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(54) **AIR MAINTENANCE TIRE ASSEMBLY**

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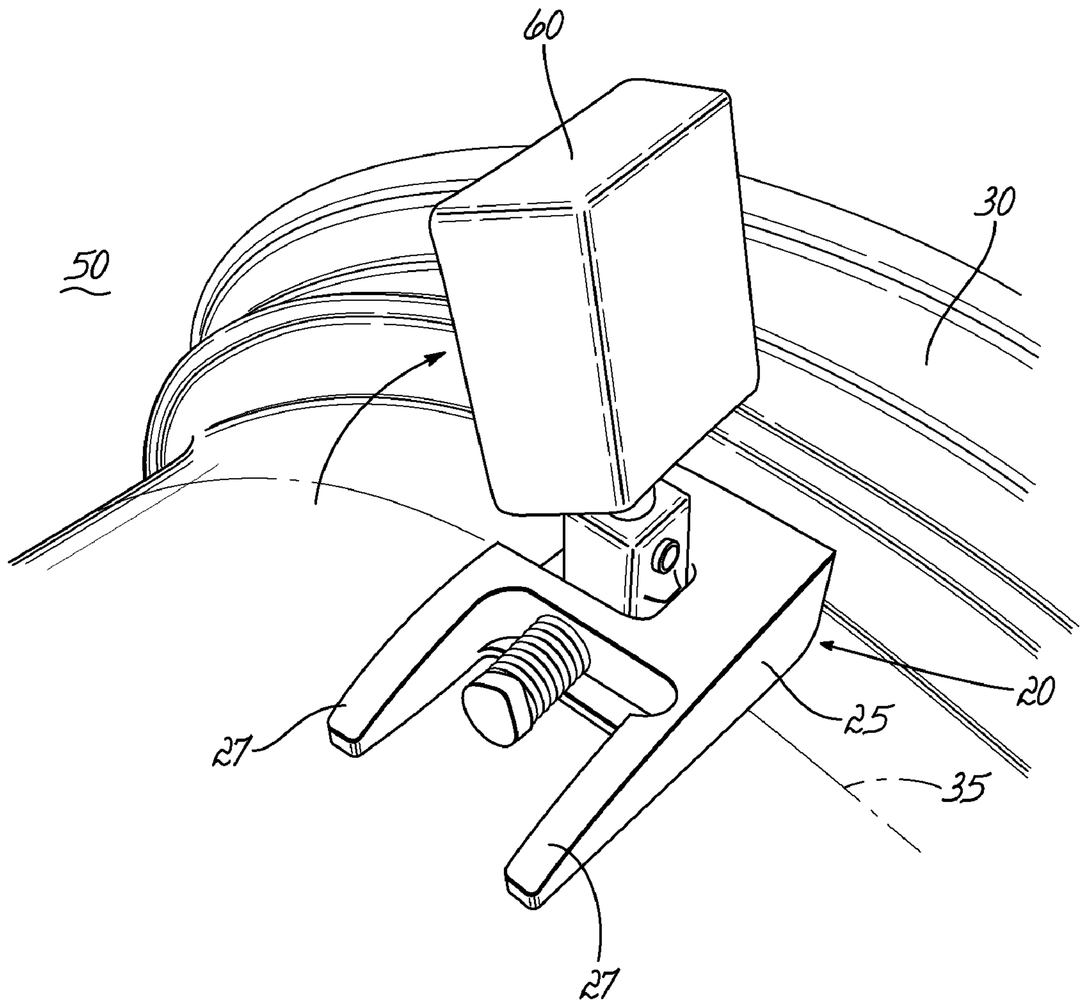
(57) **ABSTRACT**

A pumping device is used with a pneumatic tire mounted on a tire rim to keep the pneumatic tire from becoming underinflated. The device includes a pumping device attached to the tire rim, a dynamic mass mechanically confined to rotational movement relative to the pumping device and the tire rim, the dynamic mass moving in response to a minimum angular acceleration and a minimum angular velocity of the tire rim and pumping ambient air into the pumping device, an intake port for ambient air to enter the pumping device, and an exhaust port for forcing pressurized air into a tire cavity of the pneumatic tire for restoring air loss from an inflation volume within the tire cavity, the dynamic mass and the pumping device both being weighted equally on each side of a centerline of the tire rim.



