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(71) Applicant: VOLVO TRUCK CORPORATION [—/SE]; c/o Volvo Business Service AB, Avd. 501842 ARHK5, SE-405 08 Göteborg (SE).

(72) Inventors: LEXÉN, Daniel; Linbanevägen 26, SE-438 35 Landvetter (SE). RYDÉN, Lasse; Ungmästaregatan 33, SE-415 06 Göteborg (SE).

(74) Agent: JÖNRUP, Emil; Volvo Technology Corporation, Volvo Corporate Intellectual Property, Dept: BF14100, M1.7, SE-405 08 Göteborg (SE).

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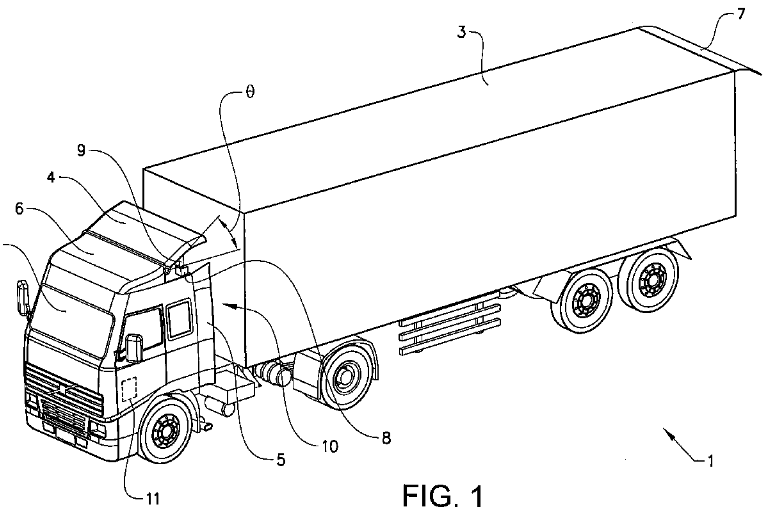

FIG. 1

(57) Abstract: The present invention relates to a system for improving the aerodynamic conditions around a ground traveling vehicle (1), the system comprising a measuring unit (10', 10") configured to measure air aerodynamic conditions, a control unit (11) configured to receive input data from said measuring unit (10', 10"), and at least one adjustable wind deflector (4, 5, 7), wherein the control unit (11) is further configured to generate output data comprising an indication of at least one favorable position of the wind deflector 4, 5, 7 and wherein the measuring unit (10', 10") measures air aerodynamic conditions by measuring the movement of airborne particles. The invention also relates to a ground traveling vehicle (1) comprising the inventive system and a related method for improving the aerodynamic conditions around a vehicle.

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System and method for improving aerodynamic conditions around a ground travelling vehicle

Field of the Invention

The present invention relates to the field of vehicle aerodynamics, and more specifically to a system and a method for improving the aerodynamic conditions around a ground traveling vehicle. In addition, the invention also relates to a ground traveling vehicle comprising the system for improving the aerodynamic conditions.

Background of the Invention

In the art of vehicle design, it is well known that air resistance generates unfavorable forces on traveling vehicles, leading to reduced speed and higher fuel consumption. In motion, the majority of air resistance on a vehicle can be localized to certain areas, such as the front surface of the vehicle (the windshield, hood etc). Another zone especially exposed to air resistance is the area located behind a vertical surface, such as the area behind a vehicle cab or a trailer. Behind this particular area, high air turbulence is present together with a low air pressure, which generate a so called “drag force” on the vehicle. The impact of air resistance to a vehicle represents a substantial amount of the vehicle’s total fuel consumption. Therefore, improvements in the aerodynamic conditions around a moving vehicle may have an important impact on the fuel consumption.

To reduce air resistance, vehicles are often designed with a streamlined and thus more favorable aerodynamic shape. Another common solution is to provide the vehicle with spoilers or wind deflectors so that the airflows around the vehicle can be diverted. On on-highway trucks, wind deflectors are normally located on top of the vehicle cab or positioned vertically along the vertical edges of the cab.

In particular, an on-highway truck often consists of an independent hauling vehicle that can be connected to different trailers. Consequently, the geometry of this “composed” vehicle is often changing and the wind deflectors need to be adjusted each time the truck is being connected to a new trailer.

An example of a vehicle with an adjustable spoiler is disclosed in US 4,810,022. The adjustable spoiler is included in a system, which analyzes a number of external and internal vehicle operating parameters in order to determine if high stability or reduced air resistance should be prioritized, whereby the spoiler is positioned accordingly. Among other sensors included in the system, a cross-wind sensor is mounted at a point particularly exposed to cross-winds. The sensor is enclosed within a housing with internal flow paths, in which the cross-wind airflow is directed and measured by means of pressure sensors.

However, the environment around the vehicle commonly contains contaminants such as dirt, oil and water. A problem with the type of wind sensors as described in US 4,810,022 is a lack of reliability and durability in such harsh conditions.

Hence, there exists a need for a system for improving the aerodynamic conditions around a ground traveling vehicle, which system is not as sensitive to the conditions in which it is utilized.

Summary of the Invention

In view of the above mentioned and other draw-backs of prior art, it is an object of the present invention to provide an improved system and method for reducing the air resistance to a ground traveling vehicle.

According to a first aspect of the present invention, this and other objects are achieved by a system for improving the aerodynamic conditions around a ground traveling vehicle, the system comprising:

- a measuring unit configured to measure aerodynamic conditions,
- a control unit configured to receive input data from the measuring unit, and

- at least one adjustable wind deflector,

wherein the control unit is further configured to generate output data comprising an indication of at least one favorable position of the wind deflector, and wherein the measuring unit measures the aerodynamic conditions by measuring the movement of airborne particles.

The present invention is based on the realization that aerodynamic conditions around a vehicle can be measured and improved. In particular, by measuring the movements of airborne particles, the aerodynamic conditions around the vehicle, in terms of the direction of wind flows and laminar and turbulent flow, can be determined. The measurement of the aerodynamic conditions includes measuring the direction of particles in an air flow. Additionally, the measurement may also include other parameters, such as particle speed, air pressure and/or air density. Moreover, with the present invention, changes in the aerodynamic conditions around a vehicle may be monitored over a period of time. Specifically, the airborne particles typically consist of naturally occurring aerosols, as for instance water droplets, fog, smoke or various pollution particles, which follow the movements of the air. Additionally, the airborne particles may origin in substances from the vehicle, such as heat, noise and condensation water from a HVAC or an air drier system etc. The airborne particles are therefore suitable to be used as trace elements for aerodynamic conditions. Hence, a measuring unit can be arranged to measure the aerodynamic conditions from the movements of airborne particles.

Advantages with the present invention include that aerodynamic conditions can be measured with high accuracy, and that favorable positions of at least one adjustable wind deflector can be determined. A favorable wind deflector position implies a position which generates a minimum drag force on the vehicle, in comparison to other possible positions of the wind deflector, ranging from a minimum to a full deflection. Moreover, the favorable wind deflector position implies an indication of the most favorable wind deflector position in relation to a unique aerodynamic phenomenon in a specific location around the vehicle.

