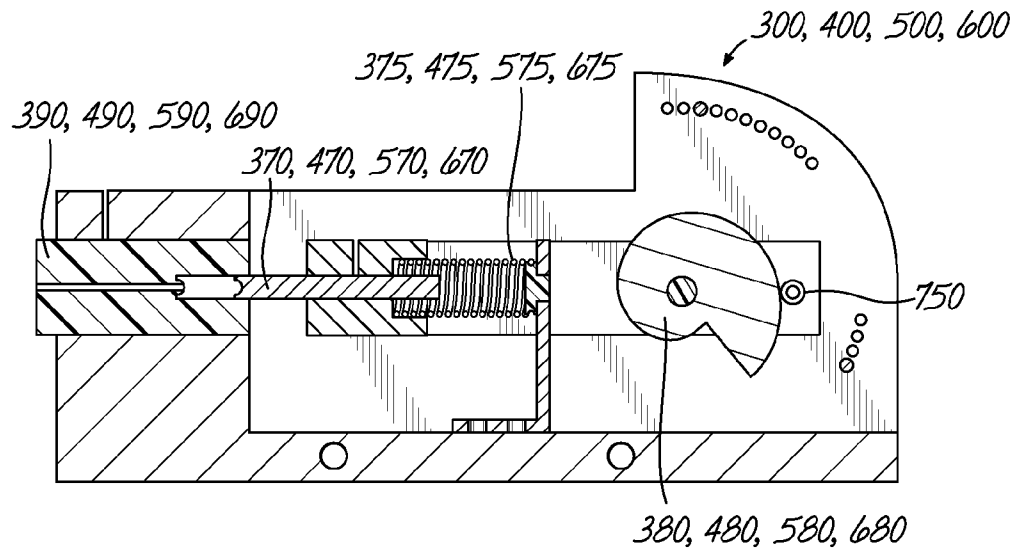




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(19) **United States**(12) **Patent Application Publication**  
**Chawla et al.**(10) **Pub. No.: US 2015/0147200 A1**(43) **Pub. Date: May 28, 2015**(54) **AIR MAINTENANCE TIRE ASSEMBLY****Publication Classification**(71) Applicant: **The Goodyear Tire & Rubber Company**, Akron, OH (US)(51) **Int. Cl.**  
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CPC ..... **F04B 17/06** (2013.01)(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 pumping device includes a housing attached to the tire rim, a dynamic mass mechanically confined to rotational movement relative to the housing and the tire rim, the dynamic mass moving in response to a minimum angular velocity of the tire rim and pumping ambient air into the housing, an intake port for ambient air to enter the housing, 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.

(73) Assignee: **The Goodyear Tire & Rubber Company**, Akron, OH (US)(21) Appl. No.: **14/091,922**(22) Filed: **Nov. 27, 2013**

