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(54) **Title**: SYSTEM FOR AUTOMATIC WARNING AND/OR BRAKING IN A VEHICLE

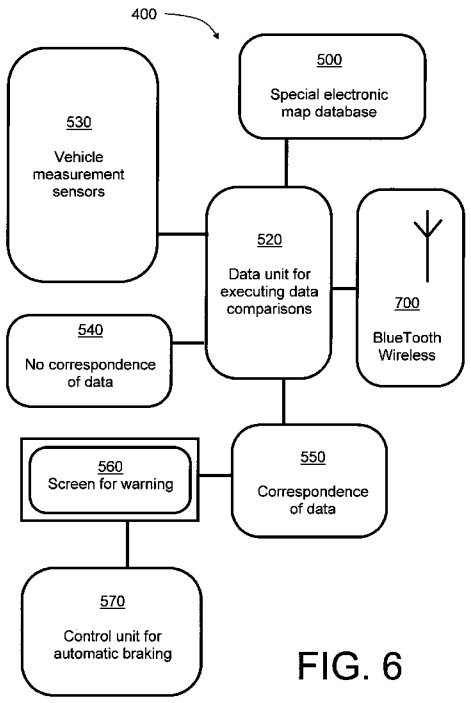

FIG. 6

(57) **Abstract**: A system (400) for controlling friction level and road grip between tyres (130) of a vehicle and a road surface (200) is distinguished in that it includes units for registering parameters which can influence road grip, together with means (560) for warning and/or implementing action when a lower threshold level is approached. More precisely, the system (400) utilizes means (530) for measuring and registering one or more values for parameters such as: - road surface characteristics in real time; - a manner in which the vehicle is driven by its driver, for example in respect of speed; and - the vehicle's position along the road (50). The system includes a data unit (520) equipped with a computation unit for comparing measured values with one or more values for: - properties of the road under optimal conditions determined under optimal conditions; and - technical characteristics of the vehicle. The means for warning and/or implementing action (560) when the aforementioned threshold values are exceeded are implemented such that the system (400) is operable to provide the driver with a warning regarding a status of the road and/or to execute a speed reduction in a controlled and automatic manner.

WO 2010/019045 A1

SYSTEM FOR AUTOMATIC WARNING AND/OR BRAKING IN A VEHICLE

Field of the invention

The present invention relates to systems for automatically warning and/or braking in vehicles, for example by monitoring friction levels and road grip between one or more tyres of a vehicle and a surface of a road bearing the tyres of the vehicle. Moreover, the invention also concerns method of implementing aforesaid automatic warning and/or braking in vehicles. Furthermore, the present invention also relates to software products stored on machine readable media, the software products being executable on computing hardware for implementing aforesaid methods.

Background of the invention

It is well known that traffic accidents occur as a result of vehicles experiencing reduced grip onto road surfaces such that drivers of the vehicles lose control and steering. Such loss of grip often results in vehicles gliding into incorrect traffic lanes and colliding with other vehicles travelling in opposite directions thereto, or that the vehicles veer off roads along which they have been travelling, in both cases with catastrophic consequences.

The most important factors which affect grip of a vehicle tyre (American English: "tire") onto a road surface are as follows:

(a) a coefficient of friction of the tyres;

(b) a coefficient of friction of the road surface;

(c) a weight of the vehicle.

In addition to these parameters (a) to (c) which affect road grip, a travelling speed of the vehicle, and centrifugal forces associated therewith, have a major significance for the aforementioned road grip. Moreover, a manner of driving by a driver of the vehicle is also a significant factor.

Roads have mutually different types of upper exposed road surfaces such as gravel, Earth, asphalt, concrete, cobbled stones and similar. These different types of upper surfaces at a given instance in time exhibit mutually different coefficients of friction in comparison to tyres on a vehicle, and therewith mutually different road grip in mutually different weather conditions. Temperature and dampness in air affect the road grip of the tyre, and this grip is further affected by water, snow, dust or oil and similar which are to be found along upper exposed surfaces of roads.

The general equation for friction (Coulombic friction) is given by Equation 1 (Eq. 1):

$$R = \mu N \qquad \text{Eq. 1}$$

wherein

R = a frictional force;

μ = a coefficient of friction;

N = a force normal to road surface.

The coefficient of friction μ, or the friction number as it is also known, is a number describing a state which is indicative of a relationship between the frictional force R and the normal force N. The friction number μ is dependent upon an area of contact between two bodies which are in frictional contact. The area of the contact region has no relevance to how large the friction is between the two bodies. When sticking surfaces are being considered, it is not appropriate to use Equation 1 (Eq. 1) which describes friction. For sticking surfaces, an area of contact surface plays a role and the normal forces can play a lesser role. In relation to vehicles, the friction number μ for rubber, for example as used for fabricating tyres, against a road surface is in a range of 0.4 to 1.0 for a dry road surface, is in a range of 0.05 to 0.9 for a wet road surface, and is 0.002 for ice on the road surface.

Tyre friction

For vehicles in daily traffic, there are not presently available practical instruments which are able to register an exact grip between tyres of the vehicles and associated road surfaces bearing the tyres of the vehicles. On runways of airports, there are presently employed specially constructed instruments with associated wheels which, under safe conditions, are subject to braking to a standstill (known as "variable slip" which gives a measurement for braking processes in the form of a braking curve). There are beneficially implemented several measurements during braking. A measurement wheel can also be forced to brake to a degree where slippage occurs relative to a bearing surface in contact with the wheel. It is also known to use camera equipment for registering an exposed surface of a road and its consistence (ice, snow, etc.) in order to evaluate associated friction numbers μ; earlier literature refers to heat cameras (infrared sensitive) and laser-camera technology. We refer, for example, to a SINTEF report from December 2001: "Winter friction project – season 2000/2001", by Torgeir Vaa.

Summary of the invention

In relation to the present invention, such friction measuring technology can be used for direct measurements of exact frictional relationship between tyres and associated bearing road

surfaces under "ideal conditions", wherein associated data for "ideal conditions" can be recorded into a database as standard values S1. Moreover, the camera-provided measurements under these "ideal conditions" are also logged into the database. Later camera-provided measurement data S2, which are derived from normal driving trips, are compared with these originally camera-provided measurements and their associated standard values S1 and a deviation ΔS between these is then an indication of frictional grip onto the road surface during the normal driving trips. Although camera-provided measurements are referred to here, it will be appreciated that other types of sensors can optionally be employed.

The type of tyre (American: "tire"), its surface texture and pattern depth have relevance for the grip of the tyres and thereby a grip of their associated vehicle onto a road surface. The aforementioned measurement instruments for measuring road friction and road surface state can also be used for measuring/registering, amongst others, tyre surface pattern and tyre pattern depth. Such measurement of tyre surface pattern and tyre pattern depth is important on account of the pattern of the tyre being progressively worn down during vehicle driving, and frictional characteristics of the pattern will thus be changing continuously; over a longer term, such frictional characteristics are reduced in response to each of the tyres becoming worn.

In relation to the present invention, there is an object to reduce a risk of accidents which can arise as a consequence of insufficient road surface grip, namely when a friction level between tyre outer surfaces and a road surface bearing the tyres is too low such that the driver loses control over an associated vehicle onto which the tyres are mounted.

Moreover, it is a further object of the invention to give the driver an opportunity to monitor the friction level between tyres and corresponding road surfaces onto which they grip, and/or to warn the driver regarding the friction level approaching a limit whereat grip of tyres onto the road surface is lost or likely to be lost.

It is in consequence an object of the invention to provide a system which is operable to execute an estimation of the aforementioned variable probable friction level, the system being operable to warn the driver and/or to implement an active intervention, which involves commencement of a controlled braking of the vehicle, for example, under application of an ABS-braking system of the vehicle.

It is further an object of the invention to provide a system wherein evaluation of risk in an event that the vehicle's grip on the road surface falls below a safety threshold is based upon an evaluation executed by a data system in the vehicle, wherein parameters which individual sensors register and send to the data processing unit are compared against standard values for the same parameters, and wherein results of the comparison, in the form of a probable grip of tyres of the vehicle onto the road, is presented as information to the driver of the vehicle.

According to a first aspect of the invention, the system is characterized in that it comprises units for registering parameters which can influence road-surface grip, together with means for warning and/or taking action when a lower threshold value for the road-surface grip is reached. Such a system is defined in appended claim 1.

Examples of embodiments of the invention are defined in the accompanying claims 2 to 18.

According to a second aspect of the invention, there is provided a method of utilizing the system; the method is defined in appended claim 19.

According to a third aspect of the invention, there is provided a software product executable on computing hardware for implementing the method pursuant the second aspect of the invention; the software product is defined in appended claim 20.

According to a fourth aspect of the invention, there is provided a dataset product for use by the software product for enabling the system pursuant to the first aspect of the invention to function.

According to a fifth aspect of the invention, there is provided a central database apparatus arrangement operable to support one or more vehicle-mounted systems pursuant to the first aspect of the invention. Beneficially, such central database apparatus arrangements are operable to enable data from a vehicle-mounted system on a first vehicle to be conveyed via the central database apparatus arrangement pursuant to the fifth aspect of the invention to a vehicle-mounted system mounted in a second vehicle; such an arrangement enables a central database apparatus to be updated together with enabling both vehicles to benefit from data acquired regarding a state of a section of road along which both vehicles travel. Such updating is beneficially implemented automatically for reducing cost and ensuring that the systems are maintained up-to-date, for example in response to changing hazards and local weather and road conditions. The database arrangement is beneficially operable to

communicate with the vehicle-mounted systems is real time using wireless communication, or periodically, for example via Internet connection through personal computers (PC). Such periodic communication can be achieved by the vehicle-mounted systems having a detachable data module which users can couple to the USB ports of their personal computers (PCs) for exchanging data via Internet with the database apparatus arrangement.

According to the fifth aspect of the invention, there is provided a central database apparatus arrangement as claimed in appended claim 21: there is provided a central database apparatus arrangement for use with one or more vehicle-mounted systems pursuant to the first aspect of the invention, characterized in that the database apparatus arrangement is operable to maintain a database including geographical location information (P) and corresponding road frictional information, wherein the database apparatus arrangement is operable:

(a) to receive sensor data and associated positional data indicative of road surface friction conditions from the one or more systems for updating the database; and/or

(b) to download sensor data and associated positional data indicative of road surface friction conditions from said database to one or more systems for enabling the one or more systems to warn their users of potential loss of friction and/or implementing braking action to assist vehicles equipped with the one or more systems.

Optionally, the apparatus arrangement is operable such that communication between the one or more systems and the database apparatus arrangement is implemented via at least one of: mobile wireless communication, Internet connection.