According to an exemplary embodiment of the invention, the measuring unit comprises a Radar arrangement or a Doppler-Radar arrangement.

According to an exemplary embodiment of the invention, the measuring unit comprises a Lidar (Light Detection and Ranging) arrangement or a Doppler-Lidar arrangement.

The Radar and the Lidar measuring units include no exposed moveable parts, in direct contact with the air to be measured. Therefore, these systems are designed to endure the typically harsh environment around a vehicle, accommodating dirt, oil and corrosion. When airborne particles receive a transmitted signal from the Radar or the Lidar arrangement, they reflect the received signal by altering certain modulated frequencies of backscattered signals. In order to profile the wind, the backscattered signal can be analyzed in wind vectors, which give the speed and the direction of the wind. Consequently, aerodynamic conditions can be measured and visualized in three dimensions.

According to an exemplary embodiment of the invention, the measuring unit comprises a pulsed Lidar arrangement or a pulsed Doppler-Lidar arrangement. According to an exemplary embodiment of the invention, the measuring unit comprises a pulsed Radar arrangement or a pulsed Doppler-Radar arrangement. An advantage with a pulsed signal emitting measuring arrangement is that the risk of overloading signal processing circuitry is reduced.

According to an alternative embodiment of the invention, the measuring unit comprises an acoustic signal emitting measuring unit. An acoustic signal emitting measuring unit provides for an alternative signal emitting measuring unit.

According to an exemplary embodiment of the invention, the measuring unit comprises an ionized air measuring unit for measuring the movement of ionized particles in the air. The ionized air measuring unit provides an alternative arrangement for measuring aerodynamic conditions. The ionized air measuring unit measures direction of airborne particles by tracing the particles from their static content. The ionized air measuring unit has a durable design, comprising no moveable sensor parts exposed to the harsh environment around the vehicle.

According to an exemplary embodiment of the invention, the ionized air measuring unit comprises means for introducing particles with an electrical charge into the wind flow. Notably, the movements of the charged particles give rise to an electrostatic field, which in turn creates a measurable electric charge. Consequently, the direction of the wind may be measured by the position of and change in electric charge.

According to an exemplary embodiment of the invention, the introduced particles comprise water droplets.

According to an exemplary embodiment of the invention, the system is further comprising:

- an adjustment device operable by the control unit,
- actuating means connected to at least one variable wind deflector and displaceable by the adjustment device,

wherein the actuating means is adapted to displace the variable wind deflector to a favorable position, as indicated by the control unit. In particular, the adjustment device may be any device which is capable of providing a motion to a wind deflector, such as a mechanical, pneumatic or hydraulic device. The adjustment device may for instance comprise a mechanical, pneumatic or hydraulic drive motor arrangement. Another example of an adjustment device is a “parasitic system”, which is in connection with and extracts energy from other mechanical, pneumatic or hydraulic vehicle systems. The adjustment device and actuator system allows for an automatic wind deflector adjustment. Less time and effort is then required for the driver to manually measure and adjust the wind deflectors, whereas some are especially difficult to access, like e.g. the roof-mounted cab deflector. Moreover, the adjustment of the wind deflectors is ensured to be accurately performed, independently of the technical skills of the driver.

According to a second aspect of the invention, it relates to a ground traveling vehicle comprising the system in accordance with the first aspect of the present invention. According to one exemplary embodiment, the wind deflector may be mounted to a vehicle body at a fixed location by pivotal fastening means. The pivotal fastening means allows for a variable wind deflector position, defined by an angle or a displacement of the wind deflector in relation to the vehicle body.

According to an exemplary embodiment, the ground traveling vehicle is a truck vehicle adapted to haul a trailer or a trailer adapted to be hauled by a truck and wherein the measuring unit is provided on either the truck or the trailer. The truck vehicle can for example be a highway truck which is either connectable to a trailer in a releasable manner or rigidly connected with the trailer.

According to an exemplary embodiment, the measuring system is mounted in the space between the vehicle and the trailer. Such a placement is beneficial since it is a well-suited position for measuring aerodynamic conditions.

According to an exemplary embodiment, an emitted signal from the Radar or Lidar arrangement is directed towards a point on the surface of the trailer, which surface is directed towards the truck which is located between a truck and a trailer.

The space between the truck and the trailer is characterized by high turbulence levels. While the vehicle is also being subject to turbulence on other surfaces, the turbulence that is present between the two vehicles is especially inconvenient in terms of air resistance and drag forces acting upon the vehicle.

According to an exemplary embodiment, an emitted signal from the Radar or Lidar arrangement is directed along at least one of the sides of the vehicle, parallel or at an angle in regards to the travel direction of the vehicle. By this measurement, the aerodynamic conditions next to the vehicle can be measured and a favorable position for vertical side-mounted deflectors can be determined.

According to an exemplary embodiment, the invention relates to a ground traveling vehicle, wherein an ionized air measuring unit is arranged in a space between the truck and the trailer. As mentioned above, the space between the truck and the trailer is both an area protected from potential impact and is characterized as a high turbulence space.

According to an exemplary embodiment, the ionized air measuring unit is mounted on a lower chassis on a truck vehicle or a trailer. Advantages include that the aerodynamic conditions under the vehicle can be measured. Moreover, if there are wind deflectors under the vehicle, their favorable positions may be determined.

According to another exemplary embodiment, the system comprises several measuring units, which are arranged at different locations of the vehicle. As the vehicle may be provided with several wind deflectors and the impact and magnitude of the aerodynamic conditions may vary at different points around the vehicle, the measuring units may be mounted and arranged to measure in different points with high turbulence.

According to an exemplary embodiment, the wind deflector is provided on the roof of a truck cab.

According to a third aspect of the present invention, it relates to a method for improving the aerodynamic conditions around a ground traveling vehicle with at least one variable wind deflector, comprising the steps of:

- measuring the movement of particles in air surrounding the vehicle,
- determining aerodynamic conditions based on the measurement of said movement of particles,
- determining a favorable position of said at least one variable wind deflector.

The advantages of the method are substantially analogous with the advantages of the first aspect of the present invention. Advantages include that aerodynamic conditions can be measured with high accuracy, and that favorable positions of at least one wind deflector is continuously determined by a real-time evaluation of the present aerodynamic situation.

According to an exemplary embodiment, the step of determining a favorable position of the at least one adjustable wind deflector is followed by a step of positioning at least one adjustable wind deflector in a favorable position.

According to an exemplary embodiment, the steps of measuring the movement of particles in air surrounding the vehicle, determining aerodynamic conditions based on the measurement of said movement of particles, and determining a favorable position of said at least one adjustable wind deflector are repeated continuously as the vehicle is operated. By repeating the measurement, the position of the wind deflector can be continuously evaluated in relation to the present aerodynamic situation. Moreover, the measurement values may be either average values or a momentary peak values.

In an exemplary embodiment, the measurement of the aerodynamic conditions is executed at fixed intervals when the vehicle is in motion, to continuously ensure that the wind deflector is in a favorable position. This means that the favorable positions are either revalued during the entire trip, or during certain cyclic times. Further, the favorable positions may also be revaluated at relevant ranges of vehicle speed. In an exemplary method, the measurement is initialized when the vehicle has reached the relevant speed range for measurement, i.e. when the vehicle has reached a certain speed where the advantages of a correct wind deflector positioning are noticeable.

