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Fuel efficiency system for a vehicle

Abstract

Vehicle systems and components are set forth, which aim to reduce rolling friction caused in part by the contact between the vehicle's tires and the ground surface over which the vehicle is traversing. These systems and/or components thereof may increase the overall fuel efficiency of a vehicle. In the examples provided, the systems and/or components change the tread contact patch of one or more tires during movement of the vehicle.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application is a division of U.S. patent application Ser. No. 15/954,452, filed on Apr. 16, 2018, which is a divisional of U.S. patent application Ser. No. 14/605,743, filed on Jan. 26, 2015, and the disclosures of which are incorporated by reference herein in their entirety.

BACKGROUND
(1) A vehicle's fuel economy is the result of its total resistance to movement. This includes overcoming inertia, driveline friction, road grades, tire rolling resistance and air drag. The relative percent of influence that these factors represent during stop-and-go city driving are very different from steady, state highway driving.
(2) To improve the fuel efficiency in the transportation industry, various approaches have been employed in order to reduce the rolling resistance of a vehicle tire. Generally described, some of these methods include the utilization of harder material or employment of greater inflation pressures in order to achieve lower rolling resistance.
(3) The transportation industry is continuously looking for ways to improve fuel efficiency of a vehicle by reducing rolling resistance. The disclosed subject matter aims to provide such a system.
SUMMARY
(4) This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.
(5) In accordance with an embodiment of the present disclosure, a system is provided for improving the fuel efficiency of a vehicle. The system includes at least one wheel composing of a tire mounted to a rim and forming an inner cavity. The tire includes sidewalls that extend outwardly from the rim to shoulders that are interconnected via a tread at a crown area of the tire. The system also includes a linear actuator positioned within the inner cavity of the tire. In one embodiment, the linear actuator is configured to be in contact with the rim at one end and the tire at the other end. The system also includes a power storage source configured to store power. The power storage source is selectively connected to the linear actuator. The system further includes a controller configured to selectively supply power from the power storage source to the linear actuator in order to extend the linear actuator in such a manner as to lengthen the side walls of the tire and to reduce

the amount of tread that contacts the ground.
(6) In accordance with an embodiment of the present disclosure, a system is provided for improving the fuel efficiency of a vehicle. The system includes first and second wheels each comprising a tire mounted to a rim and forming an inner cavity. The tire includes sidewalls that extend outwardly from the rim to shoulders that are interconnected via a tread at a crown area of the tire. The system also includes a linear actuator positioned within the inner cavity of each tire such that the linear actuator contacts the rim at one end and the tire at the other end, wherein the linear actuator is configured to apply opposite forces again the tire and the rim as the linear actuator actuates between a normal state and an extended state. The system also includes a power storage source configured to store power. The power storage source is selectively connected to the linear actuator. The system further includes a controller configured to selectively supply power from the power storage source to the linear actuator in response to signals from one or more sensors in order to transition the linear actuator from the normal state to the extended state, wherein the transition from the normal state to the extended state of the actuator in one embodiment lengthens the side walls of the tire and reduces the amount of tread that contacts the ground.
(7) In accordance with an embodiment of the present disclosure, a method is provided for increasing the efficiency of a vehicle having at least one wheel in contact with a ground surface. The wheel of the vehicle includes a tire mounted to a rim and forming an inner cavity. The tire has sidewalls that extend outwardly from the rim to shoulders that are interconnected via a tread at a crown area of the tire. The method comprises sensing a least one vehicle operational parameter selected from a group consisting of vehicle speed, sensed vehicle operational parameter, adjusting tread contact with the ground surface from a first contact patch to a second contact patch.