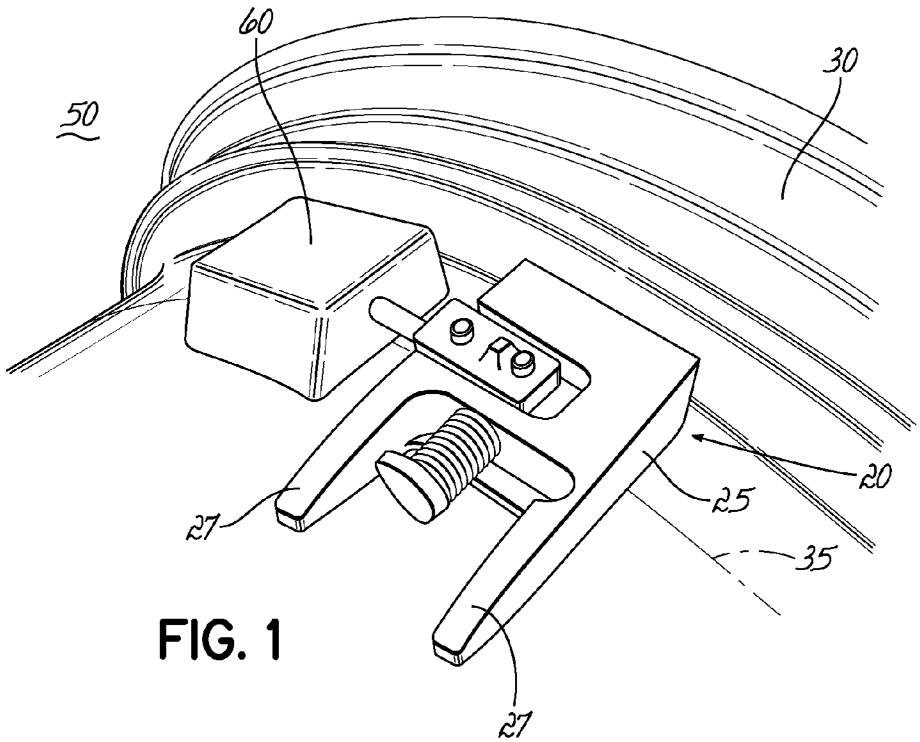


FIG. 1

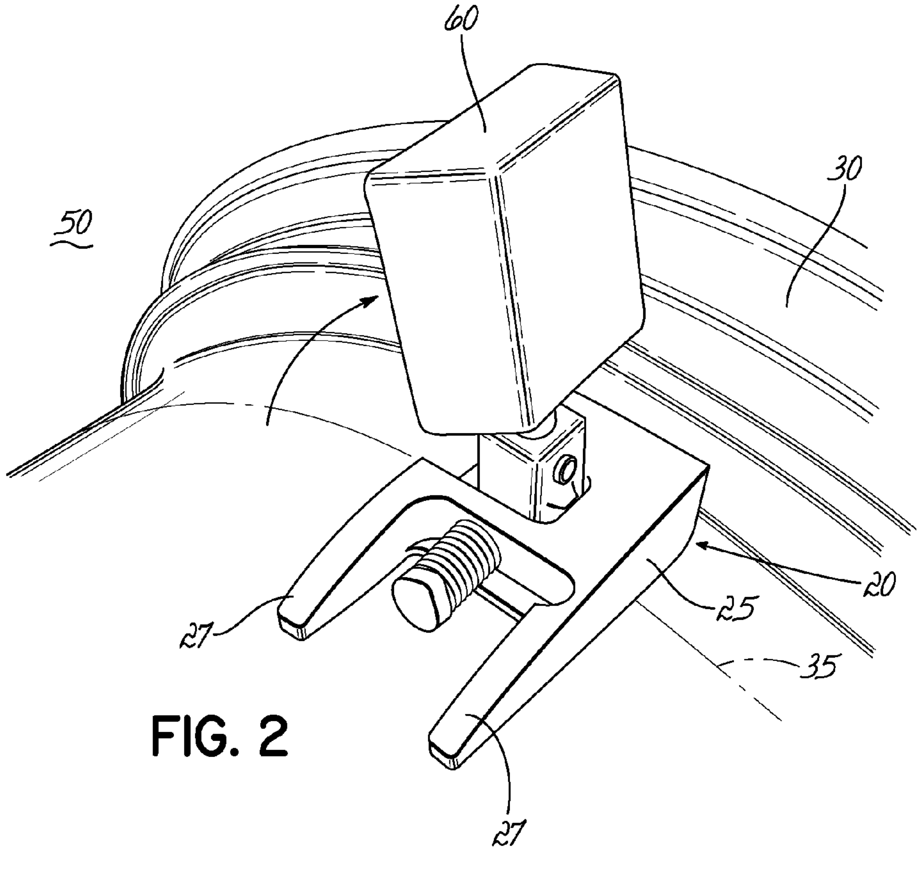


FIG. 2

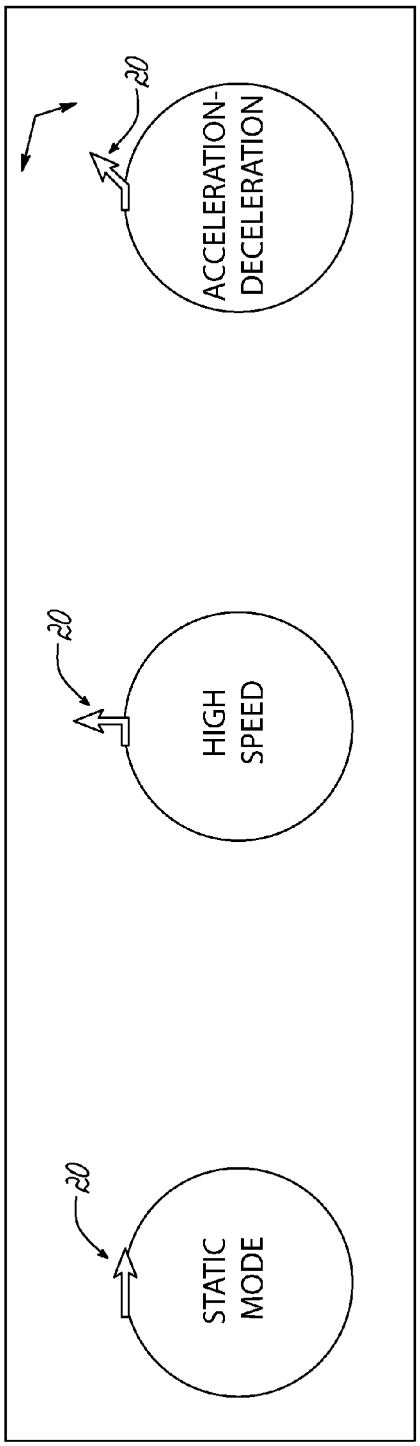

ACCELERATION-
DECELERATION
HIGH
SPEED
STATIC
MODE
20
20
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FIG. 3

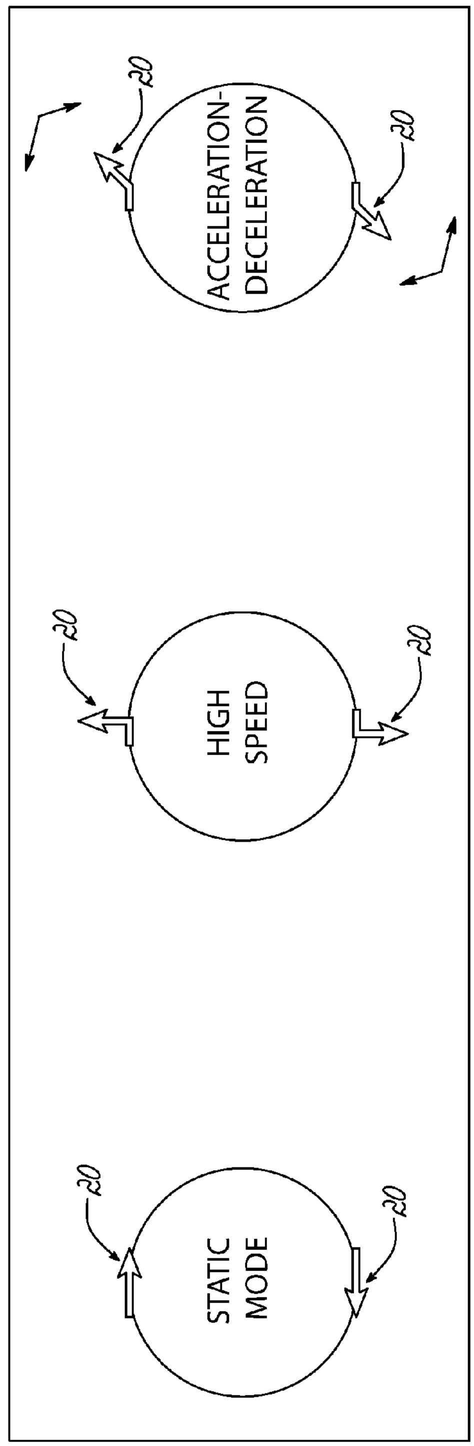
ACCELERATION-
DECELERATION
HIGH
SPEED
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FIG. 4

AIR MAINTENANCE TIRE ASSEMBLY

FIELD OF THE INVENTION

[0001] The present invention generally relates to automotive and other vehicles, and more specifically, to a wheel for such a vehicle which includes a pump for automatically inflating a pneumatic tire mounted on the wheel.

BACKGROUND OF THE INVENTION

[0002] Low tire pressure is a major cause of excessive fuel consumption, tire wear, and impaired steerability. A typical pneumatic tire will leak about 25 percent of its pressure per year due to rubber's inherent permeability. It is thus good practice to check/maintain tire pressure on a regular basis.

