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(54) **Traffic control system**

Verkehrssteuerungssystem

Système de commande de trafic

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Description

Field of the invention

[0001] The present invention relates to a traffic control system, for example to a control and monitoring system for temporary or permanent traffic signals.

Background to the invention

[0002] Known sets of temporary or permanent traffic signals comprise a set of signal heads, each for controlling traffic flow through a respective traffic leg. Operation of the signal heads is controlled using a signal controller which controls the cyclical display of red, amber and green signals on the signal heads.

[0003] In the simplest control system, green and red times for each signal head in each signal cycle have a fixed length, which may be set, for instance, at the time of installation of the temporary traffic lights.

[0004] In an alternative known control system, each signal head has associated with it an above ground detector (AGD) in the form of a microwave sensor mounted on the signal head, for sensing the presence of a vehicle. The control system may operate a vehicle actuation (VA) method. A minimum green time is set, which defines the minimum length of time that each signal head displays a green signal during each signal cycle. The green time for a particular signal head is extensible beyond the minimum green time, and up to a maximum green time, if one or more vehicles are detected by the sensor for that signal head. Alternatively or additionally, after each signal cycle all signal heads are turned to red and maintained on red until a vehicle is detected by a sensor for one of the signal heads. The signal cycle is then operated, with the first green signal of the cycle being displayed on the signal head for which the presence of a vehicle has been detected.

[0005] The microprocessor optimised vehicle actuation (MOVA) system is an example of a more sophisticated vehicle actuation (VA) system. The system includes a pair of below-ground detectors associated with each signal head, one located at a greater distance from the stop line then the other. Vehicles are counted over each pair of detectors, and estimates of vehicles queuing at or on the approach to a junction, for each leg of the junction, are obtained at any given time, During each stage of each signal cycle, the system decides whether, and for how long, to extend a particular green signal beyond the minimum green time in dependence upon the number of vehicles that have passed over the detectors at each leg of the junction. The MOVA system has two modes of operation, one of which is adapted for un-congested conditions, and the other of which is adapted for situations in which queues are present on one or more approaches to a junction.

[0006] The MOVA system generally operates to control a single set of traffic lights, although linked MOVA systems co-ordinating two or three closely-spaced, adjacent traffic signals have also been deployed, for instance at signal-controlled roundabouts. The system controller is installed locally in a control box associated with the set of traffic lights.

[0007] Linked set of traffic lights are also known, in which signal timings for different sets of traffic lights at different locations are linked, either by operation in dependence upon a common timing signal (for example derived mains frequency) or by communication between controllers for each set of traffic lights, linked together by cable.

[0008] In the known SCOOT system, a central traffic computer is used to set timings of signal cycles in a co-ordinated fashion for many different sets of traffic signals across a wide area, for instance across an entire city or city centre, based on the outputs from a network of induction loop detectors that detect the presence or absence of vehicles.

[0009] It is in general more straightforward to set appropriate green and red times for permanent traffic lights than is the case for temporary traffic lights, as likely traffic flows, in the absence of abnormal conditions, may be more predictable and as the effects of different signal timing cycles may be observed over a significant period of time.

[0010] WO 02/35496 A1 describes a system for controlling alternative light signals when a regular traffic light is out of function, by plugging in main and slave modules that communicate with each other by means of radio signals.

[0011] It is an aim of the present invention to provide improved, or at least alternative, temporary and/or permanent traffic control systems.

Summary of the invention

[0012] In a first aspect of the invention there is provided a traffic control system according to claim 1.

[0013] In another aspect of the invention there is provided a method of controlling operation of a traffic control system according to claim 6.

Detailed description of embodiments

[0014] Embodiments of the invention are now described, by way of non-limiting example, and are illustrated in the following figures, in which:-

Figure 1 is a schematic diagram of a known temporary traffic light system;
Figure 2 is a schematic diagram of a traffic light system according to one related example;
Figure 3 is a schematic diagram of a variant of the system of Figure 2;
Figure 4 is a schematic diagram of another variant of the system of Figure 2;
Figure 5 is a schematic diagram showing the layout

of the system of Figure 2, installed at a traffic junction;

Figure 6 is a schematic diagram of a detector;

Figure 7 is a schematic diagram of a system controller;

Figure 8 is a schematic diagram showing the layout of a further example, installed on a road;

Figure 9 is a schematic diagram showing the layout of another example installed on a road;

Figure 10 is a schematic diagram of an electronic sign;

Figures 11 and 12 are schematic diagrams showing the layout of further examples;

Figure 13 is a schematic diagram illustrating communication between a controller of a traffic control system and one or more remote devices;

Figure 14 is a schematic diagram of a layout of an embodiment;

Figure 15 is a schematic diagram of a light sensing device installed on a traffic light signal unit; and

Figures 16 and 17 are schematic diagrams showing the layout of other examples.

[0015] A known temporary traffic light system is shown in Figure 1. The system of Figure 1 is similar to traffic light systems described in UK patent application GB 2 435 708, in the name of Hatton Traffic Management Limited.

[0016] The system of Figure 1 comprises a 4-phase traffic light control system and a set of traffic lights for a 4-way junction, and comprising four signal units 3a-3d, each provided with a respective controller 2a to 2d, and each connected to a respective battery (not shown). In the example of Figure 1, the controllers 2a-2d are essentially identical. Each one is switchable to either master controller or slave controller mode operation. This is done when the control system is initially set up. In the present case the first controller 2a, is designated to be the master controller, and the other three are slave controllers 2b-2d. In a variant of the system of Figure 1, there is a single dedicated master controller 2a and the other controllers 2b-2d are dedicated slave controllers and the controllers are not switchable between master and slave modes.

[0017] Each signal unit 3a-3d is provided with a wireless modem 5 for sending and receiving signal transmissions from one or more other controllers as appropriate. Each signal unit 3a-3d may also be provided with a vehicle actuated sensor, in the form of a detector 4, and a signal head control unit 8 that controls operation of red, green and amber lights of the signal unit, in response to control instructions from the master controller. The detector 4 of Figure 1 is a radar detector, a microwave detector, or an infrared detector.

[0018] On detecting a vehicle, the detector 4 positioned on top of each signal unit 3, generates an output signal, which is registered by the controller 2 for that signal unit. If the controller in question is not the master controller 2a then data is sent via the wireless modem 5 of the signal unit to the master controller 2a indicating that a vehicle has been detected by the signal unit in question.

[0019] The master controller controls the length of each green phase according to a vehicle actuation (VA) technique, in dependence upon the signals received from the detector 4 of its signal unit, and from the data received from the other signal units indicative of the detection of vehicles. The master controller sends control signals to the signal head control units 8, either directly in the case of the signal head control unit 8 included in the same signal unit as the master controller, or via the wireless modems in the case of the other signal head control units 8.

[0020] A manual control handset (not shown) is attachable to, or may be integrated with, the controllers 2, and can be used in the manual operation mode or for setting parameters, such as minimum or maximum green time, for other modes of operation.

[0021] The system can be set to manual operation mode, fixed time operation mode, demand responsive operation mode or all red.

[0022] In demand responsive operation mode, the control signal to begin a sequence is sent from the master controller to the signal head control unit 8 of the signal unit which registered the first demand, which then begins its sequence. If a constant demand is registered on that signal unit the light remains at green until the demand has passed. If another signal unit registers a demand the first signal unit runs out its remaining green time, turns through amber and waits for a red clearance time before the next signal unit begins a new sequence and so on. The master controller maintains a roving contact with the signal units to check for any malfunctions. If any malfunctions are registered the system sets all heads to red and then restarts.

[0023] A traffic light system according to one related example is shown in Figure 2, in which like features are indicated by like reference numerals. In this example, the system is a modification of the known system of Figure 1. It is a feature of the example that it can be relatively straightforward to produce by modifying certain existing systems.

[0024] The system of Figure 2 includes a system controller 14 that includes a processor and wireless communication circuitry, and that is used to control operation of the system. The system of Figure 2 also includes a set of above ground detectors 12 associated with each signal unit 3, and a road user interface, for instance in the form of an electronic sign unit 13, associated with each signal unit 3. In the example of Figure 2, there are four detectors 52 in each set of detectors 12. However, any suitable number of detectors may be provided in each set. In variants of the system of Figure 2 the detectors 52 are below ground detectors rather than above ground detectors.

[0025] The system is powered through the use of, for example but not limited to, one or more of mains power, rechargeable batteries, solar cells and mobile wind turbines.

[0026] The system controller 14 is configured to communicate wirelessly with any of the controllers 2a-d. In operation the system controller usually communicates with the designated master controller 2a, and sets and varies as appropriate the signal cycle timings, including green and red times, to be used by the master controller 2a, or the algorithm to be used by the master controller 2a to set the signal cycle timings. The master controller 2a then controls operation of the signal units 3 as described above. The system controller 14 effectively uses the master controller 2a to apply system cycle timings selected by the system controller 14.

[0027] The system controller 14 sets the signal cycle timings in dependence upon signals received from the sets of detectors 12. Thus, the example of Figure 2 provides a modification of an existing system to provide additional detectors. The example of Figure 2 also provides, for example:- different algorithms for determining signal cycle times, including green and red times; for the measurement of various additional parameters and the use of those parameters in setting signal cycle times; for the automatic sensing of the position of the various detectors; for the sending of data representing position from each of the detectors or sets of detectors; for the integration of the system into a network of traffic signals; and for communication with a user. Those features will be discussed in more detail below.

[0028] A variant of the example of Figure 2 is shown in Figure 3. In this case a single controller 2 is provided, rather than a set of controllers 2a-2d. The system controller 14 controls operation of the system by controlling operation of the controller 2, which in turn controls operation of the signal units 3.

[0029] Another variant of the example of Figure 2 is shown in Figure 4. In this case the signal controller 14 communicates directly with the signal units, and no additional controller 2 is present.

[0030] The examples of Figures 2 and 3 are shown as modifications of existing systems, but may also be entirely purpose-made. Various connections and communications between components of the systems are shown as being wireless, but any or all of those connections or communications may be wired rather than wireless. The systems of Figures 2, 3 and 4 are temporary traffic light systems but may also be permanent traffic light systems.

[0031] The detectors 52, and signal units 3 of the example of Figures 2 to 4 are shown installed at a traffic junction in Figure 5. The signal units are used to control the flow of traffic through a control region 50 indicated by dashed lines on Figure 5. In certain modes of operations, the system controller 14 controls system timings in dependence on at least one parameter associated with one or more monitoring zones 54, shown on Figure 5 by dotted regions. The at least one parameter may be representative of or associated with traffic within the monitoring zone.

[0032] In the example of Figure 5, the detectors are mounted at the roadside in the direction of travel on the approach to the control region to monitor the movement and type of traffic. In variants of the system of Figure 5, detectors may be on both the inlet and outlet of any leg of a junction, to detect vehicles both approaching and moving away from the control region.

[0033] A detector 52 used in the system of Figures 2 and 5 is shown schematically in Figure 6. In the example of Figure 6, the detector is a self-contained unit that may be attached to a lamppost or other street furniture. Alternatively, the detector may be mounted on a dedicated post or other support. The detector unit may comprise a protective housing.

[0034] The detector 52 comprises wireless communication circuitry 60, a control processor 61, GPS or GSM circuitry 62, and a battery (not shown) or other power source or mains connection.

[0035] The detector 52 also includes a vehicle detection sensor 64 for detecting the presence or absence, or passage, of a vehicle in a detection region associated with the sensor.

[0036] The control processor is a Microchip PICI18F4620, which is an 8-bit flash programmable RISC processor with a variety of digital and analog I/O ports. The wireless communication circuitry comprises a TI CC2420 r.f. transceiver integrated circuit and a PCB antenna operates under the IEEE 802.15.4 protocol, and provides a 250kbits/sec data rate using a direct sequence spread spectrum (DSSS) offset QPSK modulation format in one mode of operation.

[0037] The Microchip PICI18F4620, the TI CC2420 r.f. transceiver integrated circuit and the PCB antenna are included in a 26pin surface mount module.

[0038] The power supply for the detector comprises a 3.5V lithium cell, for example lithium thionyl chloride D cell or Li-ion rechargeable battery. (which may be recharged by associated photovoltaic cells). The power is supplied to the module via a LDO linear regulator circuit that provides a 3V supply.

[0039] The vehicle detection sensor 64 comprises a 40KHz Prowave 400PT160 ultrasonic transducer, powered by a 5V input obtained from the power supply via a step-up converter circuit. In an alternative example separate transmit and receive transducers (for example Prowave 400ET180 and 400ER180) are used.

[0040] The ultrasonic transducer is activated by applying a complementary (push-pull) pair of square wave signals that drive a pulse into the transducer via a MOSFET driver IC and a 1:5 step-up transformer. A diode T-R switch network enables the same transducer to then receive signals that echo back from traffic. The signals are fed through an op-amp based differential amplifier with a gain of 100, a second order bandpass filter and finally an envelope detector circuit before being fed into the control processor. In one mode of operation a 20 cycle, 40 KHz pulse is used by the transducer and 10 pulses per second are transmitted. The ultrasonic transducer is mounted, if possible, at a height of 0.8m above the ground, which corresponds to the door level (widest point) of an average small car.

[0041] It is a feature of the system that each detector may include one or more additional sensors, or may comprise other sensors in place of vehicle detection sensors 64. In the example of Figure 6, the detector 52 also includes an air quality sensor 66.

[0042] In alternative related examples, the detector includes a sensor for determining an environmental parameter as well as or instead of the vehicle detection sensor 64, and the controller 14 is configured to control the timing of display of traffic control signals on the signal units 3a, 3b, 3c, 3d in dependence on the environmental parameter.

[0043] Any suitable sensors may be included in the detectors. Each detector may comprise, for example, one or more of an acoustic sensor, proximity sensor, vibration sensor, visual recognition system, laser sensor, induction loop sensor, pressure sensor, radar sensor, ultrasonic sensor, infra-red sensor, transponder, air quality sensor, RFID sensor, mobile phone, piezo-electronic sensor, magnetometer sensor and temperature sensor. The RFID sensors are able to detect the presence of and/or read data from RFID tags on vehicles, if present.