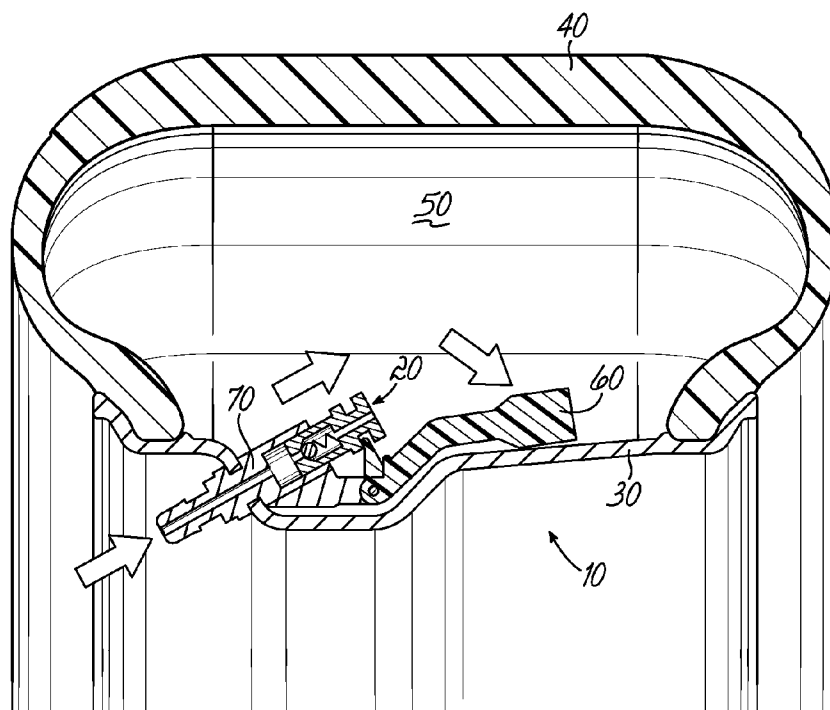


FIG. 1

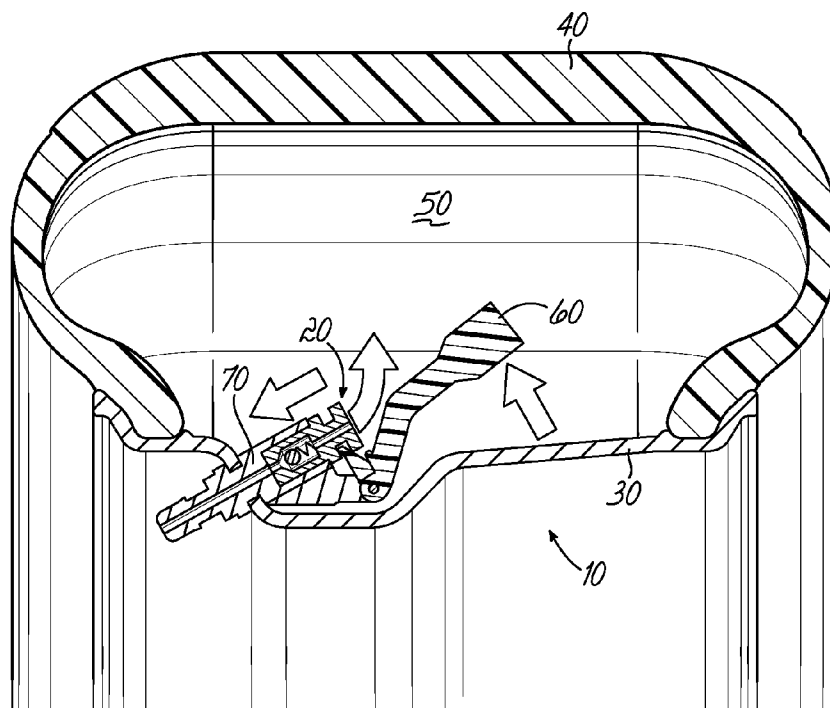


FIG. 2

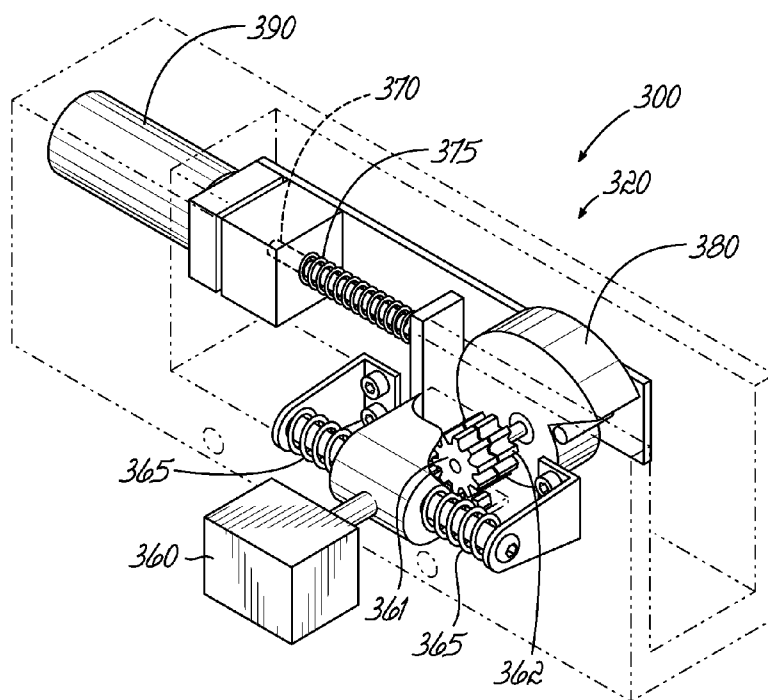


FIG. 3

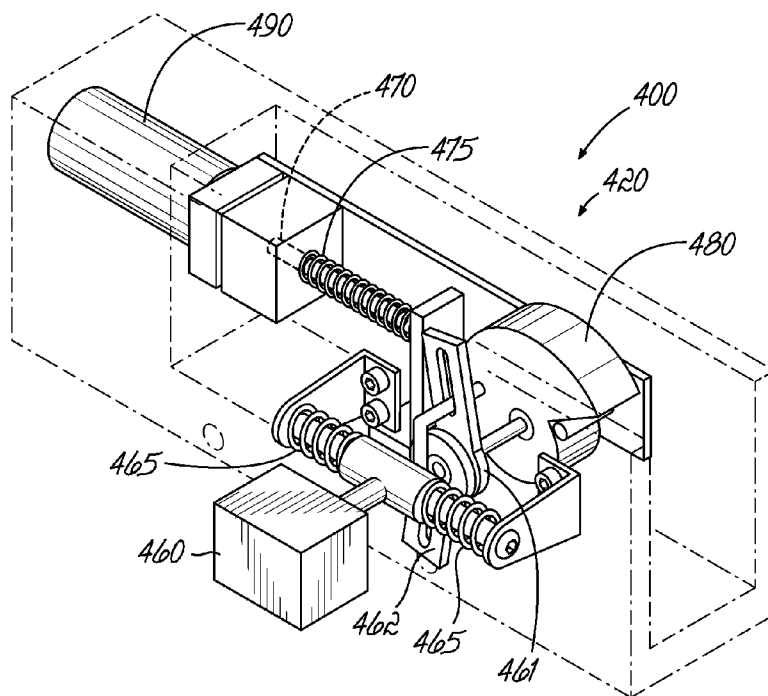


FIG. 4

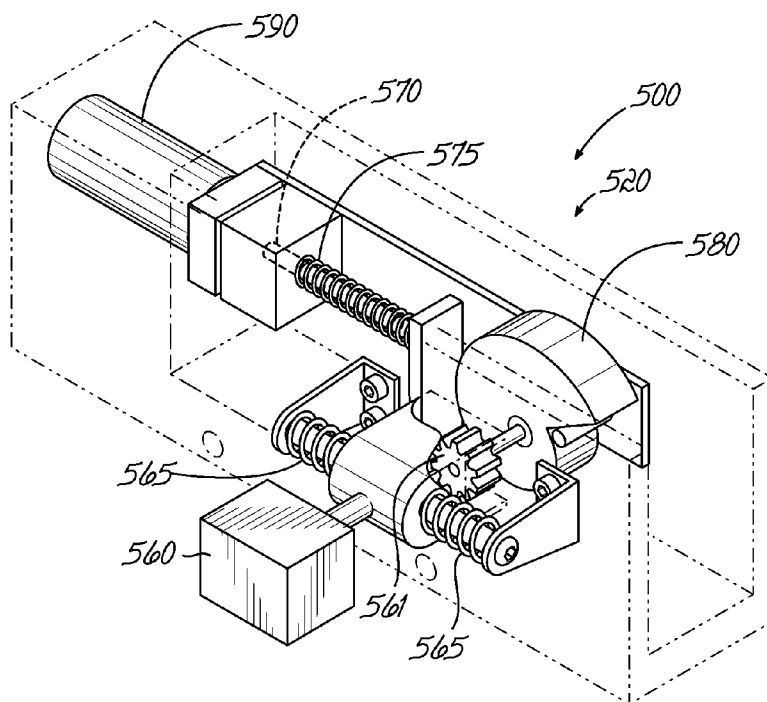


FIG. 5

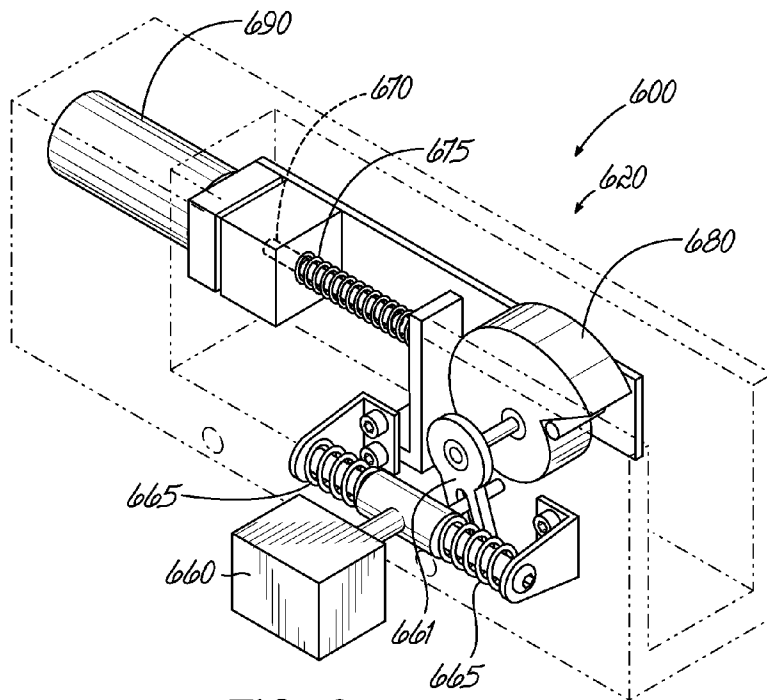


FIG. 6

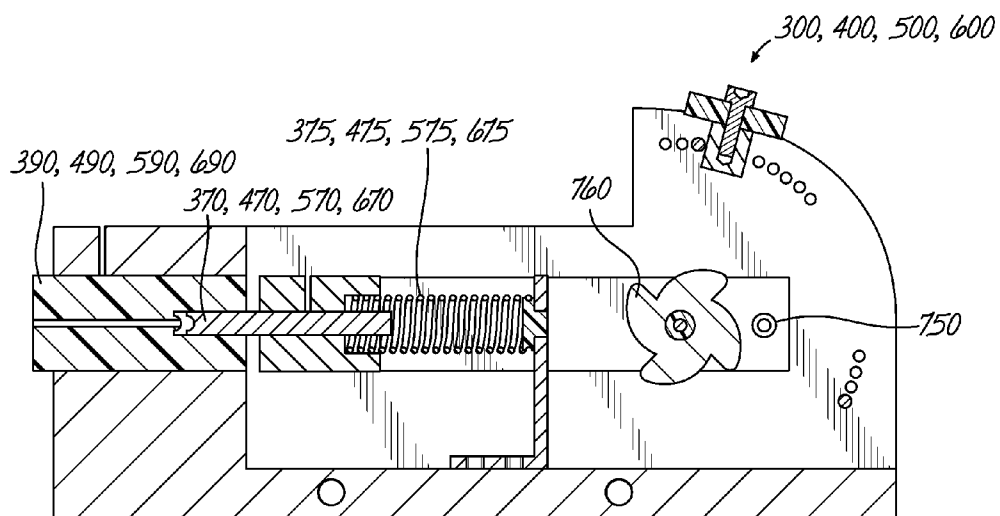


FIG. 7

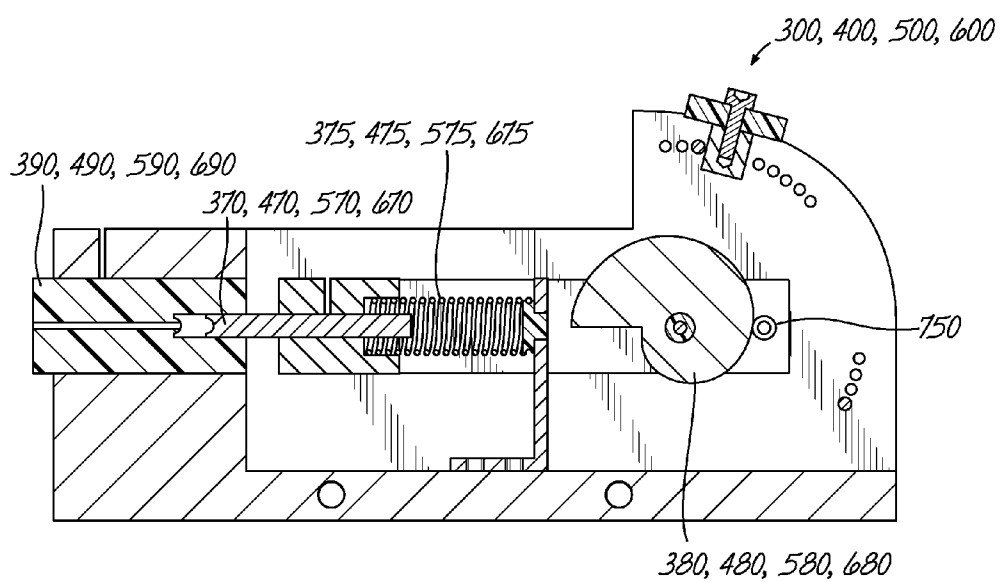


FIG. 8

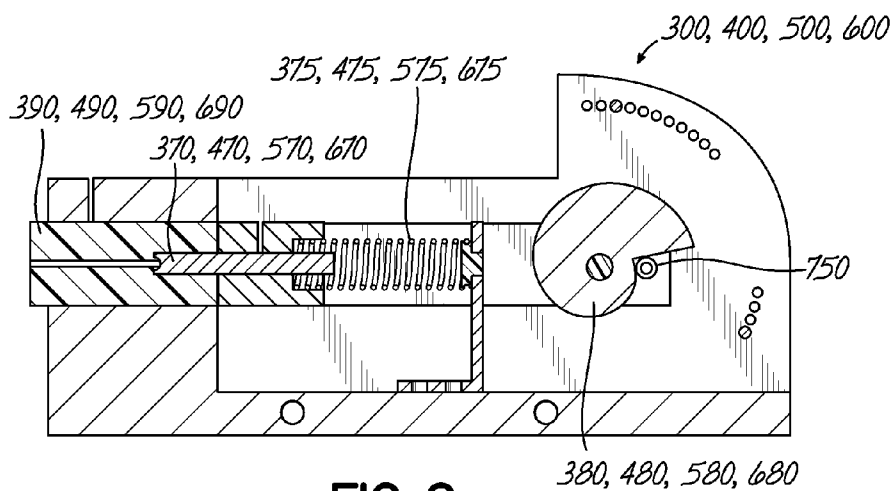


FIG. 9

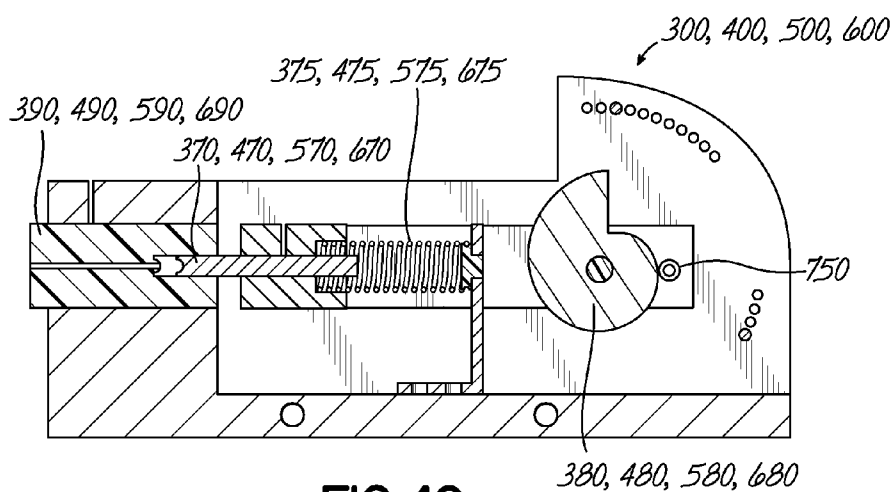


FIG. 10

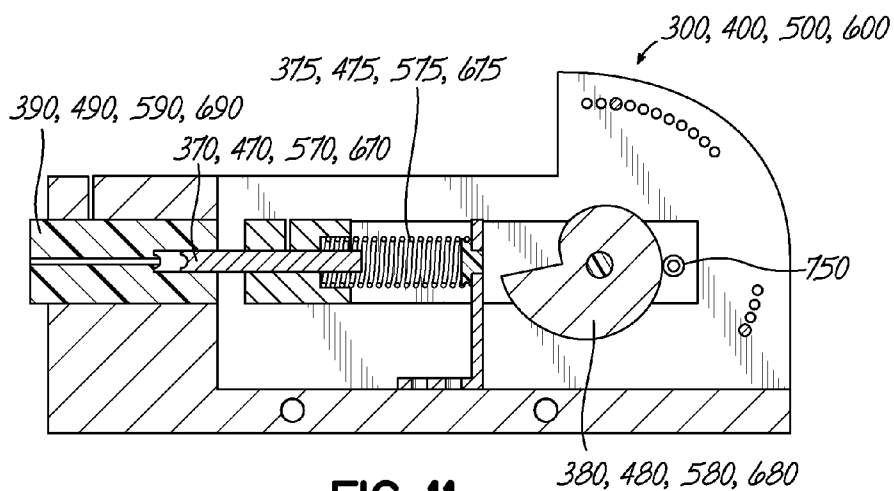


FIG. 11

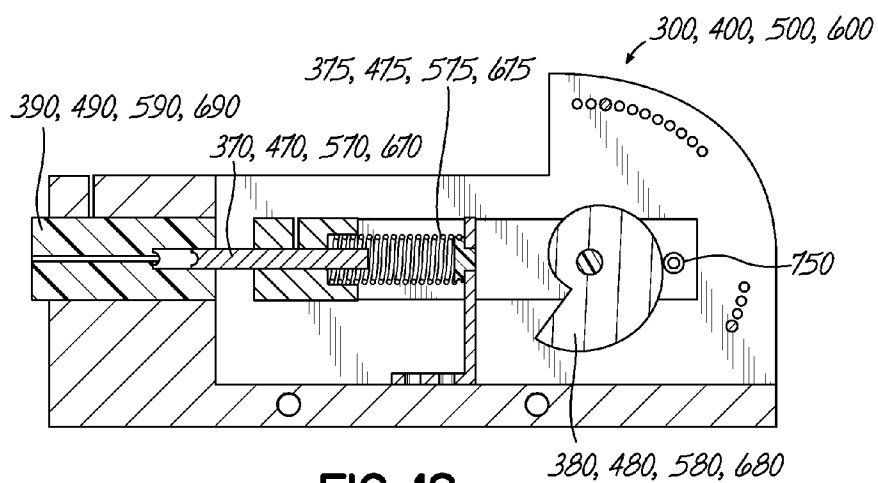


FIG. 12

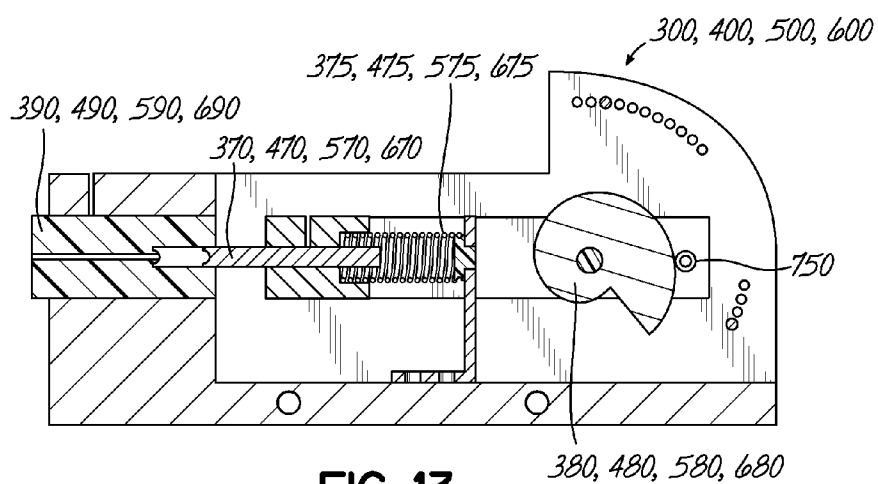


FIG. 13

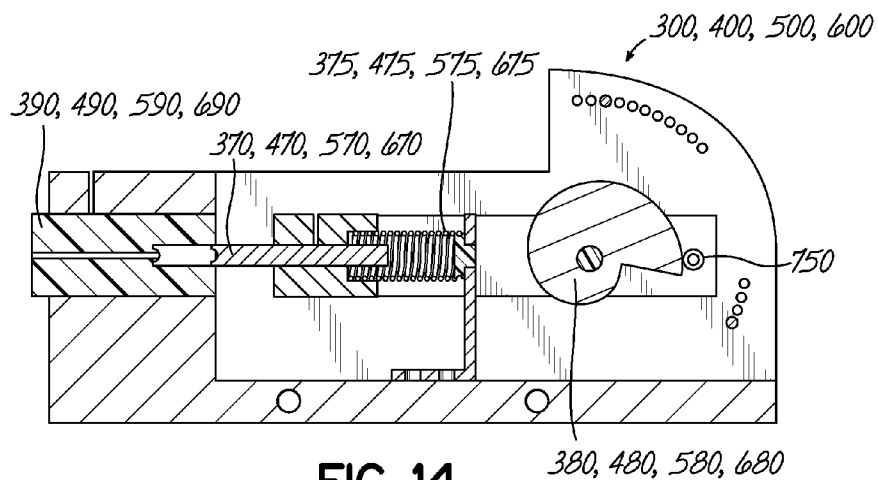


FIG. 14

## 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 pumping device in accordance with the present invention is used with a pneumatic tire mounted on a tire rim to keep the pneumatic tire from becoming underinflated. The pumping device includes a housing attached to the tire rim, a dynamic mass