Description

DESCRIPTION OF THE DRAWINGS
(1) The foregoing aspects and many of the attendant advantages of the disclosed subject matter will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:
(2) FIG. **1** is a schematic diagram of one example of a fuel efficiency system in accordance with aspects of the present disclosure;
(3) FIG. **2** is a cross sectional view of a tire and hub combination incorporating components of the fuel efficient system of FIG. **1**, the tire and hub combination in a normal state; and
(4) FIG. **3** is a cross sectional view of a tire and hub combination incorporating components of the fuel efficient system of FIG. **1**, the tire and hub combination in a system activated state; and
(5) FIG. **4** is a schematic diagram of one example of a controller in accordance with aspects of the present disclosure.
DETAILED DESCRIPTION
(6) The detailed description set forth below in connection with the appended drawings, where like numerals reference like elements, is intended as a description of various embodiments of the disclosed subject matter and is not intended to represent the only embodiments. Each embodiment described in this disclosure is provided merely as an example or illustration and should not be construed as preferred or advantageous over other embodiments. The illustrative examples provided herein are not intended to be exhaustive or to limit the claimed subject matter to the precise forms disclosed.
(7) The following discussion proceeds with reference to examples of fuel efficiency systems suitable for use with vehicles, such as Class 8 trucks and/or trailers. Generally described, representative examples of the systems and components described herein aim to reduce rolling

friction caused in part by the contact between the vehicle's tires and the ground surface over which the vehicle is traversing. As such, the systems and/or components thereof may increase the overall fuel efficiency of a vehicle. In the examples disclosed herein, the system changes the tread contact patch of each tire during movement of the vehicle. In some embodiments, the system can be activated after the vehicle has attained a minimum threshold speed (e.g., 45 mph or greater). Additionally or alternatively, some embodiments of the system prohibit activation of the system if the vehicle has attained a maximum threshold speed (e.g., 75 mph or greater). Further, in some embodiments, the system can transition from its activated state to its unactivated state if the operator of the vehicle engages a particular system on the vehicle, such as, for example, application of the vehicle brakes.

(8) In the following description, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments of the present disclosure. It will be apparent to one skilled in the art, however, that many embodiments of the present disclosure may be practiced without some or all of the specific details. In some instances, well-known process steps have not been described in detail in order to not unnecessarily obscure various aspects of the present disclosure. Further, it will be appreciated that embodiments of the present disclosure may employ any combination of features described herein.

(9) Although representative embodiments of the present disclosure is described with reference to Class 8 trucks, it will be appreciated that aspects of the present disclosure have wide application, and therefore, may be suitable for use with many types of powered vehicles, such as passenger vehicles, buses, RVs, commercial vehicles, light and medium duty vehicles, and the like, as well as non-powered vehicles, such as trailers and the like. Accordingly, the following descriptions and illustrations herein should be considered illustrative in nature, and thus, not limiting the scope of the claimed subject matter.

(10) Turning now to FIG. **1**, there is shown a schematic diagram of one example of a fuel efficiency system, generally designated **20**, in accordance with aspects of the present disclosure. As shown in FIG. **1**, the system **20** includes a gas compressor **24**, a power storage source, such as an accumulator or compressed gas tank **28** charged by the gas compressor **24**, one or more of linear actuators **32** associated with each tire of the vehicle, and a control unit **34**, comprised of, for example, a controller **36** and a valve arrangement **38**, that selectively controls the actuation of the plurality of linear actuators **32**.

(11) The system **20** can include a manual input, such as an on/off switch **40**, for activating/deactivating the system **20**, or the system **20** can be activated and/or deactivated upon receipt of suitable control signals from another vehicle controller or from one or more vehicle sensors **42**A-N. The one or more sensors **42**A-N in some embodiments are configured to measure/determine, for example, one or more of vehicle speed, vehicle acceleration, vehicle yaw, vehicle roll, vehicle braking, etc. In use, activation of the system **20** reduces the effective contact surface of the tires with the ground, referred to herein the tire patch or ground contact patch. Deactivation of the system returns the tires from the narrower contact patch shown in the activated state of FIG. **3** to their normal shape with a wider contact patch, as shown in FIG. **2**.

(12) FIG. **2** is a partial cross-sectional view of a wheel **46** for a vehicle that incorporates one or more components of the system **20**. As shown in FIG. **2**, the wheel **46** includes a tubeless tire **48** mounted on a rim **50**. In the embodiment shown, the tire **48** includes left and right beads **54** that interface with flange sections of the rim **50** in a conventional manner, side walls **58** that extend outwardly from the beads **54** to shoulders **60**, and a tread **62** that interconnects the shoulders **60** at the crown area of the tire **48**. It will be appreciated that the tire **48** may include many other conventional components, including but not limited to an inner liner, belts, plies, and the like. The tread **62** can have any known or future developed tread pattern, and can be chosen at least in part based on its intended application. Once inflated with air via its conventional inflation valve **66** to an acceptable pressure, for example, as suggested by the tire's manufacturer, and supporting the

weight of the associated vehicle, the tread **62** assumes its "normal" contact patch **68**, as shown in FIG. **2**.