[0003] However, even checking tire pressure every few weeks may not prevent these adverse affects when a slow leak is present, and the leak may go undetected unless a careful record is maintained of how frequently the pressure in each tire has to be replenished. A fast leak or flat condition may rapidly cause damage to the tire and even render it unusable in a short period of time even though this condition may go unnoticed by an inexperienced driver until it is too late.

[0004] It is thus desirable to have some mechanism that automatically replenishes the tire pressure when it is lower than its optimal amount. Conventional tire pumps may be mounted on vehicle wheels and utilize centrifugal force to automatically pump air from the atmosphere into a tire cavity and thereby maintain the tire pressure at a predetermined value.

[0005] These pumps may be two-stage pumps with a piston radially movable in a cylinder to draw air from the atmosphere into a primary chamber and pump air from a secondary chamber into the tire cavity when the piston is moved outward by centrifugal force resulting from movement of the vehicle and rotation of the wheels. The piston may be moved inward by a spring when the vehicle stops to transfer air from the primary chamber into the secondary chamber. In order to keep the mass of the piston and the force and size of the spring within practical limits, the piston and spring may be made small enough that the piston may begin to move outward in response to a small centrifugal force resulting from a low vehicle speed.

[0006] This causes a problem when the vehicle is operated at low speed in the rain, and/or on terrain including loose particulate matter such as dirt or sand. If the pump does not have an inlet filter, operation under such adverse conditions may cause contaminants to be drawn into the pump and clog the inlet and outlet valves and/or even be pumped into the tire. If the pump does have an inlet filter, the filter may become clogged. These conditions may render the pump inoperable.

[0007] Friction between the piston and the wall of the cylinder when the pump is operating also may cause wear and reduction of the service life of the pump. Since pneumatic tires typically leak slowly, an automatic tire pump may only be required to operate during a fraction of the time the vehicle is running to maintain the pressure at the optimal value. Conventional tire pumps may operate continuously, and are thereby subjected to more wear than is necessary.