According to a sixth aspect of the invention, there is provided a method of operating a database apparatus as defined in appended claim 21: there is provided a method of operating a database apparatus arrangement pursuant to the fifth aspect of the invention, characterized in that the method includes:

(a) receiving sensor data and associated positional data indicative of road surface friction conditions from one or more systems for updating the database; and/or

(b) downloading sensor data and associated positional data indicative of road surface friction conditions from the database to one or more systems for enabling the one or more systems to warn their users of potential loss of friction and/or implementing braking action to assist vehicles equipped with the one or more systems.

The present invention thus provides a new system which is adapted to monitor a degree of friction, namely a friction level, between a vehicle, namely its tyres, and a road surface

bearing the vehicle. In an event of a low friction level occurring, for example on account of ice being formed on the road surface, the system will automatically implement a safety procedure, namely provide a warning to a driver of the vehicle, and thereafter, if necessary, execute a controlled speed reduction (braking) as a consequence of the warning. There is beneficially additionally provided for the system a data unit furnished with a database wherefrom, for various speeds of the vehicle, it is feasible to calculate the vehicle's frictional coefficient against the road surface. Thereby, information in the database can define threshold levels for responsible driving. These threshold values can be transferred to a supervising unit of the system which can warn the driver and/or implement a controlled braking activity.

The system has a computing unit, namely a data processing device, which continuously computes a responsible estimated friction level for the vehicle under all conditions and speeds. In a situation that the friction level of the tyres against the road surface is reduced and that the level approaches a lower acceptable threshold, the system will warn the vehicle's driver with sound and text for assisting the vehicle's driver to reduce the speed of the vehicle to safe regimes.

In an event that the tyres of the vehicle have a friction level which is reduced by road conditions below an acceptable level, the system will automatically implement a controlled braking to reduce the speed of the vehicle to a responsible level.

Advantage of the system:

By using this system, potentially fewer traffic accidents will occur, for example when heavier vehicles are involved. The system can, for example, be mounted in all vehicles with ABS and ESP systems. By using the system, it will thus be safer to drive in traffic in diverse weather conditions.

Function and manner of operation:

The friction level between tyres of the vehicle and a road surface supporting the vehicle via its tyres is measured continuously by two units implemented as specially constructed friction sensors which are beneficially mounted before both front wheels of the vehicle. Tyre pressure, for example, is an important parameter influencing tyre friction. The sensors are operable to measure properties of the road surface. The friction level is computed in a data unit which has a database furnished with a set of reference parameters; such reference parameters can, for example, include external temperature and relative humidity which are taken into account in computations executed in the data unit.

The friction level on the road surface is also evaluated in respect of the vehicle. Here there are several values which need to be taken into consideration, amongst others the vehicle's weight, speed and friction levels of all the tyres of the vehicle. The friction level is measured continuously and is compared with a responsible level for the vehicle for avoiding occurrence of accidents. In a situation where the friction level is lower than that required, the system warns the vehicle's driver and/or implements a braking action.

Additionally, the data unit is furnished with a database which enables, for each speed of the vehicle, friction coefficients and hence friction levels in respect of the road surface, to be computed. Information in the database can thereby establish threshold levels for responsible driving. These threshold levels can be transferred to a management unit which is operable to warn the driver of the vehicle and/or execute a controlled braking.

As aforementioned, the system operates within two areas, namely early warning and avoidance braking.

The vehicle-mounted system is implemented as an interconnected combination of several units including one or more of:

(a) a display, for example dash-board display, for presenting warnings to the driver of the vehicle with sound and text;

(b) a control unit for regulating braking of the vehicle;

(c) an optical friction measuring apparatus for monitoring tyre and road conditions;

(d) a weight sensor which is mounted to an outer surface of each of the vehicle's spring arrangement and/or shock-absorber arrangement, and on one or more wheels of one or more trailers when such are coupled to the vehicle;

(e) an external temperature sensor for measuring ambient external temperature in a vicinity of the vehicle, for example using an aspirated thermocouple thermometer and/or an infra-red imaging thermometer device;

(f) a wind speed measuring device for monitoring ambient wind experienced by the vehicle, for example severe cross-winds which can cause sideways forces to be experienced by the vehicle which can cause the vehicle to swerve in operation;

(g) an air humidity measuring device for measuring external relative in a vicinity of the vehicle;

(h) a daylight sensor for measuring ambient light levels, for example indicative of sunlight which can dry a road surface and thereby improve its frictional characteristics;

(i) a speed and distance measuring device, for example for use when computing expected centrifugal forces to be experienced by the vehicle when travelling around a bend;

(j) a measuring unit for sensing a turning angle and a roll angle of the vehicle, for example for use in computing lateral forces being experienced or likely to be experienced by the vehicle which could cause it to slip on the road surface;

(k) a height measuring device, for example for measuring an altitude of the vehicle above sea level and/or for measuring a height of the vehicle in an event that a roof rack is added to the vehicle which renders the vehicle more top-heavy and which could cause the vehicle more easily to tip when travelling along bends in roads;

(l) a centrifugal force measuring device, for example implemented as a differential accelerometer arrangement and/or a configuration of solid-state gyroscopes;

(m) an accelerometer for measuring linear acceleration of the vehicle, for example for determining a risk of wheel slip during braking actions executed by the driver of the vehicle;

(n) an electrical noise sensor, for example for measuring thunderstorm occurrence and/or man-made electrical signals such as electromagnetic radiation emitted from radio stations and microwave Doppler speed cameras along a road;

(o) a compass for measuring an orientation of the vehicle in respect of the Earth's magnetic poles;

(p) a radar arrangement, for example a microwave short-distance radar for measuring properties of the road surface such as occurrence of an ice layer thereupon;

(q) an optical camera, for example for imaging road surface conditions for determining a presence of water, ice or snow on the road surface;

(r) a tyre friction monitor for monitoring friction level provided by the tyres of the vehicle;

(s) one or more air pressure sensors for tyres of the vehicle, for example air pressure sensors implemented as RFID units with pressure sensors mounted onto tyre valves and/or hubs of one or more wheels of the vehicle;

(t) an ABS braking system;

(u) an ESP stability control arrangement;

(v) a special map, for example as provided in a data memory of the system;

(w) a GPS position measuring device for monitoring a spatial position of the vehicle in respect of a constellation of geostationary and/or orbiting GPS satellites;

(x) a data processing unit provided with Internet coupling for communicating with the Internet;

(y) a data processing unit provided with an alternative type of communication link from the vehicle, for example an alternative wireless data link; and

(z) a wireless or radio link for exchanging data with the vehicle.

Regarding tyre friction measurement:

The tyre friction monitor is beneficially a measuring instrument mounted in respect of all wheels of the vehicle, and also in respect of the wheels of any trailer coupled to the vehicle. The monitor is operable to measure, amongst other details, a depth in a tyre thread pattern on tyres of the vehicle, and also monitors properties of the outer surface of the tyres. The tyre friction monitor, as aforementioned for measuring road conditions and for evaluating frictional conditions and a state of the road surface, is utilized for measuring/registering tyre surface patterns and tyre pattern depth. The tyre pattern of a tyre is worn down during driving, and the frictional characteristics of the tyre are correspondingly changing continuously in use; over a longer term, frictional characteristics of the tyres deteriorate with use. The vehicle's data unit and associated database include information/data regarding different tyre types, and also information regarding winter tyre types with and without spikes and in addition can take into account use of chains for enhancing adhesion, for example in severe icy or snowy conditions. Moreover, the system includes means for manually registering into the database when tyres are changed or replaced, for example when exchanging between summer tyres and winter tyres which can include spikes, or a change from one type of tyre to another type of tyre such as changing between radial and cross-ply. The system is also capable of taking into account a designation of manufacture of tyres, for example "Viking", "Nokian", "Michelin" which are registered trade marks. All tyres from various different manufacturers have their special characteristics which are beneficially recorded in the aforementioned database. It is intended that the system itself optionally has an operational functionality to determine when a tyre is changed on the vehicle. Beneficially, tyres of the vehicle are equipped with radio frequency identification devices (RFID) modules or tags which transmit a code identifying a type and manufacturer of the tyres to the system; the system has beneficially corresponding data for the tyres in its database and is thereby able to compute likely frictional level expected from the tyres when in operation on the vehicle.

When it concerns tyre friction measurement, a unit is included in the system for measuring tyre thread depth. Such a unit can be implemented, for example, as a radar sensor, for example a short millimetric wavelength microwave radar system. Beneficially, the unit also comprises a heat-seeking camera, namely an infra-red camera, for sensing the temperature of the tyre which can have significance for a friction coefficient exhibited by the tyre when in use.

Software and function

In order to implement the invention, there is a requirement for significant computing power controlled by the use of appropriate software provided as one or more software products. Beneficially, the system includes a data unit provided with one or more executable software products. The one or more software products when executed upon a data processor of the data unit are operable to transfer and process measured data for one or more active measurement sensors mounted upon the vehicle, preferably from all active measurement sensors of the vehicle namely for determining parameters which can influence the vehicle's grip on the road.

Moreover, the measured data is evaluated against information in a database, for example wherein a pre-generated navigational map is provided. In one embodiment of the invention, there is utilized in the system an especially constructed pre-generated map of an entire road network of a region, country or continent. This road map advantageously includes different physical data pertaining to given road sections, for example data concerning turning angle, roll angle, and height and spatial positions whereat the road surface has been scanned and characterized. Such road surfaces properties, for example road surface roughness, road surface type (asphalt, gravel, etc.) and similar, are examples of original registered data stored in the pre-generated road map under ideal dry weather conditions which thereby defines optimal driving conditions in respect of road surface grip. Properties of road sections provided and recorded in the database of the system have a major significance with regard to grip of the vehicle onto the road surface. Data regarding road surface friction recorded in the pre-generated road map is modified in response to measured road conditions to obtain an indication of anticipated friction of tyres on the road surface in compromised situations, for example in wet or icy weather conditions. One or more sensors mounted onto the vehicle enable such measured road conditions to be determined.

In connection with driving around curves/bends, centrifugal forces are also influential with regard to friction of the vehicle's tyres and thereby grip on the road; vehicles often lose grip when travelling around bends in compromised weather conditions on account of centrifugal forces experienced by the vehicle. The system is operable to determine a precise position of its vehicle along a road by navigation; when the position of the vehicle is known in respect of the aforementioned road map, the data unit can identify from the map where bends and turns in the trajectory of the vehicle occur and thereby anticipate likely forces which the vehicle will experience and which have to be handled by tyres of the vehicle. Thereby, the data unit will calculate instantaneous effects of centrifugal forces on the vehicle's friction on the road and thereby be able to anticipate dangerous sections of the road whereat enhanced driving care

is required, suitably adjusted in respect of weather conditions and road conditions as monitored by aforementioned sensors included on the vehicle and coupled to provide measurement data to the data unit.