(13) In accordance with an aspect of the present disclosure, at least one linear actuator **32** of the system **20** is disposed within the interior cavity **70** of the tire **48** when the tire is mounted to the rim **50**. In the embodiment shown, the linear actuator **32** includes an expandable bag or bellows **72** that extends circumferentially around the rim **50**. The bellows **72** is sealed at its inner and outer ends via inner and outer bead plates **74** and **76**, thereby defining a gas sealed cavity **78**. When installed, the inner plate **74** contacts the central section of the rim **50** and the outer plate **76** contacts the inside of the tire **48** below the tread **62**. In some embodiments, the plates **74** and **76** may be optionally secured to the rim **50** and tire **48**, respectively, via chemical fastening techniques, among others. In other embodiments, only the inner plate **74** is secured to the rim **50** while the outer plate is maintain in place against the tire **48** based on, for example, the height and/or rigidity of the bellows assembly.

(14) The bellows **72** is constructed out of a stretchable but sturdy material, such as natural or synthetic rubber, elastomeric polymers, a rubber and polyurethane composite, etc. The bellows **72** is configured with stiff sidewalls so that the bellows **72** is primary expandable lengthwise in order to apply opposite forces against the tire **48** and rim **50**. In some embodiments, the sidewalls of the bellows may be stiffened by reinforcement means, such as belts, ribs, springs or bands, etc., of steel, Kevlar, etc. In other embodiments, the bellows **72** is stiffened in the appropriate regions by engineering the elastomeric matrix. In one embodiment, the bellows **72** is constructed out of a textile-reinforced rubber.

(15) An inflation/deflation port **80** is provided in gas communication with the gas sealed cavity **78** of the bellows **72**. In the embodiment shown, the port **80** is formed by an air fitting **82** that extends through the rim **50** and one wall or plate of the bellows **72**. The port **80** is connected to the inflation/deflation control unit **34** via suitable supply lines **84**, etc. In the embodiment shown in FIGS. **2** and **3**, the port **80** is connected in gas communication with the compressed gas tank **28** via valve arrangement **36**, and supply lines **84** and **86**. While one port **80** is shown in the embodiment of FIGS. **2** and **3**, it will be appreciated that multiple ports may be circumferentially positioned around the rim **50** of each wheel in a spaced apart manner and interconnected via any suitable arrangement of a distribution manifold or diverter, supply lines, and other optional components, etc. It will be appreciated that the number and size of the ports can be selected in order to affect the inflation/deflation rate of the bellows **72**.

(16) In one embodiment, the valve arrangement **38** is operably connected in-between the port **80** of each wheel and the compressed gas tank **28** for controlling or regulating the timing and/or quantity of pressurized gas routed to the bellows **72**. The valve arrangement **160** may include one or more valves, including electrically controllable valves, such as solenoid valves, etc., one or more mechanically controllable valves (e.g., pressure controlled, etc.), and associated components for controlling or regulating the flow of compressed gas from the compressed gas tank **28** to the bellows **72**. Additionally, the valve arrangement **38** may include one or more valves, including one or more electrically controllable valves or mechanically controllable valves, and any associated components for controlling or regulating the flow of compressed gas from the bellows **72** to atmosphere.

(17) As was described above, the valve arrangement **38** may be electrically controlled by the controller **36**, one embodiment of which is shown schematically in FIG. **4**. The controller **36** is connected in electrical communication with the valve arrangement **38** and other components, for example, one or more sensors **42**A-N, as will be described in detail below. The controller **36** may include logic for controlling the inflation/deflation of the bellows **72**. It will be appreciated by one skilled in the art that the logic may be implemented in a variety of configurations, including but not limited to, hardware, software, and combinations thereof.