[0008] Another conventional pump may be mounted to a vehicle's wheel and be powered by the wheel's motion during normal vehicle operation thereby maintaining an optimal tire inflation pressure. The pump may be a positive displacement, piston-type compressor wherein the piston responds to the centrifugal force generated by the wheel's rotation or to the vertical acceleration generated by the wheel's response to bumps in the road. The piston may be a small diameter, but may include an upper extension made of dense material. Thus, there may be sufficient mass responding to rotation or the motion from bumps to move the piston and create the necessary pressure for inflation. The piston may be returned by a spring once the forces acting upon the piston decline due to a slow vehicle speed, a smooth driving surface, or both.

[0009] The pump may include inlet and outlet check valves. The pump/inflator may be mounted to the wheel either within the tire cavity or external to the tire. If the centrifugal forces of rotation are to propel the piston, the axis of the cylinder may be oriented radially. If the pump is designed to be energized by the wheel's reaction to bumps in the road, it may be oriented tangential to a circle centered at the wheel axis. It may also have a double acting piston. Compression would then take place when the compressor would be approximately at 3:00 o'clock or 9:00 o'clock in its rotation with the wheel as a bump would be hit by the wheel.

[0010] For the case of centrifugal force for piston action, there may be one compression stroke for each excursion of automobile speed from stationary or some minimum speed up to the automobile speed which translates into adequate rotational speed to generate the needed piston force to create air flow into the tire cavity. For the case in which bumps in the road actuate the piston, the compression strokes may be more random than the bumps themselves since the strokes would only occur when the axis of the compressor would be aligned in its rotation to a direction more or less parallel with the wheel motion caused by the bump.

[0011] Pressure regulation may be provided by designing the pump's compression ratio to limit the delivery pressure to that desired to be the maximum tire inflation pressure. Compression ratio may be the ratio of cylinder volume at the start of a piston stroke to the volume remaining in the cylinder at the end of the piston's stroke. Compression ratio for a given basic design may be set at the time of manufacture by either limiting the piston travel or by providing additional "dead" volume within the piston. One method for this may be to drill a hole in the bottom of the piston at the time of manufacture, the depth of the hole being set to obtain the desired pressure development.

[0012] When the pump is actuated by centrifugal force, the pump may work with the piston gradually progressing along the cylinder against the compressed charge of air in the cylinder as the vehicle accelerates and the wheel rotation rate increases. Once the charge of air exceeds the existing tire pressure plus the discharge valve cracking differential pressure, any increased vehicle speed causes additional stroke movement of the piston and discharge of the compressed air into the tire cavity. As the vehicle slows or stops, the piston return spring may have returned the piston to its location at the beginning of its stroke and the pumping process may begin again with new vehicle motion. With typical passenger car operation including many stops and starts, the pump may deliver a small charge of air each time the vehicle accelerates from a speed low enough to allow the piston return spring to return the piston to a speed high enough to force the piston to compress air and discharge compressed air into the tire cavity.

[0013] In order to maximize the force available for driving the piston to compress the air in the cylinder, the piston may have an enlarged end made of dense material. The enlarged end may be opposite the end of the piston that fits into the cylinder, with its diameter being larger than the piston diameter. The enlarged end may be constructed of brass, lead, and/or other high density material(s). This conventional pump may eliminate extra tire wear and fuel consumption caused by underinflated tires. Where only a small leak occurs, this pump may extend mileage before the tire becomes completely uninflated or flat.

SUMMARY OF THE INVENTION

[0014] A device in accordance with the present invention uses a pneumatic tire mounted on a tire rim to keep the pneumatic tire from becoming underinflated. The device includes a pumping device attached to the tire rim, a dynamic mass mechanically confined to rotational movement relative to the pumping device and the tire rim, the dynamic mass moving in response to a minimum angular acceleration and a minimum angular velocity of the tire rim and pumping ambient air into the pumping device, an intake port for ambient air to enter the pumping device, and an exhaust port for forcing pressurized air into a tire cavity of the pneumatic tire for restoring air loss from an inflation volume within the tire cavity, the dynamic mass and the pumping device both being weighted equally on each side of a centerline of the tire rim.

