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(54) **BICYCLE REAR SUSPENSION**

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(57) **ABSTRACT**

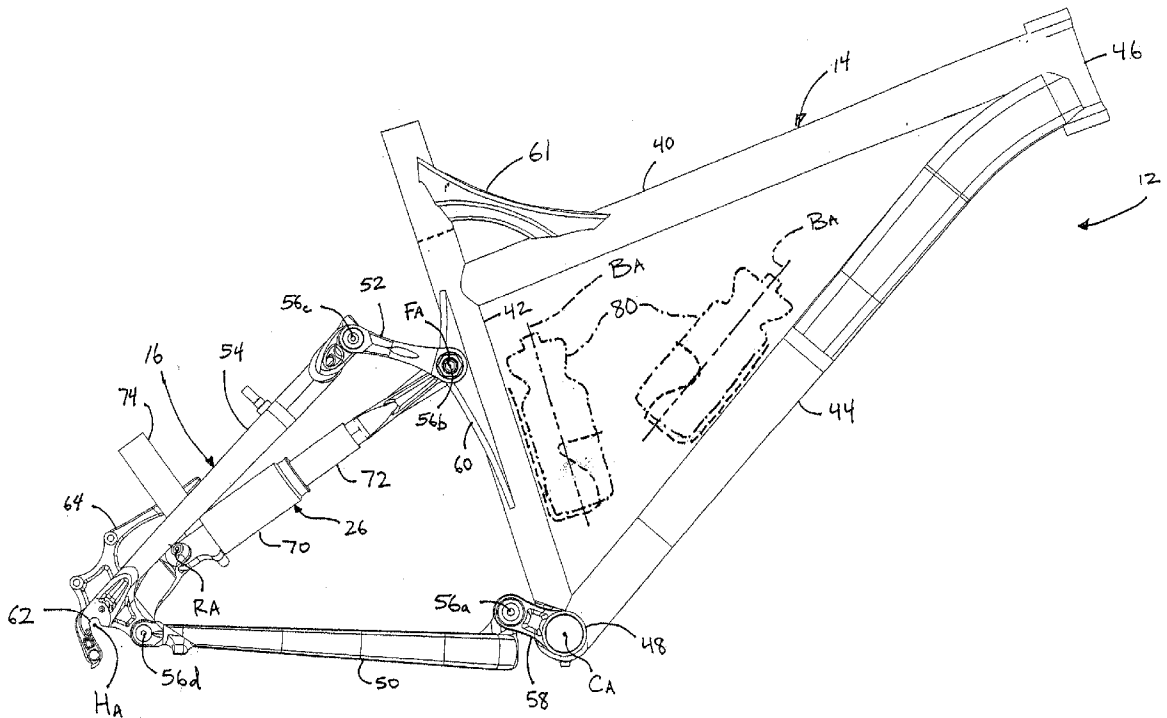
A bicycle including a frame having a main frame portion and an articulating frame portion pivotally mounted to the main frame portion and carrying a rear wheel of the bicycle at a hub axis. A shock absorber is operably connected between the main frame portion and the articulating frame portion to provide resistance to articulating motion of the articulating frame portion. A rearward end of the shock absorber preferably is pivotally mounted to the articulating frame portion at a location near the hub axis. The shock absorber preferably is positioned within a perimeter defined in a vertical plane generally by the articulating frame portion.

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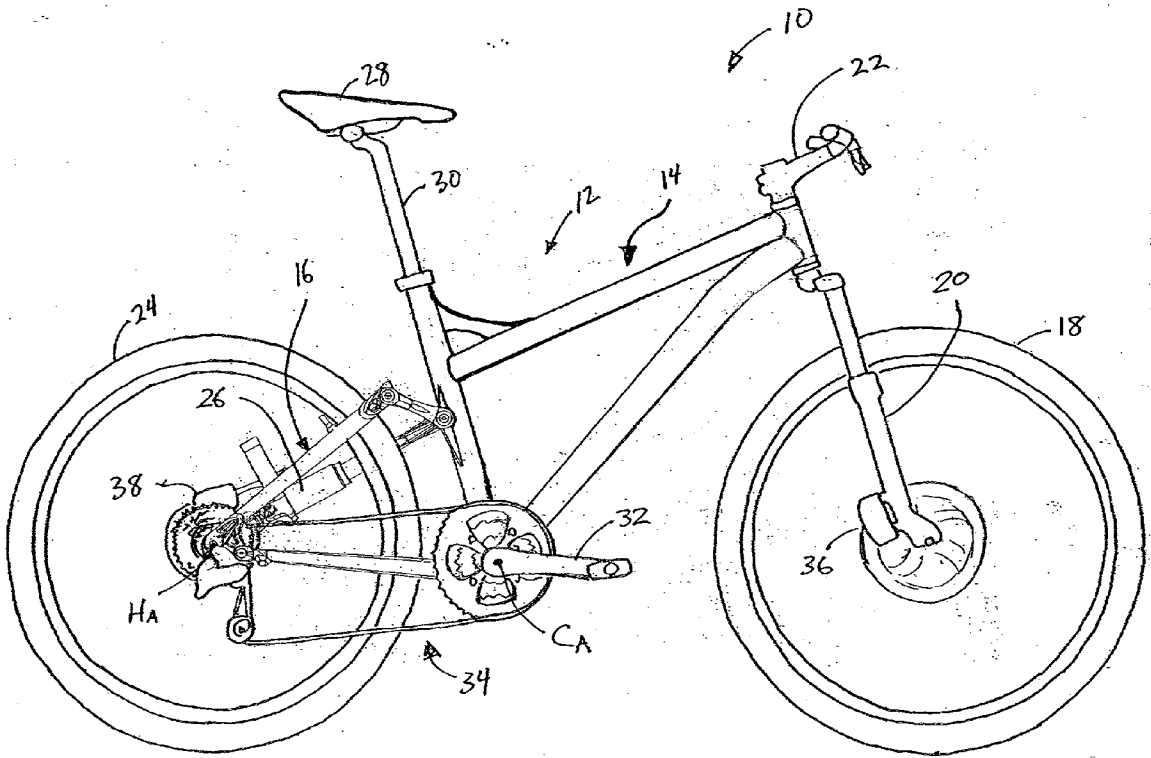