[0044] As mentioned above, each detector 52 in the system of Figures 2 and 5 also includes GPS or GSM circuitry 62 for determining the position of the detector. Alternatively GPS or GSM circuitry 62 is provided for each set of sensors 12 rather than for each individual sensor 52.

[0045] As the detectors 52 or set of detectors 12 are able to determine their own positions using the GPS or GSM circuitry, and are also able to transmit those positions to the system controller 14, the system is particularly versatile and straightforward to set up. The detectors may not be limited to being in particular positions and the position of the detectors may be selected in dependence upon a particular junction layout or upon traffic conditions. The system controller 14 may alter the signal timings, or algorithms used to determine the system timings, automatically in dependence upon the positions of the detectors or sets of detectors.

[0046] In operation, each detector or set of detectors sends signals to the system controller 14, which generates traffic flow data from the signals. In some variants, each detector communicates with the system controller directly. In other variants, some of the detectors communicate with the system controller 14 via one or more other detectors. The detectors may thus be daisy chained, either wirelessly or via wired connections. Those variants are particularly useful when the detectors have a short communication range or where It is desired to locate at least some of the detectors a large distance from the system controller 14, which Is usually located near the control region.

[0047] A system controller 14 is shown In Figure 7, and comprises a processor 70, a memory 72, communication circuitry 74, and a battery (not shown) or other power source or mains connection. The communication circuitry 74 is usually wireless communication circuitry, but in some variants that system controller 14 may comprise communication circuitry for wired communication as well as or instead of the wireless communication circuitry. The processor comprises an initialisation module 75, a traffic signal control module 76, a position monitoring module 77, and a communications module 78 for controlling transmission and reception of signals via the communication circuitry 74. The processor 70 and wireless communication circuitry 74 of the system controller 14 are of the same or similar type as the control processor and wireless communication circuitry of the detector of Figure 6, with the control processor being suitably programmed with software for implementing the various modules 75, 76, 77, 78 and other functions. However, any suitable processor and communication circuitry can be used. The processor can be a suitably programmed general purpose processor or can be a dedicated processor In which functions are implemented in software, dedicated hardware, or a mixture of software and dedicated hardware.

[0048] The system controller 14 can be programmed or otherwise configured to apply any one of a number of different algorithms or other processes in order to determine the signal timings. In some modes of operation the system controller 14 determines and/or varies signal timings in real time in dependence upon output from the detectors. Thus, as traffic conditions change the system controller 14 can immediately respond by varying the signal timings appropriately. The signal timings can be varied between successive signal cycles. The system controller 14 is able to vary the signal timings in response to variations in traffic conditions at different times of day or due to, for example, events or accidents.

[0049] The system controller 14 can determine one or more traffic-rotated parameters, such as level of flow, amount of traffic, number of vehicles waiting, type of vehicle and direction of travel from the signals from the detectors, usually in real time. In addition the system controller may determine and monitor the value of other parameters such as level of emissions, level of noise, vibration, temperature and position.

[0050] The system controller 14 processes the resulting data In real-time and calculates the most effective control sequence and/or signal timings, and instructs operation of the signal heads either directly or via controller 2. In some modes of operation, the system controller 14 is configured to determine the values of the traffic-related or other parameters for the at least one monitoring zone 54.

[0051] In one example, the system controller 14 controls signals timings In dependence on traffic volumes and/or flow rates on each approach to a junction and on average levels of pollutants produced by vehicles, such as carbon monoxide or sulphur based compounds, on each approach to a junction. If pollutant levels build up above a predetermined level then the system controller 14 may prioritise reducing the levels of stationary traffic an one or more of the approaches, if higher pollution levels are expected from stationary traffic.

[0052] In certain modes of operation, the system controller 14 applies adaptive techniques to determine the signal timing. In one such mode of operation, the controller 14 uses neural network techniques to determine the signal timings.

[0053] In another mode of operation, the system controller 14 calculates the best form of traffic signal pattern for the current level of traffic. Through prior modelling of the types of traffic flows experienced at temporary and permanent traffic control sites a set of possible signal patterns or algorithms are obtained, and those signal patterns or algorithms are stored by the system controller 14. One of those signal patterns or algorithms is selected by the system controller 14 to be used to control signal timings. The parameters of the signal pattern or algorithm may be altered In real time by the system controller 14 or another signal pattern or algorithm may be selected, as traffic characteristics or other parameters vary over time.

[0054] Many of the algorithms, in particular vehicle actuation or demand responsive algorithms, that can be used by the controller 14 to control the timings of signals displayed by the signal units 3a-3d include or are dependent on the position of the detectors.

[0055] For example, correct determination of the value of a traffic related parameter (for example the length of a queue, the speed of a vehicle or the estimated time for a detected vehicle to arrive at a signal unit) which may be used by or included in an algorithm and which is determined from the outputs of the detectors 3a-3d, depends on the correct position of the detectors being known by the controller 14. The position of the detectors can be determined from the GPS circuitry included in the detectors. The GPS circuitry can also be used to time stamp measurements by the detectors. In the case of the speed of a vehicle, the value of the speed may in one example be determined from the time difference between detection of the vehicle by two spatially separated detectors, in which case it is necessary to know the separation of the detector, In another example, an algorithm may specify that a green time is to be extended if the controller 14 determines from outputs from the detectors that a vehicle is detected (and/or is moving at above is predetermined speed) within a predetermined distance of a signal unit 3a or stop line, which again requires that the controller 14 knows the correct position of the detectors 52a, 62b. In a further example, an algorithm comprises the feature of extending a green time if a vehicle is detected by a detector that is at a position that is such that the vehicle would be expected to reach a signal unit within a predetermined time (for example 4 seconds) based upon a measured or expected speed, which requires that the controller knows the correct position of the detectors.

[0056] A set of signal timing algorithms, and parameters for those signal timing algorithms are stored In the memory 72. The initialisation module 75 selects one of the signal timing algorithms in dependence on the mode of operation that has been selected and/or In dependence on the positions of the detectors. The initialisation module may also calculate values of parameters to be used by the selected signal timing algorithm using the determined positions of the detectors.

[0057] Control of the signal units 3a-3d is then passed to the traffic signal control module 76, and the signals units are operated In accordance with the selected mode of operation and/or algorithm. The traffic signal control module 16 receives detection signals from the detectors 52a, 52b (and from the detectors of the other legs of the junction), processes the detection signals in dependence on the position of the detectors to generate control signals for controlling the timings of signals displayed by the signal units 3a-3d, and provides the controls signals to the signal units 3a-3d.

[0058] Another related example is illustrated in Figure 8, in which the traffic control system is used to control traffic through an area of roadworks 100. In this example, carriageways 102, 104 approaching the roadworks 100 from different directions can be treated as different legs of junction. A signal unit 3a, 3b is provided for each carriageway 102, 104. The positions of the detectors are determined relative to the signal units 3a, 3b which are installed adjacent to temporary stop lines 106, 108. A single detector 52 is provided for each signal unit 3a, 3b. The traffic control system controls traffic in a control region delimited by the stop lines 106, 108

[0059] As mentioned above, the system also includes road user interfaces for communicating with drivers. The road user interfaces 13 in the example of Figure 5 are, for example, LED based lighting boards, and are controlled by the system controller 14. Alternatively, the road user interfaces may be any other suitable display devices. Each board or other display device is able to communicate with the system controller 14 and to indicate to a driver or other user information specific to the control site or roadway where the system is installed, or concerning operation of the system, or concerning traffic flow through the junction. The information may be real time information. In one example, a road user interface 13 may be used to indicate, for example, current average queuing or wait time at that approach to the control region, or an estimate of the time before the driver or other user will pass through the control region, or an estimate of the number of red-green signal cycles before the driver or other user will pass through the control region, and/or any other desired message. The road user interface 13 may also provide other information concerning the system or junction where it is installed, for instance indicating that the system is under active control, and/or that priority is being given to one or more other legs of the junction, which may occur either temporarily (for instance in the case of significant queues on other legs of the junction) or for an extended period of time (for instance in the case of anticipated increased traffic flow on the other leg or legs due to the start or finish of a public event) or permanently.

[0060] Each road user interface 13 can be located at or near a signal unit 3, but is often located remotely on the approach to a signal unit, in order to provide advance information to road users.

[0061] An example of a traffic control system in which several display devices 13a, 13b, 13c, 13d in the form of electronic signs are provided on each approach to a set of roadworks is illustrated in Figure 9 (which is not to scale). The example is a variant of the example of Figure 8 and also includes detectors 52, which are not shown in Figure 9 for clarity.

[0062] Two electronic signs 13a, 13b or 13c, 13d are provided for each carriageway on the approach to the roadworks. Each electronic sign includes an LED display area 110, a sign controller 112 and wireless circuitry 114 for communication with the system controller 14, as illustrated in Figure 10. The system controller 14 controls the information that is displayed by each electronic sign 13a, 13b, 13c, 13d by sending control signals to the sign controller 112 via the wireless circuitry 114 for that electronic sign.

[0063] The information that is displayed by each electronic sign can be linked to the traffic control procedure applied by the system controller 14 and to traffic conditions detected by the detectors 52. The information that is displayed by each electronic sign can also be synchronised with the timing of the operation of the signal units.

[0064] For example, if traffic is queuing in advance of the roadworks the electronic signs 13a, 13b can be controlled to display information indicating that there is a traffic queue and/or the length of the queue or queuing time and/or the length of time that is likely to be needed to pass through the roadworks

[0065] If there is a traffic queue and electronic sign 13a is in advance of the start of the queue, it can be controlled to display the message "Roadworks ahead. Traffic queuing. Current queue time 5 minutes". If electronic sign 13b is at a location after the start of the queue, it can be controlled to display the message "Queue time from here 3 minutes". Alternatively the electronic signs 13a, 13b may be configured to display a message indicating an estimated total time to get through the roadworks, (including any queuing time).

[0066] At least one of the electronic signs 13a, 13b can also be controlled to suggest possible diversions in advance of the roadwork. In that case the electronic sign in question is usually located before at least one turning or roundabout, in advance of the control region, which can be taken by vehicles in order to follow the suggested diversion. For example, the electronic sign can be controlled to display a message "Diversion in operation, Turn left here to avoid roadworks" or "Diversion in operation. Take second left to avoid roadworks". The electronic sign can also be controlled to display an estimated time that may be saved if the diversion is followed, for example "5 minutes travel time may be saved by taking diversion". The controller can determine the estimated time saving by processing the output signal from the detectors to estimate travel time via the control region, and comparing it to an expected time of travel via the diversion.

[0067] The estimated times may be determined from the length of any queue (determined by the presence or absence of stationary vehicles at each detector), the cycle times of the traffic lights, and the expected time to travel through the roadworks, based on expected average speeds. Alternatively, the estimated times may be determined by tracking individual vehicles between their approach to the traffic lights and their exit from the traffic lights. The tracking of individual vehicles is described in more detail below.

[0068] If there is no queue then one or both of electronic signs 13a, 13b may be controlled to display the message "Roadworks ahead. Temporary traffic lights. No queue at present".

[0069] In another mode of operation, the controller 14 is configured to estimate a threshold or optimum speed of a vehicle approaching the signal units in order to maintain a desired rate of flow of vehicles through the roadworks. The estimate may be based upon the speed of vehicles approaching the signal units measured by the detectors and may be synchronised with the timing of operation of the signal units. For example if the controller calculates that an approaching vehicle or vehicles will not pass through the traffic lights before they turn to red, it may control the electronic signs 13a, 13b to issue the message "Slow down. Traffic lights approaching" and/or display a hazard or warning sign. Alternatively, if the controller calculates that the vehicle or vehicles are approaching the traffic lights at a speed that means the signal unit 3a will display a green signal on arrival, it may provide no information or may provide the message "Please maintain your spead."

[0070] The controller 14 is able to operate each electronic sign to present tailored messages to each vehicle. For example, if the controller 14 detects that a vehicle is approaching one of the signs 13a, and Is within a threshold distance of the sign, it is able to control the sign to display a message tailored to that vehicle. For example, if that vehicle is travelling too fast compared to the estimated optimum speed to enable the vehicle to pass through the traffic lights (or, alternatively, to safely stop before the traffic lights) it displays a message to that vehicle to slow down. When that vehicle passes the sign, the message is turned off. If the next vehicle to approach the sign, within the threshold distance, is travelling at the correct speed then no message is displayed on the sign.

[0071] In a variant of the example of Figure 9, each electronic sign includes GPS or GSM circuitry and is configured to determine its position and to provide its position to the controller 14. The controller 14 can control the information displayed by each electronic sign in dependence on the position of the electronic sign.

[0072] As mentioned above, in certain examples, individual vehicles can be identified and tracked by the controller 14. One such example is illustrated in Figure 11. The example is a variant of the example of Figure 8. In this case, two detectors 52a, 52b are located at each approach to the roadworks. Associated with each detector is an automatic number plate recognition (ANPR) camera system 120a, 120b that is aligned with the carriageway 102 and is operable to process images of vehicle number plates of vehicles as they approach the ANPR camera system 120a, 120b, and to determine at least part of the registration number of each vehicle from the images using optical character recognition (OCR) techniques. Any suitable, commercially available ANPR camera can be used, for example.

[0073] A communications device is included in, or associated with, each ANPR camera system and is configured to stream time-stamped registration number data representative of detected registration numbers to the controller 14 as each successive vehicle passes the ANPR camera system 120a, 120b.

[0074] As well as being detected using the ANPR camera systems 120a, 120b, each vehicle is also detected by the detectors 52a, 52b and time-stamped detection data is also sent from each detector 52a, 52b to the controller 14. In the example of Figure 11, the detection data from the detectors 52a, 52b indicates the presence or absence of a vehicle at the detectors 52a, 52b at a particular time but does not identify the vehicle. However, the controller 14 is operable to correlate the detection data from the detectors 52a, 52b with the registration number data from the ANPR camera systems 120a, 120b to determine the precise time each identified vehicle was present at each detector 52a, 52b. As the location of each detector 52a, 52b is known accurately, the speed of individual vehicles can be determined from the detection data.