mechanically confined to rotational movement relative to the housing and the tire rim, the dynamic mass moving in response to a minimum angular velocity of the tire rim and pumping ambient air into the housing, an intake port for ambient air to enter the housing, 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.

**[0015]** According to another aspect of the present invention, the dynamic mass is mechanically confined to rotational movement relative to the pneumatic tire.

**[0016]** According to still 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.

**[0017]** According to yet another aspect of the present invention, a plane about which the dynamic mass rotates passes through an axis of rotation of the tire rim.

**[0018]** According to still another aspect of the present invention, pivoting movement of the dynamic mass transfers work energy to air pressure in the housing.

**[0019]** According to yet another aspect of the present invention, a first check valve is disposed proximate to the intake port for preventing air from flowing out of the housing.

**[0020]** According to still another aspect of the present invention, a second check valve is disposed proximate to the exhaust port for preventing air from flowing out of the tire cavity and into the housing.

**[0021]** According to yet another aspect of the present invention, a biasing element returns the housing from a high volume intake condition to a low volume exhaust condition.

**[0022]** According to still another aspect of the present invention, the first check valve and the second check valve are self checking ball-type check valves.

**[0023]** According to yet another aspect of the present invention, a gear rotates by movement of the dynamic mass.

**[0024]** According to still another aspect of the present invention, a biasing member restores an actuation cam to an initial position.

**[0025]** According to yet another aspect of the present invention, a slot arm rotates by movement of the dynamic mass.

**[0026]** According to still another aspect of the present invention, two coaxial gears rotate by movement of the dynamic mass.

**[0027]** According to yet another aspect of the present invention, a second housing is attached to the tire rim diametrically opposite the first housing.

**[0028]** 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.

**[0029]** According to yet another aspect of the present invention, two springs return the dynamic mass to a neutral position.

**[0030]** According to still another aspect of the present invention, an additional spring returns a cam to an initial position.

**[0031]** According to yet another aspect of the present invention, two slot arms rotate an actuation cam in a single direction.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0032]** FIG. 1 is a schematic representation of a sectional view of a pump in accordance with the present invention.

**[0033]** FIG. 2 is an enlarged schematic representation of the pump of FIG. 1 showing the pump under a different condition.