FIGURE 1

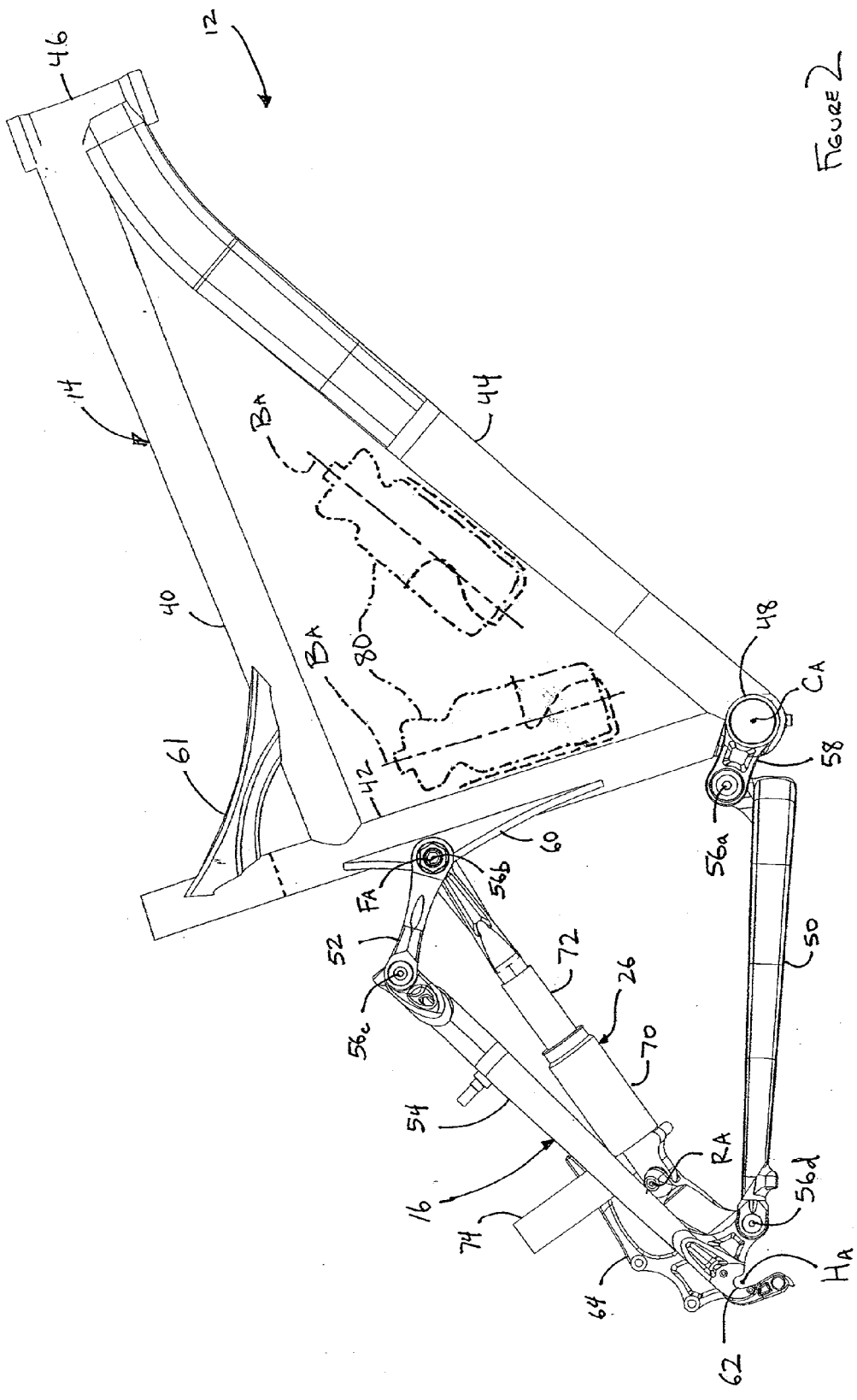


FIGURE 2

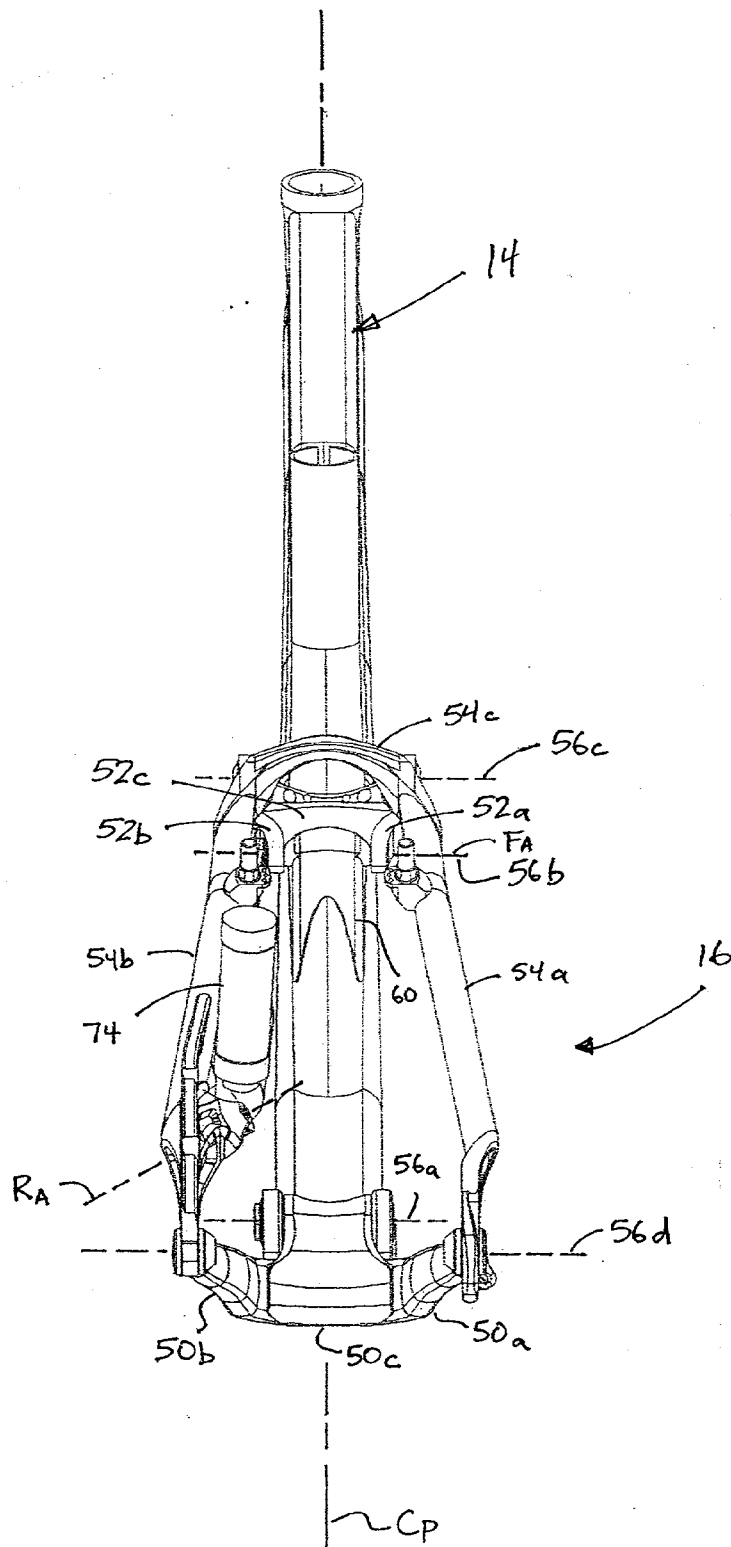


FIGURE 3

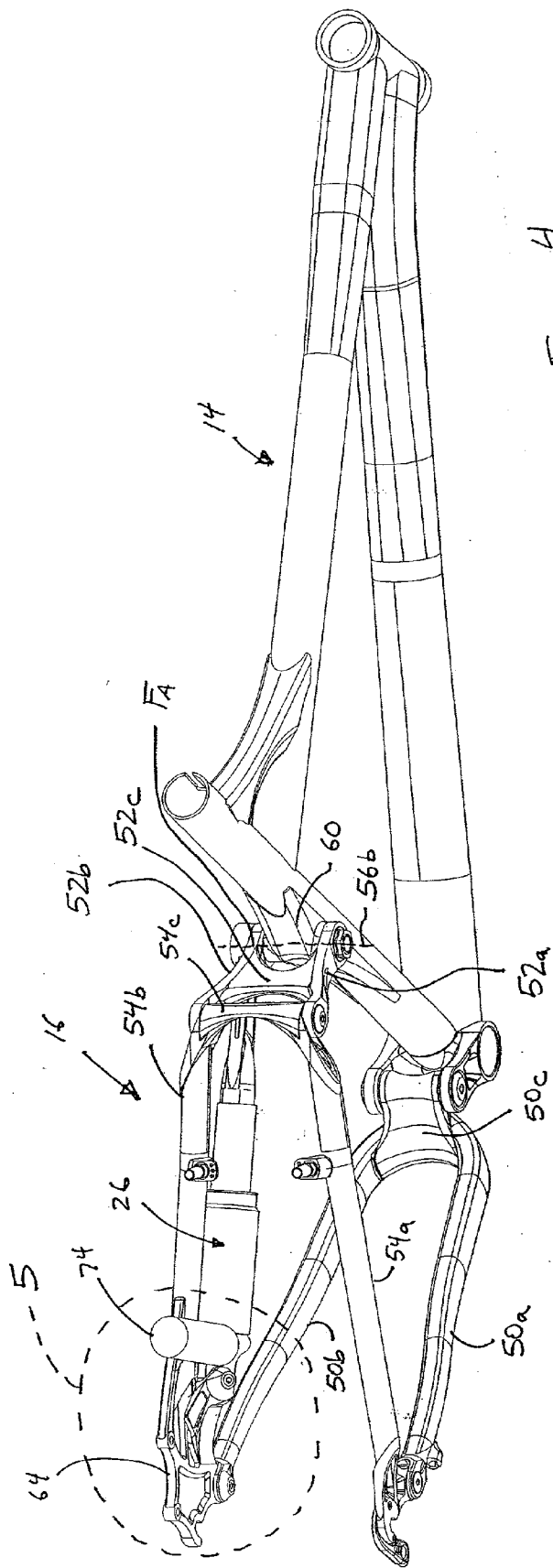


FIGURE 4

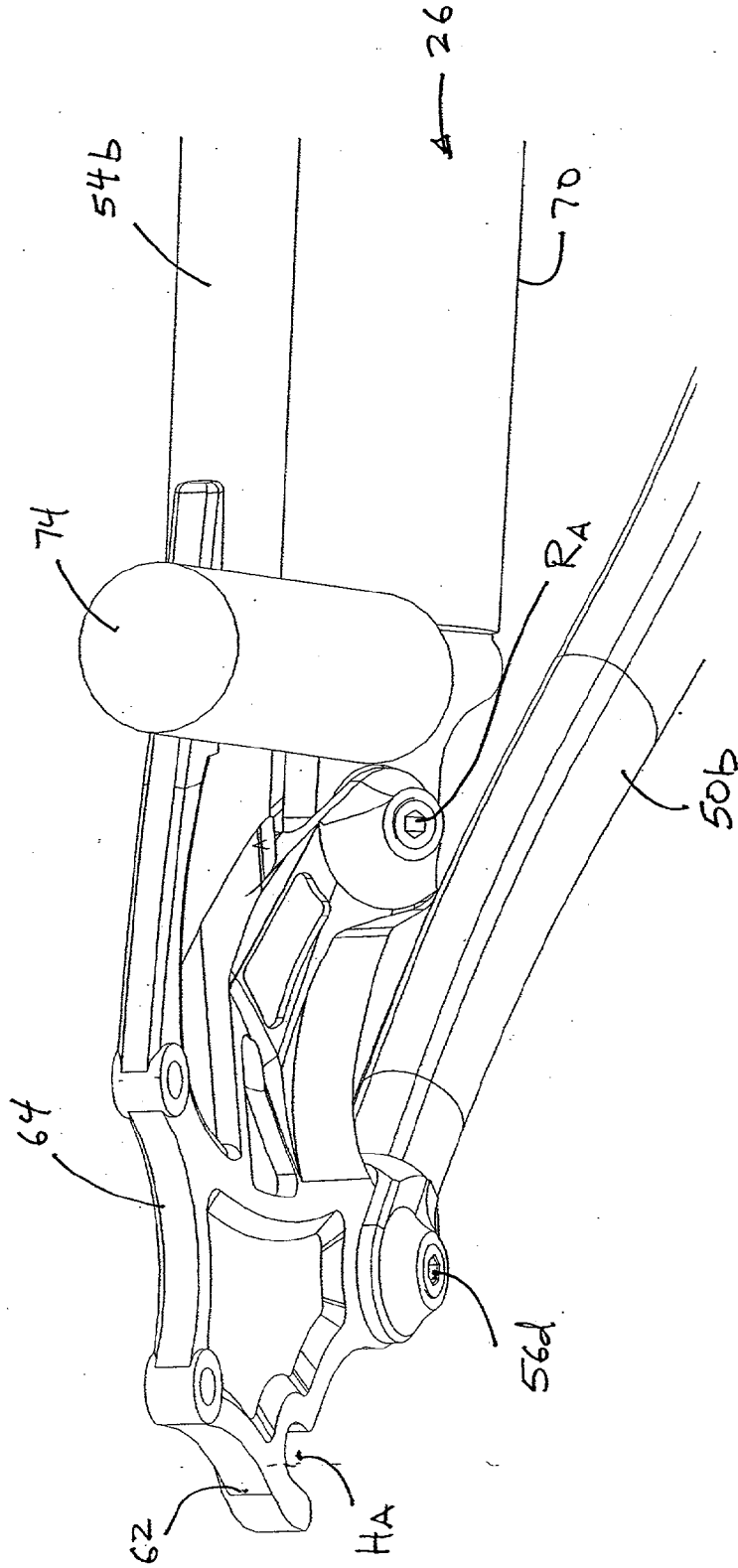


FIGURE 5

## BICYCLE REAR SUSPENSION

### BACKGROUND OF THE INVENTION

#### [0001] 1. Field of the Invention

[0002] The present invention relates generally to vehicle suspension systems. More particularly, the present invention relates to a rear wheel suspension assembly suitable for use in connection with off-road bicycles.

#### [0003] 2. Description of the Related Art

[0004] Off-road bicycles, or mountain bikes, may be equipped with front and rear suspension assemblies operably positioned between the front and rear wheels, respectively, and the frame of the bicycle. Providing front and rear suspension on a mountain bike potentially improves handling and performance by absorbing bumps, and other rough trail conditions, which may be encountered while riding off-road. However, because mountain bikes are typically pedal-driven, i.e., use the rider's power output to propel the bicycle, the provision of rear suspension, especially, may undesirably absorb a rider's power output, resulting in wasted effort.

[0005] Accordingly, rear suspension systems commonly incorporated on engine-driven vehicles, such as motorcycles, have proven ineffective for use with pedal-driven vehicles, such as mountain bikes. In addition, because a mountain bike is propelled solely by power output from the rider, it is desirable that the rear suspension assembly be lightweight. Rear suspension systems of engine-driven vehicles commonly emphasize strength over weight and, therefore, have not been widely incorporated on mountain bikes.