In another exemplary embodiment, the calculation, determination and positioning of a wind deflector position in a favorable position is activated when the received measurement values exceed reference values defined in a moving average filter. If the measurement includes more than one measurement series, the biasing effect from temporary influences, such as e.g. shear winds or turbulence from other vehicles can be reduced. According to an exemplary embodiment, the measurement may be coordinated with the movement of the wind deflector between a first position, in which the deflector is completely deactivated to a second position, in which the deflector is set at full deflection. The coordinated measurement and deflector movement enables the system to measure the aerodynamic conditions as a function of the deflector position. This simulation function may be performed at the beginning of the trip, or when the vehicle reaches a certain speed.

According to an exemplary embodiment, the step of positioning the at least one adjustable wind deflector into a favorable position is executed if the same favorable position has been determined at least two consecutive times. If the favorable wind deflector position is based on more than one measurement, the biasing effect from temporary influences, such as e.g. shear winds or turbulence from other vehicles can be reduced.

According to an exemplary embodiment, the step of determining a favorable wind deflector position may only be performed after the detected levels of aerodynamic conditions are exceeding predetermined threshold values. In particular this results in less data load on the control unit and consequently a faster and more reliable processing capability.

According to an exemplary embodiment, the movement of particles is measured by means of a Radar or Lidar measuring arrangement. The Radar and Lidar measuring systems include no exposed moveable parts, in direct contact with the air to be measured. Therefore, the system is designed to endure the typically harsh environment around a vehicle, including e.g. dirt, oil and corrosion.

According to another embodiment, the step of measuring the movement of particles comprises:

- ionizing particles in air surrounding the vehicle, and
- measuring the movement of at least some of the ionized particles by means of an ionized air measuring unit.

By measuring the movement of particles, an alternative method for measuring aerodynamic conditions may be applied to the present invention. If the measurement of aerodynamic conditions is required in a well-defined and specific zone, the method including the measurement of ionized particles may be performed with advantage.

Brief description of the drawings

The invention will now be described in more detail with reference to the accompanying drawings, which by way of example illustrate the present invention and in which:

Fig. 1 is a schematic perspective view of a vehicle equipped with the inventive system,

Fig. 2 is a schematic side-elevation view of a vehicle equipped with the inventive system according to an exemplary embodiment,

Fig. 3 is a schematic side-elevation view of a vehicle equipped with the inventive system according to another exemplary embodiment,

Fig. 4 is a flowchart of an exemplary method for improving the aerodynamic conditions around a vehicle.

Fig. 5 is a flowchart of another exemplary method for improving the aerodynamic conditions around a vehicle.

Detailed description of the drawings

In the following description, the present invention is described with reference to an on-highway truck vehicle. It should be noted that this by no means limits the scope of the present invention, which is equally applicable on other types of ground traveling vehicles, such as busses, cars, utility vehicles, machinery and off-road machinery. Moreover, the present invention is also applicable for the above mentioned ground traveling vehicles in combination with connected trailers. Moreover, and in particular, the present invention is especially useful for vehicles as their travel speed exceeds 45 km/h.

Fig. 1 shows a vehicle 1 in a configuration consisting of a highway truck 2 releasably connected to a trailer 3. In this particular illustration, several wind deflectors for diverting the airflow around the vehicle are mounted at different positions; one top deflector 4 on the roof 6 of the vehicle cab, two side deflectors 5 located on each side of the cab and a deflector 7 at the rear end of the trailer 3. However, it is also possible to arrange either more or less wind deflectors. The wind deflectors 4, 5, 7 may be manufactured from any resistant material, such as metal or plastics. Preferably the material should be of light weight. The wind deflectors 4, 5, 7 are pivotally mounted in relation to the vehicle 1, in such a way that each deflector 4, 5, 7 can be adjusted in various positions. In order to fix the wind deflector 4, 5, 7 in a certain position, a locking member (not illustrated) is connected to the wind deflector 4, 5, 7. The locking member ensures that the deflector 4, 5, 7 is immovable even when it is subject to an applied force/load from air resistance. In the following, the present invention will be described in relation to the roof-mounted wind deflector 4. In this embodiment, an adjustment device in the form of a drive motor 8 is operably connected to the wind deflectors 4 through at least one actuator 9, which enables the wind deflector 4 to be automatically adjusted, whereby the angle θ between the vehicle 1 and the deflector 4 can be set. Not illustrated in the drawings, but the wind deflectors 5, 7 mounted on the vehicle may also be connected to adjustment arrangements by which their respective angle relative the vehicle body may be adjusted. There are several possible designs for a locking member for holding the wind deflector at a fixed position in relation to the vehicle; it may be e.g. an individual arrangement or a component in co-operation with the actuator 9.

In line with an object of the invention, the deflector 4 should be positioned in a favorable position, i.e. a position that generates a low turbulence level. If the turbulence level is kept at a minimum, it also implies that the associated drag-forces will be at a minimum, which in turn contributes to lower the fuel consumption. In the present invention, the favorable positions are determined by means of a measuring unit 10 and a control unit 11. In particular, the measuring unit 10 is adapted to measure the direction of airborne particles, and to transmit the measuring data to the control unit 11. Notably, the direction and behavior of airborne particles is a relevant air flow characteristics for determining an optimal deflector position. The measuring unit 10 will be further explained in relation to different embodiments of the present invention. The control unit 11 is adapted to perform further calculations from the measurement data, in order to determine different levels of aerodynamic conditions, drag forces, favorable deflector positions and generate aerodynamic output data.

Fig. 2 shows an exemplary embodiment of the present invention, comprising a non-contact signal emitting measuring unit 10' for measuring the speed and direction of particles in the air surrounding the vehicle 1. The signal emitting measuring unit 10' may consist of a Lidar arrangement, emitting infrared laser light signals, a Radar arrangement, emitting electromagnetic reference signals, or an acoustic signal emitting arrangement. Both the Radar and the Lidar systems are based on the principle that an emitted reference signal 14 is reflected on airborne particles. The movement of these particles alters a certain reflected signal, which can be received by a detector and receiver unit in the measuring unit. A processing circuitry in the measuring unit is arranged to further analyze the received signal, whereby the radial wind speed and direction can be measured. The measuring unit 10' may be mounted, as illustrated, on the rear vertical side 21 of the vehicle cab, in-between the truck 2 and the trailer 3.

In order to determine the major aerodynamic forces acting upon the vehicle, the measuring unit 10' is directed to points where high turbulence is typically generated. Points with high turbulence are normally concentrated to the space located directly behind the vehicle cab as well as the space behind the rear surface of the trailer. A measuring point can be selected by directing the signal to a point 15, located close to the upper edge of the trailer. However, there can be other turbulent extreme points that depend on the aerodynamic shape of the vehicle, which can be determined through e.g. field tests and included for measurement.

If the need of measuring aerodynamic conditions is concentrated to one point or one restricted space, the system may comprise one coherent part. Alternatively, separate remote sensing means, comprising the signal transmitter and receivers can be mounted at several positions, and directed to measure into points with high turbulence, while the measuring unit's processing circuitry and the control unit 11 may be arranged in a central location.