[0015] According to another aspect of the present invention, the dynamic mass comprises ⅔ of the weight of the device and the pumping device comprises ⅓ of the weight of the device.

[0016] According to still another aspect of the present invention, the pumping device weighs between 100 grams and 300 grams.

[0017] According to yet another aspect of the present invention, the pumping device further includes at least one extension arm extending laterally from the pumping device.

[0018] According to still another aspect of the present invention, the dynamic mass is angled radially inward from the pumping device when the dynamic mass engages the tire rim.

[0019] According to yet another aspect of the present invention, a second pumping device and a second dynamic mass are both mounted at a diametrically opposite location on the tire rim from the first pumping device and the first dynamic mass.

[0020] According to still another aspect of the present invention, both dynamic masses move simultaneously in response to angular accelerations/decelerations of the tire rim.

[0021] According to yet another aspect of the present invention, a biasing element returns the dynamic mass to a position engaging the tire rim.

[0022] According to still another aspect of the present invention, the dynamic mass is mechanically confined to rotational movement relative to the pneumatic tire.

[0023] According to yet another aspect of the present invention, the dynamic mass changes position corresponding to angular velocities of the tire rim rising above and moving below a predetermined angular velocity.

[0024] According to still another aspect of the present invention, a plane about which the dynamic mass rotates passes through an axis of rotation of the tire rim.

[0025] According to yet another aspect of the present invention, pivoting movement of the dynamic mass transfers work energy to air pressure in the pumping device.

[0026] According to still another aspect of the present invention, a first check valve disposed proximate to the intake port for preventing air from flowing out of the pumping device.

[0027] According to yet another aspect of the present invention, a second check valve disposed proximate to the exhaust port for preventing air from flowing out of the tire cavity and into the pumping device.

[0028] According to still another aspect of the present invention, a biasing element returns the pumping device from a high volume intake condition to a low volume exhaust condition.

[0029] According to yet another aspect of the present invention, the first check valve and the second check valve are self checking ball-type check valves.

[0030] According to still another aspect of the present invention, the dynamic mass pivots to pump pressurized air from the pumping device and forcing pressurized air into the tire cavity.

[0031] According to yet another aspect of the present invention, the pumping device receives ambient air from an exterior of the pumping device and exhausts pressurized air into the tire cavity simultaneously.

[0032] According to still another aspect of the present invention, the pumping device also restores air loss from an inflation volume within a second tire cavity of a second pneumatic tire.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. **1** is a schematic representation of a pump in accordance with the present invention.

[0034] FIG. **2** is a schematic representation of the pump of FIG. **1** showing the pump under a different condition.

[0035] FIG. **3** is a schematic representation of a layout using the pump of FIG. **1**.

[0036] FIG. **4** is a schematic representation of the pump of FIG. **1** using another layout.

DETAILED DESCRIPTION OF EXAMPLES OF THE PRESENT INVENTION

[0037] An air pumping device in accordance with the present invention may be utilized with a tire rim and pneumatic tire. The pumping device may affixed to the tire rim for the purpose of restoring air loss from an inflation volume of the pneumatic tire. The pumping device may include a dynamic mass mechanically confined to movement about a transmission mechanism and a pumping chamber.

[0038] The air pumping device may include one or more chambers and multiple valves. The chamber volume may be altered by the mechanical motion of the dynamic mass. One or more biasing elements, such as springs, may be incorporated to return the chamber volume from a high volume to a low volume, or vise versa. The valves may be configured to allow the chamber to intake air from the exterior of the inflation space and to exhaust the inspired air to the interior of the inflation space (e.g., a tire cavity). The valves may be self-checking, or may be mechanically opened and closed under the influence of an auxiliary mechanism (e.g., electrical, pneumatic, hydraulic, etc.). A pressure regulating element may be included for the purpose of limiting the ability of the air pumping device to elevate the pressure of the inflation space beyond a preferred level. Upon sensing a target pressure, or as the target pressure is approached, the regulating element may suddenly or progressively disable the air pumping device by locking, releasing, closing, opening, etc. any number of functional elements such as ports, valves, mechanical linkages, etc.