[0075] A further detector 52c and ANPR camera system 120c is located adjacent to the carriageway 103 at the exit to the roadworks, and can be used to detect and identify individual vehicles as they exit the roadworks. The controller 14 is configured to determine the time taken for individual vehicles to pass through the roadworks, based on the detection date from the detectors 52a, 52b, 52c correlated with individual vehicles.

[0076] In other known applications, registration number data obtained using ANPR camera systems is usually correlated with other data obtained from vehicle databases, for example owner or vehicle information. It is a feature of the example of Figure 11 that such further owner or vehicle data does not need to be obtained. Instead the registration number data is merely used to track vehicles through the traffic light system. Usually the registration number data is deleted by the controller 14 after a vehicle has left the traffic lights (although such registration number data can be retained if required) as there is no need to maintain a record of the identity of the vehicles that have passed through the traffic light system. It is a feature of the example of Figure 11 that it is not necessary for the ANPR camera systems to recognise the whole of each registration number, it is usually sufficient for only part of each registration number to be recognised in order to distinguish between successive vehicles passing through the traffic light system.

[0077] In other related examples, other systems for identifying individual vehicles can be used instead of ANPR camera systems. For example, known imaging systems that comprise a camera or cameras and a processor running image recognition or other image processing software can be used to determine the area of passing vehicles and/or to recognise the shape of passing vehicles, and to identify individual vehicles and/or to determine vehicle type from the determined vehicle area or recognised vehicle shape. In another example, on- or below-ground pressure or force sensors are used to distinguish individual vehicles and/or to determine vehicle type, based on the pressure or force exerted on the sensors by passing vehicles.

[0078] The speed and time data determined using the ANPR camera systems (or other system for distinguishing or identifying individual vehicles or vehicle types) and detectors can be used by the controller 14 for a variety of purposes, including determining the messages to be displayed to drivers on electronic signs 13a, 13b. Electronic signs 13a, 13b are included in the example of Figure 11 but are not shown for reasons of clarity. Detectors and ANPR cameras are also installed on the other carriageway 104 for detecting vehicles passing through the roadworks in the opposite direction, but are also not shown in Figure 11 for clarity.

[0079] Data from the detectors and/or from the ANPR camera systems can be used to determine the category of each vehicle that passes by the detectors. Vehicle categories can include, for example, car, bus , lorry, bicycle, motorcycle, and van or minibus. Vehicle categories can also include petrol, diesel, electric or hybrid engine types.

[0080] In one related example, in which the detectors include environmental detectors for measuring exhaust gases, the vehicle type is determined from the level and type of exhaust gases. In such examples the controller 14 can be configured to distinguish between highly polluting vehicles (for example large lorries or buses) and other vehicles. The controller 14 can be configured to alter signal timings, for example, extending a green time, in response to detecting the approach of a highly polluting vehicle to ensure that the vehicle is not stopped by the traffic lights, or to ensure the waiting time for such a vehicle at the traffic lights is minimised.

[0081] In examples in which the controller is operable to distinguish detector data relating to individual vehicles, for example in an example including ANPR camera systems, the controller can be configured to distinguish vehicle type from speed or acceleration characteristics on approach to the traffic lights. On average the speed and acceleration characteristics of vehicles differs in dependence on the type of vehicle, for example the speed and acceleration characteristics of cars are, on average, different to the speed and acceleration characteristics of buses or lorries. If vehicle type is to be distinguished from speed or acceleration characteristics on approach to the traffic lights, a relatively large number of spaced-apart detectors is usually used, for example 5 or more detectors, and at least some of the detectors are usually at greater than a threshold distance (for example, 50m) from the traffic lights if the vehicle type data is to be used in real time control. The controller determines the time at which each identified vehicle passes the detectors, calculates speed and/or acceleration data and uses for example a look-up table, pattern matching or correlation techniques to determine which vehicle type most closely matches the speed and/or acceleration data.

[0082] The determined vehicle type data can be stored and used in subsequent analysis of the different types of vehicle passing through the traffic lights. That analysis can be used to determine appropriate signal timing algorithms or can be used more generally in traffic flow analysis.

[0083] In the examples of Figures 9 to 11, information is provided to drivers via electronic signs. In alternative examples the same or similar information is provided to drivers via their mobile phones. One such example is illustrated in Figure 12.

[0084] The system of Figure 12 is similar to that of Figure 9, but includes a Bluetooth transmitter 130 or other wireless transmitter that is associated with and controlled by the controller. The controller includes a broadcast/multicast module 132 for broadcasting or multicasting data via the Bluetooth transmitter or other wireless transmitter. The transmission range 134 of the Bluetooth transmitter is indicated by the dashed line in Figure 12, and usually has a radius of up to 100m.

[0085] In one mode of operation, the broadcast/multicast module 132 periodically sends interrogation messages via the Bluetooth transmitter 130 to identify all mobile phones within the transmission radius. The broad cast/multicest module 132 transmits to each of the identified mobile phones a text message, e-mail or image data that contains information concerning, for example, the length of the traffic queue on the approach to the traffic lights, the likely queuing time and/or in the case of temporary traffic lights the length of time that is likely to be needed to pass through any roadworks or other disruption that may be associated with the traffic lights. The broadcast/multicast module 132 may be configured to transmit such text messages, e-mails or image data when there is a queue of greater than a threshold length at the traffic lights, for example as determined by the detectors.

[0086] Many other devices in addition to mobile phones are now Bluetooth-enabled, such as laptop computers and satellite navigation devices, and the broadcast/multicast module 132 can be configured to transmit to all identified devices of all suitable types the text message, e-mail or image data, for display to a user.

[0087] The controller may also be configured to display on the electronic displays 13 (if present) that a text message, e-mail or image data has been sent to mobile phones or other Bluetooth-enabled devices and advising users to check their mobile phones or other devices. Usually the controller would include in the message an instruction that only passengers, rather than drivers, should check their mobile phones or other devices due to safety considerations.

[0088] Although the use of Bluetooth has been described in relation to sending information to a user, any other suitable wireless protocol may also be used. The example of Figure 12 includes only a single Bluetooth or other wireless transmitter 130, but in alternative examples several Bluetooth or other wireless transmitters 130 are provided, at and on the approach to the traffic lights in order to extend the range and/or power of the transmissions.

[0089] In variants of the example of Figure 12, a short-range radio transmitter is provided in place of the Bluetooth transmitter 130. In such variants the broadcast/multicast module 132 is configured to generate automatically speech content to be broadcast via the short range radio transmitter. The speech content can be generated using any known speech generation software, which is included in the broadcast/multicast module. The speech content comprises a message including a first standard part, for example "Traffic queue, current average wait time" and a further, variable part, for example "10 minutes" generated by the controller from the average wait time determined from detector data. In such variants, the controller is configured to control the electronic displays to display a message indicating that information concerning the traffic lights and/or roadworks, is broadcast via radio and indicating the frequency to which the radio should be tuned to obtain the broadcast information. An unattributed, free-to-use frequency is usually used.

[0090] The examples described above in relation to Figure 12 rely on local broadcasting or multicasting of traffic, delay or other information concerning the traffic lights, roadworks or other cause of delay. In other examples, the controller 14 is in communication with a remote traffic light monitoring centre 140, as illustrated in Figure 13. The remote control centre comprises a server comprising a control processor 142, storage 144 for storing traffic and other data, and wireless/wired communication circuitry 146 for communicating with the controller 14 and other devices.

[0091] In operation, the controller 14 transmits to the traffic light monitoring centre 140 data concerning traffic conditions in the vicinity of the traffic lights, for example traffic queue lengths, vehicle speeds and/or wait times that it has determined from detector data or other measurement data. Alternatively or additionally the controller 14 can transmit unprocessed or partially processed detector data or other measurement data to the traffic light monitoring centre 140 and the control processor 142 processes the data to determine queue lengths; vehicle speeds, wait times or other parameters.

[0092] The traffic light monitoring centre 140 in the example of Figure 13 is in communication with a satellite navigation service provider 148, and provides the determined queue length, vehicle speed and/or wait time or other data to the satellite navigation service provider 148.

Some satellite navigation service providers now provide data updates representative of current traffic conditions to subscribers or other users, which enable the users portable navigation devices to take into account current traffic conditions in determining routes or travel times. In the example of Figure 13, the satellite navigation service provider 148 is able to include in its data updates to users live or average queue length, vehicle speed and/or wait time data for the traffic lights provided by the traffic light monitoring centre 140, and which may be based on detector data obtained from the detectors at the traffic lights. The traffic light monitoring centre 140 is also able to provide the satellite navigation service provider with location data representative of the precise location of temporary traffic lights and/or roadworks or other causes of delay. That location data is particularly straightforward to provide in examples in which the detectors or other components of the traffic light system include GPS devices or other location-determining devices.

[0093] In the example of Figure 13, the traffic light monitoring centre 140 is also configured to provide data to a Highways Agency traffic centre 150, a Local Authority traffic centre 152 and/or any other traffic management agency, or indeed any organisation that processes or analyses or otherwise uses traffic data, including broadcasters, satellite navigation service providers or research or monitoring organisations. The traffic centres 150, 152 may provide central control of existing, permanent traffic lights for example using the SCOOT or other similar system. By providing traffic light data relating to operation of temporary traffic lights (for example representing traffic light location, queue times, wait times and/or traffic speeds) to the traffic centres, the traffic centres are able to alter operating parameters of existing permanent traffic lights if desired. In particular, the operating parameters (for example average green or red times, or cycle durations) of existing permanent traffic lights in the vicinity of the temporary traffic lights can be altered.

[0094] The example of Figure 13 is operable to integrate temporary traffic lights into an existing permanent traffic light system, by transmitting traffic data to a control centre for the permanent traffic light system, enabling the traffic control centre to alter the operation of the existing permanent traffic light system, as described in the preceding paragraph. However, that approach requires modification of operation of the permanent traffic light system, and also requires that the permanent traffic lights are under central control. In many cases, it is not desired to modify the operation of existing permanent traffic light system, and many existing permanent traffic lights are locally controlled and in any event are not integrated into a wider area traffic control system.

[0095] An embodiment is illustrated in Figure 14 in which a temporary traffic light system is integrated with a local permanent traffic light system 160. The temporary traffic light system is similar to that illustrated in Figure 5, and includes a traffic light system controller 14 that is operable to communicate with and control, either via wired or wireless communication, detectors 52, electronic signs 13, and traffic light signal units 3a-3d. Connections from the traffic light system controller 14 to those components are not shown in Figure 14, for clarity.

[0096] The permanent traffic light system 160 comprises a set of further traffic light signal units 162a-162d and a further system controller 164 for controlling operation of the further traffic light signal units 162a-162d.

[0097] The temporary traffic light system of Figure 14 further includes a set of light sensing devices 164a-164d for sensing the state of the further traffic light units. One of the light sensing devices 164a is illustrated in Figure 15 installed on the further traffic light signal unit 162a. The light sensing device 164a comprises three light sensors 166a-166c each clipped or otherwise attached to the further signal unit. Each of the light sensors 166a-166c is aligned with one of the red 168a, amber 168b and green 168c lights of the further signal unit 162a and is operable to detect whether that light is lit or not lit. The light sensing device also comprises a processing unit 170 that comprises a processor 172, wireless communication circuitry 174 and antenna 176, for processing the outputs from the sensors are transmitting state data representative of the state of each traffic light signal unit to the system controller 14. Although four light sensing devices 164a-164d are shown in Figure 14, it has been found that it can be sufficient to provide a single light sensing device 162a, on one of the signal units 166a.

[0098] The system controller 1A in the embodiment of Figure 14 is configured to synchronise operation of the temporary traffic light system with that of the permanent traffic light system based on the state data provided by the light sensing devices 164a-164d. The synchronisation can be provided in various ways. In the simplest synchronisation mode, the controller 14 sets the duration of a red-green cycle of the temporary traffic lights to be equal to the duration of a red-green cycle of the permanent traffic lights.

[0099] In one mode of operation, an estimate is determined of the time It would take on average for a vehicle to travel from the permanent traffic light system to the temporary traffic light system (for example from signal unit 162d to signal unit 3c). The estimated time can be estimated by an operator and provided to the controller 14. Alternatively a further detector 52 and/or ANPR camera system of the temporary system can be installed adjacent to the permanent traffic light system, and the time take for vehicles to travel between the permanent traffic light and the temporary traffic light system can be measured.

[0100] In one synchronisation mode, the controller 14 then synchronises the temporary traffic light system to the permanent traffic light system, for example to provide a green wave so that vehicle receiving a green signal from signal unit 162c also should expect to receive a green signal from traffic light unit 3c, based on the estimated or measured travel times between the traffic light systems.

[0101] In a further synchronisation mode, an operator can input to the controller 14 which leg or legs of the junction controlled by the permanent traffic light system have the highest priority (for instance which legs have the highest expected volume of traffic) and the controller 14 then synchronises the temporary traffic light system to the permanent traffic light system, so that vehicles arriving from the highest priority leg or legs of the junction can expect to receive a green signal from the temporary traffic light system, based on the estimated or measured travel times.

[0102] In another mode of operation of the embodiment of Figures 14 and 15, the controller 14 is configured to vary the timings of the temporary traffic light system relative to the timings of the permanent traffic light system determined from the state data, and to monitor the effect of the variation of timings on traffic conditions (for example vehicle throughput or vehicle queue length or time) determined from data from the detectors 52.

[0103] For example, the controller 14 may vary the time offset between the end of a green signal at one of the signal units (for example signal unit 162c) of the permanent system and the start of a green signal at one of the signal units (for example signal unit 3c) and monitor the impact of different time offsets on traffic conditions. The controller 14 can then select a time offset (or other signal timing parameter) to optimise traffic conditions.