The program products executing upon a data processor of the data unit are operable to implement a computation of grip of the vehicle upon the road. By precise position measurement for the vehicle in the special pre-generated map, the data unit will be temporally ahead by computing a forthcoming turning curve's properties, namely something which affects grip on the road surface. This leads to the data unit computing ahead of trajectory which threshold values pertain to the vehicle's speed within the curve/turn, related to the grip on the road surface.

In a situation wherein the grip of tyres of the vehicle on the road surface passes a lower threshold level, namely that the grip on the road surface is reduced or compromised, the system is operable to warn the driver of the vehicle via warning signals, for example by presenting a visual warning on a dashboard screen of the vehicle or by generating an audible warning sound signal or by some other way of attracting attention of the driver of the vehicle.

In addition, the pre-generated navigation map is stored in the database; data from the map is employed actively as a point of reference for determination/measurement of grip of tyres of the vehicle onto the road surface as aforementioned. In the system pursuant to the present invention, there are beneficially used pre-generation maps with associated additional data, for example as described in Norwegian patent application no. 2008 2337 which belongs to Applicant. The foundation for such a map is, for example, generated by laser scanning from an aircraft, for example from one or more photographs derived from imaging vertically down towards ground, and one or more oblique photographs, for example imaged from different oblique angles.

The map which is used in the system pursuant to the present invention is based upon a map database wherein there are logged a range of parameters which can influence the frictional relationship between vehicle tyres and the road surface. Such a map database is fundamental to operation of the system and in developed form is conveniently referred in this connection as being a "special electronic map". The electronic map is constructed as region-upon-region with a basis that the selected map producer's road map is used as a foundation onto which all measurements taken from special equipped instruments via use of a registration vehicle are added to generate the electronic map.

The system comprises its own data unit which executes its own computations for determining operational parameters of the vehicle relative to a section of road along which the vehicle travels, in that the system in addition utilizes the system's navigation map which is pre-generated and stored into the vehicle's data apparatus. The system functions such that all the measurements undertaken by the vehicle's sensors are evaluated against data of the navigation map in the data unit and thereby a position of the vehicle on the map is determined; based upon the identified position, a most probable indication of grip on the road surface at the identified position is determined, where necessary modified in response to factors which can influence grip on the road at the identified position. Beneficially, the vehicle's exact position as identified by navigation is shown on a screen or display which is mounted in association with the vehicle's dashboard. The map, which is stored electronically in memory of the data unit, is beneficially based on a GPS-map showing streets, roads and all usual map details. Optionally, GPS position measurement can be used to determine a position of the vehicle within the special electronic map.

For every road, there are stored contours of the road over an entire length of the road, namely that one has measured, registered and stored following parameters for the road:

(i) its compass direction - *Kr*;
(ii) its climbing angle, namely angle of inclination – *Sv*;
(iii) its angle of roll – *Kv*; and
(iv) its height over sea level – *hoh*.

In order to implement the aforementioned system, the vehicle is equipped with the following instrumentation:

(a) a display for showing navigational information;
(b) a measurement unit for sensing turning angle and angle of roll;
(c) air pressure sensors for tyres;
(d) speed and distance measuring devices;
(e) a compass;
(f) a radar device;
(g) an optical camera;
(h) an electrical noise sensor;
(i) a pre-generated navigation map;
(j) a data unit with Internet coupling;
(k) a data unit with alternative communication coupling;
(m) the system also includes a GPS-unit and utilizes associated signals as an additional reference;

(n) a radio link for communicating data;

(o) one or more accelerometers for sensing acceleration of the vehicle when in movement; and

(p) a height measuring sensor, for example an altitude sensor, a sensor for measuring a height of the vehicle above a road surface supporting the vehicle.

The system measures and registers these parameters continuously as a function of travelled section of road, namely that the apparatus continuously registers changes in a compass direction of the road, climbing angle of the road, tilt angle of the road surface and height over sea level (*hoh*). When it concerns compass direction, it is advantageous to employ an electronic/digital compass which senses geographical directions, and which transfers the vehicle's travelling direction in digital format to the database.

All the measured values, which change during the course of travelling along a section of road, form a reference data set for determination of an instantaneous position of the vehicle, by way of the measurement values changing as a consequence of the driven section of road being compared, for example by correlation, neural network or similar, with one or more corresponding pre-generated data sets which are measured and stored in the data unit of the system; reference is made to Equation 2 (Eq. 2) in this respect for executing position determination within the system:

$$P = f\Delta Kr + \frac{\Delta Sv}{\Delta V} + \frac{\Delta Kv}{\Delta V} + \frac{\Delta hoh}{\Delta V} \qquad \text{Eq. 2}$$

In addition, the parameters such as pressure within tyres of the vehicle, speed and travelled distance travelled by the vehicle, a radar image of the road section and surrounding terrain traversed by the vehicle, and electrical noise along the road in which the vehicle is travelling are measured and registered in data memory. The electrical noise measuring device registers the level of electrical signals and magnetism and transfers them to the database whereat they are evaluated up against allowed values; such registered electrical noise is beneficially employed in correlation or neural network analysis for determining a position of the vehicle in respect of the pre-generated map stored in the system. The system comprises also an optical camera which is continuously operable to photograph surroundings which change in response to movement of the vehicle along its section of road.

As aforementioned, tyres of the vehicle additionally comprise a measuring device which registers tyre pressure and conveys such measurement further to the system. Based upon

tyre pressure measurements, the system is operable to implement a compensation on account of this tyre pressure being susceptible to changing with time and influencing friction grip of the vehicle to the road surface. More precisely, the system optionally comprises a radio "Bluetooth"-unit for signal communication between the system and wheels of the vehicle and their associated tyres.

The true value set for these parameters for a given section of road is measured beforehand, and stored in the data unit's map memory. When the vehicle travels along a given distance of road, all the measured values are registered, a radar image is registered, images of the terrain and electrical noise are registered, and the data unit then implements a comparison, for example a correlation and/or neural network analysis. When there is complete or partial correspondence between measured and stored value sets for these parameters, such correspondence is presented on a display of the vehicle which shows a precise instantaneous spatial position of the vehicle along the actual section of road. Changes in the vehicle's position along the road are shown continuously on the map presented in graphical form, to the driver, precisely in a manner akin to contemporary maps.

The major advantage of this system is that all necessary instruments and data processing for determining a position of the vehicle, are implemented within the vehicle, and one is therefore not dependent upon external instruments or signals in order to determine the position of the vehicle, for example in contradistinction to GPS systems which require external signals to geostationary satellites in order to function correctly. The present invention is capable of operating without GPS position measurement active or, alternatively, with such GPS measurement active depending on preferred implementation of the invention.

Image capture from satellite, transfer

Contemporary quality of images provided from satellites is so high that they can be used in combination with GPS-systems for providing a reference point for roads and driving conditions. The image quality is expected to be yet better in future satellite- and image capture systems. For example, it is possible to derive the pre-generated map for downloading to the system of the vehicle from satellite measurements, thereby avoiding a need for test vehicles to be initially driven around a road network to compile the aforementioned pre-generated electronic map.

Image transfer

Today, technological solutions are offered within imaging and optics such that small details in a geographical region (just like a face) are susceptible to being recognized with small cameras, for example as offered for the camera Canon Digt Ixus 970 IS.

Computations which the data unit implements

The angle of inclination α is measured in respect of the road in a direction of travel. The angle α which is encountered is defined in relation to a horizontal angle which has a value 0. The angle of roll of the vehicle β is measured in respect of the road section in the driving direction. The angle β that is thereby derived is in relation to the horizontal angle, wherein this angle β is measured in respect of an axis which is orthogonal, namely 90 degrees, in relation to a direction of measurement of angle of inclination α.

Velocity- and distance-measurement devices of the vehicle provide insight regarding vehicle speed for use in computations, together with an indication of distances already travelled. Moreover, the compass provides information regarding distances of the vehicle from terrain and building constructions. In the vehicle, electrical noise sensors have associated therewith a receiver for electronic noise signals and magnetism. In a situation that the sensors receive higher signals than expected and values of the signals affect some of the other measuring u\instruments, these higher signals are utilized in the data unit and employed to correct measurement values; for example, higher signals than expected can either be indicative of unexpected road surface conditions. By using the camera, an image of the terrain in the surroundings of the vehicle is captured. Comparisons are made in respect of height of the vehicle in relation to sea level, namely altitude of the vehicle; it is to be borne in mind that temperature falls on average by 1°C for every 100 metres increase in height above sea level. By using the accelerometer, changes in speed are sensed, namely acceleration and/or deceleration of the vehicle are sensed for determining forces acting upon the vehicle and hence forces being resisted by tyres of the vehicle supported on the road surface. Measuring instruments are used for monitoring changes in gravitational force along the road; gravitation force can vary, for example, at various positions along the road and can, for example, be used for navigation purposes for determining a position of the vehicle along the road.

In database of the system, there is stored a digital navigation map which has saved in respect thereto details regarding the same measurement units and associated data as the system itself executes in operation. That is to say, a vehicle has earlier driven through all

actual sections of road of the navigation map and registered all the relevant measurement data in a data memory for subsequent use by the data unit of the system.

Advantages with this system are that:

(a) it is possible to navigate under all conditions and establish the position of the vehicle more accurately, for example the system is not dependent upon having available a GPS-satellite connection;

(b) fewer deviations in navigation arise in practice which allows the driver to more easily keep attention on the traffic situation and use of the vehicle will be more pleasant;

(c) when the system assists to reduce deviations of the vehicle, there arises a benefit of more secure and safe driving and thereby fewer accidents, for example reduced injury and loss of life.

The system functions by way of when the driver starting the vehicle and selecting a route for travel, wherein during subsequent driving along the route involves the system executing its own measurements which are evaluated up against the pre-generated navigational map. The place/position at which the driver finds himself/herself will be recognized by the system. Thereby one has a position at a starting point and navigation can begin therefrom. However, when a start position is not known, the system can acquire sensor signals for a period of travel along a section of road and then correlate against the navigational map for recognizing a most likely location for the vehicle; such a situation can arise when the vehicle is transported by ferry between two locations and then is required to identify its geographical location when leaving the ferry. In such case, the system of the vehicle is in a disorientated state. A short period can arise after leaving the ferry during which the system is inactive whilst it collects sensor signals to find its spatial location; beneficially, the system informs its user of the short period of inactivity of the system so that the user can take extra care when driving his/her vehicle to try to avoid accidents.