(18) In some embodiments, the controller **36** includes a processor **90** and memory **92**, as shown in

FIG. **4**. The memory **92** may include computer readable storage media having volatile and nonvolatile storage in read-only memory (ROM), random-access memory (RAM), and keep-alive memory (KAM), for example. The KAM may be used to store various operating variables while the processor **84** is powered down. The computer-readable storage media may be implemented using any of a number of known memory devices such as PROMs (programmable read-only memory), EPROMs (electrically PROM), EEPROMs (electrically erasable PROM), flash memory, or any other electric, magnetic, optical, or combination memory devices capable of storing data. The data includes executable instructions, used by processor **90**, in controlling the operation of the valve arrangement **38**. In other embodiments, some of the data may represent executable instructions, used by processor **90**, to control the operation of the compressor **24** and/or other controllable components of the system.

(19) As used herein, the term processor is not limited to integrated circuits referred to in the art as a computer, but broadly refers to a microcontroller, a microcomputer, a microprocessor, a programmable logic controller, an application specific integrated circuit, other programmable circuits, combinations of the above, among others. In one embodiment, the processor **84** executes instructions stored in memory **86** to provide suitable control signals to the controllable valves of the valve arrangement and to selectively supply power to compressor or to other device level circuitry.

(20) Still referring to FIG. **4**, the processor **90** communicates with various sensors **42**A-N directly or indirectly via an input/output (I/O) interface **94** and suitable communication links. The I/O interface may include conventional buffers, drivers, relays and the like, for sending device appropriate signals to the valves of the valve arrangement **38**, to the compressor **24**, etc. In doing so, the interface **94** may be implemented as a single integrated interface that provides various raw data or signal conditioning, processing, and/or conversion, short-circuit protection, and/or the like. Alternatively, one or more dedicated hardware or firmware chips may be used to condition and process particular signals before being supplied to the processor **90**. In some embodiments, the signals transmitted from the interface **94** may be suitable digital or analog signals for controlling a switching device of the valves, compressor, etc. In other embodiments, the signals transmitted from the interface **94** may be suitable voltages to directly control the valves, compressor, etc.

(21) The controller **36** may be a designated controller of the system **20** or may be part of another on-board controller, such as an engine control module (ECM). The controller **36** may also be connected to other vehicle controllers via a CAN **96**. In some embodiments, the controller **36** may receive data from the sensors **42**A-**42**N via the CAN **96**. Embodiments of the CAN **96** may be implemented using any number of different communication protocols such as, but not limited to, Society of Automotive Engineer's (“SAE”) J1587, SAE J1922, SAE J1939, SAE J1708, and combinations thereof.

(22) In accordance with aspects of the present disclosure, sensors **42**A-N may be used to provide various functionality to the system **20**. In that regard, the one or more sensors **42**A-N may include, for example, a gas pressure sensor for sensing the pressure of the pressurized gas in tank **28**. Accordingly, the controller **36** can be programmed to determine whether the compressed gas tank **28** is in need of filling by operation of the compressor **24** via output of the gas pressure sensor.

(23) The one or more sensors **42**A-N may also include a sensor configured to output a signal indicative of vehicle speed. Such a sensor may include an engine speed sensor for sensing engine speed, a wheel speed sensor for sensing the speed of the vehicle wheels, a drive shaft speed sensor for sensing the speed of drive shaft of the vehicle, or combinations thereof, etc. The information from one or more of these sensors and/or others may be utilized by the controller **36** to control the operation of the valve arrangement **38**. For example, the controller **36** may be programmed to control the valve arrangement **38** in order to supply pressurized gas to the bellows **72** when, for example, the operator activates the on/off switch **40** to the “on” position and the vehicle has reached a minimum threshold speed (e.g., 45 mph) as indicated by the one or more sensors **42**. The controller **36** may also be programmed to operate the valve arrangement **38** to terminate the supply

of pressurized gas to the bellows **72** when, for example, the one or more sensors **42** indicate that the vehicle has reached a maximum threshold speed (e.g., 75 mph or greater).

(24) In another embodiment of the system **20**, one of the sensors **42**A-N may include a brake sensor for sensing the application of brakes. In this embodiment, the controller **36** is configured to purge or "dump" the pressurized gas within the bellows **72** to atmosphere when the brakes of the vehicle **100** are applied so as to return the shape of the ground contact patch to its "normal" state. In these and other embodiments, the controller **36** is configured to operate the valve arrangement **38** to purge or "dump" the compressed gas within the bellows **72** to atmosphere when the controller determines, via output from one or more of the sensors **42**, that the vehicle's speed is below or rapidly approaching (i.e., decelerating) the minimum threshold value. It will be appreciated that other ways in which the system **20** may be controlled will readily be apparent to those skilled in the art. For example, additionally or alternatively, the controller **36** can be configured to purge or "dump" the compressed gas from the bellows **72** if the vehicle experiences excessive vehicle roll or yaw. In that regard, the one or more sensors may include vehicle yaw sensors and/or vehicle roll sensors. Excessive vehicle roll or yaw as used herein means an amount or degree of yaw or roll which would cause vehicle instability when the system is activated.

