the vehicles traveling along various critical road sections, or by electromagnetic transducers, the respective coils of which are "embedded" in the road surface to detect the passage of vehicles on the basis of the variations in magnetic flux produced by movement of the vehicles.

[0006] Road monitoring systems of the above type have the drawback of being extremely expensive. The high cost of television cameras accounts for large part of the overall cost of the system, while electromagnetic transducers are expensive both to install and maintain. In the case in hand, installation or replacement of the electromagnetic transducers involves working on the road surface at considerable cost in terms of labour and materials.

[0007] The above systems also have the drawback of providing supervisors with no more than general road traffic information, such as the daily or hourly average number of vehicles traveling along a given road section. Though useful for making statistical road traffic forecasts, such information is of little use in determining the actual traffic situation at any given instant, or forecasting future developments.

[0008] It is an object of the present invention to provide a vehicle traffic monitoring system, which is cheap and straightforward and, at the same time, provides for eliminating the aforementioned drawbacks.

[0009] It is a further object of the present invention to employ the detected data to monitor and forecast road traffic.

[0010] According to the present invention, there is provided a vehicle traffic monitoring central control unit, as claimed in Claim 1.

[0011] The present invention also relates to a vehicle traffic monitoring system, as claimed in Claim 13.

[0012] The present invention also relates to a vehicle traffic forecasting method, as claimed in Claim 14.

[0013] 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, a vehicle traffic monitoring system in accordance with the teachings of the present invention;
Figure 2 shows an electric block diagram of a vehicle traffic monitoring central control unit in accordance with the teachings of the present invention;
Figure 3 shows a time graph of the signals generated by the vehicle traffic monitoring central control unit in Figure 2;
Figure 4 shows a flow chart of the vehicle traffic forecasting method implemented by the remote processing unit forming part of the Figure 1 system.

[0014] Number 1 in Figure 1 indicates as a whole a vehicle traffic monitoring system comprising at least one vehicle traffic monitoring central control unit 2 located along a given road section 3 to detect the passage of vehicles 4 and transmit, over a communication network 5 forming part of system 1, a signal S_A containing a number of information items relative to the passage of vehicles 4 along road section 3.

[0015] System 1 also comprises a remote processing unit 6 for receiving, over communication network 5, the signal S_A transmitted by vehicle traffic monitoring central control unit 2, and for simulating vehicle traffic on the basis of the road information contained in signal S_A to forecast developments in traffic along road section 3.

[0016] In other words, and as described in detail later on, remote processing unit 6 forecasts developments in vehicle traffic along road section 3 by implementing a road traffic simulation model employing the information relative to vehicle traffic along road section 3 and transmitted in real time by vehicle traffic monitoring central control unit 2.

[0017] With reference to Figure 2, vehicle traffic monitoring central control unit 2 comprises two infrared sensor devices 7, each for supplying a vehicle presence signal S_P indicating passage of a vehicle 4 along road section 3; a clock circuit 8 for supplying a clock signal S_{TIM} indicating the instant ti at which passage of a vehicle 4 along road section 3 was detected by infrared sensor devices 7; and a processing circuit 9 for processing the clock signal S_{TIM} from clock circuit 8 and the presence signals S_P from infrared sensor devices 7 to determine a number of information items relative to the passage of vehicles 4 along road section 3, and for supplying signal S_A containing the information items.

[0018] Vehicle traffic monitoring central control unit 2 also comprises a transmitting device 10 for transmitting signal S_A over communication network 5 to remote processing unit 6.

[0019] Preferably, though not necessarily, each vehicle traffic monitoring central control unit 2 also comprises a power device 19 for powering processing circuit 9 and clock circuit 8, and which comprises a battery 20, and a solar panel 21 connected to and for constantly charging battery 20, so that vehicle traffic monitoring central control unit 2 is completely independent energy-wise, and can therefore be installed along any road section, even those with no electrical power of any sort.