**[0034]** FIG. 3 is an enlarged schematic representation of the pump of FIG. 1 with another pumping mechanism.

**[0035]** FIG. 4 is an enlarged schematic representation of the pump of FIG. 1 with still another pumping mechanism.

**[0036]** FIG. 5 is an enlarged schematic representation of the pump of FIG. 1 with yet another pumping mechanism.

**[0037]** FIG. 6 is an enlarged schematic representation of the pump of FIG. 1 with still another pumping mechanism.

**[0038]** FIG. 7 is an enlarged schematic representation of the pump of FIG. 1 with yet another pumping mechanism. FIG. 8 is an enlarged schematic representation of the pump of FIG. 1 with still another pumping mechanism.

**[0039]** FIG. 9 is an enlarged schematic representation of the mechanism of FIG. 8 under a first condition.

**[0040]** FIG. 10 is an enlarged schematic representation of the mechanism of FIG. 8 under a second condition.

**[0041]** FIG. 11 is an enlarged schematic representation of the mechanism of FIG. 8 under a third condition.

**[0042]** FIG. 12 is an enlarged schematic representation of the mechanism of FIG. 8 under a fourth condition.

**[0043]** FIG. 13 is an enlarged schematic representation of the mechanism of FIG. 8 under a fifth condition.

**[0044]** FIG. 14 is an enlarged schematic representation of the mechanism of FIG. 8 under a sixth condition.

#### DETAILED DESCRIPTION OF EXAMPLES OF THE PRESENT INVENTION

**[0045]** An air pumping device in accordance with the present invention may be utilized with a tire rim and pneumatic tire. The pumping device may be 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.

**[0046]** 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 vice 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.

**[0047]** 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.

**[0048]** 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.

**[0049]** 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.

**[0050]** 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.

**[0051]** FIG. 1 shows an example assembly 10 in accordance with the present invention mounted on a wheel rim 30 inside a tire cavity 50 of a pneumatic tire 40. The assembly 10 may include an air pumping device 20 for use on the wheel rim 30 and within the tire cavity 50 of the pneumatic tire 40. The device 20 may be affixed to the wheel rim 30 for restoring air loss from the inflation volume within the tire cavity 50. As shown in FIGS. 1 & 2, the device 20 may include a dynamic mass 60 mechanically confined to pivotal movement about a pump housing 70. The dynamic mass 60 may change rotational position when the wheel rim 30 rotates at an angular

velocity above a predetermined value. The angular velocity may create a radially outward force on the dynamic mass 60 causing the dynamic mass to pivot a ratcheting mechanism and advance a piston with the pump housing 70 thereby pumping atmospheric air from external the tire cavity 50 into the tire cavity (FIG. 2). As the angular velocity of the wheel rim 30 decreases below the predetermined value, the dynamic mass 60 may travel radially inward to its initial position thereby resetting the ratcheting mechanism and drawing atmospheric air into the pump housing 70 in preparation for a subsequent pumping cycle. The balance of the ratcheting mechanism may be adjusted to govern the pressure in the tire cavity 50 and/or the quantity of each pump stroke.

**[0052]** The pump housing 70 may have one or more chambers and corresponding valves (not shown). Biasing elements (not shown), such as springs, may be incorporated to return the chamber volume from a high volume condition (FIG. 1) to a low volume condition (FIG. 2), or vice versa. The valves may be configured to allow the pump housing 70 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 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 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.

**[0053]** FIG. 3 schematically shows another example assembly 300 in accordance with the present invention which may be mounted on a wheel rim of a pneumatic tire. The example assembly 300 may include a two stage air pumping device 320 for use on the wheel rim 30 and within or outside the tire cavity 50 of the pneumatic tire 40. The device 320 may be affixed to the wheel rim 30 for restoring air loss from the inflation volume within the tire cavity 50. The device 320 may include a dynamic mass 360 mechanically confined to movement by a pump shaft 370. The dynamic mass 360 may change position according to the shocks/vibrations to the dynamic mass by the wheel rim 30. The plane about which the dynamic mass 360 moves may be coplanar with the rotational plane of the wheel rim 30, or slightly askew of the rotational plane. The movement of the dynamic mass 360 may in turn transfer work energy to air pressure in the tire cavity 50.

**[0054]** The device 320 may provide generally radially movement of the dynamic mass 360 to sequentially affect an intake stroke or an exhaust stroke, thereby eliminating a need for a biasing element to affect either an intake or exhaust stroke. The device 320 may include multiple and/or reversing RPM changes (such as an initial acceleration, deceleration and/or second acceleration) to affect one full intake/exhaust cycle of the device 320. To affect this full stroke, the dynamic mass 360 may move in one direction or an opposite direction thereby rotating an actuation cam 380 that enacts linear movement of the pump shaft 370 for the intake/exhaust stroke of a pump chamber 390 to force air into the tire cavity 50. The pump housing 370 may have one or more chambers and corresponding valves (not shown), similar to the arrangement of FIGS. 1-2. The valves may be configured to allow the pump

housing 370 to intake air from the exterior and to exhaust the inspired air from the pump housing 370 to the tire cavity 50.

[0055] The dynamic mass 360 may transfer linear shock energy to a first gear 361 in one linear direction and a second gear 362 in a second opposite linear direction, each rotating the actuation cam 380 incremental amounts in a single rotational direction. Biasing elements, such as the springs 365 may return the dynamic mass 360 to its neutral position. A biasing element 375 may bias the shaft 370 in a single linear direction.