[0039] The transmission device may allow various interaction modes between the dynamic mass and the air pumping device. One such transmission device may result in the mechanical integration of numerous movement reversals of the dynamic mass to affect a single intake and exhaust cycle, thereby allowing a wide degree of shock magnitudes to be captured, stored, and/or periodically released to drive operation of the air pumping device. Another transmission device may allow a variable mechanical advantage profile to exist over a full range of movement of the dynamic mass, thereby allowing work energy from the dynamic mass to be balanced with the variable energy requirement of the air pumping device. Still another transmission device, particularly one in which a biasing element is present in the air pumping device, may utilize the work energy of the dynamic mass to affect the exhaust of air from the air pumping device or, alternatively, the intake of air into the air pumping device.

[0040] The pumping device may be electro-mechanical, harvesting of mechanical energy from the movement of the dynamic mass and converting it to stored electrical energy in a capacitive device, utilizing an electro-mechanical device, then releasing that electrical energy by the same or a different electro-mechanical device to affect the pumping operation.

[0041] The air pumping device may be mounted to the tire rim in several ways. First, the air pumping device may utilize existing rim features and eliminate the need to modify the rim in any way. For example, the air pumping device may utilize the inflation valve access hole in the tire rim wall to provide both a fastening point and an ambient air intake port. Such a mounting may integrate the inflation valve function into its structure, or interface with an industry standard inflation valve. Second, the device may be configured to be mounted at any position on the tire rim and within the inflation space or tire cavity, generally, thereby not requiring modification of the tire rim to structurally ground the air pumping device to the tire rim and providing an access port for the intake of ambient air.

[0042] The air pumping device in accordance with the present invention may lead to lower operating costs for vehicle owners and provide tire manufacturers additional options for achieving government mandated performance measures. As shown in FIGS. **1-2**, a mechanical device **20** in accordance with the present invention may be mounted on a tire rim **30** and convert momentum/weight over multiple acceleration/deceleration and/or high speed cycles of the tire rim into pressurized air for the tire cavity **50** of a pneumatic tire (not shown). A dynamic mass **60** may comprise ⅔ of the weight of the mechanical device **20** and a pumping device **25** may comprise ⅓ of the weight fixed on a centerline **35** of the tire rim **30**. One example mechanical device **20** may weigh about 200 grams. The mechanical device **20** and dynamic mass **60** may both be mounted to the tire rim **30** and symmetrically weighted about the centerline **35** of the tire rim **30** for optimizing rim and tire lateral balance. The lateral length of extension arms **27** of the pumping device **25** may be adjusted so that both the dynamic mass **60** and the pumping device **25** both have an equal weight on either side of the centerline **35**. The dynamic mass **60** may also angled radially inward so that it may engage the tire rim **30** more securely (FIGS. **1-2**).

[0043] One device may be fixed to the centerline **35** of the tire rim **30** (FIG. **3**) or two mechanical devices may be fixed to the centerline at diametrically opposed positions (180° apart as in FIG. **4**) for optimizing radial balance of the rim and tire. Further, N mechanical devices **20** may be fixed to the centerline **35**, spaced equally 360/N° apart about the circumference of the tire rim **30**. The dynamic masses **60** may thereby move simultaneously in response to angular accelerations/decelerations of the tire rim **30**.

[0044] Thus, the mechanical device(s) **20** may be mounted to the tire rim **30** such that the dynamic mass(es) **60** convert pivotal movement of the dynamic mass(es) into in pressurized air for the tire cavity **50**. This pivotal movement of the dynamic mass **60** radially away from (FIG. **2**) and radially toward (FIG. **1**) the tire rim **30** may thereby be balanced about the tire rim **30**. The pumping device **25** may have one or more chambers and corresponding valves (not shown). Biasing elements, such as a torsion spring (FIGS. **1-2**), may be incorporated to return the chamber volume from a high volume condition (FIG. **1**) to a low volume condition (FIG. **2**), or vise versa. The valves may be configured to allow the pumping device **25** to intake air from the exterior and to exhaust the inspired air to the tire cavity **50**. The valves may be a self-checking type, or may be mechanically opened and closed under the influence of an auxiliary mechanism (not shown). A pressure regulating element (not shown) may be included for the purpose of limiting the ability of the mechanical device **20** to elevate the pressure of the tire cavity **50** above a predetermined recommended operating level. Upon sensing the target pressure, or as the target pressure is approached, the pressure regulating element may suddenly or progressively disable the mechanical device **20** by locking, releasing, closing, opening, etc. any number of functional elements, such as intake and exhaust ports, valves, mechanical linkages (not shown), etc.