Optionally, one or more first vehicles equipped with the system pursuant to the present invention and having earlier reliably determined their position with respect to their special electronic map are operable, for example via near field radio communication (NRC), to inform one or more second disorientated vehicles in their near proximity the determined positions of the one or more first vehicles. For example, vehicles equipped with systems pursuant to the present invention can be disorientated when transported by ferry from one harbour to another harbour. Such an arrangement is of advantage in that a given second vehicle equipped with the system and in a disorientated state having just arriving at a first location is informed by one or more of the one or more first vehicles at the first location regarding the

map location of the first location. Optionally, such exchange of position data between vehicles equipped with the system and in mutually near proximity can be used in addition to vehicle positions being determined by comparing sensor signals over a period of time with the special electronic map. It is thereby feasible to improve position reliability of the system as well as enabling disorientated vehicles passing in near proximity to other orientated vehicles to rapidly identify their positions and thereby become orientated. Such an exchange of position information between vehicles equipped with systems pursuant to the present invention is of immense value when a significant proportion of vehicles are equipped with systems pursuant to the present invention. The present invention is therefore potentially capable of rendering GPS position-determination systems superfluous and providing a lower-cost solution than GPS navigation. Moreover, in an event of an emergency, for example martial law in the USA in an event suspension of the US Constitution, it is generally believed that US authorities would disable civil GPS services which would render many contemporary GPS-based position determination systems for vehicles instantly disabled. The present invention provides a great advantage that it is able to function independently of GPS services. Moreover, present conventional GPS position-measurement systems are not able to provide the safety warning and/or braking functionality of the present invention on account of such conventional GPS systems being devoid of sensors for inspecting road services and tyres of vehicles.

In addition to the sensors and instruments which are used in the navigation map, the vehicle is equipped with the following instrumentation:

(a) a display which is operable to show friction/road-adhesion, with one or more warning that can come with sound and/or text;

(b) a steering unit which is operable to regulate braking of the vehicle;

(c) an optical friction measuring device for determining frictional characteristics of the one or more tyres and/or road surface;

(d) a weight sensor which is coupled or otherwise mounted onto an external surface of each of the vehicle's springs and/or shock absorber construction, and on one or more wheels of any trailers of the vehicle, for example mounted in association with every wheel of the trailer;

(e) a centrifugal force measuring arrangement, for example implemented using an angular accelerometer and/or a gyroscopic device operable to measure gyroscopic Coreolis forces;

(f) a tyre friction monitor;

(g) a tyre pressure monitor;

(h) ABS brakes;

(i) an ESP stability control.

As aforementioned, it is not possible to measure exact values for the parameter "road grip". Pursuant to the present invention, one beneficially operates with an expectation that the road grip will be reduced, based upon measurements and the system's comparison between instantaneous values and standard values which are already stored in the database.

Software:

The present invention utilizes one or more prepared software program products which are executable to access registrations and data from measuring units of the vehicle. These data are evaluated in a database. The database includes many reference parameters. For a given vehicle equipped pursuant to the present invention, there are provided threshold values for responsible driving in relation to speed, weight, road surface covering, humidity, temperature and wind conditions. In an event that these threshold values are approached during driving, the one or more program products will warn the driver of the vehicle via sound and/or visual presentation on a screen of the vehicle to indicate that the speed of the vehicle must not exceed defined levels, namely threshold values. If the speed exceeds these threshold values, the one or more program products are optionally operable to send a message to a steering unit for braking and thereby implement an automatic speed reduction of the vehicle to a responsible and safe speed range. Beneficially, the program product places great emphasis on accurately registering friction level for the vehicle and road and uses many reference points for achieving such accuracy.

Database:

The database comprises information on specific types of vehicle, for example dependent upon vehicle model number and manufacturer; the information includes one or more of weight, tyre type, tyre condition, engine power and gear arrangement. In addition there is provided a special pre-generated road map which is operable to function as a reference for the position of the vehicle; this is necessary for accurately establishing the position of the vehicle within a road network when in operation. The database also includes data regarding all types of anticipated road surface, for example asphalt, gravel, sand, earth and stone. In combination with the various road surfaces, there is also provided friction levels as a function of humidity and temperature of the road surface.

The database also includes images and videos of different states of the road surface as a function of humidity and temperature. There is also provided in the database data regarding depth levels of the different road surface layers; an example of such road surface layer is snow which lies upon an underlay of ice.

In the database, there is also provided a calendar and a clock of the system. Such time reference is provided for quality controlling computations in respect of the relevant day and time at which the vehicle is employed for executing a journey. Optionally, it is also operationally possible for the system to receive weather reports which can also be a point of reference for the one or more program products.

Special map:

The purpose of the aforementioned pre-generated special map as reference is that the friction measuring device is operable to recognize its position and is capable of receiving a confirmation regarding a state of the road surface. Together with temperature, humidity, ambient light conditions, time instance and calendar, the system is operable to compute the friction level of the road surface. The friction level is then compared with a speed of the vehicle in operation, weight of the vehicle and friction level of its tyres. Thereby, the friction level between the vehicle and the road surface is determined for being subsequently compared against threshold levels recorded in the database. In an event of deviation, depending upon magnitude, the driver of the vehicle is warned and/or the system automatically implements a controlled braking to reduce speed of the vehicle.

Navigation system:

The vehicle's navigation system functions amongst other things as a unit which is not required to show or propose any particular driving route. Moreover, it is not an intention or necessity that the navigated position identified by the system in operation is shown on a screen for the driver. In such case, the navigation itself operates in real time and only processes data which has relevance for computations within the system. The present invention is thus radically different in comparison to a contemporary GPS position determining system with map display. It is not a primary intention of the present invention to present the user with a visual indication of the geographically position of the user and his/her vehicle.

Description of the diagrams

The present invention will be described in the following in more detail, by way of example only, with reference to the following diagrams wherein:

FIG. 1 is an illustration of two vehicles **10**, **30** which mutually meet along a road **50** in a bend **60**, whereat it is important for both vehicles **10**, **30** that there is a safe grip on a road surface **200** of the road **50**;

FIG. 2 is an illustration of the vehicle **10** which includes an instrument panel (dashboard) **70**, wherein one is able to observe a road way **80** through a front windscreen **90** with a centre-line **100** shown in dotted form;

FIG. 3 is an illustration of a sensor **140** which is mounted in operation in a vicinity of a front wheel with a tyre **130** of the vehicle **10**, wherein the sensor **140** is adapted to monitor continuously properties of the tyre **130** on the front wheel, for example its tyre tread pattern type and pattern depth. In association to each tyre of the vehicle **10**, there is optionally provided such a sensor **140**, such that all tyres of the vehicle **10** are continuously monitored in operation and thereby are evaluated by a system pursuant to the present invention mounted upon the vehicle **10**;

FIG. 4 is an illustration of a sensor **150** which is mounted in a forward portion of the vehicle **10** for executing measurements of properties of the road surface **200**; optionally, the sensors **140**, **150** are integrated together, for example as an actuated scanning transducer assembly; and

FIG. 5 is a schematic illustration of a sensor unit **260** for measuring properties of foundations of the road **50** which potentially have an influence on friction levels;

FIG. 6 is a schematic diagram of functional parts of a system **400** pursuant to the present invention; and

FIG. 7 is a schematic diagram of a communication system operable to support one or more vehicle-mounted systems as illustrated in FIG. 1 to FIG. 6.

In the accompanying diagrams, an underlined number is employed to represent an item over which the underlined number is positioned or an item to which the underlined number is adjacent. A non-underlined number relates to an item identified by a line linking the non-underlined number to the item. When a number is non-underlined and accompanied by an associated arrow, the non-underlined number is used to identify a general item at which the arrow is pointing.

Description of embodiments of the invention

A system pursuant to the present invention is shown in overview in FIG. 6 and indicated generally by **400**.

As illustrated in FIG. 5, a unit **260** of the system **400** is constructed from a housing or a cabinet fabricated with waterproof glass- or plastics-material on its underside for enabling inspection of a tyre thread pattern and/or a road surface. Optionally, there is provided a cleaning unit with associated sensor which is operable to clean the glass and/or plastics material of the underside of the housing or cabinet.

In the housing or cabinet, there is mounted following units:

(a) a lamp **270** which is operable to illuminate the road surface **200** in dark ambient conditions;

(b) a heat-seeking (infra-red) camera **280**;

(c) a camera **290**, for example a laser-scanning camera, which can be used to image a depth cross-section, namely smoothness or roughness of the road surface **200**. It is, amongst other things, such a camera which is utilized in the sensor **140** for measuring a pattern type for the tyres and also their pattern depth as aforementioned. As satisfactory, or potentially even more advantageous for determining properties of the road surface **200**, microwave sensing is employed for measuring properties of the road surface **200**. Moreover, such measurements enable an overview and determination of exact and indirect data relating to friction level and grip on the road surface **200**; and

(d) a video camera **300** for imaging the road surface **200**.

With reference to the scanning camera **290**, similarly microwave sensing, which is operable to register the road surface **200** and its associated contours, the camera **290** can also be used to determine to what extent the road surface **200** is covered in a layer of snow, ice, oil or dust, gravel, sand and similar. Microwave energy, for example, is able to penetrate a distance into the road surface **200**, thereby enabling characterization of whether or not asphalt is covered by ice with a snow layer formed upon the ice layer. A laser scanner and its associated data system is optionally taught to interpret occurrence of such layers upon the road surface **200**, such that the driver can receive such information via a screen on the dashboard **70**.

In other words, the apparatus is additionally operable to "see" and register occurrence of oil spills or films on an upper exposed surface of asphalt. In dark conditions with poor driver visibility, it is not certain that the driver is aware of such spills or films which can represent a hazard in respect of grip of the vehicle upon the road surface **200**. Via information provided via the screen, the driver can adapt or correct his/her driving style accordingly.

When other sensors are taken into consideration, optical friction sensing sensors are beneficially mounted into or adjacent to front lights of the vehicle. According to one embodiment of the invention, one or more of the sensors are mounted centrally at a front of the vehicle. Such mounting of the one or more sensors can provide earlier warning by the system.

In FIG. 6, there is shown a block diagram which illustrates flow of information in the system **400** pursuant to the present invention. The system **400** comprises a special electronic map database **500**, wherein measurement data for the mutually different parameters as aforementioned are temporarily stored, the measurements being representative for ideal driving conditions, and against which later measurements can be compared. There is also provided a data processing unit. Signals generated in operation from the mutually different sensors are transferred to the data processing unit **520** whereat they are processed and compared with previously recorded basic data.

A degree of similarity is shown on the screen which is an indication of actual grip onto the road surface **200**, and this is represented by way of boxes **540**, **550**. The result of the comparison is shown on the screen **560**. This system **400** is also coupled to the vehicle's own driving computer system **570** which is operable to apply selectively controlled braking in an event that the driver himself/herself does not react with such braking action. The screen **560** presents, for example, a most probable grip on the road surface **200** with help of a pointer which moves relative to a graphical presentation scale.