[0056] FIG. 4 schematically shows another example assembly 400 in accordance with the present invention which may be mounted on a wheel rim of a pneumatic tire. The example assembly 400 may include a two stage air pumping device 420 for use on the wheel rim 30 and within or outside the tire cavity 50 of the pneumatic tire 40. The device 420 may be affixed to the wheel rim 30 for restoring air loss from the inflation volume within the tire cavity 50. The device 420 may include a dynamic mass 460 mechanically confined to movement by a pump shaft 470. The dynamic mass 460 may change position according to the shocks/vibrations to the dynamic mass by the wheel rim 30. The plane about which the dynamic mass 460 moves may be coplanar with the rotational plane of the wheel rim 30, or slightly askew of the rotational plane. The movement of the dynamic mass 460 may in turn transfer work energy to air pressure in the tire cavity 50.

[0057] The device 420 may provide generally radially movement of the dynamic mass 460 to sequentially affect an intake stroke or an exhaust stroke, thereby eliminating a need for a biasing element to affect either an intake or exhaust stroke. The device 420 may include multiple and/or reversing RPM changes (such as an initial acceleration, deceleration and/or second acceleration) to affect one full intake/exhaust cycle of the device 420. To affect this full stroke, the dynamic mass 460 may move in one direction or an opposite direction thereby rotating an actuation cam 480 that enacts linear movement of the pump shaft 470 for the intake/exhaust stroke of a pump chamber 490 to force air into the tire cavity 50. The pump housing 470 may have one or more chambers and corresponding valves (not shown), similar to the arrangement of FIGS. 1-2. The valves may be configured to allow the pump housing 470 to intake air from the exterior and to exhaust the inspired air from the pump housing 470 to the tire cavity 50.

[0058] The dynamic mass 460 may transfer linear shock energy to a first slot arm 461 in one linear direction and a second slot arm 462 in a second opposite linear direction, each rotating the actuation cam 480 incremental amounts in a single rotational direction. Biasing elements, such as the springs 465 may return the dynamic mass 460 to its neutral position. A biasing element 475 may bias the shaft 470 in a single linear direction.

[0059] FIG. 5 schematically shows another example assembly 500 in accordance with the present invention which may be mounted on a wheel rim of a pneumatic tire. The example assembly 500 may include a one stage air pumping device 520 for use on the wheel rim 30 and within or outside the tire cavity 50 of the pneumatic tire 40. The device 520 may be affixed to the wheel rim 30 for restoring air loss from the inflation volume within the tire cavity 50. The device 520 may include a dynamic mass 560 mechanically confined to movement by a pump shaft 570. The dynamic mass 560 may change position according to the shocks/vibrations to the dynamic mass by the wheel rim 30. The plane about which the dynamic mass 560 moves may be coplanar with the rotational

plane of the wheel rim 30, or slightly askew of the rotational plane. The movement of the dynamic mass 560 may in turn transfer work energy to air pressure in the tire cavity 50.

[0060] The device 520 may provide generally radially movement of the dynamic mass 560 to sequentially affect an intake stroke or an exhaust stroke, thereby eliminating a need for a biasing element to affect either an intake or exhaust stroke. The device 520 may include multiple and/or reversing RPM changes (such as an initial acceleration, deceleration and/or second acceleration) to affect one full single directional intake/exhaust cycle of the device 520. To affect this full stroke, the dynamic mass 560 may move in one direction or an opposite direction thereby rotating an actuation cam 580 that enacts linear movement of the pump shaft 570 for the intake/exhaust stroke of a pump chamber 590 to force air into the tire cavity 50. The pump housing 570 may have one or more chambers and corresponding valves (not shown), similar to the arrangement of FIGS. 1-2. The valves may be configured to allow the pump housing 570 to intake air from the exterior and to exhaust the inspired air from the pump housing 570 to the tire cavity 50.

[0061] The dynamic mass 560 may transfer linear shock energy to a single gear 561 in one linear direction and in a second opposite linear direction, only one direction rotating the actuation cam 580 incremental amounts in a single rotational direction. Biasing elements, such as the springs 565 may return the dynamic mass 560 to its neutral position. A biasing element 575 may bias the shaft 570 in a single linear direction.

[0062] FIG. 6 schematically shows another example assembly 600 in accordance with the present invention which may be mounted on a wheel rim of a pneumatic tire. The example assembly 600 may include a single stage air pumping device 620 for use on the wheel rim 30 and within or outside the tire cavity 50 of the pneumatic tire 40. The device 620 may be affixed to the wheel rim 30 for restoring air loss from the inflation volume within the tire cavity 50. The device 620 may include a dynamic mass 660 mechanically confined to movement by a pump shaft 670. The dynamic mass 660 may change position according to the shocks/vibrations to the dynamic mass by the wheel rim 30. The plane about which the dynamic mass 660 moves may be coplanar with the rotational plane of the wheel rim 30, or slightly askew of the rotational plane. The movement of the dynamic mass 660 may in turn transfer work energy to air pressure in the tire cavity 50.

[0063] The device 620 may provide generally radially movement of the dynamic mass 660 to sequentially affect an intake stroke or an exhaust stroke, thereby eliminating a need for a biasing element to affect either an intake or exhaust stroke. The device 620 may include multiple and/or reversing RPM changes (such as an initial acceleration, deceleration and/or second acceleration) to affect one full intake/exhaust cycle of the device 620. To affect this full stroke, the dynamic mass 660 may move in one direction or an opposite direction thereby rotating an actuation cam 680 that enacts linear movement of the pump shaft 670 for the intake/exhaust stroke of a pump chamber 690 to force air into the tire cavity 50. The pump housing 670 may have one or more chambers and corresponding valves (not shown), similar to the arrangement of FIGS. 1-2. The valves may be configured to allow the pump housing 670 to intake air from the exterior and to exhaust the inspired air from the pump housing 670 to the tire cavity 50.

[0064] The dynamic mass 660 may transfer linear shock energy to a single slot arm 661 in one linear direction and in

a second opposite linear direction, only one direction rotating the actuation cam 680 incremental amounts in a single rotational direction. Biasing elements, such as the springs 665 may return the dynamic mass 660 to its neutral position. A biasing element 675 may bias the shaft 670 in a single linear direction.