[0006] Mountain bike rear suspension designs, utilizing multiple linkage members, are currently used and are often effective at isolating pedal-induced and brake-induced forces from acting on the rear suspension. However, one problem associated with prior mountain bike rear suspension designs involves placement of the rear shock absorber. Due to the relatively complex nature of common mountain bike rear suspension assemblies, the placement of the rear shock absorber has often precluded the use of a traditional triangular mainframe of the mountain bike. For example, typical rear shock placement has either precluded the use of a vertical seat tube member of the mainframe, or has been positioned within the internal space defined by the mainframe. As the down tube and the seat tube members of the mainframe have traditionally been provided with mounts, or bosses, for mounting of water bottle cages, many designs incorporating rear suspension assemblies have inhibited the use of one, or both, of the traditional water bottle cage locations due to the placement of the rear shock absorber.

### SUMMARY OF THE INVENTION

[0007] Preferred embodiments of the present invention desirably inhibit pedal-induced forces and brake-induced forces from acting on the rear suspension while maintaining the use of a traditional triangular mainframe of the mountain bike. In addition, one end of the rear shock absorber is desirably positioned close to the axis of rotation of the rear wheel, or the hub axis. Accordingly, if an inertia valve is incorporated within the rear shock absorber, it may be

positioned near the hub axis, where the greatest inertial forces are present. As a result, the sensitivity of the inertia valve is increased.

[0008] A preferred embodiment is a bicycle frame having a main frame portion and an articulating frame portion. The articulating frame portion including a pair of lower arms having a forward end and a rearward end. The forward ends being pivotally connected to the main frame portion at a first pivot axis. The articulating frame portion also includes a pair of upper arms having a lower end and an upper end, the lower ends being pivotally connected near the rearward ends of the lower arms at a second pivot axis. One of the rearward ends of the lower arms and the lower ends of the upper arms define a hub axis. The articulating frame portion additionally includes a link pivotally connected to the upper ends of the upper arms at a third pivot axis and pivotally connected to the main frame portion at a fourth pivot axis. A shock absorber is pivotally connected to either the main frame portion or the link at a fifth pivot axis and pivotally connected to the articulating frame portion at a sixth pivot axis, the sixth pivot axis being located near the hub axis.

[0009] A preferred embodiment is a bicycle frame including a main frame portion comprising a top tube, a seat tube and a down tube arranged in a generally triangular arrangement and defining a generally triangular space therebetween. A first water bottle mount is defined on the seat tube and faces the space. The first mount is sized and shaped to permit a first water bottle holder to be secured to the seat tube at the first mount. A second water bottle mount is defined on the down tube and facing the space. The second mount is sized and shaped to permit a second water bottle holder to be secured to the down tube at the second mount. The bicycle frame further includes an articulating frame portion comprising a pair of lower arms having a forward end and a rearward end, a pair of upper arms having a lower end and an upper end, and a link. The forward ends of the lower arms are pivotally connected to the main frame and the lower ends of the upper arms are pivotally connected near the rearward ends of the lower arms. The link is pivotally connected to the upper ends of the upper arms at a first end and pivotally connected to the main frame. A hub axis is defined by one of the lower ends of the upper arms and the rearward ends of the lower arms. A shock absorber is pivotally connected to either the main frame or the link at a first end and pivotally connected to the articulating frame portion near the hub axis at a second end.

[0010] A preferred embodiment is a bicycle frame including a main frame portion comprising a seat tube. An upper mounting bracket is connected to the seat tube and a lower mounting bracket is connected to the main frame. The frame also includes an articulating frame portion including a pair of lower arms having a forward end and a rearward end. The forward ends being pivotally connected to the lower mounting bracket. The articulating frame portion additionally includes a pair of upper arms having a lower end and an upper end, the lower ends being pivotally connected near the rearward ends of the lower arms. One of the rearward ends of the lower arms and the lower ends of the upper arms define a hub axis. A link is pivotally connected to the upper ends of the upper arms and pivotally connected to the upper mounting bracket. A shock absorber is pivotally connected to either the main frame portion or the link and pivotally connected to the articulating frame portion near the hub axis.

[0011] A preferred embodiment is a bicycle frame comprised of a main frame portion and an articulating frame portion. The articulating frame portion is comprised of a pair of lower arms having a forward end and a rearward end, the forward ends being pivotally connected to the main frame portion. The articulating frame portion also includes a pair of upper arms having a lower end and an upper end, the lower ends being pivotally connected near the rearward ends of the lower arms. One of the rearward ends of the lower arms and the lower ends of the upper arms define a hub axis. A link is pivotally connected to the upper ends of the upper arms and pivotally connected to the main frame portion. A shock absorber is connected to the bicycle frame and is arranged to provide a force resisting movement of the articulating frame portion with respect to the main frame portion, a first end of the shock absorber being pivotally connected to the articulating frame portion near the hub axis.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0012] These and other features, aspects and advantages of the present invention are described below with reference to a preferred embodiment, that is intended to illustrate, but not to limit the present invention. The drawings contain five figures.

[0013] FIG. 1 is a side elevational view of an off-road bicycle, or mountain bike, incorporating a preferred frame and rear suspension assembly;

[0014] FIG. 2 is a side elevational view of the bicycle frame and rear suspension assembly of FIG. 1 with certain components of the bicycle removed for clarity;

[0015] FIG. 3 is a rear elevational view of the bicycle frame of FIG. 2;

[0016] FIG. 4 is a perspective view showing the top, right and rear sides of the bicycle frame of FIG. 2; and

[0017] FIG. 5 is an enlarged perspective view of a rear brake bracket and a connection of the rear shock absorber to the bicycle frame indicated by the circle labeled with the reference numeral 5 in FIG. 4.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] FIG. 1 illustrates an off-road bicycle, or mountain bike 10, including a preferred rear suspension assembly. The bicycle 10 is described herein with reference to a coordinate system wherein a longitudinal axis extends from a forward end to a rearward end of the bicycle 10. A vertical, central plane  $C_p$ , generally bisects the bicycle 10 and contains the longitudinal axis. A lateral axis extends normal to the longitudinal axis and within a horizontal plane. In addition, relative heights are generally expressed as elevations in reference to a horizontal surface on which the bicycle 10 is supported in an upright position. Similarly, relative forward and rearward positions are expressed as distances in reference to a vertical axis, which is normal to the horizontal surface. The above-described coordinate system is provided for the convenience of describing the embodiment illustrated in FIGS. 1-5, and is not intended to limit the scope of the present invention.

[0019] The bicycle 10 includes a frame 12 comprised of a generally triangular mainframe portion 14 and an articulating

frame portion, or subframe 16. The subframe 16 is pivotally connected to the mainframe 14, as is described in greater detail below.

[0020] The bicycle 10 also includes a front wheel 18 carried by a front suspension assembly, or front fork 20. A steerer tube (not shown) is journaled for limited rotation about a steering axis defined by the mainframe 14. The fork 20 is secured to the mainframe 14 by a handlebar assembly 22, as is well known in the art.

[0021] A rear wheel 24 of the bicycle 10 is carried by the subframe 16. A shock absorber 26 is pivotally connected to both the mainframe 14 and the subframe 16 to provide resistance to the pivoting motion of the subframe 16 and, thus, provide resistance to the suspension travel of the rear wheel 24.

[0022] In addition, a seat 28 is connected to the frame 14 by a seat post 30, which is received within the seat tube 42. The seat 28 provides support for a rider of the bicycle 10. A pedal crank assembly 32 is rotatably supported by the mainframe 14 and drives a multi-speed chain drive arrangement 34, as is well known in the art.