The sensor types which are described in the foregoing are operable to measure parameters which can have a bearing in respect of friction level between a tyre and a corresponding road surface in contact with the tyre. When all these sensors are in operation, accumulative data from these sensors are stored in the database. For each measurement value for each parameter, the data processing unit **520** implements a comparison with the recorded measurement values which are stored beforehand.

A comparison unit included in the data processing unit **520** collects in all these values for determining deviation from the previously recorded values, and the data processing unit **520** selects a manner in which a sum (SUMMEN) of all these values is to be interpreted when the vehicle's grip on the road surface **200** is to be evaluated.

Alternatives when the present invention is in operation can be sub-divided into three groups:

(A) the data processing unit **520** interprets SUMMEN such that the vehicle is being driven along the road in such a manner that the grip of the vehicle onto the road surface **200** is completely responsible, without there being any need for any form of warning to be sent to the driver;

(B) the data processing unit **520** interprets SUMMEN such that the vehicle is being driven along the road in such a manner that lies within a dangerous range wherein frictional grip onto the road surface **200** can be potentially lost. On the display **560**, there is then shown a warning to the driver in the form of text, flashing light signal or there is generated a sound signal that there is a danger in respect of grip onto the road surface **200**; and

(C) the data processing unit **520** interprets SUMMEN such that the vehicle is being driven in such a manner that it is close to losing grip onto the road surface **200**. The data processing unit **520** overrides the driver's will, and activates the braking system **570** of the vehicle, including ABS functionality, in order to implement necessary intervention and reduce a speed of the vehicle in a controlled manner.

Driving stop in a condition of slippery road surfaces:

Situations can arise that the road surface **200** is so super-slippery as a consequence of wet ice, or so-called "skating rink", or there is an oil slick or other "slippery" chemicals on the road. In such situations, it can even be dangerous to start up a vehicle from a parked condition. The system **400** controls simultaneously a driving state of the vehicle in relation to all the conditions which can influence its frictional grip onto the road. Optionally, the system **400** is operable to bar use of the vehicle, for example in a situation that frictional road grip is catastrophically bad, for example in a manner akin to an "alcohol lock" which presents a driver utilizing a vehicle when the driver is in a compromised state in consequence of consumption of alcoholic beverages. Such bar to use of the vehicle is beneficially implemented by selectively deactivating or disabling the ignition arrangement of the vehicle, such that the engine of the vehicle cannot be started. As aforementioned, such an implementation can be compared with an "alcohol-lock" which prevents a vehicle being started when the driver is under the influence of alcohol.

When measurement signals from one or more sensors are absent or become unavailable:

In an event that the system **400** in a given unexpected situation does not have satisfactory reference data, the system **400** desists from executing comparison computations. Such cessation of comparison computations is notified to the driver of the vehicle, namely that the

system **400** is out of action. Such notification is beneficially conveyed via the display or screen **560**.

Such cessation of the system **400** to execute computations relates both to the sum of the values (SUMMEN) and for signals from each sensors. In an event of a signal from one or more of the sensors being of low quality, for example in an event of approaching malfunction of one of the sensors due to contamination and/or damage, the system **400** can optionally elect to ignore the one or more signals, and rely on a reduced number of properly functioning sensors; thereby, operating reliability of the system can be enhanced by such selective use of sensors provided on the vehicle.

The system **400** pursuant to the present invention is well adapted for use in personal vehicles, for example small automobiles, motorcycles. Moreover, the system **400** is susceptible to being utilized in all types of vehicles for which road grip has a major importance for safe transportation of loads and people, for example: load-bearing vehicles such as trucks, busses, construction equipment, and even aircraft. An especially potentially important area for use of the present invention includes: snow clearance vehicles, snow ploughs, snow pulverising vehicles, for example as used on mountain roads which can have harsh terrain.

The system **400** is beneficially provided with one or more arrangements **700** for enabling the system to communicate with other devices and communication networks remote from the vehicle **10** into which the system **400** is installed. Such one or more arrangements can beneficially include at least one of:

(a) a BlueTooth or similar near field radio (NFR) communication link of a few milliWatts (mW) power for interfacing to a user's mobile telephone, wherein the user's mobile telephone has downloaded thereto a software application, for example a Java application, which enables the system **400** coupled by BlueTooth of similar NFR to the mobile telephone. The mobile telephone enables wireless access for the system **400** to a telephone network and one or more data servers coupled thereto for uploading data from the system **400** to the one or more data servers, and/or downloading data from the one or more servers to the system **400**;

(b) a wireless link for directly linking the system **400** to a wireless communication network; such communication can be spatially cellular in a similar manner to conventional mobile telephones; and

(c) by a part of the system **400** being dismounted and coupled to data apparatus coupled to a communication network linking one or more data servers; for example, use of a

USB connector in a generally similar manner to a conventional USB memory stick for personal computers is beneficially employed in relation to the system **400**.

By such an approach, valuable data collated by sensors of the system **400** can be used to update the one or more servers, for example providing a database of information, as well as data updates can be loaded to the system **400**, for example hazardous sections of roads, road works, new speed restriction zones, changes in road layout, and so forth.

The system **400** is thus capable of conveying information generated by its sensors to the one or more servers, for example for use for warning other drivers via their systems **400**, as well as ensure accuracy and quality of information stored at the one or more servers. It is thus possible to implement automatic low-cost updating of information progressively stored and conveyed from the one or more data servers.

It will be appreciated that the system **400** is capable of being operated such that vehicles **10A** adapted pursuant to the present invention provide data from their sensors to a central network site (for example an Internet web-site) **800** including information regarding the geographical locations **P1** of the vehicles **10A** and sensed road conditions pertaining at these locations **P1**; such an arrangement is illustrated in FIG. 7. The central network site **800** is operable to update its database **810** as well as provide information concerning the road conditions at the locations **P2, P3, P4** to other vehicles **10B**, **10C**, **10D** adapted pursuant to the present invention which travel concurrently or subsequently in the aforesaid geographical locations **P1**. For example, the vehicle **10A** adapted pursuant to the present invention travels along a mountain road at the locations **P1** whereat sensors of the vehicle **10A** identify poor tyre friction on the road surface **200** there, for example due to poor road surface **200**; the information is conveyed to the central network site **800** as illustrated in FIG. 7, for example via a wireless data link **820** implemented using mobile telephone infrastructure. The database **810** is updated that poor road friction is to be expected along the mountain road at the locations **P1** and the central network site **800** also updates the database of the other vehicles **10B**, **10C**, **10D** adapted pursuant to the present invention coupled to the network site **800** via one or more wireless data links **830**. When these other vehicles **10B**, **10C**, **10D** are subsequently driven along the mountain road at the locations **P1**, their systems **400** from updated information from the network site **800** expect a low friction threshold along the mountain road and warn their drivers accordingly and/or implementing a braking operation as deemed necessary by the system **400**.

Each vehicle **10** with its associated system **400** can provide sensor signal information and corresponding geographical location information to the central network site **800**, as well as

receiving updated information from the central network site **800**. Thus, other drivers equipped with systems **400** in communication with the network site **800** can receive information from the central network site **800** regarding actual road friction conditions as a function of geographical map location. By such an arrangement, the system **400** with its associated sensors mounted on each vehicle **10** is capable of maintaining the central network site **800** automatically updated for the benefit of other vehicles **10** also equipped with the system **400** with its associated sensors and also periodically or continuously in communication with the central network site **800**. A user of the system **400** is thus able to receive a pre-warning regarding driving conditions and frictional grip in respect of the given section of road. Such communication from systems **400** pursuant to the present invention installed into vehicles **10** to the central network site **800** is implemented either in real-time using wireless Internet or similar, or is implemented by users of the system **400** periodically demounting at least a part of the system **400** and coupling it via a personal computer (PC) or telephone connection point to the central network site **800** for purposes of exchanging data. For example, a portion of the system **400** is beneficially implemented as a detachable data module equipped with an inexpensive USB interface which users can remove from their vehicles **10** and couple via their personal computers (PC) through the Internet to the central network site **800** implemented as a cluster of one or more data servers; the modules are thereby capable of updating the central network site **800**. Other users coupling their corresponding modules into their personal computers (PC) can download updates regarding road friction conditions expected for various geographical locations **P**. Such updating via normal personal computer (PC) can be implemented on an occasional basis, for example daily or weekly. Moreover, new roads and routes with their associated contour information can be automatically downloaded by users driving around in their vehicles **10** to the central network site **800**, thereby reducing a cost of providing service from the central network site **800**, thereby providing a more economical service to users which can financially undermine contemporary GPS road navigation schemes as well as providing additional functionality relating to friction monitoring with associated low-of-friction warning and/or automatic braking of vehicles **10** to prevent occurrence of accidents.

It is important that the central network site **800**, for example implemented as a cluster of servers, is provided with reliable data for updating its parameter information, road information and sensor data. In order to reduce a risk of deliberate falsification of data provided to the central network site **800**, the central network site **800** is beneficially operable to update its records when N vehicles travelling along a same section of road indicate an specific unusual conditions, for example a dangerous ice patch, a slippery snow covering, loose gravel, sand and so forth. Beneficially several vehicles **10**, namely $N > 1$, via their respective systems

400 are required to download their sensor data relating to unusual road conditions at a given spatial section of road before the central network **800** updates its records pertaining to the section of road. For certain categories of dangerous hazard, for example black ice and oil spills which are especially dangerous, the central network site **800** has its database updated on a single communication, namely N=1, from a system **400** to the central network site **800** indicating poor tyre grip on a given section of road, the information being subsequently disseminated to other systems **400** to update their parameters relating to the section of road. Thus, in other words, the central network site **800** is operable to receive sensor information and corresponding processed data from one or more systems **400**, and filter the data for taking a decision whether or not to update information in the central network site **800** for subsequent dissemination to other systems **400**, wherein the filtering is dependent upon the nature of hazard or condition conveyed in the data provided to the central network site **800**. Such filtration reduces a risk of deliberate damage or degrading of integrity of data at the central network site **800** by malicious third party activities which could have safety implications.

The system **400** is beneficially sold in kit form for retrofitting to vehicles, for example with installation executed by users and/or authorised automotive workshops and dealers. Alternatively, the system **400** is sold as a component part for integration into new vehicle designs, for example as component parts to an automotive assembly line. Communication to the central network site **800** and receiving updates therefrom is beneficially subject to payment of a regular subscription fee. Beneficially, each system **400** is provided with a unique identification code by which it can be recognized by the central network site **800**. A degree to which a given system **400** is updated with information, for example with respect of frequency of updating, can be made dependent upon a magnitude of subscription fee paid and/or a degree to which the given system **400** is equipped with sensors and hence its use to the central network site **800** for providing it with useful information regarding road conditions, for example for the benefit of other users equipped with the system **400**.