[0045] The mechanical device(s) **20** may be mounted by adhesive means or other suitable fastening means. While only one or two mechanical devices **20** on a rim **30** are shown in the drawings, for the case of dual truck wheels, one wheel might have two devices mounted diametrically opposite each other for balance with each device feeding compressed air to each of the two tires of the dual wheel.

[0046] While a certain representative examples and details have been shown for the purpose of illustrating the present invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the present invention.

What is claimed:

1. A device for use with a pneumatic tire mounted on a tire rim to keep the pneumatic tire from becoming underinflated, the device comprising:

a pumping device attached to the tire rim;

a dynamic mass mechanically confined to rotational movement relative to the pumping device and the tire rim, the dynamic mass moving in response to a minimum angular acceleration and a minimum angular velocity of the tire rim and pumping ambient air into the pumping device;

an intake port for ambient air to enter the pumping device; and

an exhaust port for forcing pressurized air into a tire cavity of the pneumatic tire for restoring air loss from an inflation volume within the tire cavity, the dynamic mass and the pumping device both being weighted equally on each side of a centerline of the tire rim.

2. The device as set forth in claim **1** wherein the dynamic mass comprises ⅔ of the weight of the device and the pumping device comprises ⅓ of the weight of the device.

3. The device as set forth in claim **2** wherein the pumping device weighs between 100 grams and 300 grams.

4. The device as set forth in claim **1** wherein the pumping device further includes at least one extension arm extending laterally from the pumping device.

5. The device as set forth in claim **1** wherein the dynamic mass is angled radially inward from the pumping device when the dynamic mass engages the tire rim.

6. The device as set forth in claim **1** further including a second pumping device and a second dynamic mass are both mounted at a diametrically opposite location on the tire rim from the first pumping device and the first dynamic mass.

7. The device as set forth in claim **6** wherein both dynamic masses move simultaneously in response to angular accelerations/decelerations of the tire rim.

8. The device as set forth in claim **1** further including a biasing element for returning the dynamic mass to a position engaging the tire rim.

9. The device as set forth in claim **1** wherein the dynamic mass is mechanically confined to rotational movement relative to the pneumatic tire.

10. The device as set forth in claim **1** wherein the dynamic mass changes position corresponding to angular velocities of the tire rim rising above and moving below a predetermined angular velocity.

11. The device as set forth in claim **1** wherein a plane about which the dynamic mass rotates passes through an axis of rotation of the tire rim.

12. The device as set forth in claim **1** wherein pivoting movement of the dynamic mass transfers work energy to air pressure in the pumping device.

13. The device as set forth in claim **1** further including a first check valve disposed proximate to the intake port for preventing air from flowing out of the pumping device.

14. The device as set forth in claim **13** further including a second check valve disposed proximate to the exhaust port for preventing air from flowing out of the tire cavity and into the pumping device.

15. The device as set forth in claim **14** further including a biasing element for returning the pumping device from a high volume intake condition to a low volume exhaust condition.

16. The device as set forth in claim **15** wherein the first check valve and the second check valve are self checking ball-type check valves.

17. The pumping device as set forth in claim **1** wherein the dynamic mass pivots to pump pressurized air from the pumping device and forcing pressurized air into the tire cavity.

18. The device as set forth in claim **1** wherein the pumping device receives ambient air from an exterior of the pumping device and exhausts pressurized air into the tire cavity simultaneously.

19. The device as set forth in claim **1** wherein the pumping device also restores air loss from an inflation volume within a second tire cavity of a second pneumatic tire.

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