[0104] The controller 14 can be configured to automatically update signal timings of the temporary traffic light system as the signal timings of the permanent traffic signal vary (for example as timings of the permanent traffic signal vary on a daily cycle or due to vehicle-actuation). The state data from the light sending devices can be provided to the controller 14 in real time or near real time, and the controller 14 can be configured to vary the signal timings of the temporary traffic light system in response to the state data in real time or near real time (for example, by ensuring that the temporary traffic lights move to the next stage of a signal cycle an offset time after the permanent traffic lights have moved to the next stage of a signal cycle).

[0105] The embodiment of Figures 14 and 15 is able to provide synchronisation of a temporary traffic light system with a permanent traffic light system without requiring any interference with the control system of the permanent traffic light system.

[0106] In the examples and embodiment described above, detection data from detectors 52 is used for a variety of purposes, including setting or varying signal timings, providing visual or audible messages to users, monitoring traffic conditions, and integrating different sets of traffic signals. The detectors in the examples of Figure 1 to 13 and the embodiment illustrated in Figures 14 and 15 have generally been located on the approach to, or exit from, a set of traffic light signal units. However, in variants of each of the examples or in variants of the embodiment, detectors are also located at intermediate positions between traffic lights signal units of a set of traffic light signal units. Thus, the presence or absence of vehicles or other traffic-related parameters can be detected within the or a control region that is controlled by the traffic light signal units.

[0107] It has been found that the provision of detectors within a control region can be particularly useful in relation to a temporary traffic light system or other temporary traffic system. Temporary traffic light systems are usually provided when there is some disruption to normal traffic conditions, for example roadworks. It is often the case that roadworks or other disruption extend for relatively large distances and thus temporary traffic light systems are often controlling traffic through a large control region. As the control region can be large, there can be significant variations in traffic flows within the control region, and traffic events (for example accidents or delays) can occur within the control region, each of which can significantly affect efficient operation of the temporary traffic control system or other traffic control measures. It has been found that the provision of detectors within a control region can also be useful in the context of permanent traffic light systems in some circumstances.

[0108] An example of a traffic control system that includes detectors within a control region between traffic light signal units is illustrated in Figure 16. The traffic control system is for controlling traffic around a roadwork area 180 on one carriageway 180 of a road. The traffic from each direction is allowed to travel alternately along the carriageway 184.

[0109] Temporary stop lines 186, 188 and associated traffic light signal units 3a, 3b are provided at each side of the roadwork area 180. The temporary stop lines 186, 188 define a control region within which traffic is controlled by the traffic control system using the traffic light signal units 3a, 3b. The control region of the example of Figure 16 is several hundred metres in length.

[0110] The traffic light signal units are in wired or wireless communication with a controller 14, which controls the signal timings of the traffic light signal units. Detectors (not shown) are provided on the approach to the temporary stop lines in each direction, and are arranged and operated in similar fashion to that described in relation to one or more other examples described herein. The controller 14 is able to control the signal timings in dependence on detection signals from the detectors. Electronic signs and/or ANPR camera systems can also be provided on the approach to and/or exit from the stop lines, if desired, and operated in a similar fashion to that described above.

[0111] In addition to detectors on the approach to the stop lines, detectors 52a, 52b, 52c are provided within the control region between the stop lines 186, 188 (and between the signal units 3a, 3b). The detectors 52a, 52b, 52c are in wired or wireless communication with the controller 14.

[0112] Electronic signs 13a, 13b, one facing in each direction of traffic flow, are also provided within the control region and are in wired or wireless communication with, and controlled by, the controller 14. ANPR camera systems can also be provided within the control region, if desired.

[0113] It is a feature of the example of Figure 16 that the controller 14 can be configured to control the signal timings, and/or to control information provided to users via the electronic signs 13a, 13b, in dependence on outputs from the detectors 52a, 52b, 52c within the control region.

[0114] In some modes of operation, the signal timings are set at the controller 14 (either set manually or set automatically by the controller 14, for example in dependence on outputs from detectors located on the approach to the control region) but may subsequently be varied in dependence on outputs from the detectors in the control region. In one example of such a mode of operation, the controller 14 monitors the passage of vehicles past each of the detectors 52a, 52b, 52c. If the controller 14 determines that one or more vehicles have been delayed within the control region it may be configured to extend the current green time beyond that determined by the original signal timings to enable the delayed vehicle or vehicles time to exit the control region, before switching the direction of traffic flow within the control region. Thus, it can be ensured that all vehicles have cleared the control region before switching traffic flow direction.

[0115] The feature described in the preceding paragraph can be particularly useful for temporary traffic light systems associated with roadworks, as driving conditions through roadworks can be relatively difficult, with increased variability of vehicle speeds and increased possibilities of delays (for example due to accident or hesitancy of drivers) of individual vehicles within the region. It has been found that the appropriate green or red times for each cycle may vary from cycle to cycle in dependence on driver behaviour.

[0116] As described above, in examples of the system a or the controller 14 is operable to determine vehicle types (for example, using detectors and/or ANPR camera systems). Vehicle type information can be particularly useful for traffic control systems such as that of Figure 16, which are controlling relatively long control regions with alternating traffic flow directions. In one variant of Figure 16, the controller 14 is operable to determine the types of vehicle approaching the control region, and to extend a green time if one or more slow-moving vehicle types are identified, to allow the vehicles of slow-moving type to clear the control region before moving to the next stage of the signal cycle and switching traffic flow direction.

[0117] Information can be provided to drivers or passengers of vehicles passing through the control region, for example using the electronic signs 13a, 13b. The information can be information relating to the roadworks or control region (for example, the length of the roadworks or control region, average and/or estimated time to get through the control region, maximum speed limit through the control region). The information provided can also be varied in dependence on outputs from the detectors within the control region (which may also be used in varying signal times as already described).

[0118] In one example the controller 14 monitors the speed of vehicles passing through the control region and displays a message to them via the electronic signs if they are determined by the controller to be travelling above or below a threshold maximum or minimum speed. The speed can be determined by monitoring output from the detectors. It is particularly straightforward to monitor speeds in the case of a single lane control region as there is no possibility of vehicles overtaking one another, and the order of outputs from successive detectors 52a, 52b, 52c can be correlated directly with individual vehicles. Individual vehicles can also be identified and their monitored using ANPR camera systems, if provided within the control region, using techniques as described herein.

[0119] In another example, the controller 14 determines the vehicle type of vehicles passing through the control region and controls the electronic signs to display messages that depend on or relate to vehicle type. For example, if there are two or more lanes for use in one direction by vehicles in the control region, the electronic signs can be controlled to instruct certain vehicle types (for example cars and motorcycles) to use one lane and other vehicle types (for example lorries) to use another lane. The controller can also actively monitor passing vehicles and provide further messages based on vehicle type. For example, if the controller identifies that a car is travelling in a lorry-only lane it can control one of the electronic signs to display the message "Change lanes. This is a lorry-only lane". In another example where a priority lane for buses, emergency vehicles and other authorises vehicles is provided, the controller can determine whether a vehicle using the lane is a non-authorised vehicle based on automatically determined vehicle type, and instruct it to change lanes using the electronic signs;

[0120] In another example, an additional proximity detector or detectors (not shown in Figure 16) is provided that is associated with plant, power lines or other sensitive equipment, and is operable to determine the proximity to the proximity detector of vehicles passing through the control region. The proximity detector or detectors is, for example, an ultrasonic detector similar to those described above and configured to determine the proximity of vehicles from time-of-flight measurements. The proximity detector or detectors are in wired or wireless communication with the controller 14. If the controller 14 determines from outputs from the proximity detector or detectors that a vehicle is within a threshold minimum distance to the proximity detector it controls one of the electronic displays 13a, 13b to display an appropriate message instructing a driver to move their vehicle (for example "move left, too close to edge of lane"). In such an example each electronic display 13a, 13b and each proximity is usually a suitable distance before the plant, power lines or other sensitive equipment in one of the directions of travel, to ensure that drivers can be instructed to move before they reach the plant, power lines or other sensitive equipment.

[0121] As well as the possible presence of low bridges, stationary plant, power lines or other sensitive equipment within or near the control region, traffic flow through the control region can be affected by the movement of plant within the control region. For example, in Figure 16 a temporary entrance 190 to the control region is provided to allow access to plant (for example, lorries or other vehicles, diggers or road-laying equipment) to or from, or within, the roadworks. It can be seen in Figure 16 that a further vehicle detector 52d is provided at the temporary entrance 190. The further vehicle detector 52d is in wired or wireless communication with the controller 14, and is operable to detect the presence of plant that requires access to the control region. If the controller 14 determines from output from the further vehicle detector 52d that plant is present on the temporary entrance 190 it temporarily switches both signal units 3a, 3d to red, after completion of the current green phase, to allow access of the plant to the control region. A further signal unit (not shown) may be provided at the temporary entrance and the controller 14 can be configured to temporarily switch the further signal unit from red to green to indicate to the plant that access is allowed.

[0122] The further vehicle detector 52d can be replaced by a push-button or remotely operated or other user input device, in communication with the controller 14. The user input device can be operated by an operator (for example the driver of the plant or a colleague) to indicate that the plant requires access to the control region.

[0123] The further vehicle detector 52d and the further signal unit (if provided) are usually portable, as the parked or working location of the plant, and any temporary entrance 190, may well change position over time as the roadworks progress.

[0124] In a variant of the example of Figure 16 further traffic light signal units 3c, 3d (not shown in Figure 16) are provided at an intermediate position within the control region for controlling vehicles travelling along the control region. When switched on the intermediate traffic light signal unit 3c can be operated (under control of the controller 14) to stop vehicles within the control region. In one mode of operation, such an intermediate traffic light signal unit 3c is provided adjacent to the temporary entrance 190 and is operated only when plant wishes to gain access to the control region. By using such an intermediate signal unit 3c, delays associated with plant accessing the control region can be reduced as it is not necessary to clear the control region of vehicles to allow the plant access. That can be particularly important when the control region is long.

[0125] In one example, illustrated in Figure 17, the control region is not delimited by stop lines and traffic light signal units. Instead there is free flow of traffic in both directions and the control region is any portion of the road which is controlled or monitored, which may be adjacent or near the roadworks 180 as shown in Figure 17, and may be a region in which a traffic restriction is in place (for example, cones and/or reduced lane size or number). As described above the intermediate traffic light control units 3c, 3d can be operated by the controller 14 to display a red signal to stop traffic on both carriageways to allow plant access to the control region upon input via the user input device or upon detection of the plant by the further detector 52d.

[0126] In the example of Figure 17, the controller 14 also monitors traffic flows using the detectors 52a-52c and/or displays or otherwise provides information to vehicle occupants in one or more of the ways already described, for example via the electronic signs 13a, 13b. In a variant of the example of Figure 17, no further detector 52d or intermediate traffic light control units 3c, 3d are provided and the controller 14 operates to monitor traffic data from the detectors 52a-52c and to provide information to occupants of vehicles in dependence upon outputs from the detectors 52a-52c, for example via the electronic signs 13a, 13b.

[0127] In variants of the examples and embodiment described herein, the detectors 52 and the system controller 14 are used with or without the signal units 3 and signs 13 for data collection and logging. Data may be stored in the system controller 14 and downloaded on disc, tape or chip or may be transmitted directly to a remote point. The remote point may comprise for example a remote traffic light monitoring centre, a satellite navigation service provider, a Highways Agency traffic centre 150, a Local Authority traffic centre 152 and/or any other traffic management agency as described in relation to Figure 13.

[0128] In one mode of operation, the detectors and the controller are used for automatic gathering of traffic flow data in advance of installation of temporary traffic lights, in order to set parameters (for example, signal timing parameters) for the temporary traffic lights.

[0129] In another mode of operation, the detectors and the controller are used for automatic gathering of traffic flow data at the site of an existing, permanent traffic light system in advance of installation of a temporary traffic light system at the same site. The temporary traffic light system can be controlled to use one or more different signal unit control algorithms or timings than the permanent traffic light system (which are switched off during operation of the temporary traffic light system). A comparison of the effect of the algorithms and/or timings used by the permanent and temporary traffic light systems can be performed based on the gathered traffic flow data.

[0130] Particular detectors, controllers, traffic control devices (for example traffic light signal units) and apparatus for providing information to users (for example, electronic signs or wireless communication devices) have been described in relation to the embodiment of Figures 14 and 15. However, embodiments are not limited to those particular detectors, controllers, traffic control devices and apparatus for providing information to users that have been described, and any suitable detectors, controllers, traffic control devices and apparatus for providing information to users are provided in alternative embodiments.

[0131] The systems may be installed on any desired section of road or roads, and are not limited, for example, to use on road junctions. The systems may be used to provide control or monitoring of any type of road layout or parts of such road layouts, including feeder lanes, bus or other priority lanes, and left- or right- turn lanes.

[0132] It will be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention, which is defined by the appended claims.

Claims

1. A traffic control system comprising:-
at least one traffic light signal unit (3);
a controller (14) for controlling the timing of operation of the at least one traffic light signal unit (3); and
means for monitoring the state of at least one further traffic control system comprising at least one further traffic light signal unit (162a), wherein:-
the controller (14) is configured to control the timing of operation of the at least one traffic light signal unit (3) in dependence on the determined state of the at least one further traffic control system, thereby to synchronise the timing of operation of the traffic light signal units of the traffic control system and the further traffic control system;
the traffic control system comprises a temporary traffic control system and the further traffic control system comprises a permanent traffic control system (160).
the monitoring means comprises an optical sensing apparatus (164a) for sensing light output from the at least one further traffic light signal unit (162a); and
the controller (14) is configured to control the at least one traffic light signal unit (3) to move to a next stage of a signal cycle an offset time after the at least one further traffic light unit of the at least one further traffic control system moves to a next stage of a signal cycle.

2. A system according to Claim 1, wherein the determined state of the at least one other traffic control system comprises a state of at least one light of the at least one further traffic light signal unit (162a).

3. A system according to Claim 1, wherein the controller (14) is configured to synchronise the timing based on estimated or measured travel times so as to provide a green wave between the traffic control system and the further traffic control system.