Modifications to embodiments of the invention described in the foregoing are possible without departing from the scope of the invention as defined by the accompanying claims.

The system **400** functions by way of when the driver starting the vehicle and selecting a route for travel, wherein during subsequent driving along the route involves the system **400** executing its own measurements which are evaluated up against the pre-generated navigational map. The place/position at which the driver finds himself/herself will be recognized by the system **400**. Thereby one has a position at a starting point and navigation

can begin therefrom. However, when a start position is not known, the system can acquire sensor signals for a period of travel along a section of road and then correlate or otherwise comparing against the navigational map for recognizing a most likely location for the vehicle; such a situation can arise when the vehicle is transported by ferry between two locations and then is required to identify its geographical location when leaving the ferry. In such case, the system **400** of the vehicle is in a disorientated state. A short period can arise after leaving the ferry during which the system **400** is inactive whilst it collects sensor signals to find its spatial location; beneficially, the system **400** informs its user of the short period of inactivity of the system so that the user can take extra care when driving his/her vehicle to try to avoid accidents.

Optionally, one or more first vehicles equipped with the system **400** pursuant to the present invention and having earlier reliably determined their position with respect to their special electronic map are operable, for example via near field radio communication (NRC), to inform one or more second disorientated vehicles in their near proximity the determined positions of the one or more first vehicles. Optionally, such near-field communication is beneficially provided via the one or more arrangements **700**. For example, vehicles equipped with systems **400** pursuant to the present invention can be disorientated when transported by ferry from one harbour to another harbour. Such an arrangement is of advantage in that a given second vehicle equipped with the system **400** and in a disorientated state having just arriving at a first location is informed by one or more of the one or more first vehicles at the first location equipped with the system **400** regarding the map location of the first location. Optionally, such exchange of position data between vehicles equipped with the system **400** and in mutually near proximity can be used in addition to vehicle positions being determined by comparing sensor signals over a period of time with the special electronic map. It is thereby feasible to improve position reliability of the system **400** as well as enabling disorientated vehicles passing in near proximity to other orientated vehicles to rapidly identify their positions and thereby become orientated. Such an exchange of position information between vehicles equipped with systems **400** pursuant to the present invention is of immense value when a significant proportion of vehicles are equipped with systems **400** pursuant to the present invention. The present invention is therefore potentially capable of rendering GPS position-determination systems superfluous and providing a lower-cost solution than GPS navigation. Moreover, in an event of an emergency, for example martial law in the USA in an event suspension of the US Constitution, it is generally believed that US authorities would disable civil GPS services which would render many contemporary GPS-based position determination systems for vehicles instantly disabled. The present invention provides a great advantage that its system **400** is able to function independently of GPS

services. Moreover, present conventional GPS position-measurement systems are not able to provide the safety warning and/or braking functionality of the present invention on account of such conventional GPS systems being devoid of sensors for inspecting road services and tyres of vehicles. The system **400** pursuant to the present invention represents a very considerable technological breakthrough.

Expressions such as "including", "comprising", "incorporating", "consisting of", "have", "is" used to describe and claim the present invention are intended to be construed in a non-exclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular is also to be construed to relate to the plural.

Numerals included within parentheses in the accompanying claims are intended to assist understanding of the claims and should not be construed in any way to limit subject matter claimed by these claims.

CLAIMS

1. A system (400) for warning and/or braking in a vehicle (10, 30) in respect of friction levels and road surface grip between tyres (130) of the vehicle (10, 30) and a road surface (200) of a road (50) onto which the tyres (130) are in contact when in operation,

characterized in that

there is included a unit (500, 520, 530, 540, 550, 560, 570) for registering parameters which influence the road surface grip, together with means (560, 570) for warning and/or executing action when a lower threshold value for road surface grip is reached.

2. A system (400) as claimed in claim 1, wherein the system is implemented such that:

(a) said unit includes means (530) for measuring and registering one or more values for parameters in relation to:

- properties of the road surface (200) in real time;
- a manner of movement of the vehicle in a form of velocity;
- a geographical location of the vehicle in relation to the road surface (200);

(b) a data processing unit (520) includes a computational unit for comparing measured values against one or more values for:

- road surface grip in an optimal state established under standard conditions;
- a technical state of the vehicle, and

(c) said means for warning and/or executing when said lower threshold value is attained is operable such that said means provides a driver of the vehicle with a warning regarding a state of road surface grip and/or with a braking reduction by controlled and automatic intervention.

3. A system (400) as claimed in any one of claims 1 to 2, wherein the system includes a comparison unit (520) for computing one or more deviations of said one or more measured and registered values from corresponding standard/optimal values, and wherein the system is operable to determine a manner in which a summation (SUMMEN) of such one or more deviations is to be responded to in relation to grip of the vehicle upon the road surface (200), such that:

(a) the system is operable to interpret the summation (SUMMEN) to indicate that the vehicle is being driven along the road (50) in a manner such that the road surface grip is responsible, without there being any need for warning the driver of the vehicle;

(b) the system is operable to interpret the summation (SUMMEN) to indicate that the vehicle is travelling in a manner which is within a regime in which road surface grip is potentially lost, with a warning being sent to the driver regarding risk of a loss of grip; or

(c) the system is operable to interpret the summation (SUMMEN) to indicate that the vehicle is being driven along the road in a manner such that the vehicle is about to lose road surface grip, with an activation of the vehicle's braking system against the diver's will including use of an ABS-braking system and other necessary actions for reducing a speed of the vehicle in a controlled manner.

4. A system (400) as claimed in any one of the preceding claims, wherein the system includes a pre-generated electronic road map (500) including physical data pertaining to one or more sections of road (!6), said physical data including one or more of:

(a) turning angle of the vehicle;

(b) roll angle and height of the vehicle;

(c) surface characteristics of the one or more sections of road, such as surface roughness, surface type such as asphalt or gravel;

said physical data being determined under standard dry conditions, identified and stored in association with said electronic road map for defining standard or optimal driving conditions pertain to grip on said one or more sections of road.

5. A system (400) as claimed in claim 4, wherein the system (400) includes a near-proximity communication arrangement (700) for communicating a position of the vehicle (10, 30) with other vehicles in near proximity also equipped with the system (400) and operable to exchange such position information by near-proximity communication.

6. A system (400) as claimed in any one of the preceding claims,

wherein properties of the road surface of the road are measured in real time by using laser-scanning technology and/or microwave technology which scans and registers road surfaces and road contours, for determining said road surfaces are covered by one or more of: snow, ice, oil, dust, gravel, sand; and

wherein said driver is provided with said properties via a display and/or audio indicator of the vehicle.

7. A system (400) as claimed in claim 6, wherein laser scanning technology and/or microwave technology is included for determining a quality measure if the road surface is covered with one or more layers including at least one of:

(a) dust;

(b) oil;

(c) ice; and

(d) snow.

8. A system (400) as claimed in any one of the preceding claims, wherein the system comprises at least one of:

(a) a display (560) for providing warnings via sound and/or text to the driver of the vehicle;

(b) a control unit (570) for regulating braking action for reducing a speed of the vehicle;

(c) an optical measuring device (530) for scanning to determine a state of the road surface (200) and tyres of the vehicle;

(d) a weight sensor mounted on an external surface of at least one spring of said vehicle and/or on at least one shock absorber of said vehicle for measuring a weight of the vehicle;

(e) an external temperature measuring device for measuring temperatures along the road (50);

(f) a wind speed measuring device for measuring wind speeds along the road (50) to which the vehicle is exposed;

(g) a humidity sensor for measuring humidity along the road (50);

(h) a daylight sensor for measuring daylight intensity along the road (50);

(i) a speed and distance measuring device for measuring a travelling speed and/or distance that the vehicle travels along the road (50) in operation;

(j) a measuring device for measuring turning angle and roll angle of the vehicle;

(k) a height sensor for measuring a height of the vehicle (altitude);

(l) a centrifugal force measuring sensor for measuring centrifugal force acting in operation on the vehicle;

(m) an accelerometer for measuring acceleration of the vehicle;

(n) an electrical noise sensor for measuring air-transmitted electrical noise received at the vehicle;

(o) a compass for measuring an orientation of the vehicle relative to the Earth's magnetic poles;

(p) a radar system for sensing in an external region around the vehicle using microwave radiation;

(q) an optical camera (280) for imaging a region in an external vicinity to the vehicle;

(r) a tyre friction monitor;

(s) one or more air pressure sensors for measuring air pressure of one or more tyres (130) of the vehicle;

(t) an ABS braking system (570);

(u) an ESP stability control;

(v) a special electronic map dataset (500);

(w) a GPS receiver for determining a spatial position of the vehicle;

(x) a data unit for providing Internet communication coupling;

(y) a data unit for alternative communication to an external site to the vehicle; and

(z) a radio link for providing wireless communication with the vehicle.

9. A system (400) as claimed in any one of the preceding claims, wherein the tyre friction monitor is operable to register one or more of the parameters:

(i) tyre pattern design;

(ii) tyre pattern depth;

(iii) tyre manufacturer;

(iv) tyre type, namely winter tyres or summer tyres;

(v) a presence of chains added to the tyres to improve grip.

10. A system (400) as claimed in any one of the preceding claims, wherein said electronic map (500) has pre-stored therein contours of the road (50) over an entire route, said contours include one or more of:

(a) compass directions – *Kr*;

(b) inclination angles – *Sv*;

(c) roll angles – *Kv*; and

(d) high over sea level – *hoh*.

11. A system (400) as claimed in claim 9, wherein the vehicle is equipped with one or more instruments including:

(i) a display (560) for showing navigation information to the driver of the vehicle;

(ii) a measuring device for measuring turning angles and roll angles;

(iii) one or more sensors (530) for measuring air pressure within one or more tyres (130) of the vehicle;

(iv) a measuring device for sensing speed of the vehicle along the road and its distance travelled therealong;

(v) a compass for measuring an orientation of the vehicle relative to the Earth's magnetic poles;

(vi) a radar device for interrogating an external region to the vehicle using microwave radiation;

(vii) a camera for generating one or more optical images of a region external to the vehicle;

(viii) an electrical noise device for sensing electrical noise received at the vehicle;

(ix) a pre-generated electronic navigation map;

(x) a data unit provided with an Internet communication connection;

(xi) a data unit provided with an alternative communication connection;

(xii) a GPS position-determining unit which provides a positional refence in relation to GPS satellite arrangements;

(xiii) a wireless communication connection for providing external communication to the system;

(xiv) an accelerometer for measuring acceleration f the vehicle in one or more directions; and

(xv) an altitude sensor.

12. A system (400) as claimed in any one of the preceding claims, wherein via an GPS system overhead satellite images are communicated to the system for comparison with corresponding pre-stored images of the system for determining driving conditions along the road.