Fig. 3 illustrates another exemplary embodiment of the measuring unit according to the present invention. An ionizing air measuring unit 10" is mounted in a space, typically exposed to high turbulence, such as the space behind the rear vertical wall of a highway truck. In particular, the ionizing measurement unit 10" detects the presence and magnitude of aerodynamic conditions, which are concentrated to a particular point or space around the truck. The ionizing air measuring unit 10" comprises a housing 16 with internal flow channels. An ionizing device 18 may be centrally arranged inside the housing 16 or at the inlets 17 of the flow channels and is adapted to electrically ionize the airborne particles. Additionally, a supplementary amount of airborne particles may be generated by means 20 for introducing a mist of particles into the wind flow as it enters the channels. The particles may be provided with a modified electric charge, which differs in relation to the non-modified and naturally occurring particles in the air surrounding the vehicle. In particular, the modified electric charge may be either a positive charge or a negative charge. Moreover the mist of particles may comprise water droplets.

Sensors 19 mounted at the inlet 17 and outlet 17' of the flow channels are configured to trace the movement of the ionized particles.

The ionizing air measuring unit 10" is adapted to measure aerodynamic conditions by first receiving the wind in the flow channels and in a following step ionizing the naturally occurring particles in the airflow, whereby the direction and ionic charge characteristics of the particles may be traced. The sensors 19 mounted at the inlets 17 and outlets 17' of the flow channels are in connection with an electrostatic field detector, which is adapted to measure the voltage or power differential of the electrical field such that the measured values relate to the direction of the particles as they travel through the flow channels.

In both embodiments described above, the measurement unit 10', 10" provides measurement data in terms of the travel direction of airborne particles. The measurement data is communicated to the control unit 11, which determines the aerodynamic conditions. Based on the levels of the aerodynamic conditions, the control unit 11 also determines favorable deflector positions and displacement distances needed to adjust the deflectors 4 to the favorable position. In order to analyze the measurement data, determine favorable deflector positions and displacement distances, the control unit 11 may be in communication with a central vehicle control unit 22 for performing cross-checks with other vehicle operating parameters such as speed, acceleration and geometric deflector surface data.

The output data from the control unit 11 may be communicated back to the central vehicle control unit 22 and/or to a user interface 23. Moreover, the control unit 11 may be adapted to calculate the required displacement of the actuator 9 and activate the displacement of the actuators, in order to reach favorable wind deflector positions.

The control unit 11 may be mounted in an accessible place, protected from dirt, corrosion, wind and other deteriorating conditions. Therefore, as illustrated in fig. 2, the control unit 11 may be mounted inside the cab or in the engine compartment of the vehicle.

The system has been described as comprising an automatic wind deflector adjustment function. Nevertheless, in an alternative (not shown) embodiment, the described drive motor and actuator arrangement may be excluded, whereby the adjustment operation of the wind deflectors is performed manually. This could be an advantage for systems with few wind deflectors, where less components and attachments are required.

In fig. 4, an exemplary method for improving the aerodynamic conditions around the ground traveling vehicle is illustrated in a schematic flow chart, and will be described hereafter. This exemplary method is based on a Radar or Lidar measurement method.

The measuring system is first activated in a step S1, when the truck reaches a certain predetermined speed. In a second step S2, the measuring unit 10', is measuring the movement of airborne particles in the air surrounding the vehicle. Preferably, the measuring unit is performing a consistency check of at least two consecutive measurement series within a short time interval.

In a following step S3, the measurement data is communicated to the control unit 11, which determines the actual data for the aerodynamic conditions, based on the speed and direction of the airborne particles. Additionally, the Radar or Lidar system may include other parameters for measurement, such as air pressure, air temperature and air density. The control unit 11 profiles the wind such that the aerodynamic conditions in the airflows adjacent to the vehicle are determined. Following, in step S4, the actual data on the aerodynamic conditions is compared to a predetermined set of rules in order to determine and classify the turbulence level. The predetermined set of rules may either be predetermined values, which are based on the conceptual data of the vehicle 1 and may for example comprise ranges of air flow values, classified as normal, high or low in relation to the laminar and turbulent air flow. The predetermined set of rules for air flow intensity is linked to variable vehicle operating parameters, such as speed, and acceleration. In order to determine the air flow level, the control unit 11 is communicating with at least one central vehicle control unit (ECU) for obtaining the required information in regards to the variable operating parameters. In a practical example, corrective action will be taken by the system if the air flow level exceeds the “normal” value range in respect to turbulent and laminar flows.

The step S5 of determining a favorable position of at least one variable wind deflector 4 is initialized after the air flow level is determined in relation to the predetermined set of rules. The wind profile data comprising speed and direction of the airflows together with geometric data on the wind deflector are processed together in the control unit 11 in order to determine a favorable wind deflector position. In a following step S6, the wind deflector 4 may be positioned in the favorable position. The measurement may be activated regularly at certain intervals by means of a time-based loop, so that the favorable position is continuously evaluated and adapted to present aerodynamic situations. As an alternative, the step of determining a favorable wind deflector position may only be performed after air flow levels are defined as “high” in respect to laminar and turbulent flows; in particular this results in less data load on the control unit and consequently a faster and more reliable processing capability. Additionally or alternatively, the system may detect when the air flow level is increasing in terms of turbulence and the setting of the wind deflector starts deviating from an optimal setting. Following, the detection of the deviation, the system may automatically initiate and perform a corrective flow measurement and positioning of the wind deflector.

On the other hand, when the movement of ionized particles is measured by an ionizing air measuring unit 10", it implies a few modifications to the exemplary method as previously described in relation to fig. 4. In particular, the travel direction of airborne particles may be a unique representative value of particle movement. Consequently, the aerodynamic condition, in terms of the direction of the airflows, at the specific measurement location adjacent to the ionizing air measuring unit 10" can be determined. Moreover, the aerodynamic condition in terms of the direction of the wind flows may be classified in relation to normal/predetermined air flow directions at an optimal wind deflector positioning. Following, the step of determining a favorable wind deflector position can be performed in a similar manner as described in relation to fig. 4, except from that the wind profile data is only based on the direction of the airborne particles. Thereafter, the wind deflector is positioned in a favorable position. The measurement may also be activated regularly at certain intervals by means of a time-based loop, such that the favorable position is continuously evaluated and adapted to present aerodynamic situations.

An example of another exemplary method is illustrated in fig. 5, which is based on the previous method, with a few modifications. In a first step S11, the measuring system is either automatically or manually activated. In a second step S12, the wind deflector 4 is positioned in an initial position, i.e. a deactivated and horizontal position. In a third step S13, the movement of airborne particles in the air surrounding the vehicle 1 is measured. During the step of measuring the movement of airborne particles, the wind deflector 4 is gradually raised, which enables the system to measure actual values of the aerodynamic conditions based on actual deflector positions. In a fourth step S14, the aerodynamic conditions are calculated. In a fifth step S15, the captured data of the aerodynamic conditions is compared to a predetermined set of rules, which may be predetermined values which are based on conceptual data and may comprise ranges of air flow values, classified as normal, high or low in respect to the principles of laminar and turbulent flow. The predetermined rules for air flow intensity are linked to variable vehicle operating parameters such as speed and acceleration.