4. A system according to any preceding claim, further comprising attachment means for attaching the optical sensing apparatus (164a) to the further traffic control system, for example at least one detachable clip or clamp.

5. A system according to any preceding claim, wherein the traffic control system is arranged to control flow of traffic for a first control region, for example a first junction, and the further traffic control system is arranged to control flow of traffic for a second, different control region, for example a second, different junction.

6. A method of controlling operation of a traffic control system that comprises at least one traffic light signal unit (3), the method comprising:-
monitoring the state of at least one further traffic control system that comprises at least one further traffic light signal unit (162a); and
controlling the timing of operation of the at least one traffic light signal unit (3) of the traffic control system in dependence on the determined state of the at least one further traffic control system, thereby to sychronise the timing of operation of the traffic light signal units of the traffic control system and the further traffic control system,
wherein the traffic control system comprises a temporary traffic control system and the further traffic control system comprises a permanent traffic control system;
the monitoring comprises sensing light output from the at least one further traffic light signal unit (162a); and
the method further comprises controlling the at least one traffic light signal unit (3) to move to a next stage of a signal cycle an offset time after the at least one further traffic light unit of the at least one further traffic control system moves to a next stage of a signal cycle.

7. A method according to Claim 6, comprising varying a time offset between the end of a signal of a traffic light signal unit (3) included in the at least one further traffic control system and the start of a signal at one of the traffic light signal units (3) of the traffic control system, monitoring the impact of different time offsets on traffic conditions, and selecting a time offset to optimise traffic conditions.

Patentansprüche

1. Verkehrssteuerungssystem, umfassend:

mindestens eine Verkehrslichtsignaleinheit (3);
eine Steuerung (14) zum Steuern des Betriebstakts der mindestens einen Verkehrslichtsignaleinheit (3); und

Mittel zum Überwachen des Zustands mindestens eines weiteren Verkehrssteuerungssystems, das mindestens eine weitere Verkehrslichtsignaleinheit (162a) umfasst, wobei:

die Steuerung (14) so konfiguriert ist, dass sie den Betriebstakt der mindestens einen Verkehrslichtsignaleinheit (3) in Abhängigkeit vom bestimmten Zustand des mindestens einen weiteren Verkehrssteuerungssystems steuert, um dadurch den Betriebstakt der Verkehrslichtsignaleinheiten des Verkehrssteuerungssystems und des weiteren Verkehrssteuerungssystems zu synchronisieren;
das Verkehrssteuerungssystem ein temporäres Verkehrssteuerungssystem umfasst, und das weitere Verkehrssteuerungssystem ein permanentes Verkehrssteuerungssystem (160) umfasst;
das Überwachungsmittel eine optische Abtastvorrichtung (164a) zum Abtasten der Lichtausgabe von der mindestens einen weiteren Verkehrslichtsignaleinheit (162a) umfasst; und
die Steuerung (14) so konfiguriert ist, dass sie die mindestens eine Verkehrslichtsignaleinheit (3) so steuert, dass sie eine Verschiebungszeit nach dem Übergang der mindestens einen weiteren Verkehrslichtsignaleinheit des mindestens einen weiteren Verkehrssteuerungssystems zu einer nächsten Stufe eines Signalzyklus zu einer nächsten Stufe eines Signalzyklus übergeht.

2. System nach Anspruch 1, wobei der bestimmte Zustand des mindestens einen weiteren Verkehrssteuerungssystems einen Zustand mindestens eines Lichts der mindestens einen weiteren Verkehrsichsignaleinheit (162a) umfasst.

3. System nach Anspruch 1, wobei die Steuerung (14) so konfiguriert ist, dass sie den Takt basierend auf geschätzten oder gemessenen Fahrzeiten synchronisiert, um eine grüne Welle zwischen dem Verkehrssteuerungssystem und dem weiteren Verkehrssteuerungssystem bereitzustellen.

4. System nach einem der vorhergehenden Ansprüche, ferner umfassend Befestigungsmittel zum Befestigen der optischen Abtastvorrichtung (164a) am weiteren Verkehrssteuerungssystem, zum Beispiel mindestens eine lösbare Schelle oder Klemme.

5. System nach einem der vorhergehenden Ansprüche, wobei das Verkehrssteuerungssystem so ausgelegt ist, dass es Verkehrsfluss für einen ersten Steuerbereich, zum Beispiel eine erste Straßenkreuzung, steuert, und das weitere Verkehrssteuerungssystem so ausgelegt ist, dass es Verkehrsfluss für einen zweiten, anderen Steuerbereich, zum Beispiel eine zweite, andere Straßenkreuzung, bereitstellt.

6. Verfahren zum Steuern des Betriebs eines Verkehrssteuerungssystem, das mindestens eine Verkehrslichtsignaleinheit (3) umfasst, wobei das Verfahren umfasst:

Überwachen des Zustands mindestens eines weiteren Verkehrssteuerungssystems, das mindestens eine weitere Verkehrslichtsignaleinheit (162a), und
Steuern des Betriebstakts der mindestens einen Verkehrslichtsignaleinheit (3) des Verkehrssteuerungssystems in Abhängigkeit vom bestimmten Zustand des mindestens einen weiteren Verkehrssteuerungssystems, um dadurch den Betriebstakt der Verkehrslichtsignaleinheiten des Verkehrssteuerungssystems und des weiteren Verkehrssteuerungssystems zu synchronisieren;
wobei das Verkehrssteuerungssystem ein temporäres Verkehrssteuerungssystem umfasst, und das weitere Verkehrssteuerungssystem ein permanentes Verkehrssteuerungssystem umfasst;
das Überwachen ein Abtasten der Lichtausgabe von der mindestens einen weiteren Verkehrslichtsignaleinheit (162a) umfasst; und
das Verfahren ferner ein derartiges Steuern der mindestens einen Verkehrslichtsignaleinheit (3) umfasst, dass sie eine Verschiebungszeit nach dem Übergang der mindestens einen weiteren Verkehrslichtsignaleinheit des mindestens einen weiteren Verkehrssteuerungssystems zu einer nächsten Stufe eines Signalzyklus zu einer nächsten Stufe eines Signalzyklus übergeht.

7. Verfahren nach Anspruch 6, umfassend ein Ändern einer Zeitverschiebung zwischen dem Ende eines Signals einer Verkehrslichtsignaleinheit (3), die im mindestens einen weiteren Verkehrssteuerungssystem enthalten ist, und dem Beginn eines Signals an einer der Verkehrslichtsignaleinheiten (3) des Verkehrssteuerungssystems, l'rberwachen der Auswirkung von verschiedenen Zeitverschiebungen auf Verkehrsbedingungen und Auswählen einer Zeitverschiebung zum Optimieren von Verkehrsbedingungen.

Revendications

1. Système de régulation de la circulation comprenant :

au moins une unité de signalisation routière lumineuse (3) ;
un organe de régulation (14) destiné à réguler le rythme d'intervention de l'au moins une unité de signalisation routière lumineuse (3) ; et
un moyen de surveillance de l'état d'au moins un système supplémentaire de régulation de la circulation, comprenant au moins une unité supplémentaire de signalisation routière lumineuse (162a), dans lequel :

l'organe de régulation (14) est configuré pour réguler le rythme d'intervention de l'au moins une unité de signalisation routière lumineuse (3) en fonction de l'état déterminé de l'au moins un système supplémentaire de régulation de la circulation, pour ainsi synchroniser le rythme d'intervention des unités de signalisation routière lumineuse du système de régulation de la circulation et du système supplémentaire de régulation de la circulation ;
le système de régulation de la circulation comprend un système temporaire de régulation de la circulation, et le système supplémentaire de régulation de la circulation comprend un système permanent de régulation de la circulation (160) ;
le moyen de surveillance comprend un dispositif de détection optique (164a) destiné à détecter la lumière émise par l'au moins une unité supplémentaire de signalisation routière lumineuse (162a) ; et
l'organe de régulation (14) est configuré pour réguler l'au moins une unité de signalisation routière lumineuse (3) de manière qu'elle passe au stade suivant d'un cycle de signalisation avec un certain décalage de temps après que l'au moins une unité supplémentaire de signalisation routière lumineuse de l'au moins un système supplémentaire de régulation de la circulation est passée au stade suivant d'un cycle de signalisation.

2. Système selon la revendication 1, dans lequel l'état déterminé de l'au moins un système supplémentaire de régulation de la circulation comprend un état relatif à au moins un feu de l'au moins une unité supplémentaire de signalisation routière lumineuse (162a).

3. Système selon la revendication 1, dans lequel l'organe de régulation (14) est configuré pour synchroniser le rythme, en se fondant sur des temps de déplacement estimés ou mesurés, de manière à produire une « vague verte » entre le système de régulation de la circulation et le système supplémentaire de régulation de la circulation.

4. Système selon l'une quelconque des revendications précédentes, comprenant en outre un moyen de fixation destiné à fixer le dispositif de détection optique (164a) sur le système supplémentaire de régulation de la circulation, par exemple au moins une agrafe ou pince amovible.

5. Système selon l'une quelconque des revendications précédentes, dans lequel le système de régulation de la circulation est agencé pour réguler le flux de circulation relativement à une première zone de contrôle, par exemple un premier carrefour, et le système supplémentaire de régulation de la circulation est agencé pour réguler le flux de circulation relativement à une seconde zone de contrôle distincte, par exemple un second carrefour distinct.

6. Procédé de régulation de l'intervention d'un système de régulation de la circulation qui comprend au moins une unité de signalisation routière lumineuse (3), le procédé comprenant :

la surveillance de l'état d'au moins un système supplémentaire de régulation de la circulation comprenant au moins une unité supplémentaire de signalisation routière lumineuse (162a) ; et
la régulation du rythme d'intervention de l'au moins une unité de signalisation routière lumineuse (3) du système de régulation de la circulation en fonction de l'état déterminé de l'au moins un système supplémentaire de régulation de la circulation, pour ainsi synchroniser le rythme d'intervention des unités de signalisation routière lumineuse du système de régulation de la circulation et du système supplémentaire de régulation de la circulation ;
dans lequel le système de régulation de la circulation comprend un système temporaire de régulation de la circulation, et le système supplémentaire de régulation de la circulation comprend un système permanent de régulation de la circulation ;
la surveillance comprend la détection de la lumière émise par l'au moins une unité supplémentaire de signalisation routière lumineuse (162a) ; et
le procédé comprend en outre la régulation de l'au moins une unité de signalisation routière lumineuse (3) de manière qu'elle passe au stade suivant d'un cycle de signalisation avec un certain décalage de temps après que l'au moins une unité supplémentaire de signalisation routière lumineuse de l'au moins un système supplémentaire de régulation de la circulation est passée au stade suivant d'un cycle de signalisation.

7. Procédé selon la revendication 6, comprenant la variation d'un décalage de temps entre la fin d'un signal d'une unité de signalisation routière lumineuse (3) faisant partie de l'au moins un système supplémentaire de régulation de la circulation et le début d'un signal présent sur l'une des unités de signalisation routière lumineuse (3) du système de régulation de la circulation, la surveillance de l'effet de différents décalages de temps sur les conditions de circulation, et la sélection d'un décalage de temps permettant d'optimiser les conditions de circulation.