(25) One method of operating the system **20** will be described with reference to FIGS. **1-3**. During forward movement of a vehicle equipped with the system **20**, a driver may wish to activate the system **20** in order to realized better fuel efficiency. In that regard, the operator may push or otherwise turn the on/off switch **40** to the "on" position. Once activated, the controller **36** monitors the one or more sensors **42**A-**42**N for data indicative of the vehicle's speed. If it is determined by the controller **36** that the vehicle has attained the minimum threshold speed, the controller **36** transmits suitable control signals to the valve arrangement **38** in order to supply pressurized gas of a suitable pressure from the compressed gas tank **28** to the actuators **32** associated with each wheel. In doing so, the pressurized gas travels through the supply lines to the bellows **72** via each port **80**. As the pressurized gas enters the bellows, the bellows **72** inflates and expands in a length-wise direction. As it expands, the plates **74** and **76** of the bellows **72** apply opposite forces against the rim **50** of the wheel and the tread **62** of the tire, thereby elongating the effective length of the tire side walls **58** and reducing the ground contact patch **68** of the tires to the "system activated" contact patch **100**, as shown in FIG. **3**. The system activated contact patch is less than half of the ground contact patch **68** in one embodiment.

(26) It will be appreciated that the systems described herein are capable of continual use throughout the life of the vehicle although it may require routine maintenance or repair. It will be appreciated that the systems described herein can be installed at the time of vehicle manufacture or can be retrofitting on existing vehicles. Once one of the systems described herein is installed in the vehicle, the system can continue to be used after the tires have reached their useful life. In that regard, the system in some embodiments allows simple removal of the old tire(s) and installation of the new tire(s).

(27) It should be noted that for purposes of this disclosure, terminology such as "upper," "lower," "vertical," "horizontal," "inwardly," "outwardly," "inner," "outer," "front," "rear," etc., should be construed as descriptive and not limiting the scope of the claimed subject matter. Further, the use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless limited otherwise, the terms "connected," "coupled," "secured," "mounted" and variations thereof herein are used broadly and encompass direct and indirect connections, couplings, securements and mountings.

(28) The principles, representative embodiments, and modes of operation of the present disclosure have been described in the foregoing description. However, aspects of the present disclosure which are intended to be protected are not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. It will be appreciated that variations and changes may be made by others, and

equivalents employed, without departing from the spirit of the present disclosure. Accordingly, it is expressly intended that all such variations, changes, and equivalents fall within the spirit and scope of the present disclosure, as claimed.