In a following step S16, the air flow data is adjusted based on calibration factors, which typically depend on the vehicle characteristics, such as the effect from the variable shape of the wind deflector 4, variations in wheel alignments and etc. Additionally or alternatively, the air flow data is adjusted based on an experience factor. The experience factor may correct the air flow data by adding trends of typical variations, which are not related to the vehicle 1 itself, but to the surroundings, such as the typical variations in the cargo/load. For instance, the experience factor may describe how the location of the load is typically shifting in the trailer 3. The experience factor may also be generated by continuously collecting and storing data in a database, such that an adaptive sensibility may be built up and calculated from the data.

In a further step S17, the favorable wind deflector position is determined. Following that, in step S18, the system controls if the favorable position lies within or outside the geometrically accessible range of the wind deflector 4. If the favorable wind deflector position can be reached, the wind deflector 4 is moved into and locked in the desired position in a following step S19. Thereafter, in step S20, the deflector position may be verified/re-checked at a regular time interval (for instance every 30 min) to avoid an excessive data load from a continuous measurement and thus provide for a better stability in the system. The check involves a time-based loop of checking that the actual geometric position of the wind deflector 4 corresponds to the measured favorable position. The system may save the favorable position and refer to it for a certain time interval. A second check is performed in a following step S21 at another (longer time interval), and includes a complete measurement series to re-evaluate the favorable deflector position. For instance, changes in the vehicle's gross weight may result in that the experience factor will be re-calculated. Alternatively, the favorable position is determined at one time only, and then kept until a new measurement is actively initiated by the vehicle operator. In a final step S22, the measuring system is deactivated, either automatically or manually.

However, if the favorable position cannot be reached as determined in step S18, the wind deflector may be reset to an initial position in a step S19'. The initial position may be a deactivated (i.e. a horizontal position) or a default position, which may be considered as a position that on the average provides for a minimized drag force on the vehicle. The default position may be a predetermined position, based on conceptual data for the vehicle 1. If the favorable position may not be reached, the system may be allowed to deactivate and the re-check time parameter is turned off in a step S20'.

The skilled person will realize that the present invention by no means is limited to the described exemplary embodiments. For example, another possibility is that the different measurement functions may be manually activated and/or deactivated by the driver. For example if the truck and trailer combination remains unchanged and the load is essentially unchanged, the driver might want to deactivate the functionality. It can also be that the operator wants to activate the system at a specific point in time, in order to reassure that the wind deflectors are in a favorable position.

Other possible modifications include that the measuring arrangement may have different mounting locations on the vehicle. For instance, one or several measuring units may be mounted on the lower chassis of the vehicle if there is need to determine the aerodynamic conditions under the vehicle or around the vehicle's chassis.

The scope of the present invention also includes possibilities to arrange a dedicated measuring unit for any type of wind deflector mounted in any location on the vehicle. Hence, a vehicle may be provided with a plurality of measuring units and wind deflectors. Additionally, the arrangements related to the drive motor, actuator and locking may be designed in various ways and should therefore not be limited to the examples particularly discussed in this disclosure.

The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS

1. A system for improving the aerodynamic conditions around a ground traveling vehicle (1), said system comprising:

a measuring unit (10, 10', 10") configured to measure aerodynamic conditions,

a control unit (11) configured to receive input data from said measuring unit (10, 10', 10"), and

at least one adjustable wind deflector (4, 5, 7),

wherein the control unit (11) is further configured to generate output data comprising an indication of at least one favorable position of said wind deflector (4, 5, 7), and

wherein the measuring unit (10, 10', 10") measures the aerodynamic conditions by measuring the movement of airborne particles.

2. A system according to claim 1, wherein the measuring unit (10') comprises a Radar arrangement or a Doppler-Radar arrangement.

3. A system according to claim 1, wherein the measuring unit (10') comprises a Lidar or a Doppler-Lidar arrangement.

4. A system according to claim 1, wherein the measuring unit (10") comprises an ionized air measuring unit for measuring the movement of ionized particles in the air.

5. A system according to any one of the preceeding claims, further comprising:

an adjustment device (8) operable by the control unit (11),

actuating means (9) connected to the at least one adjustable wind deflector (4, 5, 7), and displaceable by the adjustment device (8),

wherein the actuating means (9) is adapted to displace the adjustable wind deflector (4, 5, 7) to a favorable position, as indicated by the control unit

(11).

6. A ground traveling vehicle (1), comprising the system according to any one of the preceding claims.

7. A ground traveling vehicle (1) according to claim 6, wherein the ground traveling vehicle is a truck vehicle (2) adapted to haul a trailer (3), or a trailer (3) adapted to be hauled by a truck (2), and wherein the measuring unit (10) is provided on either the truck (2) or the trailer (3).

8. A ground traveling vehicle (1) according to claim 7, wherein an emitted signal (14) from the Radar or Lidar arrangement is directed towards a point (15) on the surface of the trailer (3), which surface is directed towards the truck (2).

9. A ground traveling vehicle (1) according to claim 7, wherein the ionized air measuring unit (10") is arranged in a space between the truck (2) and the trailer (3).

10. A method for improving the aerodynamic conditions around a ground traveling vehicle (1) with at least one adjustable wind deflector (4, 5, 7), comprising the steps of:

measuring the movement of airborne particles in air surrounding the vehicle (1),

determining aerodynamic conditions based on the measurement of said movement of airborne particles,

determining a favorable position of said at least one adjustable wind deflector (4, 5, 7).

11. A method according to claim 10, wherein the step of determining a favorable position of the at least one adjustable wind deflector (4, 5, 7) is followed by a step of positioning said at least one adjustable wind deflector (4, 5, 7) in said favorable position.

12. A method according to any one of claims 10-11, wherein the steps of measuring the movement of particles in air surrounding the vehicle, determining aerodynamic conditions based on the measurement of said movement of particles, and determining a favorable position of said at least one adjustable wind deflector (4, 5, 7) are repeated continuously as the vehicle (1) is operated.

13. A method according to any one of claims 10-12, wherein the step of positioning said at least one adjustable wind deflector (4, 5, 7), into said favorable position is executed if the same favorable position has been determined at least two consecutive times.

14. A method according to any one of claims 10 – 13, wherein the movement of particles is measured by means of a Radar or Lidar measuring arrangement (10').

15. A method according to any one of claims 11 – 13, wherein the step of measuring the movement of particles comprises:

ionizing particles in air surrounding the vehicle (1), and

measuring the movement of at least some of the ionized particles by means of an ionized air measuring unit (10").