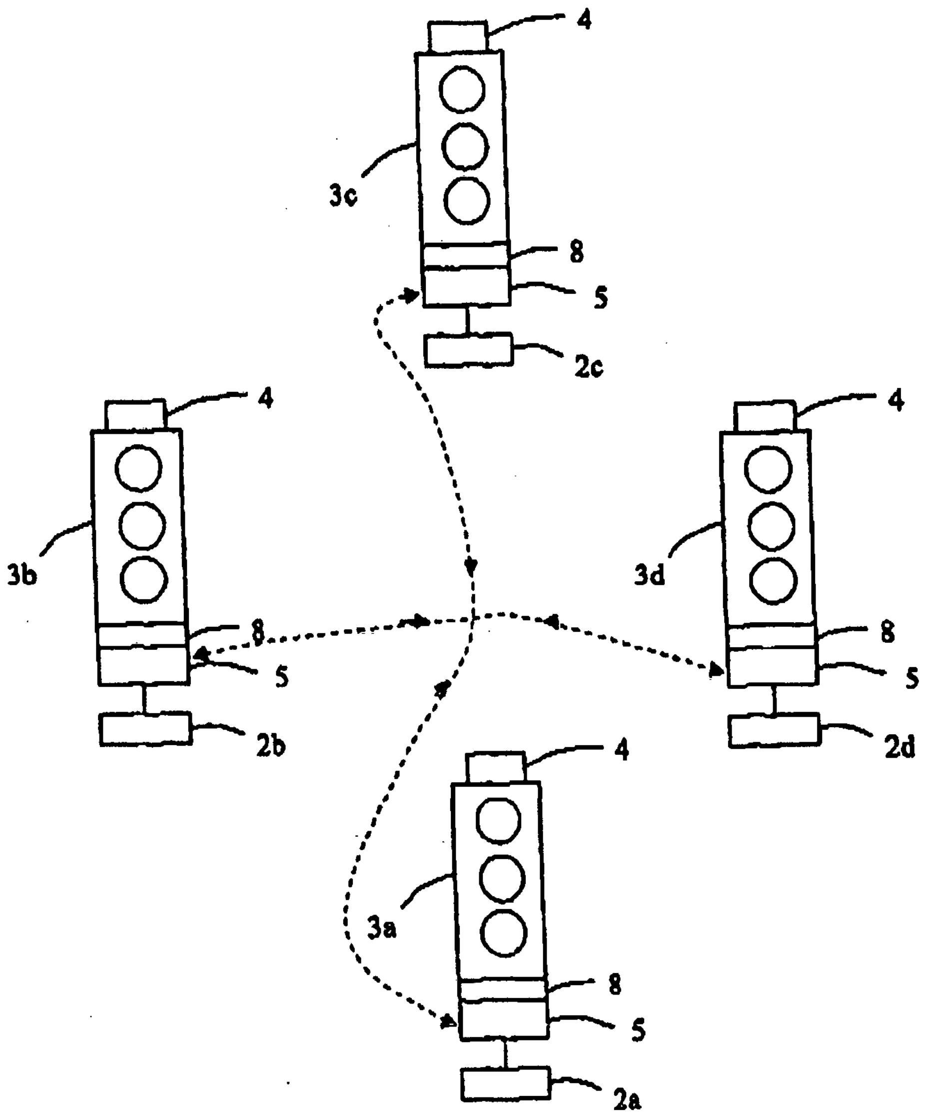
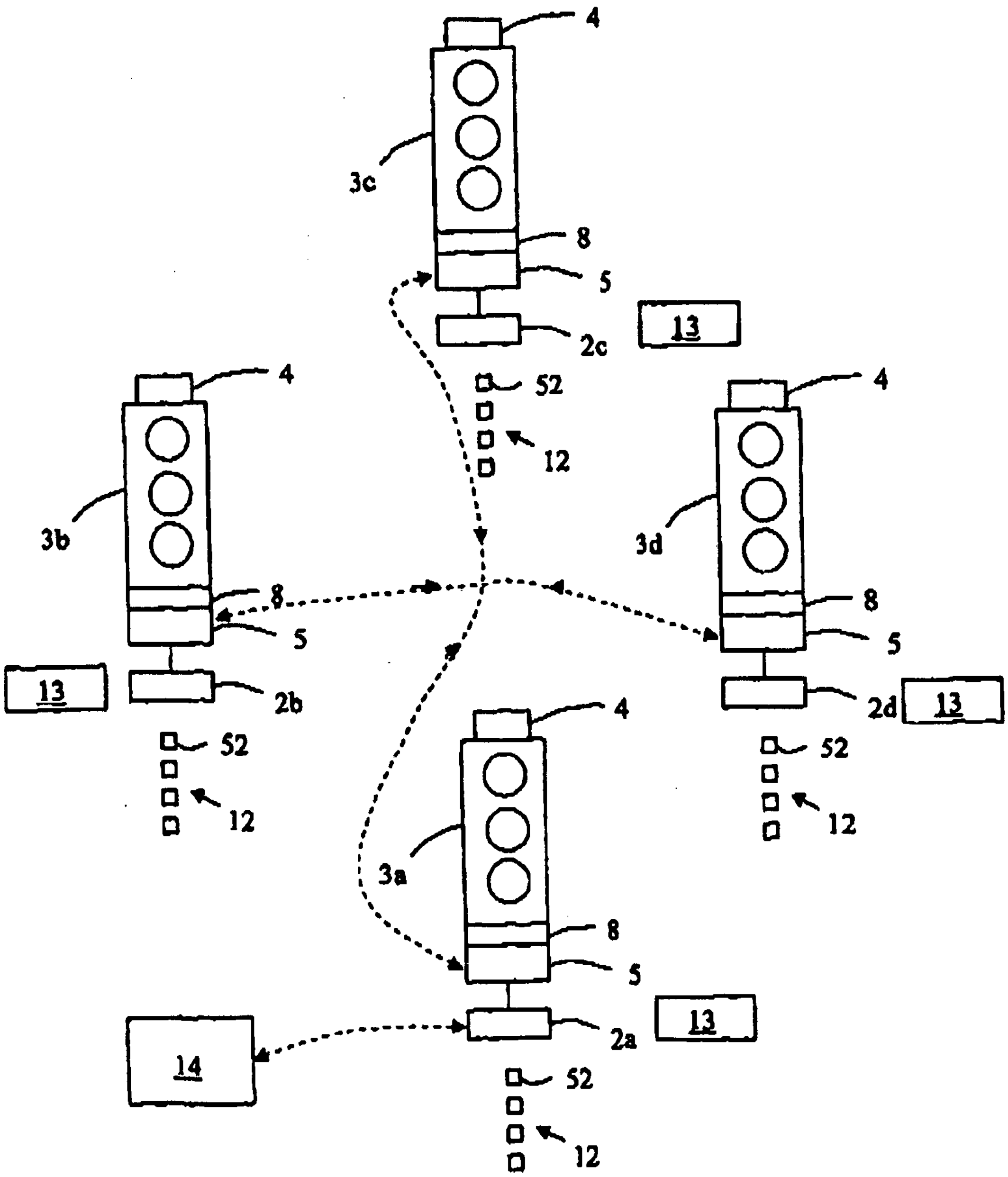


Fig.1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2c
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4
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2d
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14
2a
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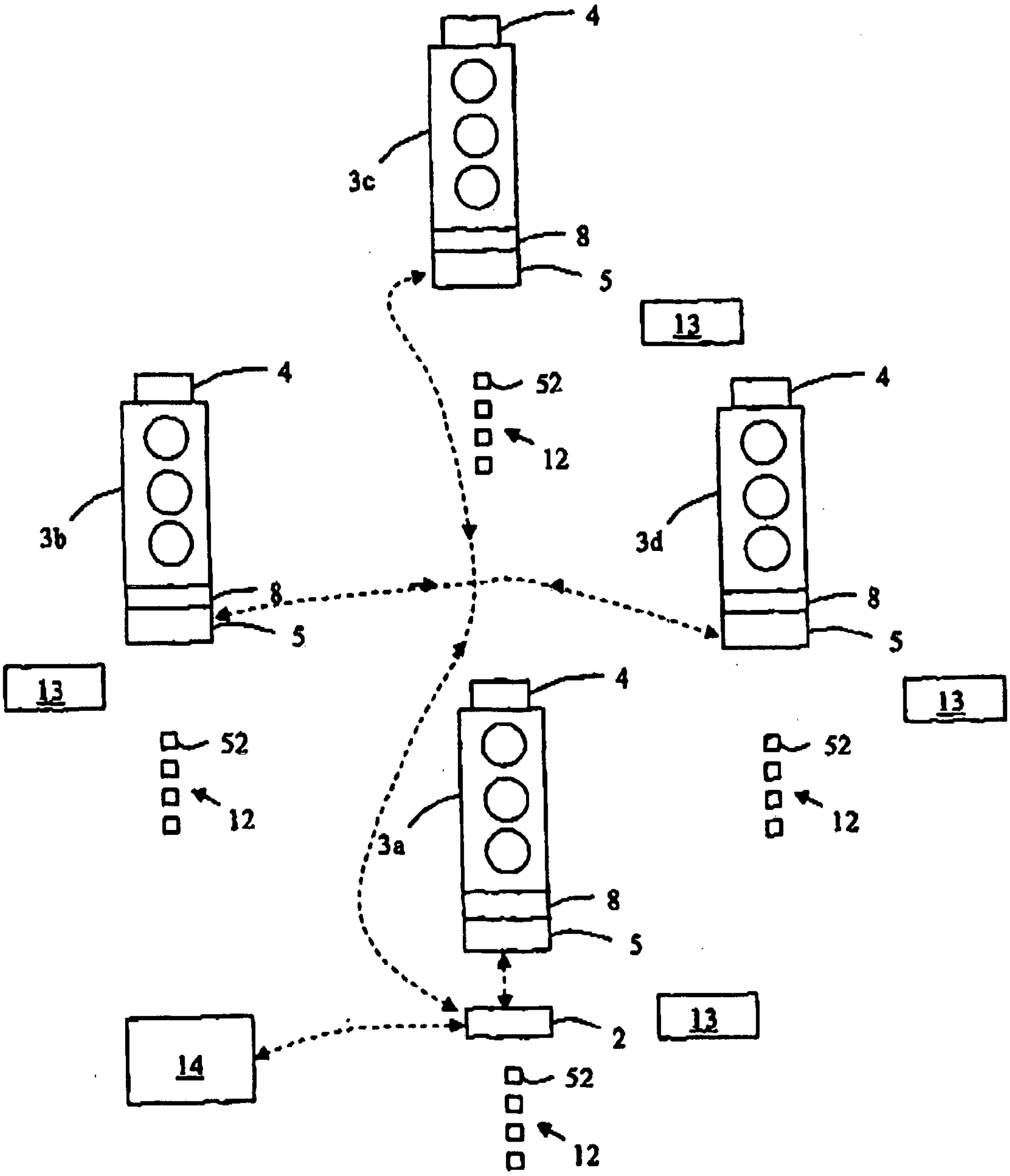
12

Fig.2



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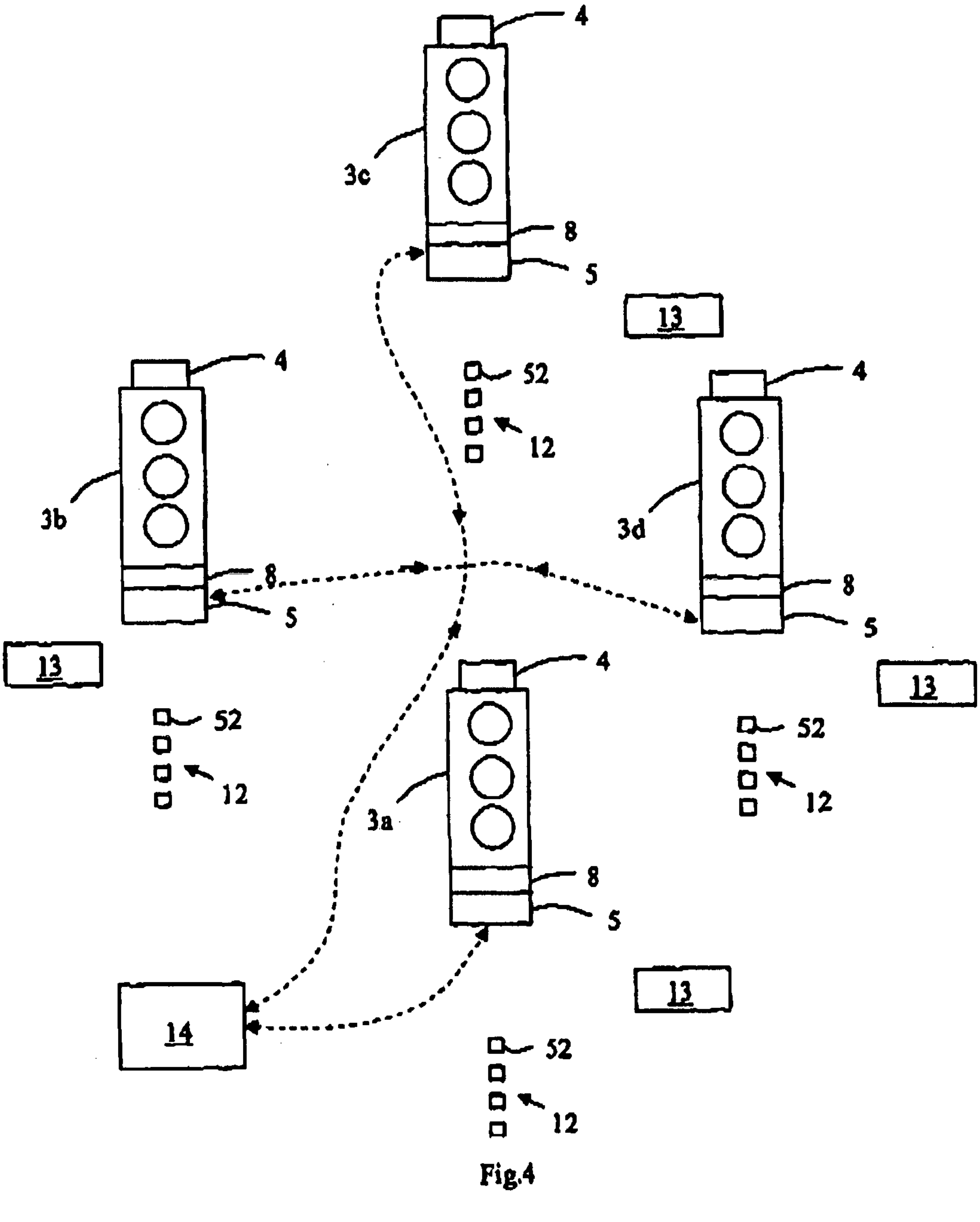