[0020] With reference to Figures 1 and 2, the two infrared sensor devices 7 of vehicle traffic monitoring central control unit 2 are aligned one after the other in a direction substantially parallel to the road being monitored, and, in the example shown, can be installed on any supporting member 11 across and over the road. For example, supporting member 11 may be defined by a gantry structure extending across the road, and infrared sensor devices 7 may be fitted to the cross member of the gantry structure, facing the road one after the other in a direction parallel to the road, i.e. perpendicular to the cross member of the gantry structure. Supporting member 11 supporting infrared sensor devices 7 may be defined by any overhead structure extending across the road, such as a flyovers, bridges, road signs, billboards, etc.

[0021] System 1 can also monitor roads with more than one lane; in which case, vehicle traffic monitoring central control unit 2 comprises two infrared sensor devices 7, arranged as described above, for each traffic direction (Figure 1).

[0022] With reference to Figure 2, each infrared sensor device 7 comprises a pyroelectric sensor 12 sensitive to changes in temperature, i.e. to the infrared radiation emitted by a body, and for converting such changes into electric presence signal S_P; and a focusing device 13 defined, for example, by a parabolic mirror 13 located over pyroelectric sensor 12, so that pyroelectric sensor 12 is preferably, though not necessarily, located at the focal point of parabolic mirror 13. More specifically, focusing device, i.e. parabolic mirror, 13 provides for focusing the infrared radiation from road section 3 onto pyroelectric sensor 12.

[0023] It should be pointed out that parabolic mirror 13 is sized to have a given cover angle of, say, 30°, so that infrared sensor device 7 covers a given range of road section 3.

[0024] Processing circuit 9 comprises an amplifying and comparing circuit 14, which receives presence signals S_P from pyroelectric sensors 12, and rectifies and compares each signal S_P with a predetermined threshold to supply substantially digital presence signals S_P. In the example shown, for each incoming presence signal S_P, amplifying and comparing circuit 14 supplies a presence signal S_P having a high logic level when the predetermined threshold is exceeded by the presence signal S_P from pyroelectric sensor 12, i.e. when passage of a vehicle 4 is detected, and having a low logic level when the predetermined threshold is not exceeded by the presence signal S_P from pyroelectric sensor 12, i.e. when no vehicle 4 is detected along road section 3. In the example shown, Figure 3 shows a time graph of two presence signals S_P supplied by amplifying and comparing circuit 14 when passage of a vehicle 4 along road section 3 is detected.

[0025] Processing circuit 9 also comprises a known coding circuit 15 comprising, for example, a decoder, which receives the digital presence signals S_P from amplifying and comparing circuit 14, and supplies a word defined by N bits (in the Figure 2 example, N=2), each associated with a respective infrared sensor device 7. Each bit therefore indicates the status of the respective infrared sensor device 7, while transition of the bit (1-0 and 0-1) indicates a vehicle is entering or leaving the range covered by infrared sensor device 7.

[0026] Decoding circuit 15 also supplies a transition signal S_T indicating a word bit status change.

[0027] With reference to Figure 2, processing circuit 9 also comprises a storage, e.g. FIFO storage, device 17 for receiving both transition signal S_T and the signal coding the word from coding circuit 15, and for storing the words in a predetermined order at each transition of any one bit in the word, i.e. at each disturbance (change in temperature detected by the infrared sensor devices) within the range covered by each infrared sensor device 7.

[0028] Storage device 17 also receives clock signal S_{TIM}, the value of which is stored by storage device 17 whenever a pickup is made and a new word is stored, i.e. whenever another transition of the bits in the word is detected as a result of passage of a vehicle 4 within the road range covered by an infrared sensor device 7.

[0029] Processing circuit 9 also comprises a microprocessor 18 for reading the vehicle passage data in storage device 17, i.e. the words supplied by coding circuit 15 and the instants in time at which the words were stored, and for processing such information to determine a number of indications concerning the passage of vehicles 4 along load section 3. For example, from the stored information, microprocessor 18 is able to determine the speed, length and traveling direction of the vehicle.