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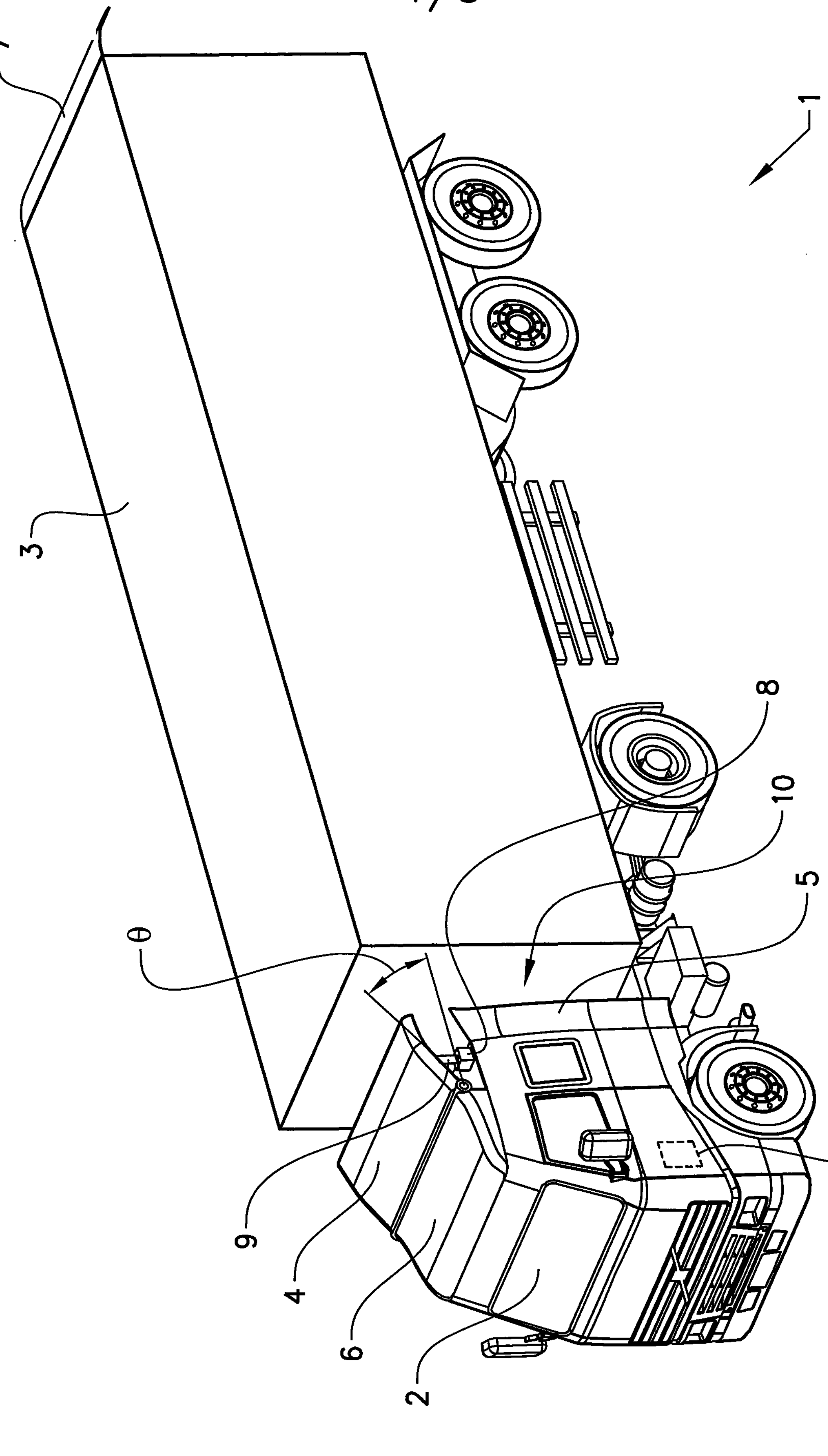