Fig.4

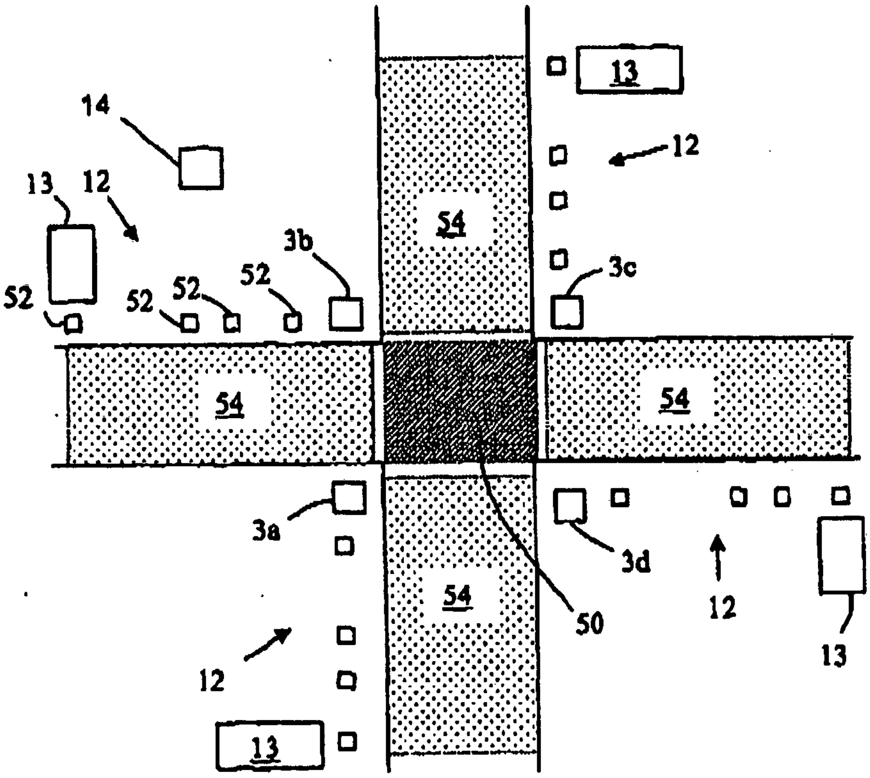


Fig.5

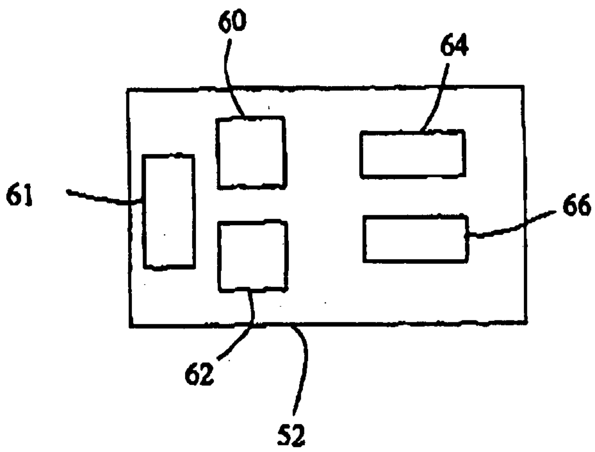


Fig.6

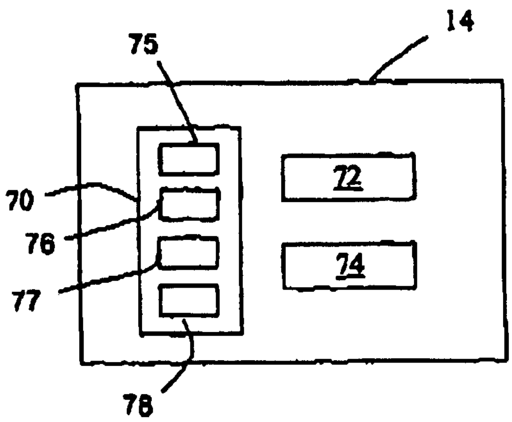


Fig.7

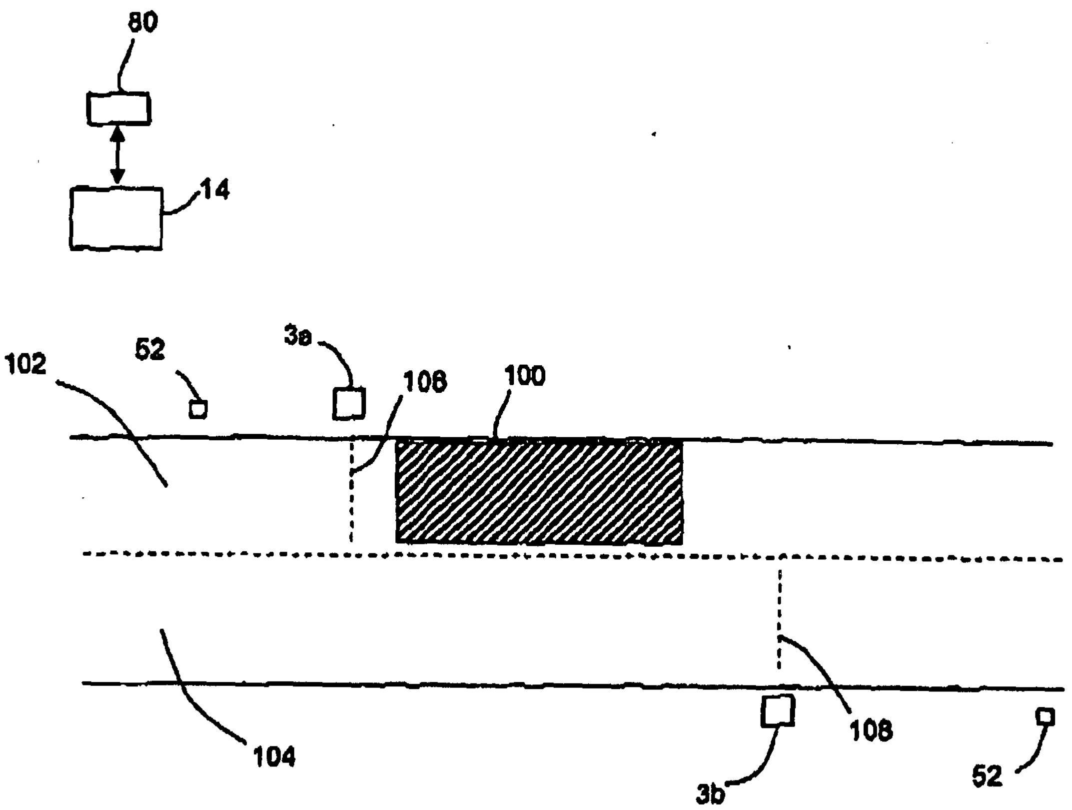
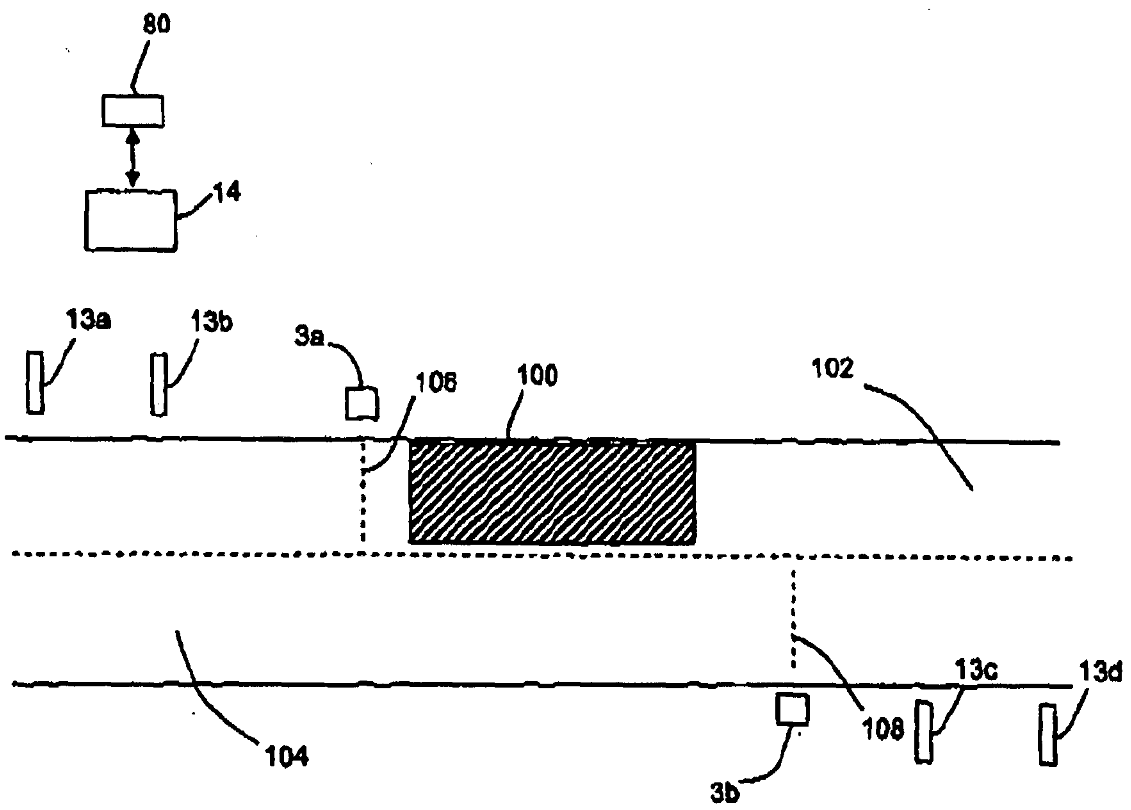


Fig.8



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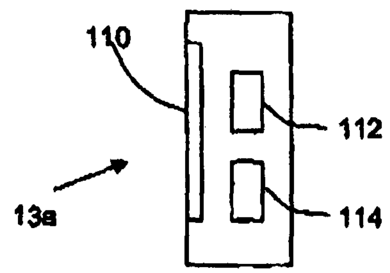

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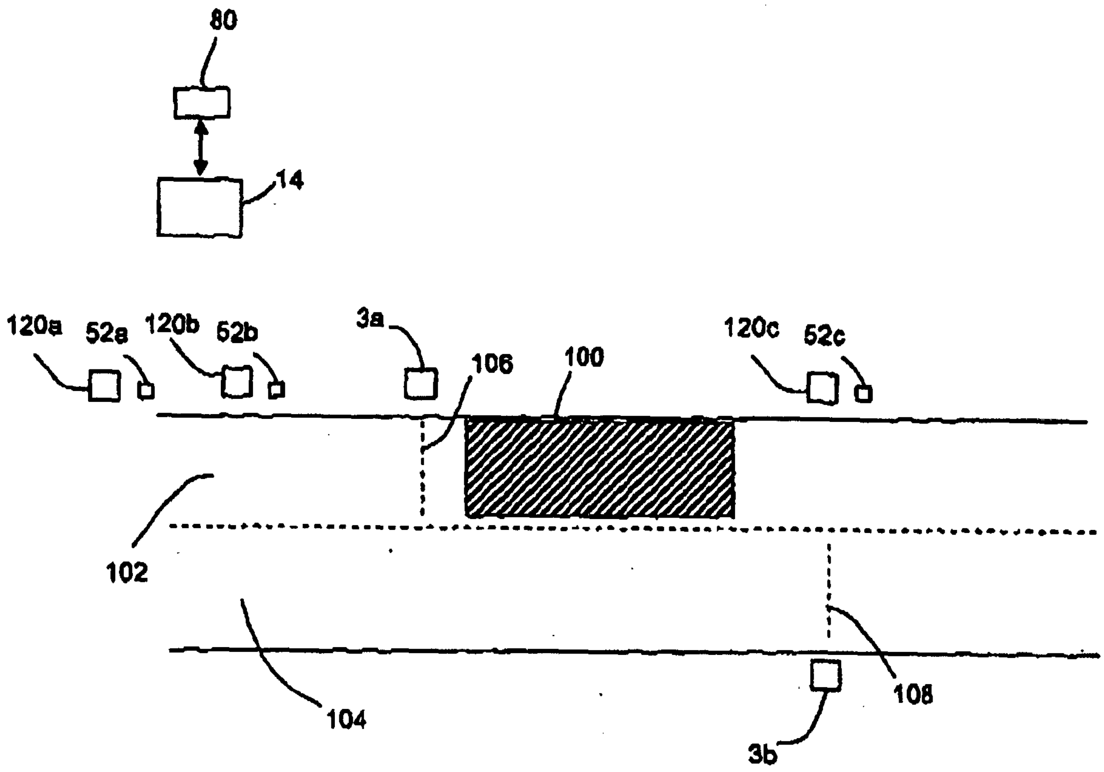