[0023] The bicycle 10 also includes front and rear brake systems 36, 38 for slowing and stopping the bicycle 10. Although the front and rear brakes 36, 38 are illustrated as disc type brakes, alternatively, rim type brakes may be provided, as will be appreciated by one of skill in the art. Rider controls (not shown) are commonly provided on the handlebar assembly 22 and are operable to control shifting of the multi-speed chain drive arrangement 34 and front and rear brake systems 36, 38.

[0024] With reference to FIGS. 2-5, the bicycle frame 12 and rear shock absorber 26 are illustrated with the remaining components of the bicycle 10 removed for clarity. As described above, the bicycle frame 12 is primarily comprised of a mainframe portion 14 and an articulating frame portion, or subframe 16.

[0025] With reference to FIG. 2, the mainframe 14 includes a top tube 40, a seat tube 42 and a down tube 44 connected to form a generally triangular shape. The top tube 40, seat tube 42 and down tube 44 also define a generally triangular space between them. The seat tube 42 extends in an upward direction and, preferably, slightly skewed in a rearward direction from a horizontal plane. The top tube 40 and down tube 44 extend in a forward direction from the seat tube 42 and connect to a head tube 46. The head tube 46 rotatably supports the steerer tube (not shown) of the front fork 20, as described above.

[0026] A bottom bracket shell 48 preferably is provided at the junction between the seat tube 42 and the down tube 44. The bottom bracket shell 48 rotatably supports the pedal crank assembly 32, as described above in relation to FIG. 1, in a manner well known in the art.

[0027] As described above, the subframe 16 is pivotally connected to the mainframe 14 and supports the rear wheel 24 of the bicycle 10. The subframe 16 is configured to allow the rear wheel 24 to move generally vertically along a curvilinear path from a first, i.e., extended or relaxed, position of the subframe 16 to a second, or compressed, position of the subframe 16. This motion permits the rear



wheel **24** and suspension assembly to absorb bumps that may be encountered during use of the bicycle **10**.

[0028] A lower arm **50** and a link **52** are pivotally connected to the mainframe **14** at their respective forward ends. An upper arm **54** is pivotally connected to the lower arm **50** at its lower end and the link **52** at its upper end. Thus, the upper arm **54** is carried by the lower arm **50** and the link **52** and, desirably, carries the rear wheel **24** of the bicycle **10**.

[0029] With reference to FIGS. 3 and 4, each of the lower arm **50**, link **52** and upper arm **54** include a pair of arm portions, which are positioned on opposing sides of the rear wheel **24**. That is, the mainframe **14** and wheels **18**, **24** lie substantially in a central, vertical plane  $C_p$  of the bicycle **10** and each of the lower arm **50**, link **52** and upper arm **54** desirably include arm portions spaced laterally on each side of the central plane. Alternatively, a single-sided subframe assembly may be provided which includes arm portions on only one side of the rear wheel **24**, as will be appreciated by one of skill in the art. The illustrated design is preferred, however, for superior strength, balance and low weight.

[0030] Both the main frame **14** and the subframe **16** preferably are constructed from tubular pieces of metal. Preferably, the tubes are made of aluminum or steel, however, other suitable materials, such as composites for example, may also be used. The individual tubes comprising the bicycle frame **12** may be joined by any suitable process, such as welding, brazing, or bonding, for example. Alternatively, all, or a portion, of the main frame **14** and/or subframe **16** may be a unitary structure.

[0031] In the illustrated embodiment, the lower arm **50**, also referred to as the swing arm or chain stay, includes right and left arm portions **50a**, **50b** (as viewed from the rear of the bicycle **10**). Desirably, a bridge portion **50c** interconnects the forward ends of the right and left lower arms **50a**, **50b** to inhibit twisting of the arm portions **50a** and **50b** in response to lateral forces. Similarly, the upper arm **54** includes a right arm portion **54a** and a left arm portion **54b** interconnected by a bridge portion **54c** at their respective upper ends. Desirably, the link **52** also includes a right arm portion **52a** and a left arm portion **52b**. Preferably, the right arm and left arm portions **52a**, **52b** are interconnected by a bridge portion **52c** extending therebetween at approximately the mid-point of each link arm **52a**, **52b**.

[0032] As described above, the mainframe **14**, lower arm **50**, link **52** and upper arm **54** are interconnected by a plurality of pivotal connections, generally referred to by the reference numeral **56**. The location of the pivots **56** and the relative lengths and relative angles of the lower arm **50**, link **52** and upper arm **54** advantageously isolate pedal-induced and brake-induced forces from causing unwanted pivoting motion of the subframe **16**. This is achieved, at least in part, by providing a near-vertical travel path of the rear wheel **24**, as described above.

[0033] Preferably, the pivot **56a** between the lower arm **50** and the mainframe **14** is located above a crank axis  $C_A$ , generally defined by a central axis of the bottom bracket shell **48**. In the illustrated embodiment, a bracket **58** is desirably connected to the mainframe **14** near the bottom bracket shell **48** and, preferably, extends both rearwardly and upwardly to receive a forward end of the lower arm **50** at the pivotal connection **56a**.

[0034] The pivot **56b** between the link **52** and the mainframe **14** is desirably located on, or near, the seat tube **42**. The seat tube **42** provides an advantageous location to mount the subframe **16** and, specifically, the link **52** because of the strength of the seat tube **42**, which is due at least in part to the inherent strength and rigidity of the triangular arrangement of the main frame **14**. Accordingly, the entire bicycle frame **12** is strong and laterally rigid without requiring the arms **50**, **54** or link **52** of the subframe **16** to be made larger or thicker. As a result, the entire frame **12** can be relatively lightweight, while remaining desirably strong.

[0035] Preferably, a bracket **60** is connected to the seat tube **42** and the forward end of the link **52** is pivotally connected to the bracket **60** at the pivot **56b**. In addition to supporting the link **52**, the bracket **60** desirably acts as a gusset, to further improve the seat tube's **42** resistance to bending and torsional forces.

[0036] In the illustrated embodiment, a rear end of the top tube **40** is connected to the seat tube **42** in proximity to the pivot **56b**. Accordingly, forces transmitted from the subframe **16** and shock absorber **26** to the mainframe **14** are directed substantially along the longitudinal axis of the top tube **40**. That is, a compressive force is exerted on the top tube **40**. Because a tubular member's axial strength (i.e., tensile or compressive strength) is typically greater than its radial, or bending, strength, the seat tube **42** of the preferred arrangement supports, and substantially prevents bending or torsion of, the seat tube **42**. Advantageously, the distance between the junction of the top tube **40** and the seat tube **42** and the pivot **56b** is less than four inches and, preferably, is less than two and one-half inches.

[0037] Additionally, the location of the connection between the top tube **40** and the seat tube **42** relative to the location of the pivot **56b** desirably remains substantially constant for all the different sizes of the bicycle frame **12**. Accordingly, the top tube **40** advantageously provides support for the seat tube **42** in resisting forces transmitted by the subframe **16** or shock absorber **26** independent of the frame size. However, desirably, the length of the seat tube **42** extending above the top tube **40** may vary according to frame size, as illustrated in phantom in FIG. 2. For some, or all, of the frame sizes, a gusset **61** may extend upward from the top tube **40** to the seat tube **42** to provide additional support to the portion of the seat tube **42** above the top tube **40**. Alternatively, or additionally, the seat tube **42** may be shaped, i.e., deformed into a non-circular cross-section, to increase the tubes resistance to bending or torsion, as will be appreciated by one of skill in the art.