Claims

1. A wheel, comprising: a rim; a tire mounted on the rim and having tread; an interior cavity defined by the tire and the rim; an actuator positioned within the interior cavity and extending entirely across the interior cavity from the rim to the tire and being offset from lateral sidewalls of the tire, the actuator having a gas-sealed cavity and being adjustable in height between at least a first configuration and a second configuration with the actuator remaining in contact with an interior surface of the tire located opposite of the tread of the tire in each of the first configuration and the second configuration during normal pressurization of the tire, and the actuator comprising a first plate coupled to the rim, a second plate coupled to the interior surface of the tire, and a bellows coupled to the first plate and the second plate; a first air valve in fluid communication with the interior cavity of the tire; and a second air valve in fluid communication with the gas-sealed cavity of the actuator.
2. The wheel of claim 1, wherein the first plate, the second plate, and the bellows form the gas-sealed cavity of the actuator.
3. The wheel of claim 1, wherein the bellows circumferentially extends around the rim.
4. The wheel of claim 1, wherein: the rim includes a tire mount surface; the tire is on the tire mount surface of the rim, and the tire includes: the interior surface; an exterior surface opposite to the interior surface; and the tread, which extends along the exterior surface of the tire, the tread including: an unactivated ground contact patch surface area; and an activated ground contact patch surface area less than the unactivated ground contact patch surface area; the actuator is configured to, in operation, expand to move the tread from the unactivated ground contact patch surface area to the activated ground contact patch surface area and to deflate to move the tread from the activated ground contact patch surface area to the unactivated ground contact patch surface area; the second air valve extends through the rim to be in fluid communication with the gas-sealed cavity of the actuator; and the second air valve is configured to deflate and inflate the actuator.
5. The wheel of claim 4, wherein the bellows, in operation, is in the activated state when greater than a threshold of 45-mph (miles per hour) to improve fuel efficiency of a vehicle on which the wheel is mounted.
6. The wheel of claim 4, wherein the bellows, in operation, is in the activated state when greater than a threshold of 75-mph (miles per hour) to improve fuel efficiency of a vehicle on which the wheel is mounted.
7. A wheel, comprising: a rim; a tire mounted on the rim and having tread; an interior cavity defined by the tire and the rim; an actuator positioned within the interior cavity and extending entirely across the interior cavity from the rim to the tire and being offset from lateral sidewalls of the tire, the actuator having a gas-sealed cavity and being adjustable in height between at least a first configuration and a second configuration with the actuator remaining in contact with an interior surface of the tire located opposite of the tread of the tire in each of the first configuration and the second configuration during normal pressurization of the tire; a first air valve in fluid communication with the interior cavity of the tire; and a second air valve in fluid communication with the gas-sealed cavity of the actuator, and wherein the tire further comprises a slit at the interior surface of the tire that is aligned with the actuator.
8. The wheel of claim 7, wherein the slit is configured to, in operation, reduce stress and strain on the tire when the actuator is expanded from an unactivated state to an activated state.
9. The wheel of claim 7, wherein the actuator further comprises: a first plate coupled to the rim; a second plate coupled to the interior surface of the tire, the second plate underlies the slit at the

interior surface of the tire; and a bellows coupled to the first plate and the second plate.
10. The wheel of claim 9, wherein the first plate, the second plate, and the bellows define the gas-sealed cavity of the actuator.
11. A wheel, comprising: a rim; a tire mounted on the rim and having tread; an interior cavity defined by the tire and the rim; an actuator positioned within the interior cavity and extending entirely across the interior cavity from the rim to the tire and being offset from lateral sidewalls of the tire, the actuator having a gas-sealed cavity and being adjustable in height between at least a first configuration and a second configuration with the actuator remaining in contact with an interior surface of the tire located opposite of the tread of the tire in each of the first configuration and the second configuration during normal pressurization of the tire; a first air valve in fluid communication with the interior cavity of the tire; and a second air valve in fluid communication with the gas-sealed cavity of the actuator, and wherein: the first air valve further comprises: a first air fitting that extends through the rim to be in fluid communication with the gas-sealed cavity of the actuator; and an inflation and deflation port at an end of the first air fitting and in the gas-sealed cavity of the actuator, the inflation and deflation port configured to inflate and deflate the actuator; the second air valve further comprises: a second air fitting that extends through the rim and through the actuator to be in fluid communication with the interior cavity defined by the tire and the rim; and a port at an end of the second air fitting and in the interior cavity defined by the tire and the rim.
12. The wheel of claim 11, wherein: the actuator further comprises a bellows; and the first air fitting extends through the bellows.
13. A vehicle, comprising: the wheel of claim 1, wherein the second air valve includes an inflation and deflation port within the gas-sealed cavity of the actuator, and the inflation and deflation port is configured to inflate and deflate the actuator between an activated state and an unactivated state; and a controller in electrical communication with the air valve to inflate and deflate the actuator through the inflation and deflation port of the second air valve, the controller configured to, in operation, inflate the actuator when a speed of the vehicle is larger than a threshold speed.
14. The vehicle of claim 13, wherein the threshold speed is greater than 45-mph (miles per hour).
15. The vehicle of claim 13, wherein the threshold speed is greater than 75-mph (miles per hour).
16. The vehicle of claim 13, wherein: the tire includes: a slit at the interior surface that is aligned with the actuator, overlies the actuator, and is configured to, in operation, reduce stress and strain on the tire when the actuator is expanded from the unactivated state to the activated state by introducing air into gas-sealed cavity of the actuator through the inflation and deflation port of the second air valve.