FIG. 1

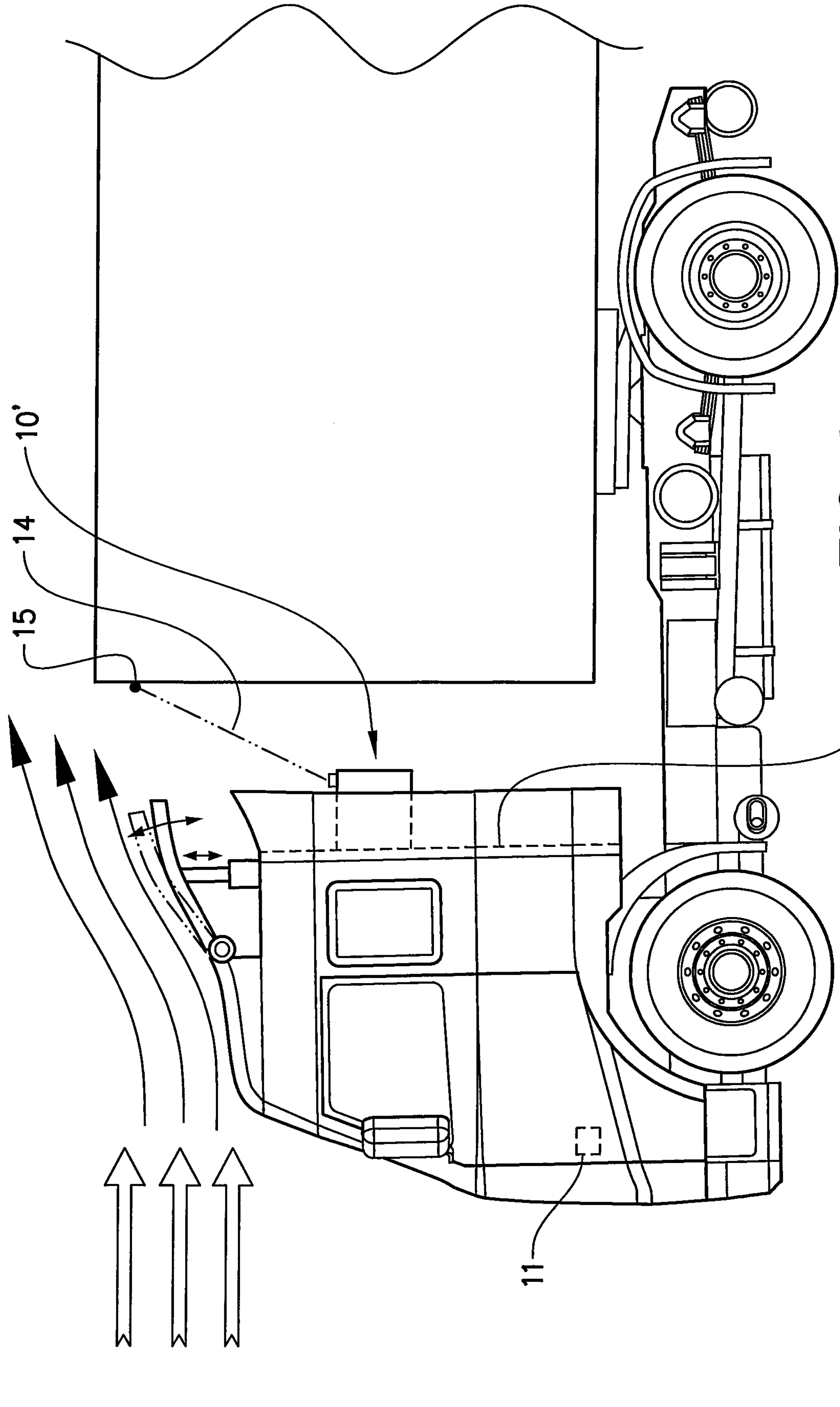

FIG. 2

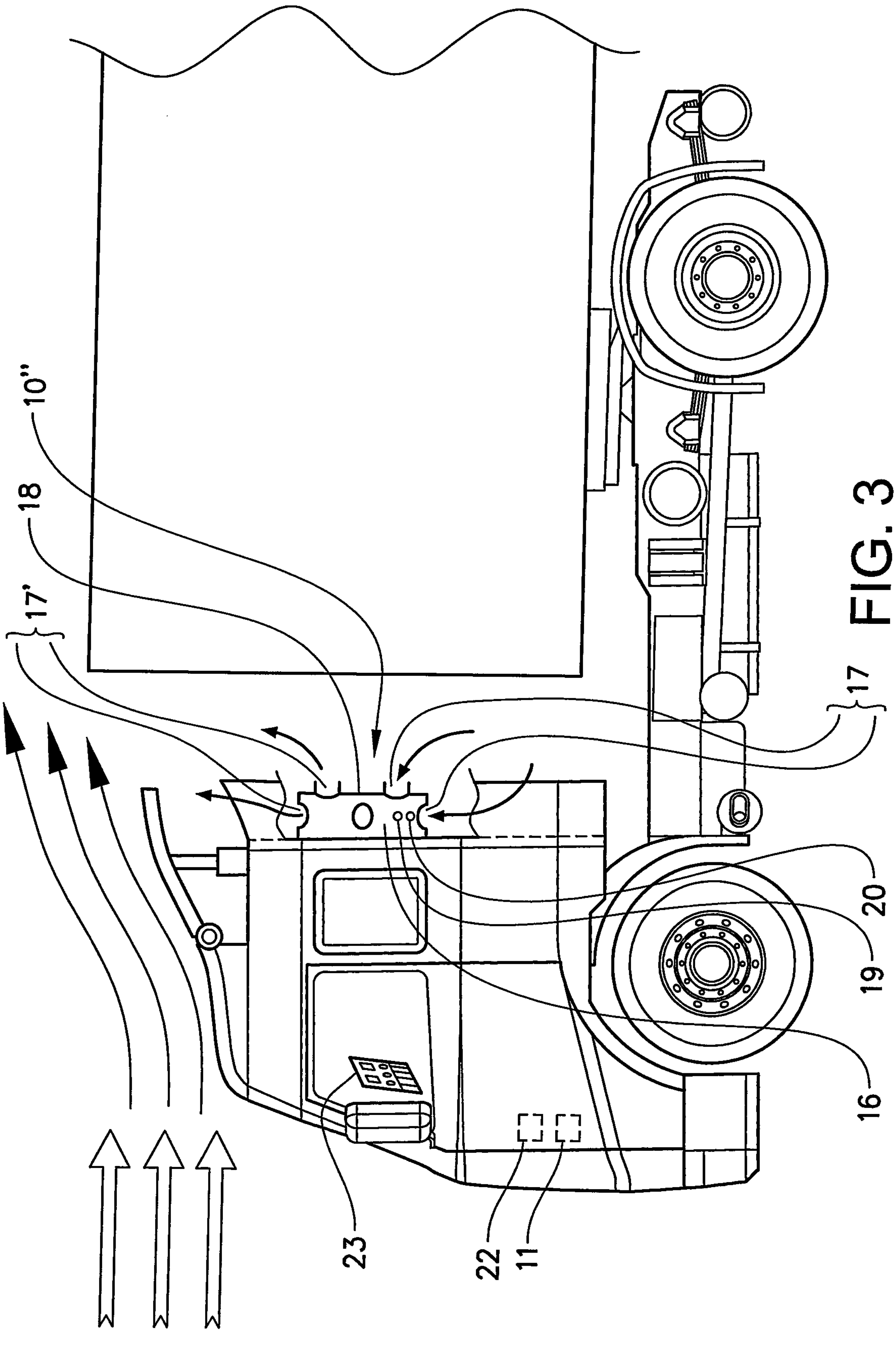

FIG. 3

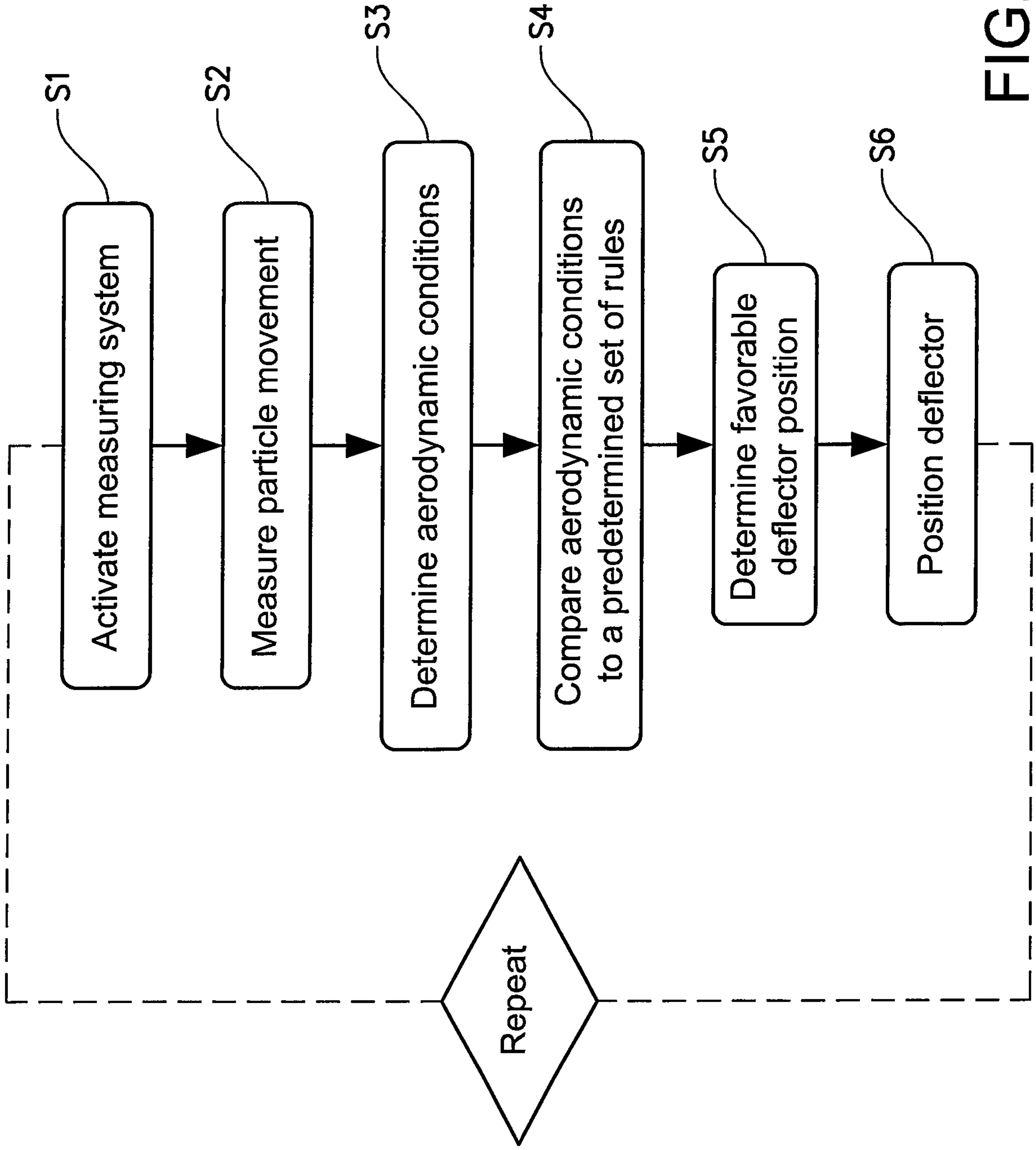
S1
Activate measuring system
S2
Measure particle movement
S3
Determine aerodynamic conditions
S4
Compare aerodynamic conditions to a predetermined set of rules
S5
Determine favorable deflector position
S6
Position deflector
Repeat