[0038] A pivotal connection **56c** between a rear end of the link **52** and an upper end of the upper arm **54** is desirably positioned above the pivot **56b** between the forward end of the link **52** and the mainframe **14**. That is, the pivot **56c** preferably is located vertically higher than the pivot **56b** when the subframe **16** is in its relaxed, or extended position. Desirably, the pivot **56c** is located at, or near the bridge portion **54c** of the upper arm **54**.

[0039] A pivotal connection **56d** between the upper arm **54** and the lower arm **50** is desirably positioned below a dropout **62** formed on the upper arm member **54**. The dropout **62** supports an axle (not shown) of the rear wheel **24**, as is known in the art. The axle of the rear wheel **24** defines an axis of rotation of the rear wheel **24**, or a hub axis  $H_A$ .

Accordingly, the hub axis  $H_A$  desirably is located above the pivot **56d**. Desirably, the connection **56d** is located at, or near, one of the rearward end of the lower arm **50** and the lower end of the upper arm **54**. Preferably, the connection **56d** is less than about five inches and, more preferably, less than about two inches from one of the rearward end of the lower arm **50** and the lower end of the upper arm **54**.

[0040] The above-described pivot locations have been found to advantageously isolate pedal-induced and brake-induced forces from being transmitted to the rear suspension of the bicycle **10**. As such, these pivot locations are preferred locations. In addition, it is preferred that an imaginary line extending between the pivots **56a** and **56d** crosses an imaginary line extending between the hub axis  $H_A$  and the crank axis  $C_A$ . Alternatively, other relative lengths and angles of the subframe **16** members and/or other pivot locations may also be used. For example, the pivot **56a** between the mainframe **14** and the lower arm **50** may alternatively be positioned below, or concentric with, the crank axis  $C_A$ . In addition, the pivot **56d** between the lower arm **50** and the upper arm **54** may alternatively be positioned above the hub axis  $H_A$ , resulting in the rear wheel **24** being carried by the lower arm **50**. Also, the link **52** may be longer than the illustrated embodiment, and may even be approximately the same length as the lower arm **50**, such that the upper arm **54** is held in an approximately vertical orientation. In addition, other modifications apparent to one of skill in the art may also be incorporated.

[0041] Desirably, one or more bearing assemblies are provided at each pivot **56** to permit smooth pivoting motion of the rear suspension. Alternatively, bushings or other suitable constructions may also be used, as may be determined by one of skill in the art.

[0042] As mentioned above, the rear shock absorber **26** is operably positioned between the subframe **16** and the mainframe **14** to provide resistance to articulating movement of the subframe **16** and, thus, the rear wheel **24**. Preferably, a first, or forward, end of the shock absorber **26** is connected to the mainframe **14** and a second, or rearward, end of the shock absorber **26** is connected to the upper arm **54**. However, the forward end of the shock absorber **26** may be connected to a member of the articulating frame portion, such as the link **52**. In the illustrated embodiment, the forward end of the shock absorber **26** preferably is pivotally connected to the seat tube **42** of the mainframe **14**. Preferably, the forward end of the shock absorber **26** is connected to the bracket **60** and a forward end pivot axis  $FA$  of the shock absorber **26** is coaxial with the pivot **56b** between the link **52** and the mainframe **14**.

[0043] A bracket **64** is connected to the subframe **16** and, preferably, the upper arm **54** and is configured to support a rear brake assembly **38** (FIG. 1), as is known in the art. The bracket **64** preferably is welded to the subframe **16**, however, other suitable connection methods may also be used. A second end of the shock absorber **26** is preferably connected to the bracket **64** and is pivotal about a rearward end pivot axis  $R_A$ . By connecting both the rear brake assembly **38** and the shock absorber **26** to one bracket **64**, redundant brackets are eliminated thereby reducing the overall number of parts and the overall weight of the bicycle frame **12**. As illustrated in FIG. 5, the bracket **64** preferably also includes the left-side dropout **62**, which cooperates with the right-side

dropout **62** to support the rear wheel **24** and define the hub axis  $H_A$ . In addition, the bracket **64** defines the left-side pivot **56d** between the left upper arm portion **54b** and the left lower arm portion **50b**. That is, in a preferred embodiment, the left upper arm portion **54b** is connected to the bracket **64**, which is, in turn, connected to the left lower arm portion **50b**.

[0044] The illustrated shock absorber **26** has a main shock body including a shock shaft portion **70** telescopingly engaged with a shock body portion **72**. Desirably the shock absorber **26** provides both a spring force and a damping force, as is known in the art. The spring force is related to the relative position between the shock shaft **70** and the shock body **72** while the damping force is related to the relative speed between the shock shaft **70** and the shock body **72**. The spring assembly may comprise an air spring assembly (as illustrated), a coil spring assembly, or other suitable suspension springs, as may be determined by one of skill in the art. In addition, the shock absorber **26** may be mounted in a reverse orientation from the illustrated embodiment. That is, the shock shaft **70** may be connected to the main frame **14** and the shock body **72** connected to the subframe **16**, as will be appreciated by one of skill in the art.

[0045] Preferably, the damping system comprises a piston movable within a fluid cylinder of the shock absorber **26** and fixed for movement with one of the shock shaft **70** and shock body **72**. The piston preferably forces hydraulic fluid within the fluid chamber through one or more restrictive flow paths to generate a damping force when the shock absorber **26** is both extending and compressing, as is known in the art. One or more flow paths may be provided for each of, or both, extending motion and compressing motion of the shock absorber **26**. In addition, the restriction of one or more of the flow paths may be externally adjustable to permit adjustment of the damping force provided by the shock absorber **26**.

[0046] Desirably, the fluid cylinder within the shock absorber **26** is connected to a reservoir chamber defined within a reservoir member **74** of the shock **26**. Although the illustrated reservoir member **74** is directly connected to the main body of the shock absorber **26**, alternatively, the reservoir **74** and shock absorber **26** may be connected by a hydraulic hose connection.

[0047] Desirably, an inertia valve arrangement is operably positioned between the fluid cylinder of the shock absorber **26** and the fluid chamber of the reservoir **74** and is arranged to selectively alter the damping force provided by the shock absorber **26**. As will be appreciated by one of skill in the art, an inertia valve assembly commonly includes a inertia mass biased into a closed position, i.e., covering one or more fluid ports, by a biasing member, such as a coil spring.

[0048] When an acceleration force of acting on the shock absorber **26**, along the direction of movement of the inertia mass, exceeds a predetermined threshold, the inertia mass opens against the biasing force of the spring to uncover the fluid ports. Hydraulic fluid is permitted to flow through the opened fluid ports, thereby increasing the total fluid flow within the shock absorber **26** and reducing the damping force. In the illustrated embodiment, the inertia valve preferably remains closed in response to accelerations originating at the sprung mass (i.e., the main frame **14** and rider of the bicycle **10**) and opens in response to accelerations above a predetermined threshold, which originate at the unsprung

mass (i.e., the subframe 16 and rear wheel 24 of the bicycle 10). An exemplary shock absorber incorporating an inertia valve arrangement is described in U.S. Pat. No. 6,267,400, which is assigned to the assignee of the present application.