[0065] FIG. 7 shows an example four leafed actuation cam 760 for the assemblies 300, 400, 500, 600. This cam 760 may impart pumping strokes to the pumping chambers 390, 490, 590, 690 more often than the cam of FIGS. 3-6, but each pumping stroke may be less pressurized.

[0066] FIG. 8 shows the assemblies 300, 400, 500, 600 of FIGS. 3-6 and the relationship of the actuation cam 380, 480, 580, 680 to an actuation member, such as a pin 750 (not shown in FIGS. 3-6). FIGS. 9-14 illustrate one complete stroke of the shaft 370, 470, 570, 670 and the corresponding rotational position of the cam 380, 480, 580, 680. In FIG. 9, the assembly 330, 400, 500, 600 has completed a previous stroke and the shaft 370, 470, 570, 670 has been linearly translated back to an initial position by the biasing element 375, 475, 575, 675.

[0067] In FIG. 10, the cam 380, 480, 580, 680 has been rotated about 90° counterclockwise from the position of FIG. 9 (e.g., by the dynamic mass 360 and gears 361, 361; or by the dynamic mass 460 and slot arms 461, 462; or by the dynamic mass 560 and the single gear 562; or by the dynamic mass 660 and the single slot arm 661). The cam 380, 480, 580, 680 has thereby pushed the pin 750 and the shaft 370, 470, 570, 670 a small amount to the right in FIG. 10 and compressed the biasing member 375, 475, 575, 675 a small linear amount.

[0068] In FIG. 11, the cam 380, 480, 580, 680 has been rotated about 180° counterclockwise from the position of FIG. 9. The cam 380, 480, 580, 680 has thereby not pushed the pin 750 and the shaft 370, 470, 570, 670 any amount to the right in FIG. 11 and compressed the biasing member 375, 475, 575, 675 no linear amount from FIG. 10.

[0069] In FIG. 12, the cam 380, 480, 580, 680 has been rotated about 225° counterclockwise from the position of FIG. 9. The cam 380, 480, 580, 680 has thereby pushed the pin 750 and the shaft 370, 470, 570, 670 a relatively large amount to the right in FIG. 12 and compressed the biasing member 375, 475, 575, 675 a larger amount from FIG. 11.

[0070] In FIG. 13, the cam 380, 480, 580, 680 has been rotated about 300° counterclockwise from the position of FIG. 9. The cam 380, 480, 580, 680 has thereby pushed the pin 750 and the shaft 370, 470, 570, 670 a relatively larger amount to the right in FIG. 13 and compressed the biasing member 375, 475, 575, 675 a larger amount from FIG. 12.

[0071] In FIG. 14, the cam 380, 480, 580, 680 has been rotated about 350° counterclockwise from the position of FIG. 9. The cam 380, 480, 580, 680 has thereby pushed the pin 750 and the shaft 370, 470, 570, 670 a largest or maximum amount to the right in FIG. 14 and compressed the biasing member 375, 475, 575, 675 to a minimum from FIG. 13. As the cam 380, 480, 580, 680 continues the final 10° counterclockwise back to the position of FIG. 9, the biasing element 375, 475, 575, 675 may linearly translate the shaft 370, 470, 570, 670 back to the position of FIG. 9 to begin a subsequent pumping stroke.

[0072] While the rim mounted assemblies 10, 300, 400, 500, 600 have been shown in FIGS. 1-14 mounted to a rim exterior by a bolt and washer configuration, it might also be mounted by adhesive means. Another means may be with a bracket which fits under the wheel bolts. While only a single

device 20, 220, 320, 420, 520, 620 on a rim 30 is 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.

[0073] 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 pumping device for use with a pneumatic tire mounted on a tire rim to keep the pneumatic tire from becoming under-inflated, the pumping device comprising:

- a housing attached to the tire rim;
- a dynamic mass mechanically confined to rotational movement relative to the housing and the tire rim, the dynamic mass moving in response to a minimum angular velocity of the tire rim and pumping ambient air into the housing;
- an intake port for ambient air to enter the housing; 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.

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

3. The pumping 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.

4. The pumping 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.

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

6. The pumping 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 housing.

7. The pumping device as set forth in claim 6 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 housing.

8. The pumping device as set forth in claim 7 further including a biasing element for returning the housing from a high volume intake condition to a low volume exhaust condition.

9. The pumping device as set forth in claim 8 wherein the first check valve and the second check valve are self checking ball-type check valves.

10. The pumping device as set forth in claim 1 further including a gear rotating to pump pressurized air from the housing and forcing pressurized air into the tire cavity.

11. The pumping device as set forth in claim 10 wherein the housing receives ambient air from an exterior of the housing and exhausts pressurized air into the tire cavity simultaneously.

12. The pumping device as set forth in claim 1 further including a gear rotated by movement of the dynamic mass.

13. The pumping device as set forth in claim 12 further including a biasing member for restoring an actuation cam to an initial position.

**14.** The pumping device as set forth in claim **1** further including a slot arm rotated by movement of the dynamic mass.

**15.** The pumping device as set forth in claim **1** further including two coaxial gears rotated by movement of the dynamic mass.

**16.** The pumping device as set forth in claim **1** further including a second housing attached to the tire rim diametrically opposite the first housing.

**17.** The pumping device as set forth in claim **16** wherein the pumping device also restores air loss from an inflation volume within a second tire cavity of a second pneumatic tire.

**18.** The pumping device as set forth in claim **1** further including two springs for returning the dynamic mass to a neutral position.

**19.** The pumping device as set forth in claim **18** further including an additional spring for returning a cam to an initial position.

**20.** The pumping device as set forth in claim **1** further including two slot arms for rotating an actuation cam in a single direction.

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