[0030] More specifically, with reference to Figure 3, speed may be determined, for example, from the ratio between the time interval D_{T1}=t2-t1 between the leading edges of the two binary signals S_P, and the distance D between the two infrared sensor devices 7; traveling direction may be determined from the time sequence of the leading or trailing edges of the signals; and the length of vehicle 4 may be determined, for example, from the time interval D_{T2}=t3-t1 in which vehicle 4 occupies the road range covered by an infrared sensor device 7.

[0031] Following such processing, microprocessor 18 codes all the information relative to the passage of vehicle 4 in a single signal S_A, and supplies signal S_A, e.g. via a serial connection, to transmitting device 10.

[0032] Signal S_A coding the data relative to the passage of vehicles 4 along road section 3 is transmitted by transmitting device 10 over communication network

5 to remote processing unit 6. Transmitting device 10 may be defined by a personal computer comprising a modem communicating with remote processing station 6 over a communication network 5 defined, for example, by an Internet or Intranet network. Alternatively, information may be transmitted between vehicle traffic monitoring central control unit 2 and remote processing unit 6 over a communication network 5 defined, in the example shown, by a GSM or UMTS telephone network. In which case, vehicle traffic monitoring central control unit 2 will comprise a transmitting device 10 defined, for example, by a GSM or UMTS telephone module for receiving signal S_A from microprocessor 18 and transmitting it over communication network 5 to remote processing unit 6.

[0033] Vehicle traffic monitoring central control unit 2 may also perform a self-diagnosis test to indicate it is operating correctly. For which purpose, infrared sensor devices 7 may comprise a number of LED's (not shown) arranged, for example, in a ring outside parabolic mirror 13 and activated by a pulse signal supplied by mircroprocessor 18. When activated, the LED's generate a light beam which, reflected by the road section, is detected by infrared sensor device 7, which generates presence signal S_P, which, in this case, is used as a TEST signal.

[0034] Remote processing unit 6 receives, instant by instant, the signal S_A coding the information relative to the passage of vehicles 4 along road section 3, and, on the basis of the information received, implements a road traffic forecasting method to forecast traffic along road section 3.

[0035] More specifically, the road traffic forecasting method implemented by remote processing unit 6 is based on a known cellular automata road model published on 5 May, 2000, by the EDP Sciences magazine "The European Physical Journal" in an article entitled "A cellular automata model for highway traffic".

[0036] More specifically, in the above model, the monitored road has a start point and an end point, and is divided into two lanes, each in turn divided into a number of cells of given length (e.g. 5 meters), each of which may or may not be occupied by a vehicle traveling at a given maximum speed.

[0037] When implemented by remote processing unit 6, the above model provides for determining developments in traffic instant by instant, as of a start instant t_0 corresponding to a number of initial conditions, such as initial traffic density, initial status of each cell, and the maximum speed of vehicles 4, so as to forecast the status of each cell, and therefore of the road, at any successive instant t_0+Dt.

[0038] With reference to Figure 4, the road traffic forecasting method employing the above model commences with a block 100, in which the traffic cellular automata model parameters are initialized on the basis of the data detected by vehicle traffic monitoring central control unit 2, i.e. on the basis of real-time incoming data, such as the speed of vehicles 4 in the cell defined by the monitored road section.

[0039] Block 100 is followed by a block 110, in which remote processing unit 6 simulates road traffic by applying the cellular automata model to the real-time incoming data. In other words, in block 110, the real-time incoming data from the road traffic monitoring central control unit/s along respective road sections 3 establish the initial conditions of the model.

[0040] Block 110 is followed by a block 120, which gives a traffic forecast at instant t_0+t_R, where t_R is the unit reference time interval used in the simulation.

[0041] In connection with the above, it should be pointed out that block 120 may be followed by block 110, which repeats the simulation on the basis of the data determined in block 120 at instant t_0+t_R.

[0042] The method may therefore perform N number of cycles (block 110-block 120) to give a road traffic forecast relative to instant t_0+N*t_R.