[0049] By mounting the end of the shock absorber 26 closest to the inertia valve arrangement to the upper arm 54 at a position near the hub axis  $H_A$ , inertia forces acting on the wheel 24 most effectively influence the inertia mass. In the illustrated embodiment, the inertia mass is positioned within the reservoir 74. Accordingly, the end of the shock absorber 26 to which the reservoir 74 is mounted, desirably is connected to the subframe 16 at a position, or pivot axis  $R_A$ , near the hub axis  $H_A$  and, preferably, to a bracket 64 on the upper arm 54. Such an arrangement increases the sensitivity of the inertia valve. Alternatively, the reservoir 74 may be positioned at, or even rearward of, the hub axis  $H_A$  to further increase the sensitivity of the inertia valve. Desirably, the rearward shock mount axis  $R_A$  is located on one of the rearward half of the lower arm 50 and the lower half of the upper arm 54. Preferably, the shock mount axis  $R_A$  is located within approximately five inches and, more preferably, within approximately four inches of the hub axis  $H_A$ .

[0050] Preferably, the shock absorber 26 is mounted to the bicycle frame 12 such that the main body (i.e., the shaft portion 70 and body portion 72) is positioned substantially within a perimeter defined in a generally vertical plane by the lower arms 50, link 52, upper arms 54 and portion of the main frame 14 between pivots 56a and 56b. With such an arrangement, the main body of the shock absorber 26 advantageously lowers the center of gravity of the bicycle 10 and is protected from damage by the lower arms 50, link 52, upper arms 54 and portion of the main frame 14. In the illustrated embodiment, the reservoir 74 is positioned substantially outside of the above-described perimeter. However, alternate positioning of the reservoir 74, from that shown, is also possible, including positioning the reservoir 74 within the perimeter.

[0051] With reference to FIGS. 3 and 4, preferably the reservoir 74 is positioned between the upper arm portions 54b and 54a and, more preferably, immediately adjacent to the left side upper arm portion 54b, to permit adequate clearance for the rear wheel 24 of the bicycle 10 between the reservoir 74 and the right side upper arm portion 54a. By positioning the reservoir 74 between the upper arm portions 54a, 54b, the reservoir 74 is substantially protected from damage.

[0052] Desirably, the rearward pivot axis  $R_A$  of the shock absorber 26 is skewed relative to the forward pivot axis  $F_A$  of the shock absorber 26 and the pivot axes 56 of the subframe 16. As mentioned above, the forward pivot axis  $F_A$  and subframe pivot axes 56 desirably are substantially horizontal, or perpendicular to a vertical, longitudinal central plane  $C_p$  of the bicycle. Such an arrangement permits increased clearance for the rear wheel 24 while retaining the shock absorber 26 substantially within a plane defined by the lower arm 50 and upper arm 54, to protect the shock absorber 26 from damage. With reference to FIG. 4, the forward end of the shock absorber 26 preferably is positioned to the outside of the left arm of the link 52b. That is, the left arm of the link 52b is positioned between the forward end of the shock 26 and the mounting bracket 60.

[0053] As mentioned above, the subframe 16 pivots with respect to the main frame 14 to move the rear wheel 24 along

a wheel travel path. As will be appreciated by one of skill in the art, the travel path of the rear wheel 24 may be linear, curvilinear, or arcuate. The travel path defines a distance from the relaxed position of the subframe 16 to the compressed position of the subframe 16, as described above. Advantageously, with the preferred rear suspension assembly, a shock absorber 26 having a relatively large amount of travel (i.e., movement from the fully extended position to the fully compressed position, or stroke length) may be employed. Thus, for each incremental movement of the rear wheel 24 along its travel path, the shock absorber 26 compresses a greater amount than in prior art bicycle rear suspension designs. A long-travel shock absorber advantageously contains a greater amount of hydraulic fluid, which reduces heat build-up within the shock 26, thereby improving performance.

[0054] Preferably, the shock absorber 26 has from about one and one-half to two and one-half inches of travel and, more preferably, about one and three-quarters to two inches of travel. In addition, the average ratio of rear wheel 24 travel to shock absorber 26 travel desirably is less than about 2.6:1, preferably less than about 2:1 and, more preferably, is about 1.8:1.

[0055] With reference to FIGS. 1 and 2, the illustrated rear suspension assembly permits the use of a traditional, triangular arrangement main frame 14. This is due, at least in part, to the advantageous placement of the rear shock absorber 26 substantially within the subframe 16. Accordingly, a rider may insert his or her arm through the triangular space created by the main frame 14 and hoist the bicycle 10 onto his or her shoulder for carrying. This is often advantageous when sections of an off-road trail may be too difficult to traverse while riding. In addition, a pair of water bottle mounts may be provided in traditional locations on the seat tube 42 and down tube 44, so that bottle cages for holding water bottles 80 may be mounted thereto, as illustrated in phantom in FIG. 2. The placement of the water bottles 80 within the triangular space created by the main frame 14 permits convenient access to water bottles 80 and, importantly, permit two water bottles 80 to be carried. A significant number of bicycle frames utilizing rear suspension only provide one water bottle mount location, or provide a second water bottle mount in an inconvenient location, such as the underneath side of the down tube 44, for example.

[0056] As is conventional, preferred water bottle mounts commonly comprise a pair of threaded apertures spaced axially from one another within one side wall of a tube member of the bicycle frame 14. Threaded fasteners are used to mount a bottle holder, or cage, to the frame 14. The bottle cage is typically constructed from bent metal wire or tubing and is configured to support a water bottle 80 substantially parallel with a longitudinal axis of the tube member of the frame 14, such as the seat tube 42 and down tube 44 in the embodiment of FIG. 2.

[0057] A preferred bottle cage permits a water bottle 80 to be placed into or removed from the cage by a sliding motion along an axis  $B_A$ , which is substantially parallel to the longitudinal axis of the frame tube that the cage is mounted to. Thus, ample room within the triangular space of the frame 14 is necessary to be able to slide the water bottle 80 along the axis  $B_A$  until it is removed from the cage. Such

cages are preferred because of their low weight and ability to securely hold a water bottle **80**, even when the bicycle **10** is ridden over rough terrain. More complex cages that permit use in smaller areas, such as cages that pivot sideways relative to the bicycle frame **12**, are less preferred by cyclists because of their increased weight and potential to pivot undesirably when the bicycle **10** encounters rough terrain.

[**0058**] Preferred embodiments of the present bicycle frame **12** advantageously achieve a number of other benefits over prior bicycle frame designs. The provision of a triangular main frame **14** and not positioning the shock absorber **26** within the triangular space within the main frame **14** makes possible other desirable features of the present bicycle frame **12**. For example, without being required to provide space along the axis of the seat tube **42** for the shock absorber **26**, the seat tube **42**/top tube **40** junction can be positioned vertically lower to provide a frame **12** having a low stand-over height. Stand-over height may be defined as the clearance of a rider straddling the top tube **40** of the bicycle **10** with both feet on the ground. Low stand-over height is especially beneficial in technical off-road bicycling, wherein the rider may have to remove his feet from the bicycle pedals unexpectedly. In addition, the low position of the top tube **40** combined with the low position of the rear shock absorber **26** produces a bicycle frame **10** with an advantageously low center of gravity. As will be appreciated by one of skill in the art, a low center of gravity generally improves the handling characteristics of a bicycle.