13. A system (400) as claimed in any one of the preceding claims, wherein the system is operable to prevent driving of the vehicle along the road (50) in an event that the system detects that there is insufficient frictional grip onto the road (50).

14. A system (400) as claimed in claim 13, wherein the system is operable to prevent movement of the vehicle when the road (50) is more slippery than an extreme slipperiness threshold arising when the road (50) is covered in wet ice, when the road (50) is covered in oil or chemical, and it is dangerous to activate the vehicle from a parked state, such that an ignition of the vehicle is deactivated such that an engine of the vehicle cannot be brought into operation.

15. A system (400) as claimed in any one of the preceding claims, wherein the weight sensor is coupled onto an exterior surface of each of the vehicle's springs and/or shock absorbers, and on one or more wheels of any trailers attached to the vehicle.

16. A system (400) as claimed in any one of the preceding claims, wherein said system includes a unit for measuring tyre pattern depth, for example via a radar sensor, and an infrared sensor for monitoring a temperature of one or more tyres of the vehicle which can influence in operation grip of the vehicle on the road.

17. A system (400) as claimed in any one of the preceding claims, wherein in a situation where it is not possible to establish satisfactory reference points for acquisition of measurement values in real time, the system is operable to cease executing comparison computations, and wherein the system is operable to notify the driver of the vehicle that the system is not then in an operative state.

18. A system (400) as claimed in claim 1, wherein the system is adapted to execute a selection to ignore sensor signals from one or more sensors, in an event that measurement from one or more of the sensors (530) is of low quality and/or a failure has occurred in respect of one or more of the sensors (530).

19. A method of operating a system (400) as claimed in any on of the preceding claims, said system being operable to control friction levels and road surface grip between tyres (130) of a vehicle and a road surface (200) of a road (50),

characterized in that

said method includes steps of:

(a) utilizing a unit for registering parameters which influence the road surface grip; together with

(b) utilizing means (560) for warning and/or executing action when a lower threshold value for road surface grip is reached.

20. A software product recorded on a machine readable data carrier, said product being executable on computing hardware (520) for implementing a method as claimed in claim 19.

21. A central database apparatus arrangement (800) for use with one or more vehicle-mounted systems (400) pursuant to any one of claims 1 to 18, characterized in that said

database apparatus arrangement (800) is operable to maintain a database (810) including geographical location information (P) and corresponding road frictional information, wherein said database apparatus arrangement (800) is operable:

(a) to receive sensor data and associated positional data indicative of road surface friction conditions from said one or more systems (400) for updating said database (810); and/or

(b) to download sensor data and associated positional data indicative of road surface friction conditions from said database (810) to one or more systems (400) for enabling the one or more systems (400) to warn their users of potential loss of friction and/or implementing braking action to assist vehicles equipped with said one or more systems (400).

22. An apparatus arrangement as claimed in claim 21, wherein communication between said one or more systems (400) and said database apparatus arrangement (800) is implemented via at least one of: mobile wireless communication, Internet connection.

23. A method of operating a database apparatus arrangement (800) as claimed in claim 21, characterized in that said method includes:

(a) receiving sensor data and associated positional data indicative of road surface friction conditions from one or more systems (400) for updating said database (810); and/or

(b) downloading sensor data and associated positional data indicative of road surface friction conditions from said database (810) to one or more systems (400) for enabling the one or more systems (400) to warn their users of potential loss of friction and/or implementing braking action to assist vehicles equipped with said one or more systems (400).