[0043] The above road traffic forecast may be transmitted to vehicle users to warn of any critical traffic ' situations which may arise.

[0044] The vehicle traffic monitoring system described has the big advantage of being relatively cheap and easy to install, by featuring reasonably priced commercial devices, circuits and sensors.

[0045] Besides monitoring road traffic, the vehicle traffic monitoring system described also has the big advantage of also being applicable to rail and sea traffic.

[0046] Finally, simulating traffic developments on the basis of real-time incoming data enables the system to provide a much more reliable vehicle traffic forecast as compared with known methods.

[0047] Clearly, changes may be made to vehicle traffic monitoring system 1 as described and illustrated herein without, however, departing from the scope of the present invention.

[0048] In particular, infrared sensor devices 7 may be defined by thermopiles.

[0049] Vehicle traffic monitoring central control unit 2 may comprise at least one ultrasound sensor installed at infrared sensor devices 7 over the road, and for supplying microprocessor 18 with a signal indicating a stationary vehicle on the road section.

[0050] Finally, as opposed to infrared sensor devices, other types of sensors, e.g. laser, radar or ultrasound, may be used.

Claims

1. A vehicle traffic monitoring central control unit (2) installable along a road section (3); **characterized by** comprising:

- at least one first sensor means (7) supplying a first signal (S_P) indicating the passage of a vehicle (4) along said road section (3);

- clock means (8) for supplying a clock signal (S_{TIM}) indicating the instant at which passage of said vehicle (4) past said first sensor means (7) occurs;
- processing means (9) for processing said first signal (S_P) and said clock signal (S_{TIM}) to obtain a number of information items relating to the flow of vehicles (4) along said road section (3), and for supplying an information signal (S_A) containing said information items;
- transmitting means (10) for transmitting said information signal (S_A) over a communication network (5) to a remote processing unit (6) for forecasting, as a function of said information items, road traffic along said road section (3).

2. A vehicle traffic monitoring central control unit as claimed in Claim 1, **characterized by** comprising at least one second sensor means (7) for supplying a second signal (S_P), indicating the passage of a vehicle (4) along said road section (3), to said processing means (9), to allow said processing means to determine, by processing said first and said second signal (S_P), the speed of the vehicles (4) along said road section (3); said first and said second sensor means (7) being installed aligned one after the other in a direction substantially parallel to said road section.

3. A vehicle traffic monitoring central control unit as claimed in Claim 2, **characterized in that** said first and said second sensor means (7) are installed on supporting means (11) over said road section.

4. A vehicle traffic monitoring central control unit as claimed in any one of the foregoing Claims, **characterized in that** said first and said second sensor means (7) are infrared sensors.

5. A vehicle traffic monitoring central control unit as claimed in any one of the foregoing Claims, **characterized in that** each said sensor means (7) comprises a pyroelectric sensor (12) sensitive to variations in the infrared radiation emitted by a body, and for converting such variations into said signal (S_P).

6. A vehicle traffic monitoring central control unit as claimed in Claim 5, **characterized by** comprising focusing means (13) for focusing onto said pyroelectric sensor (12) the infrared radiation generated by the vehicles (4) traveling along said road section (3).

7. A vehicle traffic monitoring central control unit as claimed in Claim 5 or 6, **characterized in that** said focusing means (13) comprise a parabolic mirror (13).

8. A vehicle traffic monitoring central control unit as claimed in any one of Claims 2 to 7, **characterized in that** said processing means (9) comprise an amplifying and comparing circuit (14) for rectifying and comparing each of said first and said second signal (S_P) with a predetermined threshold, so as to supply a digital presence signal (S_P).

9. A vehicle traffic monitoring central control unit as claimed in Claim 8, **characterized in that** said processing means (9) comprise a storage device (17) for storing the information items relating to said first and said second signal (S_P), and the time instants coded in said clock signals (S_{TIM}).