Fig.11

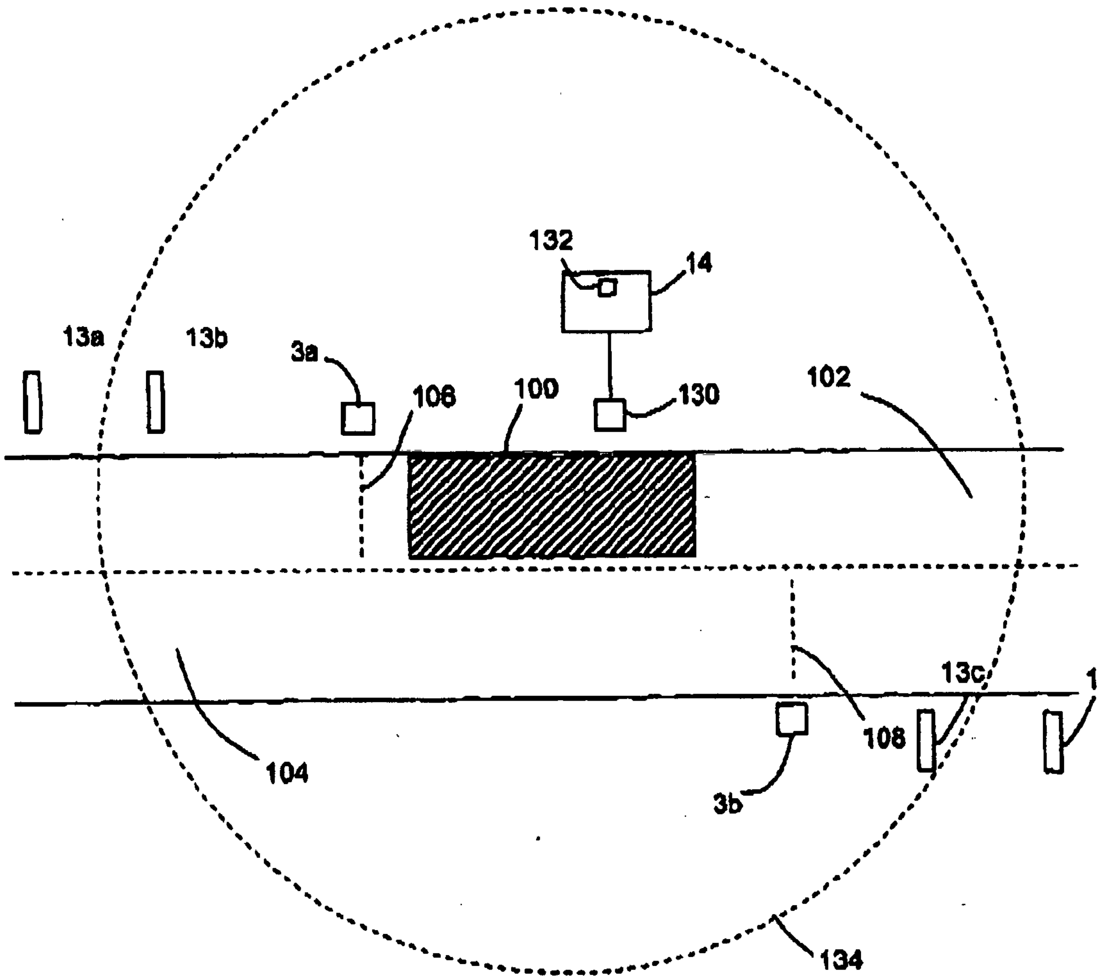

Fig.12

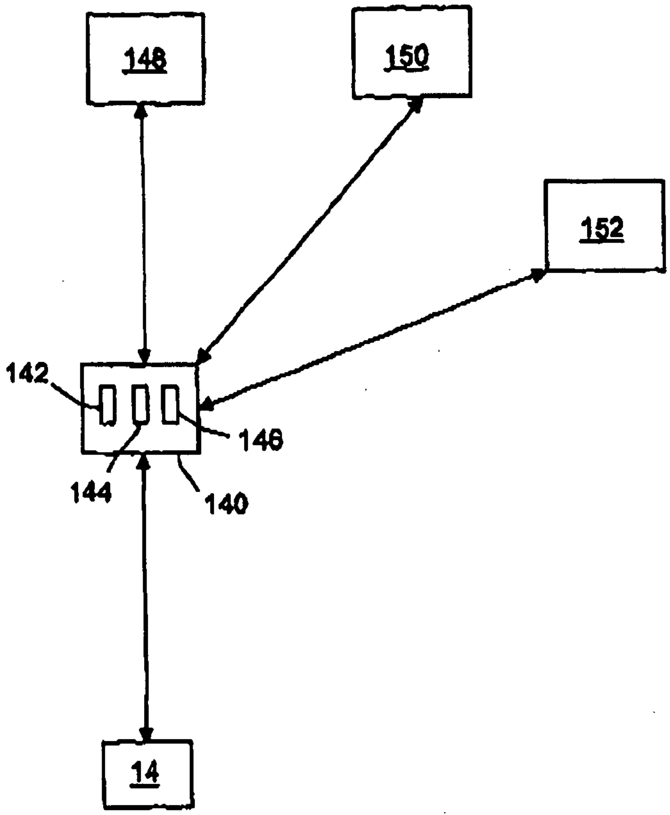

Fig.13

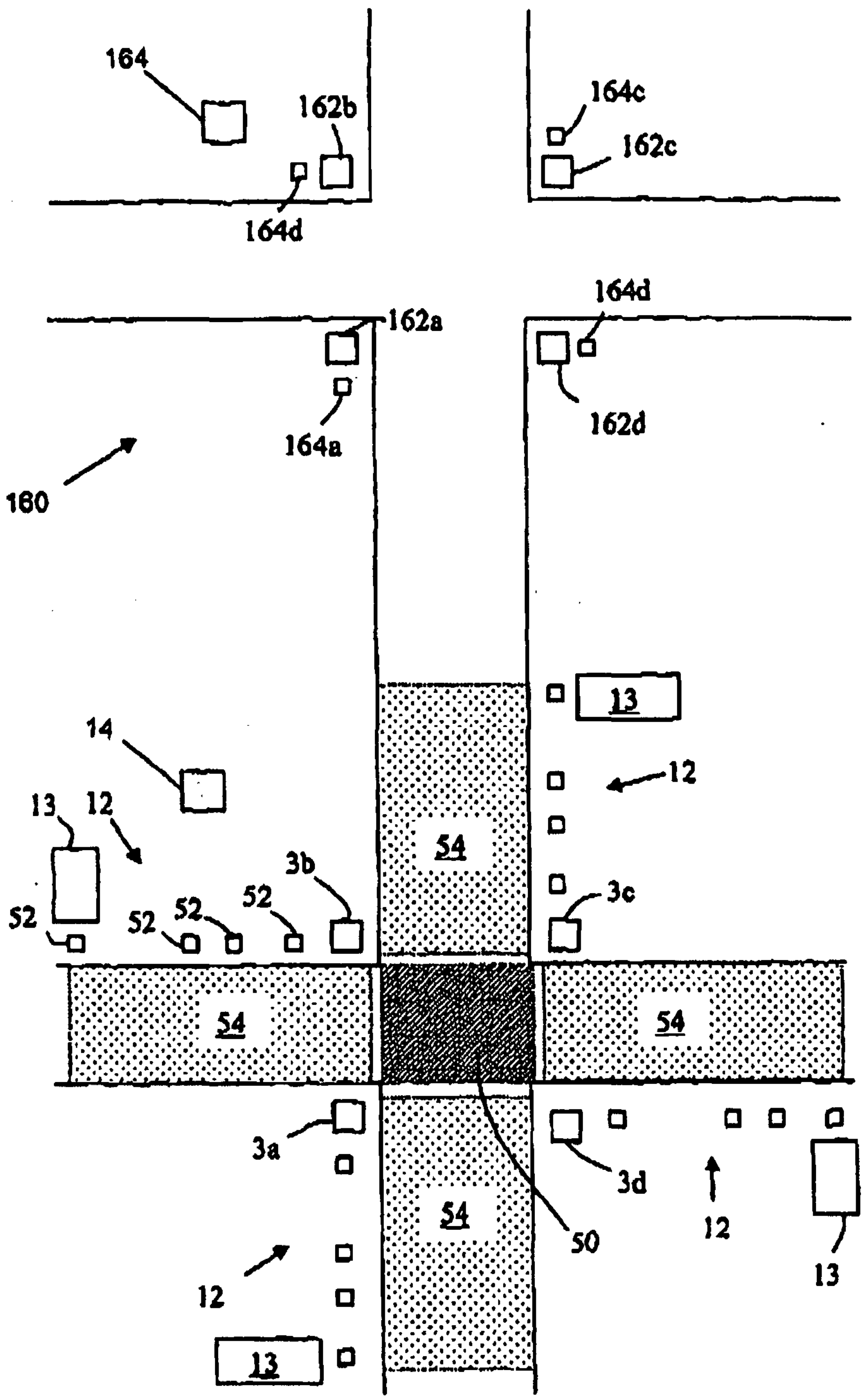
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Fig.14

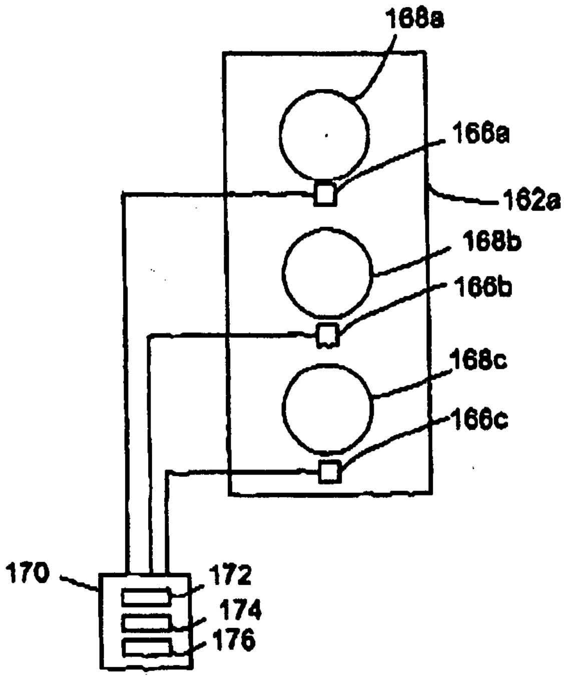

Fig.15

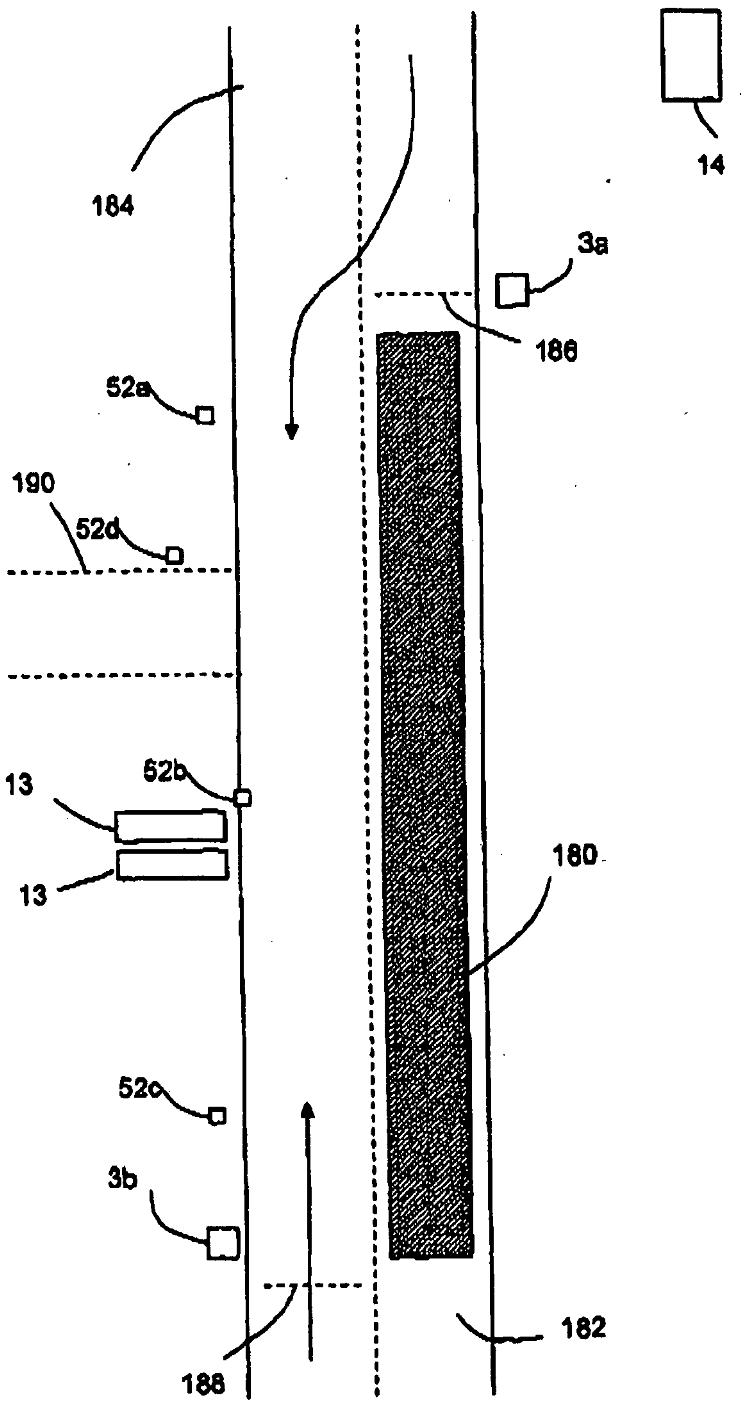

Fig.16

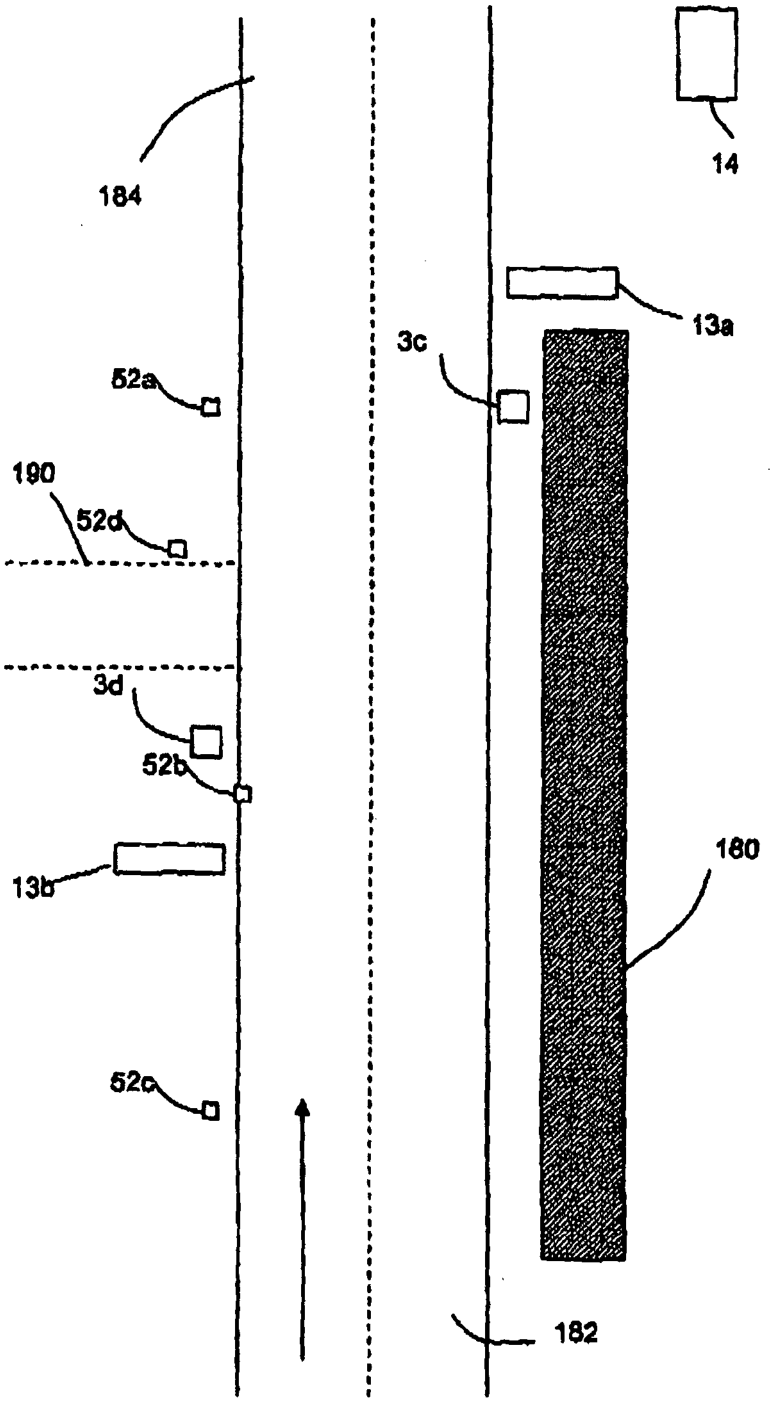

Fig.17

REFERENCES CITED IN THE DESCRIPTION

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- GB 2435708 A **[0015]**