[**0059**] Furthermore, it is possible to produce a bicycle frame **12** having a relatively short seat tube **42** because it is not necessary to provide room within the triangular space of the main frame for the shock absorber **26**. As a result, frames **12** may be produced to accommodate shorter riders, who may be unable to comfortably fit on many prior art bicycles incorporating rear suspension. In addition, the provision of a seat tube **42** that is uninterrupted by a shock absorber **26** permits the seat **28** to be temporarily lowered to allow a rider of the bicycle **10** to shift his or her body weight without being impeded by the seat **28**. Lowering the seat **28** is especially advantageous during technical off-road riding including steep downhill sections, to permit a rider to easily shift his or her weight backward on the bicycle **10**, for example.

[**0060**] Although this invention has been disclosed in the context of a preferred embodiment, it will be understood by those of skill in the art that the present invention extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof. Accordingly, the invention is to be defined solely by the appended claims.

What is claimed is:

1. A bicycle frame, comprising:

a main frame portion;

an articulating frame portion comprising:

a pair of lower arms having a forward end and a rearward end, said forward ends being pivotally connected to said main frame portion at a first pivot axis;

a pair of upper arms having a lower end and an upper end, said lower ends being pivotally connected near

said rearward ends of said lower arms at a second pivot axis, one of said rearward ends of said lower arms and said lower ends of said upper arms defining a hub axis;

a link pivotally connected to said upper ends of said upper arms at a third pivot axis and pivotally connected to said main frame portion at a fourth pivot axis; and

a shock absorber pivotally connected to one of said main frame portion and said link at a fifth pivot axis and pivotally connected to said articulating frame portion at a sixth pivot axis, said sixth pivot axis being located near said hub axis.

2. The bicycle frame of claim 1, wherein said main frame portion additionally comprises a seat tube, said first pivot axis and said fourth pivot axis one of intersecting and being located adjacent said seat tube.

3. The bicycle frame of claim 1, said articulating frame portion additionally comprising a bracket for mounting a rear brake assembly, said sixth pivot axis being located on said bracket.

4. The bicycle frame of claim 1, wherein said fourth pivot axis and said fifth pivot axis are at least proximate one another.

5. The bicycle frame of claim 4, wherein said fourth pivot axis and said fifth pivot axis are coaxial.

6. The bicycle frame of claim 1, said main frame additionally comprising a bottom bracket shell defining a crank axis, wherein said first pivot axis is above said crank axis.

7. The bicycle frame of claim 1, wherein said hub axis is defined by said upper arms.

8. The bicycle frame of claim 7, wherein said hub axis is above said second pivot axis.

9. The bicycle frame of claim 1, wherein said fifth pivot axis and said sixth pivot axis are non-parallel.

10. The bicycle frame of claim 1, wherein said lower arms define a first length between said first pivot axis and second pivot axis and said link defines a second length between said third pivot axis and said fourth pivot axis, said second length being less than said first length.

11. The bicycle frame of claim 10, wherein said second length is less than one half of said first length.

12. The bicycle frame of claim 10, wherein said second length is less than one third of said first length.

13. The bicycle frame of claim 1, wherein said lower arms, said upper arms, said link and said main frame portion define a perimeter in a vertical plane, said shock absorber comprising a main shock body, said main shock body being positioned substantially within said perimeter.

14. The bicycle frame of claim 13, wherein said shock absorber additionally comprises a reservoir connected to said main shock body, said reservoir being positioned substantially outside of said perimeter.

15. A bicycle frame, comprising:

a main frame portion comprising a top tube, a seat tube and a down tube arranged in a generally triangular arrangement defining a generally triangular space therebetween, a first water bottle mount defined on said seat tube and facing said space, said first mount sized and shaped to permit a first water bottle holder to be secured to said seat tube at said first mount and a second water bottle mount defined on said down tube and facing said space, said second mount sized and shaped to permit a

second water bottle holder to be secured to said down tube at said second mount;

an articulating frame portion comprising a pair of lower arms having a forward end and a rearward end, a pair of upper arms having a lower end and an upper end, and a link, said forward ends of said lower arms being pivotally connected to said main frame, said lower ends of said upper arms being pivotally connected near said rearward ends of said lower arms, said link being pivotally connected to said upper ends of said upper arms at a first end and pivotally connected to said main frame, a hub axis defined by one of said lower ends of said upper arms and said rearward ends of said lower arms; and

a shock absorber pivotally connected to one of said main frame and said link at a first end and pivotally connected to said articulating frame portion near said hub axis at a second end.

**16.** The bicycle frame of claim 15, wherein said articulating frame portion additionally comprises a bracket for mounting a rear brake assembly, said pivotal connection between said shock absorber and said articulating frame portion being located on said bracket.

**17.** The bicycle frame of claim 15, wherein said pivotal connection between said link and said main frame defines a first pivot axis and said pivotal connection between said shock absorber and said main frame defines a second pivot axis, said first pivot axis and said second pivot axis being at least proximate one another.

**18.** The bicycle frame of claim 17, wherein said first pivot axis and said second pivot axis are coaxial.

**19.** A bicycle frame, comprising:

a main frame portion comprising a seat tube;

an upper mounting bracket connected to said seat tube;

a lower mounting bracket connected to said main frame;

an articulating frame portion comprising:

a pair of lower arms having a forward end and a rearward end, said forward ends being pivotally connected to said lower mounting bracket;

a pair of upper arms having a lower end and an upper end, said lower ends being pivotally connected near said rearward ends of said lower arms, one of said rearward ends of said lower arms and said lower ends of said upper arms defining a hub axis;

a link pivotally connected to said upper ends of said upper arms and pivotally connected to said upper mounting bracket; and

a shock absorber pivotally connected to one of said main frame portion and said link at a first end and pivotally connected to said articulating frame portion near said hub axis at a second end.

**20.** The bicycle frame of claim 19, wherein said articulating frame portion additionally comprises a bracket for mounting a rear brake assembly, said pivotal connection between said shock absorber and said articulating frame portion being located on said bracket.

**21.** The bicycle frame of claim 19, wherein said pivotal connection between said link and said upper mounting bracket defines a first pivot axis and said pivotal connection between said shock absorber and said main frame defines a second pivot axis, said first pivot axis and said second pivot axis being at least proximate one another.

**22.** The bicycle frame of claim 21, wherein said first pivot axis and said second pivot axis are coaxial.

**23.** A bicycle frame, comprising:

a main frame portion;

an articulating frame portion comprising:

a pair of lower arms having a forward end and a rearward end, said forward ends being pivotally connected to said main frame portion;

a pair of upper arms having a lower end and an upper end, said lower ends being pivotally connected near said rearward ends of said lower arms, one of said rearward ends of said lower arms and said lower ends of said upper arms defining a hub axis;

a link pivotally connected to said upper ends of said upper arms and pivotally connected to said main frame portion; and

a shock absorber connected to said bicycle frame and being arranged to provide a force resisting movement of said articulating frame portion with respect to said main frame portion, a first end of said shock absorber being pivotally connected to said articulating frame portion near said hub axis.

**24.** The bicycle frame of claim 23, wherein said pivotal connection between said first end of said shock absorber and said articulating frame portion is within about five inches of said hub axis.

**25.** The bicycle frame of claim 23, wherein said pivotal connection between said first end of said shock absorber and said articulating frame portion is behind said hub axis

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