10. A vehicle traffic monitoring central control unit as claimed in any one of the foregoing Claims, **characterized in that** said transmitting means (10) comprise a communication device for transmitting said information signal (S_A) over said communication network (5) to said remote processing unit (6).

11. A vehicle traffic monitoring central control unit as claimed in any one of Claims 1 to 9, **characterized in that** said transmitting means (10) comprise a data transmission module operating to a predetermined standard protocol, and for receiving the information signal (S_A) and transmitting it over the communication network (5) to the remote processing unit (6).

12. A vehicle traffic monitoring central control unit as claimed in any one of the foregoing Claims, **characterized by** comprising light-emitting means activated by a pulse signal supplied by said processing means (9) to permit self-diagnosis of the vehicle traffic monitoring central control unit (2).

13. A vehicle traffic monitoring system, **characterized by** comprising:

- at least one vehicle traffic monitoring central control unit (2) as claimed in any one of the foregoing Claims;
- a remote processing unit (6) for receiving an information signal (S_A) transmitted by said vehicle traffic monitoring central control unit (2), and for implementing a vehicle traffic simulation model on the basis of the information obtained from said information signal (S_A), so as to forecast developments in vehicle traffic along a road section (3);
- a communication network (5) by which the vehicle traffic monitoring central control unit (2) transmits said information signal (S_A) to said remote processing unit (6).

14. A vehicle traffic forecasting method, **characterized**

by comprising the steps of:

- detecting a number of road data items, relating to the passage of vehicles along at least one given road section (3) forming part of a road, by means of at least one vehicle traffic monitoring central control unit (2) installed along said at least one road section (3);
- transmitting the data items detected by said at least one vehicle traffic monitoring central control unit (2) to a remote processing unit (6) over a communication network (5);
- implementing, by means of said remote processing unit (6), a road traffic forecasting method on the basis of the data items detected by said at least one vehicle traffic monitoring central control unit (2), so as to provide a forecast of traffic along the road section (3).

15. A vehicle traffic forecasting method as claimed in Claim 14, **characterized in that** said step of implementing said traffic forecasting method comprises the step of implementing a cellular automata model of the road.