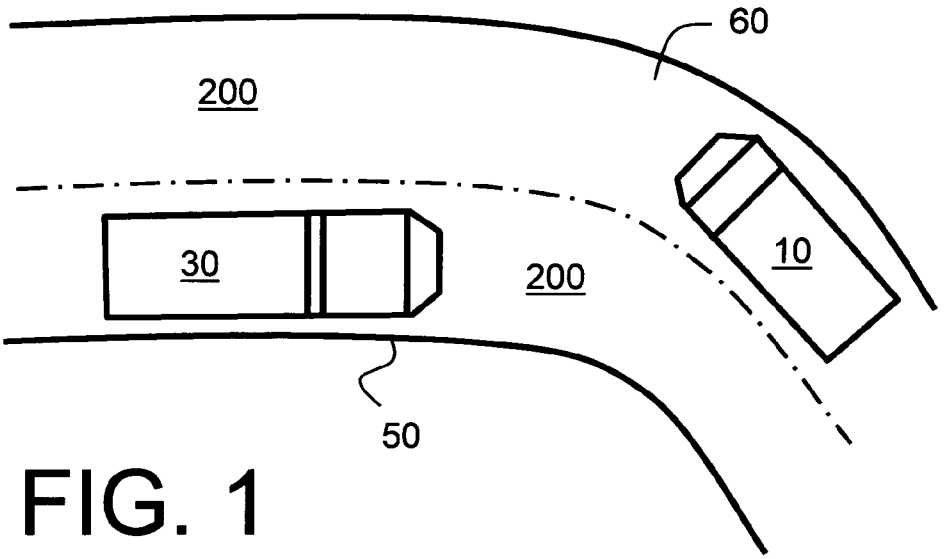

FIG. 1

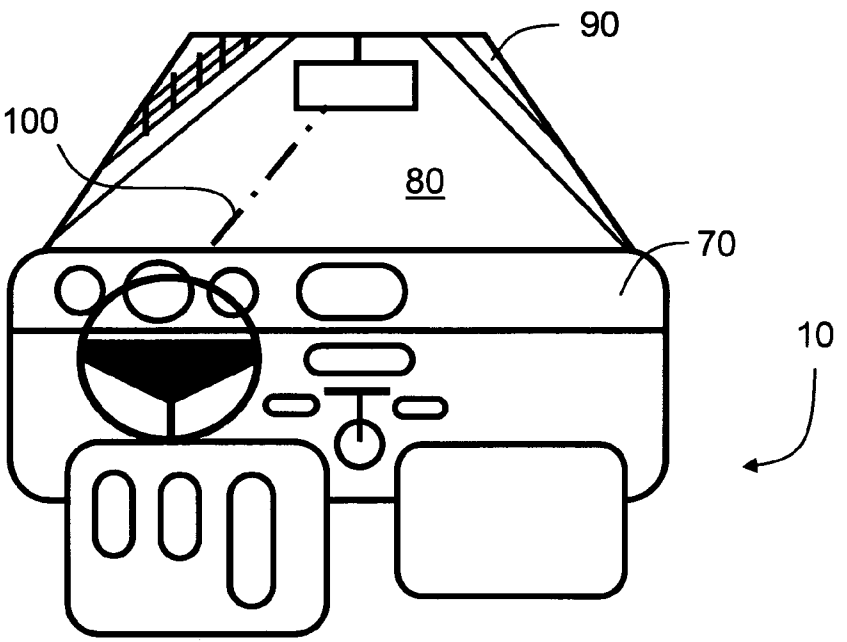

FIG. 2

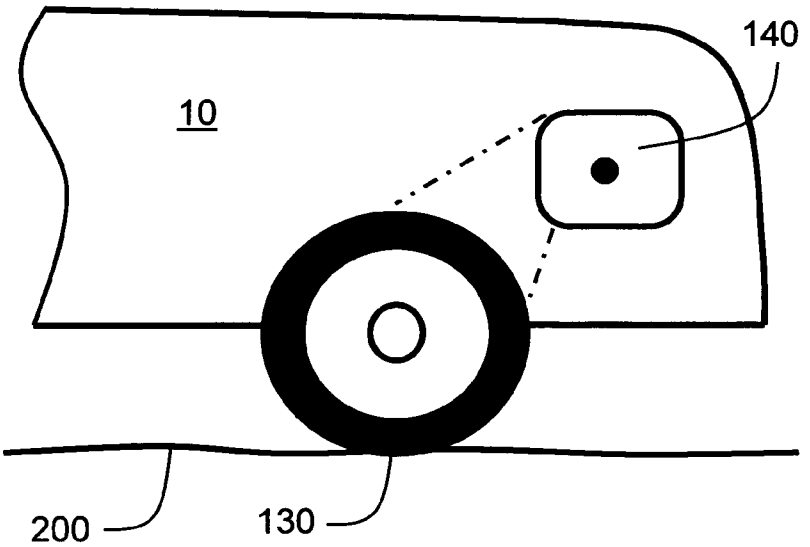

FIG. 3

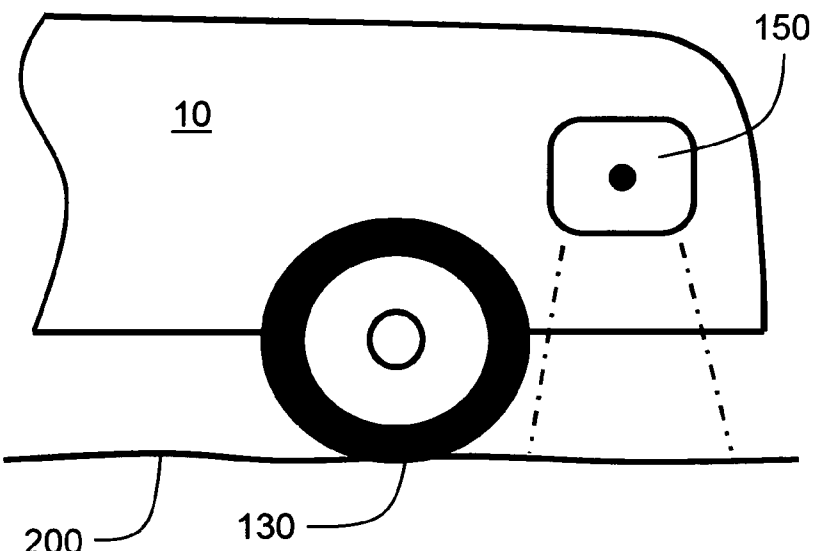

FIG. 4

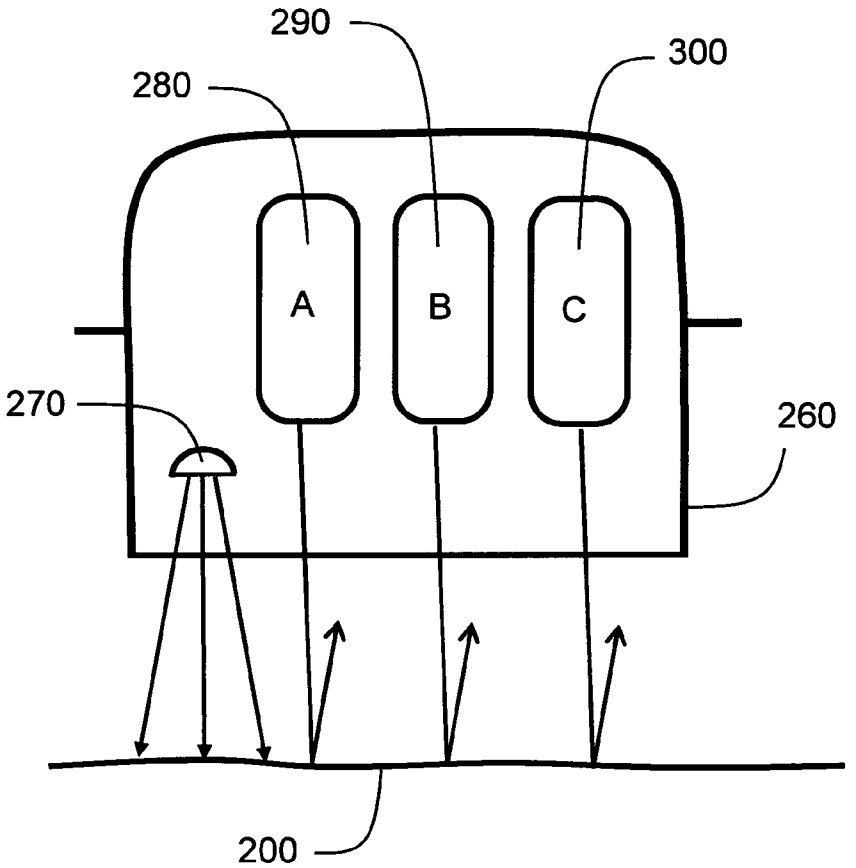

FIG. 5

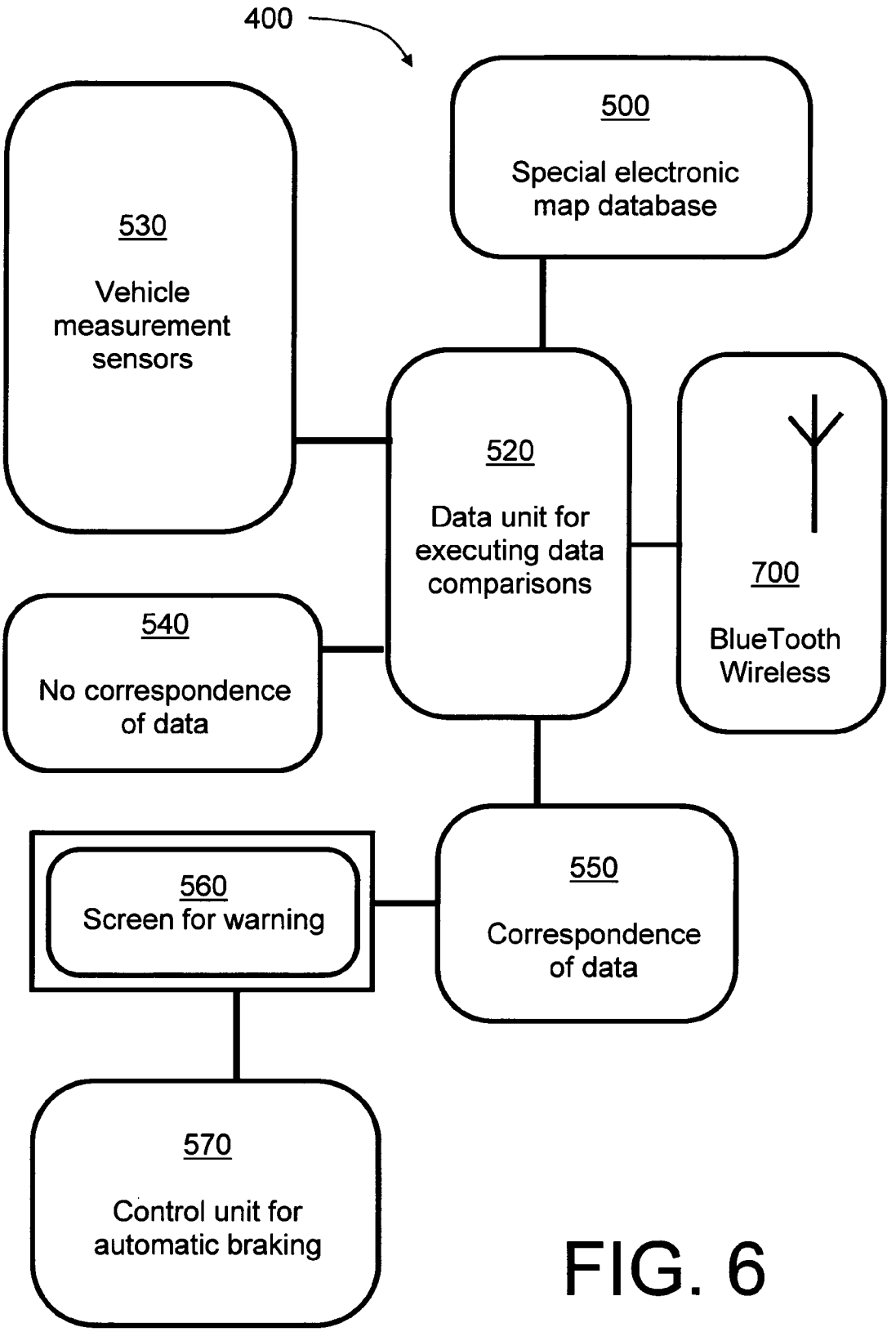
400
500
Special electronic map database
530
Vehicle measurement sensors
520
Data unit for executing data comparisons
700
BlueTooth Wireless
540
No correspondence of data
560
Screen for warning
550
Correspondence of data
570
Control unit for automatic braking

FIG. 6

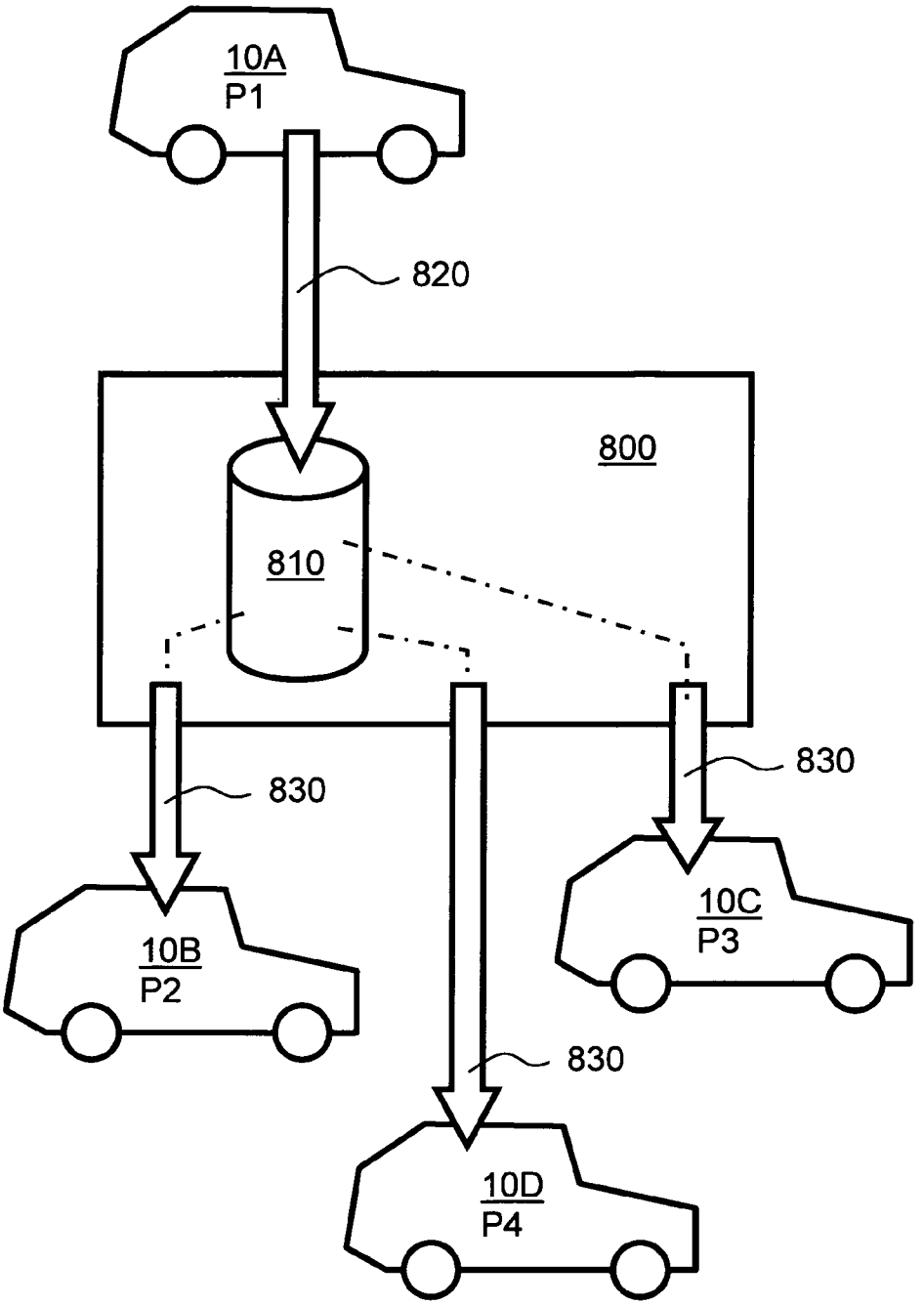

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 2009 000271

A. CLASSIFICATION OF SUBJECT MATTER
B60K 28/16 (2006.01), B60K 28/00 (2006.01), B60T 8/172 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60K, B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NO, SE, DK, FI (classes as above)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/016485 A1 (NEDERLANDSE ORGANISATIE VOOR TOEGEPASTNATUURWE TENSCHAPPELIJK ONDERZOEK TNO) 26 February 2004 (2004-02-26) *The whole document*	1-23
A	US 6173231 B1 (CHOJNACKI, R.) 09 January 2001 (2001-01-09) *The whole document*	1-23
A	EP 1179446 A1 (NISSAN MOTOR COMPANY, LIMITED) 13 February 2002 (2002-02-13) *The whole document*	1-23
A	DE 10126459 C1 (DAIMLER CHRYSLER AG) 16 January 2003 (2003-01-16) *The whole document*	1-23
A	DE 19609488 A1 (HONDA MOTOR CO LTD) 02 October 1996 (1996-10-02) *The whole document*	1-23

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2009	0
Name and mailing address of the ISA/ Nordic Patent Institute Helgeshøj Allé 81, 2630 Taastrup, Denmark Facsimile No. +45 43 50 80 08	Authorized officer Nebojsa Markovic Telephone No. +47 22 38 76 22

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO 2009 000271

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