FIG. 4

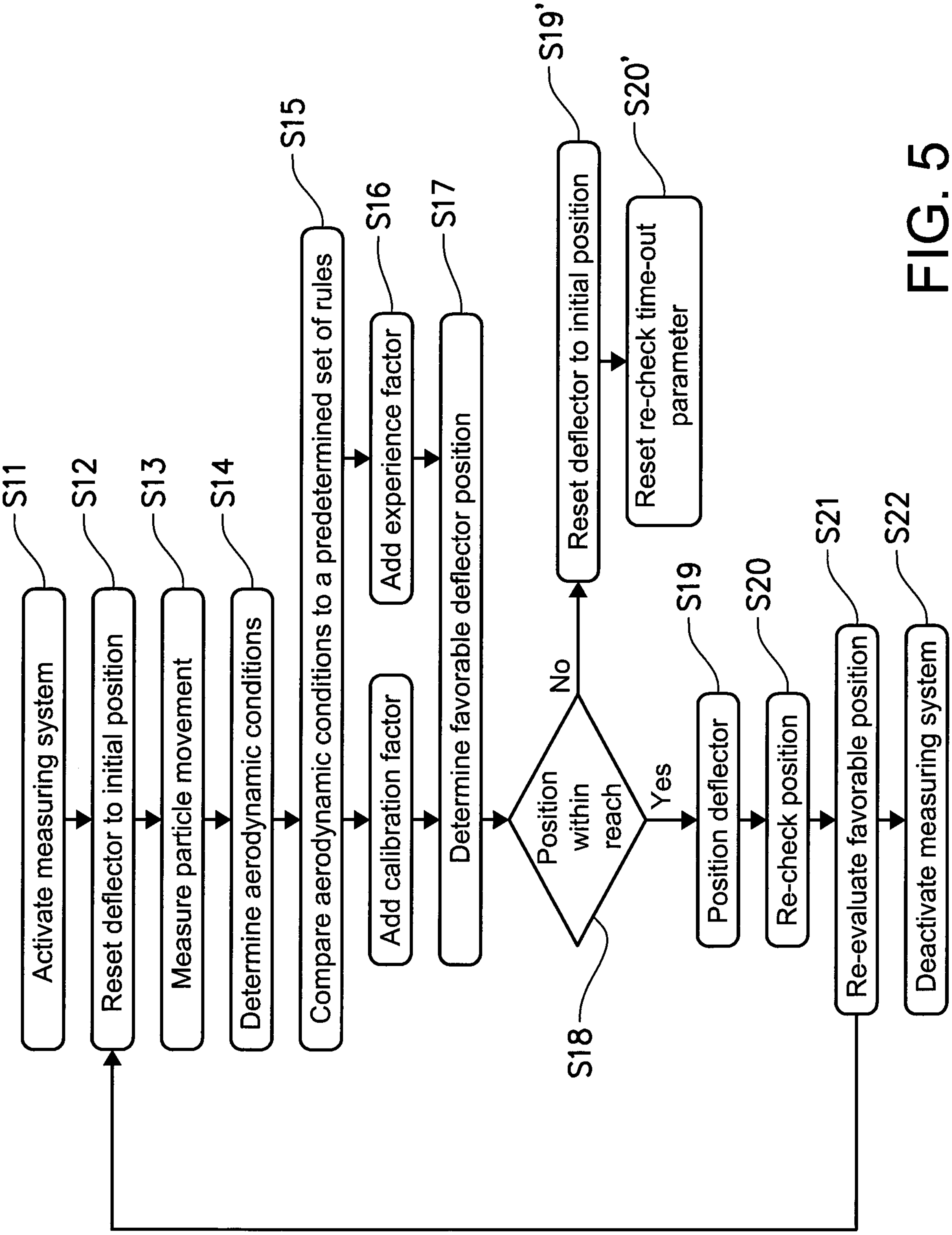
S11
Activate measuring system
S12
Reset deflector to initial position
S13
Measure particle movement
S14
Determine aerodynamic conditions
S15
Compare aerodynamic conditions to a predetermined set of rules
S16
Add calibration factor
Add experience factor
S17
Determine favorable deflector position
S18
Position within reach
No
Yes
S19'
Reset deflector to initial position
S20'
Reset re-check time-out parameter
S19
Position deflector
S20
Re-check position
S21
Re-evaluate favorable position
S22
Deactivate measuring system

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/000029

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B62D, G01M

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20110035119 A1 (SANDGREN ERIC), 10 February 2011 (2011-02-10); whole document --	1-15
A	GB 2435246 A (DECOMA U K LTD), 22 August 2007 (2007-08-22); whole document --	1-15
A	US 20090248242 A1 (COHEN SAMUEL L ET AL), 1 October 2009 (2009-10-01); whole document --	1-15
A	US 20030227194 A1 (FARLOW JOHN RANDOLPH ET AL), 11 December 2003 (2003-12-11); whole document --	1-15

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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
09-01-2014	09-01-2014

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Agneta Seidel Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/000029

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2008180630 A (TOKYO ELECTRIC POWER CO), 7 August 2008 (2008-08-07); whole document --	2-3, 14-15
A	JP 2010243309 A (JAPAN AEROSPACE EXPLORATION), 28 October 2010 (2010-10-28); whole document --	2-3, 14-15
A	EP 2175281 A1 (SIEMENS AG), 14 April 2010 (2010-04-14); whole document --	2-3, 14
A	US 5872621 A (WILKERSON THOMAS D ET AL), 16 February 1999 (1999-02-16); whole document -- --------	2-3, 14

Continuation of: second sheet

International Patent Classification (IPC)

B62D 35/00 (2006.01)
B62D 37/02 (2006.01)
G01M 9/06 (2006.01)

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GB	2435246	A	22/08/2007	NONE			
US	20090248242	A1	01/10/2009	AU	2009201176	A1	15/10/2009
				CA	2658432	A1	27/09/2009
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				AU	2003204573	B2	02/10/2008
				CA	2431382	A1	06/12/2003
				CA	2431380	A1	06/12/2003
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				MX	PA03005084	A	12/02/2004
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JP	2008180630	A	07/08/2008	NONE			
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EP	2175281	A1	14/04/2010	CN	101718799	A	02/06/2010
				US	20100085557	A1	08/04/2010
				US	8139206	B2	20/03/2012
US	5872621	A	16/02/1999	NONE			