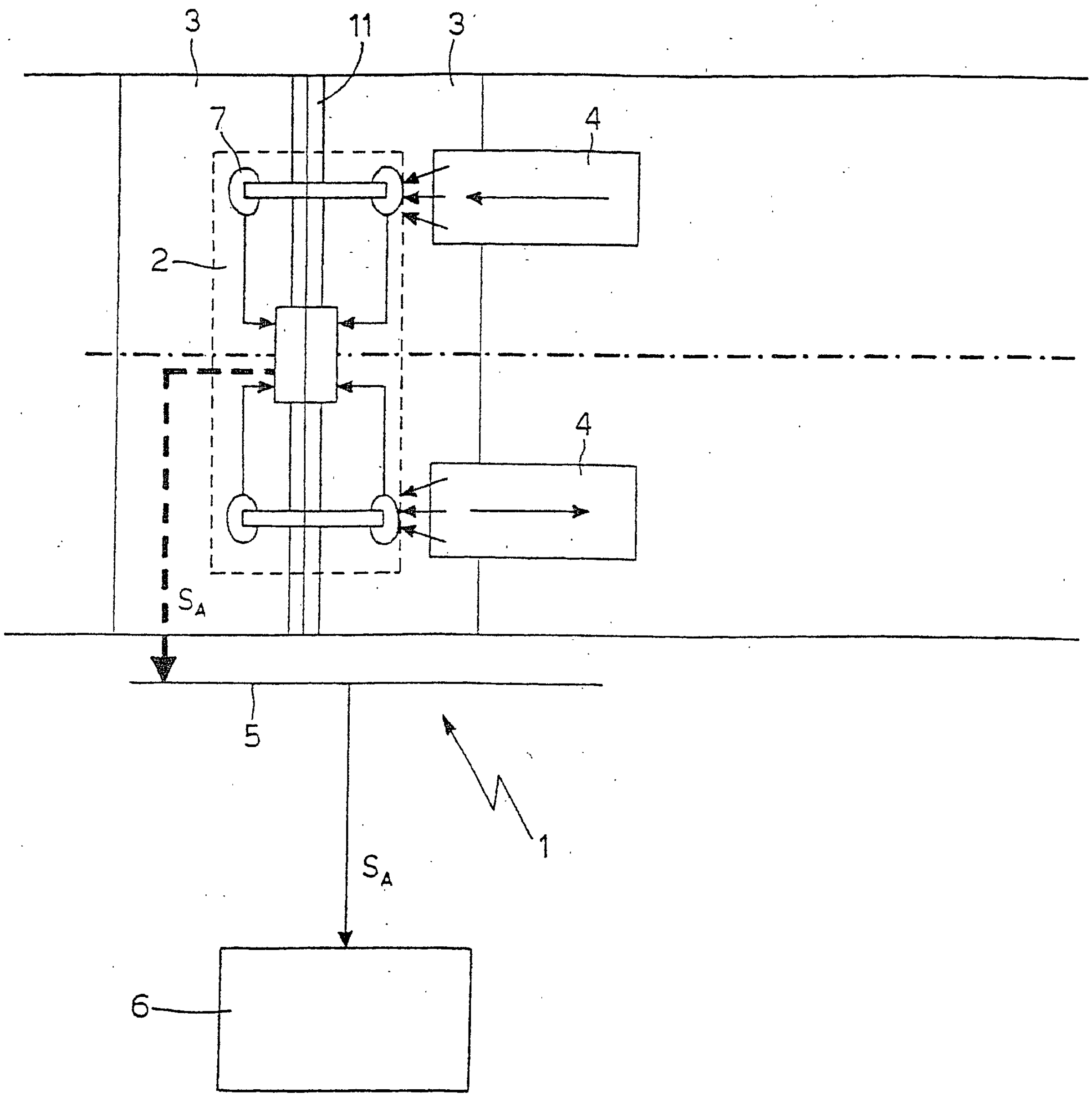

Fig.1

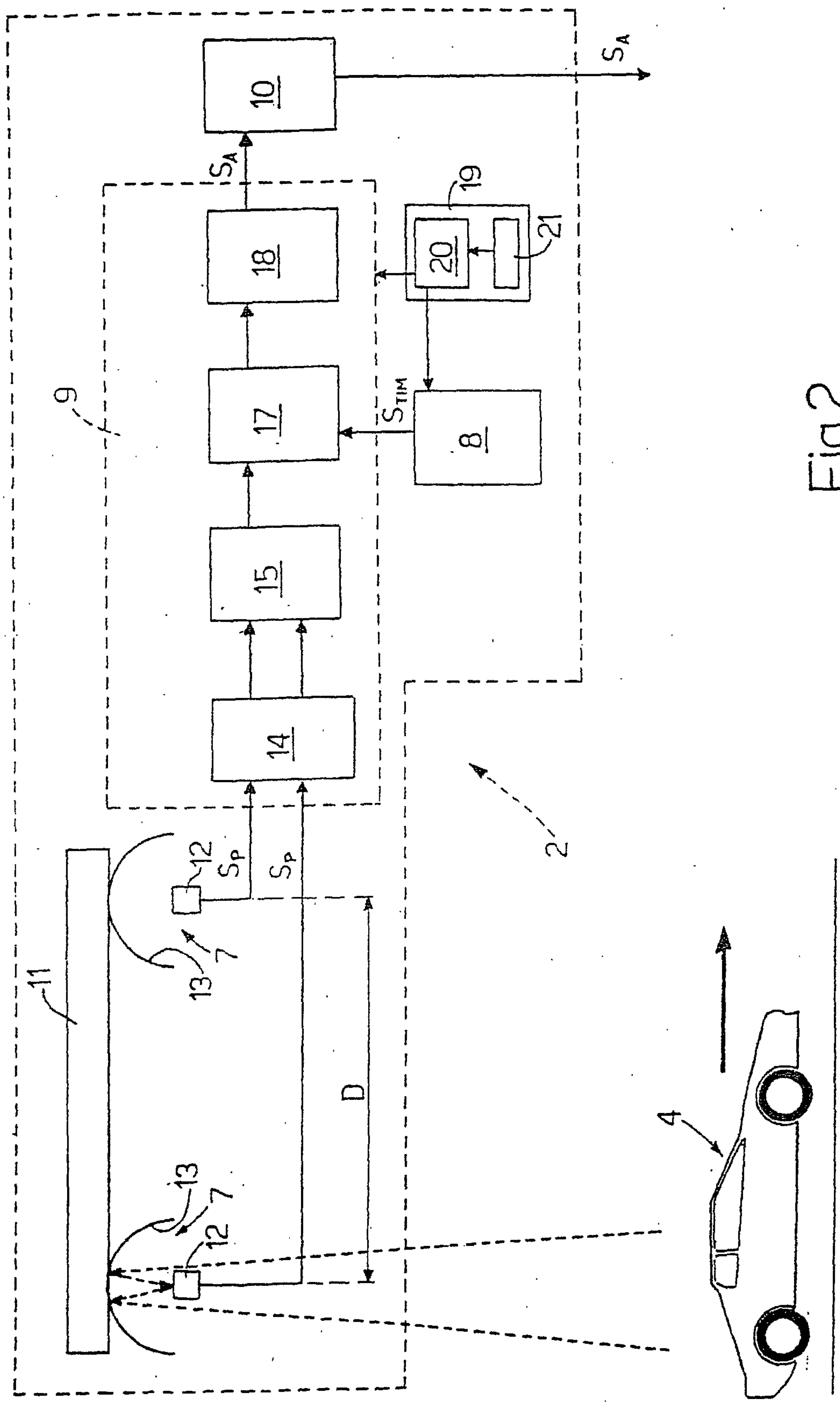

Fig.2

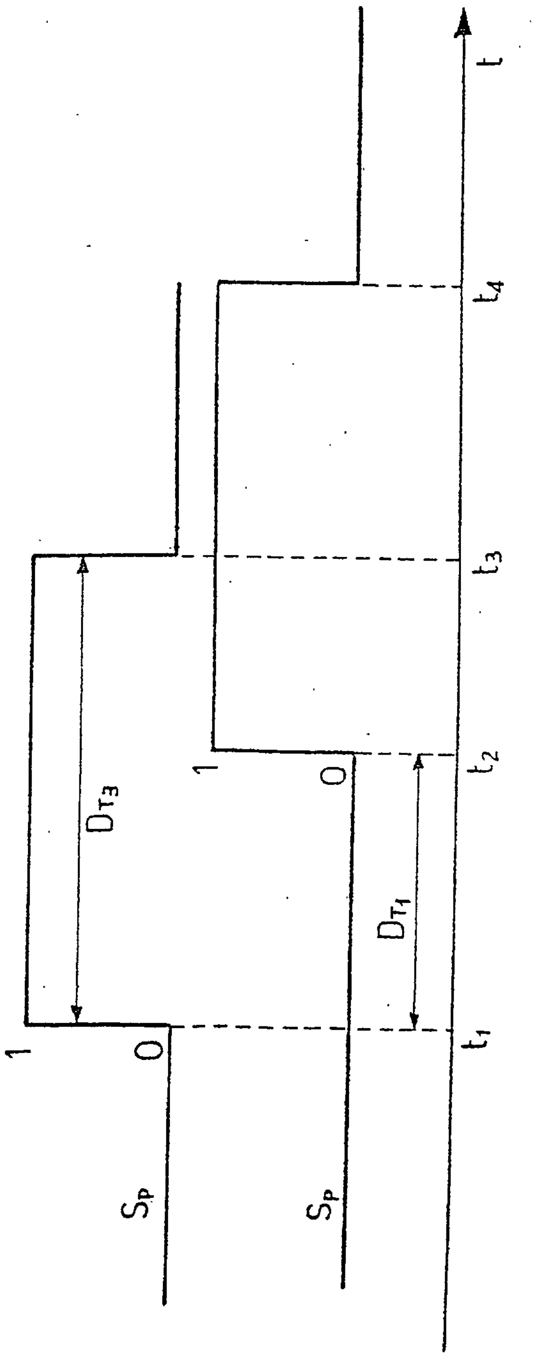

Fig.3

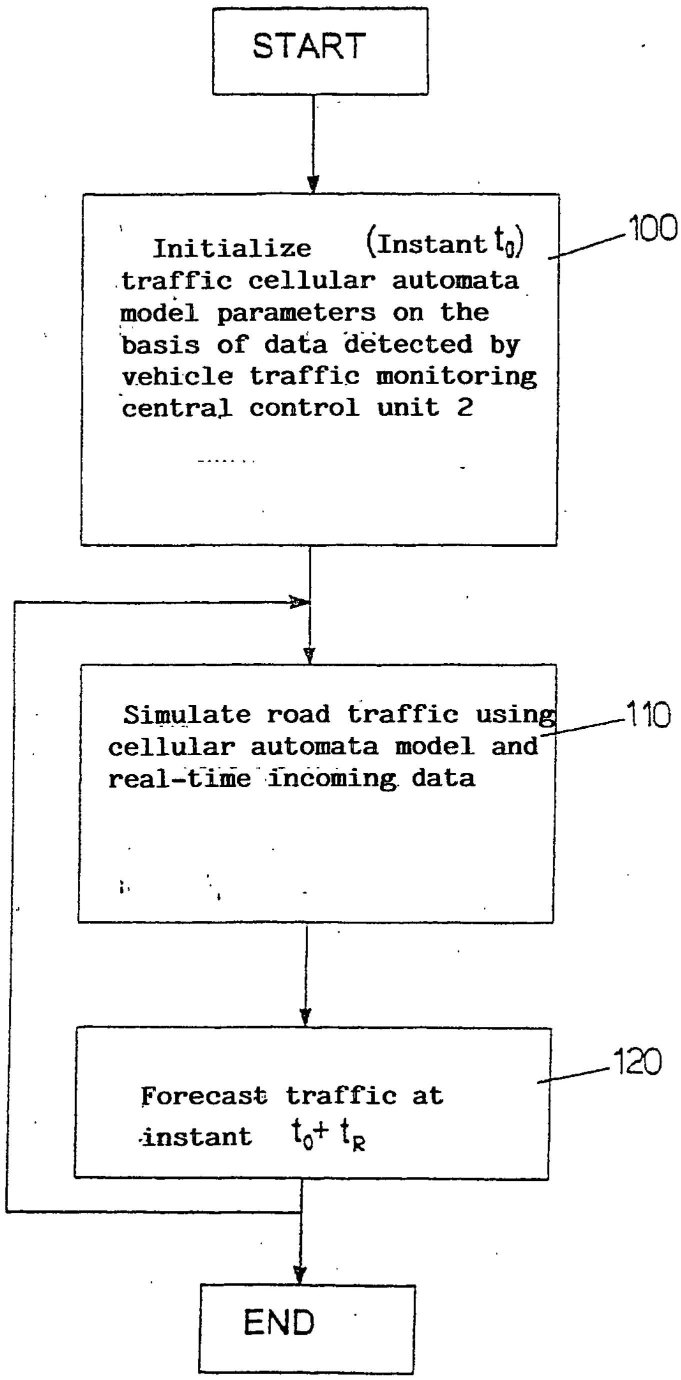
START
Initialize (Instant t_0) traffic cellular automata model parameters on the basis of data detected by vehicle traffic monitoring central control unit 2
100
Simulate road traffic using cellular automata model and real-time incoming data
110
Forecast traffic at instant $t_0 + t_R$
120
END

Fig.4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 01 3090

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 January 2003	Flores Jiménez, A

CATEGORY OF CITED DOCUMENTS

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